The impact of commodity price volatility on stock prices

A case study from the exhaust gas treatment industry within the stainless steel value chain

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Abbreviations

Abbreviation	Description
ADF	Augmented Dickey Fuller
AI	Artificial Intelligence
AIC	Akaike’s Information Criterion
ANOVA	Analysis of Variance
AR	Annual Report
ARCH	Autoregressive Conditional Heteroscedascity
ARMA	Autoregressive Moving Average
AS	Alloy Surcharge / Supplement to pricing to reflect special alloys
AST	Acciai Speciali di Terni / TK steel mill
Base price	Agreed list price excluding alloy surcharges
BMW	Bayerische Motorenwerke
Cboe	Chicago Board of Options and Exchange
CBAM	Carbon Border adjustment mechanism
CEO	Chief Executive Officer
CNY	Chinese Yuan Renminbi
COMEX	(New York) Commodity Exchange
Commodity	any unprocessed or partially processed good, as grain, fruits, and vegetables, non-ferrous or precious metals.
CO_2	Carbon Dioxide
CSR	Corporate Social Responsibility
CV	Coefficient of Variation or RSD
DOSPERT	Domain-Specific Risk-Taking
EC	European Community
ECM	Error Correction Model
ECSC	European Coal Steel Commission
Effective price	Base price including alloy components
ERM	Enterprise Risk Management
EU	European Union
EWMA	Exponential Weighted Moving Average
FCA	Financial Conduct Authority
GARCH	Generalised Autoregressive conditional heteroscedascity
HMM	Hidden Markov Model
HSE	Health Safety and Environment
HWWI	Hamburger Weltwirtschafts Institut
ICE	Internal combustion engine
LAMO	Linear Anthropocentric, Mechanistic, and Ordered
LTC	Long-term cost reduction. Incentive for the customer that is reflecting price decreases year on year
Mill	Steel production plant, here stainless steel production site
NAS	North American Stainless, part of Acerinox

Abbreviation	Description
NPI	Nickel Pig Iron
OEM	Original Equipment Manufacturer / automotive producers
PBOC	People´s Bank of China
PMCC	Pearson´s Product Moment Correlation Coefficient
PSH	Prebisch-Singer Hypothesis
QUAL	Qualitative Research
QUAN	Quantitative Research
REE	Rare Earth Elements
RIE	Recognised Investment Exchange
RQ	Research Question
RO	Research Objective
RSD	Relative Standard Deviation
RSI	Relationship Specific Investment
SC	Supply Chain
SCM	Supply Chain Management
SCRM	Supply Chain Risk management
SHFE	Shanghai Futures Exchange
SMR	Steel & Metals Market Research GmbH
SSC	Steel Service Center, Distribution, and processing after steel production
Steel pooling	The steel is centrally negotiated for own usage and usage of sub suppliers
TCE	Transaction Costs Economics
Tier 1	Supplier that supplies directly to the automotive manufacturer
TKN	ThyssenKruppNirosta AG
USP	Unique Selling Proposition
VAR	Vector Auto-regression
VC	Value Chain
VIX	Volatility Index by Cboe
Volatility	In finance, volatility is the degree of variation of a trading price series over time as measured by the standard deviation of returns
WW II	World war II (1939 to 1945)

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Abstract

Commodity price volatility (CPV), its impacts and potential price mitigation strategies along the stainless steel value chain are the subject of this research. The phenomena of price fluctuation attract increasing attention in literature, academia, manufacturing, and none manufacturing industries like the banking industry. CPV has the potential to influence the prospects and the prosperity of companies, expressed in the share price. The share price is deployed as it condenses these business prospects; hence, it is a gauge of the economic state of the company and future business expectations of the industry. The manufacturing industry faces an increasingly unstable business environment and a rising complexity. The recent pandemic outbreak (COVID-19) illustrates the vulnerability of the industry and the necessity of mitigation scenarios. The term Volatility-Uncertainty-Complexity & Ambiguity (*VUCA*) describes this combination in literature. The stainless steel value chain experiences price fluctuations and its impacts from the mining industry to the customers, like the exhaust gas treatment system producer. The competitiveness of the industry is determined by a high level of fixed costs, which is evident in steel production sites; and among others, is affected by raw material price fluctuations. The raw material may account for up to 70% of the product price. This commercial and hence financial situation challenges the stainless steel business. This research sheds light on the particularities of the industry with the means of statistics (i.e., Generalised Autoregressive Conditional Heteroscedasticity (GARCH) and an Autoregressive Distributed Lag (ARDL) modelling). These statistic models help to gauge the time varying impact of the price variations and study the impact of CPV on share prices. These findings contribute to the risk management in the stainless steel industry by offering a forecast method and a selection of mitigation approaches. This research deploys times series models with multiple variables and hypotheses testing. These findings are transferrable to other industries. The investigation centred on an industry survey (questionnaire) and five in-depth interviews with stainless steel producers' executives. This research will carve out the differences between the stainless steel producers while coping with commodity price volatility. Also, it addresses the existence of price mitigation strategies and the ability of companies to mitigate commodity price fluctuations. The experience and knowledge of commodity price volatility determines the selection of the mitigation scenarios to defend the financial stability of the manufacturing industry (e.g., automotive).

The goal of this research is to study and measure the commodity price volatility, to help companies to discover new opportunities and competition. However, this thesis will although

assist companies in deploying mitigation strategies in case of disruptive phenomena and understand the risks associated to political and financial instability.

JEL Classifications	
C12	Hypothesis Testing: General
C32	Time-Series Models
D8	Information, Knowledge, and Uncertainty
D81	Criteria for Decision-Making under Risk and Uncertainty
E23	Production
G32	Financial Risk and Risk Management
L61	Metals and Metal Products
L72	Mining, Extraction, and Refining: Other Non-renewable Resources
Q02	Commodity Markets
Q31	Demand and Supply, Prices

1 Introduction

In the stainless steel industry, price fluctuations are an everyday occurrence. Raw material prices rise and fall constantly. However, these price fluctuations impact the companies. It may derail earnings and impact the financial position. Therefore, price fluctuations and their impacts are examined in this thesis. It is a business risk linked to the price volatility of raw materials like Nickel[1], Iron ore and Ferrochrome (ferrous[2] and non-ferrous[3] metals). However, it is not the sole existing influence, other influences (e.g., natural disasters, market, and credit risks) exist in the value chain. The share price development combines the financial situation of the company and its prospects. Therefore, the influences of the raw material price swings are compared to the stock price. The stainless steel business is as unique as other industries and bears its wordings and terms. An example is the terminology between commodity and raw material that might bear some confusion and is, hence, explained. The examined input materials are required to produce stainless steel. This thesis refers to raw material instead of the general term commodities. The meaning of commodity in this thesis is related to a commercial product, merchandise, primary good (Pearcey, 2019). In the industry, goods of common characteristics are referred to as commodity/ies, in the sense of a commercial homogenous product–traded in bulk at an exchange-.

The literature review examines the commodity terminus. Hence, the routine is to refer to the metals that are traded at an exchange as commodity rather than raw material. This thesis deploys the expression commodity or raw material for the mentioned metals. However, the term commodity price volatility is deployed in literature, rather than raw material volatility. In this research, the value chain starts with the mining activities to the exhaust gas treatment producer (Figure 1).

The price of stainless steel is driven, for a dominant part, by the raw material price (APS, personal communication, 2019; AST, personal communication, 2019). Regarding the stainless steel material characteristics, it should be noted that there are a few elements that have a significant impact. In parallel, those elements often determine the final price of the material. Hence, there is a material price risk. Carbon steel grades have been eliminated from the exhaust system because of the limitations of the material characteristics towards the technical

[1] Throughout the thesis, the main raw materials will be highlighted through a capital initial letter
[2] Ferrous metals a large percentage of the chemical composition is iron
[3] Nonferrous metals contain no significant amount of iron

requirements like acid and heat resistance. Carbon steel to stainless steel is beside the material properties a value driver, which is equal to an increased price volatility risk. In literature, it is termed *commodity price volatility risk*.

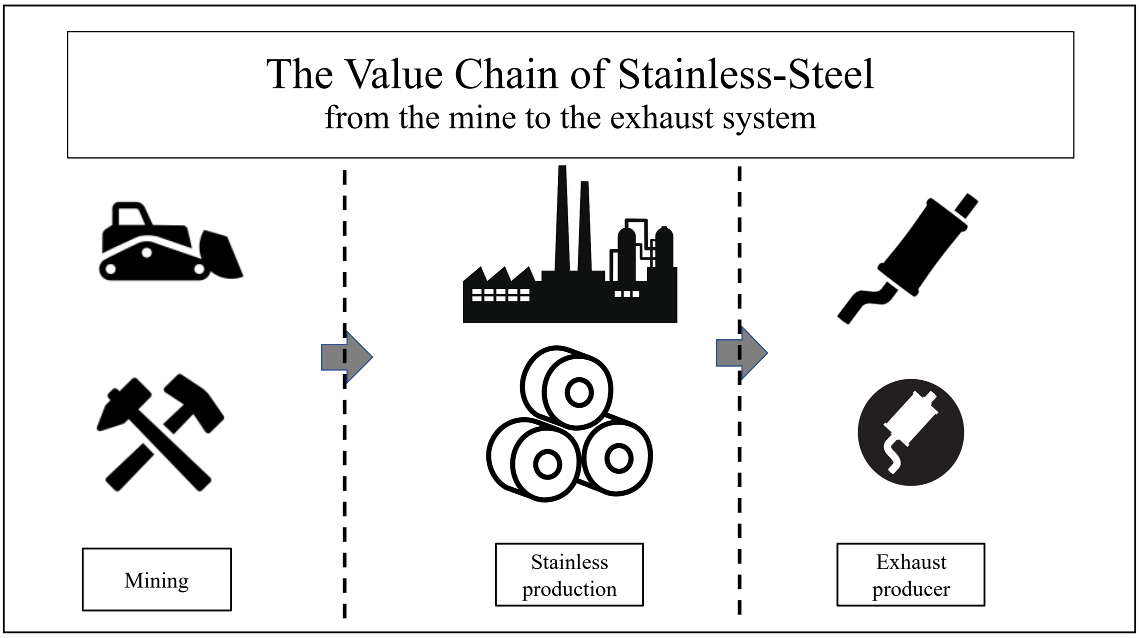

Figure 1 Value chain of stainless steel, Source: own data

Stainless is the material of choice. The price risk develops in line with the demand for the material quality. Material characteristics like resistance against heat, acids, salt, and intergranular corrosion are determined by alloys like Nickel, Titanium, Chromium, among others. The exhaust gas treatment industry is linked to the automotive industry. This sector represents around 90% of the total stainless steel consumption in this industry (D. Lebherz, personal communication, 2018). The industry is very price sensitive (Eberspächer, 2016; Markets & Markets, 2017; Mohr et al., 2013; Tiwari, 2020) and, therefore, price fluctuations are a concern. Price fluctuations counter the efforts of the suppliers to have a stable and decreasing input cost base. Particularly, in the first and second Tier (Figure 2), as margins are often razor thin.

Environmental and technology aspects challenge the automotive sector. The fast-moving Electric Mobility (E-mobility) is a business threat that might disrupt the exhaust industry (Moll, 2020). Few big customers, the automotive producers, are finding a supplier pool that turns into a "built to print" market. However, the Tier 1 suppliers desire to be a technology partner and not a manufacturing shop with a value proposition (Eberspächer, 2016). Only a few companies are from a negotiation perspective on the same level as the "Original Equipment Manufacturers" (OEM). Often these hold key technologies that are not part of the

OEM's manufacturing portfolio, as these concentrated on the core business of assembling vehicles. Hence, the margin pressure is enormous when combined with the prerequisite requirements to serve the global activities of the automotive producers. Apart from studying the adaption to CPV, this research examines mitigation strategies and the impact on the stock prices within the automotive stainless steel industry. If a mitigation is workable, which strategies are applied? Is the price fluctuation passed through to the next level in the value creation, to the last customer? This research answers these questions and, thus, it assesses whether CPV is a threat or an opportunity.

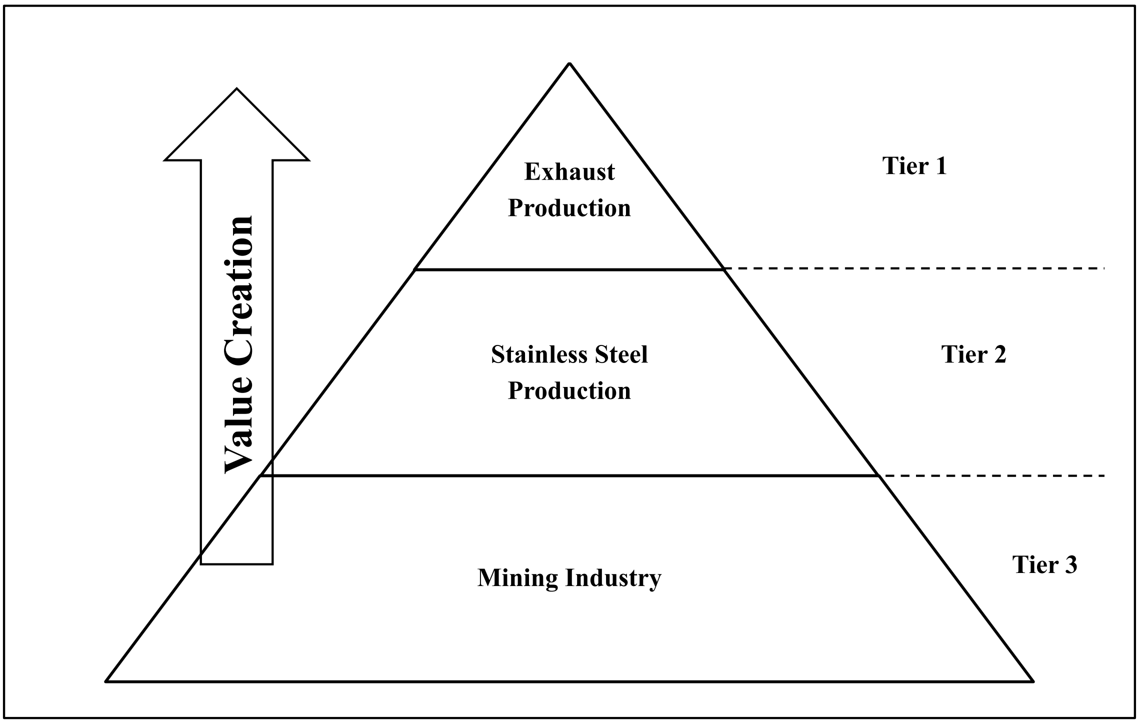

Figure 2 Supplier structure in the Automotive sector, Source: own data

The findings of this study also apply to sectors exposed to price-sensitive products. This research represents to the best of the authors' knowledge the first in-depth study of raw material price volatility in the stainless steel and the exhaust system business. It provides insights into metal prices and the profitability along the automotive consumption. It suggests that these markets are not immune to commodity price volatility (ACX, personal communication, 2019; APS, personal communication, 2019). The share prices are standing for the ideal method of measurement. It includes hard facts like profitability, however, the market belief and overall expectations of the share/- and stakeholders are represented.

Price volatility is not unique to the automotive industry under investigation. It exists in diverse industry sectors (e.g., Oil and Gas prices or currency exchange rate fluctuations). These examples distress the industry/commodity prices and hence consumer prices (Ågren, 2006;

Zsidisin et al., 2017). The overall supply and demand pattern cannot explain the price swings. Low-margin products, often coincided with a high material content, are vulnerable to input price fluctuations. These raw material price fluctuations are an exogenous influence, like oil prices are an exogenous effect to the (Álvarez et al., 2011). They are outside the sphere of influence of the companies. These commodity goods are often traded at a metal exchange, like the London Metal Exchange (LME). A firm price setting (list price) is a common method if the product is categorised as a catalogue product, like white goods, furniture, or automotive final customer sales price. Commodity price volatility affects profitability. This is similar in other industries. Price adjustment clauses to reflect the price volatility of the input materials are not a common practice in this market. The price risk is not passed to the last customer. It remains in the value chain of the producer.

This thesis focuses on CPV in value chains and not on the physical supply chain from ore to the finished part. To clarify the meaning, *this thesis concentrates on the operational and strategic options to mitigate commodity price volatility in a value chain setting*. The deeper understanding is sought with the focus on the niche market of the stainless-steel industry.

The stainless steel market is a niche market compared to the carbon steel market. The annual production volume of the carbon steel market is approx. 1.8 billion tons in 2018 (World Steel Association, 2020) and the stainless steel market comprises 51 million tons in 2018 (ISSF, 2020). The stainless steel market is less than 3% of it. The carbon steel production is less sophisticated, and even more commoditised. The product is highly standardised and similar grades are available by diverse producers across the globe. Further details are listed in Annex 1.

The value stream from raw material (i.e., Nickel and Iron ore) to the exhaust gas system is studied. The transformation of raw materials into stainless steel (i.e., flat material) and further to a part is researched (Figure 2). The value creation into an exhaust gas treatment system is examined. The exhaust system reduces the environmental impact of internal combustion engines of the automotive industry (Figure 1). These are applications like individual (i.e., passenger cars) and mass transportation (i.e., busses or trucks). The management of the implied risks/uncertainties and the mitigation scenarios are examined. Four major statistical methods are deployed to investigate the potential influence of raw material price variations:

- Correlation and multiple regression analysis
- Generalised autoregressive conditional heteroscedasticity (GARCH)
- Autoregressive distributed lag (ARDL)

The first statistical methods examine existence and strength of the relation between the commodity and stock prices of the firms in the value chain.

The GARCH model is deployed to model volatility and predicts future values. The ARDL method displays the time-varying effect of the data series. The crucial difference between a GARCH and an ARDL model is that the latter includes exogenous variables (and their distributed lags) while the GARCH does not.

This research endeavours to present the understandings of mechanisms and measures to cope with commodity price volatility. The actual exhaust product manufacturing is the third level in the value creation. The stainless steel sector is characterised as an oligopoly in Europe and the USA, the principal consuming markets. However, the stainless steel industry is affected by enormous production capacities in Asia (Moll, 2020). The national interest of the producing countries leads to a situation where trade restrictions, like tariff and non-tariff barriers, bias the balance of supply and demand. A free market is not existing anymore, and the definition and interpretation of common interest is a flexible term. The producers or nations or group of nations like the European Community (EU) influence the perception of it. The changing economic environment is another uncertainty that contributes to price risks.

The interviews with board members and even one CEO in Europe and the USA captured the stainless steel producers’ perspective. As part of the literature review, the annual reports (AR) are analysed. Explaining the answers to the interviews that revealed different mitigation approaches. The thesis deploys these to triangulate the research findings.

This thesis is structured into six sections: the introduction, the aims and objectives, the literature review, methodology, results, and the conclusions.

This thesis was in parts discussed during lectures at HS Koblenz in Germany, once in 2017 at the early stages of my dissertation and twice in 2019 (i.e., April and December). The risk management aspect, including potential mitigation strategies, was presented and reviewed with students of the supply chain section of the institute. The sessions have been held in cooperation with Prof. Dr.-Ing. Elmar Bräkling, Fachbereich Wirtschaftswissenschaften Allgemeine BWL. It was him that encouraged me to pursuit my doctorate.

Furthermore, the risk identification and the use of artificial intelligence (AI) in the mitigation strategies to alleviate price risks have been presented at the Hochschule (HS) in Munich between 2020 and 2021. Hosted by Prof. Dr - Ing. Joerg Elias of Hochschule München (Munich), the University of Applied Sciences.

At both universities, the topic raised interest and the comments of fellow students, and particularly Prof. Dr - Ing. Elias has been helpful in the final stages of this thesis. The influence of CPV was presented on several steel and stainless steel conferences during the last years. The author has been a guest speaker at Focus Rostfrei in Düsseldorf in 2018.
Diverse presentations about price volatility and its impacts have been held in Vienna (2016), Lisbon (2017), Helsinki (2018), Philadelphia (2018) and Seville (2019) for the leading stainless steel conference organised by SMR/Austria. The findings of this thesis will be presented at EurOMA 2022 in Berlin for an oral presentation in person at the Conference.

1.1 Industry knowledge

Ferrochrome, Iron ore and Nickel are the principal ingredients to produce stainless steel. The price volatility of these elements influences the production price, hence, the Costs of Goods Sold (COGS). The alloy surcharge (AS) is part of the effective price of stainless steel. Stainless steel mills deploy the AS to pass the price volatility risk of the alloy elements to the customers.
The major driver of the stainless steel price volatility is Nickel. The stainless steel industry consumes almost 2/3 of the comprehensive Nickel production (White, 2019). For Ferrochrome, this rate is even higher, the Indian Stainless steel organisation estimates that stainless steel producers consume 77% of the global production. Another 19% is deployed for grades, like engineering steels and alloy steels. Other steel grades consume the remaining 4% (Mathur, 2015). The consumption of these two elements depends therefore on the production output of stainless steel. The strong association might explain why no further research has been dedicated to this niche market. However, the raw materials experience annual price fluctuations typically above 10%.

Nickel was for a long time mainly associated with the production of stainless steel. The increasing demand in other areas, like the potential usage in the battery packages of electrical vehicles (EV), attracts attention of a wider industry and banking industry. It is part of the elements known as rare earth[4] or precious metals[5] or non-ferrous metals. Hence, another reason for the price movements is rooted in the power of the financial sector. The term "financialisation" describes the financial interest (Arezki, Loungani, et al., 2014; Miffre & Brooks, 2013;

[4] Rare earth elements (REE) are a set of seventeen metallic elements. The fifteen lanthanides on the periodic table plus scandium and yttrium

[5] Precious metals have rare and have a high economic value are e.g., Gold, Silver, Titanium

Silvennoinen & Thorp, 2013). The banking industry is not interested in supply or consumption. However, financial solutions (e.g., hedging) to mitigate price risk or to support the trade of these commodities are offered. Mayer, Rathgeber and Wanner (2017) investigated the influence of financialisation on metal spot prices and on price volatility. One finding is that trading positions do not per se influence the volatility of commodities. Despite the assumption that the financial sector drives and influences prices, there is no unambiguous evidence that trading activity influences commodity prices or volatility (Mayer et al., 2017). On some occasions, trading activities impact the price trend, as other investors may want to take part in the trend and follow it. The decision is based on the ratio of others. The expression herd-behaviour describes this pattern in literature (Arezki, Loungani, et al., 2014; Auinger, 2015, p. 36; Piot-Lepetit et al., 2011, p. 151). The price development of raw materials may impact other similar raw material prices, which is often described as "*spill-over*" effect, as the price dynamics reflect on each other (Hammoudeh et al., 2010). However, often price developments move together and are referred to as "*co-movements*". Both terms are detailed in this thesis. The term "related commodities" is deployed for raw materials which are in the same group, like ferrous or non-ferrous metals. Iron ore and Ferrochrome are ferrous metals, Nickel is a non-ferrous metal but these do not move always at the same pace.

1.2 Researcher's motivation

The desire to understand price fluctuations in the stainless steel sector was a need that started after entering the steel industry. It became a determination ever since. The starting point was the high-quality/ engineering steel sector in 1991. One of the first challenges was to understand and to cope with the material price volatility of carbon steels grades. These impacted the competitiveness of the production and the trade of these steel grades.

Throughout my professional career, the perspective on price fluctuations changed. It was a common concern at diverse business settings. It spanned from a bright steel production, a trading house, a steel service centre (SSC) and an automotive Tier 1 supplier. The exposure is different however, the interest in understanding price volatility remained. Diverse levels along the value chain have a different view of the material price, whereas commodity prices in the mining are the essential price factor. The value of stainless steel as raw material increases when it is processed into a final product. Hence, manufacturing operations add value to the stainless steel raw material. This results in declining raw material costs compared to the total product price. The value share decreases gradually with an increased value creation. The price of the input material becomes less critical for the value of the product that is often a consumer product. However, the stainless steel mill is exposed to CPV for a longer period. This period spans from the purchase of the metals to the payment of the product. During this time, the price volatility has an immediate impact on the profitability of the stainless steel producer. In the trading environment, the price volatility is an opportunity to maximise the profit, while for exhaust gas treatment system producers it makes up a business risk.

Hence, price volatility often represents a threat to profitability. Price fluctuations are not predictable and, therefore, interfere with a stable continuous business. Uncertainty about the material costs is a concern for financial planning and budgeting processes. Material cost swings impact the cash-flow. This volatile business environment requires strict management and controlling. Otherwise, it may jeopardise liquidity, hence financial stability. CPV is considered as a financial risk (Krause & Tse, 2016; Zsidisin et al., 2017, p. 3). It is under the umbrella of supply chain risks, which are typically classified as financial risks, as this impact the financial position of the company (i.e., cash flow). Despite the price fluctuations, the material availability occurred without similar turbulences (Poitras, 2013, pp. 33–35). Hence, the route to market is still intact. The mitigation is not viable without an understanding of these phenomena. For the automotive suppliers (i.e., Tier 1 and Tier 2) the price mitigation is crucial to a long-term profitability, as displayed in Figure 2. The negotiation power towards automotive producers is mostly limited and hence not able to include price risks. CPV may restrict the opportunity for sub-suppliers (Tier 2 or below) to balance the cost of stainless steel with the value-creating content. These mixed viewpoints and risk prepositions (from mining business to the exhaust gas treatment system production) are also researched.

The idiom of the “prudent and conscientious merchant“ underlines the necessity to proactively cope with risk and uncertainty. Previous research on existing and applied mitigation scenarios in different business sectors and cultures inspired this research. The possibility of accessing a network of industry experts was an essential advantage for this thesis. Notably, the automotive industry is currently anxious about tightened environmental regulations and the emergence of E-mobility. Moreover, the automotive industry is important for many countries, especially for those having many car-making industries and a substantial Tier 1 industry.

Hence, the enterprise-wide risk management (ERM) can be an important contributor to a competitive, profitable business. It reduces the probabilities of technical or operational recalls or other consequences that are a likely risk to manufacturers (Darrin & Zmoira, 2015). However, there is a need to cope with commodity price volatility versus the criticality of goods or the risks/uncertainties that are often associated with supply chain management. The impacts of price fluctuations and hence the selection and implementation of mitigation strategies are vital for the firms in the automotive value chain. However, this topic gains little attention in the literature (Fraser et al., 2014, p. 3; Gaudenzi et al., 2017). Hence, the stainless steel business is disregarded. This is underpinned by the initial research routines of the literature review. Given the economic importance of the metals market, the findings of this research are applicable to every industry that is exposed to commodity products. Commodity materials are considered the “life blood” of international trade and henceforth, any fluctuation might have its implications for the industry that is exposed to these materials (Zhang & Chen, 2014).This research is hence not limited to the stainless steel industry. The understanding of these price dynamics is fundamental. This includes the inter-market relationships, like spill-over effects and co-movements between metals and share prices (Batten et al., 2010). The burden of CPV may be alleviated and managed.

The industry insights of the author are an asset for this thesis. This setting is the base for the in-depth understanding of the commodity price volatility and its consequences in the stainless steel industry.

This research work has turned out to be longer than intended, partly because of the wealth of information, but also because quantitative and qualitative aspects have been considered thoroughly. This research contains the essential statements. Additional information is provided in diverse annexes. For the convenience of the reader, the following table has been drawn up.

Table 1 Chapter and referenced Annexes, Source: own data

Chapter	Annex referenced
1	1
2	1,5,6,7,14
3	1,2,6,8,16,21
4	1,34,5,6,7,8,10,11,14,21
5	1,3,6,8,10,12,13,14,15,17,18,19,20,21
6	12,13

2 Aim, Objectives & Research questions

This section elaborates on the aim and the objectives. It demonstrates the requirement to research commodity price volatility and its impacts. Besides, it presents appropriate mitigation strategies. The prediction is that commodity markets (Pindyck, 2004, pp. 1029–1031) will remain volatile in the future. Hence, price volatility of raw materials is not a temporary effect. Companies are not immune to CPV, the ability to manage these without failing is protecting the long-term financial stability of these. The research questions are categorised into three groups. The specific meaning and the definition of volatility are the starting points of this thesis. Despite its widespread use, the term volatility is not clearly defined. This can lead to ambiguities, especially when interpreting the range of fluctuation. Thus, these are examined with the first research questions (i.e., 1.1; 1.2; 1.3). This research uses mainly secondary data, while primary data is generated and analysed to support the findings of the literature review and to triangulate the statistical findings.

Primary data (i.e., questionnaires and interviews) enable the investigation of different mitigation scenarios (RQ´s 2.1 and 2.2). The third group of research questions investigates mitigation schemes and the impact of exogenous events like political or financial disruptions (RQ´s 3.1 and 3.2). The overview of the research questions is given in Table 2.

2.1 The Aim

This research aims to investigate and model commodity price volatility. It explores its impact on the stock prices along the value chain in the stainless steel business. The value chain comprises the mining industry, the stainless steel producing companies, and further to the exhaust gas treatment system producers. The research objectives guide this research and assure a reasonable and reliable progress.

2.2 Research Objectives and Research Questions

Evolving from the aim, the research questions and the research objectives are the rail guards for this thesis. Table 2 displays the connexions:

Table 2 Research questions & objectives, Source: own data

	Research question	Chapter	Research Phase			Results	Methodology	Research Objective		
			1	2	3					
	What is volatility									
1.1	a) how is it defined?,	2.2.2	x			5.1.1	4.3.1	1	2	
	b) how is it measured?	2.2.2	x			5.2	4.3.1	1	2	3
1.2	Which is the appropriate calculation method to do so?	2.2.2	x			5.2	4.3.1	1	2	
	Which effects does the commodity price volatility have on									
1.3	a) the share prices of the affected companies?	2.2.2	x			5.2.3	4.3.1	1	2	3
	b) the profitability of the stainless-steel producers?	2.2.2	x			5.2.6	4.3.1	3		
2.1	Which mitigation strategies do exist?	2.2.3		x	x	5.3	4.3.2 & 4.3.3	4		
2.2	How can these mitigation strategies been differentiated and linked to the stainless-steel industry?	2.2.3		x	x	5.4	4.3.2 & 4.3.3	5		
	Political & Financial risks									
3.1	What was the impactof the US trade restrictions (Act 232)?	2.2.4		x	x	5.5	4.3.2 & 4.3.3	6	7	
3.2	What was the impact of the financial crisis in 2008?	2.2.4		x	x	5.5	4.3.2 & 4.3.3	6	7	

To align the research questions and the objectives, these are categorised into three diverse groups to reflect the major streams of this research. Table 2 links research objectives, methodology, and results to the respective research questions. It adds to the readability of the thesis.

2.2.1 Price volatility – Research Group 1

2.2.1.1 Research Objectives – Group 1

The first group of research objectives investigates the terminus commodity price volatility (CPV) from a definition to the calculation. It researches the volatility modelling and the time-varying effect of the price fluctuations:

- Objective 1: Elucidate and model CPV with the aid of statistical means and time series analysis
- Objective 2: Research the impact of CPV on the share prices of
    a) mining companies,
    b) stainless steel producers, and
    c) exhaust gas treatment producers
- Objective 3: Research the time-varying impact of CPV on share prices

These objectives have been derived from the repercussions that price volatility has on companies. The foundation of the research is the clarification and understanding of commodity (raw material) price volatility. Hence, the initial step defines the meaning of it. The research objectives support the clarification of it with statistics and time series analysis to lay a foundation for further investigations. Product production and distribution cycle caused a retard to the raw material price changes to other value creation levels, hence, the time-varying impact is researched. Modelling of the volatility by a GARCH model (Annex 14) complement the descriptive statistics. Time-varying impacts of commodity price volatility are calculated with the support of ARDL models (Annex 5). The statistic section (5.1) investigates the connection between the commodity metals and the stock prices of the firms in the value string. For this purpose, the quantitative research investigates the price development of these elements and clarifies the impact that spills over to other metals or share prices.

2.2.1.2 Research Questions – Group 1

To support these objectives, the research questions research and guide the term volatility, the measurement, and:

1.1 What is volatility?
- a) how is it defined?
- b) how is it measured?

1.2 What is the calculation method?

1.3 What impact does the commodity price volatility have on
- a) share prices of the affected companies?
- b) profitability of the stainless steel producers?

This research investigates the drivers and the impact of CPV on the stainless steel environment. The research elaborates on the countermeasures to balance or to mitigate the impact of CPV on the financial stability and longer-term financial prospect of companies. The existence and application of mitigation scenarios and their relevance are investigated.

2.2.2 Mitigation strategies- Research Group 2

2.2.2.1 Research Objectives– Group 2

The second group of research objectives charts the existing and applied mitigation schemes in the stainless steel industry. Literature is the principal source for the listing of the mitigation scenarios. The questionnaire (Annex 6) and the interviews (Annex 7) are the primary data streams to triangulate the existing strategies versus the implemented strategies in the value chain. These strategies are highlighted and explored.

- Objective 4: Identify existing commodity price volatility mitigation strategies in the stainless steel industry.
- Objective 5: Explore the impact of mitigation strategies on the various levels of the stainless steel supply chain.

An overview was conducted to analyse the existing mitigation scenarios. This research ventures the common clustering of these business strategies. The intention and the impact of the strategies are explained. The existing literatures is linked to the stainless steel business.

The risk categories of political and financial risks are assessed in research group 3. As an example of a political risk, the announcement of trade restrictions by the United States of America in 2018 (US trade Act 232) is investigated. As an example of a financial risk, the global fiscal crisis of 2008 is assessed. It is referred to as the Lehman impact. They link the repercussions of the incident to the stainless sector. Existing statistical methods to verify volatility are examined. The listed statistical methods are deployed to verify the ability to forecast price developments. These forecasts, depending on the reliability and the risk appetite, may lay the foundation for relevant mitigation scenarios.

The understanding of the diversity and interrelationships of value chain risks are explained. The requirement for tailored solutions to balance effective risk-reduction strategies is underlined as a compulsory business activity to safeguard financial stability. In a complex environment, this may lead to a risk-adjusted value chain that improves the financial performance and leads to a competitive advantage (Manuj, 2013; Manuj & Mentzer, 2008b).

In Literature commodity price volatility is often regarded as a subcategory of supply chain risk management (SCRM) (Fischl et al., 2014; Gaudenzi et al., 2017; Ghoshal, 1987). Price volatility is one of the diverse risks that may disturb the value stream of the product. The difference between the material supply chain and the commercial component, which is examined in this thesis, is emphasised at this point. However, the findings regarding the CPV of this research contribute to the SCRM.

The foundation of an active price risk management is examined. This research investigates endogenous risk mitigation strategies, including sourcing, contractual, and financing strategies. However, exogenous strategies are elaborated among these are vertical integration and diversification. The justification of the mitigation scenarios for the stainless sector is guiding the objectives. The integrative approach was initiated by Henry Ford, one pioneer of integration, who investigated every component of production if it is suited to be produced internally (Masten et al., 1989). This approach might have influenced the Toyota Production System, which is a reference in the automotive sector. A different direction of thought is linked to the supply chain network approach. It supports the in-depth cooperation between the partner companies in a cross functional setting (Spear & Bowen, 1999).

2.2.2.2 Research Questions– Group 2

The relevant research questions to answer research objectives 4 & 5, to identify suitable mitigation scenarios and the exploration of the impacts, are:

2.1 What mitigation strategies exist?

2.2 How can those mitigation strategies be differentiated and connected to the stainless steel industry?

2.2.3 Application of mitigation strategies- Research Group 3

2.2.3.1 Research Objectives– Group 3

The third group of objectives examines the existing mitigation schemes and the potential measures to ease the impact of price fluctuations in extraordinary circumstances, e.g., disaster situations. The risk management of commodity price volatility is challenging in "stable times"[6], but it might be stressed in exceptional times. There are "force majeure"[7] events. A (natural) disaster is an adverse, sudden exogenous event caused by natural processes. These are not in the control of companies. This thesis examines the scenarios of a fiscal crisis and a political event. One example is the World financial crisis and the trade restrictions of the US administration in 2018. The consequences of sudden exogenous events on CPV are examined. The conclusions identify mitigation strategies for commodity price related impacts.

What is true for a natural disaster such as an earthquake or a tsunami might be controversial for other events. This thesis is not targeting to clarify these philosophical differences of interpretation. The intention is to use these events as an example to verify the examined CPV mitigation scenarios.

- Objective 6: Study the selection and the impact of the price mitigation strategies in case of disasters or events that are exogenous and spring up.
- Objective 7: Study the risks accrued by a financial crisis and a political change in the trade environment

[6] Stable times is a subjective expression for periods that exhibit relatively low volatility, likewise for exceptional times

[7] Unexpected event (e.g., war, crime, or an earthquake) that hinders someone from doing something

Objectives 6 and 7 research and guide the reasoning and the selection of mitigation scenarios. What is a suitable mitigation strategy to alleviate exogenous occurrences? The existence, selection, application, and implementation in the value chain are examined.

On the assumption that an enterprise risk management (ERM) defines different scenarios, this research examines the effectiveness of different strategies in diverse business risk scenarios. The two mentioned risk events are investigated to verify the mitigation scenarios. Pursuing the research objectives, it analyses which main exogenous risk exposure exists for companies. Figure 3 displays the tensions in the share prices regarding commodity price volatility. It parades the individual way of the value creation to reach financial stability. The figure sketches also the understanding of the purpose and inter-linkages of the mitigation strategies. It impacts the mining, stainless steel and exhaust gas treatment system, makers. The alleviation strategies are targeted to offset the price variance impact on the financial stability.

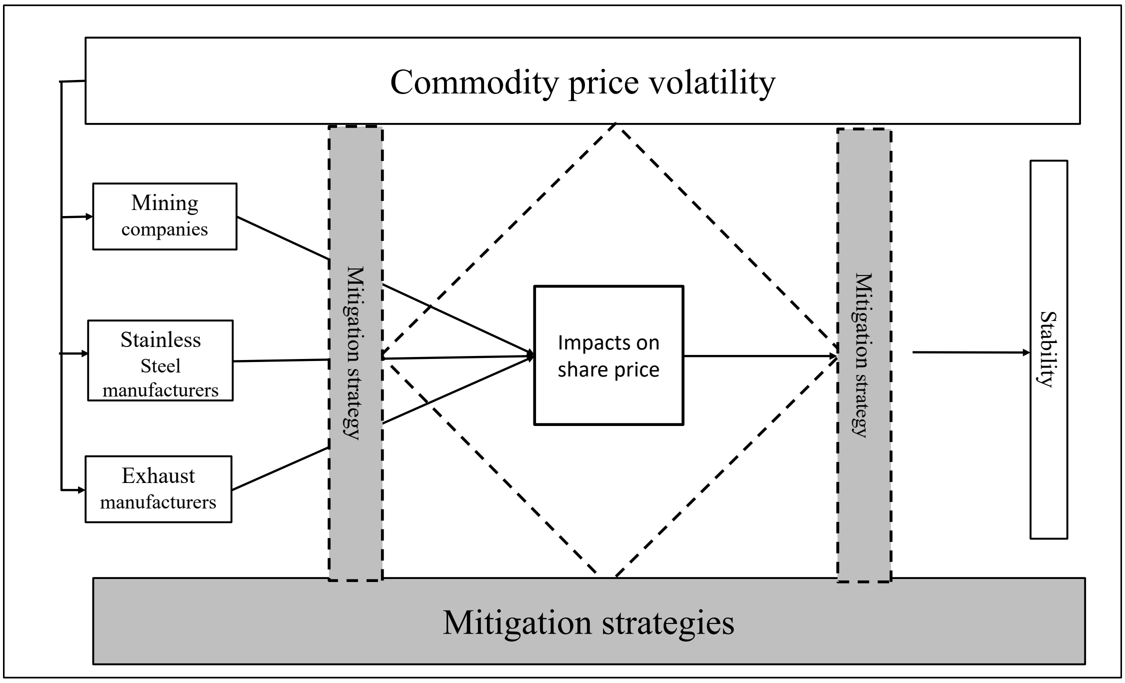

Figure 3 Mitigation strategies, Source: own data

2.2.3.2 Research Questions—Group 3

3.1 Political risks / trade restrictions

What was the impact of the announcement of trade restrictions and import duties imposed by the United States of America in 2018 (Trade Act 232)?

3.2 Financials risk

What was the impact of the Lehman bankruptcy that caused the 2008 financial crisis?

At the example of two events, this thesis researches the risk mitigation strategies for the impact on the share prices. This research deploys the Lehman crisis as an example of an event that affected most industries. It started in the banking industry and infected the global economy. It is a fair assumption to say that it was a sudden occurrence.

However, the political decision to erect trade barriers is different. The reduced import rate was a political promise to secure the goodwill of the industry and the voters in these industries during an election campaign in the USA. Hence, the word lobbyism[8] occurs in this research. The aspect of price volatility in the value chain is examined. Therefore, the impact of CPV on each level is investigated. The relationship between the commodity shares and the impact of commodity price volatility is researched.

2.3 Research flow chart

This research follows a clear path from introduction to conclusions. The research design is detailed in section 4.2. The research flow, if compared to a river flow, is fed by several "tributaries" that congregate in the main flow. This research comprises three phases of data collection in the research design. There are inter-linkages between these phases and cumulate in the result section.

However, the research flow is universal to examine diverse industries. The traditional research design flow chart is the backbone of this thesis. However, it expands into several data collection methods and includes methods of quantitative and qualitative data processing. The multiple sources and the different methods deployed to complete this thesis are detailed in the methodology section.

The parallel design of the deployed mixed-methods allows for an understanding of the complexity of this research. The chosen research design and flow are documented to allow for the reliability and robustness of the research thesis. The research flow is described in Figure 4.

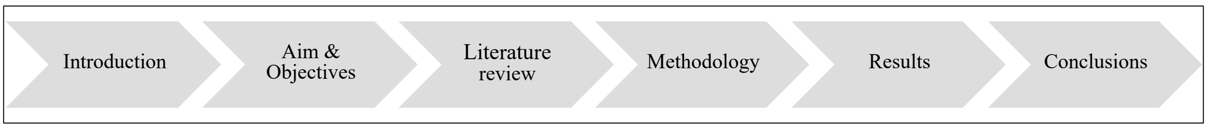

Figure 4 Flow of research, Source: own data

[8] Lobbyism, the engagement of persons to actively influence political decision makers

3 Literature review

3.1 Introduction

The literature review begun with the help of the internet database *Web of Science*, which is a collection of databases. A main advantage is the indexation of literature around sciences, social sciences, among others.

The review began first with the term “Steel”, followed by “Price”, “Mitigation” and “Volatility”, which constitute the main keywords for this research. The numbers behind the terms show the amount of published literature found. There are only two publications containing these four keywords. This number justifies that research on commodity price volatility in the stainless steel industry is underrepresented. The search for a specific term (e.g., Steel) constitutes a routine search. The results of the first routine search are displayed in Figure 5 and Figure 6.

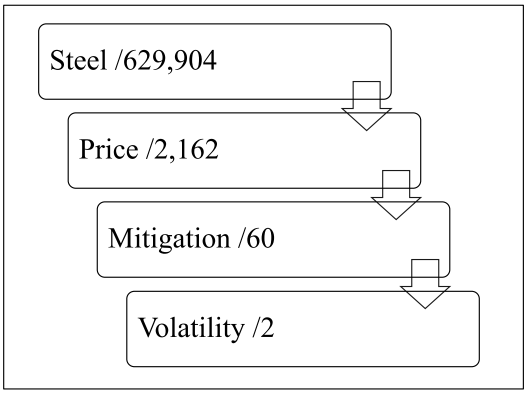

Figure 5 Literature search routine steel, Source: own data

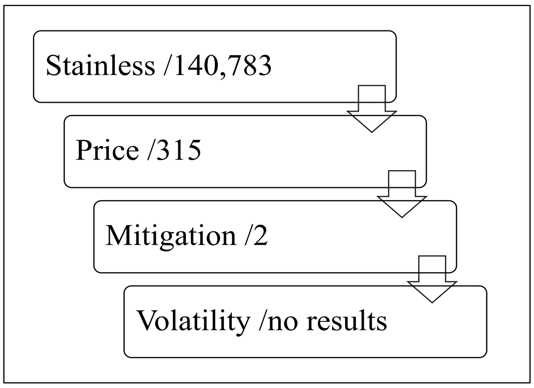

Figure 6 Literature search routine stainless steel, Source: own data

he 6-digit numbers for the terms “steel” and “stainless steel” indicate the number of scientific publications about the words “steel” and “ stainless steel”, however, not regarding economic topics. This finding underpins the research and development that is pertinent to new materials or new material characteristics. Despite the lack of literature on business-related topics, this research deploys literature on CPV, which is not specific to the steel or stainless steel business. The existing literature on commodities is the basis for the implications and the conclusions in the literature review. The list of results with the publication details is recorded in Annex 16. The resesearch on CPV is explained in this section.

However, this research bridges the gap to the stainless steel business, despite the limited amount of literature.

3.2 Volatility and the impact

This section supports the research objectives 1, 2 & 3 and answer the research questions 1.1, 1.2 and 1.3.

3.2.1 Origin of the term volatility (Etymology)

This section elucidates the term and the understanding of CPV (RO 1). Although the term volatility is used extensively in the literature, its meaning remains still vague.
The etymological definition of volatility is the noun from the adjective “volatile” which was mentioned in the 1590s as "fine or light," also as "evaporating rapidly" (Dictionary, 2018). The French word “volatile” descends from the Latin word “volatilis”. It means "fleeting, transitory, swift, rapid, flying, winged" from the past meaning “volare" to fly (from volant). In the sense of "readily changing, flighty, fickle" first recorded in the 1640s. “Volatiles” in Middle English meant "birds, butterflies and other winged creatures" (Online Etymology Dictionary, 2018). This expression was transferred to the economic meaning of fluctuation or with swings and sharp amplitudes. In finance and commerce, sudden, often drastic changes in prices or returns characterise volatility (Aizenman & Pinto, 2005a, pp. 521–523; Cashin & McDermott, 2002, p. 188; Pellegrino et al., 2019).
The phenomenon of sudden price swings is often associated with the rapid information flow across diverse media. The speed and the amount of information intensified in the last decades. However, business intelligence has not yet coped with these developments (Hammoudeh et al., 2010).
The different intensity of commodity price volatility on the various levels is investigated. The stronger influence of the financial investors in the commodity/raw material markets accompanies an increased interest by companies associated with commodity metals. Understanding CPV has become a requirement in recent years. The sensitivity of commodity markets increased because of inter-linkages with the financial community and a rapid information exchange, hence market liquidity and the influence of investors (Mensi et al., 2013). Volatility was studied, measured, and described in the stock market environment (Amadeo, 2018; Pindyck, 2004; Pindyck & Rotemberg, 1990).
Kennon (2018) describes volatility as “The volatility refers to the frequency and severity with which the market price fluctuates”. Another definition of volatility is “the pace at which prices move higher or lower and how wildly they swing”. A simplistic definition can be found in the book “Essentials of Enterprise Risk Management, which describes volatility as

"how much a value moves around" (Nason & Fleming, 2018, p. 40). Another technical definition refers to volatility as "a quantitative measure of the directionless extent of the variability of the price" (Piot-Lepetit et al., 2011, pp. 45–47). Volatility measures the frequency and magnitude of price movements, both up and down, over a certain period.

The financial risks are well researched compared to other enterprise risks. One explanation might be the proximity to the financial markets (Mayer et al., 2017). A reason might be the amount of data that exists in this financial environment, hence the references to a financialisation of the raw material market (2.2.2.1).

There is a need to forecast volatility in the financial and manufacturing industry. This need has been also demonstrated in literature for various other industries (Mensi et al., 2013; Nason & Fleming, 2018, p. 81). Information might be viewed as an advantage for other market participants. However, the forecast of prices is not typically incorporated in the DNA of consumers. Analysing information is nowadays the key to a successful and profitable business. As the idiom "A danger foreseen is half avoided" suggests. Short-term forecasting can be described as a tactical method. It considers historical data and price patterns, such as seasonality, anticipating the prices for the next few days or weeks, even longer periods. Long-term price forecasting is a strategic approach. It encompasses industry outlooks, capacity and demand forecasts, substitution and potential disruptions that may contribute to the price formation (Zsidisin et al., 2017, pp. 47–51). Commodity price volatility more than spill-overs is a global phenomenon (Delle Chiaie et al., 2017; Ng, 2000; Wang & Wang, 2010). The volatility of prices is puzzling for diverse groups, including researchers, statisticians, academics, and investors. To all of them, it is essential to understand the price fluctuations, the time-lag effect and the cross-market transmission of it (Mensi et al., 2013).

3.2.2 Risk and uncertainty

This section discusses the origin of volatility in literature. Macro-economic reasoning for commodity price volatility is the variability because of short-term production and consumption elasticities that are not in balance. The reactivity of mining operations is low; there are often several months or years between production agreements and the sale of the refined metal. In the mining and steel industry, capacity decisions are made before the prices are settled. The investments cycles are not short-term decisions. Hence, these decisions depend on anticipated prices and consumption. The existing price levels are not considered. Hence, there is a prior time between expected and the realised prices that might follow the supply and demand pattern.

A fundamental characteristic of volatility is the negative impact on economic growth, which is not offset by the positive sway of commodity booms. The "resource curse" paradox describes volatility, rather than a profusion of commodities (Cavalcanti De, 2015). This paradox is the connection between a wealth of natural resources. Paradoxically, this often goes hand in hand with an economic performance and governance challenges. Literature often describes Nigeria and Norway as examples. Norway has managed natural resource revenues for the benefit of its inhabitants, while Nigeria has struggled with its economic development and prosperity despite its natural resource wealth (Alichi & Arezki, 2009; Shaffer & Ziyadov, 2012, pp. 21–25). CPV remains a major cause of vulnerability in low-income countries, or low margin companies. Therefore, it represents a major risk to the value chain.

In literature, volatility is strongly associated with variability and risk terms. The movement or the fluctuations are referred to as variability while the risk is the unknown movement (Aizenman & Pinto, 2005a, pp. 48–51). The unknown movement is often an exogenous factor (not influenceable), often unexpected, like natural disasters or trade restrictions.

Creating a distinction between volatility, uncertainty, and might be pedantic. However, there is a subtle difference in economics. *Uncertainty* refers to uncertain surroundings and anticipated positive or negative outcomes. Hence, a situation where several outcomes are feasible, but the outcome of probabilities is not possible. *Risk*, in contrast, permits the assignment of probabilities to diverse outcomes. Volatility (variability) associates to risk. It provides a measure of the variation or movement in an economic variable or some function of that variable. An example is a growth rate (Aizenman & Pinto, 2005b, 2005a). However, the variation as a statistic value might not capture the risk. Volatility is a measure of variability. It may not fully measure the potential benefit or loss (C.-F. Lee & Lee, 2006). *Uncertainty* is also defined as a disturbance that is not forecast able (Jurado et al., 2015).

In general, uncertainty is defined as the conditional volatility of an unpredictable disturbance (Joets et al., 2017). Measuring uncertainty and examining its impacts on market developments remains a challenge. It is a question for economists because no objective dimension exists in literature. There is no common volatility measurement. The standard practice relies on robustness checks. Various methods are deployed to understand the cyclical components of the data series (Aizenman & Pinto, 2005a). Hence, volatility remains a universal term however, it does not generate a mutual understanding.

The term ”normal volatility" is often associated with a price change of less than 10% percent, deployed among risk experts (Aizenman & Pinto, 2005a, pp. 48–51). Pragmatic considerations have led to the 10% that defines "normal" commodity price volatility. But the pragmatic use of this 10% value is not adding to the definition nor to a risk assumption. This threshold is often denoted as acceptable volatility. From an academic point of view, this interpretation might be too vague, like the occasional separation between “normal” volatility and “extreme” volatility (or “crisis”). The separation is problematic. Extreme data points could be from the “tails” of the distribution and hence still be acceptable to the distribution. However, in extreme shocks, the likelihood and rate of occurrence might remain unnoticed if these are below the threshold level. Fluctuations exceeding the threshold level are severe volatility. The level and the “trend” of direction are important variables. Hence, it enables the understanding of the impacts (Aizenman & Pinto, 2005a, pp. 48–51). Therefore, the time effect must be valued if the fluctuations are “extreme” and in short distances or “less” extreme in longer periods. In contrast to descriptive findings, the CV offers a single value that leads to a reading of price volatility. However, the sample size must avoid biased series, which might be disturbed by outliers.

3.2.3 Volatility in the commodity/metals market

The necessity to cope with commodity price volatility has gained attention in the literature as an increasing share of interested parties is involved (Buhl et al., 2011; Schoenherr et al., 2012). As an example, the following articles constitute the basis to study price volatility in the stainless steel industry “Risk management of precious metals” (Hammoudeh et al., 2011), “Dynamics of Oil price, precious metal prices and exchange rate” (Sari et al., 2010), “Correlations and volatility spill-overs across commodity and stock markets” (Mensi et al., 2013), “Dynamic spill-over effects among crude Oil, precious metal and agricultural commodity futures markets” (Kang et al., 2017), “The commodities roller coaster” (International Monetary Fund, 2015) or “We don’t quite know what we are talking about” (Goldstein & Taleb, 2007). The following publications were also useful for this topic (Borghesi & Gaudenzi, 2013; Costantino et al., 2016; Gaudenzi et al., 2017; Qazi et al., 2018; Zsidisin et al., 2017). Volatility is associated with uncertainty and ambiguity. Prices that going down and bouncing back with sharp amplitudes manifest instability phenomena. Certain psychological studies showed that the investment community is comfortable when the price volatility is low. Commodity price volatility might be regarded as an indicator of market inefficiency. The research of Földarvi and van Leeuwen (2011) argues that market maturity is associated with a lesser extent CPV. This assumption may contradict the Samuelson maturity effect (Samuelson, 1965, 1973). The latter suggests that an increased volatility occurs once commodity markets reached maturity. Increased volatility might be perceived as a dysfunction of the market. The market efficiency is increased, and no trader can "outsmart" other players because of past market intelligence. Bauwens (2012, pp. 318–320) made the same argument. Whereas the linkages and the cross functions between the raw material markets and the share prices are still puzzling for the market participants (Mensi et al., 2013).

The quantitative measurement of volatility is compulsory for implementing most financial theories and mitigation scenarios required for the assessment of financial markets. Volatility is difficult to measure despite its importance. However, there are many ways to measure volatility, there is not a universal method (Aizenman & Pinto, 2005a, p. 545; Bauwens et al., 2012, pp. 319–323). Initial verifications are robustness checks, time, and dispersion related aspects of the data series.

Recent literature refers to higher commodity prices and higher commodity price volatility and the implied risk to the profits of enterprises. The CPV describes raw material price fluctuations (M.-H. Chen, 2010; Costantino et al., 2016; Merener & Steglich, 2018).

Explaining how prices change differs from explaining of why prices change. The reason for the price change (volatility) is sometimes a more philosophical question. Many general explanations for price changes can be offered next to the supply and demand function. These may include influencing or manipulating news about the supply or demand situation of the commodity. The real reason for the fluctuation is often not tangible. However, an enormous amount of information, including financial data, macroeconomic news, emotions and additional reasonings exists. This confirms the existing risk and uncertainty in the market and the *VUCA* environment of the current period (2.2.3). These price changes are not inevitably reflecting the supply and demand situation of the physical markets. For non-storable goods like agricultural goods, the price inelasticity is another source of price fluctuation (Arezki, Lederman, et al., 2014; Földvári & van Leeuwen, 2011). The price inelasticity presents the results of an inadequate supply and demand situation. It seems, however, impossible to provide specific explanations for most price changes (Taylor, 2007).

Supply and demand influence the prices of commodity materials; however, trading activities and speculation are not to be neglected. Henceforth, commodity prices can be volatile (Zsidisin & Hartley, 2012). The recent surge in commodity prices brought new momentum to the debate in academic and policy circles. The price development includes the large swings in raw material prices and their determinants and co-movements between data series (Byrne et al., 2013).

The commodity securities markets have grown substantially since 2000. Financial activity by institutional investors, hedge funds and exchange-traded funds (EFTs) influences the raw material market. Not all the involved parties have an interest in the physical supply of goods (Silvennoinen & Thorp, 2013). This opens the possibility that noise trading and momentum strategies can influence prices, however, it still remains controversial whether such trading has a role in sharp price fluctuations of commodity prices. There is empirical evidence of financialisation and quantification of the speculative component (i.e., Oil prices). The research of Hamilton (1983) indicates that severe production disruptions caused price shocks. These oil price shocks impact the equity market (Adams, 2014; Bouri et al., 2017). Despite the overwhelming amount of information, the stock markets typically anticipate these price changes and future financial impacts (Jones & Kaul, 1996) in the past and did so in recent years (S.-S. Chen, 2010; Xu et al., 2019; Zhang & Chen, 2014). The quick information paired with market efficiency (Arezki, Loungani, et al., 2014). However, high frequency trading activities are using bits of a second to trade (Budish et al., 2015).

Following the argumentation of these articles and publications, it is assumed that time-lag volatility in raw material prices exists (Kanniainen & Piché, 2013). Literature has been investigating the movements, co-movements, interdependencies, and impact of volatility in the commodity market and in the financial market. These price movements interest the financial market to forecast volatility to take coherent mitigating measures and even exploit opportunities from price fluctuations (Arezki, Hadri, et al., 2014; Arezki, Loungani, et al., 2014).

High volatility characterises commodity prices (Giovannini et al., 2019; Miffre & Brooks, 2013; Sensoy, 2013; United Nations Conference on Trade and Development, 2019). Many factors attribute to price volatility. The increased pace of business is one factor. The new economy witnessed a departure from traditional investment standards. Volatility can also be related to many diverse causes. Supply shortages and sudden demand increases might have been and will always be a reason to cause price swings (Hamilton, 1983). However, the tight connection between markets increases impacts of exogenous price fluctuations (Khan et al., 2019; Xu et al., 2019). Often these are caused by political trade restrictions and the weather or/and supply interruptions. However, the pace of change becomes faster and in shorter periods (months as opposed to years). Because of the speed of information, the period between cause and effects reduces (i.e., Nickel export ban of Indonesian government and idling Ferrochrome smelters in South Africa). Thus, time is of essence to describe and research cause and effects (Batten et al., 2010).

Price volatility is a normal occurrence and is desirable when the price setting is in the hands of an individual company (K. Hendricks & Singhal, 2005). Even the same product may have different prices (i.e., petrol). The term "excess-volatility" denotes the negative interpretation of price fluctuations (Piot-Lepetit et al., 2011, p. 24). The increased pace of business converts itself to more eruptive price movements. To mitigate or to capitalise on volatile raw material markets, the market players are required to manage the commodity price volatility risk, both from an operational and a strategic perspective. One reason for the progressively eruptive price swings may lie in the speed of information (e.g., when disruptive decisions are made) (Kilian & Park, 2009; Mensi et al., 2013).

However, investors often show interest in volatility indexes. The VIX Index portrays the expected volatility in the equity market. A tool to anticipate future price volatility. The overall movement of stock and commodity prices may move upward in the longer-term perspective (Fundukian, 2012, pp. 766–767). This contradicts with the Prebisch-Singer hypothesis. It states that raw material costs are relative to the product price and decreases over time. The volatility is a product of supply and demand (fundamentals), however, increasingly affected by trading and speculation activities (Zsidisin & Hartley, 2012). Commodity prices show robust responses to both demand and supply shocks. These aggregated shocks explain the price movements and remain persistent (Giovannini et al., 2019). Another source of price fluctuation is the "*noise trading*" produced by opportunistic investors. It occurs when investment or trading decisions are based on incorrect perceptions (Kaufman, 2013, pp. 8–12). This market behaviour creates a financial opportunity for more sophisticated investors (Corporate Finance Institute, 2020). The price finding is disturbed . It is not based on the actual supply and demand balance (Teall, 2013). Noise trading is part of the financialisation of the commodity market.

The long-term behaviour of metal prices has been researched extensively. Chen (2010) researches CPV of twenty-one metals including Aluminium, Nickel, Iron ore and even carbon steel. The articles suggest that world metal prices (commodities) are volatile (M.-H. Chen, 2010, p. 134). However, this publication, like many others, lacks a definition of volatility and does not study the quantitative aspect of volatility fluctuations.

Based on previous discussion, the definition of volatility remains an open question. Also, the characterisation of volatility in quantitative terms has not been well researched.

Although the oscillations are unpredictable, this research defines volatility in explicit quantitative terms (i.e., scale). This enables to segregate levels of volatility for an interpretation of the severity.

Volatility is not without a trend (Aizenman & Pinto, 2005b, pp. 2–5). These diverse characteristics are distinguished as “crisis or boom” and “trend or structural” volatility. Crisis/boom volatility is characterised by large, onetime swings in an economic variable, for example, a large swing in output growth. Trend volatility is represented by an alteration that stays constant over time (trend). However, a trend is typically identified retrospectively (Algieri & Leccadito, 2018). These patterns might reflect the long-term supply and demand situation of raw material, but might be biased by other events in the market (Achzet & Helbig, 2013; Pindyck, 2001). The fluctuations can be recurrent and moderate, albeit unpredictable (M.-H. Chen, 2010; Costantino et al., 2016). The variances of the random disturbances are not constant over time, dispersed. This is called *heteroscedasticity*. However, a certain trend might become apparent when the data are viewed over a longer period (Aizenman & Pinto, 2005a, pp. 521–523). Some price developments can be associated with the so-called “herd behaviour” and speculative noise trading (Pindyck, 2001; Pindyck & Rotemberg, 1990)

The expected future production capacity and downstream demand of stainless steel market is, henceforth, not the sole reason for CPV. Literature offers explanations for the dynamic price changes (i.e., shortages or supply disruptions, however speculation (i.e., noise trading and speculation) bias the price finds. At the example of inelastic Oil prices, a mismatch (i.e., supply shortages) may cause drastic price swings and vice-versa (Chun et al., 2019). Despite the long-term trend, this finding applies to the inelastic set up of the raw material excavation. Therefore, the price is led by the future production capacity and demand, however; the price is biased by short-term events. Cuddington and Nülle (2014) even argue that there is no general tendency in the long-term raw material prices. Therefore, price fluctuations can be regarded as an exogenous influence in the price finding (Pindyck, 2004). In literature, a mutual understanding exists that commodity prices are more volatile compared to other products like consumer goods. One explanation is the inelasticity of production capacity and demand (Arezki, Hadri, et al., 2014; Dwyer et al., 2011; Joets et al., 2017). This statement is in line with Deaton (1999), who described the ambiguity of price swings in the commodity sector with the statement, “What commodity prices lack in trend; they make up for in variance”. There is limited research that went into volatile circumstances (Carr et al., 1998). The research of Chen (2010) investigates the price changes in the metal market. This publication suggests that during 1972-2007 macroeconomic factors did, on average, accumulate for 34%

of the price volatility, compared to 16% for the period before 1972. Hence, for the latter time phase, 2/3 is a commodity-specific price volatility (M.-H. Chen, 2010).

The increasing volatility of commodity prices (Christopher & Holweg, 2017) has been studied in the past by many researchers. Distinct mitigation strategies, such as substitution, are discussed to avoid dependence or an amount of dependence on a particular raw material (Pellegrino et al., 2019). These price fluctuations and the associated risk challenge manufacturing companies. Hence, there is the necessity to reduce this commodity price risk (Achzet & Helbig, 2013; Borghesi & Gaudenzi, 2013; Costantino et al., 2016). Dramatic fluctuations in commodity prices seem to accompany inflated commodity prices (Giovannini et al., 2019). Next to the commodity price volatility, the uncertainty of the economic situation is mirrored in the VIX index, see section 4.3.1.5. Volatile prices are a concern to consumers, producers, and mining industries as volatile metal prices impact the financial situation of companies (Costantino et al., 2016; Zsidisin et al., 2017, p. 13). The financial risk affects profitability and long-term survival (Griffin et al., 2019). Steep price rises might generate a "windfall profit[9]" for an existing commodity stock. However, higher raw material prices translate to higher costs for new supplies (Borghesi & Gaudenzi, 2013, p. 21; Pellegrino et al., 2019). Hence, the business must direct more liquidity into raw materials (e.g., for the restocking and replenishment). The increased costs vice versa, the sharp price falls for a stocked commodity might create a "windfall loss[10]". The CPV influences the cash flow of the companies and might have damaging consequences (Borghesi & Gaudenzi, 2013, p. 95). Sudden price swings do not reflect the physical product flow. Prices might swing even when the supply and demand is in balance, detailed by noise trading and financialisation of the raw material markets. Business risk and returns are correlated negatively despite the hypothesis that risk and returns are positively correlated (Figenbaum & Thomas, 1986). Hence, more risk per se does not lead to increased profits.

Research on the volatility dynamics of raw material (or industrial) metals is limited in contrast to energy and precious metals commodities (Gaudenzi et al., 2017; Pellegrino et al., 2019; Todorova et al., 2014). An extensive amount of research is centred on the volatility of exchange rates and commodity prices and the potential links. Sari (2010) investigates the relationship between the US dollar/Euro exchange rate and precious metals and Oil. She confirms a close link, particularly after exogenous shocks occur. The linkages between Oil price

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[9] Wind fall profit, an unforeseen, unplanned, or unplannable profit

[10] Wind fall losses, an unforeseen, unplanned, or unplannable loss

fluctuations may influence raw material commodity prices in the short run. However, the impact differs depending on the researched metal market and the cause of the Oil price fluctuation (e.g., demand, supply or speculative demand shocks) (Ahmadi et al., 2016; Behmiri & Manera, 2015). The influence of Gold and Oil price fluctuations on the stock market in India has been researched. The strong link between these price fluctuations and the Indian VIX was confirmed (Bouri et al., 2017). Inter-linkages among Gold and Silver have been researched and a stable relationship is confirmed between the price movements of both metals (Lucey & Tully, 2006). The relationship between commodity prices (i.e. Gold and Oil) and the stock markets has been researched for the BRICS[11] (Mensi et al., 2014). Note that this publication suggests a strong link to the VIX in bear market conditions. Chen (2010) examines the relationship between commodity metal prices and confirms a substantial volatility that is associated with these. However, there is no link between potential co-movements or the driving force of the price fluctuations. The connection between the and other commodity products. The spill-over effects between Oil and commodity prices (i.e., Gold and Silver) are researched, including the time-lag of the effects (Kang et al., 2017). Overall, the relationship between the diverse mentioned prices is stronger in times of crisis.

The insight into the interdependencies of diverse exchange rate and raw material markets allows an understanding of the Nickel market. However, the time-lag component is crucial for the comprehension of impact and consequences of it (Mensi et al., 2013). The literature argues that given the economic and financial importance of the commodity metals market, the understanding of price dynamics and volatility is rather fundamental. The academic understanding of CPV, the potential linkages between the commodity market fundamentals and the finance industry are crucial for this thesis. This understanding is a primary key to manage commodity price volatility (Arezki, Loungani, et al., 2014). The bond between the markets and the assets should be tracked to mitigate the ambiguity of the trade and the usage of these commodities (Batten et al., 2010; Fischl et al., 2014). The potential strategic business advantage to mitigate CPV becomes clear when under margin pressure, as the automotive Tier 1 supplier industry.

For precious metals in contrast to ferrous and non-ferrous metals, the availability of the product is of strategic importance to certain industry sectors (Achzet & Helbig, 2013). In literature, described as “criticality” of the raw materials. The E-mobility sector and the defence

[11] BRICS states are Brazil, Russia, India, China, and South Africa

industry are stable consumers of these precious metals. Sometimes, availability is crucial for governments. In rare cases, the critical raw materials secure the defence abilities of the military sector. Hence, there is also a governmental interest in the metals market (Fischl et al., 2014; Gaudenzi et al., 2017).

Despite the governmental interference in markets. The supplier network approach may mitigate commodity price volatility and the inherent price risks, on several businesses. This approach is detailed in section 3.3.4. It details an in-depth supplier collaboration that incorporates sharing financial and price risk (Ellram et al., 2002).

Nearly 25 percent of the global merchandise trade comprises primary commodities. According to the World Bank's World Development Indicators (Cashin & Pattillo, 2000), the price movements and the longer-term pricing perspective are of significance to the manufacturing industry. The sharp fluctuations and long-run trend movements present severe challenges for the industry and the producers (Cashin & McDermott, 2002). The commodity exports are often representing a significant part of the gross domestic product (GDP) of raw material exporting countries. IMF publications are commenting on the negative impact of CPV on long-term economic growth (Cashin & McDermott, 2002). An increase in commodity prices is often better for the economies, as higher prices are beneficial from a business and governmental perspective. However, the mentioned "resource curse" might jeopardise the benefits. The volatility itself is the challenge. A slow response to these price swings may threaten the economic situation of the exporting country (Alichi & Arezki, 2009). Companies, in contrast, are better at responding to these price fluctuations. These companies have an economic interest in a well-founded control of the allocated resources. Therefore, they manage investments in a more sophisticated way, in contrast to political parties or policy makers (Deaton, 1999).

For the stainless steel industry, the following two graphs (Figure 7 & Figure 8) depict the price fluctuations of the AS for the main automotive exhaust grades 1.4509/AISI 441 and 1.4301/AISI 304 for the period from 2002 to 2019.

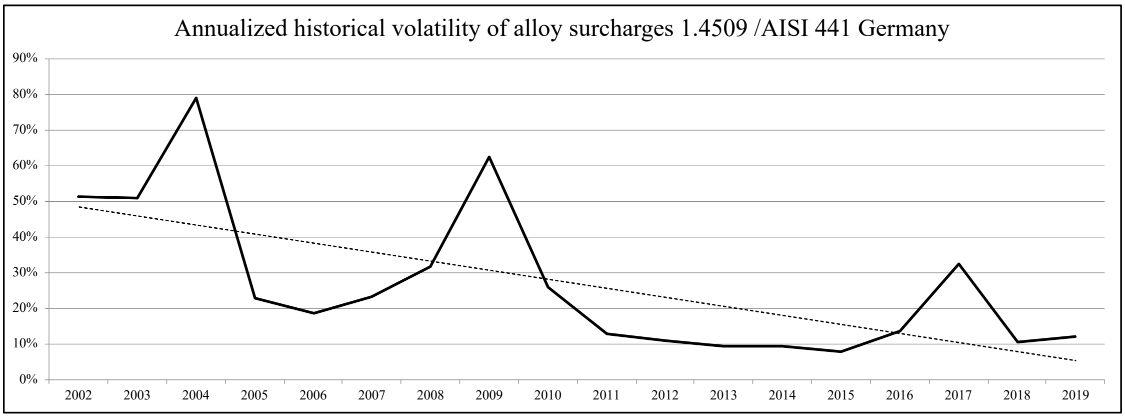

Figure 7 Historical volatility 304/1.4301 Germany, Source: own data

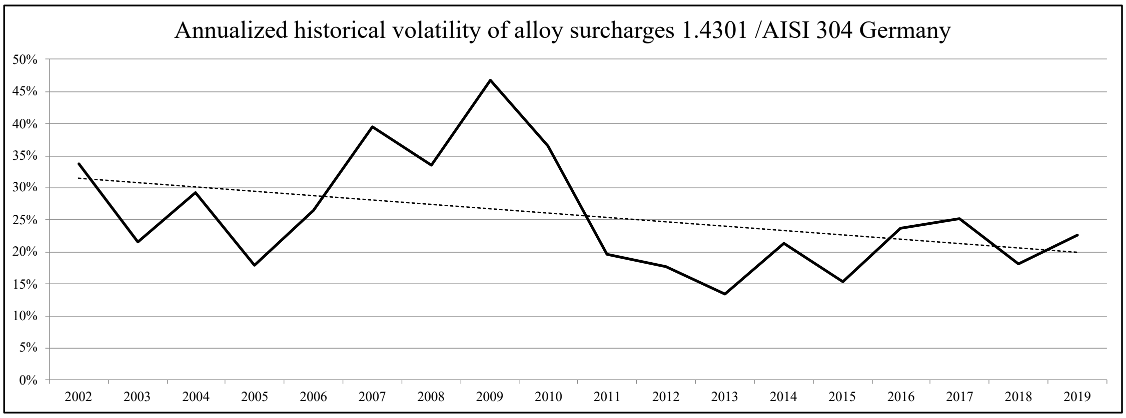

Figure 8 Historical volatility 441/1.4509 Germany, Source: own data

Furthermore, raw material prices may impact the share price of companies (Mensi et al., 2013, 2014; Sari et al., 2010). The link between the raw material price development and the share prices is investigated. The profitability of companies might reflect the commodity price volatility.

Literature hardly acknowledges Ferrochrome; one explanation is that it is not traded at one of the major metal exchanges. The commodity price impacts are not researched nor elaborated. Hence, it is an important objective to bring clarification into raw material price volatility. Describing the particularities of the stainless steel business would go beyond this section. Therefore, a detailed background information is attached (Annex 1). This briefing covers the industry specifics hence, this thesis focuses on commodity price volatility and impacts.

Prebisch-Singer Hypothesis

Prebisch (1959) claimed that commodity prices should decline relative to the price of the manufactured goods that contain the raw material in question. This is the Prebisch–Singer hypothesis (PSH) (Arezki, Hadri, et al., 2014; Ghoshray, 2011). The PSH has been challenged several times. It does not apply to all commodities, because of volatility rates of over 50% per annum (Svedberg & Tilton, 2011). There are statements in the literature that commodity prices will fall in the long-term. But this trend becomes a secondary issue because of the intense price fluctuations. The concern lies in the management of the fluctuation spreads (Arezki, Hadri, et al., 2014). There is no real trend in the commodity prices over the decades, neither in a positive nor in a negative direction, which challenges the Prebisch-Singer hypothesis (Cuddington & Nülle, 2014). Shocks to commodity prices occur often and are sincere. Hence, forecasting commodity prices or volatility becomes challenging, given also the fact that in recent years, volatility increased (Arezki, Lederman, et al., 2014; International Monetary Fund, 2015).

Based on the fluctuations of the VIX (Figure 9), these have decreased until 2007. During the economic crisis 2008/2009, the fluctuations increased (up to 80%) and then plunged. Thereafter, a period of relative stability is observed until the beginning of 2019. The exception is severe fluctuations at the beginning of 2010, end of 2011 (up to 50%), end of 2015 (>40%), end of 2017 and end of 2018 (both years <40%). The swings decreased over the years. Looking at the spikes, a certain clustering of price hikes is evident.

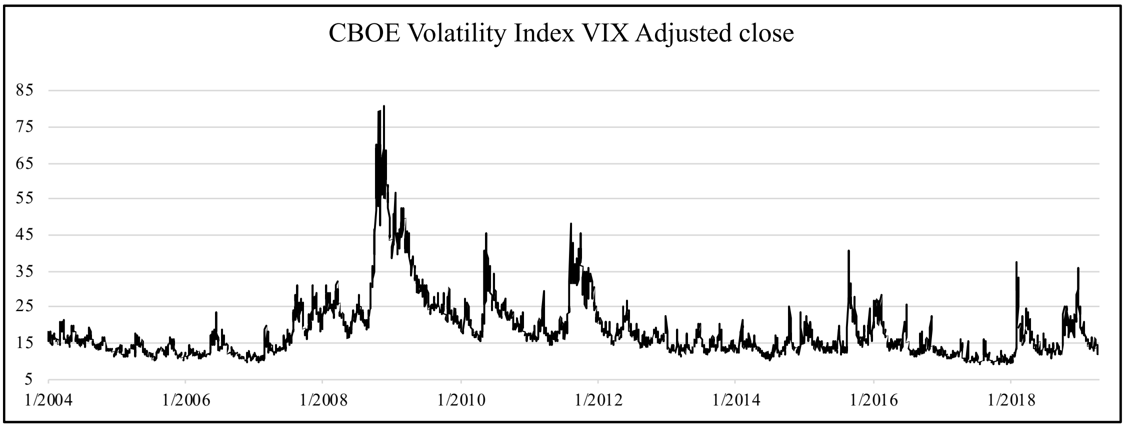

Figure 9 VIX 2004-19 Source: VIX report 2004

The “normal” volatility (i.e., 10% threshold) is seldomly not exceeded. Based on the alloy surcharge changes, including the annual volatility (Figure 7 and Figure 8, p.29), the alloy surcharge (AS) fluctuations are in contrast to the changes of the VIX. The spikes in the volatility of the VIX can be described at the alloy surcharge development. Based on the trend line, it can be concluded that the price fluctuations for both austenitic and ferritic materials show a decreasing trend. This is in divergence with findings of the IMF (2015) and Arezki (2014), but identical with the overall volatility of the VIX.

The price changes for both materials show an increasing trend over the investigated time. These price changes are raising a critical question about volatility. The raw material commodity price volatility is around 10% annually. Price volatility tends to spike for a certain time (e.g., months) before lower levels are reported. It looks like the price fluctuations are becoming more frequent but less extreme, like in the period around the global financial crisis in 2008/2009. Therefore, it is important to interpret the volatility of raw material prices. Volatility brings risks but also opportunities to traders and investors. There are many reasons why volatility occurs in commodity markets. Supply disruptions can have diverse reasons, often political unrest, or extreme weather in commodity-producing countries. These turbulences can create CPV. New financial instruments or methods, (i.e., ETF`s) can influence metals volatility, as well. CPV may be caused by changing demand patterns of a product (i.e., stainless steel) that uses raw material (i.e., Nickel) as input material. Market participants, from different expectations of profitable opportunities, perform hedging transaction however, they are not interested in the supply of the raw material. These factors contribute to the volatility of commodities over time and across markets (Joets et al., 2017; G. Power et al., 2013; Tadesse et al., 2014). The literature provides in-depth analyses and insights into the volatility, the potentiality of spill-over effects and/ or the market fundamentals. (Kang et al., 2017, 2017). The literature reviews explanations and patterns for price volatility. Authors like Cuddington and Rossen argue that super cycles might shed light on the price movements and the rationale behind the price fluctuations (Cuddington & Nülle, 2014; Rossen, 2015).

Supply and demand can drive these cycles. Often the individual commodity prices tend to move together (e.g., co-movements or spill-over effects) and display strong positive correlations (P. Chen, 2015; Jotikasthira et al., 2015). The occurrence of commodity price super cycles is a concern for producers and policy makers (Erten & Ocampo, 2012). However, these super cycles are often identified with a time gap, as these occurrences must be researched. For a long time, trends in raw material prices have been viewed a central policy topic for commodity-dependent (i.e., developing) countries. Future price expectations often reflect on the decision about an adaption of the production (-mining) capacity. However, investment projects might take several years to completion in the capital-intensive mining and stainless steel industry. The involved firms must observe medium-term price trends. Surges in commodity prices are often deployed by financial investors to participate in increasing or decreasing prices. Hence, these price patterns influence investment decisions. Financial corporations developed commodity portfolios not solely as an investment product but also an increased demand in commodity markets (Erten & Ocampo, 2012).

The forecasting of future developments of prices although is important to the manufacturing industry. However, it faces various challenges. Despite distinct statistical methods and information sources available, it is impossible to forecast prices when relying solely on historic data. This represents a naïve approach, "Moreover, models are built on a finite set of parameters, while reality affords us infinite sources of risks" (Taleb, 1997). The statistical calculations and models produce results, but these results are not always compatible with reality.

3.2.4 Price volatility in the stainless-steel market

The stainless-steel market has not been researched so far from an academic commodity price volatility perspective. Hence, RO 3 links the impact of commodity price fluctuations to the share price of the companies in the stainless steel industry. The impact of the commodity price swings for these three value creation levels is also investigated in this research.

Xiarchos (2009) examines the price mechanisms of the primary metal and steel scrap market. Although the role of financial investment in the raw material market increased over the past decade, it did not alter the price dynamics significantly (Dwyer et al., 2011; Mayer et al., 2017; Miffre & Brooks, 2013). Hence, literature supports the price equilibrium as the production capacity/supply and demand in the longer term (Christopher, 2000). However, this is not undisputed, the increasing share of trading and speculation in commodities may lead to an increased CPV (Mensi et al., 2013; Miffre & Brooks, 2013; Silvennoinen & Thorp, 2013; Vivian & Wohar, 2012). For most commodities, although the impact has been small, it still exists.

Diverse price influencing factors are described and calculated for various situations. Markets refer to symptoms, like the spill-over effect. Examples are the stock market and the commodities Oil, Gold, and Wheat (Mensi et al., 2013), or precious metals (Sensoy, 2013, pp. 504–511). Another example is the impacts between the stock market and the Chinese and the US economy (Xu et al., 2019, pp. 310–320) or the effects of Oil price shocks (Zhang & Chen, 2014, pp. 32–41).

Spill-over/ co- movements of commodities

In particular, Dwyer and Gardner (2011), argue that there is no substantial evidence that financial markets have an adverse impact on commodity markets. This is based on longer period research and its relevance to the economy. However, although there is evidence of co-movements between prices of related commodities (Sari et al., 2010), there is no evidence that commodities in general display identical price trends (Pindyck, 2001). There is limited evidence that the price volatility of these metals is influenced by exogenous events (Batten et al., 2010). However, Batten argues that the spill-over effect for precious metals does not apply to all metals. In his article, the example of Silver is the exception to this rule. The rule mentions that commodity materials in one class or family show similar patterns of volatility (Batten et al., 2010).

In times of crisis and in times of steep increase of commodity prices, the cash market also becomes a principal factor in the price detection process. This is evidenced by the recent drastic increase in world food prices. The conclusions of Peri (2013) emphasise that price setting is more related to fundamental patterns rather than to financial trading in futures markets. This article elaborates on the findings from the agricultural market but may also be considered for metal commodities. A more recent article investigates the relationship between Oil and correlations on the stock markets in the United States (USA) and China. Interdependencies of the metals markets (e.g., co-movements of prices) strengthened after the financial crisis in 2008 (Xu et al., 2019). The spill-over effects and co-movements are a global phenomenon according to the European Central Bank (ECB) (Delle Chiaie et al., 2017). The risk management in the precious metal market is attracting attention, due to the price surges prior to 2008 (Hammoudeh et al., 2011; Sari et al., 2010). However, none of these articles mentions Nickel or Ferrochrome.

These price inducing impacts have been researched in the literature at an extensive level. Because of limited research regarding the stainless steel industry, there are references made to the Oil and commodity markets. Agricultural commodities are part of the research of the World Bank and, hence, deployed as a reference and benchmark for the raw material metals. The agricultural and raw materials markets are stressed by price volatility that may derail the earnings of companies and even countries. When these rely for a dominant part on these earnings of the agricultural sector (e.g., developing countries).

3.2.5 Origin of Risk management

Commodity price risk threatens even the strongest-planned business strategy. Unanticipated price variations may distort earnings and disrupt growth plans (Tevelson et al., 2007). Under the SCRM, the raw material price exposure is classified as a financial risk. The variations in the purchase price impact profitability and cash flow (Allen, 2012, pp. 153–166; Ku & Chang, 2012). However, the term commodity price volatility remains connected to business risks in general, but specifically to the financial risks (Borghesi & Gaudenzi, 2013, p. 21).

The price risk exposure originates from raw material and from products that contain a substantial proportion of price volatile raw materials. Another reason may be products of sub-suppliers, which contain price volatile products. Hence, it is not limited to direct sourced products and goods (Costantino et al., 2016). Global value chains offer options to leverage on input costs. Therefore, these constitute an economic advantage. However, managing these complex supply chains contains an inherent supply risk that is challenged by cost- and price gains (Manuj & Mentzer, 2008b). Global procurement activities bear the risk of slow reacting supply routes. That burden comes with an increased inventory and cash flow requirements (Rezapour et al., 2017).

Modern risk management has its origin in many unrelated disciplines, such as military risk analysis, personal and commercial, strategic, or operational and environmental risks. These are part of the VUCA world (Bennis, 1985). These disciplines contribute to the understanding of ERM or risk management (Clarke & Varma, 1999). However, it is noted that the responses to the VUCA world conflicts with thinking in a "Linear Anthropocentric, Mechanistic, and Ordered" (LAMO) way. A potential opportunity is the application of mental models to overcome the limitations of linear thinking to a nonlinear real world (Cabrera & Cabrera, 2018). Mitigation strategies may be clustered into different subgroups. The overall risk management emerges and constitutes increasing importance to cope with ambiguity in business. The literature provides evidence that risk management has a positive impact on the firm value (stock price) (Smithson & Simkins, 2005). Risk management in this thesis considers financial implications rather than a disruption of the supply chain (Ellram et al., 2002; Jüttner et al., 2003).

3.2.6 The connection between commodity price volatility and share prices

This section examines the impact of raw material price fluctuations on share prices. This link answers RO 3. The link between raw material price variations and stock prices has been investigated in various publications. In most publications, as mentioned previously, the focus is on commodity materials such as Gold and Oil (Creti et al., 2013; Cunado & Perez de Gracia, 2014). The impact of the Oil price on the altering of the share prices has also been investigated in literature (Ågren, 2006). This publication researches the impact of Oil prices on the stock prices of the S&P 500[12] companies. The general impact of commodity prices on stocks is discussed by Carter (2017). Other researchers approached the influence of price fluctuations of Oil, Gas, and Wheat on the stock market in the example of the S&P 500 companies (Bouri et al., 2017; Mensi et al., 2013). The authors refer to raw material price fluctuations as an early indicator to predict potential impacts on stock prices. This correlation is stronger in times of crisis, such as the global financial crisis in 2008, than in "normal" periods (Creti et

[12] S&P 500, Standard and Poor's (SPX 500) stock market index

al., 2013). Literature distinguishes between a macroeconomic perspective and an industry perspective.

3.2.6.1 Market perspective

The impact of the Oil price volatility on the economy was tested and verified by Hamilton (1983). His pioneering article regarding the correlation between the Oil price and the repercussions to the US economy since WW II. He curves out the impact of exogenous events (e.g., Iranian nationalisation of assets, Suez crisis) that caused Oil price increases. These increases led to a recession of the US economy and subsequently impacted the stock market. However, cause and effect do not occur at the same time. There is a time-lag. Hamilton (1983) assumes that these price fluctuations are rooted in exogenous incidents. The author also claims that the negative impact of increased Oil prices on the economy is not a coincidence in periods of crisis – or during Oil price shock periods. These price shocks are characterised by an increased volatility (Cunado & Perez de Gracia, 2014; Zhu et al., 2016). This connection between the commodity Oil and the stock market; was researched by Jones and Kaul (1996); by comparing the stock markets of the US, Canada, Japan and the UK. The latter two stock markets are overly sensitive to oil price fluctuations. In terms of the market level, this was the first research (i.e., the impact of oil price changes on stock markets). Kilian and Park (2009) stress the influence of Oil fluctuations on stock prices. The article accentuates the negative impact of Oil price increases on stock market returns, in particularly when caused by exogenous events (i.e., demand shocks). However, it is argued that price increases due to supply disruptions do not influence stock returns as negatively. It is concluded that two-thirds of the stock price fluctuations of the S&P 500 companies are attributed to Oil price changes. The authors argue that for the US economy, rising oil prices that are based on a positive global business situation stimulate the US economy immediately. However, the higher Oil prices will slow the US economy in the longer term. Another publication underlines the predictive element of the oil prices on equity prices.

Increasing Oil prices are associated with a negative impact on stock prices (Driesprong et al., 2008; Jones & Kaul, 1996). It seems that Oil prices influence the economy, hence stock returns. However, the economic development does not influence the Oil prices (Sadorsky, 1999). The impact of business related news on equity prices is confirmed, typically this leads to an immediate adjustment of stock prices (N.-F. Chen et al., 1986). The overall stock market (S&P 500) is impacted by Oil price changes; however, the prediction of future returns is increased when negative price developments are considered. This assumption was tested for

the period from 1859 to 2013 (Narayan & Gupta, 2015). This publication considers the S&P 500 companies, hence a conclusion that applies to these companies.
For South Korea, a recent publication underlines the negative impact of Oil price volatility and the spill-over effects on the economy. It even mentions government interventions like strategic reserves and a lower dependency on Oil imports to mitigate the exposure to exogenous events. Most interesting was the mentioning of an increased communication with the Oil producers (Masih et al., 2011). This approach elaborates on the supplier cooperation to strategically mitigate price volatility.

3.2.6.2 Industry perspective

The statement about the entire market can be inconsistent with individual industries, because of a different exposure to raw material price fluctuations. For this reason, the literature also examines the industry perspective. Faff and Chan (1998) have been one of the first to research raw material price volatility and the impacts on distinct industry stocks. The publication links the impact of gold price changes to gold miners stock prices. It concludes that the price changes are a robust, significant impact. The impact of Oil price changes may have positive and negative impacts on diverse industry segments. At the example, of the Australian stock market, negative impacts (i.e., higher raw material input costs) are reported for the transportation, packaging, and paper industry. However, the share prices of Oil & Gas and diversified companies are positively impacted (Brailsford & Faff, 1996). Other literature follows the industry sector approach and investigates the impact of Oil price movements (i.e., IT, transportation, consumer goods) in the G-7 countries. It stresses the impact of Oil price changes on the US transportation sector (B.-J. Lee et al., 2012). There is empirical evidence, that a strong link between Oil prices and the stock price of Oil companies exists in the press (Kar, 2021; Pacampara, 2021). The stock price of miners is also related to raw material (commodity) prices (Shingler, 2012). Regarding the steel industry, the raw material prices have a similar impact (Y. Ma & Wang, 2021). The article stresses the time-lag between raw material prices (i.e., scrap and Iron ore) and Chinese steel stock prices. Iron ore prices demonstrate the highest correlation to the steel stock prices.
The literature shows various examples in which the strong correlation between raw material costs and share prices (e.g., producers and consumers) is drawn. These are, in particular, the Oil industry and the Oil price, as well as the relationship between Gold prices and mine operators, as shown in the example of Australia. It can also be seen in the relationship between Iron ore prices and the share prices of mining companies.

The exposure and the direction of the impacts depend on diverse influencing factors. Notably the exposure, the degree of dependency and if the company is a net producer or consumer of the raw material (M.-H. Chen, 2010). Hence, the vulnerability depends on the exclusivity of the product towards the commercial proposition of the value creating to mitigate the commodity price volatility risk.

The inter-linkage between commodity raw materials and stock prices are examined from different angles (e.g., the influence on the profitability of the companies). The change in perspectives is the distinguishing feature. Some articles mention an overreaction of the markets and thus point to an irrational or exaggerated influence (Kilian, 2008; Kilian & Park, 2009). The change in commodity raw material prices can thus be seen in the share price of the companies/industries. During financial crises, the link between commodity prices (e.g., Oil, Gold and Coffee) and the stock prices of the S&P 5oo strengthens (Creti et al., 2013; Sheikh et al., 2020). However, the impact of the raw material prices of is not undisputed (N.-F. Chen et al., 1986).

The impact of the input materials on the evolution of the companies' share prices gained attention in the literature (Aggarwal et al., 2012; Driesprong et al., 2008; Joets et al., 2017). Hence, the relationship between raw materials and the share prices of the companies is discussed and proven. This research deals with the commodity raw materials Nickel, Ferrochrome and Iron ore. Despite lower geopolitical and economic importance compared to Oil, it is fundamental for the steel and stainless-steel production.

However, trade restrictions in the USA might benefit domestic steel mills, but not the manufacturing industry (Gutierrez & Vianna, 2018).

The impact of raw material prices on stainless steel production has not been researched so far. However, based on the example of the transportation companies in the US; there is a negative impact of Oil price changes to the stock returns as mentioned before. The US transportation industry is like the stainless steel industry; both consume approximately 2/3 of a certain raw material (i.e., Nickel and Oil); hence, these markets represent the main consumer of this particular raw material. This connection links raw materials to the transportation industry and the stainless steel market. In 2006, 66% of all petroleum products went directly or indirectly into the transportation industry (Aggarwal et al., 2012). Nickel production is consumed at the same share by the stainless steel industry (White, 2019). Therefore, a robust relationship between raw material input costs and share prices is assumed.

Literature offers publications about the steel market. The link between scrap price development and stock returns in Japan and China was recently examined (Y. Ma & Wang, 2021;

Omura et al., 2016). However, these do not mention or draw a connection to the stainless steel industry.

The predictive source of the steel scrap prices for the stock returns is one link, the other link may be the VIX. The VIX indicates the expected future stock market volatility. A greater fear or risk is expressed by a higher VIX. Therefore, changes in the VIX are asymmetric to stock market returns (Smales, 2016). The link between commodities and VIX is mentioned in several articles (Bouri et al., 2017; Obi et al., 2018; Schwert, 2011). Therefore, it may be regarded as a potential indicator about the stock price development in the stainless steel industry.

3.2.7 Methods to describe volatility

The existence of volatility and the measurement of it is one of the primary objectives of this research (RO1&2). The literature is detailed in describing, modelling, and forecasting volatility and the future results. The connection between the raw material commodities and the share prices was discussed and proven. Literature refers to the VIX to forecasting future changes in the stock market (Obi et al., 2018; Silvennoinen & Thorp, 2013). This index is a reference in the financial community to forecast the future market expectation and stock returns (Smales, 2016). The VIX considers historic volatility to predict future market developments with a certain methodology. In the literature, the link between the VIX and commodities exists for the Oil and Gold prices (Bouri et al., 2017; Cunado & Perez de Gracia, 2014; Mensi et al., 2013); the same link is drawn for Silver and precious metals as prices (Batten et al., 2010; Lucey & Tully, 2006).

The limitation of this index is the referencing of the S&P 500, hence US listed companies. However, this limitation weakens as the US stock market represents a principal share of the global stock market. Besides, it is part of the overall market and hence a “thermometer“ of the international economy. The following companies are stock listed in the USA *Vale, AK Steel, Tenneco, BHP Billiton.* Therefore, the VIX captures the stock price situations and market sentiment. The opportunity to link the alteration of raw material commodities with the market expectation is a unique combination.

Obi (2018) deploys the VIX to explain the expected market risk (to the stock market, hence to share prices) in the connection between Oil and the equity market. In other markets like China, Europe and India, there exists a relevant literature to support the link between Oil and the stock market returns (Sun-Yong & Hong, 2020; Xu et al., 2019).

The Chicago Board Options Exchange (Cboe) compiled the VIX index. It is applied in financial studies to capture the impact of expected market risks (Tagliaferro & O'Neill, 2017). The VIX is calculated on the implied volatilities of the S&P 500 index options (SPX) and signifies the market's expectation of 30-day future volatility. Thus, this index is considered the leading global indicator. Introduced in 1993, the VIX proved itself as a recognised gauge of market volatility. The VIX is negatively correlated with stock returns (Silvennoinen & Thorp, 2013).

In the financial market, the VIX became the synonym for measuring volatility and forecasting the returns (Summa, 2020; Williams, 2013). It is not a unique method of volatility measurement, but it has been introduced to the financial markets and has therefore a "first-mover" advantage. The crucial difference compared to statistical volatility is the forward-looking aspect. Financial professionals have a desire to forecast volatility, as it opens new opportunities (Auinger, 2015, pp. 37–39).

The United Nations Conference on Trade and Development (UNCTAD) refers, among others, to this index as the measure of volatility and dispersion (Jurado et al., 2015; United Nations Conference on Trade and Development, 2019). The VIX figures the expected annualised change in the S&P 500 index over the following 30 days (Cboe, 2018b). The result is a value (VIX score) that displays the expected market risk (Kaeck & Alexander, 2012).

The calculation method was amended in 2004. The peak values have been reached during the world monetary crisis (Figure 9). That started in 2007 and reached its drastic peak around the Lehman Brothers insolvency in September 2008. Another peak is the autumn/ winter of the year 2011, the aftermath of the Fukushima tsunami. The peak in 2015 rooted in the devaluation of the Chinese yuan renminbi (CNY) against the US dollar, announced by the People's Bank of China (PBOC). The rising VIX in February 2018 was, according to the US media, not a fundamental shift. However, it was rather an event that captures the mix of sentiments and some computer-programmed trading that led to uncertainty (J. Cox, 2018; Empire, 2018). The peak at the end of 2018 reflects the trade restrictions of the US administration and the geopolitical tensions between the US and China. However, it comprised the ongoing Brexit discussions (Egan, 2015; Riley, 2015). The global fiscal crisis is discussed in section 5.5.2. The chart in Figure 10 shows a less volatile view as of 2010, with a peak in late 2011.

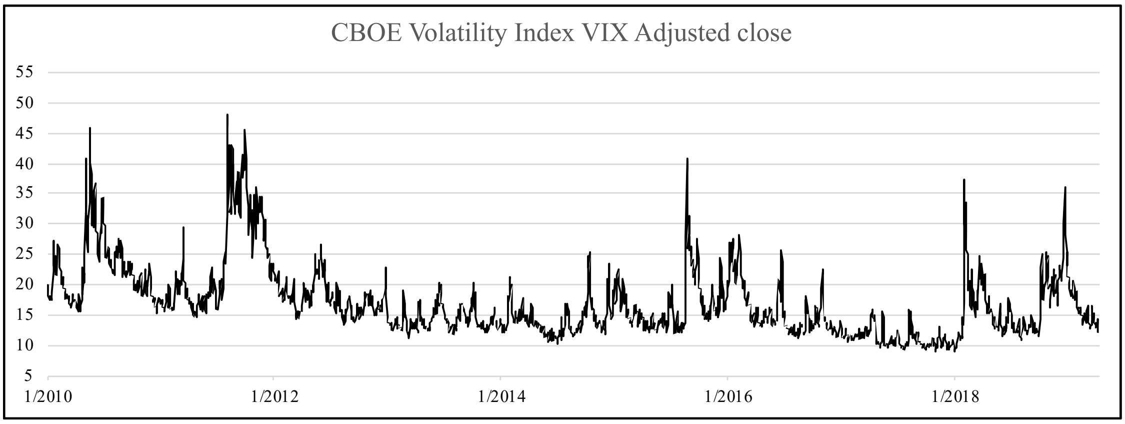

Figure 10 VIX 2010-19, Source: VIX report

The volatility index is not giving an interpretation of the VIX value. An increasing value is equal to higher market uncertainty. Lower values represent less volatility, hence less ambiguity (Cboe, 2018c). The VIX is not ranking volatility a priori (Silvennoinen & Thorp, 2013). An interpretation of the VIX value is therefore subjective. The pure value is not a sign of the severity of the expected consequences. It represents a market sentiment and, hence; it constitutes a tool to display volatility. The missing calibration of the results leads to a subjective, relative value of the disclosed market risk expectation.

3.2.8 GARCH Model and ARDL bound testing method

Price volatility is considered a risk or an opportunity in the market. The common theme for both positions is the ability to forecast price series into the future. It is fundamental for the selection of the mitigation scenarios and for the investors to pursuit opportunities.

The historic price datasets are the foundation for the forecasting of future prices (auto-regression). The output variable (future price) depends on its own historic (previous) values (prices) and a stochastic term.

External events like policy changes and crises may cause temporary (outlier) or permanent (structural break) alterations in the volatility. The determination of these break points is vital to understand the root cause. Neglecting the existence of volatility breaks can lead to misinterpretations (Jain & Biswal, 2016; Sensoy, 2013; Vivian & Wohar, 2012)

The GARCH model is grounded in the Autoregressive Conditional Heteroscedastic (ARCH) process introduced by Engle (1982). It was further developed by Bollerslev (1986) in his article "Generalisation of ARCH process", which became the GARCH model. Hence, it became a crucial way to model price volatility. Literature has grown since introducing the GARCH framework. Volatility is modelled as conditional, based on the data points in a specific period (Bollerslev et al., 2009; Karali & Power, 2013).

Understanding price volatility is of particular interest for traders to hedge contracts and set profits and limits. Also, policymakers aim to take price volatility into consideration prior to their decision making. According to Alexander and Lazar (2009), modelling price volatility is of interest for researchers, consumers, producers, traders, and governments. One assumption of the GARCH approach is the conditional normal distribution of the error terms. The standard GARCH model may not be the best approach for capturing heavy tails, large kurtosis, extreme events, and extensions. Thus, it is possible to assume different distributions of the error structure, or to add asymmetric terms such as leverage effects in the variance process. The general symmetrical GARCH model can be deployed to study several state conditions. It contributes to the economic interpretation: one component can represent a "stable" state, while another component with high variance could represent a "crash" or "stressful" state (which seldom happens).

The GARCH model describes the volatility and permits an understanding of the severity of volatility beyond the usual statistical calculations, such as average values and standard deviations. The model is adequate for capturing any persistence in the commodity markets and its volatility pattern. (Mensi et al., 2013).

Bouri (2017) deploys the multivariate GARCH model to examine linkages between the Gold market in India and the spill-over effects on the equity market.

The GARCH model in this thesis is deployed to examine the dynamic relationship between the commodity raw material prices and the stock market prices. The bivariate approach of the GARCH model enables to research the direction of the influence, the relation among the volatilities and co-volatilities of several price series. The research of Oil price uncertainties and the impact on the stock market deploys a variation of the GARCH model (Ågren, 2006). Karolyi (1995) deploys the GARCH model to research stock price volatility and spill-over effects. Mensi (2013) deploys the GARCH model to research spill-over effects from the commodity market (i.e., Gold, Oil and Food prices) to the stock market. The relevant RQ (1.3) examines whether price volatility in the raw material prices influences share price swings in the value chain. Is the volatility of one commodity transmitted to another commodity or share price directly (through its conditional variance) or indirectly (through its conditional covariances)? According to Bauwens (2006) the strength (correlation) of the influence might depend on the economic situation. In times of high volatility (like in financial crisis) the correlation might be higher. This is in line with the findings of Mensi (2013) for spill-over effects from commodity materials (i.e., Gold, Wheat, and Oil). The future volatility is captured with a GARCH (1,1) model in his statistic section. Which was confirmed by Arouri (2012) for the spill-over effect from Oil prices to European stock indices. For this purpose, the calculations with the GARCH model are important for understanding the price volatility of commodity raw materials. The bivariate analysis identifies the influencing factors. The direction and the strength of the relationship, as the example of Yang and Gonta (2013) for the Swedish stock market. However, strength and direction might vary across industries. Sadorsky (2012) examines the spill-over effects between the Oil prices and the stock prices of clean energy companies, he does so with a GARCH model.

Literature suggests a time-lag between cause and effect of the impact. Starting with Hamilton (1983), Jones and Kaul (1996) and Sadorsky (1999) the time-lag is mentioned. More recent articles (Y. Ma & Wang, 2021; Smales, 2016) stress the importance of the period between cause and effect. This underlines that there is not an immediate effect, despite the increased speed of information, as mentioned in this thesis. Hence, the GARCH (*p,q*) is an adequate method for the research of the volatility in the stainless steel industry.

The time-lag between cause and effect requires additional methods. Recent publications link the Autoregressive Distributed Lag (ARDL) bounds testing method with the commodity raw material market and the stock market (Bildirici & Turkmen, 2015; Jain & Biswal, 2016; Sari et al., 2010). Obi (2018) used the ARDL model to research the impact of Oil price fluctuations on the exchange rate of the US Dollar. In contrast to the other deployed statistics, the ARDL is a recent method. The model examines the impact of implied volatility on the short- and long-run negative relations between raw material and stock prices at the value creation levels. The long-run relationship between the input values is explored following Pesaran and Shin (1996) by the ARDL. It researches the cointegration or bound procedures.

Cointegration is a systemic co-movement among two or more variables over the long-run. The ARDL model, as a general dynamic specification, uses the lags of the dependent variable and the lagged and contemporaneous values of the independent variables. Through which the short-run impact can be directly projected and the long-run equilibrium relationship can be indirectly estimated (Jain & Ghosh, 2013). Another decisive advantage of the ARDL model is the reparametrize the cointegration to the Error Correction Model (ECM). The reparametrized result gives the short-run dynamics and long-run relationship of the underlying variables (Nkoro & Uko, 2016).

The existing statistical methods, the correlations, and multiple regression calculations assume that the long-run relationship properties are present. This means that the mean values, medians and (standard) deviations are constant over time and are not interdependent. Lucey and Tully (2006) confirmed this assumption by bringing the example of the relationship between

Gold and Silver. They showed that this relationship strengthens and weakens over time but is prevalent in the long-run. The variability in any economic variable may bring a change to another economic variable, but not always. The raw material commodities may impact the stock prices within a delayed period, while a multiple range may have a delayed influence on the share prices (Chetty, 2018).

However, this is not necessarily the case over the course of the observation period. To address this shortcoming, the ARDL cointegration technique or bound cointegration technique is deployed (Nkoro & Uko, 2016). The important advantage of ARDL bounds tests procedure is that it can be employed regardless of whether the underlying variables are stationary, integrated of order, or fractionally integrated (Jain & Biswal, 2016).

The special focus of the ARDL testing methods is on the so-called crisis moments (research objective 6 & 7). The examination of violent raw material price fluctuations on share prices. This time lag, the influence, the consequences can be the approach to a suitable price mitigation strategy. The basic understanding between cause, impact and the time lag of the occurrence is necessary. This understanding is the prerequisite for selecting the price mitigation strategy. These aspects answer RO 5 & 6 supporting research question group 3.

In this thesis, the ARDL testing method links the raw material commodity price movements to the selection and implementation of the price alleviation strategies. A potential time delay is a potential time advantage to implement commodity price volatility mitigation strategies.

3.2.9 Impacts of volatility

The literature reveals that in recent years, in particular after the world financial crisis (2008/2009), the average annual volatility of commodity prices increased over the last decades (Dobbs et al., 2013; Vivian & Wohar, 2012). Increasing volatility leads to challenges for companies and their risk management. The exposure to such price volatility increases with value or supply chain complexity (Zsidisin & Hartley, 2012). Risk can also result from other product prices, since commodities often embody a constant portion of their input costs (Pellegrino et al., 2019). For the commodity producers, the commodity price volatility is the major risk (Merener & Steglich, 2018). The risk of price setting that directly impacts profitability. Hence, it is not treated as an uncertainty in this thesis. The findings of the questionnaire that was deployed for this research (Annex 6) stresses price risk as the major business risk in the stainless steel industry (i.e., Question 6 of the questionnaire).

This ambiguity may have a significant impact on the prices for commodity materials (Buhl et al., 2011; Gaudenzi et al., 2017). Hence, the desire to forecast and manage price volatility to alleviate the burden on the financial performance of a company (Christoffersen & Diebold, 2000; Giunipero & Eltantawy, 2004; M. Power, 2009). The risk should be mitigated to lessen the impact of price fluctuations of these metals. This is one finding of the survey that was conducted in this publication. The impact of material price volatility is challenging different segments from the producing countries to the consumers (Cavalcanti De, 2015). Sustained periods of high price volatility create important business difficulties (Karali & Power, 2013) and impact the cash flow. Hence, the predictability and the stability of the price attract increasing interest.

However, the GARCH allows to forecast the price movements. Thus, increases the predictability of price movements to adopt the company's position to demand and cash to meet financial and customer requirements.

The literature provides an in-depth evaluation and insights into the potential of spill-over effects and/ or the market factors. (Kang et al., 2017; G. Power & Robinson, 2013). Literature investigates explanations and patterns for price volatility. The economic importance of these commodity metals justifies the need to understand the price dynamics and volatility linkages between these commodities. This includes the spill-over effects between metals in the ferrous and non-ferrous markets (Batten et al., 2010; Kang et al., 2017; Todorova et al., 2014). The management of these inter-relationships is required in adopting and implementing a suitable price mitigation strategy.

Samuelson Effect

The literature of commodity price fluctuations goes back to John M. Keynes (1937). There is an unknown a risk in future price developments that is not be foreseen. This finding and the Samuelson maturity effect suggest that the price finding does not always follow the supply and demand function. There is an element in the price that past price patterns cannot explain, even though it is the intention of many forecasting models. It cannot explain the price forecast and hence the commodity price volatility forecast with the price function. Past price movements cannot capture future expectations for the product and future request and offer patterns.

Commodity prices become more unpredictable in the longer run particular, when reaching a maturity state. This effect is the Samuelson maturity effect (Samuelson, 1965, 1973). However, if the commodity is in sharp demand, the prices are exploding because of the potential fear of scarcity. It is expected that spot price volatility will most probably exceed future price volatility. The reason is that long-term prices (Geman & Smith, 2013) respond to long-term news. However, short-term prices respond to short- and long-term news, including all kinds of ‘‘noise’’ induced by short-term trading.

Noise trading

Besides the brief explanation of noise trading and the erratic movements that associated with fundamental trends, noise trading influences the price. Because of information technological (IT) developments and the instant electronic information exchange, noise in trading became a common pattern (Kaufman, 2013, pp. 10–15).

The effects of the noise trading are displayed in Figure 11. It shows the impact of high, medium and no noise in the prices. The values on this figure are given by Kaufman (2013, pp. 11–15).

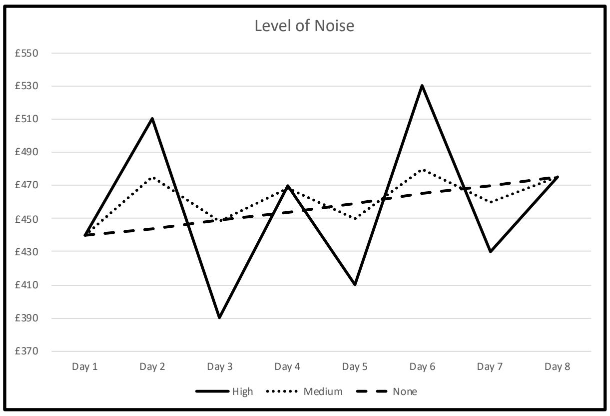

Figure 11 Level of noise/ volatility, Referenced from Kaufman

The finding is that most commodity prices trail global business cycles. Demand shocks cause sharp, sometimes delayed, price movements. The reason is the inelasticity of production (capacities). These cannot cover the short-term peaks in consumption (Joets et al., 2017). This statement refers to earlier research of Kilian about the reasons for Oil price swings (Kilian, 2008). If demand and supply do not match, the capacity constraints that coincide with a stronger than expected demand could suggest a reason for price volatility. This is in line with the outcomes of some research works that financialisation of the commodity trading has a limited impact on the price volatility (P. Chen, 2015; Goede de, 2004). However, some other articles argue it remains unclear how much of a short-run price movement is explained by rational behaviour and the corresponding shifts of supply and demand. Some of the price volatility in commodities is not based on such "fundamentals" but is the result of speculative noise trading or herd behaviour. There is evidence in the literature to support this assumption (Anand et al., 2008; Pindyck, 2004; Vivian & Wohar, 2012).

Not all price patterns or price clusters can be explained with the past values. There is a triggering variable that impacts the commodity price, and this variable is not constant. (Mandelbrot, 1966). The calculation needs to include the exogenous influencing factors. Samuelson (1973) refers to any future price for commodities as a “speculative” price. Since uncertainty prevails, no price can accurately be predicted. However, future prices might fluctuate randomly between certain values that can be described as “normal” (Aizenman & Pinto, 2005b, p. 50).

A potential linkage between the price volatility and other commodities is researched (P. Chen, 2015; Piot-Lepetit et al., 2011, pp. 3–8; Rossen, 2015). A significant feature of commodities is that their prices exhibit a strong tendency to move together. This is valid for commodities that have similar characteristics or fall into the same commodity group (Erten & Ocampo, 2012; Pindyck & Rotemberg, 1990). Similar commodities are for example metals (e.g., ferrous, non- ferrous metals), or petroleum (e.g., Crude Oil, Brent) products, or agricultural (e.g., wheat, corn) products. However, precious-metals (i.e., cobalt, rhenium, platinum group metals, and rare earth elements) are often associated with the term “criticality”. These metals are required for strategic industry, including the defence industry. Hence, the price might become a second priority versus the availability of these finite resources (Griffin et al., 2019).

The price movements of raw material metals and the impact on the share prices are researched in section 5.1. Literature discusses commodity price volatility. However, the academic debate about impact and consequences of price fluctuations in the value creation chain is missing.

3.3 Commodity price volatility mitigation strategies

This section depicts the risk mitigation schemes in the stainless steel industry. It focuses on two aspects, procurement, and financials. Procurement has a wide range of methods to minimise price risks, as detailed by Gaudenzi (2017). However, risk and uncertainty are not constant. Different industrial eras have distinct challenges. The second train of thoughts is the financial aspect and the instruments to mitigate the price ambiguity. It associates with an increased level of risk. The increased volatility is displayed in Figure 9, the VIX values. A crisis is often accompanied by an augmented level of volatility (Mensi et al., 2013; Sensoy, 2013). The price fluctuations and the inherent risk reiterate the business requirement to formalise risk management.

3.3.1 Procurement

In recent years, risk management experiences a wider interest (Fischl et al., 2014). The world financial crisis and several commodity booms exposed the financial implications of volatile raw material prices. These are the conclusions from previous challenges and the realisation that it has become a VUCA world. Administering and analysing exogenous events is at present a rather unknown in business life (Jüttner et al., 2003). The attention in literature turns from raw material or agricultural industry to the non-governmental business segment. Risk management becomes more prominent. The surge of risk or risk advisory boards in stock listed companies underpins this development. Both the miners (i.e., Vale, BHP Billiton and Nornickel) and stainless steel producers (i.e., Acerinox, Aperam, AST, Outokumpu) elucidate risk board activities in the annual reports, thus confirm this trend.

Extensive literature exists on SCRM. It considers conceptual theories and empirical explorations for managing business risks. The existing literature focuses on disasters or trigger events (Qazi et al., 2018; Thun & Hoenig, 2011) that may lead to a disruption in the physical supply chain (Kaplan & Mikes, 2012; Paul et al., 2017; Rezapour et al., 2017). These are often multifaceted chains of events and interactions (Heckmann et al., 2015; Qazi et al., 2018). It displays the supply chain network as a set-up of connected and independent organisations working together. The aim is to control, manage and improve the flow of communication and material from supplier to the end-users, see Christopher (2005, pp. 6–28). Intercompany sourcing activities are the so called piggyback contracts (demand pooling) that allow for increased commercial terms (Gaudenzi et al., 2017). These contracts are a simplistic form of supplier cooperation and the belief that crowd intelligence is worthwhile investigating.

Recent research suggests that the overall business environment becomes more competitive (Coffman & Ganguli, 2018; Costantino et al., 2016; Deloitte India, 2018). The risk of business interruption, the fear of natural disasters, pressure on margins, the disruptions through recent technologies are identified as major threats to the economy. The rising importance of SCRM confirms the crucial role of procurement. Procurement becomes a key value contributor (Busellato, 2021). The questionnaire was deployed to understand the potential mitigation strategies in the stainless steel industry and contribute to this research. The complete answers to the questionnaire are detailed, see Annex 21. Noteworthy is question 5 of the survey that seeks understanding of the relevant mitigation strategies in the industry. Procurement oversees a bundle of diverse contracts; this adds complexity to the organisation (Zsidisin et al., 2017, pp. 75–78).

Procurement has a major influence on the added value and profitability of a company. The researched companies spend more than half of their sales turnover in purchased parts, stainless steel, and services. From the author's own experience, particularly in the exhaust gas treatment system production, the value creation share is approximately 30%. Therefore, the efficient and fruitful interactions with suppliers are vital to the short-/ and long-term competitiveness (Schiele, 2007). The procurement of stainless steel or related products is impacted by CPV. It has a significant impact on the prices paid for commodity materials or parts not only in the stainless steel industry (Buhl et al., 2011; Gaudenzi et al., 2017).
The existing knowledge of the price volatility of these commodities is rather limited. (Pellegrino et al., 2019; Todorova et al., 2014). It was Fischl (2014) who examined the literature focussing on price volatility. However, research on commodity price volatility seems to be still immature (Gaudenzi et al., 2017). To understand the mitigation strategies for manufacturing companies, it is important to understand which schemes already exist for the producers of the commoditised raw material.
Although the literature on SCRM has been extensive on mitigation scenarios for risk assessment (Dowd, 2006; Häger & Andersen, 2010), risk mitigation (Delnooz et al., 2014; Paul et al., 2017; Qazi et al., 2018) and supply chain disruption (K. Hendricks & Singhal, 2005; Paul et al., 2017). Noteworthy is the article of Qazi (2018) "Supply chain risk network management: A Bayesian belief network and expected utility-based approach for managing supply chain risks". It aims for a holistic view of risk network management but fails to address price volatility as a risk. However, the publication offers a comprehensive literature overview. An deeper understanding of CPV is a focus in the publications of Zsidisin (2017; 2017; 2012) Gaudenzi (2013; 2017), Costantino (2016) and Pellegrino (2019), these centre around it and discuss impacts. Whereas Carter (2017) "A review of the literature on commodity risk management" focuses on hedging as a financial instrument in different business segments and perspectives (i.e., producer and consumers). It draws a link to the share price evolution.

3.3.2 Mining – commodities

The global mining and metals industry has a strong but volatile outlook (Tufano, 1998). It focuses on future growth through expanding production, without losing sight of operational efficiency and cost optimisation. The mining industry is challenged by changing expectations in its social permit to operate, skills shortages, executing capital projects and meeting government revenue expectations (Moghaddam, 2018). As an important industrial commodity, it has a substantial impact on the industry and the macro-economy (Wu & Hu, 2016). Therefore, it is a concern for consumers and transformers of the products, like stainless steel and aluminium.

Business cycles with major expansion and contraction phases are the persistent factor of commodity price volatility (Delle Chiaie et al., 2017). This risk is a universal phenomenon (Zsidisin et al., 2017, p. 17). The presence of the Samuelson effect and the increased volatility in mature markets are associated with a price risk, especially when these markets are mature and well established. Extensive literature exists on the agricultural sector prevailing about Africa and Latin-American (Arezki, Hadri, et al., 2014; Cashin & Pattillo, 2000). The link between the two materials or products is that they are grown or mined in the form in which they can be used or sold without delay. In contrast to indirect production, usually these are not mixed with other products and sold with minor processing (without adding a second product).

Other publications compare volatility to an unpredictable price ride (Arezki, Loungani, et al., 2014). The International Institute for Sustainable Development (IISD) focuses on the price volatility of agricultural products, like coffee (Brown et al., 2008, pp. 1–22; Rutten & Youssef, 2007, pp. 1–47). The IISD investigates into tools and methods for governments and the producers of the commodities to smoothen the impact of volatile revenue streams. A stable income stream is important in particular for developing countries that depend on the export of commoditised products. These suffer from price volatility and the associated risks (Potts et al., 2009). Producers of commoditised products, even from different business segments (mining, agricultural, etc.) face similar challenges. The tools and methods to cope with commodity price volatility are different depending on the size, economic importance of the industry or company. The typical ones are:

- horizontal and vertical diversification
- market-based risk management instruments
- compensatory finance mechanisms
- enhanced business management capacity
- policies (anti-competitive and transparency)

These instruments or tools are described and investigated in the literature in various publications (Brown et al., 2008; Potts et al., 2009; Rutten & Youssef, 2007, pp. 36–40). Producers and customers both face price ambiguity caused by commodity price volatility. However, the perspective is different; the impact lies in the opposite profitability of the two sides. If one side maximises the margin, the margin on the other side (consumer) is negatively affected (i.e., margin reduction). This applies to diverse types of commodity products. At the production site, it represents a cause for unpredictable revenues, which causes risky investment decisions. In the sense that the economic pricing environment is unpredictable, and the investments cycles are far longer than the price range of these commodities. The expansion or withdraw from commodities and the need for diversification might be misjudged as the revenues are not plannable. This thesis will not investigate into the potential political, economic and compliance topics at the developing countries. Neither are the consequences of the "Dutch disease" (e.g., import of inflation and currency devaluation) explored. This phenomena may occur in countries that export natural resources and import inflation (Wijnbergen van, 1984).

The sole dependency on a single asset is inherent to risk and uncertainty. The prospect of the economy or a business relies on a single product. Hence, literature reveals the mitigation strategy of horizontal and vertical diversification/integration (Williamson, 1979, 2005) for industries and companies. This rationale is consistent over time and across the value chain. It links to the mitigation strategies of this thesis in section.

In the automotive industry diversification is often linked to the thoughts of Henry Ford, as practised at Ford Motor Company. The diversification secured the supply of material and minimised raw material price exposure (Langlois & Robertson, 1989). The approach of Henry Ford even included the harvesting of rubber for tyres in the rainforest of Brazil (Fordlandia) (Graves, 1935, pp. 109–114; Kranton & Minehart, 2000). It was Henry Ford´s aim to operate a self-sufficiency automotive production. The company owned, operated, and coordinated all resources to produce vehicles, including the Rouge Steel production in Michigan (The Henry Ford, 2021). Economies of scale and technology accelerated vertical integration. However, for Ford, it was a requirement to secure the raw materials and to increase production output. Reinforced vertical integration reduce transaction costs between the aligned partner companies (Williamson, 1981). The World Bank links diversification with economic resilience against price volatility (Kituyi, 2019). Diverse income streams smoothen potential commodity price volatility risks.

To produce the principal parts in the same company, creates autonomy from sub-suppliers. That was a trend among the big US car manufacturers, like Ford and GM. At the beginning of the last century after the "Great depression" they moved to a more flexible supplier network approach (Liker, 2004, pp. 202–204). Fierce competition and market ambiguity asked for an adopted concept to the economies of scale era (Christopher, 2000). After World War II, this trend reversed several times and concluded in the Toyota Production System (TPS). TPS is a management philosophy that incorporates the supplier network approach, with a free flow of communication and knowledge (Kamal & Ferdousi, 2009). Toyota mitigates through strategic partnerships and alliances the dependency on limitation factors like production capability and capacity. Toyota does this because large Japanese companies are expected to organise in a collaborative network (Dyer & Nobeoka, 2000). It is a cultural issue that enables economic transactions and profitability. This noteworthy consideration is valid for producers and the consumers of commodities (Ichiba, 2015; Marksberry, 2012).

For mining companies, diversification might be a challenging task. Diversification into other raw materials is the natural option to mitigate price risk and dependency from one commodity material, if applicable, like for geological reasons (Kituyi, 2019).

The *mitigation strategy of compensatory finance mechanisms* is tailored to smooth out revenues. Therefore, it employs relief payments to governments if unforeseen events like natural disasters (e.g., droughts or floods) occur. Examples of compensatory finance mechanisms include the International Monetary Fund's (IMF) among other governmental or central bank administered schemes (Brown et al., 2008, pp. 26–27). These mitigation strategies are deployed for agricultural producers. These mitigation strategies are not applicable in a business environment (i.e., automotive industry).

The mitigation strategy of enhanced business management capacity by education and advanced learning is suitable for all business environments. This generic statement will be elaborated, see section 3.5.

The mitigation strategy that includes policies to reduce anti-competitive practices and to increase market transparency is desirable for all businesses. Trading platforms (i.e., LME) are subject to legislation and legal restrictions. In the business environment, anti-competitive behaviour is monitored and enforced by internal rules and by legislation and regulations. An example is the Sarbanes-Oxley Act of 2002 and the successor the Dodd-Frank Act (Arezki, Loungani, et al., 2014; Vakkur & Herrera, 2013, pp. 1–3). These enforce corporate governance regulation to ensure functioning and anti-competitive behaviour of corporations or individuals employed by them. In addition, companies have enforced the "Code of Conduct". These regulations ensure good corporate social responsibility (CSR) and are the main pillars of good corporate governance. One of the main benefits, besides compliance with the applicable legislation, is that the reputation of the enterprises is not damaged. Preventing corporate fraud is a main objective of these regulations (Vakkur & Herrera, 2013, p. 64). The mitigation strategy of damage limitation is undoubtedly important for companies and governments. However, its relevance to this work is limited. However, the lobbying aspects of the mining and steel industry are present and will be explored in the thesis's remainder. Lobbying can lead to tariff and non-tariff trade barriers with the aim of giving the domestic steel industry a competitive advantage (AK Steel, 2018, p. 2). As trade restrictions are often countered with trade restrictions of the economic areas concerned, these measures can build up. There seems to be no limit to creativity in preventing unwanted imports or other political/diplomatic restrictions (Bown, 2013; Corr, 1997).

3.3.3 Manufacturing companies

Despite increased commodity price volatility levels, literature on commodity price risk management is limited when manufacturing companies are involved (Schoenherr et al., 2012). Price risk management aims to reduce the price (risk) exposure. It desires to limit and control risks rather than avoiding business risks. The identification and evaluation of the risks are the initial steps in the risk management process. The RM targets at the early identification, of risks, enabling an immediate mitigation of the exposure (Weigel, 2017, pp. 87–90). Risk management allocates resources preventing events that might never occur (Kaplan & Mikes, 2012). The effective mitigation of commodity price volatility must be addressed by their consumers.

In supply chain risk management, the term ''risk'' is defined as ''the variation in the distribution of supply /value chain outcomes, their likelihood, and their subjective values'' (Jüttner et al., 2003). These ambiguities in any shape might affect the interaction or the physical material flow across organisation borders (Clarke & Varma, 1999; Colicchia & Strozzi, 2012). Manufacturing companies associate risk often with a monetary loss. Whether the risk is a danger, threat, damage, injury, loss, or any other unsought impacts, risk results from the probability of a loss and the implication, it might have to the individual company (Manuj, 2013; Mitchell, 1995). Therefore, for an event *n*:

$$\text{Risk}_n = \text{Probability}\ (\text{Loss}_n)\ \text{x Significance}\ (\text{Loss}_n) \qquad (1)$$

In the last century, Bowman (1980) identified and proved the negative relationship between risk and return in the last century. This finding is a guiding principle to understand emerging risk management approaches (Figenbaum & Thomas, 1986). The company value may suffer in the sense that it plunges after an unexpected event that deteriorated the company's earnings. The trust placed in the company can be disturbed, too. This affects shareholders and stakeholders who have stakes in the company or its products. The lost trust has a negative impact on the value of the company. Hence, the company value is at risk (Nocco & Stulz, 2006). There have been relentless examples of a failing or not existing enterprise risk management (ERM). The disaster events jeopardised the value or sometimes the entire company (e.g., *Barings Bank, Lehman Brothers, Credit Suisse, BP/ Deep Water Horizon, Bhopal Chemical plant, Exxon Valdez*). A major difference between the financial and the manufacturing industry is that the latter is, to a certain extent, averse to the risk management approach. It is meant for commercial, not technical decisions. Risk procedures on a drilling rack are well advanced. However, the financial risks are often solely linked to the hedging of currencies or commodities.

Stainless steel industry and commodity price volatility
Commodity price volatility is often managed by the procurement management. However, it may be a strategic risk/uncertainty, handled on a tactical level (Kaplan & Mikes, 2012). However, in 2014, an article offered an initial review. It exposed limited research on the commodity price topic (Fischl et al., 2014). This article stresses the limited amount of research on manufacturing and producing companies. This explains why there is a missing link in the literature on price risks and stainless steel (Carter et al., 2017; Deloitte India, 2018).
Three years later, it is Gaudenzi (2017) who sheds light on the decisions influencing the selection of commodity price risk mitigation strategies. The article examines the selection process of price risk strategies. It includes an overview of the alleviation strategies that are of operational importance and a detailed literature overview. These findings are common with similar literature overviews that analyses price mitigation scenarios of non-financial companies (Carter et al., 2017). The typical clustering of risk mitigation strategies for manufacturing companies, in contrast to the strategies of the base materials industry, identifies three principal categories:

- Sourcing
- Contractual
- Financing

The *sourcing strategies* are listed as purchase timing, supplier switching, vertical integration, and commodity substitution. These strategies are internal procurement strategies, as these do not involve an external party. The method to switch among suppliers and/or substituting commodities is a valid scenario to mitigate risk and to reduce cost in most cases (Inemek & Matthyssens, 2013; Williamson, 2007). This approach might require a cross divisional cooperation to secure a flawless substitution. The authors lack to elaborate on switching costs. However, these are often not accounted for but are part of the total cost assumption (Costantino et al., 2016; Pellegrino et al., 2019). However, the total cost approach of supply chain decision in mitigating price risks is elaborated (Gaudenzi et al., 2021).

The transaction costs might be low for long-term contracts and long-term cooperation. However, internal costs increase with every supplier switch. Independency from the existing supply base, increases transaction costs and adds complexity to the sourcing and procurement administration (Shi et al., 2011; Williamson, 1979). The cost of switching suppliers varies from industry and application. In rare cases – such as in the automotive sector- the supplier switch is impossible without informing the customer and auditing the new supplier. The auditing and validation expenses must be factored into the cost comparison. In the automotive sector, switching the supplier comprises diverse regulations, like the *IATF 16949,* and involves increased costs and customer approval.
The *contractual strategies* include the escalator clauses (price agreed within tolerance bands, index relation possible), staggering contracts (prices are agreed in relation to certain quantity levels), demand pooling (piggy-back). Also, the option that commodity price adjustments are passed to the customer.
The *financial contracts* are leading to the mitigation options of financial (options, futures or other derivates to offset potential commodity price increases in the future) or cross hedging. This method is applied when the market liquidity of a certain commodity is low or not given, while a similar commodity with higher market liquidity is hedged instead. The approach might have specific legal requirements. This thesis refers to hedging as a risk minimisation tool, and as a variance minimising or avoiding hedging risks. Hedging has the aim of reducing risk, not to speculate with different other hedging possibilities (Culp & Miller, 1995).
The price risk mitigation strategy can combine approaches. The combination of tools is a viable option to balance risk exposure, like hedging in combination with contractual agreements.

3.3.4 Supply chain cooperation

This section examines the cooperation of diverse companies that contribute to the value chain of the stainless steel business. This thesis examines whether cooperation might constitute a mitigation strategy to alleviate CPV. The cooperation might span over the value creation levels of the raw material, or product, or services.
A multi-level, multi-organisational approach is what the cooperation can be. The key is intellectual cooperation that spans beyond the flow of goods (Fruin, 2008).

Collaboration allows to extend the organisation's expertise and resources with the aid of other organisations to a common cooperation advantage (Huxham & Vangen, 2005, pp. 3–4). Synchronising the businesses with the inter-connection of communication flows of the participants is the principal task (Horvath, 2001). The aim is to build a resilient forecasting intelligence technique enabled by information technologies, including machine learning and artificial intelligence (AI) (Nason & Fleming, 2018). To achieve this, an in-depth cooperation among the participants in the value chain is a prerequisite. It is based on organisational learning to collect and implement new knowledge (Dyer & Nobeoka, 2000). Within the value chain context, the ultimate competitive advantage is not within one company. However, it is in the leverage of business intelligence that is inherent in the value chain and the transformation of the existing business to form a resilient network (Horvath, 2001). The era of artificial intelligence (AI) influences or changes the business cooperation already. Digitalisation and AI will end the industrial age and will change the economies of scale in the mid or long run. The new enabler is the availability and the conclusions from digitalisation and AI, the specific improvement of processes and forecasting (Boos, 2019).

The role of the procurement function within the interconnected supplier network or supplier cooperation is challenging. Procurement incorporates more functions and requires a different mindset, due to the cooperation with internal and external stakeholders. Thus, this way of thinking and the willingness to cooperate should become a part of the DNA of an organisation. It cannot be driven by individual departments (e.g., procurement) (Asanuma, 1988). The concept of multi-organisational cooperation is well established in the literature (C. Yang & Chen, 2007). The definition spans from value chain cooperation to supply chain network/ cooperation or other terms, the idea of swarm intelligence is incorporated in this thought (Soni et al., 2019). With the establishment of cooperative credit associations across Europe in the mid-19th century, the idea of a knowledges sharing begun and became faster. An example are the first cooperatives, formed by Herman Schulze Delitzsch and Friedrich Wilhelm Raiffeisen in Germany in 1840. Despite the financial transactions, the cooperatives offered information exchange and a physical place to share best practices (Guinnane, 2001). This cooperation scheme originated in the combined efforts of small businesses (e.g., farmers or artisans). Ever since, the concept of cooperation is a common pattern across businesses. The terminology of inter-firm cooperation changed in the cause of time; however, the meaning remains the same. The underlying reasons for a cooperation are still the same. The collaborative supply chain is a driving force to achieve efficiency and value (Horvath, 2001; Qazi et al., 2018). This effort is supported or enabled by information technology solution and the growing share of artificial intelligence and automation. These initiatives allow for continuous growth and profitability of the network partners.

Networking between companies enables the ability to manage complex interdependencies, like transactional or cooperative links between companies (Grandori & Soda, 1995). The combined efforts can offer a better result than an individual approach. Cooperation exists in many aspects of economic pursuit and gains influence versus the standalone approach (Fawcett et al., 2008). This ranges across a range of economic occurrences from knowledge spill-over to business phases (Watanabe et al., 2015, pp. 1–2). The increasing importance of networks in various industries originated to an extent in the knowledge and expertise that is dispersed at different locations or persons. This often happens in booming and complex industries. Networks facilitate innovation in common parlance easier than individual approaches (Novak & Stern, 2009; Powell et al., 1996).

An in-depth cooperation between various organisations is in line with the evolution of the "Five forces framework" by Porter (2004). This framework of the five industry or business forces (i.e., the role of potential entrants, suppliers, buyers, substitutes, and rivalry amongst competitors) is static. It neglects the phenomena of dynamic alterations in a competitive business environment. It does not, however, incorporate the network aspect in the original Porter Model. The supporting functions, technological and market paths are not resonated in the model. The consequences of innovation and continuous improvement are neglected (Teece, 2009, pp. 20–22).

The advantages of knowledge sharing, which was incorporated into the cooperatives and started in the 19th century, is nowadays an essential part of the *Toyota production system (TPS)*.

However, TPS has a strong bond towards the lean management approach. It is the most and effective and efficient way to organise a serial production in the automotive segment. TPS has been studied at an intensive level in diverse research publications (Dyer et al., 1998; Fruin, 2008; Spear, 2004). The focus of this thesis is on the knowledge sharing network aspect of the *Toyota* supplier collaboration ideal. In particular, Principle 11 "Respect your extended network of partners and suppliers by challenging them and helping them to improve" (Liker, 2004, pp. 199–220). This approach closes the gap between the supplier or inter-firm network cooperation. Toyota offers a supplier consultation to improve efficiency and cooperation among the companies (Dyer & Nobeoka, 2000). However, it is not proven if this form of cooperation is a suitable mitigation strategy to manage commodity price volatility or other business risks.

The literature offers a variety of publications on inter-firm cooperation. The interconnection and working together of companies and corporations that are often independent of an economic stance. However, the Japanese idea of "*keiretsu"* the vertically linked networks between companies is regularly expressed by a substantial number of intergroup transactions. The bond regarding financial ownership and/or control mechanisms between the companies does not always mirror this strong cooperation on the operational level (Dyer & Nobeoka, 2000; Fruin, 2008, pp. 251–252). The intercompany bond is created based on the cooperation and the creation of knowledge. The knowledge sharing and knowledge-creating process is incorporated in the Japanese way of knowledge accumulation with the target to create innovation (Krogh et al., 2012; Nonaka & Takeuchi, 1995; Nonaka & Toyama, 2005). The keiretsu approach is a non-vertically integrated system, which is characterised by a low level of internationalisation and flexible contracts. An elevated level of relationship-specific investments (RSI) that refers to investments in relations that are of no other use outside the specific relationship (Ichiba, 2015) characterises "*keiretsu*". Despite the higher transaction costs to maintain non-vertical integrated systems, (Williamson, 1979) it is not possible to find a contractual agreement. However, these cooperation's cope with future challenges for upstream and downstream companies. Hence, the lower tier company should invest in the relationship with the upstream company (i.e., customer). It enables to grasps future needs and creates positive interactions to protect the inherent commercial position in the value chain (Grossman & Hart, 1986).

These close links between the supplier and the buyer in the automotive business attracted attention and are observed by "western" researchers. One of the initial researches into the close ties amongst companies in Asia dates back to the 1980s (Dyer, 1996; Williamson, 1971). This research examined the likely negative effects of these close bonds. Williamson (1983) was one of the first researchers to establish the term "hostage situation" in the economic literature.

In the hostage situation, one company controls the economic destiny of the smaller company. This creates a dependency, usually through the awarding of contracts. The hostage or prisoner company dependents on these contracts. This can lead to economic and intellectual dependence. The hostage company must cooperate. Very large hurdles are thus built up, which make it difficult or impossible to change clients (Williamson, 1983). Close inter-firm cooperation generates efficiencies. It centres on decreasing transactional costs (Dyer & Chu, 2003; Williamson, 1979). This cost reduction is a desired outcome in the automotive industry in which yearly prices reductions are expected. This is in line with the author's experience in the automotive industry. The authority of the customer might lead to a hostage situation for the supplier.

The literature reveals the "unusual" situation in the supply chain network where trust and inter-firm dependencies and inter-firm financial ties are common. This cooperation framework between the economical parties involved lowers the boundaries of resistance and mistrust between these, leading to transaction costs economics (TCE). These costs are reduced and eliminated. The origin of these transaction costs is linked to Coase (1937). The principal cost reduction is the diminishing of "safeguards" and risk margins. When there is a high degree of trustiness, the buyer and seller exchange goods and/ or services on more competitive terms. The decreased monetary security margin in this relationship and the reliability allows more favourable commercial terms (Williamson, 2005, 2007).

The reduction or avoidance of TCE between the companies and the capacity to create innovations is a focal point. To achieve this or because of the existing mutual trust (Anderson, 2003). The Relationship-specific investments (RSI) among the companies allow to build trust and reliability that enable open and close cooperation (Crawford, 1990). The free flow of information and knowledge generates value in the procurement, innovations, and technical improvements in the product or diverse processes (e.g., production, quality) (Inemek & Matthyssens, 2013). The stable and mutual long-term commitment and knowledge sharing in a network diminishes the transaction costs and is beneficial in the sense of an efficient cooperation (Dyer & Nobeoka, 2000; Fruin, 2008). This effect can be also seen in the increased productivity in production lines (Ahmadjian & Oxley, 2013).

The conceptual framework between the "typical" approaches of "arm-length[13]" and "knowledge-sharing" and the impacts on the ability to oversee CPV is researched. *GM* is a characteristic example of a large company that initiated the bidding process in the US automotive industry, creating the "arm-length" approach (Dyer & Chu, 2011). This approach suggests that the bidder is always kept on a "distance" while no personal or company specific relation (e.g., technical, or R&D departments) is acceptable. This approach is later supported by inherent compliance risks (i.e., fraud).

In contrast to this negotiation behaviour, the supply chain knowledge sharing network offers a unique approach. The selection of negotiation approaches impacts the ability of a company

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[13] An arm's length deal is a transaction in which the buyer and seller act in their own self-interest without one party influencing each other; it also ensures that there is no collusion between the parties

or a SC network to cope with goods price volatility. The knowledge sharing network or the *keiretsu* relationship are examined versus the conventional "arm-length" approach in the VUCA world (Dyer et al., 2018; Fruin, 1998, pp. 283–286).

Sharing risk is the common decision to accept uncertainty. It is also a common approach in the product development. However, the cooperation approach is deployed in the set-up of a new production site or the pricing risk of raw material input materials (Huxham & Vangen, 2005, pp. 3–5). This aspect has not been duly investigated in the literature. This thesis examines the potentials of a supplier cooperation to master commodity price volatility and the impacts.

3.3.5 Value creation

The physical supply chain of stainless steel starts with raw materials and spans to the stainless steel production further to slitting/cutting into the required sizes. It is trailed by stamping or shaping operations ending up in an assembled part for the exhaust gas treatment system. Note that the physical supply chain is an important topic, but not the focus of this thesis. The value chain or the value creation activities of the three main industry levels are the nuclei. The value added to the various production stages is the basis. Each of these stages increases the value by extracting and processing the raw material (e.g., Iron ore, Nickel). The production of stainless steel and the provision of the products, and the mechanical forming and welding of sheet metal components into an exhaust system. This transformation leads to value creation after each stage.

It is defined as the activities of a company to generate a value based on the input costs. In such a way that the output value is greater than the original cost of creating these outputs (Porter, 2008). Compared to the concept of the supply chain, the value creation part of the company is of essence. The impact for each value creation level is different as the value-add increases at each level (Figure 1, p. 2). Hence, the value of the processed or transformed product impacts each level to a different extent.

Despite the value creation at each level, the raw material content prevails for the mining and the stainless steel production, it is detailed in Annex 1. Hence, the value creation is often not sufficient to counter CPV risks towards the product price. The share of raw material costs or price fluctuations on the final price occurs in different amounts. If the proportion of stainless steel material in a sheet is very substantial, the proportion of stainless steel material in the price of a mobile phone is not significant in value.

A strategic orientation towards value creation in a company can be a key point in lessening commodity price volatility risks. The increased value or reduced level of inventory risks and costs and, over time, the improved and streamlined productivity of management functions may generate a price mitigation strategy (Horvath, 2001). This is a generic conclusion and not stainless steel specific.

The stainless steel industry is often regarded as an “old economy”; it is asset driven, with a major portion of fixed costs (Pfundstein et al., 2010). Thus, (stainless) steel production sites require large investments to erect a steel plant. Hence, the traditional way of production follows the economies of scale approach. It suggests that profitability increases with production output.

Steel products, even stainless steel products, are specified and often a few grades and gauges dominate the consumption. Therefore, steel production plants reduce complexity and often favour these commoditised steel products; a quantity driven approach (based on the experience of the author (i.e., Acerinox). However, this is even more related to carbon steel. The industry is chronically exposed to overcapacity. Once the steel capacity is installed, there are high exit costs. The closure of a plant may last for several years. Production cannot amend limitlessly the production output of a blast furnace operation. From a production volume process, the electric arc furnaces (EAF) process is the flexible approach and manages changing production volumes better compared to the blast furnace production. The production capacity of integrated steel-production processes cannot be adjusted easily. Because of the complex idling and bringing back a series of integrated facilities, e.g., the blast furnace, steel shops and hot and cold strip mills. Bringing down a blast furnace entails the risk of damaging the refractory bricks (Mouton et al., 2002). The value creation in this asset driven industry is a fine balance between the aspect of economies of scale and the production of higher margin products.

The industry's low profit margins do not allow for mismatch when production costs are considered, while the price and margin pressure roots in the existing overcapacity. Hence, it stands for the price volatility and commercial risk of passing these volatile costs to the customer base. The supply and demand situation are important, like the mining industry, where the production costs are driven by high fix-costs and the demand inelasticity.

Most of the global steel production is commodity business, thus exposed to raw material costs. The demand for stainless steel increases year after year by almost 6%. While the production, in 1950, was at 1 million tons, the production was at 51 million tons in 2020. Production capacity and demand are increasing steadily, despite in some years (e.g., COVID-19).

The increased demand is mainly produced in Asia (Moll, 2020). The raw material consumption diverted from Europe to Asia. This is particularly the case for stainless steel scrap, which is the base for the EAF production route, see Annex 1. The material availability and supply uncertainty create price fluctuations. Furthermore, Nickel is demanded for battery packs of electrical vehicles. Both industries demand Nickel. These two factors (demand increase and CPV) in conjunction with supply chain challenges have brought greater levels of uncertainty to price volatility and demand patterns.

Although the regional structure of the industry applies certain standards, such as ASTM (USA), JIS (Japan), and EN standards in the European Union, the lion's share of the high-volume grades can be substituted across the regions (Moll, 2020). Steel specifications are standardised, for both economic and safety reasons (Mouton et al., 2002). This assumption applies to both the carbon steel and stainless steel industry.

Hence, the value creation within the stainless steel industry is vital for the long-term financial stability of the mill, in conjunction of passing the price risk to the customer (Fischl et al., 2015). The ability to generate value in a commodity cost driven business environment is challenging but vital for survival. The survey and the interviews shed light on the value and risk strategies in a price volatile industry. This research explores the commodity price mitigation strategies under the umbrella of the value creation aspect.

The comparative cost advantages of production in the cost-effective countries and the bundling of central tasks (e.g., accounting, HR) provide further opportunities to increase the profitability in the value chain (Ghoshal, 1987; Porter, 2008). The historic importance of steel production facilities, in particular job creations, has an important regional component. While the European Coal and Steel Community (ECSC) lead to the European Union (EU) (Adenauer et al., 1951) and fostered a common link between the neighbouring countries. The economic size and regional aspect often have a historic component and is a unique composition of interests.

Local manufacturers might want to influence the trade policies of the region they produce and sell to be protected against imports from other regions and suppliers. Hence, the influencing or the lobbying towards the policy makers is important, but not in the interest of free trade. This leads to protective measures like the "buy American or America first" approach of the Trump government (2017-2021). In general, these announcements lead to decreased import volumes and higher market prices. (Corr, 1997). In recent decades, despite free trade initiatives of the World Trade Organisation (WTO) and historic trade liberalisation (e.g., Bretton Woods, Uruguay, Tokyo Round etc.) agreements seem to become less important. As new trade restrictions and protective measures arise. Newly introduced restrictions followed and gave rise to antidumping measures and other trade restrictions. These two temporary trade barrier policies can substitute each other (Bown, 2013).

3.3.6 Financial instruments

The practice of market-based risk management instruments and insurances are the most common risk mitigation strategy among commercial producers and consumers. These are not limited to commodity materials. This thesis examines these financial mitigation strategies. These mitigation strategies are a generic method and are not unique to the stainless steel industry. The stainless steel market can best be characterised as an oligopoly, a market dominated by a few large sellers (oligopolists). Buhl (2011) researches the pricing situation in a monopoly by describing other market of distinctive characteristics and a variety of suppliers and customers. According to Kaldasch (2015), the price determination for homogenous goods,- like the raw materials considered in this research- in a perfectly competitive market (many sellers and buyers) differs from an oligopoly market situation. The author describes the situation in the stainless steel market, considering the general economic situation. The stance of a risk-neutral company presents the stainless steel producers and their responsibility towards the shareholders. This is a finding from the interviews with the executives of the stainless steel mills, see Annex 2. Hedging is regarded as a security measure and not a tool to facilitate speculation. It plays a pivotal role in the predictability of the balanced financial status, hence the risk management. In particular, "risk -appetite" is a determining factor in the mitigation or the acceptance of commodity price volatility (Gaudenzi et al., 2017). The dynamic hedging strategy is suited to minimise the price risk, the "lower tail risk" and the expected shortfalls (G. Power et al., 2013). In this article, the author distinguishes the market conditions and the willingness to accept risks. For nonfinancial firms, a majority employ hedging to increase expected cash flows. However, this limits unexpected losses and increases financial predictability for the stakeholders (Giambona et al., 2018). Hedging against volatility at the firm and sectoral levels is an appropriate tool to mitigate the CPV (Arezki, Lederman, et al., 2014).

The mitigation scenarios in the commodity segment are often restricted to financial instruments, like the hedging of currencies. However, little knowledge exists on hedging precious metals. This implies that these precious or commodity metals are traded at a metal exchange and are offered as a hedging deal. The connection between the finance department and the procurement department is often still not clear. Hedging is, in theory, possible for almost every product; however, products are traded with risk premiums. Hence, hedging is not a viable option for all raw materials. The understanding of the benefits and the drawbacks of hedging operations is often not known to smaller and medium-sized businesses (Pellegrino et al., 2019). This lack of knowledge prevents the implementation of an effective CPV risk mitigation strategy (Brown et al., 2008; Rutten & Youssef, 2007). The availability and accessibility of these instruments for commodity products is not always possible. In general, hedging can reduce the impact of CPV on share prices (Carter et al., 2017). Therefore, hedging reduces speculation and allows a stable demand for the commodity (Buhl et al., 2011). Financial hedging, as with other mitigation strategies, depends on the "*risk appetite*" of the organisation and the shareholders and is affected by the financial ties to the company. The term describes the extent of risk that an organisation accepts in order to achieve its (strategic) objectives (Barfield, 2004). Hence, it combines risk and will to achieve ambitious goals, and it considers the risk capacity of a company (Rittenberg & Martens, 2012). In other words, the risk that a company can economically bear. The stakeholders often predetermine this risk. Hedging is a risk limiting option (Carter et al., 2017; Tufano, 1996). It reduces risk and enables predictability (Culp & Miller, 1995). Independent investors accept the associated profitability risk of a volatile industry. Therefore, hedging is contra productive (Petersen & Thiagarajan, 2000) regarding profit maximisation. Hedging operations a bought with a premium –as costs for the hedge- reducing the profit margin (Breeden & Viswanathan, 2016; Culp & Miller, 1995).

The ratio of the production quantity that is hedged is another substantial decision for the producing or consuming (manufacturing) companies. It is possible for every company to use the financial method of hedging. The application of hedging depends on the risk appetite of the stake and shareholders. This includes the decision about the extent to which these are accepted. The decisions have multi-facets like cost and risk and finical planning restraints (Breeden & Viswanathan, 2016; Petersen & Thiagarajan, 2000).

The size of the enterprise and the exposure to a single asset (product) or a diversified range of products play another role in the decision making. Larger enterprises are more vulnerable to price fluctuations (Tufano, 1998). Derived from the airline industry, the financial situation of the company also contributes to the selection of price risk mitigation strategies. Companies with a sound financial situation are more often risk-averse than troubled participants (Bartram, 2015; Carter et al., 2006; Treanor et al., 2014).

3.4 Selection of mitigation strategies

The selection of the risk mitigation strategy depends on the circumstances of the individual business situation. An effective commodity price volatility risk management strategy remains crucial for commodity-dependent industries and manufacturing companies (Bakas & Triantafyllou, 2018; Combes & Guillaumont, 2002). The resilience -regarding CPV- increases with the use of risk mitigation schemes (Arezki, Loungani, et al., 2014; Delnooz et al., 2014). Diversification for commodity producers is important as it reduces the exposure to price fluctuations (Kituyi, 2019; Merener & Steglich, 2018). The exposure to price fluctuations is reduced by business activities in diverse markets. It is a protection against price risks. The application of the risk mitigation strategies is a specific solution towards a specific exposure (risk). There is no single universal mitigation strategy. The selection is a unique decision that incorporates the financial, emotional, operational, and strategic interest of the corporation or industry. The parameters are (Fischl et al., 2014; Jüttner et al., 2003; Qazi et al., 2018):

- Risk appetite
- Circumstances (exogenous factors)
- Commodity types
- Share of the commodity in the value chain
- Duration of the mitigation
- Contractual situation
- Financial situation
- Costs
- Mitigation strategy
- Beneficiaries (e.g., stakeholders, banks, insurances)

The risk that an organisation, a function, or a procurement organisation is taking can be measured with a “Domain-Specific Risk-Taking” (Dospert) Scale. This framework measures the risk attitude/ risk appetite of a person or an organisation (Weber et al., 2002). It also reveals the relative and the absolute risk attitude. This framework can model the situational influences, e.g., in crises and the personal situation effects (Blais & Weber, 2006).

Lo (1999) adds to the influence of price, probability, and preference of the contractual parties. This article refers to a perfect match of supply and demand, which is a more philosophical, rather than a practical stance and not in line with the commodity environment. However, it reveals the risk preference. It is a subjective rather than objective assumption. The application of a risk mitigation strategy is not always based on data. The RM, as described in section

3.3, is often managed on a tactical perspective. This might lead to an inconsistent approach in the selection of the tools and methods.

Decisions grounded in inconsistent and subjective facts can lead to unintended exposure or financial losses (Lo, 1999). The term probability or the risk preference should represent the company and shareholder targets to dilute the CPV risk and to increase the value of the corporation. This leads to the risk mitigation preference or the "risk appetite" of the stakeholders. It is a pretermination, which is associated with selection of the mitigation approach (Denton et al., 2012; Laycock, 2015, pp. 12–14). The prevailing assumption is that both seller and buyer are interested in stabilising the financial transactions (revenue or spend). This precondition is an assumption, not a fact. The contractual parties might accept the CPV to a different extent as the transactional partner. Price volatility is a bidirectional occurrence, which represents an opportunity and a risk (Gaudenzi et al., 2017; Manuj & Mentzer, 2008b).

The knowledge of risk might change our business' behaviour or the choice of raw material price alleviation strategies (Engle, 2004). An understanding of the corporation's commodity price volatility exposure starts with a holistic perspective on the risk. It includes all the means, tools, methods, and preferences that are employed to analyse the current status. This fact-based investigation leads to the selection of the CPV mitigation strategy in a certain situation, it is based on six steps (Denton et al., 2012).

This comprehensive approach includes the simulation of commodity prices to elaborate on the expected gross exposure of the business, including buying and selling volumes. Based on the expected exposure, potential mitigation strategies are examined, which leads to the net CPV exposure. The impact on the financial stability of the company is examined as the final step.

Jüttner (2003) advocates four steps (i.e., risk assessment, definition of risk concept, identification of risk drivers and the mitigation) to examine the exposure to risks. However, both advocate a structured approach, independent of the segregation steps.

This approach creates awareness in the organisation of the price fluctuation risk. Similar approaches are described in literature (Delnooz et al., 2014; Deloitte India, 2018). The awareness regarding price fluctuation risks is an essential step to safeguard the financial stability of the company.

To the best of the author's knowledge, no literature exists on when to apply and which method. The mitigation scenarios are listed and compared but not rated towards practicability or economic circumstances. The recent research by Pellegrino (2019) identifies the gap between the practise of financial instruments and those that are not always common in the corporate environment. However, the effectiveness of the different CPV mitigation strategies is not analysed. Still, there is no benchmark between the different methods, while there is no transfer of any method to the real world. Noteworthy are the publications regarding the effectiveness of switching suppliers and material substitution (Algieri & Leccadito, 2018; Costantino et al., 2016). The selection of the suitable risk mitigation strategy is described. Exogenous factors such as supply disruptions, fundamental changes in the macroeconomics or financialisation or noise trading in commodity markets are considered (Arezki, Lederman, et al., 2014; Miffre & Brooks, 2013; Silvennoinen & Thorp, 2013).

CPV is taking an increasing share in academic publications (Costantino et al., 2016; Merener & Steglich, 2018). The SCRM perspective is often focused on the supply chain disruption scenarios and not on the commodity price volatility or its impact.

This gap in the existing literature is narrowed down with this research.

3.5 Risk management process and COSO framework

This research embraces the risk management process according to ISO 31000. The process is displayed in Figure 12.

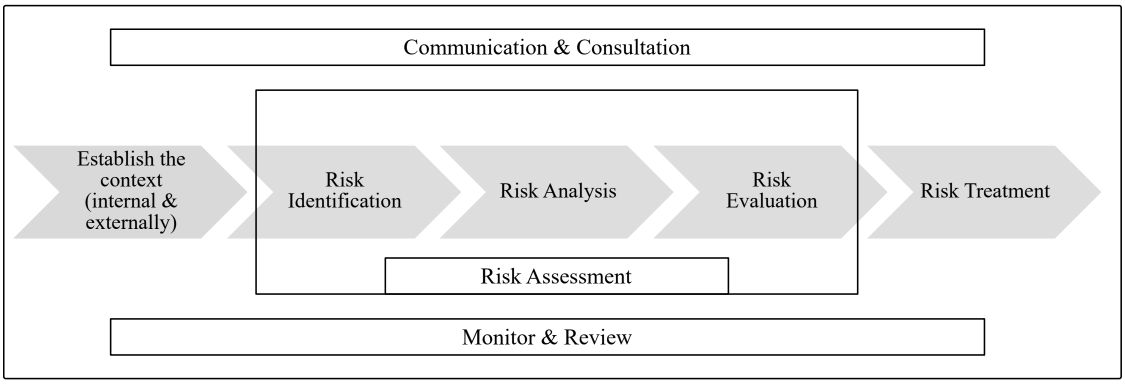

Figure 12 Risk Management Process, Referenced from ISO 31000:2009

The standard ISO 31000 (ISO Institute, 2018) was revised in 2018. Risk procedures in the corporate governance were part of the revision. The ISO 31000 defines the Risk management process for strategic and operational decisions. The ISO incorporates cognitive biases, including the assumptions and beliefs of the decision-makers (Fox, 2018). Hence, soft facts of the risk assessment are acknowledged for the risk evaluation.

Commodity price volatility is a strategic challenge however, the response is often an operational approach (Costantino et al., 2016; Gaudenzi et al., 2017; Jüttner et al., 2003). The actual preparations are operational, whereas the creation of awareness and the response strategies a strategic task. The methods and tools to measure and monitor price fluctuations are also operational and embedded in Enterprise Risk Management (ERM). Note that reporting is part of the management reporting system.

In the American-based literature, the COSO ERM Framework is compliance-driven and control based. The COSO ERM seems to be influenced more from auditors, accountants, and finance side of business. The ISO 31000 has a focus on the management and decision-making process (Gjerdrum & Peter, 2011). Hence, this research considers the risk practitioners' view rather than the compliance focus to alleviate commodity price volatility.

After listing the mitigation strategies, the subcategories are defined. Based on the "Concept map of price risk" for the manufacturing/ production context (see Figure 13) introduced by Fischl (2014, p. 484). It interprets the alleviation strategies as strategic or management/operational approaches. However, the limitations and enabling factors of an organisation and its particularities in financial or organisational contexts are yet to be considered. Despite the strategic or operational aspect of the mitigation strategy, the impact of the risk appetite constitutes a pivotal role.

In a business setting, the price risks can be over one. The CPV risk is not only a procurement and purchasing price risk. The physical supply chain (supply risk) is not examined, neither the sourcing risk in the overall price risk components, described by Fischl (2014). However, the concept map is useful to describe the CPV risk in the overall price risk context.

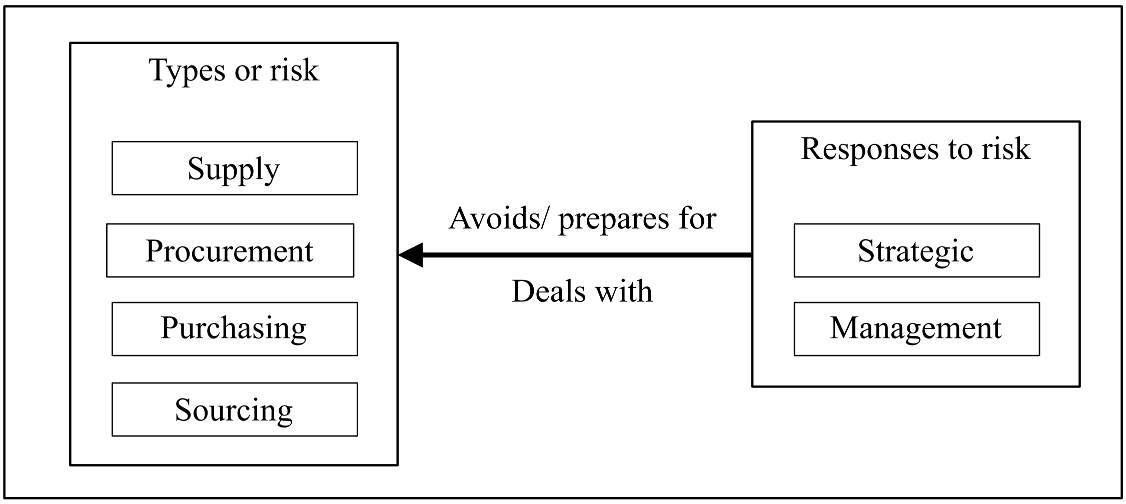

Figure 13 Concept map price risks, Referenced from: Fischl 2004

The strategic, managemental and operational responses to commodity price volatility risks are listed. These reveal the ability of an organisation to prepare for risk and to initiate the mitigation strategy. The organisational solutions to cope with CPV are strategic decisions. Thus, these require management and cross-departmental input to set the boundaries for the operational solutions. The procurement and the purchasing department must align the targets and

inventory levels, whereas the finance department must communicate the financial limitations for the expenditure of funds.
The literature reveals the three following subcategories for the clustering of existing mitigation strategies (Annex 16):

- Sourcing strategies
- Contractual strategies
- Financial strategies

3.6 Research gaps

Commodity price volatility has been researched to an extensive level of products like Crude Oil, referred to as the Oil price. Research confirms the impact of the Oil prices on the stock market.
Describing and modelling volatility is an interest of the financial community to predict patterns and to forecast future scenarios. This approach is deployed to examine currencies, commodities of all kinds. Literature exists on agricultural goods, Oil & Gas, and precious metals. Some examples are the contributions of Aizenman, Arezki and Zsidisin, among others (Arezki, Loungani, et al., 2014; Zsidisin et al., 2017, pp. 3–24) focussing on Oil & Gas price swings. These results and impacts are crucial to the mitigation of price volatility if the development of entire industries is touched. Like the export dependency of commodity materials, agriculture goods or precious metals are predominant for the national economy and the financial stability of the economy. Financial instruments apply to mitigate price volatility impacts when traded in different currencies.
The linkage between the steel and the scrap market to the stock market return is discussed. Omura (2016) describes the connection between the steel scrap market and the impact it had on the scrap market in Japan. The article confirms the predictive power of scrap prices. This early indicator was as well deployed by Alan Greenspan, the former chair of the Federal Reserve in the United States (Greenspan, 2008, p. 47). The steel scrap prices were deployed to predict the economic development (Desai, 2012). As steel scrap is the base for melting steel, it is in stronger demand when the economy is gaining pace. Or contrary when it is losing pace the demand shrinks. The usage of steel is linked with several activities, like the construction industry, but includes private consumption goods as household appliances and the automotive sector.
In-depth research of the impacts of commodity price volatility in the stainless steel value chain players is missing so far. However, this research deploys source from other commodity

related products like the Oil and Gas industry (Creti et al., 2013; Khan et al., 2019; Xu et al., 2019). Neither the search routine nor the literature review identified a single article that mentions the stainless steel industry. Even though the stainless steel market is a niche market compared to carbon steel, it consumes over 65% of the global Nickel production (White, 2019). Therefore, a connection between these markets is assumed. Hence, a necessity to research the impact of the raw material price fluctuations on the stock prices of the companies within the stainless steel value chain. The understanding and mitigation of price swings of the input costs are vital. These findings allow to safeguard financial results and future business prospect, measured by the share price. This awareness and understanding might differ depending on the position in the value creation chain.

The predominant costs of the production are determined by the raw material input. As the production method is the same across the industry (i.e., melting in electric arc furnaces (EAF)), these costs are stable. The close link between the stainless steel market and the influence of Nickel prices has not been investigated, despite the close linkage and the value portion of Nickel in the price of stainless steel.

Therefore, Nickel is the important variable in most calculations. It is a major cost driver. The LME is the leading price-setting mechanism for this commodity. However, the LME price is an indicator value and not the transaction price for the mills, which was a finding from the interviews, see Annex 8. However, for all interviewees, it is the best price-setting mechanism.

3.7 The contribution to knowledge

This research provides the framework to distinguish the term volatility in the industry context. It includes the measurement of it. This thesis contributes to the understanding of the time-varying effect of CPV on the share prices. The existing mitigation scenarios are identified and examined. Interpreting the severity of CPV is subjective and depends on diverse subjective interpretations and the risk appetite of an organisation. To overcome this gap, this research provides a rating scale. The level or severity of CPV can be measured by the coefficient of variation (CV). This method allows companies to analyse the severity of price swings. The research sheds light on the stainless steel business and the financial risk exposure because of commodity price volatility. The literature review reveals a lack of economic and academic contributions to the stainless steel industry and the inherent risk of commodity price volatility. Hence, this research contributes to the commodity price volatility literature on the aspects and peculiarities (e.g., price and demand swings) of the stainless steel industry.

A contribution to the selection process and implementation of strategies to manage price risk has been lacking.
Although there is an operational and strategic need to manage price volatility. The turnover of these companies does not reflect the performance solely. Turnover is substantially determined by volatile commodity prices. Financial planning is challenging as volatility is not following certain patterns and is hence difficult or impossible to master. This thesis lays the foundation for changing this pattern.
The quantitative section enables the prediction of future prices. Combined with the specific industry knowledge, it mitigates price risk and opens opportunities to the benefit of the companies. The multiple regression and the GARCH models have the potential capability to study price fluctuations. The ARDL models the time-lag impact of price values and allows the understanding of relevant time gaps between cause and effect of the price alteration. This deep understanding of the value chain allows the companies to react promptly to lessen commodity price volatility and negative impacts.

3.8 Summary of this section

The literature review spans from the explanation of the term volatility to the selection of the mitigation scenarios. This section aggregates the existing literature and links it to this research.
The literature review begins with an examination of the term volatility; what is volatility and how can it be defined for the economic sphere. The understanding and the interpretation of volatility is vague. The understanding of volatility and the meaning of these (raw material) price fluctuation must be defined. The definition of the term is given in the results section and is the basis for the subsequent measurement of volatility.
In the research on commodity prices, Arezki's (2015; 2014; 2014) publications and his work with and for the IMF have played an important role in the classification of CPV in the global economy. Here, the dependence of individual countries on a few export goods. The disadvantages (Dutch disease) are touched upon (Wijnbergen van, 1984). As well as the Prebisch Singer Syndrome (Prebisch, 1959), which predicts a long-term development.
The literature deals with CPV and here the publications of Gaudenzi (2017), Zsidisin (2017; 2012), Mensi (2013), Pellegrino, Costantino (2016), Ma and Wang (2021) and Chen (2010; 2010) should be mentioned as an important assistance for this research. These publications shed light on linkages and impacts for businesses and the stock market. First approaches (i.e., supplier switch, substitution) of mitigation strategies are touched upon. However, these

remain too vague. For this reason, first, the lack of attention to the stainless steel industry in the literature was presented. This sector seems to be ignored in the literature, at least from an economic point of view. The orientation of the price defence strategies for the stainless steel sector is inspired by other sectors but has not yet been applied.

The relationship between commodity prices and share prices in the three value creation categories are examined by statistical means (i.e., correlation and multiple regression; GARCH model and time delaying estimates (ARDL)).

The different risk management between the US (COSO) and the EU (ISO) are presented, two ways of looking at corporate risks. This means that raw material price risk has a significant impact on the financial stability of companies. Raw material price risk generally affects the Oil, chemical and steel industry (Bartram et al., 2009).

Enterprise Risk Management is viewed from a “preserve and protect” perspective of the financial stability. This thesis is a part of the overall risk management and thus a building block of its conceptual framework. The demarcation to the physical supply chain has been explained. The price avoidance strategies described are a fragment of the value chain. Porter (1985) refers to primary and support activities that contribute to the margin in his value chain concept. It embedded procurement and the management of commodity price volatility risks in the support functions. The value chain includes the economic contributions that are made by the exposed value creation levels (mining, steel production, exhaust industry) in this research. The share price is an important indicator, as it combines the current situation and future developments. The link between raw material price fluctuations and share prices was presented and proven.

Furthermore, a parallel was drawn with the transport sector in the USA and the stainless steel producers. The dependence on Oil corresponds to the dependence on Nickel for the stainless steel industry (almost 66%).

Thus, the Nickel price development could be related to the share prices of the stainless steel mills. The transport industry in the USA and the stainless steel plants are exposed to the price fluctuations of the exogenous Oil and Nickel prices, an exogenous variable. The impacts were researched and presented with reference to the questionnaire.

There are other examples in the literature of a relationship between raw material prices and share prices. Furthermore, other influencing variables were researched (e.g., co-movements and spill-over effects, noise trading, herd behaviour).

The impacts of price fluctuations are revealed, it suggests an influence on the prospects of the company, measured by the share price. This advocates that a company should take mitigation efforts to avoid these negative impacts, including threatening financial stability.
The importance of risk limitation and acceptance (risk appetite) is examined. The idea of co-operation has overcome the "traditional" view that a company must overcome all pitfalls alone. The idea of "supplier cooperation" is reviewed in the literature for this reason. The final section examines the value chain and the parameters that influence the choice and application of mitigation strategies to lessen the impact.

4 Methodology

4.1 Introduction

This chapter carves out the philosophical assumptions and their potential implications for the deployed research methods. This section leans on the literature of Mark Saunders (2015, 2017). The theory of how the research was conducted is explained. It is referred to as the methodology of this research. However, the methods refer to the techniques of the data collection (i.e., questionnaire and interviews) and the deployed procedures to analyse the data. The research choices and methods are guiding the philosophical assumptions (Saunders & Rojon, 2014). It is the contextual framework for this research.

In this thesis, the “Research Onion” (Figure 14, p.75) is central component of this section. The leading research philosophy is “Positivism”. The research is value-free (axiology), with a deductive (i.e., statistics) highly structured approach, researching quantitative data stream. However, there are elements of “Pragmatism” and “Interpretivism”. The “Pragmatism” as the research is initiated and sustained by the beliefs of the author (i.e., risk management and impacts of price volatility) and a reflexive researcher. The research follows and contributes to the impacts of CPV. The examination of the research objectives is conducted by diverse research (multiple-) methods. The outcome should add to the practical management of raw material price risks. The “Interpretivism” is manifested as the author is part of the stainless steel community for decades. Hence, his contributions are part of his interpretations of the industry. The sample size is small, due to the niche market situation. However, it is not the intention to generate new theories (inductive approach). This thesis is a result approach. Hence, the result is the most important topic. The system of assumptions and beliefs about the maturity of knowledge deploys both the “Positivism” and the “Pragmatism” approach. The aims and objectives lay the foundation for a practical solution to handle commodity price fluctuations and their impacts. Thus, this thesis is interested in the practical application and not in theoretical immaterial distinctions (Saunders et al., 2015, p. 143). It is value-based research with a reflective researcher (axiology) that deploys qualitative and quantitative methods, with the solution and outcome in mind (Saunders et al., 2015, p. 136).

As previously mentioned, this research employs also an “Interpretivism” approach (Saunders et al., 2017, p. 109). A few example cases characterise “Interpretivism” and stand out for its in-depth consideration and it is often applied to qualitative research. “Interpretivism” centres on business management research and the interpretation and understanding of the motivation in the selection process of mitigation schemes.

This thesis combines quantitative and qualitative data streams. It explores secondary data as raw material and share prices in the quantitative research (5.1.2 and 5.1.5) but considers primary data for qualitative analysis (5.3). The primary data is collected via a web-based questionnaire and semi-structured interviews. Section 4.1.2 and Table 3 (p.77) depict the connection between the research question and the research approach.

The methodological choice of this research is a mixed-method approach and sequential explanatory research. Quantitative methods are used to analyse secondary datasets while, it performed a qualitative analysis for the answers to the open questions in semi-structured interviews.

This research builds on the existing statistical methods (i.e., correlation and multiple regression analysis), complemented by two more time series-based methods.

The first method involves GARCH calculation by modelling the conditional volatility of the time series. GARCH models give consistent results with volatility clustering in crisis or boom periods, where the constant volatility is not known (Andersen et al., 2007; Bollerslev et al., 2009; Engle & Granger, 1987). A GARCH (p,q) process may be interpreted as a moving average (autoregressive) process (Bollerslev, 1986). The result shows the severity of price volatility.

The second method involves the understanding of the time-varying aspect of the CPV by employing an autoregressive distributed lag (ARDL) model. It determines the time-delayed impact of commodity price volatility across the value chain of stainless steel. In economic scenarios, the change in any variable might lead to a change in another variable, sometimes with an immediate impact, and sometimes with a delay (Chetty, 2018). The ARDL analyses the change in the variables over a longer period (long-run). It is based on the error correction representation on the existence of the long-run/ cointegration. ARDL estimates the impact of one independent on the dependent variable over a longer period, and models the time-varying impact (Kripfganz & Schneider, 2018; Pesaran et al., 1996). Section 4.3.1 describes the statistics, results and findings are displayed in section 5.1.7. A colour coding of the value-added stages enables easy separation.

Figure 14 shows the choices made for this research and is a fragment of the complete “Research Onion”.

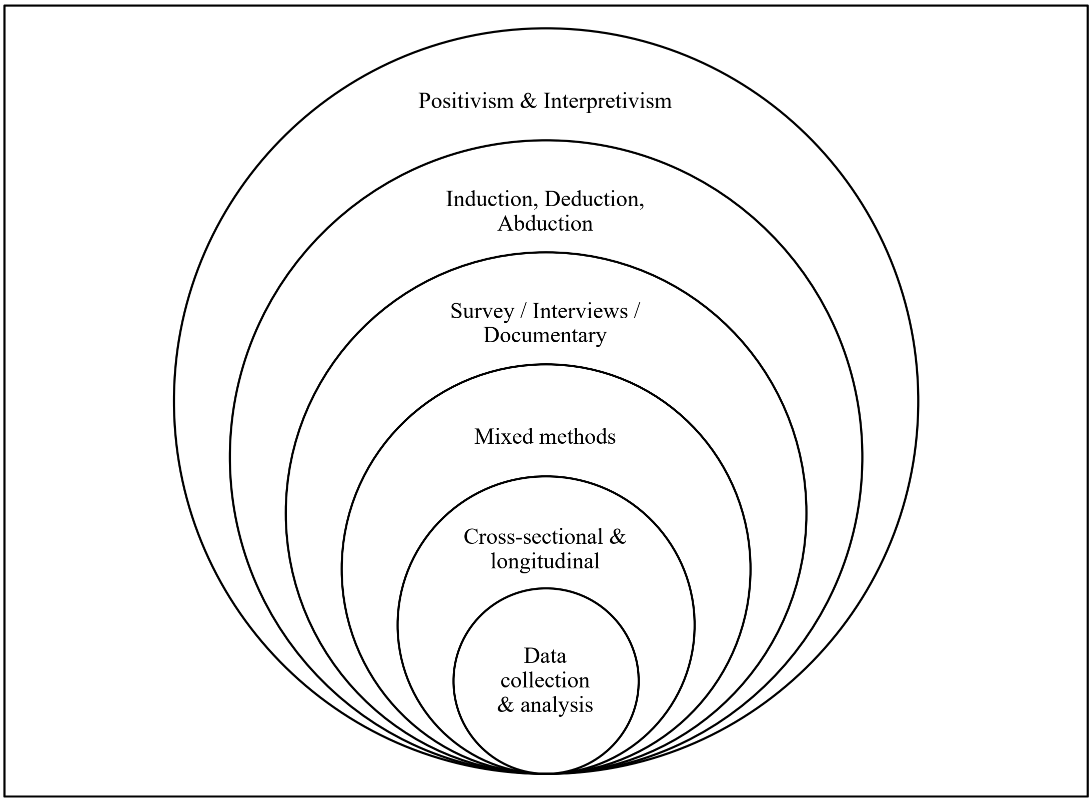

Figure 14 The "Research Onion" research design choices, Referenced from Saunders

The next sections describe the method for each layer of the "Research Onion" as elaborated by Saunders (2015). It is the framework for developing new knowledge and the assumptions made. The decisions and the reasons for those are explained.

4.1.1 Research philosophy assumptions

The research philosophy relates to the development and the nature of that knowledge (Saunders et al., 2015, pp. 122–134). To elucidate and distinguish between the different research philosophies, it is beneficial to understand the underlying assumptions of them.
The predominant research philosophy in this research is positivism. It is characterised as (Saunders et al., 2015, pp. 135–137):

- Ontology (nature of reality or being), the world is perceived as real, external, things can be granular and
- Epistemology (what constitutes acceptable knowledge), is a scientific method, facts are measurable, law-like generalisations, numbers, causal explanation, and prediction as a contribution
- Axiology (role of values), is value-free research. The researcher is detached, neutral and independent of what is researched, keeps an objective stance
- Typical methods: deductive, structured approach, large samples, quantitative methods of analysis

Secondary data series are measured and observed in controllable conditions. The statistics are structured, and the findings generate forecast able outcomes. The cause and effect of price fluctuations are the focus of this thesis. Hence, positivism is chosen as research philosophy.

However, the research has also a qualitative part. The stainless steel industry is a small market. The carving out of the mitigation strategies requires an understanding of the social aspects. Differences between the players are examined, as these might impact business decisions. The results of the questionnaire and the interviews are conducted with the author being part of the industry; practitioner-researcher or insider-research (Oliver, 2010, p. 11). Which allows for access to information and experts. However, it comes with a certain familiarisation of the industry and the companies in the stainless steel industry.

The sample size might be small; however, it is an in-depth investigation of a niche industry and the impact of CPV. The understanding and respect of the interview partners are crucial for an open discussion that allows in-depth insights into the processes of the stainless steel industry. Interpreting is key to the contribution of knowledge. Hence, the own values are limited with a structured approach and the awareness that values play a role. Therefore, interpretivism is applied in the qualitative section of this thesis.

Despite the prior explanations, this research has a strong focus on the RQ and RO. The pragmatism exists in the desire to understand the impact of the price volatility and the statistical tools to give meaning to the price swings in the stainless steel industry.

4.1.2 Research approaches

The next layer of the “Research Onion” is the research approach. Deductive approaches aim to assess an existing theory, which is the main difference between induction and deduction. The inductive approach explores the generation of alternative theory emerging from the data. Abduction combines the two research approaches; it enables the switch between these two approaches.

A specific observation is the selection and implementation of a mitigation strategy, whereas the relationship between the share and the raw material prices is a general observation.

In the business sector, the deductive approach prevails - as most managers are accustomed to this approach (Saunders et al., 2017, p. 115). The data-driven standardised approach supports the acknowledgement of the findings; statistic calculations support it. The outcome and the predictions are guided by the data series and statistics. The hypothesis testing reveals patterns. It is the foundation for the results and influences the interview questions.

This research combines all three approaches to answer the research questions. Quantitative research is approached by deductive means. The qualitative part is narrowed down with the inductive approach and the application of the mitigation scenarios is challenged from different angles and perspectives. It is the purpose to create an in-depth understanding and interpretation of deployed mitigation strategies to lessen the impact of CPV on the industry. In summary, the mix of research approaches enables triangulation. The quantitative results influence the qualitative part; however, the findings of the interviews challenge the statistical results.

Table 3 Research objectives & approach, Source: own data

No.	Research objective	Research approach
1	Elucidate and model commodity price volatility with the aid of statistical means and time series analysis	Deduction
2	Research the time-varying impact of CPV on share prices	Deduction
3	Research the impact of CPV on the share prices of (a) mining companies (b) stainless steel mills and (c) exhaust gas treatment producers	Induction
4	Identify the existing commodity price volatility mitigation strategies in the industry	Induction
5	Explore the impact of mitigation strategies on the various levels of the stainless steel supply chain.	Abduction
6	Study the selection and the impact of the price mitigation strategies in case of disasters or other exogenous events	Abduction
7	Study the risks accrued by a financial crisis or a political change in the trade environment	Abduction

4.2 Research design

The focus on the process research design is the primary aim of the next layers. It is the plan to answer the research questions, i.e., the profound base for research following the “Research Onion” (Saunders et al., 2015, pp. 124–126). The next three layers (3 to 5) are the research design and are depicted in this section:

- Methodological choices
- Research strategy/-ies
- Time horizon

4.2.1 Methodological choices

Research strategy starts with the methodological choices. This thesis deploys quantitative and qualitative research. The questionnaire collects quantitative and qualitative data (open questions, 4.3.1.1), the interviews are collecting qualitative data. The data collected from both

methods is primary data. The statistical data, like the share prices and the commodity prices, are quantitative data of existing (secondary) sources.
Therefore, there is a necessity to deploy qualitative and quantitative research methods. The data series (i.e., share and raw material prices) and the quantitative findings of the primary data (i.e., questionnaire and interviews). The mixed-method approach deploys both approaches to an equal share (Saunders et al., 2015, p. 165). It is possible that the results complement or diminish each other. The findings of the statistical calculations (hypotheses) are influencing the interview questions (4.3.1). The questionnaire contains quantitative (e.g., multiple choice) and open (qualitative) questions.
Statistics examine the secondary data, qualitative data (i.e., questionnaire and interviews) follow these findings to explore perceptions (Saunders et al., 2015, p. 169), see Figure 15. This research design is the *sequential explanatory* approach. Qualitative research follows quantitative research (Saunders et al., 2015, pp. 171–173).

4.2.2 Purpose of the research design

Descriptive statistics are the foundation for an understanding of the data series. These descriptions of the data are a forerunner to the explanation of the findings and patterns, which are referred to as explanatory. The calculations produce findings that are “explained” (explanatory research approach) with the answers to the questionnaires and the interviews. Hence, the research design chosen is *descripto-explanatory.* The causal relationship between the variables (raw material and share prices) determines the explanatory research approach. One of the guiding questions in the data collection process is the determination of the best potential mitigation strategy. The research design includes the three research phases (4.3.1; 4.3.2 and 4.3.3), detailed in Figure 15:

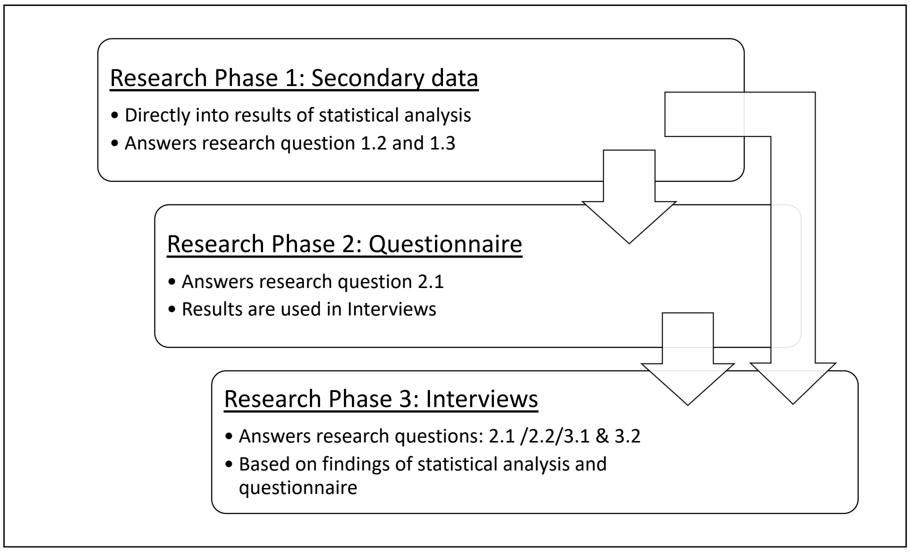

Figure 15 Research design flow chart, Source: Own data

The collection and the analysis of the secondary data is the basis of the questionnaires and the interviews, and it answers RQ 1.2 and 1.3 (5.1).

The secondary data is challenged regarding availability and consistency. The World Bank publishes metal prices (multiple-source secondary data), whereas the share prices have been retrieved from financial websites. An overview of the data source and the description of the abbreviation is given in Table 5 (p.88). The description of the metal details are given in Annex 3.

While focusing originally on the data collection and the sources, the consistency of the data came into focus. To ensure the creditability of the data and the sources, the selection process centred on public sources. The data series, such as stock prices and commodity prices, are available and consistent, as these do not change retrospectively. The initial hints of interrelationships between the data sets become apparent. These premature findings triggered an iterative and in-depth examination of the potential patterns and inter-linkages among the data sets. Section 5.1 elaborates the results.

However, the secondary sources (numeric data) probe a different research strategy. The descriptive research strategy exposes an accurate description of commodity price volatility and the impact of these fluctuations. It focuses on the impact of raw material prices changes on the share prices. The description of CPV lays the foundation for further investigations. This research work performs multiple statistical calculations, testing the hypotheses derived from the literature review. It constitutes the groundwork for the explanatory research.

4.2.3 Research strategy

The research strategy associates the research questions and the methodological choices to collect and analyse the data (Saunders et al., 2015, p. 177). Diverse research strategies are deployed as this thesis exploits quantitative and qualitative data. To research the quantitative data of the price variable, the mix of quantitative (i.e., questionnaire), qualitative methods (i.e., interviews), and the multi-method are applied. A mix of research strategies was also deployed, see Table 3 (p.77).

Case study research is associated with an in-depth examination of one specific research topic. Several examples can be examined and studied to draw out general outcomes for a broader purpose. The selection and the reasoning for certain mitigation strategies are researched. The in-depth understanding of the context and the process is curved out. Validity is demonstrated by using a rigorous approach, like statistical calculations. It ensures the repeatability and creditability of the results. The case study investigates the dynamics and the deep understanding of the phenomenon within a particular setting. It is a real-life setting and not a laboratory one, like in an experimental research strategy. The case study offers the opportunity to challenge existing theory.

This research strategy applies to the secondary data section (Figure 14, p.75). The case study is linked to a "Positivism" research philosophy and is trailing a deductive research approach (Saunders et al., 2015, p. 185). The data series are analysed with several statistical calculations. However, the calculations examine the stainless steel industry and aim to reveal some useful patterns. Hence, the causes and effects of price changes are investigated. The structured repeatable and reproducible approach enables the transfer to other industries.

The survey strategy is bonded methodologically to descriptive research. This research strategy deploys the questionnaire as a standardised tool to collect quantitative data.

For the interviews, a hybrid between deductive and inductive approaches are deployed. The research has prior findings; these are deployed in the interviews and probed with the expert knowledge and against common practise in the stainless steel mills. However, the discoveries are still open to new findings. The interviews are the qualitative follow-up of the quantitative data research. Hence, these enable the verification and understanding of the results. The overarching goal is the validation of the conclusions by employing the triangulation method. Triangulation deploys multiple sources of data or data collection methods (i.e., questionnaire and interviews) to validate prior findings (Oliver, 2010, p. 78). In this thesis, the triangulation is deployed to verify the statistical findings with the findings of the interviews. In particular,

the potential linkage between Nickel price movements and the impact to the stainless steel producers. The statistical results are questioned. The findings of the interviews confirm or reject these results and conclusions. Another example is the price mitigation strategies of the stainless steel plants. A comparison is made between literature and yellow commercial reality. Furthermore, the strategies applied are questioned. The differences are elaborated and discussed.
The embedded multi-method as the methodological choice leads to the narrative research strategy. The qualitative data of the interviews is coded for statistical analysis. The quantitative findings and the questionnaires were deployed to seek challenge and verification requirements of the senior members of the industry. The in-depth interviews allowed to be more flexible as in the fixed questionnaires to adapt to the specific situation and to verify the conclusions. Social interaction played a noteworthy role. Five interviews produced a vast amount of transcripted findings (Annex 8). The meaning and findings are carved out with the support of NVivo software. Differences, communalities, and linkages between the different interviewed persons/organisations are examined and summarised.

4.2.4 Time horizon

This thesis deploys the cross-sectional and the longitudinal time horizon. The secondary data on metal and equity prices begin in 1960, the year the World Bank started publishing these data. It is a study with longitudinal data, the share prices of the companies are recorded over a certain period.
The questionnaire and the interviews (primary data) are cross-sectional studies, as the answers are given on one occasion. The questionnaire was sent out once, with occasional reminders. The interviews took place in 2019 in Europe and the USA (4.3.2 and 4.3.3).

4.2.5 Research ethics

The research ethics are important for the assurance of anonymity of the answers derived by the questionnaires, and in particular, the narrative elements of the interviews. The Academic Ethics Policy guideline of Salford University (Cresswell, 2017) is acknowledged, see section 4.4.

4.2.6 Quality of the research design

The quality of the research design is evaluated with three criteria (reliability, validity, and validation) to ensure the appropriate measurements of the variables, the quality of data, and research design. It ensures and tests the correctness of the research results (Adams, 2014, p. 245).

Reliability covers the replication and consistency of research. The same research design should enable the same findings in prior or future research.

The internal reliability roots in the coherence during the research project. Its focus is a stable process. To ensure a consistent perspective when analysing and interpreting the research data. External reliability refers to the consistency in the data collection and analytic procedures. This research ensures reliability with publicly available data (secondary data). However, historic pricing data of the International Chromium Development Association (ICDA) and the SMR Institute (Reutte/Austria) are also included. These pricing datasets are examined by statistics, including the GARCH model and the ARDL testing models. The external reliability is ensured by the selected methods of data collection and the standard data analysis methods (IBM SPSS, “R” and NVivo). Data collection and analysis methods are consistent and are producing repeatable results. The research design offers future research to pursue the same approach and to generate the same findings.

Throughout the research, the assumptions for the analysis of the data remain the same. The online questionnaire was answered in a time setting determined by the participants. The layout and the questions remained constant. The semi-structured interview was held in a location chosen by the participants. The interviewer was the same to avoid any observer bias. However, a certain bias cannot be avoided, the inherent threat to reliability is acknowledged. Being part of the stainless steel industry; the author cannot be completely detached from the social world and the interests of the industry (Oliver, 2010, p. 117).

Validity refers to the selection of measures, the accuracy of the results and the generalisation of these findings. This can be broken down into internal and external validity. The internal validity is proven when the research demonstrates the causal relationship between the variables in the quantitative research. When the findings can be generalised, external validation is established (Saunders et al., 2015, p. 204). The stainless steel industry is a niche market; the share prices of the European and US mills are available via the mentioned financial websites. However, the share prices of the Chinese stainless steel mills are not available. Financial data of these mills is, to the best of the authors knowledge not accessible. Hence, this thesis explores the accessible mills, these are Acerinox, Aperam, AST, Outokumpu and, to a certain extent, AK Steel in the US, and Posco in South Korea. The data collection process deploys available sources of share prices and raw material prices. However, not all metal prices are accessible free of charge.

The validity of this research is safeguarded by the causal relationship between commodity and stock prices (internal validity). Despite the price fluctuations, cause and effect remain intact. The questionnaire and the interviews were conducted in a brief period, avoiding the influence of sudden events that could bias the findings. The instruments stayed the same. No participant dropped out of the interviews. The findings (e.g., mitigation strategies, raw material procurement, share price impacts) of the interviews are compared to related industries (Gold, Oil & Gas, agricultural goods etc.). Literature has carved out the impact of commodity (e.g., Oil, Gold) price volatility on the share prices (Ågren, 2006; Gao et al., 2018; Xu et al., 2019) Thus, transferring the findings of other commodity markets was a challenge itself. The dependency rate and market transparency (availability of stock prices) and raw material prices are examined and probed. The findings of other commodity markets are considered. This refers particularly to the Oil and Gold market. These raw materials are influencing the stock market. Regarding Oil there is a link to the transportation and the airline industry. Typically, rising raw material prices are trailed by decreased share prices of the main consuming industries. The dependency of price volatile components is not a unique setting. Equity markets operate the same across all industries and often reveal similar influences. Thus, these findings can be generalised to similar settings in different industries, providing external validity.

The process of verifying the research data is validation. In this thesis, triangulation is deployed to validate the outcomes. The statistical results are reviewed and analysed with the findings of the primary data (quantitative data). It deployed the member validation for the retrospective review of the interview contents and understanding. The transcripts have been sent back to the interviewees for data accuracy, amendments and final permission (Lewis-Beck et al., 2003, p. 1137). The granted permissions are part of the ethics approval process (Annex 14).

The triangulation of the research findings underpins the validation of this research. The findings of the descriptive statistics and the quantitative data research that produced primary data are verified and challenged by each other. The statistical results are verified by the interviewees. Findings are “triangulated” by the secondary data (price), the answers to the questionnaires, and the responses of interviews. The consistent and rigid application of the described process steps - reliability, validity and validation guaranteed the quality of this thesis.

4.2.7 Role as a researcher

The role of the researcher deserves some detailing. The author is by definition an “external” researcher in the sense as no personal involvement in the mentioned companies exists. The author worked for decades in the stainless steel industry. As a result, he is accustomed to language, terms, and habits. Because of the niche market perspective, the researcher might be considered as an “internal” or “practitioner” with great knowledge in that industry (Oliver, 2010, p. 114). He works in the steel industry since August 1991 and is regularly presenting industry updates at diverse steel conferences. However, it is stressed that no conflict of interest existed at any point in time. The fine distinction between sector knowledge and existing trust and knowledge about the interviewees and the organisations is considered. The differentiation between work and research and the existing reputation and trustworthiness of the author allowed to gain access to the interview partners. This role is, still, a demanding task. The operational aspect and the academic point of view are combined. The researcher is aware of the potential impact and therefore the research design is rigid (Saunders et al., 2015, pp. 207–209).

4.3 Data collection and proceedings

The data collection is separated into distinct phases. These include secondary data from several sources and the collection of primary data from the questionnaires. The questionnaire holds two open questions, however, the biggest amount of qualitative data is collected through the interviews. The exact flow and interactions are described in Figure 15 and Figure 16, respectively.

The secondary data sources are quantitative (numeric) streams. Descriptive and explanatory research analyses these data. In particular, the reliability and the validity of the data collection are defined to reinforce the results. The raw material prices originate from multiple data sources. The World Bank collects diverse data streams into the “Pink Sheet[14]”. These are monthly averaged data series. The share prices are retrieved from financial websites and are hence, like the World Bank data longitudinal data streams (see Table 5 and Table 6).

This research work requires diverse methods of analysis. The mixed-method approach is deployed to analyse the quantitative and qualitative data. In the initial research phase, the quantitative data is examined for linkages and patterns. These findings enable and support the

[14] Pink sheet accessible via www.worldbank.org/en/research/commodity-markets

collection of primary data through the questionnaire (research phase 2) and later by the interviews with experts. To differentiate these two data streams, the terms “QUAN” and “QUAL” are used if one of these is prevailing. The spelling with small letters (“quan” and “qual”) is used to separate and to value the difference between the data. The multi-method choice approach is adopted from its original design (Kuckartz, 2017, pp. 165–168).

During research phase 3, qualitative data was collected and analysed. The previous findings of the statistics and the answers to the questionnaires (triangulation) are challenged. The examples in Table 4 demonstrate the close verification of the findings. In this mixed-methods research, the verification of new knowledge is combined from three research phases. The first example in the table is the verification of the statistical results by the statements made in the interviews. In the interviews, the conclusions of the calculations and the statements of the questionnaire were discussed. This was done, first, to inform the interviewees of the results and, second, to mirror these assumptions against the experience and expertise of the steel mills. Another example is the substitution of goods and switching suppliers (Pellegrino et al., 2019), which are seen in the literature to minimise risks from price fluctuations. This was discussed intensively with *Acerinox, Ak Steel*, and *Aperam*, for example.

Table 4 Triangulation and examples

Finding 1	Finding 2	Triangulation	Example
Statistic- results and conclusions	Expert interviews	Secondary data challenged by primary data	Nickel and share prices
Mitigation strategies in literature	Expert interviews	Challenge Literature and reality	Customer selection, substitution
Questionnaire main threats, contract types	Existing literature	Verify literature and stainless steel industry	Long-term & spot buy contracts
Questionnaire main threats, contract types	Expert interviews	Verify stainless steel industry and mills perspective	Long-term & spot buy contracts

The research design in Figure 16 follows the numbered arrows. The RQ initiates the quantitative research (1). The quantitative data of the secondary sources is analysed. These findings (2) initiate further quantitative research (3) or set the base for the questionnaire and the interviews (4). These are primarily collecting qualitative, primary data. However, the quantitative data must be revisited for clarification and/or further analysis. It is a sequential-explanatory design, with the slight amendment that the findings of the quantitative findings might trigger additional quantitative data research before moving toward the qualitative research. The results complement each other in the conclusion section.

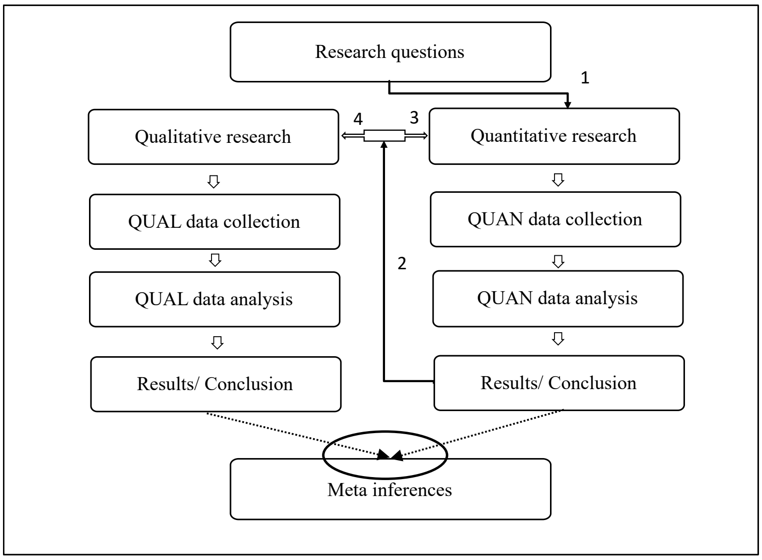

Figure 16 Parallel design mixed-methods, Referenced from Kuckartz 2017

4.3.1 Research Phase 1: Secondary data analysis

4.3.1.1 Data collection

The quantitative desk research deploys a single data collection process. The data collection process is repeatable and generates the same results. As the research progressed, data was updated to secure actuality while retrieved from identical sources. Introducing the US safeguard measures made it possible to research the impacts in a recent setting. Hence, the data series remained updated during the research period (see Figure 17). The COVID-19 impacts are not included as the pandemic is still ongoing.

Data series are financial figures, share prices and raw material prices. The sources are stated below.

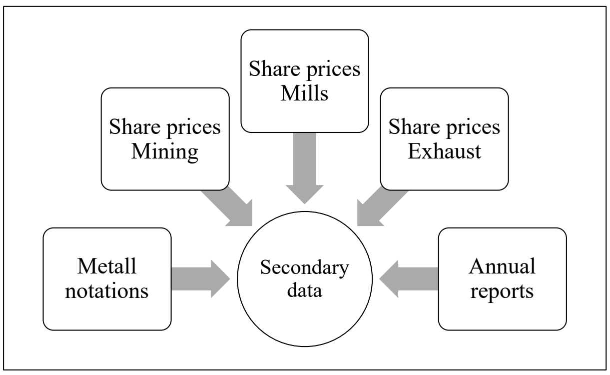

Figure 17 Secondary data sources , Source: own data

The sources and the share identification abbreviation are listed in Table 5. The metal prices and the metal contents are listed (Annex 4a-b-c) to ensure reliability and reproducibility for the validation of this research.

- Global Economic Monitor Commodities (Pink Sheet)
- Financial data as share prices, by Yahoo Finance and Arriva
- Annual reports of the miners, stainless steel and exhaust producers
- The Hamburger Weltwirtschaftsinstitut (HWWI)
- International Chromium Development Association (ICDA)
- SMR, a metal market marketing company, courtesy
- Focus Rostfrei – Stainless Steel magazine

The criteria for the selection of the secondary sources have been the availability and the trustworthiness of the independent organisation. The publications of the World Bank (i.e., Pink Sheet), of the European Central Bank (ECB), the HWWI Institute do all comply with the selection criteria (reliability, validity, reproducibility). Noteworthy, the data derived from the HWWI Institute in Hamburg and the International Chromium Development Association (ICDA) in Paris revealed the data on request of the author for this research. The data is not freely accessible. For a general audience, the data is not available. The data collected by SMR is restricted to the subscribers or to an ordering party. The data originated from secondary sources is quantitative data. These are ratio scaled variables. These contain the features of nominal, ordinal, and interval data. The ratio level, therefore, contains categories, a rank order, equal spacing, and a true zero. Hence, it is considered the highest level of the four hierarchical levels of measurement.

This thesis uses the closing data rather than future prices. The periods spanning from 1960 to the end of 2019. Metal prices are typically stated in US Dollar, the major trading currency for these metals. The data set contains 18 different price series. Table 5 displays the various categories.

This thesis refers to the following categories:

- Ferrous metals (Iron ore, Ferrochrome)
- Non-ferrous metals (Nickel, Copper, Aluminium)
- Precious metals (Gold, Silver etc.)
- Oil & Gas (Brent Oil and Natural Gas)

This is in line with the literature (Ågren, 2006; Mensi et al., 2013; Pindyck, 2001, 2004; Rossen, 2015; Sari et al., 2010) although the above mentioned categorisation is not a fixed categorisation as other interpretations exist in literature.

For this thesis, share prices are stated in local currency and not converted to the US Dollar or the Euro because the effect of the exchange rate is not researched. If not stated otherwise, the data is computed as monthly average data. The data format (USD /KG or ton) is taken from

the publications of the World Bank. The share prices are averaged to monthly averaged prices to fit the prices of the Pink Sheet data of the World Bank.
VIX data, the Index of expected future volatility (Cboe, 2018c) is obtained from the Chicago Board Options Exchange (Cboe®). The ticker symbol is "VIX".

4.3.1.2 Data analysis

The development over time, including differences and changes in the relationships of the data, as referenced in Table 5, has been investigated. First, the metal and the share prices of the companies are examined descriptively. Annex 4a-b-c, summarises the data in Excel tables. Based on this data, further statistics are calculated to identify potential relationships by correlation analysis. Stepwise multiple regression is used to analyse the strength of the relationship. A GARCH model and an ARDL calculation investigated the time-varying aspects and modelled the volatility. The commodity and share prices are ratio scaled data.

Table 5 Methodology metal listings, Source: own table

Notation	Source	Comment
Nickel	World Bank Commodity Markets Monthly prices	Nickel (LME), cathodes, minimum 99.8% purity, settlement price beginning in 2005; previously cash price
Iron ore		Iron ore (any origin) fines, spot price, CFR. China, 62% Fe beginning in December 2008; previously 63.5%
Aluminium		Aluminium (LME) London Metal Exchange, unalloyed primary ingots, high grade, minimum 99.7% purity, settlement price beginning 2005; previously cash price
Copper		Copper (LME), grade A, minimum 99.9935% purity, cathodes and wire bar shapes, settlement price
Ferrochrome		Ferrochrome. Delivered Consumers' Works, USD, 6-8% C. basis 60% Cr. Max. 1.5% Si
Stainless Scrap USA	American MetalMarket	Detroit 304 solids, clips, broker buying $/gross ton
Stainless Scrap Europe	Focus Rostfrei Germany	Germany for sheet metal waste, 17% Cr, 9% Ni – typical for 1.4301
Chromium	International Chromium Development Association	China CIF basis in USD/dry metric tonne unit, South-Africa, concentrate 44%

Table 6 Methodology share price listings, Source: Yahoo Finance

Notation	Source	Symbol
Mining companies		
BHP Billiton plc	Yahoo Finance	(BLT.L)
Nor Nickel Mining and Metallurgical		(NILSY)
Vale S.A.		(VALE)
Glencore Plc		(GLEN.L)
Stainless steel producer		
Outokumpu Oyj	Yahoo Finance	(OUT1V.HE)
Aperam S.A.		(APAM.AS)
Acerinox, S.A.		(ACX.MC)
AK Steel Holding Corporation		(AKS)
POSCO		(PKX)
Jindal Stainless Limited		(JSL.BO)
JFE Holdings, Inc.		(5411.T)
Nippon Steel & Sumitomo Metal Corp.		(NSSMY)
Exhaust gas treatment system producer		
Tenneco Inc.	Yahoo Finance	(TEN)
Faurecia S.A.		(EO.PA)
Futaba Corporation		(6986.T)
Sejong Industrial Co., Ltd.		(033530.KS)

4.3.1.3 Descriptive statistics

Descriptive statistics describe or summarise a set of data, typically by the simple key variables as frequencies, dispersions, mean, standard deviation, among others (Gray, 2004, p. 297).

The CV, see equation (2), is calculated besides the descriptive data (e.g., SD and mean). It is reviewed before the correlation and regression analysis to gain an initial understanding of the severity of the volatility. The CV compares dispersion or variation of different data populations (W. Hendricks & Robey, 1936, pp. 129–132; Salkind, 2006, pp. 774–776). In this thesis, the CV is part of the descriptive statistics. It is a relative value; hence, the comparison of different data series is feasible. The United Nations Conference on Trade and Development (UNCTAD) applies the CV calculation to reveal the diverse levels of change (Kituyi, 2019). The CV indicates with a sole figure the grade of volatility between different data series.

Coefficient of variation *(2)*

$$CV = \frac{\sigma}{\mu}$$

Where:
σ = standard deviation (SD)
μ = mean

However, the CV is sometimes criticised because the information it conveys is limited to overall volatility and there is an assumption that the data follows a normal distribution. It is a statistical method to measure volatility from a pragmatic perspective. The CV makes the mathematical and statistical use of figures easy, as the squaring of the results eliminates negative values. It is hence, a good measure of dispersion (Chikkodi & Satyaprasad, 2009, p. 1097b). It answers RQ 1.1b.

A coefficient of variation of > 0.81 shows a very strong homogeneity (Kvålseth, 2017; Landis & Koch, 1977). Even though this view originates from medical research, it is an existing and applied scale.

Table 7 Interpretation of the CV, Referenced from Kvålseth, and Landis & Koch

V value	Landis and Koch	Kvålseth
	Strength of Agreement	Description
<0.00	Poor	not mentioned
0.00-0.20	Slight	Very small
0.21 0.40	Fair	Small
0.41-0.60	Moderate	Moderate
0.61-0.80	Substantial	Large
0.81-1.00	Almost perfect	Very large

The desk research focuses on potential communalities between selected commodity materials, scrap values, and share prices of the mills. The analysis targets the relationship and the potential patterns of the data series.

If one variable changes in value, the other variable tends to change in a specific direction. The strength of the relationship (strength and direction) is assessed through correlation analysis (e.g., Pearson's correlation), as detailed in Table 17, p. 135). If the data series confirmed a strong correlation a multiple linear regression was computed to assess if the relationship is significant by testing the *F*- and *t*-values. Multicollinearity is considered, as common data series might influence each other. This is examined, similar external factors or events might disturb the examined data series. Hence, co-movements and spill-over effects should be also considered. The data series and the relationship between the variables might be biased as these belong to the same commodity groups and in case of the stainless steel mills to the same industry. This might cause multicollinearity. Multicollinearity in regression analysis occurs when two or more predictor variables are highly correlated to each other (Zach, 2019). High correlation implies multicollinearity, but the converse is not true. One can have multicollinearity among explanatory variables, but still not have high correlation between pairs of these variables (Alin, 2010). The variance inflation factor (VIF) is deployed to detect and measure collinearity in a multiple regression model. For this research multicollinearity is inevitable among the data series. As these are largely dependent from the same or similar industries and exogenous events (e.g., demand (shocks or disruptions) or macroeconomic developments). There is no escape from multicollinearity as no other independent variables are available. The raw materials in this research are present in all examined stainless steel grades. Therefore multicollinearity cannot be avoided. However, multicollinearity is not a violation of assumptions, nonetheless it goes with a decrease of precision of the prediction (Freund et al., 2006, p. 221). Therefore, multicollinearity is an immanent bias. However, it is not a threat to GARCH and ARDDL models. The findings of multiple regression analysis are triangulated, hence suggesting similar findings. For the calculation of the relationship between Nickel and the annual profit a VIF value is calculated, because this sample size is considerably small, see section 5.1.8.

To predict a future value, the dependent variable (*Y*) based on the independent values (*X*) is calculated in a multiple regression analysis. The prediction of the share price development supports the selection of mitigation scenarios. This connection is as trivial as it is important. The knowledge of the expected price movement – under statistical probability – allows the company to initiate appropriate mitigation strategies. With expected price increases, purchasing volumes can be brought forward (for purchasing plants). Producers who sell can delay the delivery and invoicing of goods until it generates windfall profits.

The software “IBM SPSS Statistics”, version 25, 26, and 27, has been deployed. The calculations for the GARCH and the ARDL have been programmed and performed in “R”. “R” is a language and environment for statistical computing and graphics. The R -Foundation is a non-profit organisation working in the public interest based in Vienna/Austria (R Foundation, 2020).

The statistic section describes the data series and examines on relationship and price movement patterns. In this thesis, explicitly between raw material prices and the share prices of the companies in the stainless steel value chain. An examination of the data series for similar fluctuations and patterns was performed. Statistical methods, detailed in the following

sections, examine these relationships between the price data series. The influence of a variable on another variable (dependent/independent) is examined. The prediction of price variability enables the selection of a suitable price mitigation strategy.
The potential link between the raw material prices and the share price of the mills and/or the exhaust gas treatment system business is also investigated. The results answer the RQ´s 1.1 to 1.3. The data is analysed to verify if potential coherence and linkages exist.
The statistical methods to examine the relationships of the numerical, continuous data are:

- Trends, median, standard deviations, averages, ranges
- Coefficient of variation/ Relative standard deviation
- Correlation coefficients
- Regression coefficients
- Generalised Autoregressive Conditional Heteroscedasticity (GARCH) model
- Autoregressive distributed lags (ARDL) testing method

4.3.1.4 Hypotheses testing

This thesis assumes that raw material price volatility impacts the share prices of the companies. This assumption might impact the companies at diverse value creation levels to a different extent. Nickel, as a prominent raw material in the production of stainless steel, constitutes one of the cost drivers of the finished product. The impact of the volatile raw material prices is linked to the share prices. The share price comprises the recent economic situation and the future development of the industry, despite other influences. Therefore, higher input costs might impact the outlook, which is condensed as share price. Volatile costs impact the financial performance of the companies (e.g., inventory costs, working capital, cash flow, hence the share prices comprise these developments as the best available financial indicator value. However, the price development of raw materials might impact the Nickel price. This might be considered as a spill-over or a co-movement of the price developments. Hence, these links are investigated.

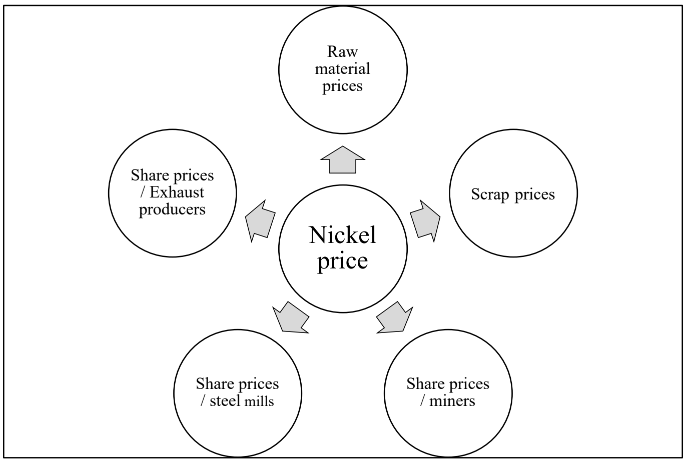

Figure 18 Nickel Hypotheses, Source: own data

It is a directional hypothesis. The impact of Nickel prices is investigated (Gray, 2004, p. 70). The tested hypotheses falsify or verify the influence of Nickel prices on raw material and share prices of the companies in the value stream of stainless steel. The null hypothesis testing is based on the following methodology.

The alternative hypothesis: H_1: $\rho > 0$,

e.g., states the assumption if Nickel prices increase, the other value changes dependently.

The null hypothesis: H_0: $\rho \leq 0$

Therefore, rejecting the null hypothesis falsifies that the independent variable changes independent from Nickel price movements, detailed in section 5.1.5. A correlation coefficient measures the strength of the linear relationship between numerical variables. The coefficient is stated as (τ). This value ranges between -1 and +1. Both values would assume a perfect negative/positive correlation (Saunders et al., 2015, p. 545). A detailed scale is given in (Table 17, p. 135) The normal distribution of the values is tested. This is important, as when this assumption is violated, the Spearman rho (τ_S) is deployed to verify the strength of the relation between the variables. However, Kendall's tau (τ) is referred to as more accurate than Spearman rho, however, it is a better fit for small sample sizes (Field, 2007, p. 182). For the consistent approach, the Spearman rho is deployed in this thesis.

The coefficient of determination to measure the strength of the relation is represented by R^2. A regression analysis is deployed to do so. As it deployed over one independent variable, it is a multiple regression analysis.

The multiple regression is given by: *(3)*

Multiple Regression analysis

$$y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots + \beta_p x_{ip} + \varepsilon$$

Where:
for $i=n$ observations:
yi= dependent variable
xi= explanatory variables
β_0= y-intercept (constant term)
β_p = slope coefficients for each explanatory variable
ε= the model's error term

Regression analysis is deployed to predict the values of the dependent variable. These calculations, as well as the coefficient correlation analysis, are computed with IBM SPSS. This software was deployed as it is fairly easy to use and is available from the University of Salford. Furthermore, relevant articles pointed to this software as a common statistical software in business research.

4.3.1.5 VIX volatility index

It was the Chicago Board Options Exchange to introduce the Volatility Index (VIX) in 1993. The index measures the market's expectation of future volatility. It is an initial suggestion about the interpretation of volatility levels, rather than the calculation of a value with a subjective meaning.
Stock indices deploy stock prices, whereas the components of the VIX are options. The VIX is based on option contracts for the S&P 500 (SPX) to calculate the expected volatility for the next 30 days. The index displays a strong temporal relationship between stock returns and volatility. According to Whaley (2009), the inventor of the VIX in 1993, the suggested relationship is inverse to the stock market prices. However, negative stock market moves display a stronger impact than positive ones.
The VIX demonstrates a strong relationship with future realised stock volatility and is, hence, deployed to predict volatility (Fleming et al., 1995). Thus, this indicator works like a market risk "thermometer" that includes the market sentiment and financial risks. Recent research proved its relevance as a market risk indicator when comparing geopolitical risks to the VIX. A similar linkage exists for Oil prices and credit risk spreads (Obi et al., 2018).
The stock markets display fluctuations of different values of share prices, commodities, currencies, etc. The literature review revealed that the VIX is a method and a measurement tool

of volatility. It is a value without a gauge. Thus, the measured values are ranked as in section 5.1.2 for the CV. The generalised formula of the VIX (Cboe, 2018c, 2018a; May, 2018) is:

The VIX calculation is given by: *(4)*

VIX Calculation

$$\sigma^2 = \frac{2}{T}\sum_i \frac{\Delta K_i}{K_i^2} e^{RT} Q(K_i) - \frac{1}{T}\left[\frac{F}{K_0} - 1\right]^2$$

, where:

σ	VIX100
T	Time to expiration
F	Forward index level derived from index option prices
K_0	First strike below the forward index level, F
K_i	Strike price of i^{th} out-of-the-money option; a call if $K_i > K_0$ and a put if $K_i < K_0$; both put and call if $K_i = K_0$
ΔK_i	Interval between strike prices – half the difference between the strike on either side of K_i: $\Delta K_i = \frac{K_{i+1} - K_{i-1}}{2}$

(Note: for ΔK for the lowest strike is the difference between the lowest strike and the next higher strike. Likewise, ΔK for the highest strike is the difference between the highest strike and the next lower strike.)

R	Risk-free interest rates to expiration
Q (K_i)	The average of the bid quote and ask quote for each option with strike K_i.

In literature, it is the "fear-gauge" or the "fear-index". The VIX is an indicator that helps to determine the market expectation. The highest VIX readings occur when substantial moves in either direction are expected. Over 25 years of experience supported the classification and the respective suggested interpretation.

The informative value of the index seems simple: the higher the VIX value, the higher the expected volatility, hence risk. The maximum value of 80.9 was noted on November 20th in 2008 (brief after the Lehman bankruptcy), the minimum value of 9.1 on November 3rd, 2017. An interpretation of the statement is not defined; therefore, it is subjective. High VIX values reflect the anxiety of investors regarding a dropping stock market (Whaley, 2009). Hence, the VIX denotes the price of insurance, investors are willing to pay to hedge their risks (Magma Capital, 2020).

Without classification (gauge), it is left to the discreet judgement of the observer to arrange further initiatives. A reliable and repeatable interpretation of the index is the basis of a deductive approach. However, the findings are biased because of the individual risk appetite. An interpretative approach is a priori subjective, as it depicts individual experiences.

The VIX provides meaning if it is analysed in a gauged system. These levels enable a repeatable and conscious interpretation of the value. It might rationalise trading behaviour and it may pre categories strategies to lessen negative impacts, like commodity price volatility. The meaning of the existing index value should guide the judgement. These levels are in line with the prior findings of Edwards and Preston (2017) and Tagliaferro, O´Neill (2017). Both have the practitioner's perspective in mind. These are listed in Table 8. However, the existing categorisation of the severity levels must be transferred to the raw material sector.

Table 8 Interpretation of VIX value, Referenced from Edwards and Tagliaferro

VIX Volatility levels	Edwards & Preston	Tagliaferro & O´Neill	Expected range of volatility in the S&P 500 over the next 30 days
Low	<12	> 10	+/-2%
Normal	>12 <20	> 16	+/-3%
High	>20	> 30	+/-6%
Crisis	n. a.	> 60	+/-12%

The four levels cluster the VIX (volatility), the value becomes a meaning. The direction of the fluctuation is indifferent towards the severity.

Volatility becomes interpretable with a set gauge. Without it, it remains an unattached value with limited (subjective) meaning. The classification provides a reference point for the mitigation strategy.
For the comparison of the volatility severity of the different data series, the CV is an important statistical tool. It allows to group the volatility across different data series.
This research contributes to knowledge with a scale to group the CPV in the stainless steel brace, founded on the CV, see section 6.1.1.5.

4.3.1.6 GARCH model

The ARCH model is the predominant model for price volatility, proposed by Nobel Prize winner Engle (1984; Engle & Watson, 1983). The 2003 Nobel Prize in Economic Sciences is shared with Clive Granger, for the ARCH model, the method of analysing economic time series with time-varying volatility.

The ARCH (q) model is given by: *(5)*

ARCH (q) model

$$a_t = \sigma_t e_t$$

Where:

$$\sigma_t = \sqrt{\omega + \sum_{i=1}^{p} \alpha_i \, a_{t-i}^2}$$

where:

α_t = Conditional *standard deviation*
σ_t = Conditional variance
e_t = *Error term* (*Gaussian white noise*)
ω =, average long-run variance (> 0)
$\alpha_{t-1}, \alpha_{t-2}, \ldots$ = previous variances
p= squared returns (p≥0)

The enhancement is the GARCH, where the variance, the standard derivation (SD) is modelled and not constant, like in the ARCH model.

The GARCH framework is widely used to study and describe volatility in financial series. It is a statistical model deployed for the analysis of time-series data, where the variance error is believed to be serially auto-correlated. The assumption is that the error terms are conditionally normally distributed and that their variance follows an autoregressive moving average process (Chappelow, 2019). The GARCH framework allows predicting a future economic value. GARCH(1,1) models are often used, when the number of unknown parameters is small.

In this thesis raw material and share prices are examined. The GARCH model is derived from the ARCH model. Bollerslev (1986) made further developments on ARCH model. He introduced the GARCH model, which extends the ARCH model, with an additional auto-regression structure within itself. An autoregressive moving average (ARMA) for the error variance was added (Bollerslev, 1986). While the ARCH model has the log-returns modelled as a white noise multiplied by the volatility, it follows an autoregressive (AR) model.

The lags are specified as GARCH (p,q), where (p) indicates the number of autoregressive lags (previous returns) and where (q) relates to the number of variances (volatility). The GARCH calculation adds the long-term mean-variance as an added parameter to this model. It allows trailing the persistence of variance around the mean. It tracks the variance of the mean for the entire time. This model places a superior emphasis on the most current values. Despite its long-term memory, it fits the clustered appearance of price volatility. Note that the standard GARCH approach is not suitable for capturing heavy tails, large kurtosis, and skewness. Kurtosis (K) and skewness (S) allow a check if a normal distribution of the values is present. Field (2007, p. 139) indicates that values above 3.29 are significant (at ρ <.05). However, there is not a universal guide with a precise categorisation of the terms. Hence, a brief characterisation is given in Table 9.

Table 9 Characteristics of kurtosis and skewness, Referenced from Field (2007)

Data characteristic	Indication of the distribution of values
Positive kurtosis	Pointy heavy tailed
Negative kurtosis	Flat and light tailed
Positive skewness	Many low values
Negative skewness	Build-up of high values

Despite the limitations, the GARCH model it is well established to capture volatility. Particularly to understand spill-over effects (raw materialwise) and the relationship from raw materials to the stock market (Batten et al., 2010; Hammoudeh et al., 2010; Jain & Biswal, 2016; Mensi et al., 2013; Sadorsky, 2012). The GARCH models, assume that negative and positive values have the same effect on volatility (R. Cox, 2014). However, volatility tends to increase in response to “bad news” and often decreases in response to “good news” (Onan et al., 2014). Another drawback is the concept of persistence of changes to the conditional variance. The topic is the duration of the changes in the conditional variance. In GARCH(1,1) models, shocks may contradict the conditional moments, due to the stationarity, when strictly applied (Cordoba, 2003). Which is in line with the findings about the VIX and the stronger impact of negative news.

The data series are assessed for stationarity. The test is performed to exclude the time-varying element of the data series, like seasonality. The non-stationary data is transferred to stationary data (variables like mean, range minimum, maximum remain constant). An Augmented Dickey-Fuller (ADF) test is performed (Dickey & Fuller, 1981). It includes the assumption of homoscedastic time series.

The price dynamics and movements or patterns are merely understood. Forecasting, even on the short-term horizon, remains an essential challenge. Hence, understanding price volatility is an actual interest that is not only limited to the financial (derivatives) markets. It is also relevant to policymakers and their interest in market stability, liquidity, and the availability of physical goods. The literature is extensive on price predictability and forecasting of future price scenarios, as it attracts the attention of researchers, consumers, producers, traders and governments (Asai et al., 2012; Hwang & Satchell, 2007; F. Ma et al., 2018).

GARCH models are often used to model financial time series that show time-varying volatility and volatility clustering, such as phases with peaks scattered with phases of relative calm. The process for a GARCH model involves three steps.

- Estimate the best fitting autoregressive (AR) model
- Calculate autocorrelations of the error term
- Test for significance

The GARCH (*p,q*) process can be also interpreted as a moving average (autoregressive) process (Bollerslev, 1986). The general process for a GARCH model comprises the three mentioned steps. First, estimating the best-fitting autoregressive model. Second, computing the autocorrelations of the error term. This is performed with the Ljung-Box test (Bollerslev et al., 2009). The Ljung-Box test, named after statisticians Ljung and Box, is a statistical test that verifies whether autocorrelation exists in a time series (Ljung & Box, 1978).

Third, testing for significance. It is recommended to consider up to $\tau/4$ (τ= number of equations in the model that fit the residuals versus the lags values of η (degrees of freedom). The null hypothesis states that there are no ARCH or GARCH errors. Rejecting the null hypothesis thus means that such errors exist in the conditional variance.

In times of increased volatility, prediction intervals are broader to model an increased amount of uncertainty. Similarly, the prediction intervals will contract at periods of lesser fluctuations (Ruppert, 2011, pp. 490–504). The key aspects of the GARCH (*p,q*) model (Harper, 2011) are:

- Autoregressive (AR): the future variance (or volatility) is a regressed function of the actual volatility; it regresses on itself
- Conditional (C): future volatility (variance) is depending (conditional) on the most recent volatility. Unconditional volatility does not depend on actual volatility.
- Heteroscedastic (H): volatility is not constant, it varies over time

The GARCH model regresses on historical or lagged terms that are squared returns or variances. The generic GARCH(*p, q*) model regresses on (*p*) squared previous returns and (*q*) variances (volatility).

The GARCH (p,q) model is given by: *(6)*

GARCH (p,q) model

$$a_t = \sigma_t e_t$$

Where:

$$\sigma_t = \sqrt{\omega + \sum_{i=1}^{p} \alpha_i a_{t-i}^2 + \sum_{i=1}^{q} \beta_i \sigma_{t-i}^2}$$

where:

α_t = Conditional *standard deviation*
σ_t = Conditional variance
e_t = *Error term* (*Gaussian white noise*)
ω =, average long-run variance (> 0)
$\alpha_{t-1}, \alpha_{t-2}, \ldots$ = previous variances

$\alpha_0 > 0$;
$\alpha_1 \geq 0$
i=1,…,q,
$\beta_j \geq 0$; i=1, ,p
p= squared returns (p≥0)
q= variances (q >0)

For *p*=0, the model turns to an ARCH (*q*) process and for *p*=*q*=0, e_t is simply a white noise signal with *N*~(0,1).

The volatility of the researched data series is modelled. The change of the moving average indicates the severity of price volatility, see section 5.1.6.
The GARCH model was favoured against the exponential moving average (EWMA). The investment bank *J.P. Morgan* introduced the EWMA model in 1994 in their Risk Metrics offering to their customers (J.P. Morgan, 1996, pp. 78–90). It is a historical smoothing process and gives more weight to the recent values. Hence, it might be an advantage or disadvantage if the historical data should play a more prominent role, less recent values play a less important role. The weight of the older values cascades exponentially, which is not desired in this research. The equation (7) is given.

The EWMA model is given by: *(7)*

EWMA model

$$\sigma^2 = (1-\lambda)\sum_{t=1}^{T} \lambda^{t-1} (r_t - \bar{r})^2$$

Where:

where:

σ = *standard deviation*
λ= *decay factor*
r = value of the series in the current period

λ (0 < λ <1)
T = returns

4.3.1.7 ARDL model

The autoregressive-distributed lag (ARDL) approach verifies and supplements the results of regression, correlation calculations, and the GARCH framework. It is a linear model with a

disturbance. The efficient estimators are the least-squares and a lagged dependent variable (Greene, 2008, pp. 682–683).
The ARDL model resolves an important topic in research; often, time series have been assumed to be stationary, which is not necessarily true. Hence, dynamic features of most time series have been ignored. Traditional regression models assume a deterministic trend and expose a long run relationship. Hence, it was assumed that means and variances of the variables were constant and not depending on time (Nkoro & Uko, 2016).
These values may differ from the results of the dynamic models. This arises when the regressors are serially correlated, incorrectly ignoring coefficient heterogeneity (Pesaran & Smith, 1995) to verify the impact of the commodity materials. Pesaran and Shin (1996) introduced the ARDL model for estimating the long-run relationships in the dynamic data series. Later, it developed for "testing the existence of a level relationship between a dependent variable and a set of regressors. Only if it is not known with certainty whether the underlying regressors are a trend or first-difference stationary" (Pesaran et al., 2001). The latter approach might attract research to assess the relationship between the commodities themselves.
The ARDL model is relevant when economic scenarios are analysed. Changes in any economic variables may bring a change in another economic variable beyond time. This change in a variable is not what reflects at once, but it distributes over future periods. Not only macro-economic variables, but other variables such as loss or profit earned that can also affect the brand image of an organisation over the period (Chetty, 2018). The mentioned regression models assume that the relationship between the variables is constant. For time-series data, this assumption might be misleading. It is possible that, like in this thesis, the share price depends on the raw material price of a previous period (Gujarati & Porter, 2010, p. 371).
This approach is challenged by the time-varying testing method ARDL. The autoregressive (AR) model specifies that the output value depends on its prior value in conjunction with a stochastic term. See details about the ARMA model in the result section 5.1.6.2.
However, an increasing interest in dynamic data models is recognised, often to examine the time delaying the impact of root causes and effects. The relevance of this work lies in the study of the long-run impact of commodity price changes on the share price of the stainless steel industry. The assessment of the time lag is key to the mitigation strategies. The elapsed time between root cause and effect or change of the share price. Therefore, the data series allows to perform an ARDL testing, see Figure 19.

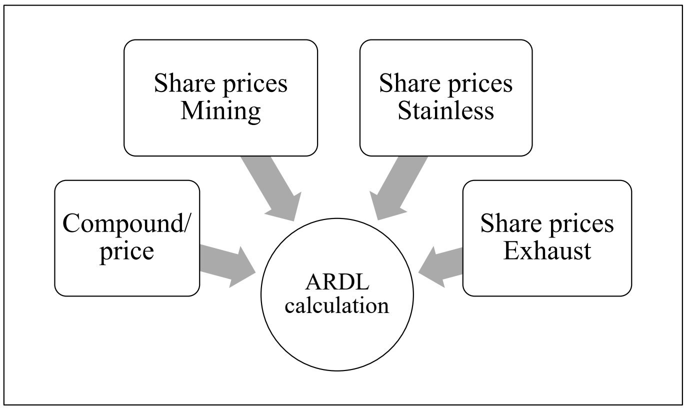

Figure 19 ARDL statistics data sources, Source: own data

To the best of the author's knowledge, no prior research has used the ARDL to approach the stainless steel industry. Built on the findings of the previous statistical calculations (i.e., correlation and the linear multiple regression analysis), the result is a one-dimensional or aggregated strength, describing the relationship. The question that remains unanswered by this calculation is the existence of a time-varying effect. The price volatility (metals and alloys) has a potential consequence of the share prices and is delayed by the respective production and/or lead time of the material. The ARDL model is hence useful to foretell these developments and to untie long-run relationships from short-run dynamics (Kripfganz & Schneider, 2018).

The ARDL calculations may forecast:

- the price of the commodity materials
- the share prices of the respective companies in the value chain of stainless steel

The model starts with a general and large model and progressively reduces its mass and alters variable with non-linear and linear restrictions. It is often deployed in the economic literature (Ghouse et al., 2018). This thesis applies ARDL and GARCH models into the stainless steel value chain by exploring the impacts of the CPV. The potential time-delayed consequences of the metal prices on the share price changes of the enterprises in the value chain are the foundation for this research. All the data is aggregated per month. This statistical method is selected to name the potential time-delayed impact between the commodity and the share price. The potential short-run and long-run relationships between these data sets are assessed. The degree to which these series are related is the principal approach, interpreted in terms of time lags. The software to compute the calculations is “R”, like for the GARCH calculation. IBM SPSS does not support these statistics.

The detailed calculation of the ARDL model is described in Annex 5. The calculation deploys four different variables. The metal prices are merged. The weighted consumption of the main stainless steel grades has been calculated in Annex 1 and is referred to as "Compound". The industry segments have been concentrated at the respective level in the value chain. The groups of miners, the stainless steel and the exhaust manufacturers have minimised the number of variables. Hence, it ensures that impacts are captured within the different levels. However, every aggregation might dilute or bias results and findings.

One basic assumption to work with time-series data is the notion of stationarity, which means time series data must not be explosive, nor trending, nor wandering. The mean, variance, and other statistical properties stay constant. A test for differencing suggests one grade of difference. A unit root test is performed to determine the number of differences required for the time series to be made stationary.

The independent variable (X) is the Compound aggregation of the metal prices according to the typical chemical analysis of the exhaust blend. The exact composition of the Compound is detailed in Annex 1. The dependent variables (Y) are the share prices of the different companies in the value creation process.

The dynamic model with lagged values of both the dependent and independent variables of the following form. The function, see equation (8), describes the lag effect of a variable on other variables:

The ARDL is given by: *(8)*

ARDL Calculation

$$y_{it} = \gamma_i + \sum_{j=1}^{p} \lambda_{ij}\, y_{i,t-j} + \sum_{j=0}^{q} \delta`_{ij}\, x_{i,t-j} + \mu_i + \varepsilon_{it}$$

where:

Y_{it}: is a vector
$X`_{t:Variables}$ be purely I(=) or I(1) or cointegrated
λ and δ : $coefficients$
γ: $constant$
i = 1

p $lags$: $dependent\ variable$
q $lags$: $exogenous, independent\ variable$
e_{it}: $error\ terms$
x: independent variable
t-i: the number of lags

The primary function to estimate the model for this thesis is the Dynamic Linear Models (dynlm) function. For the dynlm package within this thesis:

- *d ()* specifies the difference in a variable
- *L ()* is used to compute the desired lag of the variable (lag length *q*)

For example, by setting *L (q*, 0:3) we are specifying the coefficients for variable *q* of the current period and the past three periods. Setting *d (u, 1*) means we wish to calculate the difference in *u* from the previous time step. This function calculates the lag effect of a variable on other variables and its lags. This function can determine the dynamic influence of one variable on another one (Chetty, 2018).

Serial correlation or autocorrelation might be presented in a regression model when the order of the observations of the data series is relevant. Autocorrelation in the error term can arise from an auto-correlated omitted variable, or if a dependent variable Y is auto-correlated. If this autocorrelation is not adequately explained by the X's and their lags that are included in the equation. However, the ARDL gauges the distributed lag problem more proficiently than the dynamic lag models.

The ARDL model is deployed for decades to model the relationship between (economic) variables in a single-equation time-series setup. Hence, a proven model for the examination of time-varying effects and complements, verifies or falsifies the correlation and regression calculations (Kripfganz & Schneider, 2018).

4.3.2 Research Phase 2: Primary data -Questionnaire

The questionnaire (Figure 20) advanced from the findings of the quantitative desk research. It is characterised as a self-completed questionnaire. It was web-based for an easy access and an instant data collection of the answers. The questionnaire is one of the most common techniques for gathering primary data. It allows for anonymity, a time independent completion, and represents a low cost and typically easy-to-use tool, when constructed carefully (Gray, 2004, p. 188). The drawback is that response rates can be low in total or decrease during the completion of the questionnaire. Hence, the design of the questionnaire is crucial for good results. Therefore, the market research team GIM in Heidelberg supported these efforts. GIM in Heidelberg is one of the most important providers of market and marketing research services in Germany with a worldwide presence. The leading market research institute in Germany, especially in the areas of "quality", "methodological competence" and "consulting competence". The experience and the expertise have been valuable for this research. Hence, the questionnaire eliminated potential drawbacks (e.g., language, imprecision, double or assumptive questions, etc.). The understanding of the opinions and the behaviour of the participants regarding commodity price volatility and the potential existence of mitigation strategies is explored as the primary aim. The classification of commodity price volatility as a threat or an opportunity is also examined. Thus, it is important to understand if there are differences in the perception of risk concerning the business location, business size, and the position in the value chain. The potential differences in the selection of mitigation strategies in the value chain of stainless steel are examined. The investigation and the exploration of the causes are examined in section 4.3.3.

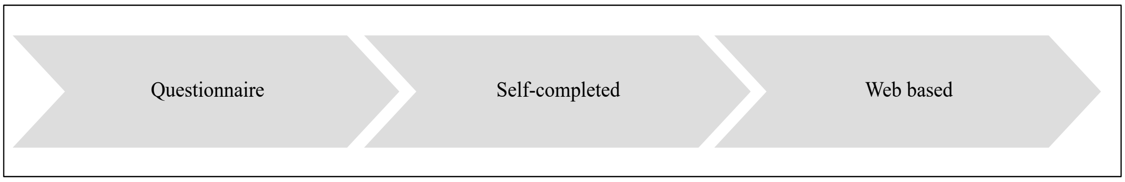

Figure 20 Type of questionnaire, Source: own data

The team of the *"Gesellschaft für Innovative Marktforschung" (GIM)* in Heidelberg supported the creation of the questionnaires. The questionnaire comprises 18 questions.

The questionnaire has:

- open and closed
- multiple choice
- list
- category
- quantity questions

Multiple-choice questions are used, sometimes with the possibility of adding comments. Questions 17 & 18 are open questions– to collect the thoughts of the participants and potential shortcomings in the closed question section. The responses are standardised for the quantitative questions (1-16), for the ease-of-use, and to ensure an acceptable participation level throughout the completion.

The questions were evaluated and retested to ensure correct output and that what is being measured is what should be measured. The ultimate design of the questionnaire in its current existence results from several discussion rounds.
Co-students and probands from the industry verified the design of the questionnaire. The first draft of the questionnaire focused on the questions and the data collection of the answers. The design and applicability were of lesser importance. All questions had to be answered in the first version, which was a rigid format. This rigid design caused criticism of the pre-testers. Some volunteers dropped out as the design had been too rigid. It did not permit to answer partially or skip questions. Not all questions could be answered by all volunteers. Hence, the design was amended and, therefore; it was accepted that not all answers were compulsory. Henceforth, the adoption of the design increased the ease of use and comfort for the participants. In return, the completion rate remained at a robust level. Also, some brief comments have been added after assessing the second test run to further describe the question. "UmfrageOnline.com" hosted the questionnaire.

Literature recommends a welcome page to accommodate a good response rate and a common design of the questions, furthermore a greeting and a virtual thank you were expressed. This was done to accommodate the respondents and introduced the purpose of the survey . The questionnaire started with fairly easy to answer questions to comfort the participants.
The questions, have been segregated in diverse sections (i.e., business related data, strategy and exposure to CPV and outlook), see Annex 6. The careful design and wording of the questions was deployed to ensure validity of the questionnaire. (Gray, 2004, p. 207).
A high reliability of questionnaire design means that if something is measured, the same result should be measured at a repetition of the questionnaire. However, as this questionnaire targets risk management, this assumption is not valid. The perception of risk may change over time and potential extreme events might trigger different answers. A free observation is impossible. Hence, the same questionnaire will produce different results as the VUCA world impacts our perception of risk. If the economic situation would not change, the answers should remain constant. Hence, the replication is hardly possible for qualitative data inquiries. Despite this limitation, the design of the questionnaire was made with the utmost care (Lewis-Beck et al., 2003, pp. 957–958).
Three test runs were conducted, the first of which was with colleagues to assess pure functionality and ease of use, as well as a mutual understanding of the questions. These were formatted after each of the three test versions. The constructive feedback of marketing executives and staff members of the GIM Heidelberg ensured the fit for the purpose of layout, consistency and sorting order of the questions. The questionnaire combines quantitative and qualitative questions (deductive approach to capture industry insights. The collection of responses from a wider audience in the stainless steel business ensured the creditability of this research. The qualitative questions covered potential shortcomings.
The questions have been answered anonymously. The assured absolute discretion added to the comfort of the participants. Further details concerning the ethical considerations are detailed in Section 4.4.
For future research, it might be valuable to repeat the questionnaire. The comparison of the results might reveal findings that change and reflect the different business environments or cycles. Knowing that recent events might influence the answers.
The prevention of a subjective stance of the author is important, as part of the global stainless steel market and hence "a priori" subjective. The data collection by questionnaire provides an objective view across the global industry and from different value creating stages. It ensured reliability and validity. The replication of the results is linked to reliability (Bryman, 2016,

pp. 40–43). Therefore, the research from a practitioner's internal researcher point of view is beneficial to access this research topic (Stenbacka, 2001) and the potential findings. However, familiarity with the industry must be considered. The basic questions or the facts might not be questioned, questions that the practitioner would not ask as the answer might be too obvious to himself. To avoid this limitation, the formulation of the questions has been probed and evaluated through three trial runs. Other limitations might be the status of the researcher to gain access to the organisation, in this case, the contact. This might explain the non-participation in the survey. Potentially, it was the lack of time to answer the questionnaire (Saunders et al., 2015, pp. 210–213). The author eluded these topics within the industry segment to ensure the needed objectivity.

The results of the desk research, the quantitative data analysis, and the questionnaire are the foundation for the interviews of the executives of the stainless steel industry. The outcome of the questions is detailed in Annex 21.

The answers to these core questions (6,7,8,11,12 and 16) provide a first sign of the risk assessment of the participants. The answers to these core questions clarify the attitude towards the commodity price risk environment of the stainless steel business and the respective mitigation strategies.

4.3.2.1 Research method

The web-based questionnaire was conducted to verify the findings of the literature review. However, an introduction mail sent before the link to the questionnaire was sent. This mail introduced the idea of the research, and it convinced the receiver to take part. On the same occasion, the introduction secured the receiver that it was not a dubious attack (e.g., phishing mail) or a cyber security threat to the participants.

The questionnaire type was deployed as it allowed a quick, cheap survey with predestined answers that allows for a convenient data analysis (Bryman & Burgess, 1994, p. 20). The questionnaire allows anonymity; it allows to reach out across the globe to grasp information and it allows for quick results. However, there are potential disadvantages that have been considered. These are dishonest answers, emotions, and sentiments. Besides, skipped questions, accessibility for all and a potential ambiguity of the questions, the attitude and the seriousness used to respondent to the questionnaire, and the inability to ask probing questions.

With the focus on capturing the sentiment within the stainless steel business regarding commodity price volatility. The questionnaire intends to capture the perception of the respondents of the main business risks and the existence of mitigation strategies. The questionnaire had four sections. The questions in the first section inquired into general business data (e.g., size, ownership, stainless steel consumption, geographical location). The second part of the questionnaire inquiries into main business risks and implemented contractual strategies and the potential mitigation strategies of the companies.

The third section inquiries about the outlook of volatility in the stainless steel industry and the expectations of an ideal commercial partner. The fourth and final section dealt with two open questions about material shortage situations and the last question asks if something was forgotten in the procurement of stainless steel.

The design allowed for a low dropout rate during the completion of the questionnaire. The first section allows to "break the ice" with easy, quick answers. The design of the questions is simple and easy to grasp. The following section dealt with the strategic exposure and the mitigation strategies to answer these questions. It was important that the respondents could concentrate on the answer and not on the design or the layout of the questions. Font sizes and the style were reviewed in several dry runs during the setup of the questionnaire, all to allow a professional and simple appearance. The questionnaire was sent across the globe; hence, the wording and the languages were under suspicion. Together with my supervisor and during the dry runs, the language was adopted to avoid misunderstandings and allow for a simple experience.

The focus was on the elimination of jargon and technical vocabularies to allow and comfort every participant. Despite the exposure to the stainless steel industry, the wording had to ensure that all educational levels, cultural backgrounds, and professions within the industry could feel comfortable with the wording of the questions. Some questions had a brief additional explanation in the text (e.g., question 12 and 14) to clarify the meaning of the question. Some questions contained a hint that multiple answers are possible (e.g., question 6, 7 and 10). The last section contained open questions these questions were intentionally placed at the end as these might not suite every respondent and hence might have resulted in a lower response rate. During the completion of the questionnaire, the answer response rate fell. Therefore, it was wise to place the open answers at the end. The expected low response rate confirms this assumption. The logical order of the questions allowed a consistent and concise approach to capture the knowledge of the respondents regarding commodity price volatility risks in the stainless steel industry.

The responses of the questionnaire confirm the assumption of the literature review section. Commodity price volatility is regarded as the main risk within the industry and the potential mitigation strategies. The questionnaire allows to draw assumptions about the risk appetite and the mitigation strategies according to the geographical location or the ownership of the company.

4.3.2.2 Data collection

The questionnaire is a standard deployed for a deductive research approach (Saunders et al., 2015, pp. 181–185). The questionnaire targets to answer research questions 1.3, 2.1, 2.2 and supports RQ 3.1, 3.2 and 3.3. It is deployed to collect descriptive and explanatory data as part of a survey strategy. The "risk-appetite" of the individual companies was challenged and, if feasible, identified. The research about the weight of risk-appetite and the way commodity price volatility is perceived as a risk or an opportunity. Further details are available with the research questions and objectives (Table 2, p.11).
The survey was sent out once, hence, a cross-sectional time horizon (Saunders et al., 2015, pp. 200–202) collecting answers at a certain period. Future research might want to explore a longitudinal approach. Hence, capturing differences and variations after certain events, like industry-wide trade barriers or after a natural disaster, might offer further insights and curve out differences over the course of time. The questionnaire was sent out in Quarter 4/ 2017 and the responses were collected within 2 months, see Table 45.
According to the definition of Saunders, it is a self-administered or self-completed questionnaire (Bryman, 2006; Saunders et al., 2015, p. 440). The respondent answered the questionnaires without the possibility of interfering with the author. During the process, the questionnaire remained in its original format, there was no change during the response period. The test persons needed between 10 and 15 minutes to answer the questionnaire. A record of the actual time taken to complete the online questionnaire was not kept. No technical problems occurred during the survey process.
842 potential participants from the entire stainless steel industry received the invitation to participate in the questionnaire in October 2017. Concerns about case convenience sampling might arise (Gray, 2004, p. 88). The contacts have been collected during the last 30 years. This collection of contacts dates from the beginning of the professional career in Germany, and later from Austria to the CEE, the Benelux and other European countries. International contacts have been built up over the last 10-15 years. Due to various changes in activity and place of residence, availability (convenience) sampling can be excluded.
Some contacts were loose contacts from receptions and trade fairs. However, at no time, an economic or other dependencies that may justify a distorted representation of the answers existed. The participants are somehow interconnected with the material stainless steel to support

the relevance of the research aim. They came from diverse commercial and technical roles and responsibilities. No pressure was exerted directly or indirectly. The sending of the questionnaire was agreed with the author's employer and was explicitly permitted. The stainless steel industry is a niche industry when seen from the perspective of stainless steel producers. From the processors' perspective, it is a broad spectrum of processors. These are companies from the most diverse sectors. The connection to stainless steel is therefore pronounced to varying degrees. Therefore, the samples represented diversity in the industry to overcome the limitations of case convenience (availability) sampling (Saunders et al., 2015, p. 304). The return of close to 200 answers suggests a descent sample size. Thus, the number of replies allows safe conclusions about the niche market stainless steel (see Annex 21). Despite the concerns about convenience sampling, the responses are verified by or with triangulation, see Table 4.
The sampling process was a non-probability (non-random sampling). It was a self-selection technique as the participants have known to the researcher, as the access to the participants would have been difficult or impossible for an external researcher. An electronic invitation (per email) started the request for participation. It supports the explanatory research approach (Saunders et al., 2015, p. 298).

4.3.2.3 Data analysis

The answers to the questionnaire, the respective findings and data are analysed by quantitative and qualitative techniques depending on the data recovered and the type of questions. The collected questionnaire data is analysed using correlation, cross-tabulation, and other descriptive and statistical techniques. The questions collected as much data as possible, with a focus on the following data analysis.

Quantitative analysis

The quantitative data the approach is deductive~~.~~ The statistical methods are described in section 4.3.1.2. The open questions and the comments are analysed with a qualitative analysis. The answers were checked for reoccurring keywords and examined for potential flaws in the research design or the layout of the questionnaire. The open-ended questions aimed to overcome possible shortcomings of the questions and provided an additional opportunity for respondents to mention issues they felt were worth mentioning.

The descriptive statistics summarise the answers. The parameters such as mean, median, mode, percentage frequency and range are deployed. The relationship between the variables will be computed using correlation and regression analysis.

Qualitative analysis

The open-question survey is analysed and reviewed for key themes and patterns. Particular attention was given to the different value creation levels and the potential impact on the risk appetite of the respondents. Another aspect is the business ownership and size. It narrowed down the potential differences in the perception of commodity price volatility risks. The open questions have been answered in keywords and seldom in complete sentences. Despite the availability of keywords, these unfiltered and non-default answers are valuable to cross-check other answers. Hence, these answers verify findings and are a pivotal part of triangulation. NVivo was not used because the database was not uniform enough. However, NVivo is deployed to analyse the transcripted interviews.

4.3.3 Research Phase 3

The qualitative questions expose the reasoning behind the choices and preferences of the participants. The prior quantitative research of research phase one and the results of the questionnaire (research phase 2) reveals some useful information about the statistical patterns but not about the motivations. Hence, it was indispensable to conduct further research by the interviews to examine the intentions (i.e., probing questions). The qualitative data enables the understanding and identification of key characteristics. Laying the foundation to research the root causes and effects of commodity price fluctuations. However, the soft factors and the risk attitude of the organisation must be carved out. Investigating the strategies deployed alleviating the effects of CPV. The description and the motivation are required to understand the reasonings behind the mitigation strategies of the involved parties. The saturation of the interview might not be achieved, as risk mitigation management is an individual decision like the risk-appetite. However, the interviews revealed deep insights into the stainless steel producers' ability to cope with the CPV. They are closing the gap between the desk research and the questionnaires to explore the reasoning behind the risk perception. The sample size of 5 interviews might be at the lower end of the expectations. However, the interviews complement findings and are not considered the sole source of the data used in this research (Saunders et al., 2015, p. 297). Though, the interviews are the third data stream for this research. The sample size represents all European and US-based stainless steel flat product producers. Hence, there is no bigger sample size for the relevant market. It is a non-probability sampling technique.

The qualitative methods follow the quantitative methods, as defined by the sequential explanatory research design. This research design allows triangulating the findings (Saunders et al., 2015, p. 170).

4.3.3.1 Research method

This research concluded interviews with the relevant stainless steel mills for the exhaust gas treatment system, producing business excluding mainland China, Japan, and South Korea. It verifies or falsifies the findings of the prior research phases. The selection of the participants was based on the market position of the producers. The mills *Acerinox, Aperam, AST, AK Steel* and *Outokumpu* dominate the market in the remaining exhaust production countries. This assumption is based on the author's experience and confirmed by the interviews. The interviews collect primary data and will answer the research questions about the existing mitigation strategies (RQ 2.1) and the understanding when these are applied (RQ 2.2). Furthermore, understanding the approach and the aftermaths of the exogenous disaster events (RQ 3.1 and 3.2). Hence, the interview was chosen, as it combined the opportunity to probe the findings and to get an understanding of the reasonings of implemented mitigation strategies. The interviews were conducted at or close to the steelwork's headquarters. The travel and time required resources. However, these appointments were needed to verify the previous findings. The personal contact and the possibility of responding to nuances and allusions made the meetings a valuable pillar of this thesis. The interview as a conversation in which one person confines the role of a researcher (Gray, 2004, p. 213). Air travel and lengthy travel arrangements were required for the meetings in Madrid and the USA. The other meetings could be reached by car.

The stainless steel mills have been chosen, as these are in the middle of the value chain. Captured in between raw material suppliers and manufacturing industry (i.e., the exhaust gas treatment system producers). Therefore, the mills are confronted with the price volatility from the input materials and vice-versa on the sales side. Hence, there should be mitigation strategies experience either from a customer or a seller perspective or with either of the commercial partners.

The semi-structured interviews in this thesis supported flexibility, however, the questions guided through the interview sessions. The structured approach allowed both parties to prepare for the session. For the interviewees, the predestined questions allowed a compliance check with the legal department. No objections have been made from the participants. The disadvantage of the flexibility was that every conversation had a slightly different focus. Some interviewees tried to get off topic, but this was safeguarded with the predestined questions.

The interviews were held with non-native speaker; therefore, the language and the ease of understanding are crucial. The questions have been adopted from similar research approaches to ensure consistency, based on my supervisor's experience. Because the interviewees all held senior positions in the company, the interviews allowed the full freedom to express their point of view. The following up and probing questions allowed to pinpoint the findings exactly.

The questions have been discussed with my supervisor to allow a flawless language and a logical order of the questions. In particular, the probing and follow-up questions have proved successful. The probing and testing of my research interview skills allowed for a consistent approach. This was required as the interviews were a unique opportunity to tap into the knowledge, experience, and expertise of the persons, hence the stainless steel mills. The participation of the interviewees was encouraged, by emphasising the protection of their privacy and the offer of a copy of this thesis after completion. It is fair to mention that all of them have been fully engaged and supportive. The confirmation of data protection as informed consent is displayed in Annex 10.

During the interviews, a friendly attitude secured a comfortable conversation. The sessions in the companies typically were not interrupted despite for beverages. Language had some influence because English is the language of commerce, but not the mother tongue of all interviewees. Hence, it was mandatory to verify the answers, based on the transcripts by the interviewees.

The disadvantage of the interviews is the time-consuming analysis of the gathered information that must be transcribed before the usage of NVivo. NVivo is a qualitative data analysis software. The application supports' qualitative researchers to organise, analyse qualitative data (i.e., interviews). It supports the coding and the categorisation of data. However, it allows queries and can visualise data. The word cloud as a prominent feature. Figure 21 depicts the word frequency of the transcribed interviews.

Figure 21 Word frequency cloud of the interviews, Source: own data

4.3.3.2 Selection of interviewees and locations

Access to the top executives of the stainless steel sector was key for the open interview sessions. The selection of the interviewees was made as it covers the entire stainless steel production producers in Europe (*Acerinox*, *Aperam*, *AST*, *Outokumpu*) and approx. 60% of the US market (*Acerinox & AK Steel*). All these companies are stock-listed and hence the financial data is available for the interested public.

The semi-structured interview is deployed for explanatory and evaluative research purposes (Saunders et al., 2015, p. 393), as in this research. The cultural diversity of the interview partners remained a challenge. The Asian mills refused to accept the interview request. Hence, the generalisations of the findings towards the entire population of the stainless steel sector-are not feasible. The accessible stainless steel community has been interviewed and all major commodity stainless steel flat producers of:

- Africa,
- Europe,
- Latin America,
- North America, except ATI /USA

Except for *ATI,* all western stainless steel producers have been interviewed, including *Aperam* (Brasil) and *Columbus* (part of *Acerinox*) in South Africa. To eliminate or decrease any limitation or difference, the setup and preparing the interviews was important. The time and place of the survey were chosen by the interview participants themselves. This was to allow a comfortable and non-intrusive atmosphere.

The interviews (Table 10) took place in person between May and August 2019 in Belgium *(Aperam*), Germany (*AST and Outokumpu*), Spain (*Acerinox*) and the USA (*AK Steel*). Interviews lasted from 60 minutes to 2.5 hours. The interview with *AK Steel* was not taped and hence not transcribed. During the interview with *Acerinox,* the recording device broke down. This interview is transcribed and based on the notes of the author. All interviews were reviewed by the interviewee and in three cases, minor changes were made to the content following the interview (member validation).

Table 10 Interview partners, Source: own table

Company	Abbreviation	Position	Production in	Interview location	Duration in h	Recorded	Transcribed
Acerinox	ACX	Board Member	ES, USA, RSA, ID	Madrid	2	Yes / partly	Partly
AK Steel	AKS	Marketing Executive	USA	West Chester	1.5	No	Notes
Aperam	APS	Sales Executive / Board Member	FR, BE, BR	Genk	2.5	Yes	Yes
AST/ TKN	AST	CEO	IT	Essen	2	Yes	Yes
Outokumpu	OTK	Anonymous	SF, DE USA	Krefeld	1.5	Yes	Yes

For privacy reasons, the exact names will not be published, hence for this thesis, the abbreviations in Table 10 are deployed. The result of the questionnaires led to the set-up of the semi-structured interview guide. To avoid potential compliance conflicts, the interview questions were sent to the interviewee before the meeting. At least two legal counsellors (i.e., Aperam and Acerinox) have been involved, no objections have been reported. However, the opportunity to ask probing questions during the interviews was important in the setup. The probing of knowledge that drained from the previous two research phases allowed a triangulation of prior results, see Table 4. Hence, the semi-structured interview allowed for prior engagement and avoiding potential conflicts or unease at the interviewee and allowed to ask probing questions (Gray, 2004, pp. 215–217). The questions of the semi-structured interview guide line led the interview sessions. Despite the prior information about the interview questions, some questions could not be answered fully or completely. This may be due to a lack of preparation, lack of knowledge, or that the interviewee did not want to give any information in the interest of not committing a compliance violation. The course of the individual interviews was determined by the persons interviewed and the course of the questions. This allowed for some flexibility in adapting to the course of the interview (Wellington & Szczerbinski, 2007, pp. 62–64). The interviews are the qualitative follow up of the sequential explanatory research design. This part of the research is associated with the mixed-methods approach. Therefore, the interviews were used to verify the prior statistical findings (triangulation). These interviews are conducted as the final data collection step. The researcher might be regarded as an internal or practitioner-researcher.

4.3.3.3 The role of the interviewer and dealing with subjectivity

The author brings a valuable understanding of the research topic. The pre-understanding allows the researcher to be under equal (intersubjectivity). This comes with the opportunity to have access to organisations and or key persons in this industry. However, the focus was to minimise the researcher effect. Knowing that a neutral stance is not feasible, the semi- structured approach of the interviews and the professional setting (i.e., board rooms) contributed to minimising flaws towards reliability and validity. This thesis follows the assumption that a thorough process limits or avoids intersubjectivity “the sharing of subjective states by two or more individuals” as defined by Scheff (2006, pp. 40–46). The subjective common set of meanings between the interviewer and the interviewee resulted in a superior quality when applying a qualitative method (Stenbacka, 2001). The potential risks of the internal researcher are described in section 4.3.

The interviews have been employed rather formally to assure the professional, academic intention of the sessions (Oliver, 2010, p. 105).

The preparation and listing commodity price volatility risks and their potential impact, compared with the latest market insights, might differ depending on the date of the interview. Market sentiments might influence the responses of the interviewees. The price evolution of Nickel or scrap or the overall market could have affected the responses. However, the interviews were held within 8 weeks and the overall market situation was not interrupted by any spikes in volatility. In summer 2019, the market was stable, see Figure 22 (1.4509/441) and Figure 23 (1.4301/304).

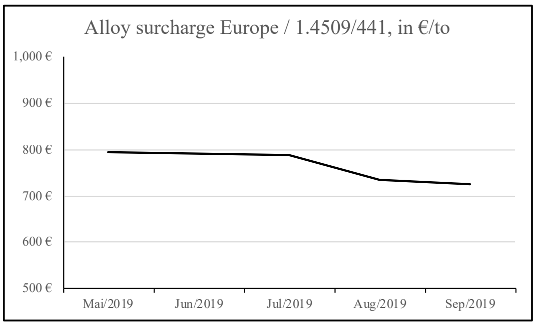

Figure 22 AS levels (441) during interview phase, Source: own data

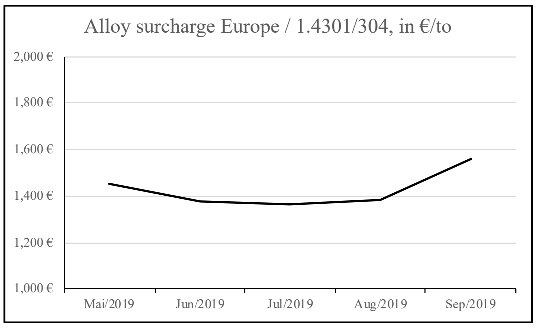

Figure 23 AS levels (304) during interview phase, Source: own data

The structured approach was chosen on purpose as it combines structure and allows a certain flexibility to revealing the underlying knowledge and facts. Despite the slow and time-consuming method of capturing and analyse (Gray, 2004, p. 218).
In preparation for the interviews, particular attention was given to the appearance of the interviewer (i.e., business outfit). The opening comments to clarify the reasoning for the interview have been carefully designed (i.e., academic interest). Furthermore, several types of questions have been written down in order to be prepared for the interviews (Saunders et al., 2015, pp. 404–413). During the interviews, the questions have been given to the interviewee as hard copy for their perusal and comfort. Attentive listening and good manners accompanied the interview sessions.

Validity

The interview questions, see Annex 7, main to answer the research questions (see Table 2), despite the measurement of volatility. This was decided as this discussion might have been too time-consuming and would have disfavoured the mitigation strategy questioning. The interview technique (semi- structured) and the careful preparation, including the set-up of the meetings across the EU and the USA, insured the trust building component. The researcher allowed sufficient time for the decision to participate. It was revealed to all interviewees that all major stainless steel mills will be part of the interview session. The location of the interviews was chosen by the interviewee to avoid travelling and time for their convenience. The one-to-one interviews allowed probing the mix of mitigation strategies, which have been part of the questionnaire. These are question 6 and 7 (main risks and mitigation strategies applied). Some statements from the previous interviews were questioned. This served the purpose of understanding. An example of this are the different strategies in procurement (i.e., *Aperam*), customer selection (i.e., *Aperam, Outokumpu*) and the role of production (i.e., *Acerinox, Aperam*). All with the purpose of lessening price fluctuations. The probing centred on hedging opportunities and about the timing. The other area of interest is a potential price difference between the LME notations and the prices the mills are paying. Hence, probing questions that require a personal interaction due to the criticalness of the information request. The interviews were set up and agreed by the interviewees with no time limit. Solely, the interview with *AK Steel* was slightly under time pressure and did not exceed the two-hour period.

Objectivity

The author is part of the stainless steel business and is employed by one of the leading exhaust gas treatment system makers in the world. Hence, the interview requests have not been denied from the executive level of the stainless steel producers. The commercial relationship with some participants could influence the answers and the attitude towards the questions. In each of the interviews, most of the questions were answered, but the focus shifted individually in the sessions. The *Aperam* company interview centred on commodity price volatility risk of the raw materials like stainless steel scrap and pure alloys and the potential to compensate or substitute pure Nickel. Whereas the *Outokumpu* discussions were pinpointed about the alloy surcharge pricing towards the customer.

Nevertheless, there are risks to the data quality involved with this set-up. The research topic is referring to the profitability of the organisations. The interviewee might, therefore, be reluctant to answer the question in all honesty.

The semi-structured interview achieved creditability and validity as clarifying questions have been possible, flanked by the industry knowledge of the interviewer.

Reliability

To ensure validity, the interviews resembled a standardised approach. However, there are conflicts of interest and hence threats to the truthfulness and honesty of the responses. Regardless, that not all business secrets might be revealed, probing questions are deployed to add to the reliability (and creditability) of the interviews. Hence, the careful preparation of the interview sessions avoided surprises about the content or the intentions of the researcher (Saunders et al., 2015, pp. 402–404). It is expected that the interviews with the top executives of the stainless steel makers added creditability to this research. These challenged the statistics and shed light on the motivation and the matureness of the strategies.

A lack of standardisation was intentionally kept to a minimum as it may impact the reliability. The interviewer has unique experiences in the industry; hence, he understands the potential comments and “political” answers. With respect and from a knowledgeable position, the data collection was performed. The repeatability is a concern, as every interview was held in diverse locations and access to the interviewees might be a restriction. Typically, the interviews took place in the meeting rooms of the companies, twice in an off-site location. The careful design of the questions enabled the collecting of the data (content validity). The intention of the questions was challenged before the interview sessions, a particular role is the language. All interview partners were non-native speakers of English, besides the contact with *AK Steel* (US English). Therefore, clarity of language was an important topic to be addressed. Here, the member validation of the transcripts is important to avoid misunderstandings. One interviewee was a native speaker, for all the others it is a second - or third language. The external or construct validity was considered. The small sample size of five interviews might raise concerns about the generalisability of the research (Saunders et al., 2015, p. 205). However, the sample size includes all European African and American stainless steel flat producers. Therefore, the interviews are appropriate for capturing the relatively small scale of players (Gray, 2004, p. 219). Hence, the sample represents this industry. The findings of the interviews and particular about the mitigation strategies can be generalised from the stainless steel industry to other commodity driven industries.

Role of interviewer

The in-depth knowledge of the stainless steel business of the author is not transferable to other interviewers; hence, this part of the research is vital, and the practitioners/expert position is not replicable for future research. This part of the knowledge is referred to as tacit knowledge. It is gained from personal experience (i.e., 30 years of industry exposure) and is built from an in-depth stainless steel industry specific experience, practise, and values. Because of the intrusive (bias tendency) element, an interview (Saunders et al., 2017, p. 397) could discomfort the interviewee. It might prompt a potential conflict with existing compliance regulations.

4.3.3.4 Interview guideline

The expert knowledge and exclusive findings of the previous research steps are the foundation of flawless communication between the researcher and the interviewees. The discussion was accompanied by sharing preliminary findings of this research. The knowledge sharing was a unique proposition of the in-depth knowledge of the researcher for this niche industry and the results of the quantitative research. Creditability and knowledge have been the key to an open information exchange.

The questions were inspired by the conclusions of research phases 1 and 2.

The type of questions deployed are:

- General Questions
- Risk Assessment and mitigation,
- Price, volatility
- Development & challenges of the stainless steel industry
- Strategy questions
- Farewell questions

4.3.3.5 Data collection

Open questions are the predominant part to identify the company's position towards commodity price volatility, risk mitigation strategies and potential uncertainties of the macroeconomic environment. These sessions delivered a wealth of information and creditability. This interview type allows diverse views and the understanding of the unique positions of the companies towards risk mitigation scenarios (Blaxter et al., 2010, p. 193; Saunders et al., 2015, pp. 402–404). As preparation for the interviewee, the list of questions (Annex 7) has been mailed before each session. The interviewee could prepare themselves and verify adherence to compliance and internal regulations and potential non-disclosure restrictions. During the actual interview, there have been different emphasises to adapt to the situation of each interviewee and organisation. These interviews explain the relationship between the variables of sections 3.3 and 3.4.
The semi-structured format was chosen because of the flexibility that is needed to explore the complexity of risk mitigation strategies and to understand the details of these. The preparation was in line with the conclusions of several known publications concerning preparation, interview setting, language and ensure that the recording is added up with notes (Adams, 2014, pp. 145–148; Saunders et al., 2015, pp. 388–435).

4.3.3.6 Data analysis

For the conduction of the interviews, a hybrid between deductive and inductive approach has been deployed. The content analysis was deployed to identify patterns in the recorded and transcripted interviews. The content analysis systematically scans the collected data to quantify the occurrence of keywords, phrases, subjects or concepts in the interviews (Gray, 2004, p. 327). Interviews yielded 49 pages of transcription. The data was broken down for the analysis into smaller bits of information. The qualitative analysis comprises three major steps, according to Dey (1993, p. 32), classifying, connecting, and describing the data in a circular process.

The statements and findings of the interviews are compared with the existing data and findings from previous analyses (e.g., sections 4.3.1.2 and 4.3.2.3). All these questions needed to be cross-checked in the interviews. The evaluation of risks and mitigation strategies specific that surfaced in the questionnaire and in the literature with the expertise and the business practise of the stainless steel producers. The verification of the existing and applied mitigation strategies in the value chain of stainless steel. The explanation for implementing diverse CPV risk lessening strategies may be linked to the geographical location or the size of the company.
The initial step was to transcribe the interview recordings. One interview was not recorded and thus a written memo was produced. All transcripts and memos have been sent to the interviewee to seek approval. All five participants gave their consent to use the information of the interviews. *AK Steel* did not grant the permission to record the session. The validation of the transcript with *AK* has revealed an error. A wrong note concerning the name of a steel plant in the USA caused the error. In all other four cases, the transcripts were used with no amendments. The final approval was needed not only to protect the participants or the companies they represented from any false communication or false facts. However, it belongs to the netiquette and respect towards the participation in this research and to comply with the university's rules and ethical standards, see section 4.4. The interviewees explicitly agreed to the interview. In two cases, the request for anonymity was granted (Annex 10).
The transcripts are in Annex 8. They were done by a professional service provider (*Mein-Transkript.de)* based in the Netherlands. The reason was the time saving, and the expected consistency of the transcripts. The transcripts have time marks for every sentence to ensure the academic requirements. In addition, time markers have been useful in the data analysis. These markers, as it was convenient to listen to the interview sessions and to compare the notes and to understand the timing of the statement. In cases, it was reiterated later in the interview again. The transcripts now eliminate ambiguities, especially in technical terms and/or unclear language. A few times, the transcript made had to be checked against the notes. There had been misunderstandings of industry-specific terms or the misinterpretation of Chinese company details. For further transcripts, the transcriber was provided with the most frequent terms, so that the conversion from speech to writing was easier.

4.3.3.7 Research Methods

The method used to break down the data is the content analysis. It is an analytical technique that codes and categorises qualitative data for a quantitative analysis (Saunders et al., 2015, p.

608). The data is coded in units of meaning and in sets of categories. The coding and the nodes condense meanings and enable the discovery of patterns in the interviews. A set of rules determines the coding of the transcripts. These rules were helpful, as the coding is a time-consuming activity that required guidance for the coding and the nodes. These comprise what is included and excluded from the categories and the meanings. The coding was done by the author, hence misunderstandings in the coding might be a rare occasion. These guidelines support the reliability and the transparency of the analysis process. After the transcripts have been coded, the collected data and categories- subcategories are examined for patterns and conclusions to answer the research questions (Auerbach & Silverstein, 2003, p. 35).
The data richness of the interview transcripts has been immense. The analysis of the qualitative data is not as structured as the statistical analyses for quantitative data. Therefore, the data was prepared. For these reasons, a software-based solution (i.e., NVivo) was deployed. Analysing the transcripted interviews is divided into several steps (Hammond & Wellington, 2012, p. 9; Miles & Huberman, 1994).

- transcription
- data reduction (i.e., selecting, grouping, coding, cases)
- data display
- conclusions

The categorisation of the data is described in this section. It was an iterative process, as the interviews and the categorisation (nods) had to be revised several times to enable a summary of the data. This process supported a consistent application of the predetermined categorisations for the cases and nodes. It enabled the classification of the quantitative data.

The previous assumptions and findings are assessed against the statements of the interview participants. This iterative process has an element of analytical induction. The verification of matching patterns was triangulated with prior findings. A particular interest was the impact of the Nickel price fluctuations and their impact on the mills, the potential mitigation strategies, and the potential substitution of raw materials. The impact of the profitability and the share price of the company the interviewee is standing for and the competing companies. The development and volatility of the metal prices and the impact of certain risk mitigation strategies and policies are questioned.

4.3.3.8 Research Instruments and categorisation

In the analysis of the transcribed data, themes and terms were grouped. In this way, the significant terms and themes could be narrowed down in the analysis process. This is the coding

of the data that can support the quantitative analysis (Oliver, 2010, p. 120). The analysis of the data has been performed with NVivo, version 11.4.3. The software allows to store, categorise, and analyse qualitative data. The tool offers the option to visualise the data. NVivo accomplishes the categorisation of the data with so-called "nodes" and "cases". The nodes/ categorisation of the data has been driven by the research topic itself to answer the research questions and partly these came from the content of the transcripts. Individual interviews have been the cases. The categorisation of the data includes two actions. First, to develop categories and second attach these categories to meaningful shares of data.
The categorisation was adopted during the coding process. Subcategories avoided that those nods contain too much data. At the end of the grouping phase, some nods have been merged into one subcategory, which helped to condense the process. This segregation was the first step to seek into patterns and relationships.

Summary
The condensed findings and potential patterns of the interviews are probed with the preliminary findings of the previous research phases, see Figure 4. The themes and relationships in the data are extracted. The main thoughts and implementation actions are compared and linked to the previous data. The reoccurrence of keywords (Table 47) is vital in identifying the major themes. The key points and findings are targeted to answer the remaining three research questions. The external influences of political influence (RQ 3.1) and financial impacts (RQ 3.2) are highlighted. The evolution or perfection of mitigation scenarios is researched.

4.4 Practical and ethical considerations

The ethical component of any type of research is important in society. Their consideration is important, as false or incorrect behaviour towards the participants may jeopardise the results. This research is spread around the globe. The questionnaires were sent and answered by participants on all continents (besides Australia). Therefore, it is important to behave and react appropriately with all persons and organisations involved in this research. Multinational approaches are always asking for a social and ethical, responsible way of acting. Saunders describes "Research ethics" as a moral and responsible way to combine the aspects of access, data collection, data analysis and the writing up of the research. Saunders (2017, pp. 75–82) defines it as "the appropriateness of the researcher's behaviour in relation to the rights of those who become the subject of a research project, or who are influenced by it". The

researcher must fulfil these requirements. Observation, interviews, and questionnaires can all be intrusive and provoke anxiety, stress in participants, or involve anxiety. Hence, the introduction letter of the questionnaires stressed the anonymity and the appropriateness to stop the completion, if any discomfort or stress might occur. The questionnaire and the interviews have been made in line with the "Code of Practice for the Conduct of Postgraduate Research Degree Programmes 2018/2019" of the University of Salford, version 3.0, effective from 01 September 2018. An Ethics approval was granted (SBSR1718-02). It respects the "Research Code of Practice", version 1.0, effective from 24th of July 2017 and the "Academic Ethics Policy" version 1.0, effective from 28th of June 2017 (Annex 11).
Still, the behaviour and approach must be in line with the social norm. This term designates the type of behaviour that a person ought to adopt in a particular situation. Hence, an utmost care is needed in seriousness, manners, and behaviours when working with different mentalities and diverse social norms that are existing in diverse business environments. The publications of Knigge (1896) are the social guidance for the researcher. The researcher is aware of the challenges. Therefore, this standard balances the pursuit of research objectives with the application of ethical research methods and procedures. It is always necessary to avoid permanent or excessive harm to participants, whether unintentional or not.
This research includes the participation of voluntaries, all participants have been free to choose to participate without no pressure or intimidation.
All participants agreed to participate by an informed consent, the proofs have been listed in Annex 10.
Anonymity was agreed for two of the interview partners. The questionnaire deployed a method of data pseudonymization, the identifying information of the respondents of the questionnaire by non-traceable identifiers. This service was offered by the service provider.

5 Results

5.1 The definition, calculation, and impact of volatility (RQ 1-1 to 1-3)

This chapter examines to what extent commodity prices are volatile and which impact this volatility has on the stainless steel value chain. Section 5.1.1 examines the definition of the term volatility. Assuming that volatility exists, the question arises whether it can be categorised. This classification enables a contribution to interpretating different degrees of volatility. These may start mitigation strategies or raise awareness within an organisation about potential commodity price risks. The scale is “a priori”, an interpretation of the price fluctuations or the severity of these fluctuations (RQ 2.1 and 2.2). Section 5.1.2 guides the calculation and measurement of price volatility in the stainless steel sector. Section 5.1.5 examines the link and the potential impact between raw material prices and the stock prices of the companies in the value chain of stainless steel. Several statistical calculations examine the impact on equity prices and profit of the mills. It includes correlation and regression analysis to examine the impact on the share prices along the value chain. This section answers research questions in group 1 that is divided into three parts (RQ 1.1, 1.2 and 1.3). However, the results of the quantitative sections are required to examine the application of mitigation strategies in the case of a political (RQ 3.1) and a financial risk (RQ 3.2). The results of the quantitive research are compared with the existing mitigation strategies (see 5.4).

5.1.1 Volatility a definition (RQ 1.1a)

The explanation of how price change differs from why prices change. Next to the supply and demand function, other elucidations exist. However, these price changes are often not mirrored by the physical markets. The underlying reasons for the price are often not tangible. These are manifold, like news about the commodity, company, industry, financial data, macroeconomic news, emotions and other reasonings.

The literature review suggests that commodity price volatility exists and there is a rationale to understand the time-varying impact. Therefore, the time lag between raw materials price fluctuations and the impact on stock prices across the value creation is researched. The prediction of volatility is examined to mitigate or pursuit opportunities that arise from price variabilities (Arezki, Hadri, et al., 2014; Arezki, Loungani, et al., 2014).

However, a clear definition of the term volatility is missing. The term is not tangible. Hence, the expression is vague in meaning. Hence, no standard interpretation exists. Volatility might refer to fluctuations of less than 0,1% or 1000% and above, therefore, the usage and meaning of volatility is subjective.

Despite the etymological designation, a generic definition of volatility is lacking. Therefore, this research must answer the initial research question (1.1a) that no definition exists to describe the term volatility in a universal sense.

The most suitable definition for the research of raw material price changes is linked to the description of the VIX (Cboe, 2018b).

Volatility describes and measures by range (minimum to maximum) and frequency of occurrence that prices experience in a certain period. The more vivid the price swings, the higher the level of volatility.

A suitable statistical calculation may support to measure and interpret raw material price swings. Measuring volatility is key to the classification and understanding. Ranking volatility allows measuring of the severity, hence, to select the mitigation scenarios.

5.1.2 The measurement of volatility (RQ 1.1b)

There are several terms in the financial sector to describe volatility, e.g., historical, implied, or realised volatility (Houstecky, 2020). In this research, the financial term of realised volatility is described, as it refers to the price changes and not option price changes (implied volatility), see Annex 3.

The variances or swings are not constant; hence, the volatility (variance, or standard deviation (SD) varies. However, the data series might follow a trend, see section 3.2.3.

Most commodity pricing distributions do not match a normal distribution. The literature describes the data with skewness, kurtosis, and heteroscedasticity. Heteroscedasticity suggests that the variance in the sample performance data is not constant. Like skewness and kurtosis, the consequences of heteroscedasticity will cause standard deviation to be an unreliable measure of volatility, hence risk.

However, in this research, the standard deviation is deployed to a certain extent to measure the volatility of past performance (historical volatility). Comparing these volatilities of data series against each other, the standard deviation might be misleading. Therefore, the measurement of volatility must be comparable.

The standard deviation or the range (i.e., minimum to maximum value) are absolute values and therefore not comparable between data series. The CV, however, is a relative value that overcomes this limitation. It measures the dispersion of data points around the mean. It enables the comparison of different data series.

The GARCH calculation is deployed to model volatility and to forecast future prices. The ARDL examines the time lag among the data series (RQ 1.3). A practitioner conducts this research; hence, complexity is kept under suspicion. Therefore, any over-complication is avoided that would limit the findings to an academic audience.
The empirical results, including the CV, are the basis for the further conclusions (Table 12, Table 13 and Table 14, p. 130). The calculations cover the period 1960-2018. Shorter periods reveal mid-term impacts, see section 5.5. This section explores the existence of volatility and its impacts. The existence of commodity price volatility is assumed but must be proven. The methodology is described in section 4.3.1 (quantitative research). The foundation is statistical computing the correlation and regression (linear and multiple) in section 5.1.5. The complete data is detailed in Annex 13. It determines whether the commodity prices are influencing the stock prices within the value chain of stainless steel. Followed by modelling of the volatility by a GARCH model (5.1.6). The third examination is an ARDL calculation (5.1.7) on the time-varying effect. Hence, if this time delay exists, it can start the mitigation selection process. Which answers research objective 2, the time-varying effect of the raw material prices on the share prices.

5.1.3 Volatility calculation for stainless steel commodity materials

After the theoretical foundations, the statistical analysis of the commodities (i.e., Iron ore, Nickel, Copper, and Aluminium) is computed. In recognition of the substantial number of tables and figures, the results are listed in Annex 12.
The empirical results of the time from 1960 to 2018 (Table 12) allow a first assessment. For Nickel, the mean value is greater than the median, so that the distribution of the values is right levelled. For Iron ore, it is left levelled. The Interquartile range (IQR) is bigger than the mean and the SD for the Nickel prices. For the Iron ore prices, the IQR is smaller than the mean, median and SD. Kurtosis and skewness for both are far above the typical range of values for asymmetry and kurtosis between -2 and +2. Which is in literature an acceptable method proving a normal distribution (Field, 2009, p. 135; Sheskin, 2003, p. 185). The values of skewness and kurtosis should be zero in a normal distribution. To verify this subjective assumption, the test of normality and the box plot diagram are computed. The values are stated in USD ($).

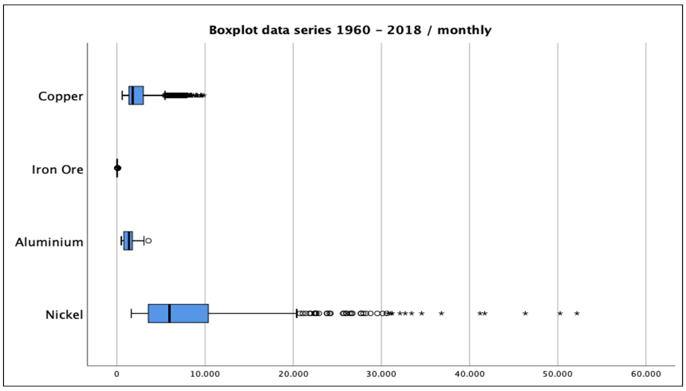

Figure 24 Box plot 1960 – 2018 overview, Source: own data

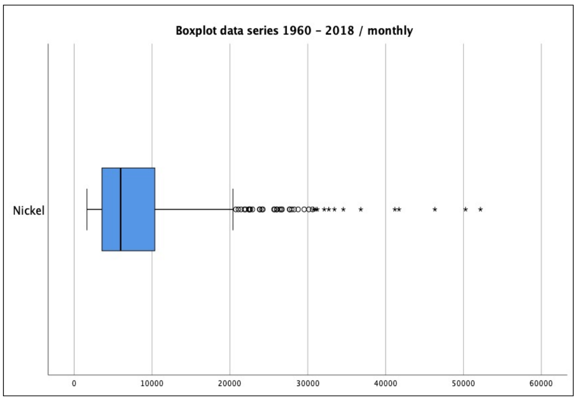

Figure 25 Box plot 1960- 2018 Nickel monthly, Source: own data

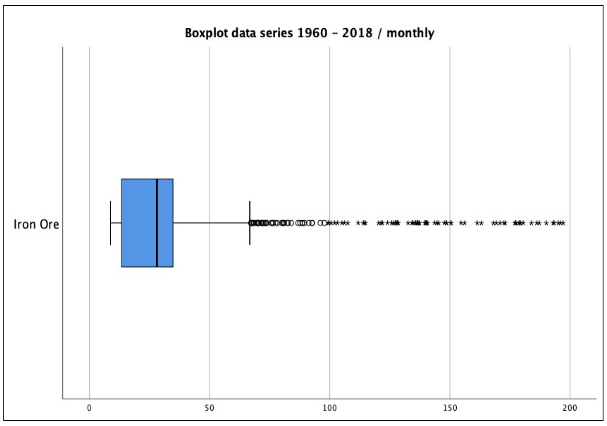

Figure 26 Box plot 1960-2018 Iron ore , Source: own data

Nickel dominates the data set spectrum of the initial box plot in Figure 24. The amplification in Figure 25 and Figure 26 illustrates the IQR and the outliers. Figure 26 depicts the same conclusion for Iron ore. The outliers are widespread. Hence, a volatile distribution of both data series is assumed.

Table 11 Test of normality 1960-2018, Source: own data

Test of normality 1960-2018						
Price	Kolmogorov-Smirnov*			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Nickel	0.18	700	0.00	0.79	700	0.00
Aluminium	0.11	700	0.00	0.95	700	0.00
Iron ore	0.31	700	0.00	0.70	700	0.00
Copper	0.23	700	0.00	0.77	700	0.00
*Lilliefors Significance Correction						

Both the Kolmogorov-Smirnoff and the Shapiro-Wilk test display the non-normal distributed data series. The assumption for a non-normal distribution is a $\rho > 0.05$. Hence, all four elements (Nickel, Aluminium, Iron ore and Copper) display non-normal distributed price

values for the period 1960 to 2018. The full tests for normality are given in Annex 13. The computed Kolmogorov and Smirnov (K&S) test verifies a non-normal distribution, hence the assumption that the data series is volatile.
Despite the non-normal distribution, the data series can, however, be tested for correlation. The Spearman correlation coefficient (Spearman's rho) overcomes this limitation. The results are ranked before a Pearson correlation is computed. Therefore, displays the impact of the independable variable on a dependent variable. The Spearman correlation was favoured to Kendall's tau, however, both are typically more accurate in describing a correlation than the Pearson correlation (Field, 2013, p. 180). For the examined data series, the independent value (*X*) in Spearman´s rho indicates volatility. Furthermore, the empirical results reveal data series with outliers, hence representing volatility. The results are displayed in section 5.1.4.

The period (number of data points) has a considerable impact on volatility. In this thesis and the respective statistics, the CV value is lower compared to shorter periods. However, further investigation is needed to judge the severity of volatility. It is detailed in the next section and answers research objective 1.

5.1.4 Statistical observations regarding commodity price volatility

To name the consequences of volatility on the equity prices, three periods are investigated. The time horizon is divided into sub-categories. The initial probe examines if the commodity prices are volatile. The detailed calculations are displayed in Annex 3. The descriptive statistics have been amended with kurtosis and skewness, and CV values. These values reveal the volatility of the data series. The T- stat calculations confirm the non-normal distribution of the data series, as detailed in Annex 13. Hence, the correlation coefficient has been performed with Spearman´s rho, as this supports the correlation analysis with non-normal distributed data series (Field, 2007, p. 179).

Coefficient of variation

The CV calculation for the researched data series suggests that the highest price volatility occurs when looking at the longest period (i.e., from 1960 onwards) compared with the other examined periods. In all industry segments studied (i.e., mining, stainless steel producers, exhaust treatment systems producers), the shorter the period, the "less severe" the amplitudes of the CV. One assumption could be that the shorter periods (fewer data points) exhibit fewer outliers and exhibit a certain consistency. However, it is based on the data series and not on a mathematical conclusion, as this observation might be coincidental.

The descriptive statistics (Table 12, Table 13 and Table 14) include mean, median, mode and range. The range is a simple measure of dispersion. For Nickel, the range decreases for the periods starting from 1960 (50,600) to 2008 (22,927) and 2013 (11,100). A similar trend is given for the SD (7,200 / 5,400 / 3,100). The CV decreased in the same period from (0.9/0.3/0.2) from very large to small according to Table 7 (p. 90).

Table 12 Descriptive statistics and CV 1960, Source: own data

Max 1960	Data availability	N	Mean	Median	Mode	Std. Deviation	Skewness	Z score Skewness	Kurtosis	Z score Kurtosis	Range	Minimum	Maximum	Coefficient of variation (CV)
Nickel	1960 Jan	700	8,289	5,970	1,742	7,230	2.2	23.4	6.5	35	50,548	1,631	52,179	0.87
Iron Ore	1960 Jan	700	41	28	10	41	2.1	22.5	3.8	20	188	9	197	1.00
Ferro-Chrome	2006 Jan	145	2,457	2,280	2,090	916	2.1	10.6	5.4	14	5,080	1,200	6,280	0.37
Outokumpu	2000 Jan	220	222	222	301	160	0.9	5.6	0.5	2	681	21	701	0.72
Aperam	2010 Dec	89	263	254	83	127	0	0.4	(1.4)	(3)	397	83	480	0.48
Acerinox	2000 Jan	220	116	114	102	30	1	6.8	1.4	4	165	65	230	0.26
AK Steel	2000 Jan	220	122	83	57	123	3	16.8	8.1	25	690	20	710	1.01
Posco	2000 Jan	220	658	644	827	347	1	3.9	0.2	1	1,693	144	1,838	0.53
Jindal Stainless	2003 Oct	175	821	806	378	404	1	3.4	0.7	2	2,191	151	2,342	0.49
JFE	2002 Aug	193	2,861	2,481	2,675	1,497	2	9.5	2.5	7	7,222	988	8,210	0.52
Tenneco	2000 Jan	220	281	250	30	200	0	2.0	(1.2)	(4)	661	14	674	0.71
Faurecia	2000 Jan	220	362	367	137	161	0	(0.4)	(1.0)	(3)	673	64	737	0.44
Futaba	2000 Dec	209	21,136	19,620	29,350	6,991	0	2.0	(0.9)	(3)	30,020	8,880	38,900	0.33
Sejong	2000 Jan	220	77,965	60,850	117,000	49,098	1	0.4	(0.6)	(2)	188,150	16,850	205,000	0.63
BHP Billiton	2000 Jan	220	11,347	11,793	2,791	6,115	0	(1.9)	(1.2)	(4)	21,803	1,989	23,792	0.54
Norilsk	2004 Aug	166	160	158	170	57	0	4.1	0.1	0	273	42	315	0.36
Vale	2002 Mar	195	146	128	25	100	1	0.2	(0.5)	(2)	379	19	398	0.68

Table 13 Descriptive statistics and CV 2008, Source: own data

2008	N	Mean	Median	Mode	Std. Deviation	Skewness	Z score Skewness	Kurtosis	Z score Kurtosis	Range	Minimum	Maximum	Coefficient of variation (CV)
Nickel	124	16,094	15,771	8,299	5,377	0.6	2.8	(0.3)	(0.6)	22,927	8,299	31,225	0.33
Iron Ore	124	108	100	41	45	0.3	1.5	(1.2)	(2.7)	157	41	197	0.41
Ferro-Chrome	121	2,548	2,300	2,090	908	2.5	11.2	6.2	14.2	4,850	1,430	6,280	0.36
304 scrap EU	121	1.1	1.1	1.0	0.3	0.5	2.1	0.4	0.9	1.5	0.5	2.0	0.26
304 scrap USA	118	1.6	1.6	2.0	0.5	0.5	2.1	(0.1)	(0.2)	2.2	0.8	3.0	0.29
Outokumpu	124	150	73	251	141	1.7	7.6	2.8	6.5	639	21	659	0.95
Aperam	89	263	254	83	127	0.1	0.4	(1.4)	(2.8)	397	83	480	0.48
Acerinox	124	115	118	102	22	0.1	0.6	(0.4)	(0.9)	102	72	174	0.19
Yieh	79	77	78	92	8.9	0.4	1.3	(1.2)	(2.2)	27	65	92	0.12
AK Steel	125	118	71	57	137	2.9	13.5	8.5	19.8	690	20	710	1.16
Posco	125	797	770	1,039	241	0.4	1.8	(0.3)	(0.7)	1,013	354	1,366	0.30
Jindal Stainless	124	695	701	378	342	0.3	1.6	(0.8)	(2.0)	1,422	151	1,573	0.49
Nippon Steel	125	27	25	16	7.5	1.7	7.9	3.6	8.3	39	16	56	0.28
JFE	125	2,362	2,178	2,145	911	1.7	7.8	3.9	9.1	4,972	988	5,960	0.39
Tenneco	125	397	425	144	179	(0.5)	(2.2)	(0.8)	(2.0)	661	14	674	0.45
Faurecia	124	273	257	137	153	1.1	5.2	1.1	2.6	673	64	737	0.56
Futaba	124	16,170	16,005	15,990	3,495	0.2	0.8	(0.4)	(0.9)	15,410	8,880	24,290	0.22
Sejong	124	109,983	114,750	117,000	42,053	0.1	0.5	(0.6)	(1.3)	174,800	30,200	205,000	0.38
BHP Billiton	125	15,569	15,930	17,431	3,751	(0.2)	(0.8)	(0.3)	(0.7)	17,028	6,764	23,792	0.24
Norilsk	125	169	167	170	48	0.3	1.4	1.0	2.3	257	42	299	0.28
Vale	125	174	144	192	97	0.5	2.2	(0.8)	(1.9)	373	25	398	0.56
Glencore	85	3,091	3,225	895	938	(0.7)	(2.5)	0.4	0.8	4,416	895	5,311	0.30

Table 14 Descriptive statistics and CV 2013, Source: own data

2013	N	Mean	Median	Mode	Std. Deviation	Skewness	Z score Skewness	Kurtosis	Z score Kurtosis	Range	Minimum	Maximum	Coefficient of variation (CV)
Nickel	64	12,802	12,848	8,299	3,087	0.4	1.3	(0.8)	(1.4)	11,103	8,299	19,401	0.24
Iron Ore	64	83	72	41	31	0.8	2.7	(0.6)	(1.0)	114	41	155	0.38
Ferro-Chrome	61	2,204	2,220	1,970	289	1.0	3.3	2.0	3.3	1,294	1,770	3,064	0.13
304 scrap EU	61	1.0	1.0	1.0	0.1	0.1	0.3	(0.5)	(0.8)	0.5	0.8	1.3	0.11
304 scrap USA	58	1.3	1.3	1.3	0.3	0.6	1.8	(0.2)	(0.2)	1.1	0.8	1.9	0.21
Outokumpu	64	55	52	21	18	0.3	1.1	(0.7)	(1.3)	73	21	93	0.34
Aperam	64	303	325	83	122	(0.4)	(1.4)	(1.1)	(1.8)	397	83	480	0.40
Acerinox	64	111	116	102	18	(0.3)	(1.1)	(0.3)	(0.5)	85	72	156	0.17
Yieh	64	74	71	67	6.9	0.5	1.7	(0.8)	(1.4)	27	65	92	0.09
AK Steel	65	53	49	57	20	0.7	2.4	0.2	(0.3)	89	20	109	0.38
Posco	65	637	666	354	142	(0.4)	(1.4)	(0.9)	(1.5)	541	354	895	0.22
Jindal Stainless	64	500	405	378	268	1.1	3.7	0.4	0.7	1,040	151	1,191	0.54
Nippon Steel	65	23	23	16	3.4	0.2	0.8	(0.0)	(0.1)	15	16	31	0.15
JFE	65	2,100	2,125	1,315	402	0.1	0.3	(0.3)	(0.6)	1,722	1,315	3,037	0.19
Tenneco	65	540	558	350	75	(0.7)	(2.4)	0.1	0.1	325	350	674	0.14
Faurecia	64	369	349	124	147	0.9	3.0	0.5	0.8	613	124	737	0.40
Futaba	64	17,582	17,255	19,620	3,587	(0.1)	(0.4)	(0.7)	(1.1)	14,340	9,950	24,290	0.20
Sejong	64	119,945	110,250	98,000	34,045	0.5	1.7	(1.1)	(1.8)	118,400	72,600	191,000	0.28
BHP Billiton	65	13,975	14,036	6,764	3,349	(0.4)	(1.2)	(0.7)	(1.2)	13,353	6,764	20,117	0.24
Norilsk	65	162	164	176	22	(0.0)	0.0	(0.7)	(1.3)	91	115	206	0.13
Vale	65	101	101	25	44	0.1	0.4	(0.9)	(1.5)	177	25	202	0.43
Glencore	64	2,804	3,101	895	853	(1.0)	(3.2)	(0.1)	(0.2)	3,142	895	4,037	0.30

a. Multiple modes exist. The smallest value is shown

Nickel displays a CV of 0.87 and Iron ore of 1 (Table 11). These values suggest a non-normal distribution, confirmed by the test of normality. The histograms are displayed in Annex 12. For Nickel, the histogram (period 1960) confirms the non-normal distribution of the data points. The kurtosis of 6.6 is displayed by the pointy and heavy-tailed distribution of values.

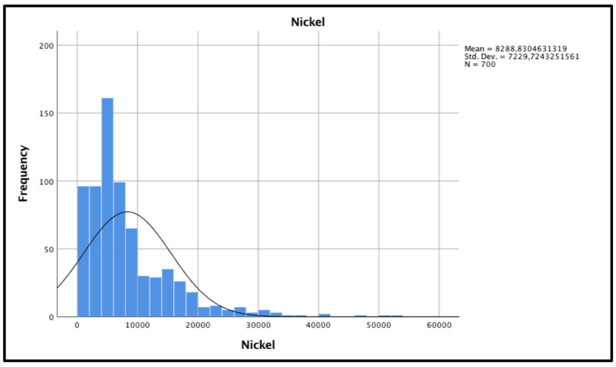

Figure 27 Histogram Nickel 1960 to 2018, Source: own data

Hence, Nickel and Iron ore are volatile for the period from 1960 (Table 12). It partly answers research objective 1 and proofs the existence of commodity price volatility.

Because of data availability, the maximum time span for the other prices is shorter. The data of *Aperam starts* in 2010, Ferrochrome in 2006, *Jindal* in 2003, *JFE* in 2002, *NorNickel* Nickel in 2004 and *Vale* in 2002.

Examining the CV results, one is <0.3 (*Acerinox*). The histogram hints at a normal distribution. Ferrochrome shows a CV below 0.4, despite the lower CV value, compared to the peer group. Ferrochrome displays z- scores above average (skewness is 10.6 and kurtosis 13.6). Therefore, considering the larger number of 145 data points, it is concluded the data is not normally distributed hence volatile.

Eight price series show a CV >0.5 (Nickel, Iron ore, *Outokumpu*, *AK Steel*, *Posco*, *Jindal*, *JFE*, *Sejong*, *BHP Billiton* and *Vale*). Thus, these are more volatile compared to the other data series. The level of volatility is to a certain extent explained by different time horizons. For Iron ore and *AK Steel*, the CV exceeds the level of ≥ 1. Hence, the SD exceeds the mean of the data set. Therefore, to complement this finding, the values according to the guiding interpretation of Table 7 are significantly greater (0x1, 3x2, 6x3, 3x4, 2x5) than for the shorter periods.

By comparing the three time periods, a trend towards decreasing levels of volatility is measured. The relative and absolute values decrease. The average CV for the first time (1960) is 0,59 and for the time as of 2008, it is 0,41, hence a decrease of 31%.

For the latter two time periods (2008; 2013), additional share price data is available and added to the statistical analysis, see section Annex 12.

To complement this finding, the values according to the Kvålseth table are lower than for the 10-year time 2008 (2x1, 12x2, 6x3, 0x4, 2x5). For the 5-year period, these values are decreasing (9x1, 11x2, 2x3, 0x4, 0x5).

The conclusion is that the level of volatility is decreasing however it is significant. It remains in a crisis mode, see Table 8.

5.1.5 The impact of Nickel price volatility

Monthly averaged data, partly from 1960 to 2020, is deployed to examine the linkages between raw material (i.e., Nickel) prices and the share prices of the companies in the stainless steel value chain. The data availability is not consistent, hence some periods contain a wider range of values (i.e., Ferrochrome and stainless steel scrap prices). This yielded up to 700 data points per data series. This thesis deploys shorter periods examining the time around the 2008 Financial Crisis (RQ3.1) and the trade restrictions in 2018 (RQ 3.2).

Researching the impact of Nickel prices a stepwise regression analysis, and hypotheses testing is performed. The stepwise regression identifies the variables with the strongest influence. However, the stepwise regression is not uncontested in literature as the software decides which terms are entered to increase, the R^2 value (Lewis, 2007). Using exploratory and predictive research, still offers an opportunity to use stepwise regression (Menard, 2002, p. 42). Nickel, the element with the highest value share is the independent value. The hypothesis testing examines the impact of Nickel prices. However, the elements Iron ore, Ferrochrome, and scrap prices are added as dependent variables to reflect the material and value contents of stainless steel.

The calculations and results are separated into subsections depicting the value chain. Hypotheses H1 to H4 investigate the influence of Nickel on other raw materials. The hypotheses H5-H7 examines the influence of Nickel on the share prices of the companies. No control variables were deployed, as neither size, location nor any meaningful variable was mentioned during the questionnaire process nor later from the interviews. Copper and Aluminium are researched and mentioned and might constitute a control variable, however, these two variables are industrial metals like Nickel.

This thesis focuses on raw material price volatility; hence, currency exchange rate effects are not investigated. Because the raw materials are traded in USD ($) and are hence not biased by exchange rate effects. The exception is the scrap notations in Europe, these are traded in €.

The last subsection examines the potential influence of raw materials on Nickel prices to review and understand potential spill-over and co-movements of price series.

Therefore, it is subsequent to research the relationship between the main raw material prices, to understand the impact of price volatility among the raw materials and the share prices. Because of the value, the research focus is on Nickel and Ferrochrome. Nickel is traded at the Metal exchanges and hence this listing is available to the interested public. The data sources for the values are listed in Table 5 for the raw material prices, and in Table 6 for the share prices.

Therefore, based on the pricing information and the value proposition, it is evident to select Nickel as the independent variable and the other elements as the dependent variable. The calculations are detailed in Annex 1. These refer to the Compound that reflects the typical material used in the exhaust gas treatment industry in weight and value.

The impact of Nickel on the different data series is, hence, probed by hypotheses. These verify or falsify the impact of Nickel prices on raw materials and stock prices of the firms in the value chain. To answer RQ 1.3, these hypotheses are investigated. The classification of the listed hypotheses represents the connection between the assumption that the Nickel price exerts an impact, see Table 15. Therefore, the hypotheses were divided into the 7 categories. Each category represents a self-contained group. The multitude of hypotheses tests is thus simplified. The hypotheses of the first 4 groups test the influence of the Nickel price on the other raw materials and the stainless steel scrap prices. For an easier overview the metals and the share prices of the companies have been separated by the double line.

Hypothesis groups 5, 6 and 7 test the influence of the Nickel price on the share prices of the companies (i.e. miners, stainless steel producers and exhaust system producers). The hypothesis testing is a vital contribution as it researches the assumed impact of Nickel prices to the share prices of the companies in the stainless steel value chain. The overall overview about the interlinkages is given in Table 2.

Table 15 List of hypotheses, Source: own data

Hypothesis	*IF*	*THAN*
1	the Nickel price increases	the price of Iron ore increases
2		the price of Ferrochrome increases
3		the price of Scrap EU increases
4		the price of Scrap USA increases
5		the share price of the mining companies increases
6		the share price of the stainless steel producer increases
7		the share price of the exhaust manufacturer increases

For these, the assumption is H_0: $r \leq 0$; H_1: $r > 0$, whereas r is the correlation coefficient (Spearman rank coefficient ρ). Hypotheses 1, 2 and 3 are researching the potential link between the Nickel price and the commodity materials to produce stainless steel. Therefore, hypotheses 5, 6 and 7 research the stimulus of Nickel and the impact on the stock price.

The detailed results of the statistical calculations are listed in Annex 13. This section contains in total 37 Hypothesises examining the linkage between Nickel and the dependent variables. 22 or 60% of these depict a strong or very strong linkage between Nickel (independent variable) and the dependent variables.

5.1.5.1 Impact of Nickel on the price of other raw materials

The hypothesis tests are conducted with stepwise regression, see Annex 13.

Table 16 Spearman´s rho 1960-2018, Source: own data

Spearman's rho correlations / Prices 1960 to 2018				
Raw Material	Nickel	Aluminium	Iron ore	Copper
Correlation Coefficient	1.00	0.93	0.89	0.90
Sig. (2-tailed)	0.00	0.00	0.00	0.00
N	696	696	696	696

Interpreting the correlation coefficient is according to the Pearson's product-moment correlation coefficient (PMCC), which deciphers the Spearman's rho value (Saunders et al., 2015, p. 545). It is detailed in Table 17.

Table 17 Interpretation strength of correlation coefficient, Referenced from Saunders (2015)

Strength of Correlation/ Pearson		Occurrence
-1	Perfect negative	
≤-0.8	Very strong negative	
≤-0.6	Strong negative	1
≤-0.35	Moderate negative	2
≤-0.2	Weak negative	3
≤0	None	
0	Perfect independence	
≥ 0	None	
≥ 0.2	Weak positive	1
≥0.35	Moderate positive	9
≥0.6	Strong positive	12
≥0.8	Very strong positive	9
1	Perfect positive	

The Spearman correlation determines the relationship between Nickel and Iron ore. It is a very strong, positive correlation *(*ρ = 0.89, n = 696, p <.001). The H_0 is rejected. The linkages to Copper and Aluminium are displayed as control variables. These depict the price movements of the elements that are loosely related to the stainless steel industry. However, the metals classify as industrial metals.

For reference reasons, the prices for Aluminium and Copper (are displayed in Annex 3. The ρ = 0.93 and ρ = 0.90 for Copper demonstrate a very strong positive correlation. The price movements are remarkably common to each other (co-movements). This leads to the conclusion that Nickel, Copper, Aluminium and Iron ore change alike.

Hypotheses testing Nickel vs. Iron ore

$H1_1$: If the Nickel price increases, the price of Iron ore increases.

$H1_0$: The Nickel prices change independently from the Iron ore price.

Table 18 Spearman's rho Nickel vs. Iron ore prices, Source: own data

Period	Correlation Coefficient	Sig. (2-tailed)	N	Strength of relation
1960-2018	0.89	0.000	696	Very strong
2000-2018	0.83	0.000	216	Very strong
2008-2018	0.87	0.000	120	Very strong

In the three-time periods, the H_0 is rejected ($\rho = 0.89$, $n = 696$, $p <.001$). Thus, there is a very strong and positive correlation between Nickel and Iron ore.

Hypotheses testing Nickel vs. Ferrochrome

$H2_1$: If the Nickel price increases, the price of Ferrochrome is increasing

$H2_0$: The Nickel prices change independently from the price of Ferrochrome.

Table 19 Spearman's rho Nickel vs. Ferrochrome prices 2000-2018, Source: own data

Correlation Coefficient	Sig. (2-tailed)	N	Strength of relation
0.36	0.000	144	Moderate
0.67	0.000	120	Strong

For the two periods, the H_0 is rejected (ρ 0.36, $n = 144$, $p <.001$). Hence, there is a moderate and a strong positive correlation between Nickel and Ferrochrome. The strength of the correlation has increased over the last decade. One of the main reasons might be that Ferrochrome is almost solely to a greater extent linked to the production of stainless steel. The main production is in South Africa and the main consuming country is China, with an increasing demand for stainless steel (US Department of the Interior, 2021, pp. 46–49). Heat resistant grades are the main consumers of this alloy. South Africa, as the main mining area, often suffers from a lack of electricity supply and other restrictions (i.e., labour cost increases and strikes), creating price volatility. The close link to the stainless steel industry links Ferrochrome and Nickel together. The main demand pattern is the same for both elements and the increasing demand in China creates a pricing power for the producers. However, as Chromium is required for superalloys, it is a strategic end-use that necessitates the creation of strategic reserves, at least in the US. The close relationship of these metals underpins multicollinearity that might bias the results with a lower accuracy of the results. However, it cannot be avoided.

Stainless steel Scrap grade 304 Europe price vs. Nickel

$H3_1$: If the Nickel price increases, the price of scrap Europe increases.

$H3_0$: the Nickel prices change independently from the scrap Europe price.

Table 20 Spearman's rho Nickel vs. stainless steel scrap 304 Europe prices, Source: own data

Period	Correlation Coefficient	Sig. (2-tailed)	N	Strength of relation
2000	No data available			
2008-2018	0.81	0.000	120	strong

For 2008-2018, the H_0 is rejected ($\rho = 0.81$, $n = 120$, $p <.001$). Hence, there is a strong and positive correlation between Nickel and SS scrap EU.

Stainless steel Scarp grade 304 USA price vs Nickel

H4$_1$: If the Nickel price increases, the price of scrap Europe increases.

H4$_0$: the Nickel prices change independently from the scrap Europe price.

Table 21 Spearman's rho Nickel vs. stainless steel 304 scrap USA prices, Source: own data

Period	Correlation Coefficient	Sig. (2-tailed)	N	Strength of relation
2000	No data available			
2008-2018	0.81	0.000	118	strong

For 2000-2018, the H_0 is rejected (ρ 0.81, n = 118, p <.001). Hence, there is a strong and positive correlation between Nickel and SS scrap USA.

The relationship between the Nickel price and both SS scrap prices is strong. The data suggest a relationship to the Nickel content (Annex 3). The scrap consists of at least 9% Nickel content is hence influenced by Nickel price fluctuations, due to the Nickel value. Another reason is the similar supply and demand situation. The stainless steel scrap price might have an element of prediction, as it is used to fill up the melting ovens to produce stainless steel. Hence, may be regarded as an "early bird" indicator, see section 3.6.
Therefore, Nickel is strongly and positively correlated with the ferrous and non-ferrous raw materials examined.

5.1.5.2 Impact of Nickel on the mining companies

H5$_1$: If the Nickel price increases, the share price of (*BHP Billiton)* increases

H5$_0$: The share price of (*BHP Billiton)* increases independently from the Nickel price

Table 22 Spearman's rho Nickel vs. share price mining companies 2000-2018, Source: own data

Miner	Correlation Coefficient	Sig. (2-tailed)	N	Strength of relation
BHP Billiton	0.70	0.000	215	strong
NorNickel	0.57	0.000	161	moderate
Vale	0.82	0.000	190	very strong
Glencore	Not sufficient data			

For the 2000-2018 period, the three hypotheses H_0 are rejected, like the first one between Nickel and the share price of *BHP Billiton* (ρ 0.70, n = 215, p <.001). Therefore, the Nickel price impacts the three examined relationships, the share prices of the mining companies, significantly for the time 2000-2018.

Table 23 Spearman's rho Nickel vs. share price mining companies 2008-2018, Source: own data

Miner	Correlation Coefficient	Sig. (2-tailed)	N	Strength of relation
BHP Billiton	0.80	0.000	120	very strong
NorNickel	0.68	0.000	120	strong
Vale	0.89	0.000	120	very strong
Glencore	0.74	0.000	81	strong

For the 2008-2018 period, all four hypotheses H_0 are rejected, alike between Nickel and the share price of *BHP Billiton* ($\rho = 0.80$, $n = 120$, $p < .001$).

Thus, the correlation is strengthened for all three relations. The correlation coefficient increases for the latter period by 0.10 points (*BHP Billiton*), whereas for *NorNickel* it strengthens by 0.11 points. During the period 2008-2018, the impact of Nickel increased compared to the period from 2000 to 2018. Thus, Nickel significantly influences the share price of the mining companies.

The significant role of the Nickel price for the share price of the mining companies is confirmed. The statistical finding matches the perception that increasing and decreasing prices reflect the business prospect of the mining industry to a significant share. It confirms the obvious finding that higher selling prices coincide with an increased the interest of investors.

5.1.5.3 Impact of Nickel on the stainless steel producers

$H6_1$: If the Nickel price increases, the share price of (*Outokumpu)* increases.

$H6_0$: the share price of (*Outokumpu)* increases independently from the Nickel price

Table 24 Spearman's rho Nickel vs. share price steel producer 2000-2018

Mill	Correlation Coefficient	Sig. (2-tailed)	N	Strength of relation
Outokumpu	0.38	0.000	216	moderate
Aperam	Not sufficient data			
Acerinox	0.62	0.000	216	strong
Yieh	Not sufficient data			
AK Steel	0.46	0.000	215	moderate
Posco	0.86	0.000	215	very strong
Jindal Stainless	0.65	0.000	171	strong
Nippon Steel	Not sufficient data			
JFE	0.52	0.000	185	moderate

For 2000-2018, all seven hypotheses (H_0) are rejected, like between Nickel and the share price of *Outokumpu* ($\rho = 0.38$, $n = 216$, $p < .001$).

However, the correlation for the "pure" stainless steel producers is stronger than for the other steel mills (*AK Steel, Posco, JFE*). Still, the exception is *Outokumpu. Note that OTK* went through a series of mergers and reorganisations during this time, which might dilute the result. The result suggests that the pure stainless steel producers (i.e., *Outokumpu, Acerinox, Jindal)* are closely linked to the Nickel price. *Posco* is the exception, the stainless steel business is in relative and absolute terms bigger than the stainless steel business of *AK Steel* in the US. *Posco* produced 2,95 million tons of stainless steel (Posco, 2011, p. 54). The stainless steel tonnage sold by *AK Steel* in 2012 did not exceed 0,6 million tons (AK Steel, 2013, p. 17), the exposure is hence, 4.5 times lower. In addition, the sales market for *AK Steel* is predominately the geographical area of North America and Mexico. Whereas *Posco*, as a global producer and supplier of stainless steel with melting units in South Korea and China (Qingdao) and several cold rolling lines across the globe (e.g., Vietnam, Turkey, China), is exposed to the global market (Posco, 2019).

Table 25 Spearman's rho Nickel vs. share price stainless steel producer 2008-2018

Mill	Correlation Coefficient	Sig. (2-tailed)	N	Strength of relation
Outokumpu	0.61	0.000	120	strong
Aperam	(-0.60)	0.000	85	strong negative
Acerinox	0.31	0.001	120	moderate
Yieh	0.84	0.000	75	very strong
AK Steel	0.66	0.000	120	strong
Posco	0.87	0.000	120	very strong
Jindal Stainless	0.64	0.000	120	strong
Nippon Steel	0.65	0.000	120	strong
JFE	0.36	0.000	120	moderate

For the 2008-2018 period, all nine hypotheses (H_0) are rejected, like between Nickel and the share price of *Outokumpu* (ρ = 0.61, n = 120, p <.001).

However, the "pure" stainless steel mills do not display a strong connection. Two correlations are weakening (*Acerinox* and *JFE*). The remaining three (*Aperam, Yieh and Nippon*) are all very strong. However, for *Aperam,* the correlation is negative. Hence, the impact of Nickel (2008-2018) on the stock price is, despite two exceptions, strong or very strong. The steel mills that produce only (pure) stainless steel, not carbon steel grades, have a stronger correlation to the Nickel prices. Because, the production quantity of stainless steel is much smaller (i.e., *Posco* produced roughly 2 million tons) compared to a total crude steel production of 35 million tons in 2011 (Posco, 2011).

Second, the proportion of Iron ore is compared to other material and value contents the decisive component for carbon steel grades. The proportion of scrap and other elements is lower due to the different production process (blast furnace) compared to the production of stainless steel.

Based on the interviews, risk management became a priority after the world financial crisis. This explains the shift from a strong to a moderate correlation for Acerinox. The mitigation strategy of limiting the exposure time to price volatility seems to be successful, compared to the other mills. Based on the changes in the correlation, the exposure of Outokumpu becomes stronger, for the other mills (i.e., Posco and Yieh) the correlation becomes less evident.

5.1.5.4 Impact of Nickel on the Exhaust gas treatment producers

$H7_1$: If the Nickel price increases, the share price of *Tenneco* increases dependently.

$H7_0$: The share price of *Tenneco* increases independently from the Nickel price

Table 26 Spearman's rho Nickel vs. share price exhaust manufacturers 2000-2018

Producer	Correlation Coefficient	Sig. (2-tailed)	N	Strength of relation
Tenneco	0.37	0.000	215	moderate
Faurecia	(0.31)	0.000	216	weak negative
Futaba	(0.32)	0.000	205	weak negative
Sejong	0.51	0.000	216	moderate

For the period 2000-2018, all four hypotheses (H_0) are rejected, like between Nickel and the stock price, in the first row of Table 26, *Tenneco* (ρ = 0.37, n = 215, p <.001).

However, the correlations are segregated into both directions of the gauge. Thus, the impact of Nickel exists but shows a low change for the latter period, 2000-2018.

Table 27 Spearman's rho Nickel vs. share price exhaust manufacturers 2008-2018

Producer	Correlation Coefficient	Sig. (2-tailed)	N	Strength of relation
Tenneco	(0.39)	0.000	120	moderate negative
Faurecia	(0.39)	0.000	120	moderate negative
Futaba	(0.29)	0.001	120	weak negative
Sejong	0.28	0.002	120	weak

For the period 2008-2018, all four hypotheses (H_0) are rejected, like between Nickel and the stock price, in the first row of Table 27, of *Tenneco* (ρ = (-0.39), n = 120, p <.001).

The correlations remain at low levels, even though the correlation for the share price of *Tenneco* is moving in an opposing direction from positive to negative (0.78 points). It is the largest swing in the examined data series. Higher Nickel prices have in 3 out of 4 incidents a negative impact on the stock price of the exhaust system producer. Hence, the producer with the highest value-add proposition compared to the excavation and the steel processing is negatively affected by the metal price movements. However, it is a weak or moderate relation.

Nonetheless, the Nickel price impacts the exhaust gas treatment system producer predominately (i.e., 3 out of 4) negatively. This supports the assumption that the exhaust gas treatment system producers are not in the position to pass the material price volatility risk to the OEM customers. Hence, it supports the assumption of unequal risk sharing. Despite the weak and moderate correlation, it sheds light on price risk that is reflected by the negotiation position of the Tier 1, a negotiation between two unequal partners. The increased value creation of the Tier 1 -from stainless steel material to a product- cannot compensate for raw material price risks. The negative impact suggests that the price risk burden is on the shoulders of the Tier 1 supplier. Increasing Nickel prices impact the share price negatively. However, this assumption is weak but existing and is biased by other factors, like the general economic development among others.

5.1.5.5 Impact of raw materials on Nickel prices

The impact of Nickel price on stock prices in the value chain of stainless steel has been demonstrated in the prior sections. However, Nickel is neither the only raw material nor the only potential influencing factor. Because of the segregated data availability, different periods are examined. These calculations are complementary to the hypotheses testing. Note, that multicollinearity in this particular case might bias the precision of the outcome, however, the results are suggesting a strong relationship.

Table 28 Spearman´s rho Nickel vs. industrial metal prices

Period	Nickel	Aluminium	Iron ore	Copper	Ferrochrome	Scrap 304 EU	Scrap 304 USA
1960-2018	1	0.93	0.89	0.90	No data availability		
2000-2010	1	0.89	0.86	0.93			
2000-2018	1	0.88	0.83	0.84			
2008-2018	1	0.81	0.87	0.83	0.67	0.81	0.81

Table 28 displays the correlation among the elements towards the Nickel price. The correlation coefficient is determined as a Spearman´s rho (non-normal distribution), see Table 28. The detailed calculations are provided in Annex 13. The descriptive analysis starts with the pricing data that is available since 1960 (Table 12).
Calculations confirm that all raw materials are significantly correlated to the Nickel price in all periods. Every value suggests a very strong positive correlation (Table 28).

A strong relationship between the metals is concluded. The exception is the correlation for Ferrochrome (strong positive). The co-movements and spill-over effects on raw material commodity prices are left for future research.

A stepwise regression analysis was performed and confirms a significant correlation for all periods (1960 – 2018; 2013-2018; 2008-2018) see Annex 13.

The model summary in Table 29 spans for 58 years and states an R^2 adjusted to 0.81, which is a remarkable tight fit to the expected values. Copper and Aluminium have the supreme impact.

Table 29 Model summary Nickel 1960-2018, Source: own data

Model Summary / Dependent Variable: Nickel monthly 1960-2018							
Model	R	R^2	Adj. R^2	Std. deviation	R^2 Change	Sig. F Change	Predictors
1	0.85	0.72	0.72	3,836	0.72	0.000	Copper
2	0.90	0.81	0.81	3,187	0.09	0.000	Copper, Aluminium
3	0.90	0.81	0.81	3,173	0.00	0.006	Copper, Al., Iron ore

For the ten-year period from 2008 to 2018, the influencing predictors are changing (Table 30 displays the significant role of Iron ore). The other prices have a minor influence on the prediction of the Nickel price.

Table 30 Model summary Nickel 2008-2018, Source: own data

Model Summary / Dependent Variable: Nickel monthly 1960-2018							
Model	R	R^2	Adj. R^2	Std. deviation	R^2 Change	Sig. F Change	Predictors
1	0.87	0.76	0.75	2,675	0.76	0.00	Iron ore
2	0.92	0.84	0.84	2,142	0.09	0.00	Iron ore, 304 scrap USA
3	0.95	0.91	0.91	1,630	0.07	0.00	Iron ore, 304 scrap USA, Copper
4	0.95	0.91	0.91	1,623	0.00	0.95	304 scrap USA, Copper
5	0.96	0.92	0.92	1,519	0.01	0.00	Scrap USA, Copper, 304 Scrap EU

This section provides insights into the prediction of the Nickel prices and how other raw material prices and scrap rates influence them. The scrap values are available for the period 2008-2018, however, for two regions (i.e., Europe and the USA).

Previous research (5.1.5) explored the CPV. The relationship has been demonstrated. Following this finding, an impact of raw materials on each other exists. Thus, there is an imminent impact and correlation between these metals. That impacts the companies in the value chain of stainless steel. Therefore, price volatility in raw materials impact share prices.

5.1.6 GARCH Model

From an econometric point of view, GARCH models are suitable for uncovering or testing dynamic relationships of time series. Not only does the specific modelling of the variance term lead to more efficient estimators. It also classical questions the random walk hypothesis, the estimation of forecast intervals, or the existence of latent factors that appear in a different light when GARCH models apply. The detailed calculations are shown in Annex 14. Price volatility may be studied using a GARCH framework. One assumption is that error terms are conditionally normally distributed. Hence, the GARCH calculation allows the prediction of future values and hence interests a variety of diverse stakeholders.

5.1.6.1 Data

The understanding of the price fluctuations requires modelling of the (price) volatility. With the aim to forecast future price trends. The GARCH model in this thesis regresses on squared returns (*p*) and variances (*q*). GARCH models regress on the observations of the previous period t-1 (Ruppert, 2011, pp. 484–490). This model deploys one lag in each of the individual conditional variance equations. Hence, it is referred to as NM(k)-GARCH(1,1) model (section 4.3.1.6).

The graphs in Annex 14 show a significant price volatility for the 10-year period. Besides the price trends, it is also helpful to provide descriptive statistics on the price data.

Table 31 GARCH descriptive statistics 2008-2018

Company	N	Min	Mean	Max	Std. Dev.	CV
BHP Billiton	2781	14.2	31.47	46.3	6.24	0.21
NorNickel	2768	3.66	16.94	31.3	4.71	0.28
Vale	2768	2.15	17.24	43.9	9.39	0.55
Glencore	1925	68.6	310	531.1	89.4	0.29
Outokumpu	2766	2.06	15	77.8	14.5	0.97
Aperam	2027	7.99	26.8	50.8	12.6	0.47
Acerinox	2809	6.90	11.5	18.3	2.22	0.19
AK Steel	2768	1.83	11.4	72.9	13.0	1.14
Posco	2768	32	79.3	148	24.3	0.31
Jindal	721	26	122.6	242	57	0.47
Nippon Steel	2715	1451	2854	7030	919	0.32
JFE	2715	956	2382	6400	909	0.38
Faurecia	2811	5.66	29	79	15.6	0.55
Tenneco	2768	0.7	70	69	17.4	0.44
Futaba	2715	836	1634	2527	344	0.21
Sejong	2729	2790	10654	22200	4152	0.39

The standard deviation of *Acerinox* share prices is the smallest (SD = 2.22) one. The *Acerinox* share price also has a small coefficient of variation, which indicates relative stability. While this is in line with the results of the previous periods. The CV for the

Acerinox share prices is the smallest within its peer group (Table 12, p.130, Table 13, Table 14) in section 5.1.4.

5.1.6.2 Price model estimation

Price estimation includes the stationary test, differencing the data and identifying the auto-regressive-moving-average (ARMA) model. The ARMA model is used to fit the compounded percentage change of prices. A unit root test is performed. Established on the result, non-stationary price data is converted to stationary data.

Table 32 GARCH ARIMA hypotheses testing

Company	Hypothesis testing		ARIMA model	
	Test statistic	P-value	Differencing	ARIMA model
BHP Billiton	-2.28	0.46	1	(1,1)
NorNickel	-2.44	0.39	1	(2,2)
Vale	-1.88	0.63	1	(2,0)
Glencore	-2.27	0.46	1	(0,0)
Outokumpu	-2.30	0.45	1	(5,1)
Aperam	-1.80	0.66	1	(1,0)
Acerinox	-2.78	0.25	1	(1,2)
AK Steel	-2.44	0.39	1	(4,3)
Posco	-2.78	0.25	1	(2,0)
Jindal	-0.13	0.99	1	(2,2)
Nippon Steel	-4.33	0.01**	1	(5,0)
JFE	-3.35	0.062	1	(3,0)
Faurecia	-2.32	0.44	1	(1,1)
Tenneco	-1.02	0.94	1	(0,0)
Futaba	-2.96	0.17	1	(1,0)
Sejong	-2.09	0.54	1	(3,2)

Just one variable (i.e., Nippon Steel) rejects the null hypothesis (H_0) (p <.05) that the data is non-stationary. Which is common for financial data as trends and periodicality often exist in financial datasets. Non-stationary data is not used in financial analysis. Hence, the differencing method is deployed to convert non-stationary data to stationary data. It is carried out by an initial differanting stage in the model, until the series is close to stationary, it exhibits no obvious trend. Please note that the higher the negative value, the stronger is the result is. Hence, the model is termed as an ARIMA model. The "I" in ARIMA refers to the differencing.

The ARIMA model is deployed to fit changes in price data. The model can be identified centred on the auto-correlation and partial auto-correlation graphs combined with the calculation of Akaike’s Information Criterion (AIC) results. It is displayed in the right two columns of Table 32. The AIC is a metric that helps to evaluate the strength of the model. It deploys the results of the maximum likelihood and the number of parameters. Typically, the maximum likelihood increases when adding more values, however, the AIC penalises for the number of parameters. A low AIC suggests a better fitting model (Holicka, 2019).

5.1.6.3 Estimation results

Based on past values, ARMA models are employed to model the conditional expectation of a process. GARCH allows modelling of the realisations of a stochastic process, imposing a specific structure of the conditional variance. The NM (1) model is equivalent to the standard GARCH(1,1). Depending on the ARMA model, the mean model is specified. For example, ARMA(1,1) means to look at the stock price at *t-1* to analyse the stock price at *t*. Table 33 displays the AIC differences, when comparing the ARMA models.

Table 33 ARMA model results

Company	AR (0,0)	AR (1,1)	AR (2,2)	AR (2,0)	AR (5,1)	AR (1,0)	AR (1,2)	AR (4,3)	AR (5,0)	AR (3,0)	AR (3,2)
BHP	5.28	1.53	1.53								
Nor-Nickel	4.31	0.94	0.94								
Vale	5.94	1.01	1.01	1.01							
Glencore	10.15	6.59	6.59								
Outokumpu	5.38	0.54	0.54		0.55						
Aperam	7.05	1.58	1.58			1.58					
Acerinox	3.33	-0.38	-0.38				-0.39				
AK Steel	4.63	0.50	0.50					0.50			
Posco	7.83	3.71	3.71	3.71							
Jindal	9.90	5.30	5.30	5.30							
Nippon	14.7	10.9	10.9						10.9		
JFE	14.8	10.8	10.7							10.8	
Faurecia	7.08	1.84	1.84								
Tenneco	7.59	2.58	2.58								
Futaba	13.5	9.56	9.56			9.56					
Sejong	18.5	13.8	13.9								13.9

The ARMA(1,1) model displays lower AIC values than the ARMA(0,0) model. Hence, the data looks reasonably fine. Also, regarding the ARMA(2,2) model, the differences in AIC are marginal, if rounded like above. Hence, the GARCH suggests that statistical reasoning can predict the next value.

The GARCH model allows forecasting of the share price. The forecasting of price developments has the potential to mitigate potential risks in the share price development. A typical application of modelling volatility is risk measurement. Value-at-Risk (VaR) is calculated at the 99% confidence level over 10 (days) periods. VaR is the loss that is expected to be exceeded only 1% of the time. The model is back-tested, and is depicted in the following Figure 28 at the example of BHP Billiton's stock price:

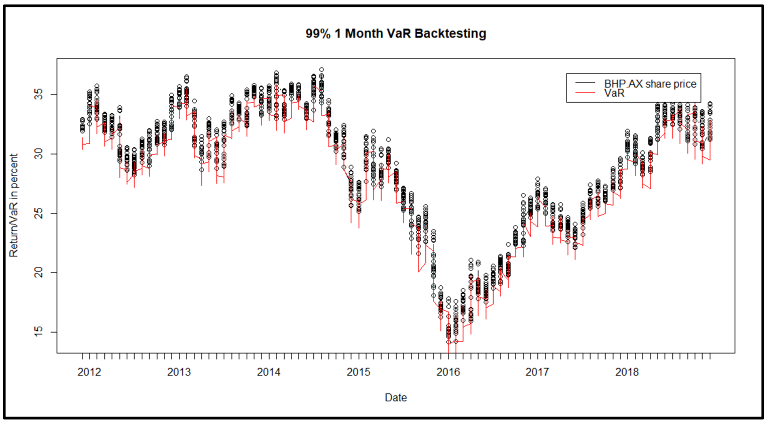

Figure 28 VaR BHP Billiton, Source: own data

The results in 5.1.5 evidence the link between the Nickel price and the share price change. Hence, the companies can influence the market expectation and the adoption of price changes. The model suggests a rare occasion to have a time advantage compared to the actual price developments in the market. It offers the potential to manage CPV rather than to react to it. The model allows regaining control of the share price alteration. The GARCH model is an essential method to model volatility from an economic and forecasting perspective. The predictive power of the GARCH is not to be underestimated.

In all interviews and the answers to the questionnaire, the word "statistical prediction" was not mentioned. Hence, one finding of this research is the applicability of statistical forecasting. It allows generating founded on historic data a time advantage. It is more advanced than the regression analysis. The results are more accurate and not biased by multicollinearity.

The data used to perform the calculations is daily data and not monthly averaged data, as in the rest of this thesis. Therefore, the GARCH model performs the prediction of the next days' value. Thus, limited by the data availability, no calculation was made for other raw materials.

5.1.7 ARDL calculation

The literature suggests that ARDL statistics are a suitable method for researching the long-run and the short-run effects of financial data series (Pesaran & Smith, 1995). To get around the problem of spurious regressions caused by non-stationarity, researchers have often performed unit root and cointegration tests (Ghouse et al., 2018). This research considers the data series 2008 to 2018 to understand the time delaying impacts of raw material price changes. The statistically significant impacts (5.1.5) are examined to understand the time delay between cause and effect. The earlier mentioned regression models assume that the relationship between the variables is constant. For time-series data, this assumption might be misleading.

The ARDL model is, hence, useful to forecast developments and to untie long-run relationships from short-run dynamics. The time-lagged influence of one variable on another variable is to be assumed. It can be demonstrated with the ARDL calculation. To examine this impact, the data set was amended to represent the value creation levels. The typical material grade for an exhaust system was deployed to examine the potential findings. The data series Compound represents this hypothetical material grade. The calculation model and the share of the ingredients are detailed in Annex 1. Hence, the ARDL calculation was computed with 4 variables:

- Compound (4% Nickel, 1% Aluminium, 76% Iron ore, 1% Copper, 17% Ferrochrome),
- Mining industry,
- Stainless steel Manufactures,
- Exhaust system producers

For these calculations of the ARDL model, the share prices of the segments have been combined. The reasoning to do so is the influence of the industry rather than on an individual company. The researched time is 2008-2018, due to data availability (i.e., scrap and Ferrochrome).

A box plot is the first calculation to reveal the distribution of the data series. The Compound and the stainless steel stock prices are displaying outliers in the positive direction. The data series of exhaust gas treatment system producers and the mining segment do not display outliers. Therefore, these are closer to a normal distribution than the other two segments on the left part of Figure 29.

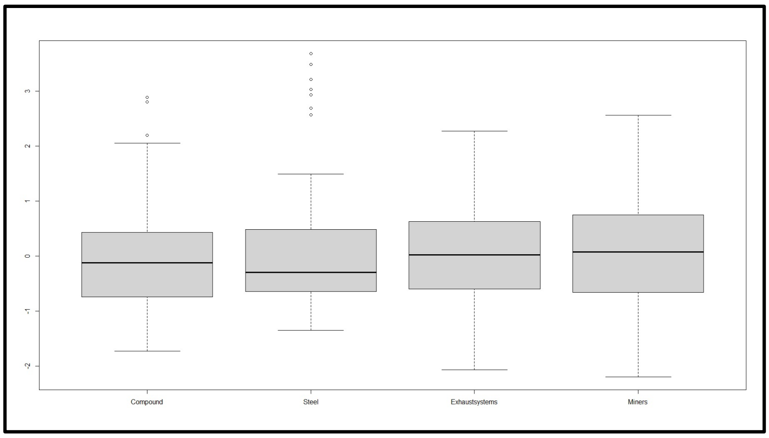

Figure 29 Box Plot (scaled data) for ARDL calculation, Source: own data

5.1.7.1 Scatterplots

The detailed consideration of the data series is displayed as a scatterplot. These reveal the initial findings. The Compound and the mills' graphs do not show the slightest resemblance to a Gaussian normal distribution. However, the graphs of miners and exhaust producer have a resemblance with a normal distribution, see Figure 30 for the view on the scatterplots.

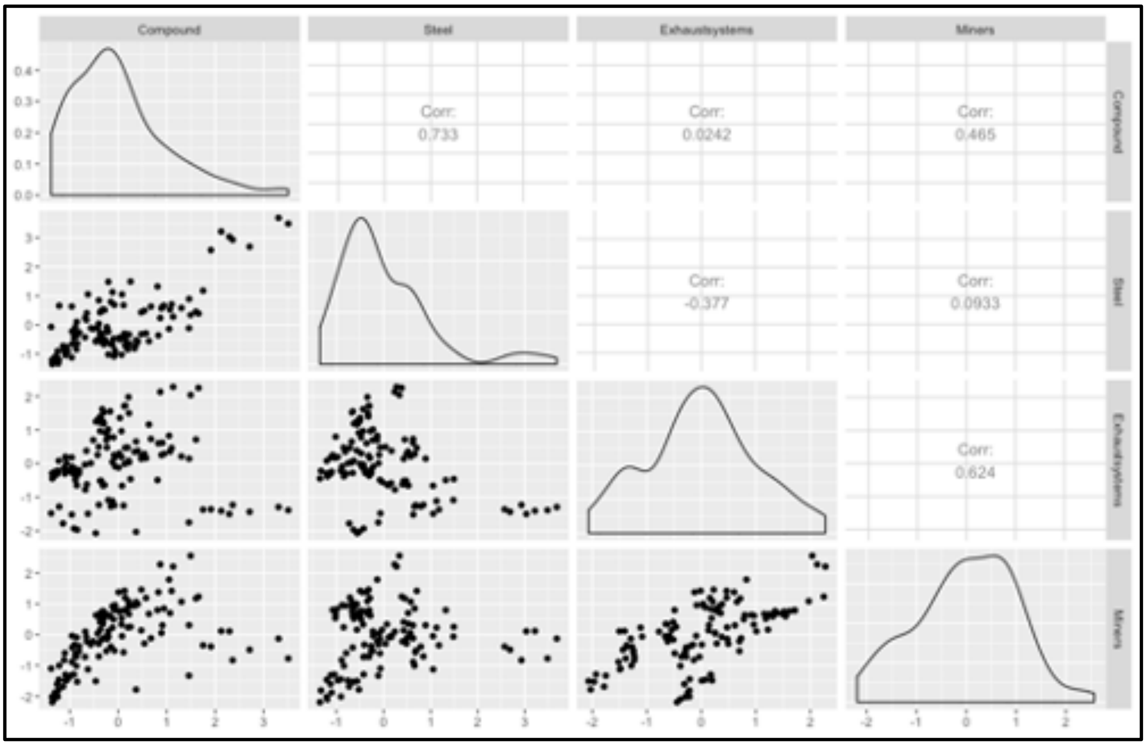

Figure 30 Matrix Scatterplot ARDL calculation, Source: own data

The data suggest the following correlation:

Table 34 ARDL correlation coefficients, Source: own data

No	Variables	Correlation coefficient	Description
1	Stainless steel industry and the Compound	0.73	strong positive
2	Stainless steel and exhaust gas industry	-0.38	moderate negative
3	Mining industry and Compound	0.49	moderate positive
4	Mining industry and exhaust gas industry	0.62	moderate positive
5	Stainless steel and mining	0.09	no relation
6	Exhaust gas industry and Compound	0.02	no relation

Two of the results are of particular interest. The strong positive relation of the first (“1”) calculation and the negative relation (“2”) line, detailed in Table 34. However, the data suggests that there is no relation between the Mining and the stainless steel business, for the exhaust system sector and the Compound. These findings are in line with the correlation and multiple regression analysis calculated that answer RQ 1.1 and RQ 1.3.

However, the averaged data series of the “pure” and the “mixed” producers are diluting the influence of Nickel on the stock prices. Thus, it confirms the strategic set-up of the steel producers to the impact of the price volatility of Nickel and Ferrochrome. The correlation strength is performed according to the PMCC (Table 17, p. 135).
In addition, a scaling of the price graphs was conducted to show the price development. This is shown in Annex 5.

5.1.7.2 Time series regression

The relationship between stainless steel and Compound is emphasised. This is the last stage of the ARDL modelling for the univariate cointegration test. Thus, there is no conditional heteroscedasticity and error autocorrelation left (Annex 5). The errors terms have been considered. The earlier findings (5.1.5) suggest that the Nickel price has an impact on the share prices of the companies in the diverse value creation levels of the stainless steel value chain. The role of Nickel was examined, and the pivotal impact confirmed. Three ARDL calculations examine the stimulus of the Compound (raw material) on the share prices.

Compound versus Miners

Table 35 ARDL Time series regression Compound vs Miners , Source: own data,

Regressors	Coefficient	Standard Error	T- Ratio	Pr(<t)
Intercept	1,251	603	2.08	0.04**
L Miners,1)	0.93	0.03	29.28	0.00***
L Compound (0:6) 0	4.16	1.83	2.27	0.02**
L Compound (0:6) 1	(-2.66)	2.00	(-1.33)	0.19
L Compound (0:6) 2	2.86	1.86	1.53	0.13
L Compound (0:6) 3	0.70	1.62	0.43	0.67
L Compound (0:6) 4	1.24	1.62	0.77	0.45
L Compound (0:6) 5	(-1.69)	1.57	-1.07	0.29
L Compound (0:6) 6	0.42	1.47	0.29	0.78
Degrees of Freedom	108	p- value		0.00
R- Square	0.90	F- Statistics		126
R Square adjusted	0.89	Residual standard error		1,469

* Significant at 0.1, **significant at 0.05, *** significant at 0

The data series Compound versus miners suggests a strong significant influence in the current month (ρ 0.02, n = 109, p <.005). Which is in line with the immanent sales of the mined products, as no further value creation activity is typically applied.

Compound versus stainless steel mills

Table 36 ARDL Time series regression Compound vs Steel mills, Source: own data

Regressors	Coefficient	Standard Error	T- Ratio	Pr(<t)
Intercept	563	155	3.62	0.00***
L Steel mills,1)	0.86	0.04	24.53	0.00***
L Compound (0:6) 0	0.96	0.47	2.06	0.04**
L Compound (0:6) 1	0.47	0.51	0.93	0.35
L Compound (0:6) 2	(-0.48)	0.48	-0.99	0.32
L Compound (0:6) 3	0.74	0.41	1.79	0.07*
L Compound (0:6) 4	0.59	0.41	1.44	0.15
L Compound (0:6) 5	(-0.53)	0.40	(-1.33)	0.19
L Compound (0:6) 6	(-0.71)	0.37	(-1.89)	0.06*
Degrees of Freedom	108	p- value		0.00
R- Square	0.90	F- Statistics		120
R Square adjusted	0.89	Residual standard error		13,130

* Significant at 0.1, **significant at 0.05, *** significant at 0

A time lagging effect, however, exists for the stainless steel manufacturers, after three (ρ 0.07, n = 109, p <0.1) and 6 periods/month (ρ -0.06, n = 109, p <0.1) and. Thus, the data advocates the assumption of three-month cycles (current months plus three periods) from the raw material input to the sales of the finished product.

Compound versus exhaust gas treatment system producer

Table 37 ARDL Time series regression Compound vs Exhaust, Source: own data

Regressors	Coefficient	Standard Error	T- Ratio	Pr(<t)
Intercept	1.11	4.53	2.46	0.02**
L Exhaust,1)	9.20	3.28	28.04	0.00***
L Compound (0:6) 0	4.14	1.64	0.25	0.80
L Compound (0:6) 1	1.78	1.78	1.00	0.32
L Compound (0:6) 2	2.13	1.66	1.28	0.20
L Compound (0:6) 3	2.96	1.46	0.20	0.84
L Compound (0:6) 4	(-1.33)	1.46	(-0.09)	0.93
L Compound (0:6) 5	6.55	1.40	0.47	0.64
L Compound (0:6) 6	3.76	1.32	0.29	0.78
Degrees of Freedom	108	p- value		0.00
R- Square	0.87	F- Statistics 91.6		91.6
R Square adjusted	0.86	Residual standard error		374.

Significant at 0.05, * significant at 0

Therefore, the data series (monthly average) suggests the strong significant influence of the Compound on all data series. However, for the exhaust gas treatment system producer, this impact is not significant. Hence, it confirms the time delaying effect. The interviews underpin the time delaying effect. This effect is partially given by the production time, however, the total process time from raw material purchase to the product sales is incorporated in the cycle time. This is confirmed by the interviews. It is solely *Acerinox* that confirms the total production time reduction as the method to mitigate CPV. Thus, the three-month cycle is the exposure time of the mills towards commodity price volatility. The six-month cycle must be investigated with future research as the cause and effect seem at all connected from a business perspective.

Therefore, the ARDL calculations curve out the existence of the time-delayed effect. Therefore, this observation leverages the mitigation schemes to suit this three-month delay. In line with the findings of sections 5.1.5 and 5.1.6, it confirms the relation and the inter-linkages between the raw material prices and the share prices. Hence, it allows an active mitigation strategy for the benefit of the companies in the stainless steel value chain. The example of *Acerinox* was indicated. It proves the existing statistical prediction that an active commodity price volatility risk management. The impact of it is measured as a change of the share prices. It suggests that an active risk management is feasible to protect the company from the exposure of raw material price changes. It demonstrates that the risk management approach of *Acerinox* to shorten the production cycle (ACX, personal communication, 2019) is a valid conclusion in line with the statistical results. Assumed by the lowest standard deviation of the share prices (5.1.6.1). Furthermore, by the interviews, and the strategic initiatives (i.e., AR's of *Acerinox)*. Therefore, the shortened production cycle has a positive impact on the exposure to raw material price risk, see section 5.1.4. Consequently, the shortening of the production cycle limits the exposure to price risk. This confirms the strategic importance of an active raw material price risk management to mitigate the impact of the price volatility.

Concluding remarks

There is evidence that raw material price changes impact companies in the value chain of stainless steel. This assumption is based on the calculations in section 5.1.5. The first statistical calculations show that a strong correlation exists. The regression analysis assumes that cause and effect seem to occur simultaneously. However, this is not necessarily the correct assumption. The ARDL calculations suggest the existence of a time lagging effect between cause (raw material price changes) and effect (share price changes).

Therefore, the ARDL calculation confirms the lagged impact of the raw materials (Compound) on the diverse value creation levels in the stainless steel business.

In this example, within the stainless-steel sector, the time lag of the price impact of the raw material by three periods (months) are assumed. The interviews with the executives of the 5 stainless steel producers strongly assume (triangulate) the time-lagged impact of the raw material prices. The time-lag is caused by production cycles, inventory restrictions and delivery times. All these causes may impact the share prices of the companies in the value chain of stainless steel. The identified delays for the value chain are consistent with the assumptions about typical production times.

For the mine operators, a no delay is identified, see Table 35. This corresponds to the short processing time of the raw materials, which are sold directly after mining – in most cases – without further processing steps.

For the steel mills (Table 36), the delay is extended to three months (ρ 0.07, $n = 109$, $p < .01$). This period corresponds to the typical lead time – from ore to stainless steel. This has been proven by the interviews. In this context, the practical reduction of production time at *Acerinox* should be mentioned. A statement from *AK Steel* stands out, which must store raw materials sometimes for months. This lengthens the lead time and thus represents a particular exposure to CPV. Ideally, this leads to profit taking (i.e., when prices rise) or to a reduction of the margin when prices fall. The price risk is deliberately prolonged. This is a strategic decision.

Despite the weak and moderate correlation coefficients, see Table 37, the ARDL calculation may suggest a time lag for exhaust gas treatment producers. This occurs in the second month (ρ 0.2, n = 109). However, it is a strong but not significant relationship. Hence, the assumption of the production cycle time cannot be confirmed entirely. The ARDL calculation suggests that value creation mitigates commodity price volatility. Which is in line with the prior findings.

The observed time lags are consistent with the production lead times from ore to finished steel, however not for the exhaust producers.

The ARDL calculation thus allows for an assumption about the temporal relationship between cause and effect. Furthermore, the calculations support the assumption that the companies could practise active risk management. This would reduce the impact of volatile commodities and sustainably protect the financial burden on the margins and thus the profit. Future research could explore the diverse impacts when dealing with daily or weekly price series to improve the understanding of the time lag effect. These findings are in line with earlier verdicts in the Oil & Gas industry (3.2.6). In this study, a similar relation for Nickel and for the stainless steel mills are confirmed.

5.1.8 Nickel price and annual profit

This section examines the relationship between the Nickel price development and the annual profit of the stainless steel mills. Quantitative methods like correlation analysis and multiple linear regression are deployed to answer RQ 1.3 (RO3). Thus, it comprises the conclusions of the prior section (I) and the influence of the Nickel price movements on the stock prices. Therefore, the ARDL results (5.1.7) confirm the time delay from occurrence to the impact. However, this research examines the potential impact of the Nickel price on the produced tonnage, turnover, number of employees and then the net profit/loss. These are calculated with the average Nickel price of the specific year. The period ranges from 2007 to 2019. This study is limited to the "pure" stainless steel producers. Therefore, the figures of *Outokumpu*, *Aperam* and *Acerinox* are compared.

The descriptive statistics are supplemented by the calculation of the CV, see Annex 20. For the ease of comparison, a graph illustrates the price developments. It compares the price alteration of Nickel versus the average sales prices of stainless steel.

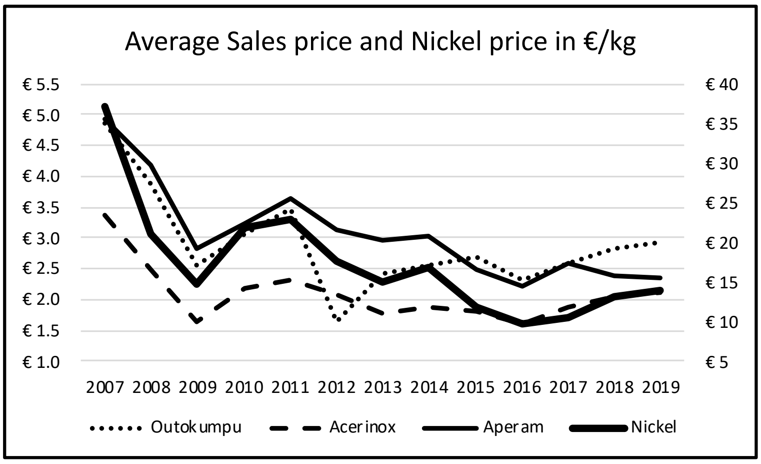

Figure 31 Average Sales & Nickel price 2007 to 2019 mills, Source: own data

The graphs in Figure 31 suggest a similar patter, in particular *Aperam* and the Nickel price move. The Nickel prices refer to the price indications on the right side of the Figure. In 2012, the average sales price of *Outokumpu* drops in contradiction to the other graphs. It might be caused by the activities in conjunction with the merger of *ThyssenKruppNirosta* (*TKN*) and *Outokumpu* (Annex 20).

Correlation calculations examined the link between the mills profit and the raw material prices besides tonnage and employees. Spearman's Rho is calculated for the net profit of the three producers (Table 38). The analysis reveals the impact of the produced quantity and the raw material input costs. The researched time spans from 2007 to 2018.

Table 38 Spearman´s Rho net profit of mills, Source: own data

Spearman´s Rho / Net profit	Outokumpu	Acerinox	Aperam
Nickel average	(-0.61)	0.03	(-0.3)
Ferrochrome average	0.03	0.33	0.4
Iron ore average	(-0.59)	(-0.24)	(-0.3)
Scrap 304 EU average	(-0.25)	0.08	0.1
Scrap 304 USA average	(-0.55)	(-0.38)	(-0.3)
Tonnage	0.05	0.40	0.66
Turnover	0.08	0.37	(-0.09)
Staff	0.06	0.04	(-0.26)
Profit	1.00	1.00	1.00

The results are consistent, since, with the specific industry set-up (high fixed costs), each unit produced has a positive impact. This is the case for *Acerinox* and *Aperam*, but there is no discernible volume effect with *Outokumpu*.

The statistical observations report a significant negative influence of the Nickel price- moderate (*Aperam*) and strong (*Outokumpu*). This finding seems logical, based on the previous calculations (5.1.5.3) for the stainless steel industry. The result -for the mills- is in line with the conclusions in section 5.4.2, regarding the mitigation scenarios. For *Acerinox,* one important part of the risk mitigation is the retention time of the input materials in the production and distribution process. The annualised data confirms the results of the reduced-price exposure.

However, there is no impact of the Ferrochrome prices on *Outokumpu*s annual profits. This can be deduced from the operation of its Ferrochrome mine in Finland. However, it influences the profit of the two producers that do not operate their own Ferrochrome mining plants. Therefore, the price fluctuations of this element do not affect *Outokumpus* financial results. This underlines the relevance of these calculations.

The negative impact of the US scrap prices at *Outokumpu* and *Acerinox* suggests exposure to the US scrap prices. This outcome is conclusive with the US-based operations (Calvert/AL and Ghent/KY) of these mills. Multicollinearity is considered as the prices might show interfering influences.

Table 39 Initial model summary mills, Source: own data

Company	R^2	Adjusted R^2	VIF max	VIF max -1
Outokumpu	0.96	0.82	237	219
Acerinox	0.88	0.38	145	139
Aperam	0.99	0.93	70	49

Due to collinearity and the “small” sample size, the adjusted R^2 is considered. The variance influencing factor (VIF) shows values of >10. Thus, the conclusions can be biased (Field, 2013, p. 242). Therefore, this value is unfavourable for predicting the producer’s profit. However, the multicollinearity confirms the strong correlation between the Nickel price and the profit development (Annex 20). Hence, the co-movement is in line with the expected results.

The timeline determines the sample size, with 12 data series and > 2 *dF.* The model is at the lower threshold, however it allows a reliable prediction (O´Brien, 2007, p. 675; Ryan, 2013, pp. 150–155).

Table 40 Adjusted model summary mills, Source: own data

Company	R^2	Adjusted R^2	VIF max	VIF max -1
Outokumpu	0.68	0.47	3.80	3.73
Acerinox	0.36	0.12	2.07	1.56
Aperam	0.71	0.60	1.79	1.49

The adjusted R^2 values are lower; hence, the prediction of the profit is less decisive. However, the prediction of the profit built on the adjusted R^2 values is valued (close to 50% of *Outokumpu*s and 60% of *Aperam*). Multicollinearity, although obvious, should be considered

as a limited perturbation (bias) of the model. However, these calculations prove the impact of the Nickel price fluctuations on the profit of the stainless steel producers.
The hypothesis confirms that the Nickel price impacts the profitability and answers RQ 1.3b.

Table 41 Annual profit steel mills 2007-2018, Source: own data

Company	Correlation Coefficient	Sig. (2-tailed)	N	Strength of relation
Outokumpu	-0.68	0.036	12	Negative strong
Aperam	-0.25	0.43	12	Negative weak
Acerinox	0.03	0.931	12	None

Time period: 2007-2018

H_1: If the Nickel price increases, the annual profit of (*Outokumpu*) increases dependently.

H_0: The annual profit (*Outokumpu*) increases independently from the Nickel price

The initial hypothesis (H_0) is rejected (ρ= -0.68, n = 12, $p < 0.05$). Therefore, there is an influence of the Nickel price towards the annual profit of *Outokumpu*.
However, the second and third hypotheses are verified. Statistically, there is no significant influence of the Nickel price on the annual profit of *Aperam* and *Acerinox*. However, the data suggests that the risk mitigation strategy of *Acerinox* alleviates the negative exposure to raw material price fluctuations. It comprises the fast and efficient transformation from raw material to the sold product. This is in line with the prior findings regarding *Acerinox*. These findings suggest *Acerinox* is less impacted by the price alterations in the raw material market than its competitors. The statistical findings of *Acerinox* are summarised in section 6.1.1.4. The share price development is less volatile compared to its peers.
The development (Figure 32) displays stable development. The other share prices display and enhanced volatility in the researched period. Hence, the mitigation strategies are offering protection against the raw material price swings.

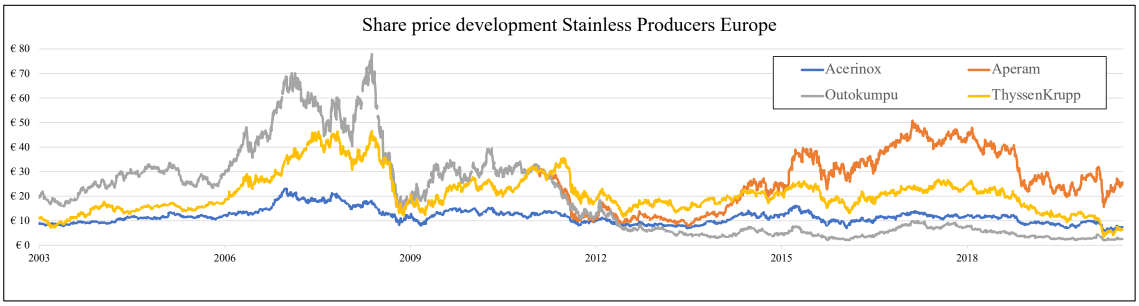

Figure 32 Share price development of stainless steel producers 2003-2020, Source: own data

However, this finding contradicts the common assumptions of the industry that the mills are more profitable when Nickel prices increase. However, there is an influence of the raw materials towards the annual profit. The results confirm a negative impact on the annual profit. The small number of observations and the co-movements of industrial metals might bias the data series. The annual averaged data overcasts price fluctuations and trends. However, the results are statistically sound. Future research might want to consider the quarterly results.

Sales price volatility

Section 5.1.5 revealed the price volatility of the commodity materials and the impact on the share prices. The profitability of the steel producers is not straight away linked to the quantitative output (tonnage sold). Following this thought, it is of interest if the sales prices display evidence of the volatile commodity components. The annual average sales price is determined, as annual turnover divided by the annual tonnage sold (Annex 20).

Table 42 Average sales price stainless 2007-2019, Source: own data

Average Nickel & Sales price per annum in €/kg				
Year	Nickel	Outokumpu	Acerinox	Aperam
2007	€37.23	€4.86	€3.38	€4.92
2008	€21.11	€3.89	€2.47	€4.17
2009	€14.65	€2.56	€1.66	€2.82
2010	€21.81	€3.06	€2.18	€3.22
2011	€22.91	€3.46	€2.31	€3.63
2012	€17.55	€1.63	€2.08	€3.13
2013	€15.03	€2.41	€1.78	€2.96
2014	€16.89	€2.55	€1.88	€3.02
2015	€11.86	€2.68	€1.82	€2.50
2016	€9.60	€2.33	€1.60	€2.22
2017	€10.41	€2.60	€1.89	€2.60
2018	€13.11	€2.83	€2.05	€2.39
2019	€13.91	€2.92	€2.13	€2.35

Table 42 lists the average sales price of Nickel and stainless steelmakers in Europe for the period 2007 to 2019. It elucidates the price volatility expressed as the annual average sales price of. However, to display the volatility, the following index value is procured.

The relative value is calculated: (9)

$$\boxed{Index\ percentage\ change\ = \frac{average\ sales\ price\ year\ (t)}{average\ sales\ price\ year\ (t-1)}}$$

Table 43 Index of change of average sales price 2007-2019, Source: own data

Average Nickel & Sales price per annum in €/kg / Index of change				
Year	Nickel	Outokumpu	Acerinox	Aperam
2007	100%	100%	100%	100%
2008	57%	80%	73%	85%
2009	39%	53%	49%	57%
2010	59%	63%	65%	65%
2011	62%	71%	68%	74%
2012	47%	33%	62%	64%
2013	40%	50%	53%	60%
2014	45%	52%	56%	61%
2015	32%	55%	54%	51%
2016	26%	48%	47%	45%
2017	28%	54%	56%	53%
2018	35%	58%	61%	48%
2019	37%	60%	63%	48%

The graph in Figure 31 reveals the proximity of the data series. Nickel prices are not the only influencing factor towards the sales prices. However, the supply and demand situation remain intact. The price development in the years 2007 to 2009 reveals the consequences of the World Financial crisis to the raw material input. However, despite an increased Nickel price, only *Outokumpu* and *Acerinox* increased the average price. *Aperam* suffered from a price decrease or the inability to pass raw material cost increases to the customer base. The production mix of the producers is not considered in these equations.

The mills with production sites in several countries, like *Aperam* (Belgium/Brazil), *Outokumpu* (Finland/USA) and Spain/USA/South Africa/Indonesia for *Acerinox,* seem to experience a similar or intricately linked price change. Therefore, the average sales price is linked to the market, hence to the raw material prices and the opportunity to pass on the costs of the alloys.

However, for *Acerinox,* since 2017, the average value surpasses the competitors, which hints to higher value-added products or the ability to increase sales prices faster.

Further research could explore if herd behaviour dramas play a pivotal role in the average price setting. Therefore, the average price should be calculated on a quarterly result basis.

5.2 Questionnaire and Interviews

Questionnaire

An overview of the demographics and some key characteristics of the respondents is detailed in Table 44.

Table 44 Questionnaire demographic data, Source: own data

Business segment	Absolute	Relative in %
Stainless mill	54	25%
Stainless Steel cold rolling	12	5%
Steel Trader	29	13%
Stainless Steel Service Centre	31	14%
Processing/ Machining of stainless steel to produce other products	68	31%
End customer/ consumer of stainless steel	13	6%
Other business segment	13	6%
Geographic location of Headquarter		
Africa	2	1%
Asia	16	9%
Australia	1	1%
Europe	146	81%
Latin America	1	1%
North America	15	8%
Exposure to stainless steel by		
Buying	57	32%
Neither	27	15%
Selling	96	53%
Exposure by annual quantity		
< 100.000 metric tons	108	60%
> 100.000	21	12%
> 250.000	51	28%
Ownership		
company with limited liability	26	14%
privately owned	83	46%
stock listed	73	40%

The respondents were all related to the stainless steel industry and held senior positions in the relevant companies. The more than half of the respondents came either from a stainless steel producer or from a company that is processing stainless steel. Therefore, the main target groups are represented. Based on the location of the HQ, the overwhelming part of the participants is from a company that is steered from Europe. Both Africa and Latin America have one stainless steel mill, both are steered from Europe (i.e., Acerinox and Aperam). In Australia, there is no stainless steel producer. Hence, the low response rate from the three continents (Latin America, Africa and Australia). The mail contacts have been collected by the author during his 30 years in the industry. Therefore, the relevance regarding to the stainless steel industry and the exposure in the industry is given. Convenience sampling is a concern, hence it is explained in the next section.

It was sent out via a web link to existing contacts in the stainless steel industry. Most of these contacts are known to the author. These contacts were collected over 20 years. 842 invitations were sent per mail. However, 4 reminders secured 192 responses, a rate of 23%.

Table 45 Questionnaire participation rate, Source: own data

Participants (aggregated)	Date	Participation rate in %	In % of total answers
96	28/10/17	11.4	50
164	05/11/17	19.4	85
171	06/11/17	20.2	89
175	11/11/17	20.7	91
177	19/11/17	20.9	92
178	26/11/17	21.1	93
182	02/12/17	21.5	95
190	17/12/17	22.5	99
191	20/12/17	22.6	99
192	28/12/17	22.7	100

This return rate is higher than the general return rate (lower than 10%) for questionnaires outside of the own organisation. However, it is lower than the potential return rates of 30-50% for postal or mail conducted surveys (Saunders et al., 2015, p. 441).

Interviews

Table 46 lists the categorisation and the occurrences. It is sorted according to the frequency of occurrence of the interview transcripts:

Table 46 NVivo Nods and cases, Source: own data

Nod	Cases	Reference
Mitigation	5	107
Price volatility	5	93
Organisation	5	91
Risk	5	87
Process	5	71
Competition / Market environment	5	70
Costs	5	65
Trade restrictions	5	54

Nod	Cases	Reference
Contracts	5	34
Substitution	5	26
CSR HSE	5	13
Overcapacity	4	12
Scrap	3	12
Backward integration Diversification	4	10
Spot business	4	10

The highest frequency is risk mitigation. It is linked to all five interviews, and this node is driven by the research objectives of research phase 2 (RQ 2.1 & 2.2), see section 2.2.2.

The data management, query, and visualisation tools offered by NVivo are enabling the connections and the linkages and patterns between the different interviews. The scanning data for a word frequency query helps to find these. It lists what is mentioned over 100 times:

Table 47 Word frequency interviews, Source: own data

Word	Frequency	In %	Similar Words
Price	313	1.63	price, priced, prices, pricing
Steel	153	0.80	steel, steels
Material	144	0.75	material, materials
Stainless	139	0.72	stainless
Risk	139	0.72	risk, risks
Market	137	0.71	market, marketing, markets
Products	130	0.68	product, production, productivity, products
Nickel	128	0.67	Nickel
Volatility	104	0.54	volatile, volatility

The coding of the collected primary data (transcript answers of the interviews) creates the frequency. The nods are the first categorisation of the data; hence, it allows an initial impression of the interviews and the focus on answering the RQ´s. The data indicates a strong emphasis on “Mitigation, Risk, Organisation and Process”.

Table 48: Nod's frequency / NVivo-coding, Source: own data

Nods	Frequency of Coding
Mitigation	107
Risk/Price volatility	93
Organisation	91
Risk/General	87
Process	71
Competition / Market environment	70
Costs	65
Risk/Trade restrictions	54
Contracts	34
Risk/Substitution	26

5.3 Mitigation strategies (Research questions Group 2)

The impact of commodity price volatility on the share prices has been examined. This section explores the existing strategies and categorisation of the strategies into sections. The findings reflect the responses of the questionnaire and the conducted expert interviews to triangulate the findings with the existing literature.

This thesis focuses on the relevant strategies to mitigate commodity price volatility in the stainless steel value chain. Hence, the selection of the mitigation scenarios does not embrace the holistic spectrum of mitigation strategies. The impact of the mitigation strategies is examined in section 5.4 and for two specific (risk) events in section 5.5. The primary data (questionnaire and interviews) is a solid foundation to research the impact of commodity price risk management in manufacturing, hence non-financial companies (e.g., not banks or insurances). The impact of commodity prices on the stock prices is almost not recognised for the steel (F, p.17) nor the stainless steel business (Figure 6, p.17). This thesis narrows the existing gap.

5.3.1 Listing of mitigation strategies (RQ 2.1)

There are diverse ways of clustering the mitigation scenarios in subcategories like operational, strategic, financial, non-financial. Before investigating the clustering process, the examined strategies (research question 2.2) are listed (research question 2.1). The literature review (3.5) reveals the ERM process and the three existing categories of risk management. Further literature about mitigation strategies and the commodity price volatility risk is listed in the literature review (3.3 and 3.4). The list of the examined strategies is displayed in Table 49 and in more detail in Annex 15. The examined literature represents a major part of the literature on commodity price volatility and potential mitigation strategies. The overview generates an understanding of mitigation strategies in literature. The headings display the keywords of the referenced mitigation strategy. Based on the literature review, the publications have been reviewed and these mitigation strategies are listed in Table 49. The numbers link the publication to the keywords. The listed mitigation strategies result from the literature review (3.3). It reveals diverse opportunities to cluster the strategies. However, it is not mentioned in all publications as it is underrepresented in literature (Gaudenzi et al., 2017). Another indication is the literature search routine at the beginning of the literature review section (Figure 6, p. 17) that could not identify any literature on price volatility in the stainless steel industry. However, as displayed, there is literature on mitigation strategies but still to a limited extent on raw material price risks.

The overview is a simplified listing, as the detailed applications are not part of the list. Which has been done to overcome over-complication. The listing displays the mitigation strategies – long-term & spot buy and vertical integration – are both mentioned in four publications, whereas customer selection and currency hedging are equally mentioned a single time. This partially contradicts the results of the questionnaire. The mitigation strategy of vertical integration is not a common pattern in the stainless steel industry; however, it is mentioned 4 times in the publications. The literature review and the questionnaire suggest that the combination of "long-term & spot buy" is a common price mitigation strategy.

Table 49 Mitigation strategies listed, Source: own data

Index usage 21, 22	Price settings mechanisms 1, 22	Sharing/ Passing of price fluctuations 11, 12, 2	Allocation flexibility 1, 3, 13	Information sharing 1,3	Tailored redundancies 3,12
SC network approach 2, 4, 16	Escalator clauses 1,18, 19	Staggering contracts 1, 23, 24	Piggy- back contracts 1, 24, 25	Redundancy of resources 3, 18, 19	Single Sourcing 8, 11
Dual / Multiple Sourcing 2, 11, 12	Operational hedging 2, 3, 6	Financial hedging 1, 3	Substitution 2,5,10	Forward buying 1, 19, 20	Demand/ Volume pooling 12, 19, 20
Purchase timing 13, 19, 23	Vertical integration 1, 9, 11, 12	Cross hedging 1, 6, 15	Inventory 3, 7, 11, 12	Insurance 6, 11	Customer selection 12
Diversification 6, 17	Option based contracts 26	Switching suppliers 1, 5, 10	Currency hedging 11	Longterm & Spotbuy 2, 3, 8, 12	Alternative recipes/specs 10, 11, 12

5.3.2 Clustering of mitigation strategies

The risk management process is described in section 3.5, as it constitutes the prerequisite for the development and introduction of active risk management in a company or organisation. The clustering of the mitigation strategies focuses on the applicability and practicability of price risk management. The grouping of the existing strategies positions the existing strategies. The listing of the mitigation strategies offers an initial overview and underlines that it is not a common occurrence in literature and just gained more attention (Gaudenzi et al., 2017). Therefore, the overview indicates the requirement to examine the mitigation strategies regarding the appropriateness in lessening raw material price fluctuations. This research demonstrates that price fluctuations can occur rapidly and in quite diverse ways. To avoid these commodity price volatility risks, it is therefore essential that the risk methodology is adapted to speed and communication.

By reviewing the mitigation scenarios, this research is not expounding on the operational or the strategic focus of each of these. In contrast, it clusters the present strategies and expands the existing academic categorisation with a fourth subcategory. Next, it stresses the importance of strategic management decisions to lessen the burden of commodity price volatility risks in the business ecosystem.

Besides the three listed price mitigation strategies (i.e., contractual, sourcing, and financial) there is room to review the strategic options. An example is the “strategic negotiation approach” that is initially included in the supply chain network approach. It is part of the Contractual column. This raises concerns about the relevance of the three columns. The listed mitigation strategies are typically operational tools, not strategic options. Hence, there is a requirement to research and categorise the mitigation strategies that are proactively deployed. The strategies that are initiated prior to price risk occurrences. It is important for a company to communicate the price risk. The direction of the price passing is a pendent topic (Deloitte India, 2018). The price risk can be passed downstream (i.e., supply base) or upstream (i.e., customer base) or a combination is workable. The OEM´s typically pass the price risk downstream to the Tier 1 supplier, whereas the stainless steel mills pass the price risk in form of the AS or fixed prices upstream. However, this depends on the negotiation power and ability of the company. The unique selling proposition (USP) or the system relevance of the company or the product might shift the bargaining position in favour of the seller. However, in other cases, the price risk can be passed or shared. However, this requires prior investment in a relationship-specific investments (RSI), see section 3.3.4 (Miwa & Ramseyer, 2000; Spencer & Qiu, 2001; Williamson, 1979) that mitigates the price volatility exposure or the price risk within the SCN (Fischl et al., 2015). Whereas the “western” method imposes the price and potentially other business risk on the weaker part of the negotiation, very often the TIER 1 supplier. It stresses the stronger economical, reputational, or negational position.

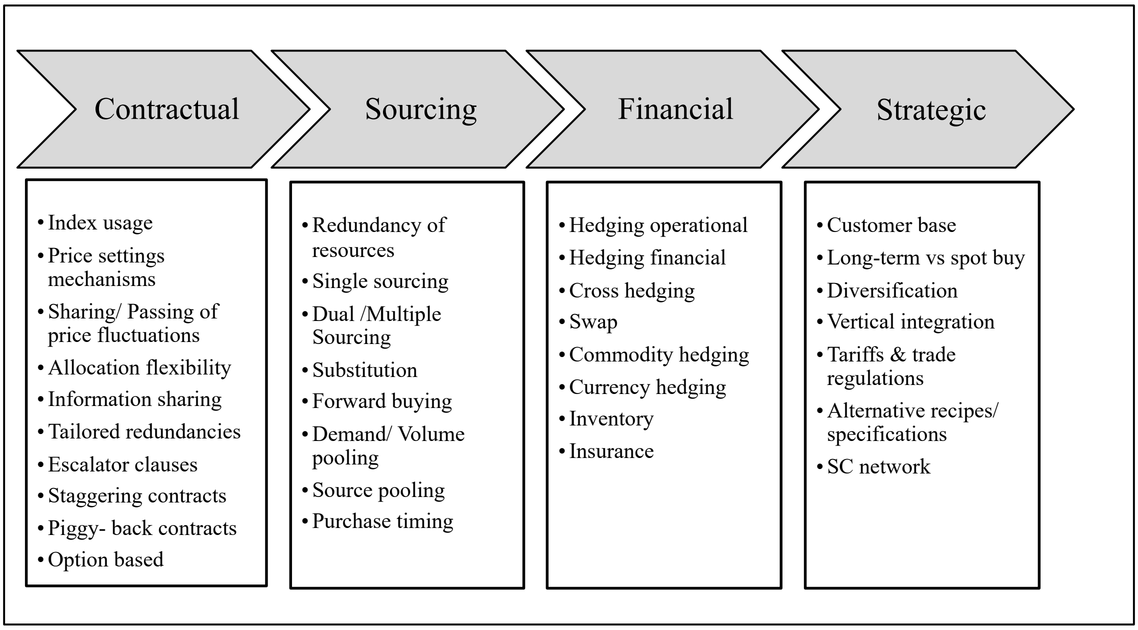

Figure 33 Clustered mitigation strategies, Source: own data

The mitigation scenarios are clustered into subcategories. However, the strategic category is added because of the necessity to expand beyond the operational aspects of ERM. The classification of mitigation strategies is not consistent or uniform in the literature; there are different concepts to divide them, if at all (Fischl et al., 2014). For this thesis, one focus is to strategically align the mitigation strategies towards price risks. The strategic positioning of the business activity in order to either prevent price risks, to pass them on or divide them between partners. These are strategic decisions and cannot be compared with reactive risk management. Since this strategic classification was not found in the literature, this classification was added. It includes the measures that a company may pursue proactively strategically to prevent price risks from raw materials.

5.3.3 Strategic price mitigation strategies

The answers to the questionnaire and the answers to the expert interviews are complimenting the existing pillars of commodity price mitigation. However, the existing mitigation schemes might still fulfil strategic tasks. Therefore, the fourth cluster combines strategic options. This category stresses the importance of the strategic need to cope with CPV prior to the risk occurrence as a strategic and not an operational tool. Literature on price mitigation strategies apart from financial (i.e., hedging) ones is still limited. (Pellegrino et al., 2019). Furthermore, due to a lack of familiarity, hedging is not widespread amongst industrial firms (Gaudenzi et al., 2017). This refers to the holistic view of price mitigation strategies.
The customer base selection is not “a priori” a price mitigation strategy. Hence, it is not exemplified in the SC or SCRM literature (Borghesi & Gaudenzi, 2013). The findings of the questionnaires – and to an extensive amount the concentrated thoughts of the interviews – allow to review this assumption. The selection and implementation of strategic choices are not independent of the sales and purchase activity. Still, it is an underestimated evaluation of the price mitigation process. Despite the academic gap, this strategic element is a fundamental mitigation strategy for at least *AST, Acerinox* and *Aperam* (APS, personal communication, 2019; AST, personal communication, 2019) to alleviate price risks. The strategic decision about the customer base includes the risk exposure and acceptance of raw material price fluctuations (Zsidisin & Hartley, 2012). It is a strategic decision to choose customer segments in such a way that raw material price risk can be passed on to customers. The companies balance the risk requirements against the profitability and production capacities. Therefore, the customer (industry) selection smoothens the order intake and increases production utilisation

rates. In the Japanese lean management environment, it terms “heijunka”. It is an essential part of the Toyota production system to create production efficacy (Ohno, 1984). The forecast ability and longer-term contracts are supplementing efficient resource planning to mitigate price volatility risk through quantity and commercial stability.
The long-term versus spot buying is an operational sourcing decision. However, to deploy this combination is a strategic decision (Shi et al., 2011). It combines the approach to secure the main demand with opportunity and risk (Barratt & Rosdahl, 2002). Therefore, it depends on the risk appetite and the maximum risk exposure a company may accept. The long-term commitment allows planning at fixed prices. Short-term flexibility is an enabler to take advantage of favourable market prices (Serel, 2007). From the industry experience, the short-term price advantages increase profitability. It is a strategic decision, as any excess material must be financed and stocked. 40% of the respondents (see Table 50) mentioned this mitigation strategy. The long-term contracts secure the cost base for a period of up to 2 years. Spot buying is among the stainless steel community reluctantly deployed as a single method to avoid price fluctuations. Spot buying covers typically immediate requirements, rather than for a build-up of stock or for future demand (Rajala, 2021; Rogers, 2022). However, spot buy purchases offer an advantage when market price levels decrease below the longer term agreements. The difference generates an extra margin for the buyer, compared to existing, typically longer-term purchase agreements. Noteworthy, that compliance must be considered with the availability of credit lines and stock facilities. The combination of both contract types enables an organisation to leverage the flexibility of the contractual situation. Hence, the combination of the methods is often deployed in the stainless steel industry. Its practical importance cannot be stressed enough. It is a tactical method; however, the usage is a strategic decision. The decision making and procurement must be agreed as a strategic mitigation method to leverage price fluctuations in once favour.

Table 50 Questionnaire strategies, Source: own data

7. What are the different buying/selling strategies your business is using to cope with Stainless-price volatility?		
Inventory control	75	45%
Longterm contracts	69	41%
Combination of Longterm contracts and spot buying	66	40%
Fixed prices	54	32%
Hedging of alloys (e.g. Nickel)	46	28%
Individual Answers	17	10%
Spot buying	13	8%
No procurement strategy is used or existing	6	4%
Participants	167	in %

The strategies of diversification and vertical integration are well described in literature. The diversification of the business has the advantages of risk-sharing or a risk balancing from diverse business segments (compare section 3.3). Vertical integration decreases the transaction costs as described by Williamson (2005) while the examples of Henry *Ford* and *Toyota* are still present (3.3.4). The idea of by-passing a market is not new, however, the delicate position of being a player in both markets might reflect on the overall market exposure of the company.

These mitigation strategies are purely strategic decisions, as the entire business model supported the implementation of strategic decisions (Gaudenzi et al., 2021). The organisation must take a prior commitment to a longer-term engagement. The interviews revealed no interest of the stainless steel mills in backward integration, in mid 2019. However, upstream vertical integration and business diversification are practical options to secure value add and direct customer contact (*AK Steel*, *Aperam, Acerinox*). For the participants of the questionnaire, see Table 51, the vertical integration is the preferred considered method. However, almost 60% are not pursuing the one or the other. This creates more exposure to price volatility, as the risk cannot be lessened by other business activities.

Table 51 Price volatility mitigation strategies, Source: own data

8. Did you consider one or both of the following strategies to mitigate the stainless-steel price volatility?		
No	91	59%
Verrtical integration	45	29%
Diversification	14	9%
Individual answers	4	3%
Participants	154	in %

After the interview, *Cliffland Cliffs*, a mining and pelletising company, a major supplier to *AK Steel* acquired them (AK Steel, 2019a). This example illustrates a forward vertical integration of the raw material supplier. The merger allows both companies to lower transaction costs and reduce price volatility for Iron ore. A major driver of price volatility for the principal product of *AK Steel* carbon grades, see Annex 3. In late 2021 *Aperam* acquired *ELG* one of the global stainless steel recycling (scrap dealers). It secures *Aperam* the strategic scrap availability, whereas the other mills have to buy from the market (Aperam, 2021).

Back in time, it was a common strategy to have own coal or/and Iron ore mines. Historically, the steel plants have been near the mines. Later, most mines concentrated on steel production as a core business. Hence, the mining business was spun off.

Regardless of this approach, the cost leader in the stainless steel market *Tsingshan* operates its own Iron ore, Nickel and Ferrochromium operations in Indonesia. In early summer 2019, the Indonesian government brought export restrictions forward. As a result, the Nickel prices increased (from US$14,735 per tonne on the LME to US$15,490). This marked the commodity's biggest one day gain since 2009 (Da Silva, 2019; Reuters, 2019; Wallace, 2019). *Tsingshan* focuses on cost control of the ingredients and operates an integrated production from ore to stainless steel. *Tsingshan* became the largest stainless steel producer in the World with an estimated capacity of close to 10 million tons (20% of the global consumption of 2019). Therefore, trade barriers are imposed to protect local markets (USA, Europe, India, and China, etc.) from these austenitic materials. This mill has the potential to disrupt the stainless steel industry.

The <u>tariff and trade barriers</u> are influencing the manufacturer and the industry. The steel industry has been the nucleolus of the European Union (EU) with the foundation of the European Coal and Steel Community (ECSC) founded in April 1951. The aim "was to ensure that the common market is supplied in an orderly manner, guarantee equal access to production, ensure that prices are kept at the lowest possible level" (Article 2 of the contract) (Adenauer et al., 1951). The first common market in Europe was set up by a steel related treaty. The industry convinced/ lobbied the government to focus more on the proper supply rather than on the lowest possible price. Infrastructure, general industry, and defence industry, among others all require stainless steel. Hence, there is an important political influence in this sector. The tools to protect the steel industry are often associated with tariffs, safeguard or anti-dumping (AD) measures. Local production is a protection against currency fluctuations and trade barriers (Chopra & Meindl, 2012, p. 45)

From this point of view, the influence of steel producers on politics and stakeholders is more important than in other sectors. The interviewees within the US steelmakers are in regular

contact with the policymakers in Washington D.C. The US trade legislation Act 232 was imposed to reduce the material imports into the US. The same political contact is ensured by the European mills to the national and EU authorities. It is a common pattern in the steel industry. Trade restrictions are a mitigation strategy for the steel industry.
The strategic decision to alter the material contents or use alternative recipes to generate a certain product is often linked to substitution as a sourcing strategy (Costantino et al., 2016). Despite the replacement of a product the mix of the contents of this product or a part product consistency is alternated (Zsidisin & Hartley, 2012). These standards of material grades offer a tolerance band for the ingredients, see Annex 1. Table 52 displays a sample calculation for the most expensive ingredients of the grade 1.4301/304.

Table 52 Material tolerances in value, Source: own data

Grade 304/1.4301	Tolerance in%	Tolerance in$	Price difference in%
∅ Nickel price $716/to	8.0 - 10.5	5.73 - 7.52	24
∅ FeCr price $574/to	17.0 - 19.5	10.05 - 11.19	10

The production within the grade limits offers substantial mitigation of commodity price volatility if the production process allows the fine-tuning of the grades. The production altering and the process efficacy are confirmed by the interview sessions. Following the route of alternation, the combination of both is applied in practice. It is a one-sided approach; it lowers the commodity price volatility exposure. The customer is penalised as the invoicing is based on the averages of the ingredients, not the actual material content. The price formula is unique to every producer. Despite the close association, there are substantial differences. The AS is stereotypically not negotiable. An exception is the option of fixed effective pricing.

Another technical aspect is the thickness tolerance. The producer manufactures at the upper tolerance band, so the quantity per time on aggregate, like a Sendzimir cold rolling line, produces more tonnage. As an example, the tolerance for a 2 mm coil is +/- 0.17mm. The gauge can be between 1.83 up to 2.17mm, according to DIN EN 10111. The mills are paid by weight and the production efficiency increases without jeopardising the customer specification by 2-5%. In the supply chain cooperation network approach (*Toyota* way), altering the characteristics stands for an advantage to both, not one party.
As an example, material grade 1.4509/441 is Titanium stabilised, whereas the *Toyota* suppliers and the local steel mills developed the material grade that has less Nickel, Ferrochrome and Titanium. The material has similar characteristics towards corrosion, heat, and pit corrosion resistance. Because of the manufacturing of *Toyota* cars across the globe, this grade is

AISI 429 or *JFE*429EX. The price difference might reach 30% and the reduced pricing roots in the material contents (based on author's experience and calculations).
The combination of the supply chain network approach and the alternation of material recipes can mitigate the CPV risk for the customer and the manufacturer. The concept of mitigation strategy altering material recipes is proven. Future research is expected to elaborate on this approach. Hence, it is a viable option to optimise price and exposure to commodity price volatility.

5.3.4 Spot versus Long-term buying pattern

After the questionnaires and the interviews (Annex 21 and Table 50), the combination of long-term and spot buy contracts is one of the three preferred options to mitigate price risks (Hong & Lee, 2013; Serel, 2007). Hence, it is a favourable option to lessen CPV risk in the stainless steel value chain.
The price data of two grades 1.4301/304 (austenitic) and 1.4509/441 (ferritic) is known, whereas the monthly alloy surcharge is given. To investigate the impacts, the following three buying patterns are compared:

- Purchase of the whole theoretical quantity on January 1st
- Purchase each quarter on the first of the month (1st Jan, March, July, October)
- Purchase of ½ lots on 1st Jan and 1st July of each year

This comparison (i.e., buying patterns) is an indication of the market price. Neither capital nor storage costs are considered. However, this calculation does not influence the result determination. The base price is constant in this calculation, no market knowledge is available to measure the spot pricing of individual sellers. This selling behaviour might cause "noise" in the market and may initiate "herd behaviour" buying patterns (Arezki, Loungani, et al., 2014; Pindyck, 2004).

The abnormality in the spot prices arises from an exaggeration of prices. This difference is influenced by the individual market assessment, but herd behaviour (2.2.1 and 3.2.3, Figure 11, p.45) cannot be excluded or avoided. Hence, spot prices are often impacted by irrational market assessments rather than the supply and demand function. Unless there is no material available, a lack of availability always has the potential to disrupt existing price levels.

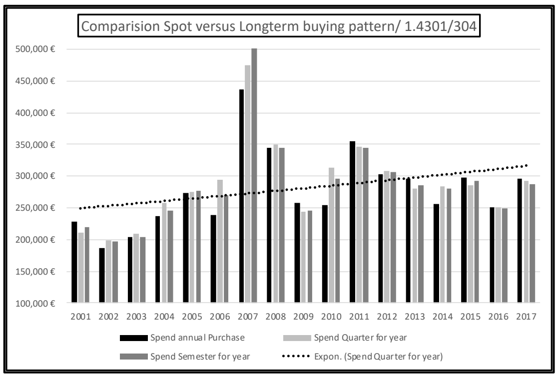

Figure 34 Buying pattern 1.4301, Source: own data

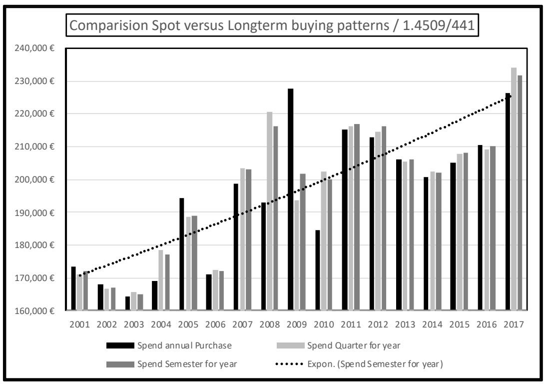

Figure 35 Buying pattern 1.4509, Source: own data

Figure 34 displays the effective price curve for 1.4301/304, with a peak in 2008, that coincidences with the Nickel price peak. The two succeeding years are the path to the world financial crisis (5.5.2). Austenitic material is the most common grade, it is a global commodity. Few tariffs or non-tariff barriers characterise these years. Figure 35 displays the same period but for ferritic material used in automotive (exhaust system), food and beverage applications, kitchen equipment, etc.

The actual values for the three buying patterns for both grades are listed in Table 53:

Table 53 Buying pattern values, Source: own data

Material grades	Spend annual Purchase	Spend Quarter	Spend Semester
1.4509/441	€3,321,240	€3,353,280	€3,355,320
	100%	101%	101%
1.4301/304	€4,711,680	€4,877,010	€4,851,120
	100%	104%	103%

The result is obvious, the price for ferritic material differs over time by 1%. The calculations neglect the costs for financing and stocking the material. For austenitic material, the difference is higher. However, differences exist, but without a clear trend (Table 54).

Table 54 Spot buy versus long-term 1.4301/304, Source: own data

Year	Spend Annual	Spend Quarter	Spend Semester	Maximum	Minimum	Average
2001	€227,400	€211,650	€219,900	€227,400	€211,650	€219,650
2002	€186,600	€199,200	€197,400	€199,200	€186,600	€194,400
2003	€203,400	€209,100	€204,600	€209,100	€203,400	€205,700
2004	€237,000	€257,550	€245,400	€257,550	€237,000	€246,650
2005	€274,200	€274,800	€277,500	€277,500	€274,200	€275,500
2006	€238,800	€294,810	€269,880	€294,810	€238,800	€267,830
2007	€436,080	€474,480	€504,240	€504,240	€436,080	€471,600
2008	€343,800	€349,800	€345,180	€349,800	€343,800	€346,260
2009	€257,760	€244,410	€246,000	€257,760	€244,410	€249,390

Year	Spend Annual	Spend Quarter	Spend Semester	Maxi-mum	Minimum	Average
2010	€253,680	€313,080	€296,520	€313,080	€253,680	€287,760
2011	€354,240	€346,650	€344,040	€354,240	€344,040	€348,310
2012	€302,160	€307,980	€306,420	€307,980	€302,160	€305,520
2013	€295,440	€281,100	€284,880	€295,440	€281,100	€287,140
2014	€256,440	€284,070	€280,260	€284,070	€256,440	€273,590
2015	€298,440	€285,300	€293,100	€298,440	€285,300	€292,280
2016	€250,440	€250,980	€249,000	€250,980	€249,000	€250,140
2017	€295,800	€292,050	€286,800	€295,800	€286,800	€291,550
Σ	**€4,711,680**	**€4,877,010**	**€4,851,120**	**€4,977,390**	**€4,634,460**	**€4,813,270**

It is concluded that, over time, no buying pattern shows a significant advantage. In shorter periods, the speculative buying pattern might have an advantage or a risk.

5.3.5 Supply chain cooperation

The Japanese way of cooperation, “keiretsu”, enables the sharing of risk and opportunity. An impressive example is *Denso* and *Toyota,* both headquartered in the Nagoya region/Japan. The close cooperation has led to a common profit margin pattern in the period between 1969-1996 that was researched by Anderson (2003) to analyse the Japanese “keiretsu”. It is a wide-ranging decision as it sets the strategic sourcing and risk mitigation (Fawcett et al., 2008). Hence, the potential hostage syndrome must be considered. It overarches the management system of the involved companies. The close cooperation between the Japanese companies raises similarities to tariff trade restrictions. The mutual benefits include the reduction of transaction costs and the benefits of an increased trust level and communication (Spencer & Qiu, 2001). Despite the economic importance in the Asian region, the literature is limited.

5.4 Impact of mitigation strategies

Research question 2.2 examines the linkage to the value creation levels in the stainless steel business. The particularities are examined and exposed, guided by RO 5. This approach is neither completely deductive nor inductive, hence it refers to the abductive research approach. The annual reports delivered the foundation for the literature research.

5.4.1 Mining industry

Raw material price fluctuations immediately impact the mining industry. An inelastic production output characterises the sector. The adaption of production capacities and demand is characterised by a time delay.

The mining industry may protect the production and thus the output product in terms of price by financial safeguards such as hedging or insurance. The production efficacy would be the decisive factor for profit maximisation. (Tufano, 1998), but none of the mining companies considers hedging the complete production (Callahan, 2002; Tufano, 1996).
The decision to use financial hedging depends on the risk appetite of the organisation and the stakeholders.

Table 55 Main commercial business risks for mining companies, Source: own data

Risks	Glencore		NorNickel		BHP		VALE	
Annual report	2018	2019	2018	2019	2018	2019	2018	2019
Commodity price volatility	x	x	x	x	x	x	x	x
Currency volatility	x	x	x	x	x	x	x	x
Trade barriers	x	x	x	x	x	x	x	x
Substitution							x	x
Global demand reduction	x	x	x	x	x	x	x	x

The business risks have been taken from the annual reports of the mining companies (Annex 17). The years 2018 and 2019 are taken as examples of business risks of the mining companies. However, business risks are changing over time and are not constant. This is a qualitative view. The literature of the annual reports (AR) revealed different risk management maturity levels, see Table 55. The reports of *NorNickel* and *BHP Billiton* are detailed. *Vale's* explanations are kept very simple and general. Potentially because *Vale's* business set-up depends on a sole product, i.e., Iron ore. The Ore is exported to an increasing share (up to 50%) to China. However, a strategic initiative to diversify the sales markets is not apparent.

The implemented risk mitigation scenarios are summarised in Table 56. All companies have identified the commodity price fluctuations and currency fluctuations as the main external business risk. The main raw material business is conducted in US dollars (Vale, 2019, p. 23). The balance sheet currency is often not the US dollar because of the location of the HQ. *Glencore* is based in Switzerland (Glencore, 2019, 2020), *NorNickel* in Russia (Nornickel, 2019, 2020), *Vale* in Brazil (Vale, 2019, 2020) and *BHP Billiton* in Australia (BHP Billiton, 2019, 2020).
However, hedging is not the most indicative option to mitigate price fluctuations. *NorNickel* (Nornickel, 2019, p. 265, 2020, p. 311) and *BHP* in 2018 (BHP Billiton, 2019, p. 34) rejected this risk mitigation strategy. Whereas *Vale* and *Glencore* hedge a certain extent for raw

material transactions. Cross hedging or derivates or swaps are implemented (Glencore, 2019, p. 120, 2019, p. 196).

Table 56 Commercial Mitigation strategies for mining companies, Source: own data

Mitigation	Glencore		NorNickel		BHP		VALE	
Annual report	2018	2019	2018	2019	2018	2019	2018	2019
Hedging Currencies	x	x	x	x		x	x	x
Hedging Commodity prices	x	x				x	x	x
Hedging Interest rates	x	x			x	x		
Customer selection	x	x	x	x	x	x		
Market selection			x	x	x	x		
Diversification - Product	x	x	x	x				
Diversification- geographic	x	x	x	x	x	x		
Lobbying	x	x	x	x			x	x
Contractual forms	x	x	x	x	x	x		
Index Pricing					x	x		
Monitoring of risk appetite	x	x	x	x	x	x	x	x
Strategic partnerships			x	x				
Upstream business activities	x	x			x	x	x	x

The conscious *selection of customers* and geographic markets among mining companies is a common means of balancing the negative impact of price and demand fluctuations. Declining sales pressure or demand, or even worse, the combination of the two risks, has a significant impact on cash flow. The principal costs are fixed costs, and almost no value-added transformation is performed at the mining companies. Therefore, the transaction prices are set around the globe. These are the decisive factor of the profitability of the mining companies.

Thus, the conscious selection of customers, accompanied by long-term cooperation or at least with long-term purchase commitments, is crucial for the planning of the business. The *diversification* of the product portfolio and the diversification of business activities, for example, into upstream business processes have been identified (Kituyi, 2019).

Therefore, *Vale* stands out. It has interests in steel mills in Brazil and the USA and a large Nickel production in Indonesia, which includes the refinery of raw Nickel. However, the other mining companies also have some refining operations through so-called smelters to ensure the value-added activities remain within the business portfolio. The findings regarding the mining industry are in line with the previous findings of the Gold industry in the USA (Callahan, 2002; Tufano, 1996). The individual risk appetite is a decisive factor in the selection of mitigation strategies. The risk portion is monitored by all researched companies, but active risk-taking is not mentioned in the annual reports of the researched miners.

To answer whether the risk management increases, the firm value depends on the risk appetite that the respective company follows. However, if shareholders strive to maximise their wealth, they are not a priori interested in stable, predictable revenues. Therefore, hedging is deployed to secure the revenues, which is in line with the conclusions of Callahan (2002). This is reflected in the non-hedging strategy of *NorNickel, as* they accept the price risk as part of the business sector.

The mines adjust the supply quantity to adopt market and company necessities. This adoption reflects the tendency of the mining operators to reach a critical mass to influence the market prices.

RO 5 cannot be concluded with a simple answer for the mining companies. However, the mining companies have various financial or contractual means at their disposal to secure the price of the sales units. It suggests that the mining companies accept CPV as part of their business model. Therefore, the impact of price swings is a strategic business decision. Surprisingly, the tendency to invest into value added operations is not very common to alleviate the price risks. This conclusion is in line with the existing literature, price volatility is accepted as part of the industry, see details about the Gold industry.

5.4.2 Stainless steel producers

Price volatility impacts stainless steel producers from purchasing to sales. It first appears with the procurement of raw materials from the miners. Price volatility is the constant unknown during the production and sales process. The mills attempt to pass price fluctuation to customers in an adequate format, see Figure 36.

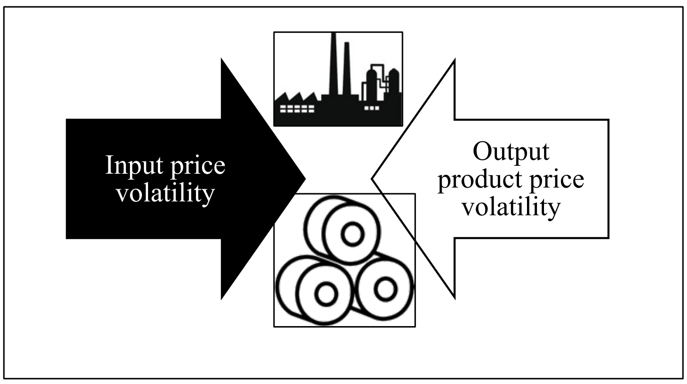

Figure 36 Tensions profitability stainless steel mills

The influence on the financial results of the stainless steel manufacturer is significant, as examined in section 5.1.5.3. The commodity price mitigation scenarios facilitate diverse choices (Table 49, p.163).

However, the outcomes of section 5.3 and the examination of the annual reports of the "pure" stainless steel mills for the years 2015, 2017, 2018 & 2019 challenge the existing strategies. The prior conclusions triangulate the findings of the literature review, the questionnaires, and interviews, guided by RO 5 to answer RQ 2.2.

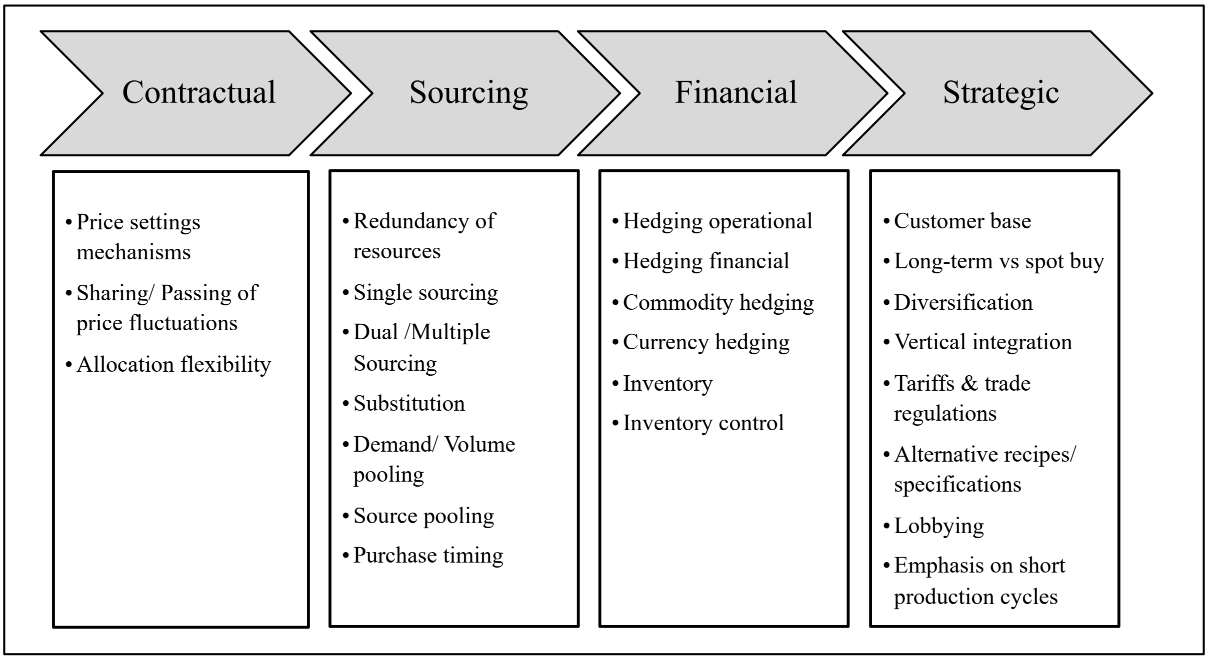

Figure 37 Mitigation strategies of stainless steel mills

The cross-examination of the annual reports focussed on the aspects of major risks and mitigation strategies (i.e., inventory control, hedging), see Figure 37. The answers to the questionnaire - employees of the mills- reveals the mitigation strategies, see Table 57.

Table 57 Questionnaire, question 7/ mills, Source: own data

7. What are the different buying/selling strategies deployed to cope with price volatility?								
Region	N	Fixed prices	Long-term	Spot	Long-term and spot	Hedging of alloys	Inventory control	No strategy
USA/EU	49	9	16	1	21	23	25	0
		9%	17%	1%	22%	24%	26%	0%
Rest of World	5	0	2	0	4	2	3	0
		0%	18%	0%	36%	18%	27%	0%

The results comprise the answers of the steel mill (selection criteria). The focus is on inventory control, hedging, long-term and spot buy opportunities. In contrast to the fixed prices and long-term agreements, which are less important than for steel service centres (SSC) and the exhaust gas treatment system producers as end customers. The SSC´s favour long-term contracts (39%), hedging, however, is applied by just 8% of the participants. Noteworthy it is a small sample; hence, the data just suggests this direction. This is detailed in Table 61 (p. 183) and Table 69 (p. 213). The data suggests that the mills deploy inventory control and hedging mitigation strategies in contrast to their customers.

In the present case, the producer hedged Nickel and Iron ore (Annex 8). Table 58 displays the major risks per category. The detailed evaluation is listed in Annex 17.

Table 58 Main risks stainless steel producers

Main Risks / Stainless steel Producers (AR 2015-2017-2018-2019)				
Mill	Contractual	Sourcing	Financial	Strategic
Acerinox	-	-	2-2-2-3	3-3-3-5
Aperam	1-1-1-1	1-1-1-1	4-6-7-7	4-5-8-8
Outokumpu	1-2-1-1	-	4-4-4-4	3-4-5-5

Table 59 reveals an overrepresentation of the financial and strategic risks, with 103 occurrences, compared to the contractual and the sourcing risks, represented by 13 occurrences. The annual reports have been examined, and the categorisation was deployed to list the occurrences of the main risks.

The existing business risks and the mitigation scenarios (Table 59) seem to match, at least in the strategic category. Hence, risk and mitigation strategies match the risk and the mitigation strategy of the mills. The strategic value-enhanced operations reconfirm this (Table 60). The AR´s of the mills were researched. These revealed a latent focus for the sourcing sector, which contradicts the results of the interviews. *Aperam* focuses on sourcing as a leverage to maximise its melting efficiency. The redundancy of resources was vital to substitute stainless steel scrap against Nickel for the efficient operation of the melting shop (APS, personal communication, 2019).

Table 59 Main mitigation strategies of stainless steel producers

Main Mitigation Strategies / Stainless steel Producers (AR 2015-2017-2018-2019)					
Mill	Contractual	Sourcing	Financial	Strategic	Comment
Acerinox	3-2-2-3	-	0-1-1-1	7-6-11-12	Executive involvement
Aperam	-	-	-	5-6-12-12	Executive involvement
Outokumpu	0-1-1-1	-	1-2-2-2	2-2-2-3	Executive involvement

The principal mitigation strategies for the stainless steel producers, according to the annual reports (Annex 17), are:

- Hedging of raw material costs (Nickel) and currencies

- Diversification
- Extension of the product range
- Seeking for Niche markets (Nickel or special alloys)
- Customer selection
- Vertical integration
- Downstream: operation of mines (*AK Steel, Aperam* & *Outokumpu*) and recycling business (*Aperam*)
- Upstream: Long products
- Operational excellence initiatives
- Labour cost per ton
- Short production cycles
- Price fluctuations are shared/passed to the customer
- Political and governmental lobbying to secure favourable trade restrictions

5.4.2.1 Hedging

Companies often hedge to lessen the currency risk (Costantino et al., 2016). It is the same as for the mining operators that attempt to mitigate this external risk for purchase and sales activities (Annex 17). The questionnaire highlighted the routine operation to hedge metals like Nickel and Iron ore (Table 57). Hedging limits the exposure to commodity price volatility and the negative impact to stocks returns (Carter et al., 2017). The interviews confirmed this routine despite *AK Steel*. They sourced via the spot market and long-term contracts (Annex 8). However, as of 2019, this scenario changed, due to the merger (*Cliffland Cliffs)*, see 5.3.3.

5.4.2.2 Diversification & vertical integration

Diversification and vertical integration are means which are without exception investments that represent a long-term engagement from the mills. The AR's discern fragments of the price mitigation strategies. The actual strategies have been probed by the interviews. Hence, just fragments have been revealed in the annual reports of the mills.
Direct customer contact is perceived as a seismograph of an increased understanding of customer requirements and the actual consumption (tonnage) of current and future requirements. Independent stockholders are often cut out. The mills organise the material availability directly for the direct customer base. Complexity is added however, it becomes a direct customer experience, without another supply level that might bias volume developments by stock level adjustments (i.e., increases or decreases). However, this approach is limited to bigger (quantity) or strategic customers, which might consume certain grades that should not become a stock item at stockholders. An example is the *Aperam* grade K44x, that is supplied solely via the *Aperam* sales network. These supply chain initiatives attempt smoothening the

material supply and demand. The speculative momentum (e.g., spot demands) is almost eliminated. The direct customer contact, and the increased level of communication that goes hand in hand with an increased market intelligence allow a better planning (Acerinox, 2020, p. 128; Aperam, 2020, p. 17; Outokumpu, 2020, p. 8).

The aftermath of opportunistic buying patterns (i.e. stockholders) results in unfavourable production utilisation rates at the mill. This is a common approach among the European and American manufacturers to seek the direct contact to the customers, but to a varying degree, see 5.4.2.3. It links with the stricter inventory control of the producer and consumer.

There is a tendency that niche or special markets should be targeted. *Acerinox* pursuits this long product business and acquired in 2019 special steel producer *VDM metals*. However, *Outokumpu* seems to focus on product synergies and the long product business. *AK Steel* works with its own- and third-party distribution networks. However, they diversified into the tube business.

Outokumpu (Ferrochrome mine) (Outokumpu, 2020, p. 85) and *Aperam* (coal activities *and scrap trading* (Aperam, 2020, p. 66)) enforce backward integration. Mining is considered a price mitigation strategy. Ferrochrome was sold to stainless steel competitors (OTK, personal communication, 2019) and permits the mill to participate. All stainless steel makers in Europe consider forward integration activities, see Table 60.

Table 60 Stainless steel mills forward integration activities, Source: Annual reports of stainless steel mills

Producer	Forward Integration plan
Acerinox	Long- products, Welding wire, Special grades
Aperam	Long products, Nickel Alloys, Special grades
Outokumpu	Long products, Special grades

The long product activities increase the utilisation rate at the melting and hot rolling process and are therefore offering higher margins (Aperam, 2020, p. 17). *Aperam (Imphy Nickel alloys*) specifies this strategy in the annual report of (2019, p. 20, 2020, p. 19). The *Acerinox* acquisition of *VDM* (2020, p. 3) is another example to mitigate the price risk in the commodity flat business with the higher margin business of special steels. This includes the high alloy welding wire offering, although these are niche markets compared to the flat (coil, sheet, and plate) business.

The mills propel the margin and enhance value adding activities by diversification. Higher-margin areas are pushed for this purpose, like the exposure to special grades. Another option is marketing to give the material a brand name to increase sales and establish a unique selling proposition (USP) for commodity products. In particular, *Aperam* (Aperam, 2020, p. 17) and

Outokumpu are pursuing the technology-driven avenue to gain a technological advantage through further product development. The R&D departments are highlighted in the annual reports. On the marketing level, despite the standardised materials, artificial names are introduced and marketed for the different product groups. The success of these measures is not evaluated; however, the producers consider it a price mitigation strategy, according to the examination of the AR´s. They depart from competitive grades and value improvement through new material characteristics.

5.4.2.3 Customer selection

The selection of customer segments is gaining importance according to the AR´s. Direct contact with the end customers improves the communication and understanding of the requirements and is regarded as a method to protect margin (i.e., elimination of third-party distribution). Furthermore, it allows to select the customers that are willing to accept the pricing risks for the products (Deloitte India, 2018). *Acerinox* states that independent wholesalers control the market. Therefore, supports the volatility of prices and distorts the apparent consumption (Acerinox, 2020, p. 129). The cyclical demand pattern represents an exposure to the underlying market risks that are sturdily correlated to the Nickel price change (Acerinox, 2020, p. 128; Outokumpu, 2020, p. 85). Therefore, the producers pursue direct customer contact. *Outokumpu* supplies 55% to end users (Outokumpu, 2020, p. 11). *Aperam* is striving to select the industry customers to guarantee a portfolio that compensates industry segment-specific demand volatility. The stainless steel demand in the automotive exhaust business is counterbalanced with an exposure to the food and beverage market (APS, personal communication, 2019; OTK, personal communication, 2019). *Aperam* is convinced that it counterbalances a sluggish demand in one business segment by another one. The example of this approach is the exhaust business and the stainless steel demand in the food and beverage business. The long-term agreements and the longer forecast horizon are an asset for a smoothened order intake (heijunka). To accommodate direct customer contact, the organisation must have sales and technical support functions. The "customer selection" enables steel mills to improve their sales and pricing policies. Customer loyalty is crucial to safeguard profitability. The customer selection process has also consequences on production diversity (APS, personal communication, 2019; AST, personal communication, 2019; OTK, personal communication, 2019). *Acerinox* and *AST* (ACX, personal communication, 2019; AST, personal communication, 2019), will enforce their activities in this direction.

E-mobility is a new market that attracts the attention of the mills; however, it is still in its infancy but growing fast. This market might substitute the internal combustion engines (ICE) and the exhaust gas treatment systems in the longer term (compare section 1). Hence, the market position contributes to a considerable extent to economic success (Acerinox, 2020, p. 129; Aperam, 2020, p. 17).
However, there is an overlap to the area of "price passing/sharing" (Contractual) and "demand pooling" or piggyback sourcing activities (Sourcing) that is coordinated among the long-term partners (Gaudenzi et al., 2017). Thus, a cooperative approach where diverse companies aggregate their demand to gain discounts or improved availability from suppliers.

5.4.2.4 Operational excellence

This section confirms the industrial evidence to strive for a leaner, more efficient, and more agile production operation. However, the AR´s revealed two extremes. *Acerinox* aims to be the most efficient producer in the world. *Aperam* focuses on health and safety and operational excellence. *Acerinox* praises the US operations of NAS as one of the most productive plants in the world (Acerinox, 2020, p. 11). *Acerinox* concentrates on short production cycles, hence minimising the time gap between raw material purchase and the sale. Thus, this operational initiative mitigates commodity price volatility. An inventory reduction is an assumed positive impact. The two-week production cycle is a benchmark in an industry that accepts lead times of up to 12 weeks (ACX, personal communication, 2019). The extraordinary short production cycle aligns with the purchase and revenue streams. Therefore, the reduced cycle times are in line with the results of the GARCH calculations. The CV of the *Acerinox* equity presents the lowest value across the examined listings from 2008 to 2018. However, this production strategy is aimed at commodity grades, not with a variety of special grades.
Acerinox pursues the strategy of cost leadership in production to lessen commodity price volatility with short replenishment cycles (Acerinox, 2020, p. 26). However, solely operational excellence might not mitigate raw material price risks (Peruvankal, 2011).

5.4.2.5 Alternative recipes/ substitution

The "strategic" mitigation scheme of substitution or alternative specifications is often deployed in cooperation with the customer. However, it differs from the production within the tolerances of the technical specifications, see Table 52 (p.169). It is a replacement of the current product. In times of crisis and economic pressure, changes can be implemented that would otherwise not have been possible. That became evident during the COVID-19 pandemic crisis again. Due to a lack of material availability, material changes and substitutions have been made rapidly to secure the production. Because of high Nickel prices and ongoing price volatility, the substitution of austenitic to ferritic materials deserves consideration. It combines lower prices and a lower price volatility. The ability to plan the price was an essential point for the changeover. Here, commercial interests outweighed technical interests (authors' knowledge of the aftermath of the crisis). The *BMW* purchasing organisation played a leading role in the substitution of the material grade.

Within a certain process window, ingredients can substitute each other. At *Aperam,* this is a conscious and controlled process with production management and procurement (APS, personal communication, 2019). Some mills are substituting pure Nickel with stainless steel scrap holding Nickel. These scrap deliveries cannot be hedged. Scrap is often a local good, hence, the limited exposure to currency volatility and time lags. Prices are fixed for shorter periods to reflect price volatility. To mitigate the price volatility of stainless steel scrap, the mills are often deploy index contracts (AST, personal communication, 2019) or option-based contracts.

5.4.2.6 Price fluctuations are shared/passed to the customer

All mills stated that volatile Nickel prices are amongst the top 3 business risks (Acerinox, 2016, p. 44, 2018, p. 54, 2019, p. 83, 2020, p. 42; Aperam, 2016, p. 24, 2018, p. 55, 2019, p. 62, 2020, p. 65; Outokumpu, 2016, p. 25, 2018, p. 127, 2019, p. 84, 2020, p. 85). *Aperam* argues that profitability is linked to the Nickel prices (Aperam, 2016, p. 181, 2018, p. 56, 2019, p. 62, 2020, p. 65). A 10% price change in Nickel converts to a 1% change in the gross margin (Acerinox, 2016, p. 101). Hence, the price exposure is balanced by the alloy surcharge system (2.2.1, 6.1.1.3 and 5.3.3). The AS enables the mills to perform a natural hedge (financial strategy). However, the time between purchase and sale of the product, several weeks (*Acerinox*) or months (*AK Steel*), is another source of commodity price volatility risk. Hence, the mitigation (price sharing/passing) is important. However, in some markets, outside the USA and Europe, the alloy surcharge system is not applied. Prices are fixed at ordering or at the date of the sales transaction (contractual- price fixation).

The stainless steel mills can work with the mitigation strategy "long-term versus spot buy" on the procurement side and the sales side, see Table 57 (p.176).

On the procurement side, the "spot buy" offers flexibility. Traders typically apply this strategy. However, it may jeopardise the price It is a commercial advantage over the "Contractual" strategies of option-based, index usage, price sharing between partners. Here, the security of supply and the commercial aspects are of crucial prominence. In phases of price reductions triggered by the declining Nickel price, see the example of the Nickel price (Figure 31). The interviews advocate that, besides the security of supply, the commercial aspects are decisive (Schlüter, 2019).

While independent SSCs and stockholding dealers favour spot transactions in crisis periods (5.4.2.3) versus the long-term agreements. This opportunistic advantage is conveyed at the expense of the manufacturers. The price risk is the major risk for *Acerinox* in 2019 (Acerinox, 2020, p. 128) Table 58 (p.177). Longer-term contracts can be secured by the plants only with regular customers or for special grades. The predictability of these quantities smoothens the capacity utilisation (heijunka) and thus the profitability of the steel mills. However, in stable times, the Service Centres in Europe do not rely on spot buy but on long-term agreements, as it can be concluded from the questionnaire responses in Table 61.

Table 61 Questionnaire, question 7/SSC, Source: own data

7. What are the different buying/selling strategies deployed to cope with price volatility?								
Region	Participants	Fixed prices	Long-term	Spot	Long-term and spot	Hedging of alloys	Inventory control	No strategy
EU	6	2	5	0	2	1	3	0
		15%	38%	0%	15%	8%	23%	0%

The long-term contracts fix the base price and a monthly adjusted AS. It is the main mitigation strategy. However, 2 respondents agreed on completely fixed prices. End-users (Table 69) have, according to the questionnaire, a different perspective, where 25% of them opt for fixed prices. Inventory control plays a major role at the SSC level, however not at the end-user level, in particular in the responses from outside the EU/USA. The tightest grip on inventory seems to occur at the steel mill level (Table 57, p. 176).

Outokumpu offers a way for the customer to select the timing for the fixation of the AS. It was introduced in 2017 for trading companies. The flexible use of this method allows the SSC to choose the best time for itself to lock in the alloying elements - via Outokumpu. This eliminates the speculative moment of the steel mill and passes the decision to the customer. It may leverage profitability with an existing or presumed market knowledge.

The steel mill can thus elegantly pass on the speculative element of the raw material price development (i.e. Nickel) to the customer. Furthermore, it secures the quantities that might otherwise go to other mills. However, this is only possible for the most common grades (i.e., 1.4301/304).

5.4.2.7 Lobbying

Lobbying is defined as the Influence of organised interest groups (e.g. associations, societies, non-governmental organisations) on the executive and the legislature (Schöbel, 2021). Since the ECSC was established, the lobbyism took place. The understanding that trade regulations impact profitability is obvious. The initial intention was to secure the availability and a fair pricing; however, these ideas might be regarded with different priorities from different perspectives. The mills are actively influencing the governmental and political players to convince them of their interests.

Protectionism is not the same across the globe. Since 2018, when the US Government tightened the import regulations, the awareness of protectionisms gained momentum again. Despite tighter trade restrictions (AD or safeguard), the trade policy of the European Community is not restrictive enough according to the mills (Acerinox, 2020, p. 3; Aperam, 2020, p. 26; Outokumpu, 2020, p. 6).

The example of introducing the US 232 in the USA led to a restricted market within weeks. The EU experienced distortions as quantities diverted to Europe and the price collapsed. For the year, import volumes averaged 30% of apparent consumption. Loopholes to avoid restrictions were not closed. The EU has opted for a quota system that response slower. Note, that the steel industry and the political system in the US are historically closely interwoven (Schuler, 1996)Besides, the decreasing prices, failure to curb imports caused an underutilisation of production capacities (Acerinox, 2020, p. 3; Aperam, 2020, p. 23; Outokumpu, 2020, p. 11).

Manufacturers with global production sites are beneficiaries and sufferers of these trade restrictions. For example, *NAS/Acerinox,* as the market leader in the USA, benefits from the -US trade restrictions. The profit in the USA exceeds the Group profit and compensates for the losses in Europe, South Africa, and Malaysia. In Europe, the parent company with its plant in Spain suffers from the high import quotas for Asian plants and, subsequently, from decreasing price levels.

The strategic price mitigation strategy tariffs & trade regulations apply to the steelworks. Often, job protection and the importance of the domestic industry are in the centre of the argumentation.

Thus, lobbying is an opportunity for the mills to exploit governmental organisations and politicians to secure a margin protection or leveraging program. In some regions, subsidies are paid for wage and salary costs (short-work allowance), avoiding the associated negative

consequences of redundancies for the economy. Targeted lobbying can give the steelworks an advantage. The close interrelation of steel mill and politics is experienced in the USA using the example of *AK Steel.* The government's policy was explicitly praised on the first page of the AR 2017 (AK Steel, 2018, p. 1). From many discussions, the author learned how tight the links to the political and governmental organisations in Washington D.C. are.
This path may be deployed if the stainless steel manufacturer already has a corresponding influence in regional but also national politics. It is by far a method of combining the egocentric interests of the mills with the macroeconomic interests. This lever is crucial to the stainless steel sector. Lobbyism is a strategic lever to influence trade restrictions to the advantage of the steel producers. It is a historic method to restrict and limit free trade in favour of the domestic producers. It is not forbidden; however, it is a method that is not accessible for the exhaust manufacturers. These are under pressure as the political interest favours E-mobility.

5.4.2.8 Environment

Aspects of environmental protection and electricity costs are moving into focus. The "Green Deal" initiative by the European Commission aims at a climate-neutral EU. The commission considers the introduction of a carbon border adjustment mechanism (CBAM). The CBAM is envisioned to balance the price of CO_2 between domestic and imports. It warrants the ambition climate objectives of the EU (European Commission, 2022). Hence, the CO_2 emissions of the Asian steel imports, are considered and adjusted to secure an equal playing field between the domestic and the imported steel products (Outokumpu, 2020, p. 7). Another approach suggests including the CO_2 emissions of the transport route. Whether the environmental aspect is advanced, this adjustment mechanism (tax) will increase the costs of steel imports into the EU. The protection of the environment is a noble gesture and obligatory to protect the health and safety of future generations. However, it might be regarded as another method to restrict the free flow of material in an increasingly restrictive trade environment. Hence, the environmental regulations are going to impact the profitability of the mills. Recently (Summer 2021), the mills have passed this price increase to the customers (authors' own experience). Hence, the strategic method of price mitigation is deployed.

5.4.3 The exhaust companies

Commodity price volatility is pressurising the Tier 1 suppliers. In this thesis, the exhaust gas treatment system producer from the input materials (purchase) and sales. Figure 38 illustrates the two directions of the CPV for the Tier 1 suppliers. The input material (i.e., stainless steel) prices are set and there are a few ways to escape the AS dictate of the mills. On the sales side, the negotiations often with much bigger OEM´s prohibit to pass on the pricing risk. Hence, the Tier1 supplier is under pressure from the purchase and the sales side. The time between purchase, delivery, and production of the parts for the OEM until the invoicing process is the risk of the exhaust system producer.

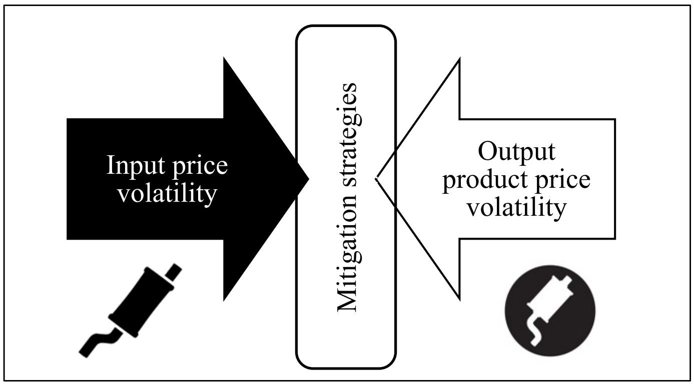

Figure 38 Exhaust producers, price volatility tensions, Source: own figure

The crucial difference is the negotiating positions of the diverse value creation stages. On the purchasing side, there are few suppliers and an increasing extent of trade barriers that limit the number of suppliers. Supplier selection is restricted because of geographical and technical reasons. The limited supply base shows an oligopoly. The mills are confronted with an oligopoly situation of raw material purchase.

The dominant OEM manufacturers are in a stronger purchase negotiation position. However, the negotiation power is not balanced. Despite innovations and cooperation with the OEM´s, the exhaust system is divided into several parts (e.g., hot, and cold ends) and these parts are sourced separately. The OEM dictates the commercial conditions. These negotiations contain the passing/sharing of the AS to an increasing extent. The OEM leaves the commodity price volatility risk to the first tier supplier. The actual price mitigation strategies are therefore concentrated on the purchase side of stainless steel.

- Long-term agreements & spot buying
- Surcharge sharing
- Material & Demand pooling
- Substitution
- Supplier cooperation
- Others

5.4.3.1 Long-term agreements (price fixation) & spot buying

This mitigation strategy is a finding of the questionnaires, see Annex 6, question 7, and Table 50 (p.167) as the predominant strategies. It combines the protection of the base or the effective prices for a certain period. Base prices are fixed in advance for a period of up to two years. The steel mills insist, however, on the application of the price passing strategy to cover the volatile cost components. For Tier 1, a reliable price hedge for an essential price component is available, thus providing certain predictability. Purchasing can react to market changes and stock up on more favourable market prices during the price-fixing period. However, this requires flexibility in the contract design and the possibility of warehousing and financing.

Another strategy is the fixation of the price, quantity, and the supply period. This contractual agreement is deployed by Asian mills that must ship in bulk to secure competitive freight rates and are enforced to secure material availability for the buyer. Often, free trade zones in proximity to the relevant seaports are deployed.

5.4.3.2 Surcharge sharing

The contractual agreement to pass the alloy surcharge to the customer might be restricted because of the negotiation position. However, it is a considerable option to mitigate the commodity price risk to the customer (Fischl et al., 2015). The recommendation of this thesis is to incorporate this limitation into the strategy of customer selection. Hence, to pass the price risk to the OEM.

The purchase side can agree with the mill a surcharge pricing system that is an individual agreement (contractual) rather than the AS published monthly by the mill. The industry can offer a fixed percentage, or a fixed discount. Index-based pricing might centre around the key ingredients (i.e., Nickel, Ferrochrome).

Thus, the common sharing of the AS represents a contractual solution limiting the commodity price exposure by reducing the risk of price fluctuations if it can be passed to the customer. The AS price is set by the mill and offers hence a tool to generate margin for the mill. The AS has to be set by each individual mill and a common list is not allowed (98/247/ECSC, 1998). Hence, the TIER 1 should use the same AS values for purchase and sales, avoiding differences between both transactions. If the purchase side of the OEM agrees with the AS pricing system, the contractual solution generates a competitive advantage for the producer.

Therefore, the adoption of these individual agreements results from intensive negotiations. However, officially these agreements do not exist, as these contradict the price risk mitigation of the mill (5.4.2.3.), except the *Outokumpu* AS system (5.4.2.6).

5.4.3.3 Material & demand pooling

Material pooling (piggyback contracts) increases the availability of the material in the physical supply chain. It allows the opportunity to share the burden and the material allocation within one group or several companies (Giunipero & Eltantawy, 2004). The common purchase in a highly competitive environment may cause compliance concerns, as a certain information content and commercial details will have to be shared among the competitors. However, it is an opportunity that is applied in the automotive segment (i.e., carbon steel purchases of Kirchhoff and Allgaier in Germany). Literature lists this approach as an opportunity (Gaudenzi et al., 2017). Material procurement is channelled and specified by the exhaust producers. The increased material availability and the demand pooling offer competitive advantages for all participants.

The CPV is counterbalanced with quantity flexible contracts. These (Shi et al., 2011; Tsay, 1999) benefit both participants. The guarantee of sale quantity and the build-in price for flexibility instead of on costs occurred by poor planning of the organisation. The supplier takes on the flexibility for the part producer (customer), however, a certain charge must be applied as the supplier dedicates production capacities. This "spare“ production capacity covers for the poor planning of the commercial partner. The production allocation comes at a cost, as the producer might not sell the reserved volumes.

It emphasises the result of the questionnaire (Table 50, p.167) that long-term agreements are paired with flexible spot buy opportunities,

In the USA and China, where the quantities are designated only for the end customer material pooling or demand pooling, is only available for specific supplier networks. This limitation strengthens the negotiation position of the producer. Bigger consumers can pool the material demand and include the sub suppliers of themselves. This generates a quantity that attracts the stainless steel suppliers. Hence, this option is a viable option if the quantity or the material grades deployed offer a package that is of strategically interests the mills.

The allocation of the quantities by the exhaust manufacturers and their subcontractors creates a monopoly-like position for the “last mile” of material supply. It is more difficult to change suppliers because of the transaction costs. Therefore, it prohibits free-market entry and may stand for a non-tariff barrier.

5.4.3.4 Substitution

This mitigation strategy is challenging. The focus is on replacing the Nickel and Ferrochrome content. To replace these ingredients is a challenge as these are decisive for the material characteristics (Annex 3). This approach requires cross-functional cooperation and is a fine balance between commercial opportunity and material failure (Gaudenzi et al., 2021). It may enhance the information exchange and the communication between the functions within the Tier 1 as well as between the Tier 1 and the OEM. The technical expertise might generate a competitive advantage, including RSI.
The Japanese automotive market embraced this challenge. Some of these grades eliminate commodity price volatility almost completely. The cooperation between the mills, the OEM´s and the TIER 1 producer led to the introduction of improved grades according to Japanese material standards (JIS). This is an insight that the author has gained in its cooperation with the Japanese steelworks (i.e., NSSC). It is therefore a subjective and yet important insight into the approach in material substitution and cooperation between Japanese companies.
The sole exception is the Japanese replacement (15CrCb) for one of the most common grades in the exhaust industry, the 1.4509/441. The Japanese grade is produced in the US to support Japanese vehicle production in the NAFTA region. This material grade has the technical potential to replace the 1.4509/441 grade with a dominant part. However, recent trade restrictions prevent a stable material availability, which is a prerequisite condition for the automotive industry. The feasibility is given; the examples are existing in the Japanese cars around the globe. However, the cooperation between the OEM, steel mill and the TIER 1 supplier is not as elaborated as in Japan.
The mitigation strategy of substitution is challenging but offers a high potential to alleviate commodity price volatility.

5.4.3.5 Supplier cooperation

Following the thought of creating knowledge and value through cooperation, the supplier cooperation or supplier network as a sharing partnership has been described in section 3.3.4. It represents typically an interconnection of companies and corporations that are economically independent. However, the Japanese *keiretsu* - the vertically linked networks between companies - is a substantial intergroup transaction between the companies (Dyer & Nobeoka, 2000; Fruin, 2008, pp. 251–252). It constitutes a knowledge sharing and knowledge-creating process (Krogh et al., 2012; Nonaka & Takeuchi, 1995; Nonaka & Toyama, 2005). The trust and inter-firm dependencies of the supplier network cooperation lowers the boundaries of resistance and mistrust and increase the cooperation. Open communication and knowledge sharing generate efficacies in procurement, innovations, and technical improvements in the product or the process. (Inemek & Matthyssens, 2013). These close links between the OEM, TIER 1 and the stainless steel producer is not solely centred around the knowledge-sharing aspect and on risk-sharing. In contrast, the close ties allow flawless communication.

The example of the material grades (i.e., substitution of 1.4509/441 by 15CrCb) meets the technical specification and lessens the commodity price risks. Hence, it is a positive example for all interlinked companies. The continuous improvement process (CIP) creates a competitive advantage. The transaction cost economics (TCE) and the relationship-specific investments (RSI) in the value chain (3.3.4) contribute to the financial results. However, the disruptive industry is driven by environmental restrictions to save the climate. Hence, changing requirements and the cost pressure lead to closer collaboration and risk-sharing. The external pressure generates the understanding of a common destiny (Huxham & Vangen, 2005, pp. 3–5).

The commodity price risk is amongst the most prominent risks in the automotive industry. Following the example in the Japanese automotive industry (*keiretsu*), the willingness and openness to share the price risks amongst the companies are persuasive. It secures competitiveness and allows to minimise margins as no safeguard margins are incorporated in the calculation, following the thoughts of “The Nature of the Firm” of Coase (1937). Whilst in the non-sharing partnerships, Tier 1 must account for and accrual for this risk solely.

Therefore, the price of the exhaust system results from the cost calculation. However, the risk appetite indicates the acceptance of commodity price risk, as AS or volatile effective price levels.

The author can confirm from the working experience with Japanese suppliers that the commodity price volatility risk is shared between the partners. Introducing the results of the material grades from the innovation-driven approach in the value chain of the stainless steel mill, Tier 1 and the OEM. The mining companies are excluded as the natural resources must be brought on the world market by the dominant players. The disadvantages might be described with the “hostage” situation and the sheer inability to introduce new suppliers to the cooperation network (Williamson, 1983).

The replication of the supplier cooperation approach is challenging, as the culture of cooperation is created based on mutual long-term trust. The existing culture is an asset to Japanese organisations. Therefore, the individual value of the employees favours this approach, however, it contradicts with “western” mindset and believes.

The mitigation strategy is deployed in Japan with success, see the example of *Denso* and *Toyota* in section 5.3.5. The risk adversity of the culture allows the interlinked companies to burden the risk commonly without jeopardising the profitability.

Hence, supplier cooperation is a price risk mitigation strategy. The result is a risk-sharing and a risk avoidance strategy amongst partners with mutual understanding and an open book calculation. It comprises knowledge sharing and creation.

The transfer of this approach into other cultural backgrounds is challenging as a company and personal culture are a severe burden for introducing the common destiny approach. This answers research question 2.2 (RO 5).

5.4.3.6 Others

Trade agreements and trade restrictions are often a barrier to the import of stainless steel products. However, as the stainless steel products become more expensive, the derived products become more expensive because of higher input cost and thus products become uncompetitive. To overcome this price disadvantage, the TIER 1 supplier avoids the tariffs on the stainless steel flat material and imports processed parts as assemblies. The opposing industrial and commercial interest of the value creation levels is resulting from the diversion of value creation. When the USA introduced the Trade Act 232, the steel imports decreased, whereas the steel price increased. Protecting the steel industry increased the price levels in the US and allowed the mills to increase profitability. Hence, from the stainless steel mill perspective, the trade restrictions had the desired result. This is based on the industry experience and the active sourcing activities and job role/responsibilities of the author. While the steel imports from China and India decreased, the value creation level in these countries increased for exhaust parts.

The semifinished part becomes less expensive, the value creation process is outsourced to countries with a strong stainless steel industry and low labour costs. The global presence of the Tier 1 exhaust manufacturers is the guiding hand in these activities. The global production plants of the Tier 1 supplier are now becoming sourcing offices for the sister companies. The activities to accrue the product share from LCC (low-cost-countries) or best-cost-countries (BCC) have increased. The economic necessity to pursue these activities impacts manufacturing jobs in the areas that are protected by trade restrictions on the raw material side.

The “steel-war” elevates to the next value creation level. Often the manufacturing industry is smaller than the steel mills and thus their voice remains unheard. The opportunity to influence the political and governmental functions is limited. However, the trade protection for the steel industry threatens manufacturing jobs due to increased costs. For the Tier 1 suppliers, this is an option to avoid increased stainless steel prices and to bypass the trade restrictions. This thesis is not judging the result, nor the intentions of trade restrictions. Its aim is focused on the illustration of the particularities and the mitigation of these trade restrictions in a competitive environment. Hence, influencing/lobbying is a strategic mitigation strategy for price risks. However, it is a long-term approach that implies an understanding of trade laws and the impact and commodity price volatility mitigation options of trade restrictions. Thus, it incorporates the ERM aspects into its strategy.

5.5 Application of mitigation strategies (Research question Group 3)

The mitigation of procurement risk is incorporated into the SCRM, hence it is part of the ERM (Manuj & Mentzer, 2008b; Qazi et al., 2018). However, CPV is still often regarded as a financial risk rather than a procurement or supply chain risk (Costantino et al., 2016). This thesis explores the impacts of two exogenous risk events (political and financial) to examine the existing mitigation strategies.

These past events underline the importance of commodity price volatility risk management and price risk mitigation scenarios. The retrospective evaluation is the limitation of this analysis. The findings suggest the goodness of fit of the CPV risk management. A crucial aspect is the forecast of price movements.

Risk management refers to external factors, which are beyond the management's influence. The sole exception are the trade restrictions, see section 5.4.2.7. This research intends to narrow the gap in the literature about commodity price volatility mitigation strategies in the value chain of the stainless-steel industry. The following section answers research objectives 6 & 7, in response to research questions 3.1 and 3.2.

It also answers the fundamental question of whether an early warning indicator exists. In this context, the special role of the VIX and the Nickel price is exploited by focusing on the companies involved in the three value creation levels (Figure 2, p.3) of stainless steel. Sections 4.3.1.5 and 5.1.5 examine the VIX and the impact of Nickel prices. The predictive power of the VIX is investigated and compared to the predictive rationality of the Nickel prices.

5.5.1 Political event (RQ 3.2)

5.5.1.1 Description of the situation

This section examines the application of mitigation scenarios for steel mills and exhaust gas producers, for example, trade restriction in the USA. The “US Trade Act 232 on the national security in the United States of the trade expansion Act of 1962” was announced on January 11th and enforced on March 23rd, 2018.

Protecting the domestic steel industry was one of the election promises of Donald Trump (45th President of the USA) in the 2016 election campaign (Singh, 2020). After the announcement, the USA domestic steel price ballooned because of the lack of import shipments (Figure 39). The graph in Figure 39 originates from the article “Trump´s Steel industry claims” (Robertson & Kiely, 2019).

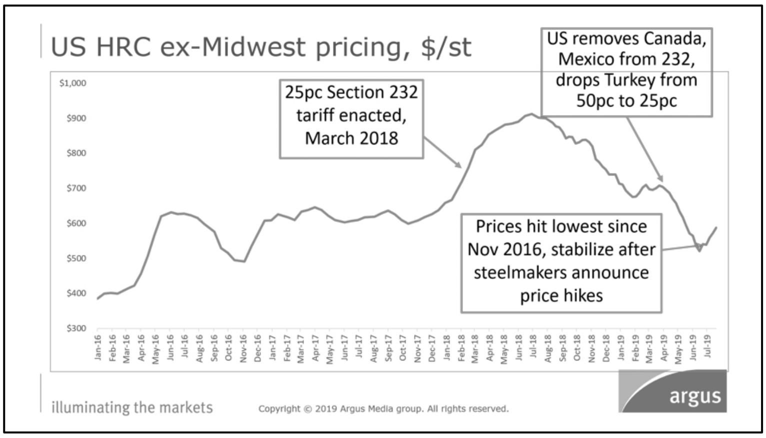

Figure 39 US steel pricing 2018, Source: Argus metals

The sudden shift in the commercial trade, due to the import restrictions, created an unbalanced situation in the steel market. The emphasis on domestic supply stretched the existing production capacities of the US steelmakers. For the exhaust material grades, the localisation efforts focussed on two mills *NAS (Acerinox Group)* and *AK Steel*. *Allegheny* (ATI) refused to produce these grades, while *Outokumpu* does not produce these grades.

The restriction of competition to these mills led to an "artificial" shortage. Hence, they adjusted the commercial contracts to optimise for profitability and production efficiency.

The main import quantities for the exhaust producers (ferritic grades) originated from Brazil, Mexico, South Korea, India. Importers cancelled existing supplies and jeopardised existing contracts unless the last customer took over the payment of the tariffs. In one case known to the author, *Aperam* stopped deliveries from its Brazilian plant to the USA despite existing agreements. Thus, it represents one example that added to the existing uncertainty and the irrational behaviour to secure material. The trade restrictions are still in place (Dec 2021), however, European origins have been excluded in November 2021 (The White House, 2021). Hence, a comprehensive overview of the impact, consistency, and competitiveness is not possible. The final repercussions of these trade restrictions might be a subject for future research, as these are still in place, and it is too early to draw final conclusions.

5.5.1.2 Statistical observations

The examination of the impacts of the 2018 trade restrictions (US 232) includes statistics, like in the prior sections, when investigating the influence of the Nickel prices on the share prices, see section 5.1.5. A correlation analysis and a multiple regression are performed to examine the relationship between the share prices and the Nickel price and the VIX. RO 7 investigates these relationships to answer RQ 3.1. The calculations are summarised in Annex 18.

Table 62 expresses a strong positive correlation between Nickel and the raw materials except for Iron ore (p=-0.08). The correlation strength is higher than compared to the VIX (i.e., VIX vs. raw materials). The share price of *Outokumpu* (-0.54) and *AK Steel (-0.60)* stands out. Both are significantly (at a 0.001 level) related to the Nickel price and the VIX. Both operate production facilities in the USA. *AK* has a US centred footprint; hence, it is considered a domestic mill. *Outokumpu* operates a production facility in the US. It is the newest of all production facilities in the USA. The correlation to Nickel is significantly negative (at p <.001 level) and displays the strongest correlation for all producers. The other significant positive correlation (p <.001) is displayed for *Posco* shares and Nickel prices. Which suggest that the Nickel price has a positive impact on the share prices. This is in line with prior findings. The correlation for the period 2008 to 2018 is (0.87 at p <.001). The correlation between Nickel and share *Posco* share prices is stronger than for all other stainless steel producers. This leads to the assumption that *Posco* is gaining from increasing Nickel prices. This suggests that processes are followed permitting a minimising of the price risk exposure or/and to pass the raw material price risk to the customers. However, none of the annual reports hints at the underlying process. One explanation might be the truly global exposure to all major sales regions (i.e., USA, Europe, Asia) that permits balancing the exposure to single markets or industries. From personal experience, the customer must convince *Posco* to become a supplier as the Korean company is very selective in the choice of customers and markets and avoids the spot market. The process towards partnership can be very time-consuming. However, once the connection is established the supply and the quality of the material is consistent and reliable. Which indicates that customer selection is an integral part of the business risk process.

Table 62 Correlation analysis 2007 to Feb 2009*, Source: own data*

Spearman's rho	Nickel	VIX
Nickel	1.000	0.461*
VIX	0.461*	1.000
Aluminium	0.714**	0.024
Iron ore	(-0.080)	0.268
Copper	0.744**	0.101
Stainless 304 scrap Europe	0.645**	0.164
Stainless 304 scrap USA	0.653**	(-0.011)
Ferrochrome	0.703**	0.150
Outokumpu	(-0.536)**	(-0.741)**
Aperam	(-0.462)*	(-0.803)**
Acerinox	(-0.246)	(-0.512)**
Yieh	(-0.050)	(-0.036)
AK Steel	(-0.595)**	(-0.651)**
Posco	0.519**	(-0.211)
Jindal Stainless	(-0.082)	(-0.683)**
Nippon Steel	(-0.261)	(-0.645)**
JFE	0.432*	(-0.429)*
Tenneco	(-0.486)*	(-0.711)**
Faurecia	0.542**	(-0.267)
Futaba	0.190	(-0.556)**
Sejong	(-0.474)*	(-0.283)
BHP Billiton	0.059	(-0.335)
Norilsk	0.646**	0.380
Vale	0.703**	0.711**
Glencore	0.430*	(-0.319)

** Significant at 0.001 level / *Significant at 0.05 level, two tailed

The correlation to the VIX is significantly negative (at 0.001 level). An increased VIX represents an increased level of uncertainty in the market, hence a negative impact on the share price. This general assumption is displayed in Table 62, however, *Vale* and *Norilsk* are the exception. However, *Vale* displays the strongest correlation for the mining companies to the VIX is significant (at 0.001 level). Note, it is opposite to the general assumption that an increased VIX value negatively impacts the share prices. According to the annual report, *Vale* has an exposure to the Chinese stainless steel market. Which suggest the US trade restrictions have not impacted Vale. The existing sales network supported increasing supply quantities to Chinese mills (Vale, 2019, p. 90). Compared to Nickel prices, three out of four correlations are significant (twice at 0.001 level, once at 0.05 level). Hence, the miners are positively impacted by the trade restrictions and the increasing Nickel prices.

However, the mills producing in the USA are impacted in the opposite way. The share price development of the stainless steel mills with production sites in the US does not benefit from the trade restrictions. The share prices, compared to the mills that do not produce in the USA, support this assumption. The trade restrictions caused uncertainty. This may explain to some extent why share prices have come under pressure. Increased costs reduced the value of shares rather than supporting increasing share prices. This was the routine in the past. The uncertainty and ambiguity in the (steel) market resulted in decreasing (steel mill) share prices. The expectation would have been that US-based producers would benefit disproportionately from import restrictions. However, the profit situation for *AK Steel* benefitted from the trade restrictions. The entire fiscal year 2018 was the most profitable year in a decade, according to Roger Newport, the CEO of *AK Steel* (AK Steel, 2019b). This underlines that lobbyism is a valid mitigation strategy for a steel producer. Without the trade protections, it might have been another loss making year for the biggest US based steel producer. It was *AK Steel* that congratulates the 45th US President for his bold and decisive against to protect the US steel industry (AK Steel, 2018, p. 2). In 2017 the annual profit was just (33 Mio$) compared to 364.4 Mio $ in 2018 and with falling steel prices see Figure 39, the annual profit reduced to 209.3 Mio $ for the fiscal year 2019. Still a major improvement compared to previous periods. These profits are based on lobbyism and trade restrictions not on production performance.

The *Acerinox* share price has hardly reacted to the restrictions, which suggests a balance of sales activities. However, it would have been the expectation that the share price would benefit from the restrictions in the USA. However, the example of *Acerinox* clearly shows that globally positioned companies are less affected by the uncertainty in the USA. This can also be seen in the example of *Posco*, which was discussed in this section. This may have happened by chance, but it seems likely that the broad positioning of sales activities was deliberately chosen to minimise market risks.

The correlation calculations for the investigated political event are of a lower strength than for the second examined exogenous event the world financial crisis.

The “goodness of fit” is also calculated (Table 63). The regression analysis indicates in this setting the root cause analysis (Nickel price movements and its impact) and forecasting (forecasting the values of the dependent variable Nickel). These calculation- the forecast of Nickel

prices- during the financial crisis is performed in Table 68 (p. 210). The goodness of fit is close to 100%, therefore, this example is chosen. The variables added statistically significance to predict the Nickel price, $F(9, 16) = 9.25$, $p < 0.001$, $R^2 = 0.84$. Despite the extraordinary event (i.e., trade restrictions/ US 232), the relation between the Nickel price and its influence on the stock price of the mills remains unaffected. Figure 40 confirms the diverging development between Nickel and the equity price. This is in line with the negative correlation between the three data series (see Annex 18). However, these findings are not in line with previous positive correlations (Table 25, p.139) in section 5.1.5.3, which confirms the extreme situation of the trade restriction.
The variables (*Outokumpu*, *Posco*, *Yieh*) added significantly to the prediction, $p < 0.05$, see Annex 18. The interpretation of the strength of the correlation is shown in Table 63.

Table 63 Political US 232, the goodness of fit R^2 values*, Source: own data*

Industry	VIX R^2	VIX Adj. R^2	Interpretation	Nickel R^2	Nickel Adj. R^2	Interpretation
Raw material	0.23	0.08	None	0.76	0.71	Strong
Mining	0.68	0.62	Moderate	0.68	0.62	Strong
Stainless Mills	0.75	0.62	Moderate	0.84	0.75	Very Strong
Producer	0.49	0.40	Weak	0.72	0.66	Strong

Despite the price changes in the domestic market, see Figure 39, the share prices of the domestic mills did not follow the increased market prices of steel. The values in Table 63 demonstrate that the relationship between Nickel prices remains intact and is strong, respectively, very strong (for the mills). This underlines the crucial importance of the Nickel values for the share price of the stainless steel producer. Therefore, this regression analysis is deployed to forecast Nickel prices at a later stage.

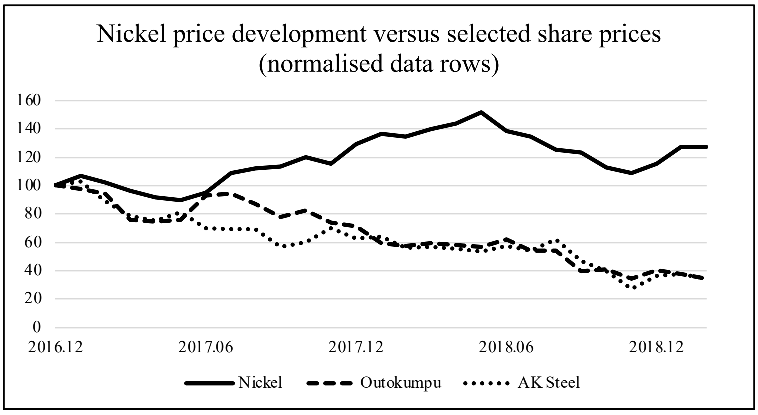

Figure 40 Price developments Nickel and US mills, Source: own figure

The normalised data rows exhibit the disconnect between the stock price evolution and the Nickel prices. The share prices do not reflect the improved margin conditions regarding the US trade proclamation 232. Therefore, the price decline was explained by the lower-than-expected apparent consumption of steel in the USA. Besides, a less restrictive stance against material originated from Canada and Mexico. The displayed stock prices are monthly averages. Therefore, daily prices might echo more erratic price movements. The steel market was affected negatively despite the trade restriction measures that aimed to protect the domestic steel industry. The disconnect between the US stainless steelmakers and the Nickel price remains, as the leading indicator for the prediction of the stock price evolution remains intact (Annex 18). Hence, the mitigation strategies are focused on Nickel price fluctuations. However, as the direction (i.e., typically a positive correlation) of the impact changes, other influencing factors might be considered. The US steel market in general was characterised by uncertainty and ambiguity before and during introducing trade restrictions which might presumably add to the negative impact. Increasing costs might not be passed to the customers as swiftly as needed to protect the margin of the steel producers in the USA. The VUCA world took its toll.

The VIX and the share price of the companies that are US-based or exposed to the US steel/exhaust market show a significant (negative) correlation. This is in line with the expectation that a high VIX represents increased volatility, hence market risk. The companies with a major production location in the US are *Outokumpu, Acerinox, AK Steel, Tenneco, and Futaba*. Note that the companies that are exposed to the US markets *Aperam, Jindal Stainless, Nippon Steel, JFE* and *Vale have no major production share in the US*.

The correlation to the Nickel price remains intact for the researched period, which confirms the relationship as analysed in section 5.1.5. Hence, the examined approach to price risks mitigation is statistically confirmed.

5.5.1.3 Contractual mitigation strategies

The long-term price-fixing has paid off for the exhaust gas manufacturer for the exogenous event of a political influence in the trade of stainless steel. Thus, the timing of the negotiations generates a price advantage that must be respected by the steelworks. In the current case, the author had concluded a multi-year supply and price agreement with the steel mill but included certain quantity ceilings and purchase commitments. However, even this long-term agreement did not guarantee the steel consuming (i.e., exhaust manufacturer) company from a flawless supply. The steel mills increased capacity utilisation rates. However, the early price increases for the researched period dropped again. However, the import of stainless steel material grinded to a standstill. These quantities had to be bought on the US spot market. The soaring prices mirror these market developments. The negotiation position shifted and was no longer related to the supply and demand function. There was no commercial foundation for the rerouting of the material flow and the value chain of stainless steel into the USA. The steel consumers have been forced to procure material from domestic suppliers as import was restricted and was getting more expensive due to the imposed tariffs. Market pressure to secure material leads to a herd behaviour of consumers towards the local producers. The consumers increased order levels to generate inventory as a comforting cushion, however, the spike in demand caused further price increases and longer delivery times. Therefore, the importer cannot sell the ordered products in the USA. Hence, because of the elimination of commercial risk, the merchandise was rerouted to other stainless steel markets, like Europe. The price risk mitigation sharing/ passing of price increases (import duties) was enforced by the importers. The margin of the importers did not allow to burden the imposed duties of 25% (The White House, 2018). One reason is that the main mills took a stronger grip on the route to market. The independent steel service centres and traders may not import the relevant quantities and had to approach the domestic mills for supply. As the import became less competitive (25% duties), the domestic mills improved their negotiation position again and reaped the reward of their lobbying efforts.

This situation created uncertainty in the procurement market and increased the price pressure. The steel mills have not honoured all existing contracts. This led to short-term production stoppages because of material shortages at the steel consumer's end.

The differences between the long-term customer/ supplier and the customer with no loyalty than the price became obvious. The approaches of tailored redundancies to protect the material availability and hence certain leverage in the negotiations towards the mills was not applicable anymore. Therefore, the mills took advantage of the momentum to influence the market. The timing of the contract negotiations and the contract duration have been of essence for the risk mitigation. Timing and close cooperation (information sharing) with the mills, including a long-term interest in the business relation allowed for contractual solutions that worked for both parties. Enabling a compromise between material availability and prices. The well-informed partner and the willingness to cooperate allowed commercial contracts that overcame the suddenly strengthened negotiating position of the steel mills.

From a contractual point of view, it was an extraordinary time. Both negotiation partners depend on each other as if in symbiosis. However, the bargaining power got out of balance and tilted to the side of the steel mills.
The SC network/cooperation approach and the findings with the aid of the literature review, worked for the exhaust gas treatment system producer in the US. Note, that the cooperative approach is not the typical negotiation approach in the US (authors experience), as both negotiating parties try to leverage the market situation to its limits. Hence, the "western" negotiation style is predominant. Despite the tense situation, cooperation between the partners has improved sometimes. The speed of events had overwhelmed both negotiating partners. In retrospect, the price situation reversed within 24 months.
The apparent consumption decreased for the exhaust industry, as semi-finished parts were imported from Asia (e.g., China and India) as well as from Mexico and Canada. The volume reduction rooted hence, in the relocation of production locations, see section 5.4.3.6. This decisive shift in the supply base for semi-finished parts had a considerable impact on the lower capacity utilisation of the steel mills and thus created price pressure, despite a restrictive import policy. The decreasing price trend is displayed in Figure 39 (p.193). The imports from Korean steel mills were limited to the import volumes of 2017 (Wirtschaftsvereinigung Stahl, 2019). The material has been rerouted to Korean consumers- automotive customers. Korean trading companies did the same and rerouted material to Korean companies in the USA. International or US customers that did not serve the Korean network have been left with no opportunity to order material anymore. This is an example of close supplier cooperation between long-term partnerships and the inter-linkages and responsibility in the "keiretsu" network.

5.5.1.4 Sourcing & trade regulations

After the announcement of the trade restrictions of the US government, the mitigation strategy of using several suppliers is indispensable. On the one hand, the multiple-source strategy allows price comparisons, but it also ensures material availability and limits spot market exposure (Borghesi & Gaudenzi, 2013; Delnooz et al., 2014). The mitigation approach to dual or multiple sourcing became apparent, as when suddenly all import quantities become uncertain (Manuj & Mentzer, 2008a).
Hence, the substitution of material was almost not possible because of the limited availability and the approval process with the OEM customer base, including the internal evaluation efforts. With semi-finished parts (e.g., stampings, tubular products), flat steel prices were

bypassed by sourcing in BCC countries. These have been India and China as the main procurement markets. However, for the North American exhaust market, Mexico gained importance in the recent years. The reasoning is the existing exposure, hence experience in the stainless steel value chain (i.e., in the exhaust industry). Based on existing relationships and supported by a global footprint of the Tier 1 suppliers, the supplier network has been adjusted to overcome the trade restrictions in the US. These supplier relations existed and are a requirement to fulfil the local content policy of the OEM manufacturer. In this crisis period, the existing cooperation could be leveraged. As most exhaust gas treatment system producer has a global presence, it was not a limitation. The existing supplier network could be used. In the past, the BCC share was used to optimise costs. Now, the existing network supported the circumvention of trade barriers (Matook et al., 2009; Qazi et al., 2018). The procurement activities allowed to implement these suppliers more prominently in the supplier network of the exhaust industry. Very often, the suppliers served several competing exhaust manufacturers. Particularly for the main suppliers in China and India. This was a benefit for all parties, as the strict automotive rules have been respected and production experience supported a flawless production. The impact of the supplier switching, or multiple source strategy, is a continuous development. This mitigation strategy coincides with the contractual/trade restriction avoidance strategy. Here, the added value portion in the manufacturing process is redirected to other territories, suppliers have been switched (Costantino et al., 2016; Zsidisin et al., 2017, p. 80).

5.5.1.5 Financial mitigation strategies

One short-term measure is to increase inventories to overcome supply shortages of the supply base. However, this strategy is driven by a swift and decisive operational procurement as there is a limited time window for this opportunity – for the allocation of quantities- from the mills (Johnson et al., 2014; Schiele, 2007). The added material, although delays the start date of the price adjustment it does not prevent postponements. However, domestic producers are the beneficiaries of the trade restrictions. These mills have not been willing to support the industry with additional supply quantities, as these additional quantities would delay price increases, hence the increased profitability. Therefore, additional volumes were restricted, and they created an artificial material shortage. Financial liquidity, the storage of the goods and the interest rates are to be considered. Even spot buy transactions have been procured to build up stock (Kouvelis et al., 2011; Rajala, 2021). However, the mills introduced allocations to prevent speculative purchase decisions (Zsidisin et al., 2017, p. 78).

Just the physical supply offers short-term protection for the steel consuming industries, not only the exhaust industry. Extended delivery times and the restrictive stance on volume increases, paired with the non-supply of import quantities (e.g., *Posco* and *Aperam*) shifted the negotiation balance in favour of the stainless steel mills. Hence, this created the business need to initiate immediate discussions with the domestic mills (i.e., *AK Steel, Outokumpu,* and *Aperam*). Even to verify short- term supply opportunities to cover for immediate requirements. This can happen in the very "lean" supply chain. No product quantity or time reserves are provided in this, as all actions are geared towards a JIT delivery. In such a case, fluctuations cannot be avoided. However, the contractional agreements might offer certain mitigation.

5.5.1.6 Strategic mitigation strategies

In case of sudden political trade restrictions, the trade flow of goods decreases with immediate impact, which in result reduces material availability rates. The restrictive trade policy was announced during the election campaign for the presidency of the 45th US President in 2016. It was achieved by the steel mills through active lobbying and influencing of government agencies.

Import restrictions and price increases pushed the exhaust gas manufacturers to adopt the procurement processes. The local share of stainless steel procurement is assessed differently in risk management, following the rapid implementation of trade restrictions in the USA. In the past, successful procurement was significantly based on commercial aspects. Now, in view of the trade restrictions, material availability that might cause CPV is an essential component of SCRM (Pellegrino et al., 2019). Local material procurement can become a competitive advantage, as imports are not possible or only possible to a limited extent. However, the main disadvantage of this procurement strategy is the greater bargaining power of the steel mills. This has been artificially improved through political influence and can distort the true market. However, possible long-term effects of the trade policy of the restrictions are not part of this thesis. Hence, price mitigation was prioritised. For the exhaust industry, the importation of parts exploded, the trade flow was diverted. Supplier switching, and the benefits of a supply chain network (see 5.5.1.4) have been the base for the swift and decisive reaction to trade limitations. Trade restrictions are associated with the classification of the goods, the TARIC numbers.

In both cases, the customer selection strategy, and the corresponding choice of suppliers by the exhaust producers have proven to be beneficial.

5.5.1.7 Trade restriction avoidance

The reduced stainless steel demand coincided with increased import volumes of value-added products. This challenged the domestic manufacturing industry. The main gainers were countries like India, Mexico, China, and Canada. Hence, it was a witch of suppliers that substituted the existing supply base in the US (Costantino et al., 2016; Pellegrino et al., 2019). The decreased demand for domestic steel in the US did therefore lead to under-utilisation of production capacities.

The author can report from his own experience that purchasing activities were focused during this period on India and Mexico. This led to a shift of the procurement activities and to the resourcing of processed parts and sub-assemblies with a negative impact on US manufacturers. The economic challenge for the exhaust manufacturers was to facilitate a swift and immediate completion. In conclusion, with political influence, a clear distinction must be made between short-term price avoidance strategies and medium-term ones.

Short-term measures are the contractual strategies that secure prices and volume for a certain period. The enterprise risk management in an ideal state provides allocates founds and credit lines for these unexpected flaws in the material availability (Zsidisin et al., 2017, p. 76). The contractual situation, however, is the stance that allows to influence the steel producers to secure the material demand as ordered, in the meaning of "*Pacta sunt servanda"*. The Latin expression for "agreements must be kept" is a fundamental principle of law. Hence, the base for the argumentation towards the mills to maintain the deliveries.

In retrospect, negotiations with the steelworks were detrimental to the customer for short-term contract periods. The artificial material shortage, the strict stance of the mills to reject non forecasted material quantities has driven up prices. Staggered contracts with certain flexibility offer the best protection against basic price fluctuations (Zsidisin et al., 2017, p. 94). Hedging measures remained unaffected.

Therefore, a confrontation with the mills was less favourable than supply chain cooperation. Hence, focussing on long-term cooperation and mutual "pain sharing" is more promising than other options like short-term actions (spot buying) (Gundepudi et al., 2001; Monczka et al., 2015, p. 63). The tactical procurement under ambiguity and uncertainty offers for a solution for short-term material needs. However, it is the long-term partnership that secure the material availability (Cohen & Agrawal, 1999). Literature argues that there are from a cost perspective decisions to be made either to proceed with a longer-term planning horizon or with shorter contract durations (Cohen & Agrawal, 1999). Overall, the supply chain cooperation and the close cooperation between the commercial partners allow better results than operating on short/ tactical contract durations with changing suppliers (Simatupang & Sridharan, 2004). Table 54 indicates that none of the buying patterns is “a priori” the best commercial decision. Note, that this calculation cannot capture the market intelligence and the market sentiments during in between the buying decisions. The decision making involves several aspects, like planning horizon, price reductions for contracts, the decision makers' risk appetite, and the perception of the uncertainty in market prices. Hence, there is evidence in literature that co-operation pays a dividend in the longer run (Hitt et al., 1997). However, it is still an option to operate on short-term or tactical contracts (Cohen & Agrawal, 1999). Inter-firm rivalry, expressed in the unwillingness to cooperate between commercial partners, prohibits a fruitful cooperation, hence neglects rationalisation potentials in the common interactions (Fawcett et al., 2008). The cost advantages of product improvements are named as the main levers to reduce costs. However, Schiele (2007) assumes that the collaborative cooperation amongst partners has the same cost reduction potential.

In the automotive industry, the close collaboration between the partners protects the partners from a potential disruption in the supply chain. The cooperation, hence, ensures material availability that is like product quality, a prerequisite for the Tier 1 suppliers (Darrin & Zmoira, 2015).

The exploitation of the negotiating position by steel producers has led to a disruption of the value chain of goods. Products are increasingly imported in disfavour of the domestic manufacturing industry. The avoidance of customs and trade laws led to a redirection of the value chain. This strategic approach is not reversible and impacts the US steel industry that should have been benefiting from the trade restrictions and the domestic manufacturing industry.

5.5.2 The financial crisis (RQ 3.2)

5.5.2.1 Description of the situation

The example of the global financial crisis (2008) is discussed to demonstrate how risk mitigation scenarios can be applied. The collapse of *Lehman Brothers* on September 15th, 2008 (Mamudi, 2008) produced a shock wave into the global financial system with wide-reaching amplitudes into the business sector. The following weeks were identified with uncertainty and ambiguity. The global economy was best described as a *VUCA* setting (2.2.3). The fall intensified the global financial crisis (Belyh, 2019). According to Ben Bernanke (2013, p. 60) former president of the Federal Reserve Bank of the USA (2006-2014), “the crisis of 2008–

2009 was a classic financial panic". The economy was depressed. European and Asian banks were often exposed to the subprime disaster that hit the global economy. Even before the collapse of Lehman Brothers, the financial market was tense, as evidenced by the drop in global stock prices. It impacted the raw material prices, as the demand dropped. However, in this economic scenario, enterprises dealt with risk and uncertainty in a *VUCA* time.
Investors considered commodities as an investment with no interest in physical transactions. The "Financialisation" of the markets might have caused the high level of volatility with certain dramatic swings like those witnessed within the Oil prices (Vivian & Wohar, 2012).
This thesis examines two prices that impact the share price alteration, the VIX and the Nickel ones. The relevance of the VIX and the Nickel price as an early sign of risk (price volatility) is analysed, as in section 5.5.1. After the risk methodology in section 3.5, after the identification of the risks, risk mitigation is a priority for enterprises to maintain financial stability and protecting profitability. The early warning signs of the VIX and Nickel are verified. Successive this train of thought, the strength of the relationship if it exists, is performed. Hence, multiple regression is performed to evaluate the probability and appropriateness of the two values (VIX and Nickel price). This section answers RQ 3.2 with the guidance of RO 6 & 7.

5.5.2.2 Statistical observations

The stock prices volatility is displayed in Annex 19 and calculated on monthly average prices. The strength of the relationship (goodness of fit) is displayed in Table 64. The influence of commodities on the stock prices of the following value-added sectors cannot be considered in isolation. The global crisis devaluated companies and metal prices. Hence, it is a fact that macroeconomic influences are overlaying the relationship between VIX/ Nickel prices. It covers the time from January 2007 to December 2009, before and after the September 2008 bankruptcy of *Lehman Brothers*.

Table 64 World financial crisis, R^2 values, Source: own data

Industry	VIX R^2	VIX Adj. R^2	Interpretation	Nickel R^2	Nickel Adj. R^2	Interpretation
Raw material	0.72	0.68	Strong	0.94	0.93	Very Strong
Mining	0.40	0.35	Weak	0.65	0.62	Moderate
Stainless Mills	0.75	0.65	Strong	0.91	0.86	Very Strong
Exhaust Producer	0.79	0.76	Strong	0.85	0.83	Strong

The results exceed >0.50 in seven of the eight calculations. 93% of the Nickel price is determined by raw materials. Note, that these results, cannot be used to perform a hypothesis test (Table 64). However, these results are above the level of being considered statistically significant. Hence, the Nickel price even more than the VIX value allows a significant assumption about the share price development. The strength is different depending on the value creation level, however, there are parallels. The strength of the correlation is lowest for the miners share prices.

The correlation coefficients for the dependent variable Nickel is stronger than for the VIX in each value creation level. Thus, by reviewing the "t" statistics, it can be inferred that Nickel prices are an early bird indicator value in times of a financial crisis, the detailed calculations are listed in Annex 19.

Hence, it is concluded that Nickel has a stronger impact on the (share) prices on each of the value creation levels. Therefore, the predictive element of Nickel for the price change of raw material and stock prices in the period of the world financial crisis 2008 is proven. It is in line with prior findings. The GARCH (5.1.6) and ARDL calculations (5.1.7) underline the pivotal role of the Nickel price impacts. This assumption leads to the selection of the relevant commodity price volatility mitigation scenarios. These scenarios are discussed in the categories defined in Table 49 (p.163).

Hence, the strong correlation between Nickel and the share prices of the companies in the value chain is researched by performing in further calculations. The correlation includes the share price of the company as the dependent variable and the metals (i.e., Aluminium, Copper, Iron ore and Nickel as the independent variables (Annex 19).

The overriding influence of Nickel and Iron ore prices is evident as displayed (Table 65, Table 66 and Table 67).

Table 65 World financial crisis „t" stats mines, Source: own data

Company	Nickel		Iron ore	
	"t"	Sig	"t"	Sig
BHP	-3.03	0.005	1.20	0.239
NorNickel	4.22	0.000	6.52	0.000
Vale	0.87	0.392	6.21	0.000

Table 65 exploits the strong correlation (under the assumption of $p < 0.05$) between Nickel and Iron ore on the stock price of the mining companies. *Glencore* is missing, as it was not established by that time.

Table 66 World financial crisis „t“stats mills, Source: own data

Company	Nickel		Iron ore	
	“t”	Sig	“t”	Sig
Outokumpu	5.71	0.000	2.50	0.018
Acerinox	4.91	0.000	-0.10	0.922
AK Steel	-0.75	0.461	5.93	0.000
Posco	2.64	0.013	3.13	0.004
Jindal	5.71	0.000	3.45	0.002
JFE	5.62	0.000	-0.58	0.565
Nippon Steel	0.64	0.531	2.17	0.043

Table 66 shows the strong correlation (under the assumption of $p < 0.05$) between the Nickel and the share price of the “pure” stainless steel mills (*Outokumpu*, *Acerinox*, *Jindal* Stainless). Hence, the mills that produce more carbon steel grades are closer related to the Iron ore price. Carbon steel grades do typically not require any alloys in the material grade. The material grades are, therefore, depend on the main ingredient Iron ore. Steel is an alloy of carbon and iron containing less than 2% carbon and less than 1% of manganese and minor amounts of phosphorus and sulphur and oxygen (World Steel Association, 2022). Even for a high tensile strength steel grade like from *SSAB* in Sweden, the alloy contents are below 3% (SSAB, 2022). Therefore, the focus is on the iron ore price that drives the cost of the steel grades. *Aperam* is missing because of its equity offering in late 2011. For future research, the cost of energy has an increasing importance, partly due to the cost of diverse emissions.

Table 67 World financial crisis „t“ stats exhaust producers, Source: own data

Company	Nickel		Iron ore	
	“t”	Sig	“t”	Sig
Tenneco	7.51	0.000	1.98	0.057
Faurecia	7.41	0.000	0.64	0.526
Sejong	2.60	0.014	-2.80	0.009
Futaba	5.30	0.000	-0.80	0.430

Table 67 shows the strong relation (under the assumption of $p < 0.05$) of the Nickel price and the share price of the exhaust system producers. Iron ore is adding ones significantly to the prediction (*Sejong*). The strong relation between the Nickel price as an early indicator of future price developments is reiterated. Compared to the relation between the Iron ore and the share prices. Therefore, the share price of the exhaust gas treatment system producers is assumed to be influenced by the Nickel price development, even in times of global economic crisis. However, literature argues that in times of crisis, the price developments are tighter bound than in “stable” times (Sheikh et al., 2020; Xu et al., 2019)

The statistical analyses suggest that the relationship between Nickel and the share price development in times of a crisis remain intact. The volatility index VIX is less suitable for predicting the future development of share prices compared to the impact of Nickel prices. Although the VIX shows a strong correlation sometimes, this is always lower than the Nickel price for all the value creation levels examined.

The same applies to Nickel and Iron ore as predictor values. Iron ore has a significant influence, but the influence of the Nickel price is more pronounced in the cases examined. This assumption guides the selection of mitigation strategies. Based on the price development of Nickel, the share price might be assumed. Table 64 shows the calculation results that are 91% for the prediction of the share price of the stainless steel producers and 85% for the exhaust manufacturers.

In this period, the *VUCA* environment challenged businesses around the globe (Bennett & Lemoine, 2014). Some of the major topics, despite many others, are listed in the Risk reports published by the Global insurance company Allianz (2022) since 2013:

- Business interruption
- Cyber crime
- Changes in legislation
- Price risks
- Political risks
- Loss of reputation
- Market developments
- Macroeconomic developments
- Climate change

These headlines describe the actual market uncertainty and ambiguity. Starting from 2013, business interruption was the main business risk. However, since 2019, it is the fear of cybercrime attacks that worries the business. However, price risks and commodity risks are for the latest "Global risks report", published for the World Economic Forum in Davos lists the main business risks. This report is more detailed (World Economic Forum, 2022, p. 11). One example of these price and commodity risks are listed in this thesis (i.e., Nickel, Ferrochrome) It is illustrated at the example of the alloy surcharge curve (1.4301/304) in Germany (Figure 41).

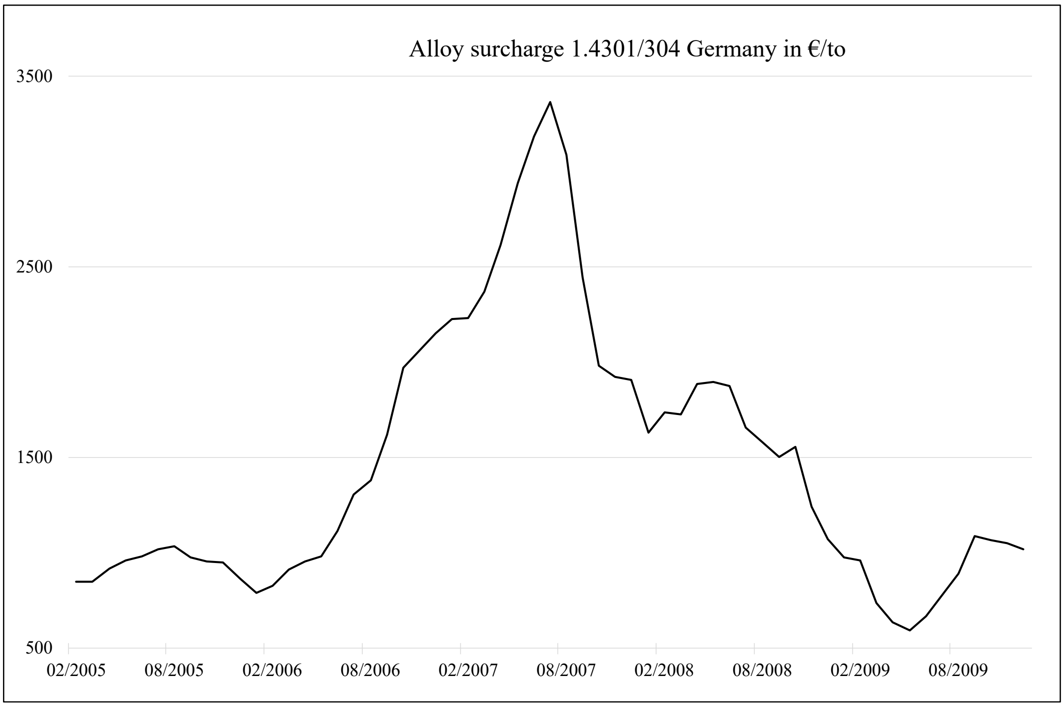

Figure 41 Alloy surcharge Germany 2005 to 2009, Source: own figure

This crisis revealed the weaknesses of the industry towards commodity price volatility risks and associated awareness of price risks. The interviews (Annex 8) verified the lack of risk awareness regarding raw material price fluctuations prior to the Financial crisis (APS, personal communication, 2019; AST, personal communication, 2019; OTK, personal communication, 2019). In its annual report, *Acerinox* (2020, p. 11) highlighted the need for short production cycles and inventory reductions. The shorter the duration of price-volatile raw materials in the plant's sphere of influence, the lower the susceptibility to price fluctuations. The consistent alignment of production to customer needs and the associated increase in profitability is, from the author's point of view, could constitute a benchmark in the stainless steel business. Price volatility is a risk, as there is a lack of knowledge about future price developments. Price volatility may create opportunities (e.g. windfall gains) and challenges (e.g., wind fall losses), volatility is not equal to a negative impact.

The regression analysis verifies the tendency, and the expected Nickle pricing (Table 68). Therefore, the Nickel price is statistically forecasted by the listed raw materials. The model summary (Annex 19) for Nickel and raw material concludes this with 94% probability. Even though solely “Ferrochrome” and the “Scrap 304 EU” are adding statically significant to the prediction $p < 0.05$.

Table 68 Nickel forecast calculated, Source: own data

Devi-ation	Nickel Month average	Date	Nickel calcu-lated	Average Month value multiplied with unstandardised co-efficient				
-12%	27,690	Jan 08	31,134	7,959	4,983	21,617	5,437	-8,862
-9%	27,955	Feb 08	30,339	9,036	4,802	21,033	5,593	-10,125
-3%	31,225	Mar 08	32,280	9,778	5,086	22,786	6,440	-11,809
-6%	28,763	Apr 08	30,431	9,629	5,060	21,033	6,729	-12,020
-9%	18,525	Oct 09	20,110	6,114	2,246	11,685	3,855	-3,790
Unstandardised Coefficients		(Constant)		Alu	Iron ore	Stainless 304 scrap Europe	Stainless 304 scrap USA	Ferro-chrome
		B	-2,885	3.3	25.8	11,685	2,228	-1.9

The calculations, the forecast of Nickel prices were performed for random months during the period of the world financial crisis. This calculation was made to verify if the prior analysis would benefit the companies in forecasting the Nickel prices. The prediction of the price direction is indicated within a tolerance band of -3% to –12% for the monthly average value. The predictive calculation of the Nickel price allows generating a time advantage that enables the selection of the mitigation strategy (-ies).

This close interdependency suggests that the prior findings are in line with the prior results of this research. Within given tolerances, the calculation results of the predictions (Table 68) suggest that it is feasible to predict the Nickel values and the direction of the price change. However, it is a cautious guideline, which may assume that statistical means benefit the enterprises in the mitigation of commodity price risks. However, it is one of the key findings of this thesis. Future research might want to explore an even better model fit to lessen the failure rate of the presented existing model.

This research demonstrates it is statistically feasible (significantly) to forecast the future Nickel price in times of crisis. Hence, the Nickel price is an early warning sign for the stock price situation in the stainless steel sector.

5.5.2.3 Contractual mitigation strategies

Mining industry

The rising uncertainty in the market since early summer 2008 signified the reluctance in the market to buy raw materials, based on the weaker demand figures of the industry.
The contractual strategies with longer-term validities were disputed as the prices rallied up and the mine operators would experience a limited profitability. Hence, a decreasing trend supports a price but with a reduced quantity sold. Only the mitigation strategy of long-term relationship and price setting, prior to the event, would have safeguarded the earnings (Delnooz et al., 2014; Watanabe et al., 2015, p. 215). However, it is contrary to the interests of the next value creation level. It is concluded that key customers are aware of the changing economic environment and uncertainty in the market. A major reason is market intelligence and the rapid exchange of information, especially via social media and industry information services. This market knowledge makes it almost impossible to take unilateral advantage of existing commercial contracts.
None of the annual reports (AR) for the respective years is available. Hence, the table is an indication, rather than a fact. Table 56 (p.174) states that index pricing is used by *BHP Billiton*, while all miners used contractual concepts, except *Vale*. *Vale* does not state this is in the AR, but it is expected that contracts are deployed to clarify the pricing conditions and periods with its customer base.
In the global economic crisis, the raw material industry had no other possibility than to influence prices by reducing the supply. The deliberate shutdown of production capacities given the economic belief that a tighter supply supports prices increases. In the environment of an economic crisis, this is an instrument that is, however, more focused cost base reductions.
The contractual mitigation strategies delay the price impact with uncertain volumes, which is a non-desirable outcome.

Stainless steel producers

Before returning the attention to the RO 7 and RQ 3.2, this section triangulates the findings with the insights from the questionnaire and the interviews. The stainless steel business is in a classic “sandwich” position, see Figure 39. Price volatility impacts the industry on both the buying- and selling sides. Thus, lower prices for raw materials, like Nickel and Nickel scrap (Scrap 304), increase the profitability of the mills. However, the customers noticed this price decrease. The spot market participants delayed purchases, as prices drop further. Thus, the

economic uncertainty spirals panic sales by stockholding traders that leads to a collapse of price and demand. This contrasts with the results of the questionnaire, as only one producer (anonymous answers prevented a second view) mentioned a spot market exposure, but unprecedented times request unprecedented reactions. In this context, the global financial crisis took place in 2008 and the questionnaire was answered in 2018. From the feedback, it is concluded that most contracts are long-term or with fixed prices. Manufacturers outside the EU/USA are more rigid with purchase contracts. This is a sign that production follows the order intake, and no stocks are created. The focus on inventory control (Table 57, p.176), supports this outcome.
The buyers are dictating the price, as demand collapsed. Many contractual options are not implementable in the sense of legally tenable between the negotiating partners. The stronger negotiating power prevails, despite existing contractual obligations. "Price setting" is possible for selected customers. Declining Nickel and metal quotations (e.g., Ferrochrome, Iron ore prices) cause a volatile alloy surcharge which is reflected in lower effective prices (prices including alloy surcharge), see details in Table 54, p.171.
Sharing or passing of prices or an index usages might help to rely on fact-based data series to reflect the pricing (Bolandifar & Chen, 2020). The precarious situation of the collapsing demand, coupled with the high fixed costs of the plants, is a delicate mixture. The answers to the questionnaire show that the mills in the US and Europe are using fixed prices (16 prices, Table 57, p.176). Hence, contract options which aim to increase sales (e.g., escalator clauses, piggyback, or staggering contracts) are pointless (Byrne et al., 2013; Gaudenzi et al., 2017; Shi et al., 2011). Production capacities are not used, hence even an "allocation flexibility", is not supporting sales volumes (Jüttner & Maklan, 2011).
The only functioning mitigation strategy is the "sharing/passing" of the new prices since both are involved commonly and share the burden accordingly together. The mills directed the sales activities on regular customers instead of lowering the even lower market price (APS, personal communication, 2019; AST, personal communication, 2019).
It is a fair assumption that the burden was with the steel producers. None index driven agreement was in place according to the interview partners.

Exhaust gas treatment system producer

The decreased demand of the automotive industry strokes the exhaust gas treatment producers. The agreements with the OEM allowed quantity fluctuations to reflect the decreased market volumes (allocation flexibility) (Jüttner & Maklan, 2011). Sometimes, the European and

American-based OEM producers agree on volumes within a tolerance band. For the exhaust producers, this was the only contractual way to regain monetary compensation for the deceased volumes.

Table 69 Questionnaire question 7/end customers, Source: own data

7. What are the different buying/selling strategies deployed to cope with price volatility?								
Region	Participants	Fixed prices	Long-term	Spot	Long-term and spot	Hedging of alloys	Inventory control	No strategy
USA/EU	69	31	30	4	21	13	24	3
		25%	24%	3%	17%	10%	19%	2%
Rest of World	10	3	6	1	4	1	0	1
		19%	38%	6%	25%	6%	0%	6%

The answers to the questionnaire suggest that the end users prefer fixed prices and long-term agreements, particularly in the EU and the USA. Knowing that the price fixation allows for a stable cost base, but cannot reflect the raw material volatility. On the purchasing side, quantity driven contracts have been renegotiated to reflect the lower market demand. Most of the burden was shared and individual agreements concluded. The responses from other geographic areas suggest that the combination of long-term and spot buy activities is a common method. However, the data series comprises 10 participants, hence, the findings are an indication. Inventory control and hedging play a minor role in the mitigation strategies of the end-users.

5.5.2.4 Sourcing mitigation strategies

Mining industry

The mining industry is not sourcing the raw materials, as these are excavated. Hence, this point is irrelevant. Just the redundancy of the resources, mines in different areas or countries, is beneficial to diversify the risk exposure from a single asset (Rutten & Youssef, 2007; Tufano, 1996). The diversification into different raw materials might reduce the risk exposure. However, this largely depends on the geological situation of the mines.

Stainless steel producers

Following the review of the AR's (2015 to 2019), none of the stainless steel producers had a major commodity price mitigation strategy in the sourcing sector (Table 59, p.177). The purchasing side of the mills secures the profitability. Procurement maintains a supplier

relationship through "single or multiple sourcing". The relationship-specific investment is the base for beneficial cooperation in crisis periods (Williamson, 1979).
The "forward buying" strategy source and demand pooling" have less importance in times of falling prices and reduced demand. Purchase timing is important. The right time and shorter delivery time ensure a price level in line with the market. The combination of pricing strategies (contractual) is of enormous economic importance. If the company assumes falling prices, short-term purchases relative to longer-term agreements can cover these. This is equivalent to having an overlap with "spot" purchases (strategic).
Overall, the economic circumstances are supporting a short-term low commitment activity from the purchase side about the price setting. It should reflect short cycles rather than long-term commitments.
The enterprise risk management (ERM) of the mills gained the increasing interest of the shareholders as the value of the company plunged. Hence, the risk exposure is readjusted or introduced for some mills (Annex 8). Therefore, the expected growth rates did not forecast a downturn in demand. Thus, the capacity extension in China was not considered as risk (ACX, personal communication, 2019; AKS, personal communication, 2019; AST, personal communication, 2019). This sharp decline hit the industry by surprise. The interviews revealed that risk management was in its infancy or not existing as a process.
For a long time, the Nickel price curve displayed only price increases. The years 2005-2007 have been extraordinary in the stainless steel business from a perspective of profitability. The Nickel price peaked in May 2007 at $54.200/ton. From this point in time, it Nickel prices reversed direction until late October 2008 with a value of below $9000/to (LME, 2020). This fall accumulated to 83% within 17 months with a decline of the monthly values that deteriorate the inventory price of goods. The timing difference between the purchase price and the selling price plays a key role in the valuation of the raw material and the ready material. The time to market becomes a competitive advantage (ACX, personal communication, 2019). The downward trend relates to the ERM activities (ACX, personal communication, 2019; APS, personal communication, 2019; AST, personal communication, 2019). The necessity to invest in the relationship (RSI), see section 3.3.3, became a lesson learned of the economic consequences of the years 2008 to 2009. The investment in relationships became apparent (Dyer et al., 1998; Dyer & Chu, 2003).

Exhaust gas treatment system

Procurement is typically focussed on economies of scale and synergies between purchase activities of different plants struggled with the new situation, which was characterised by reduced business volumes. Founded on the contractual obligations, the quantity driven contracts had to be amended to react to reduced demands and prices.
The sandwich position between the mills and OEM´s is reiterated(Annex 1). The OEM producers are larger and hold a substantial amount of economic leverage against the exhaust gas producers. The activities in times of crisis are focused on substitution of material grades in favour of less volatile and less expensive grades. The purchase timing is not in the regard of the forward buying but rather than to lessen the costs by choosing the most suited timing for the material required. Purchase decisions are based on the Nickel price forecast calculation.

5.5.2.5 Financial mitigation strategies

Mining industry

From a financial perspective, it would be obvious to suggest that the mining industry should hedge the prices of the products. Hence, the price volatility would be eradicated. However, this commodity price mitigation strategy is applied by the miners (5.4.1). Commodity price hedging in 2018/2019 was applied by all miners except *NorNickel* (Table 56, p.174). Therefore, it is part of the risk appetite of the enterprise. However, currency hedging is a routine financial operation for all miners.
From a theoretical stance, price insurance is an option that mitigates decreasing Nickel (commodity) prices. The inventory control applies to the excavated raw material. The excavation volumes can be adopted to the market requirements or and to the financial/operational requirements of the mining company. Inventory levels can influence the market price deliberately. If there are fewer freely available quantities in the market, the Nickel price can be supported, in the sense that the price rises. Similarly, production cuts can support the price, increasing the profitability of mine operators.
High inventory levels could have the opposite effect on the price. A negative price pressure. Since this is probably not desired by the mining companies, the operational tool of inventories can have a lasting effect on price discovery. Particularly as the pool of suppliers and buyers is very limited.

Stainless steel producers

For the mills, the sandwich position is also reiterated. Therefore, the classical hedge is subjective. The speculative prices of Nickel during the crisis did not allow it to outperform the market. The knowledge of the Nickel price development is almost public; hence, no information advantage seems logically possible to be gained from the producer, trader, or consumer perspective. Hence, the literature review reveals the speculative trade of raw materials. Therefore, a certain “herd behaviour” and subjective price volatility that is not in line with the fundamental supply and demand balance may occur. Built on the literature of the AR´s and the interviews, the stainless steel producers are hedging currencies, see the answers to the questionnaire (Table 69). Whereas *Aperam* hedges Nickel (2020, p. 53), *Outokumpu* hedges Nickel and Molybdenum to a certain amount (Outokumpu, 2020, p. 85).
Inventory control is the most important mitigation strategy for the stainless steel industry (Which is in line with the strict inventory concessions of *Acerinox* (Acerinox, 2020, p. 11; ACX, personal communication, 2019) and *Aperam* (APS, personal communication, 2019). Furthermore, it represents a main finding of the questionnaire responses in Table 57 (p. 176). According to the questionnaire responses (responses from mill employees), followed by hedging (24%) and the combination of long-term and spot buying contracts (22%). For the mills, inventory control and hedging is a regular mitigation strategy, compared to the customer (Table 69, p. 213) and the SSC´s (Table 61, p. 183). The limitation of financial exposure by a tight inventory control is predominantly paired with hedging of the raw materials is the mitigation strategy of choice for the mills, despite the availability of more sophisticated methods.

Exhaust gas treatment system producer

The hedging of pure Nickel is an option that was used in one exhaust producing company taken over by *Faurecia* in late 1990. A partial hedge of Nickel was made at *Zeuna Stärker*, in Augsburg, Germany (K. Wissinger, personal communication, 2019). It is not reported whether the hedging of pure Nickel was made during the financial crisis. The sole financial mitigation strategy is the inventory control by reducing the financial exposure to material cost fluctuations. Based on the findings of the questionnaire, question 7 (Table 69, p.213), inventory control is less important for the processors than for the mills. The burden of carrying inventory was pushed from the exhaust system producer to the SSC and the mill. The requirements contract specifies the short replenishment times (contractual mitigation strategy). Hence, this strategy has been implemented not only in stable times. The real mitigation happens in crisis times and with the awareness that Nickel price are volatile. Thus, lower inventory levels (working capital) reduce the financial exposure. Hence, it improves liquidity. This strategy is frequently implemented.

5.5.2.6 Strategic mitigation strategies

Mining industry

In terms of strategic options, the mine operators have a larger arsenal of avoidance strategies. In this category, "customer selection" and "strategic partnerships" are essential elements (Delnooz et al., 2014). Customer selection allows mine operators to manage the demand side and to position themselves in strategic business segments (Deloitte India, 2018). The price component can be mitigated through the partnerships, as this cooperation is important for both the sales and the customer side, including the steel mills. This long-term partnership avoids "spot buy" activities to the detriment of the mine's profitability. A certain diversification can help to offset the erosion of commodity prices. It emerges that diversification is the straightforward answer to stable earnings, and mitigates price volatility with the selection of export markets or other products (Kituyi, 2019).
Hence, lobbying might start actions to ensure the profitability, as "rescue funds" for the impacted industry. This targeted political influence is possible because of the size of the mining conglomerates. It is supported by the economic importance, often in countries with low GNP income and a high dependency on basic industries, detailed in section 3.3.2.

Stainless steel producers

The "Strategic" field of mitigation strategies offers a wide range of possibilities. In terms of the world monetary crisis, it was more a possibility to leverage on the existing decision that has been made before the world financial crisis.
This explains the reluctance to support spot business (Table 57, p.176). Therefore, pushing for long-term or fixed contracts is possible if the customers have been selected in such a way. However, it eliminates a short-term turnaround in a “depressive" market. Implementing a customer selection strategy to mitigate the impact is a long-term measure. The relationship-specific-investments (RSI) although it strengthens over time, requires resources. Spot market selling activities, in contrast, can be adopted with immediate impact to generate an increased order intake even at lower or no profit margins. However, these quantities are sold via the SSC sector, so the mills are not the price cutter in the market. In this respect, it is a buyer market.

Despite the immediate crisis in the market, the call for tariff and non-tariff barriers will go from the producers to politicians and governmental institutions. Hence, it secures industry jobs and stabilises the local economy. Therefore, these mitigation scenarios are favoured by the mills. The trade restrictions reduce competition and support the market position of local producers. For this reason, the steel mills will positively assess this policy in their own interest and support the existing market situation and will support a restrictive stance towards imported quantities. The political supported patriotism might become a burden to the mills and lead to a structural uncompetitive industry.
Still, during the world financial crisis, the mills served the spot market as they sought production quantities. The production lines (i.e. furnaces) had to be kept running to “feed the beast”, meaning to fill the production lines.

Exhaust gas treatment system producer

The processors and end customers prefer price stability. This is an outcome derived from the questionnaire (Table 69, p.213). In crisis times, the price pressure was brought forward to the mills and the SSC´s. For the sake of profitability, the exhaust producer had to push for price reductions either on the effective (including AS) or the base price that is supplemented with the AS. The AS is a method of price sharing/ passing (contractual strategies).
The price sharing/ passing mechanisms towards the customer need to be reviewed and to be aligned with the customer selection initiatives. The risk position must be defined and analysed to identify and mitigate the price risk that arises from the contractual obligations on the sales side.
For this purpose, a spot buy strategy should be used. However, previous contractual conditions had to be renegotiated. During the crisis, many contracts, see (5.5.2.3), were broken and replaced by lower price agreements. 2008 was a turbulent year, which was fuelled by the selfishness of the individual companies. Sometimes, it was done to secure their survival.

6 Recommendation & Conclusions

The summary chapter centres on the aim and objectives and results of this research. For this purpose, it explains the results, the implications, and the limitations of this thesis. Moreover suggestions for future research that emerged during this doctorate are elaborated.

6.1 Summary of results

The research flow diagram illustrates the three stages of the research process (Figure 15, p.79). Before drafting the questionnaire, the desk research produced valuable insights into patterns of CPV and the impact on share prices. Hence, the requirement to define volatility became apparent. Hence, the initial stage comprises the research questions of group 1 (RQ 1.1; 1.2 and 1.3) centring on volatility in a general sense. Research phase (RQ 2.1 & 2.2) two examined the existing mitigation strategies that are deployed to lessen the impacts of CPV. The third group (RQ 3.1 & 3.2) examined two past occurrences and the adequacy of the mitigation strategies.

Research questions group 1 (Volatility)

The first part encloses a meaningful definition of volatility (RQ 1.1). Calculation (RQ 1.2) and modelling of CPV then became the focus of this research. The CV calculation offers an initial and quick indication of the criticality of the volatility. The challenge to define the severeness of commodity price changes is elaborated. The erraticism and the range of the movements are challenging for a definition that suits academia and business expectations. Academia often concentrates on the harshness of the fluctuations and potential patterns (clustering), the dispersion and deviations. A pragmatic definition for the business, the stainless steel industry, is lacking. Therefore, the definition is straightforward and represents the business' essential requirements of an objective common understanding of volatility.
It is a business essential to minimise potential sources of price fluctuation and the impacts to the financial stability of the companies in the value chain of stainless steel. Mitigation activities may improve the financial situation, combined with the probability of outpacing the competition through predictive knowledge. In order to present a holistic viewpoint, three value creation levels , including the raw material as key ingredients into stainless steel, are examined.
Therefore, the results of multiple regression and GARCH are deployed as a method, providing a time advantage. Thus, time is of the essence when selecting the mitigation schemes.

These mitigation strategy/-ies depend on the business model and the level in the stainless steel value creation. It reiterates the importance of the organisational risk appetite in the ERM set-up.

In the literature, it is a common theme to connect the Oil price changes with the change of certain equities or industries, see section 3.2.6. It describes the causality and the relation. However, there are also counter-arguments, a close correlation between commodity and share prices cannot always be assumed (Arouri et al., 2012; Hammoudeh et al., 2010; Jones & Kaul, 1996), the supply and demand function cannot predict the share price change. The stock price was chosen as the suitable measurement method that reflects on the changes in the market. For this reason, it is assumed that a change in the raw material or input price impacts the stock price (Maghyereh et al., 2016; Wen et al., 2019). This assumption answers RQ 1.3. Th importance of Nickel in the stainless steel market is verified (5.1.5). The relation of the input material price to the stock price alteration is calculated. The stainless steel business is the largest consumer of Nickel and henceforth it may be concluded that these markets influence each other. This causality brings up the question about a potential time-varying effect. The causal relation between the time gap of (raw material) price changes and the impact allow predicting and hence mitigating the price risk to a certain extent. The particularities of each value creation level in the choice and application of price mitigation policies are examined.

Research question group 2 (mitigation strategies)

Potential strategies to counter the impact of CPV and the impact for the respective industries are researched (RQ 2.2). The burden of price volatility is counterbalanced. The firm foundation is the literature review (3.3) on the existing price mitigation scenarios (RQ 2.1). Initial categories list and segregate the existing mitigation strategies (Figure 33, p.165). This thesis expands the categorisation by a further category, the strategic mitigation strategies to underpin the importance of preventive strategies in contrast to reactive measures. The mitigation schemes are divided into operational and strategic initiatives. Commodity price volatility is a strategic commercial risk. Henceforth, the resources of the company may reflect this. The complexity of the new category, the strategic cluster, is underlined. It is a comprehensive approach, as corporate strategy, including resource planning, has a long-term impact. However, there is the tendency of enterprises to resolve strategic challenges with operational mitigation strategies. Therefore, external challenges may be misjudged as a strategic disfunction of the procurement organisation. The commercial necessity of identifying and analysing strategic

risks is stressed. Strategic risks justify a strategic counter/mitigation approach and not an operational approach. This approach may lead to a deterioration of the company's strategic profit outlook. The strategic relevance of active lobbying and customer/supplier selection is stressed, see section 5.5.
Literature is reviewed for potential opportunities to ease the impact of price fluctuations in the stainless steel business or other industries. The findings have been triangulated between the existing literature, the statistical findings, the questionnaire and the expert interviews. Therefore, these two sources of primary and diverse data streams of secondary data played a decisive role in the reflection between theory and applied practice. The existing academic literature underpins and challenges the pragmatic requirements of the companies in the value chain to run a profitable, long-term business. The literature offers a wide range of risk mitigation scenarios. However, the search routine revealed the non-existing literature for the stainless steel market. The focus on price fluctuations reduces the spectrum of literature and potential avoidance options. In the classic case, switching suppliers or multiple sourcing strategies are suggested. In the exhausts industry case, this is a rather theoretical, limited remedy. The significant consumption of stainless steel and the long-term contracts does not support an immediate change in suppliers. The limited number of stainless steel suppliers restrict other options. In sum, the negotiation position influences the mitigation scenarios. This circumstance is not reflected nor considered in literature, doubtless because stainless steel is a niche market. A shortcoming in literature is the limited range of cooperative solutions for sharing price risks. This cooperative or supply chain cooperation solution implies a change in corporate culture. Though, this approach is common in the Japanese economy. This thesis deploys the example of Denso and Toyota, which reveals the strength of mutual risk-sharing in the value chain. The decisive reference is the risk willingness of the companies. Therefore, the parameter influences the awareness, the methods, and the means of managing the impact of material price volatility.

Research question group 3 (examples)

The study concludes with the examination of two past exogenous events, which impacted the stainless steel industry. First examined example is the impact of the global economic crisis (i.e., financial disaster) in 2008 (RQ 3.2). Second, the impact of a political influence on the example of trade restrictions in 2018 by the US government (RQ 3.1) is examined. The impact of these tariff barriers on the global steel and stainless steel industry is researched.

Therefore, the examination of these exogenous events sheds light on the vulnerability of the stainless steel industry and stresses the importance of enterprise risk management. Mitigation strategies have a special significance, taking advantage of a strategic time advantage that strengthens competitiveness.

Through these two examples, the mitigation opportunities for the value chain are described and explained. The statistical methods from the description of price volatility enable the Nickel price prediction to mitigate the impact. Hence, the price development is within the limitations of statistics predictable. Multiple (auto)-regression predicts future values based on historic values. It is the theoretical basis. In conclusion, the results advocate the opportunity to generate a time advantage. Therefore, the temporal lead is a competitive advantage. It allows for the deliberate strategic selection of options. In contrast to the tactical, operational methods deployed to counter the effects. The time advantage allows the root causes to be kept in mind. Thus, active management of mitigation is achievable within the framework of ERM. The statistical derivation of price alterations is one of the contributions of this thesis. Hence, the objective is to protect the profitability and competitiveness of the respective enterprises.

6.1.1 Research question Group 1

This research paper elaborates on the imprecise description of volatility in literature and thus the different views and assessments of CPV to a common understanding, a definition. Therefore, the initial research questions are centred on the description and the definition of volatility. Hence, the necessity to explore the meaning is a consequence. Though, there is no specific definition of the term volatility in literature. Hence, the meaning and characterisation are carved out in section. However, this research offers an amended definition of volatility.

6.1.1.1 Definition of volatility

The first research question (RQ 1.1) forms the basis for further investigations in this thesis. The first three research objectives answer the definition and measurability of volatility. Section 2.2.1 highlights the essential requirement for a definition. The literature research elucidates the impact of commodity price volatility in the value chain. The reference on the share prices is explained. It is a similar relation to the influence of Gold and Oil prices on the processing industries.

The research design is set out in sections 4.1 and 4.2. The data collection and analysis are detailed in section 4.3. It includes the quantitative and qualitative part of this thesis.

Despite intensive literature research, the analysis indicates that research question 1.1 cannot be answered universally and completely, which adds to the ambiguity about the terminology volatility. A generic definition of volatility, notwithstanding the etymological definition, is not existing. Therefore, this research must answer the initial research question with the statement that there is not one definition to clarify the term volatility is available.
However, the most appropriate definition of volatility in relation to raw materials and the stainless steel industry is:
Volatility describes and measures by range (minimum to maximum) and frequency of the occurrence that price experiences in a certain period. The more vivid the price swings, the higher the level of volatility.
After defining of volatility, the logical step is to describe it. The problematic part of defining volatility is the difficulty of defining volatility thresholds and distinguishing between normal and extreme volatility. The literature often declares a 10% threshold a normal range of fluctuation. Values surpassing the 10% threshold characterise an unhealthy or crisis market situation (Aizenman & Pinto, 2005b, pp. 49–51). The definition and the derivation of a value scale that divides volatility into smaller intervals are beneficial for an interpretation. This division supports to assess the severity of volatility. The description of volatility cannot be explained without the risk appetite of the beholder. It remains a floating subjectivity of the term, as the risk willingness cannot be captured from the data series. This research is concluded with an aspect of subjectivity that reaches back to Kant and his publication, "Critique of Pure Reason". His findings concerning the non-deductive approach to axioms in philosophy and mathematics are still valid (Kant & Meiklejohn, 2009 Original published in 1781).

6.1.1.2 Measurement of volatility

Research question 1.1b, the measurement of volatility, is a pure statistical consideration. However, it is, apart from the academic angle, a pragmatic consideration. Further to the academic claim, the pragmatic determination of the price fluctuations in the business must be depicted. However, there is no universal method to measure and describe volatility. Any definition of volatility is vague in academic literature. The literature review points to the standard deviation as a common and pragmatic approach to measure the dispersion. However, it is the coefficient of variation that ensures the comparability of volatility in a pragmatic, operational format. Irrespective of the calculation method, the crucial question remains what can be derived from the result. The introduced scale bridges this gap, for an interpretation of volatility.

The simplistic approach enables an initial quick and conclusive interpretation of the results of the CV.
The more advanced methods to describe, model and predict future values are the multiple regression analysis and the GARCH statistics.
Hence, RQ 1.2 is answered. The recommended calculation method to measure commodity price volatility is the SD in combination with the CV. The CV value enables the comparison and the severity. However, any interpretation is subjective, hence not a deductive approach and has to explain with social- philosophical and value systematic approaches of the respective organisations. However, it represents a pragmatic solution for the industry. The five levels offer the opportunity for initial guidance. Volatility becomes interpretable and enables a common understanding.
Noteworthy that the length of the time series impacts the results. It does not capture the frequency of occurrence of severe events for these pragmatic calculations. The results confirm that deeper research into the statistical volatility is not given with the generic calculations. However, for a tactical reaction in the business sector, further statistical calculations, such as correlation and multiple regression calculations, are a criterion. The interdependencies and the modelling of volatility are a prerequisite to describe volatility and the consequences. The GARCH and the ARDL calculations will shed light on this connection.

6.1.1.3 Impact of commodity price volatility

The important calculations in this thesis are the statistical calculations to answer RQ 1.3a. A deductive approach by hypotheses testing. The crucial impact of Nickel prices is demonstrated. It is constructed on documentary research (methodological choice) with multiple methods (research strategy) on a longitudinal time horizon with secondary data analysed by IBM SPSS. The aim is to verify or falsify the altering of the raw materials on the stock price fluctuation of the companies.
The descriptive calculations of the data series (i.e., Annex 12 and Annex 13), followed by the correlation and the multiple linear regression calculations. These regression calculations answer and supports RO 2, see section 2.2.
The GARCH models the volatility and the irregular pattern of variation (heteroscedasticity), see section 5.1.6. The ARMA model predicts future volatility.
The understanding of the temporal relationship of the data series facilitates the generation of competitive advantages. The time advantage allows the choice of mitigation strategies to be

addressed and implemented earlier than the competition. This information lead can be decisive.

In the example of the world economic crisis, the multiple regression analysis predicted the Nickel price change and, hence, the direction of the price change. The ARDL calculation supports this finding. The findings reveal the strong positive relation between the stainless steel sector and the Compound, which represents the typical chemical analysis of the stainless steel grades. The findings of the prior hypothesis testing, the crucial role of the Nickel price fluctuations, are approved. These calculations confirmed the strong correlation of the raw materials (Compound) towards the stock price development. The multicollinearity of the data series remains a challenge. The interlinked industries might influence each other; hence, a certain industry dynamic might exist.

However, the core finding is the determination of the time lag between cause and impact. The limitation of the regression methods is the assumption that cause and effect happen at the same time with a constant strength of a relationship. However, this is not necessarily the case. Therefore, a principal achievement of this thesis is the calculation of the time delay between a raw material price change and a share price change. The time gap offers an opportunity for the selection of an operational mitigation strategy. In sum, statistical methods established the correlation and the time lag. The combination of these in the mitigation of commodity price volatility impacts contributes to the industry-specific knowledge.

These aspects are combined under the concept of industrial knowledge, without questioning these correlations. This thesis provides the academic basis for the impact of CPV on stock prices. The acceptance of assumed connections is not challenged and created a climate of company blindness. A kind of bubble exists, in which all participants accept and repeat the market laws and become a truth. In this thesis, statistical analysis questioned this assumed knowledge.

The results of the regression calculations answer research objective 2. It comprises the raw material and share prices of the value creation levels. The potential influence of the raw material prices towards the share prices is verified for all levels, however to a different extent.

The results of the hypotheses testing are illustrated in section 5.1.5, for the mining, stainless steel producers, and the exhaust system industry. These confirm the influence of Nickel on the share price development of the firms in the value creation levels. The hypotheses testing indicates the diminishing influence of the metal price changes. It confirms the assumption that value creation alleviates raw material price risk exposure. The strength of the regression analysis decreases. See Table 23 (p.138) for the mining companies, the stainless steel producers (Table 25, p.139) and the exhaust gas treatment system makers (Table 27, p.140). The strength of the correlation coefficient diminishes and even changes from positive to weak negative in two of four researched cases (*Faurecia and Futaba*).

The statistical analysis provides a new understanding of the impact of metal (i.e., Nickel) price changes on the value creation levels in the stainless steel business. The conclusions of the Oil industry (Bouri et al., 2017; Creti et al., 2013) are transferred to the stainless steel market. Thus, the dominant impact of an input raw material price on the stock price change of the industry. The literature review supports these findings. Besides the existing literature, the time-varying aspect is calculated. The pivotal role of the Nickel price for the stainless steel industry is demonstrated.

Mining Industry

For the mining industry, the commodities (Iron ore, Nickel, Ferrochrome) are impacting the share price. The findings show the dominant stimulus of the global prices for these raw materials on the stock price changes. The hypotheses testing confirmed the impact of Nickel on the other metals. However, this research identified the impact of the diverse metals on the Nickel price. These statistics confirm the fundamental influence of the Nickel price. The statistics considered multicollinearity in the analysis. Co-movements and spill-over effects are not to be neglected. According to the literature review, the prices of related elements tend to show similar price movement patterns. This research confirms the existing knowledge (Dwyer et al., 2011; Xu et al., 2019; Zhang & Chen, 2014).The conclusions of these studies are confirmed, transferred to the stainless steel business.

Specifically, *BHP Billiton´*s stock price is influenced by the statistical significance of Iron ore prices. The Nickel price and the stainless steel scrap price of the US and Europe influence the equity price of the other investigated companies. The Nickel content of the grade 304/1.4301 is at a minimum of 18% of the material contents. Hence, these companies are exposed to Nickel pricing more than to Iron ore and Ferrochrome pricing. Overall, the exposure to Nickel prices is evident. They have the strongest impact on the stock price of the mining companies.

The stainless steel scrap prices, which are often Nickel price-driven, are the second source of significant influence. The least R^2 value is 0.74 (*NorNickel*) and the maximum R^2 is 0.88 (*Vale*). These values confirm the association. Thus, the share prices of the mining business are driven by raw material commodity prices. The significant influence of commodity price fluctuation on stock prices of the mining companies in the first value creation level (5.1.5.2) is assumed with significant evidence.

However, the influence of the supply and demand price mechanism on the share pricing of the mining industry remains intact. Thus, the inelastic production influences the price and hence the stock price changes, see section 3.2.3. Henceforth, the bondage of the raw material and share prices goes beyond the simplistic supply and demand price function. From a regression perspective, there is sufficient evidence to support the strong bondage across the mining industry to the prices of the raw materials. Despite these superficial or obvious correlations, this study needs to show the statistical significance. The dependence on price fluctuations indicates the importance and urgency of price mitigation mechanisms and strategies.

Stainless steel producers

The statistical analysis provides an updated understanding of the relation between raw metal prices and equity prices in stainless steel mills. The literature review exposes the neglect of the stainless steel market in the topics of price mitigation or commercial topics. Therefore, this research contributes to the stainless steel sector by transferring existing literature and knowledge.

The impact of the commodity materials on the stock prices of the stainless steel makers is not as strong as for the miners. However, the share prices of the mills are influenced in three incidents by the Ferrochrome prices. The USA scrap rates reflect the Nickel price in two cases and in one case by Iron ore prices.

According to the calculations, the Nickel price and its fluctuations have a significant impact on the industrial sectors. The stainless steel business consumes 2/3 of the global Nickel production. Therefore, these findings support the assumption that an influence between both markets exists. The stainless steel melting process requires pure Nickel and stainless steel scrap. Pure Nickel is substituted with Nickel from stainless steel scrap when the pricing gap widens. A recent example of the price volatility of Nickel is compared to Copper and Aluminium prices (Figure 42). The Nickel prices exploded not because of a dysfunction of supply and demand, but through news releases and press publications. Indonesia, as the main exporter of Nickel ore considered a potential export ban (MEPS, 2019; Wallace, 2019). The trade restriction (political risk) sends the prices of Nickel to an unexpected price rally (Figure 45, p.236) at the recent example in 2019.

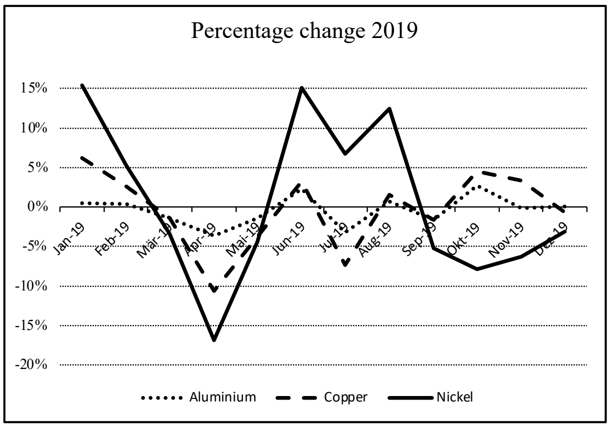

Figure 42 Percentage change Nickel 2018-2019, Referenced from: CMO Pink-Sheet

The local government leveraged the raw material reserves. Thus, the value creation of refined Nickel contributes to a larger extent to the welfare of the domestic economy. Therefore, it is a phenomenon rooted in a political decision that caused a price rally by adding uncertainty to the Nickel market. Hence, the value portion is increasing, the raw material content compared to the previous production level is inferior. The sales price of stainless steel compared to its raw material prices is higher and thus less influenced by the raw material portion. The value creation of the mills dilutes the impact of raw material costs to a certain extent. Thus, the price setting of the producers counters the raw material price change with the alloy surcharge addendum (in Europe and the USA). The mills pass the price risk to a diverse extent to the customer. In other countries, the raw material is factored into the sales prices once the material is ordered. The customer knows the exact price on the order date. It is invoiced at the delivery date.

When correlating Nickel and the share prices of the mills, the smallest R^2 value is 0.46 (*Acerinox*) and the peak R^2 is 0.87 (*Yieh*) for the time 1960 to 2018. The strategic set-up of the mills regarding the material grades produced is mirrored in the model summaries. The “pure” stainless steel mills are influenced by (exception of *Aperam*-Iron ore) by Nickel or stainless steel scrap (*Outokumpu*, *Acerinox*, *Yieh* and *Jindal*). Henceforth, the role of Nickel is apparent. The mixed mills (*AK Steel*, *Posco*, *Nippon*, *JFE*) that produce more carbon and to a lesser extent stainless steel are influenced by Ferrochrome prices. The exception is *Posco,* is an exception because of the Nickel prices. The strategic decision about the product range goes in parallel with the exposure to the relevant raw material price risks.

However, these companies separated the carbon steel parent companies from the stainless steel operations. For *Aperam,* it was part of the ArcelorMittal group and *Outokumpu* merged with *ThyssenKruppNirosta*. The stock price change, therefore, contains these special impacts.

These merger activities and implementation might have superseded the pure view of profitability and stock price direction.

Acerinox share prices have the lowest exposure to Nickel price changes, see section 5.4.2.4. Noteworthy are the short product cycles and the mill operation excellence initiatives, next to the increasing control of the route to market and the diversified customer segments. In recent years, the focus has switched from a production-driven sales approach to the understanding of the customer requirements. Therefore, Acerinox increases on a continuous level the share of value-enhancing operations (*VDM* merger and the bright annealing line in the USA) in their production portfolio.

The impact of raw material (i.e., Nickel) prices on share prices and on the profit of the mills is demonstrated. It supports the assumption of the inter-connection of these markets. Hence, the influence is diluted as the fluctuations are smoothened due to the average annualised value. Future research might aspire to examine the relationship by concentrating on quarterly publications.

This research exposes and confirms, with statistical evidence, the dominant influence of raw material on stainless steel producers. Despite internal efforts, the company's share prices depend to a certain extent on price changes beyond their control.

Exhaust gas treatment producer

Statistical analysis proves that a higher value creation share of the exhaust system business moderates the impact of commodity price volatility. The third level of the value chain reveals connections that are less strong than in the previous levels. The stock price of these enterprises is linked to a much lesser extent to the price change of the commodities. The lowest R^2 value is 0.31 (*Futaba*) and the highest R^2 is 0.53 (*Sejong*). Reviewing the change statistics, the R changes are therefore less substantial as for the previous value creation levels. Hence, it evidences the mitigating impact of value creation and diminishing material content.

The lower the material content, the lesser the stock price reflects the raw material price. Despite the value creation and the engineering value part, the raw material price changes are impacting the share price evolution. Henceforth, the statistical analysis provides the evidence. Three of the four correlation coefficients display a weak or moderate negative impact (*Tenneco, Faurecia,* and *Futaba*) for the time from 2008 to 2018 (Table 27, p.140).

The weak or moderate impact is in line with the reduced material content. However, the negative impact- the negative correlation coefficient- provides an assumption. The higher the raw material cost, so less efficient the exhaust system producers are in passing the price volatility to the customer. The mitigation strategy of price sharing and risk sharing is underutilised. For the stainless steel industry, this is a vital part of the mitigation, as the price alteration has a proven dramatic impact. Hence, the results examined the defence mechanisms for the exhaust gas treatment producers, see section 5.4.2. This is despite the partial use of the alloy surcharge pricing system. The Tier 1 producer cannot pass on the material volatility risks to the OEM. In contrast, the automotive producers use their negotiation power to overrule the obvious material price volatility risk to the prior production level (their suppliers). Hence, the exhaust producers must oversee it.

Hence, the stainless steel price volatility is not, to the complete extent, passed to the OEM´s nor their previous suppliers (Tier 2). The exhaust system producer must compensate for the price swings. Expressed as a negative correlation coefficient, hence the negative influence on the stock price change. Nickel prices negatively impact the share price of the exhaust gas treatment producers, however to a minimal extent. The negative correlation paired with the lower strength of the correlation indicates the inability to pass on price volatility risks.

Besides the existing literature, this research suggests supply chain cooperation, see section 3.3.4, at the example of the Japanese way of collaboration (keiretsu) to manage risk and uncertainty. The non-existent literature base for the stainless steel sector and the findings of the keiretsu approach is transferred from the automotive industry. Common success is more desirable than individual survival. The cultural change reflects onto the negotiation style. The results suggest that the effectiveness should be taken into consideration for future research to establish the statistical results of the different approaches to manage commodity price volatility.

Final statistical conclusions:

The conclusion of the statistics (Annex 13) is that the share price evolution is linked to raw material price fluctuations. These calculations revealed on most occasions a significant link to the price volatility of Nickel and the related scrap rates and the Ferrochrome prices.

From the 17 researched model summaries in the stepwise regression, the main influencing price components are Nickel related. The tables reveal that 14 out of 34 predicators are Nickel related (41%) and 32% by Ferrochrome prices. The value of the Nickel content is on average 50% of the typical material content and value portion, despite representing on average just 4% of the chemical content.

Statistical methods have proven the impact of CPV on stock prices. The strength of the relation depends on the positioning in the value chain. It includes the modelling of the volatility

through the GARCH model and the time delaying factor by the ARDL model. The conclusion is that the exhaust system producers are despite the elevated value creation level, are impacted by commodity price volatility.
Thus, the weight of the prices changes of the raw material is the strongest in the mining industry compared to the other value creation levels.
Thus, the mining companies express the strongest correlation with the raw material prices. The share price changes of the mining industry are attached to the commodity raw material price. The excavation costs are fixed or semifixed costs because of the level of equipment. This thesis shows that the Nickel prices are volatile and the revenue may vary. The price movement, therefore, has a direct impact on the economic outlook of the miners.
Moving up the value -/ supply chain, the stainless steel mills have been researched. The correlation, in most cases, is significant. *Aperam* and *Outokumpu* have become what they are today through acquisitions. *Aperam* unites the essential parts of the French stainless steel industry. The merger of the Finnish producer and the principal parts of the British and German stainless steel industries formed *Outokumpu*. The negative correlation of the *Aperam* stock price with the raw material commodities might be regarded as an exception to the general tendency of the researched companies.
In the last of the three value-added levels examined, the positive correlation turns into a negative one. The strength of the correlation is seldom over the level of 0.5 but is still latent existing.
Further research might want to explore the evolution of the strength in times of price increases and price decreases. Profitability is an obvious question. The unbalanced negotiation positions are taking a toll on the production level of Tier 1. The importance of maintaining profitability in a market that is characterised by unbalanced bargaining power of the participants.
The impact of the value-added operations will have to be investigated further in future research. As the upstream activities are important for the share price evolution in concurrence with the price volatility of the five mentioned commodity materials.
One conclusion to maintain a profitable market position might be to mitigate the commodity price risk by being in an unchallenged market segment. As an example, it is innovation or certain production capabilities or technologies or being a system provider rather than a part supplier.

6.1.1.4 Mills profit and raw material price development

The subsequent calculation examined the profitability of the companies to answer research question 1.3b. The research was conducted demonstrating the impact of Nickel price changes. The secondary data comprised annualised Nickel price and the annual reports of the stainless steel makers *Outokumpu*, *Aperam* and *Acerinox* (longitudinal). The target was to verify or falsify the impact of the Nickel price fluctuations on the profit of the "pure" stainless steel makers by statistical calculations. The limitations are the annualised data series and the small sample size.

The findings of the calculations reiterate the fundamental impact of Nickel price volatility. The answers to RQ 1.3b assume this result, see section 5.1.5.4. The reliance of the two industries on Nickel was discussed. The annual profit of the mills and the stock prices are impacted by Nickel price volatility. The results are not unidirectional. Henceforth, the results range from a strong negative (*Outokumpu)* and negative weak (*Aperam*) correlation to a noncorrelation at *Acerinox* (Table 38, p.154).

This contradicts the common assumption that increasing Nickel prices transforms a priori to an elevated mill profit. The assumption is that the mills manipulate the alloy surcharge setting in their favour. The initial correlation analysis reports the impact of the raw goods on profit and the impact of the produced quantity (Tonnage). Multicollinearity and the small sample size might bias the results. Increased output figures – economies of scale- tend to lead to increased profitability. However, the data suggests that increasing Nickel prices over a longer period positively impact stainless steel mills' profit.

Nickel price changes impacts the financial profit of the stainless steel producer, displayed in Table 39, p.155 and Table 40, the conclusive impact of Nickel (prices) is reiterated. Henceforth, the VIF figures confirm the impact. The multicollinearity affects the predictability of the producer's profit. Nonetheless, the strong bondage is assumed. The multiple regression analysis approves the assumption that external factors (i.e., raw material prices) impact the mills' profitability more than internal predictors (i.e., tonnage, employees, profit). The close relationship between the time series is illustrated (Figure 31, p.154). These findings contribute to the knowledge about the stainless steel business.

Future research may deal with a more detailed consideration of the time series (e.g., quarterly results). Another research approach could investigate the explicit order intake, exploring the finesses and differences between the periods. Hence, a more detailed perspective may shed light on the time lag between cause and effect (Nickel price changes and mills' profit).

The yearly discs enable the first step towards a holistic view. The differences in the correlation calculation show that understanding the differences is important. Questions to ask are why *Outokumpus* and *Aperam* annual results reveal a negative influence and *Acerinox* is almost not influenced.

The data suggest that the risk mitigation strategy of *Acerinox*, the fast and efficient transformation, is superior. The fast production from raw material to the sold product avoids the negative exposure and impact of commodity price volatility. This is in line with the prior findings regarding *Acerinox*.

- The lowest CV for the share price situation (5.1.4)
- The lowest impact of the Nickel price on the share price (5.1.5.3)
- The shortest exposure towards raw material price risk (5.1.6.1 and 5.1.7.2)

These findings suggest *Acerinox* is less impacted by the price changes in the raw material market than its competitors. The share price development compared to its peers confirms this finding.

The depiction of share prices as a normalised series displays the volatility. The relative stabilisation of the fluctuations after the global financial crisis in 2009 is remarkable. With a slight delay, the stock prices stabilise. The obvious interpretation of the stabilisation of share prices can be attributed to the risk management of the stainless steel mills. Fluctuations in the price of input materials have become the focus of the companies' attention. The active discussion and awareness of the risk potential may have led to a different assessment of the price fluctuations. Stainless steel mills are paying more attention to raw material price fluctuations.
The annual reports and the interviews confirmed this view. Hence, the robust link between Nickel and share prices approves this assumption.

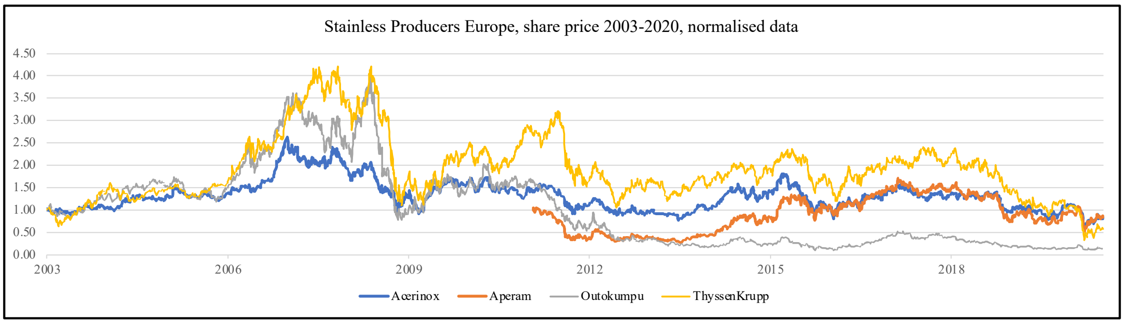

Figure 43 Percentage change Nickel 2003-2020, Source: own data

Since the price fluctuations in the world market are identical for all companies, the outcome depends on the commodity price mitigation scenarios. The questionnaires provide initial indications, and the expert interviews triangulate the results of the statistical calculations.

This is an important conclusion as it demonstrates that the company's profit depends to a major extent on external factors. The stainless steel mills can pass the raw material costs in a more sophisticated way towards the customers (price-sharing) or because of customer selection.

6.1.1.5 Scale to cluster volatility

In the financial sector, the measurement and modelling of volatility is common. The subjectivity of volatility and its impact is a gap in the literature. The calculations are made. However, interpreting volatility is lacking in the literature, hence subjective. However, the PMCC (Table 17, p.135) evidences the strength of the relationship. It is an accepted method to interpret the outcomes of the correlation coefficient analysis (Saunders et al., 2015, p. 245). However, the gap in the literature is the assessment of the fluctuations. The clustering and interpretation of the CV value is neglected.

Therefore, the introduced scale allows a common interpretation and understanding of the subjective volatility, measured as CV. The scale provides a method to measure and compare the level of volatility to map and diagram different data series and periods. It guides the initiation of mitigation strategies to protect the financial integrity of the company.

The result section establishes the calculation method to compute and research volatility. Two or more independent data series are comparable when deploying the CV. The test of normality to research if the data shows a normal distribution of values. If it is a non-normal distribution, this is regarded as strong and convincing evidence that the data series is volatile. Skewness and kurtosis determine the normal distribution. It linked the measurement of volatility to the variation value "V". It is following the research of Kvålseth and Landis and Koch (Table 7, p. 90).

The vague meaning of the term volatility requires a "firmer" definition. By dividing the measured volatility into five categories, this thesis provides aid not only in measuring the term volatility but also in classifying these results. The existing knowledge and acceptance of the Likert scale concept (Likert et al., 1934) and the PMCC scale are considered. The introduced scale provides five levels, but it is not bipolar like the original Likert scale. Hence, it should be classified as an ordered response scale rather than as a Likert scale.

In this section, this scale is deployed at the example of the data series used in this research. Four different periods are compared to evaluate the concept of a unified interpretation of the volatility of commodity materials for steel and stainless steel.

<u>Coefficient of variation over time</u>

To illustrate the inter-linkage between volatility and time, four different periods are illustrated. The CV was calculated for these, depending on the data availability. The data series listed in **Fehler! Verweisquelle konnte nicht gefunden werden.** are hence not complete for the mentioned periods. The occurrence "*N*" is listed.

Shorter periods lead often to lower CV values, hence less fluctuation. This is assumed when examining the shorter periods (2018-2020; 2019-2020 and 2020). The more recent periods display a lower CV value, but this does not a priori mean that prices are not volatile. Following the assumption that shorter periods show lower fluctuation rates (CV values), the raw materials have been investigated in greater detail in Table 70.

Table 70 Coefficient of variation development raw material as of 1960

CV	Period	1960-2020	1970-2020	2000-2021	2000-2010	2010-2020	2015-2020	2018-2020	2019-2020	2020
	N	732	612	252	120	132	72	36	24	12
Nickel		0.84	0.73	0.50	0.65	0.30	0.19	0.12	0.13	0.12
Aluminium		0.45	0.35	0.22	0.28	0.14	0.12	0.11	0.07	0.10
Iron Ore		0.96	0.86	0.55	0.72	0.37	0.29	0.23	0.18	0.19
Copper		0.79	0.71	0.43	0.61	0.18	0.13	0.09	0.10	0.13

The relative stability of commodity price volatility is misleading. It should not be regarded in isolation. The three last examined periods demonstrate a low CV value, however, the graph in Figure 45 suggests a volatile price development.

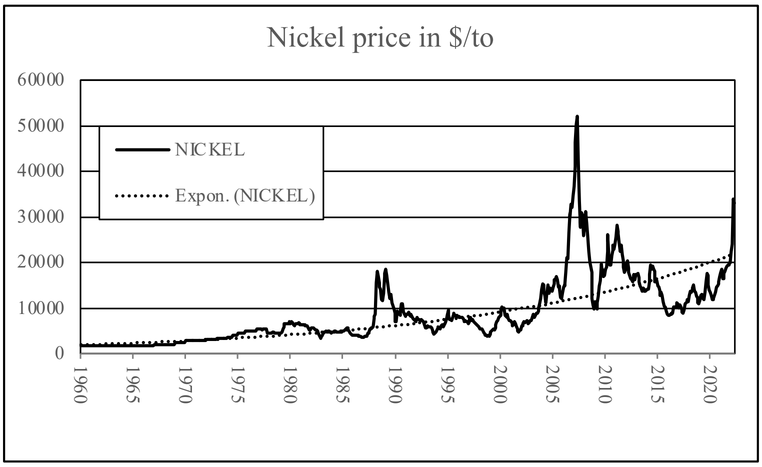

Figure 44 Nickel price development 1960 to 2020

The Nickel price varies in a range from 5019 (2020) and 6822 (2018-2020), which represents an over 50% change of the mean value (13,605 versus 6822). Hence, volatility is assumed. Therefore, the scaling of the CV seems not to be appropriate when sample sizes are below 60 data points. The data series confirms by the trend line that volatility is not inevitable without a trend, see Figure 44 and Figure 45. The above example shows that despite a deviation of 40% by the standard deviation, a relative "stable" level can occur. The fluctuations in Figure 45 illustrate a different image.

The trend of price development is an orientation that should be considered for the monetary evaluation of the inventory and commercial decisions. It includes the significance of windfall profits or losses in the risk assessment of the organisation.

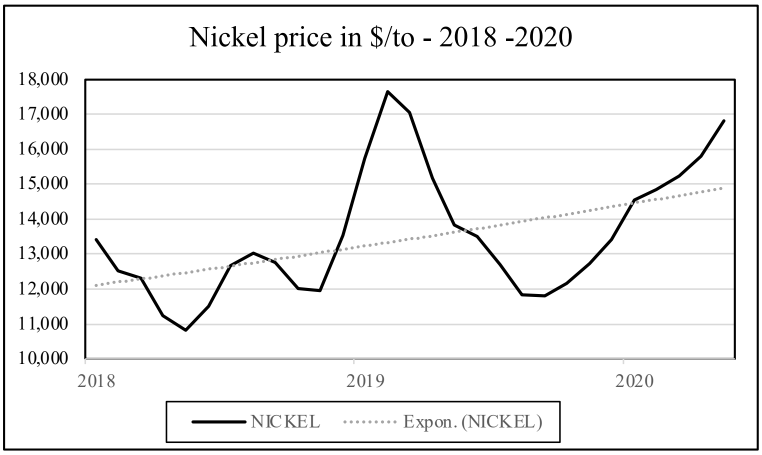

Figure 45 Nickel price development 2018-2020, Source: own data

As a side outcome, the displayed price trend of Nickel for the last 60 years contradicts the assumptions of Prebisch- Singer (Arezki, Hadri, et al., 2014; Ghoshray, 2011) that the prices of commodities should decrease in the long-run (3.2.3), as stated in the literature review section. Hence, interpreting the CV values depend on the volatility and time.

Table 71 Volatility level description,, Source: own data

Coefficient of variation CV	Volatility level description
< 0.20	Low
< 0.35	Normal low
≥ 0.35	Normal increased
≥ 0.55	Normal high
≥ 0.75	Extreme

This additional scaling of the levels of variation has been necessary to interpret and define the volatility levels of raw material and the stock prices of the impacted enterprises. The scale is leaning on the five levels, as mentioned earlier. The division of the volatility scale into five levels enables a better understanding of volatility. It facilitates a clear path to interpretation despite its diverse meaning and perceptions.

Therefore, volatility is made interpretable. This scaling is a first step towards classifying commodity price volatility and a contribution to the explicit meaning of the term volatility. Henceforth, this scale is one of the main findings of this thesis. The scale is a tool and method to interpret the measured volatility.

6.1.2 Research Question Group 2

This research section investigates mitigation approaches to avoid or lessen the impacts of commodity price volatility. Starting from the research philosophy of "Interpretivism", an abductive approach is deployed (Saunders et al., 2015, p. 145). The documentary analysis blends with the survey results and the interviews (methodological choice). Multiple methods (research strategy) approach is deployed, see section 4.3. It is a cross-sectional time horizon with secondary and primary data. The overall objective is to find a method or tool to predict and mitigate the impact of factors that affect the financial performance of the company. This impact is measured in relation to the share price.

The necessity to list the possible mitigation scenarios arises in connection with the different industrial sectors. It allows an overview of the existing mitigation strategies; however, these are divided into categories, including the strategic category. It is an outcome of the literature research. The survey results added to the findings and triangulated the theoretical price mitigation strategies and the categorisation of these. This section deploys secondary and primary data. The findings of the survey contributed to the input of the expert interviews.

The combination of different data (primary and secondary) streams and the statistical results posed a challenge to the research design see Figure 16 (p.86). This research flow comprises three phases. The phases build on each other, however, they influence each other, see Figure 15 (p.79). Hence, the different data streams could complement each other, however, it challenges each other. A necessary condition for triangulation.

The three examined industries have different requirements to limit the risk of price fluctuations. For mining companies, price volatility is an integral part of their business model. Nickel production is in the hands of a few mining conglomerates. Because of the material characteristics, a substitution is not feasible for the large portion of the demand. The sole opportunities to substitute primary Nickel in stainless steel production are Nickel-containing scrap quantities or NPI. However, all price listings of the Nickel contain input materials depend on the Nickel price.

For stainless steel producers, avoiding price changes is a major task to minimise business risk. The common avoidance strategy of "passing the (price) risk" to the customers is applied.

The time lag between the purchase, application in the production process and the invoicing of the sales process determines the exposure period. It is a permanent exposure in the risk control of price fluxes (e.g., raw material influence). The interview and the annual reports of *Acerinox* confirmed the root cause of the risk exposure. *Acerinox* confirmed the positive impact of short production times on the plant's risk position regarding commodity price volatility. The short production cycles- compared- to the competitors represent a competitive advantage from a risk mitigation perspective. Thus, the impact of the price fluctuations is limited because of the shorter exposure time. The brief time span is synonymous with a lower risk content. A reduced time gap allows a better prediction of price development. Thus, the production process is adapted to this strategic risk. The steel mill has aligned the production flow- as a strategic initiative- to minimise the exposure to strategic price risks. Noteworthy, that other financial aspect (i.e., working capital) are positively influenced as well due to lower inventory levels.

Customer selection is another strategic mitigation strategy. Thus, the mill sells to customers that either accept the price passing approach or customers that consume grades with low exposure to commodity price risks. Some material requirements are associated with a lower Nickel content, hence less fluctuation and exposure to price risk. The interviews with Aperam (APS, personal communication, 2019) and *Acerinox* (ACX, personal communication, 2019) confirmed this finding.

The instrument of influencing political functions in the sense of targeted "lobbying" is obtainable for those industries that can engage in this political and governmental environment. Thus, a certain size and funding resources are beneficial for this mitigation strategy. As an example, the steel industry is associated with this strategic approach, see section 3.3. The lobbyism that led to the trade restriction (US 232) is explained, the consequences are detailed. From a perspective of market accessibility and capacities in the steel industry, the strategic mitigation strategy of lobbying favours the lobbying interests, thus the domestic industry. The key role of the steel mills regarding employment is a well-received argument by governments and decision makers in the political arenas. At the example of a political influence, the US steel market changed to a restricted market with an increased market power of the domestic-influencers. From a steel producer perspective, active lobbyism has a crucial impact and is recommended from an overall risk mitigation perspective. Hence, this mitigation strategy is one of the preferable options. The macroeconomic disturbances for the customers of the steel industry are not considered.

This opportunity depends on the funding and the industry set-up. The fragmented industries, like the exhaust gas system producers operate from multiple geographical locations and must fulfil diverse national emission standards. The overall importance for the domestic industry is rather limited. Therefore, establishing a proper lobbyism and support to influence political decision makers is rather not feasible, hence this industry is excluded from this mitigation opportunity. An organisation in the car manufacturers' association, which represents the interests of the customers of the exhaust manufacturers, is non-existent. It resembles an unequal struggle to control impact of CPV. Exhaust gas manufacturers are in a "sandwich" position. Customers have greater bargaining power, and the steel mills hold the supply in their hands and passes the price risk on to them. Under these circumstances, it is more difficult to build in a strategic price risk portion into the material pricing (margin). This pricing risk may have a lasting impact on profitability and challenges the tolerated risks.

The adaptation of existing mitigation scenarios is clustered according to the conclusions of the prior research. The clustering reflects a modification of the existing concepts and theory. One of the key findings of this thesis is the consideration of the value chain levels. Hence, it is considered when selecting and applying the price defence strategies. The description of the method, the comparison with the primary sources, represents a significant refinement in the era of mitigation schemes. Therefore, distinct possibilities are presented.

For this purpose, the supply/value chain network approach, including the information-sharing approach, is examined. In sum, swarm intelligence may influence a mitigation strategy. The active cooperation between the members of the value chain minimises the CPV risk and mitigates the commercial risk exposure. Thus, it included the idea that the cooperative approach is superior to an individual approach. The ISO 3100 Risk Management can guide this approach.

The price risk strategy combines the risk appetite of the individual company and is influenced by the following factors, illustrated in Figure 46:

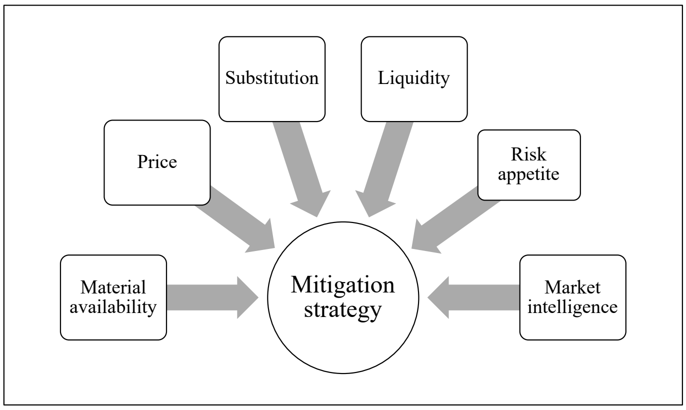

Figure 46 Influencing factors of risk mitigation strategy, Source: own figure

These are conclusions of the literature review and the primary data. Both have been examined and combined. The individual company´s decision to mitigate price risk depends on several factors. These contain specific evaluations and considerations of the market positioning. The results of the quantitative research are the foundation for predicting, price developments, cluster and rank the impacts of price fluctuations. Therefore, these identify, define, and leverage the time gap between cause and effect. With the overall target, to secure the profitability and avoid a potential derailing of the results caused by price fluctuations.

6.1.3 Research Question Group 3

The application of mitigation scenarios in the researched exogenous events is a deductive approach. However, the research philosophy is leaning towards “interpretivism”. The researcher is part of the industry, and the interpretations are a key contribution of this research. The methodological choice is a mixed-method. It deploys quantitative and qualitative elements to answer the research questions. In sum, a cross-sectional time horizon deploying primary and secondary data streams.

The third group of research questions assesses the exogenous developments and the appropriateness of the mitigation scenarios. RQ 3.1 examines the trade restrictions in the US steel industry in early 2018, RQ 3.2 examines the world monetary crisis in 2008. This specific section deploys an abductive approach. Multiple methods (research strategy) are deployed in with a cross-sectional time horizon. The aim is to change or clarify the existing theory about the impact of raw material price volatility on the stock price of enterprises. The literature review emphasised the findings of the influence of Oil & Gas pricing on the share price development of the manufacturing industry. These findings and assumptions are transferred to the stainless steel business.

These two exogenous events are examples of exploring the prior findings. Hence, the ability to predict the Nickel price fluctuations with statistical means, like the GARCH model. The time delay in the impact (i.e., ARDL calculation) offers the opportunity to mitigate input price risks. Both examples took place in a global economic environment, both originated in the USA.

6.1.3.1 Example: Political event

The selection of mitigation schemes in the event of political influence was researched in section 5.5.1 (Table 63, p.197) and Figure 40 (p.198). In the USA, as part of the political promises in the presidential election campaign in 2016. The elected 45th President implemented legislative barriers with the intention to save US steel workers' jobs. The aftermath of these trade restrictions impacted diverse stainless steel markets like Europe. The main spill-over effect was the diversion of product volumes into geographical areas that have been less restrictive with the import of steel products.
In this context, the informative value of the VIX should be emphasised. It played a significant role in the following multiple regression analyses (*Vale, Glencore,* Scrap USA, *Outokumpu, Aperam, Acerinox, AK Steel, Jindal, Nippon, JFE, Tenneco, Faurecia and Futaba*). Although the VIX itself could not be predicted, it has a role as an independent variable that significantly improves the quality of the model. It can therefore be concluded that economic uncertainty - measured by the VIX - is reflected in the stock prices. This research predicted with statistical significance the Nickel price.
Comparing VIX and Nickel pricing, Nickel has a greater significance in predicting price alterations. Hence, for the selection and implementing a mitigation strategy, the exposure to the Nickel price is the important inter-linkage. It is the root cause of the fluctuations and the inherent risks. Managing the Nickel price and the exposure to it are the answer to the mitigation decision. The influencing factors of the mitigation strategies are elaborated.

6.1.3.2 Example: Global financial crisis

Increasing uncertainty in the economy characterised the economic crisis. The performance of the VIX mirrors these findings. The price correction is reflected in the almost identical stock price movements of the companies examined in the period 2008 to 2009, see section 5.5.2. This thesis exposed the opportunity to predict Nickel prices. This is one of the fundamental results of this thesis.

By predicting the price evolution, the negative impacts of price fluctuations are avoided by implementing the appropriate buying and selling decisions. The company outlook and performance measured by the share price is safeguarded. The overall economic development impacts the stock price. However, the price fluctuations of the raw materials and the general supply and demand function likewise impact it. Therefore, it is possible to predict the Nickel price. Thus, enables a statistically significant contribution to the mitigation of the negative impact of raw material price fluctuations.

These findings are triangulated with the outcomes of the survey. Therefore, the verification of the conclusions of the primary data supported the findings regarding the exogenous occasion of the World financial crisis. These findings enable the implementation of mitigation strategies and may generate a time advantage.

6.2 Discussion / Importance of the results

6.2.1 Research Group 1

This research was segregated into three groups of research questions. The initial RQ defined volatility (RQ 1.1a) and the methods of calculation of volatility (RQ 1.1b). The research spans from simple calculation to the modelling of volatility. Therefore, the GARCH model and an ARDL calculation are applied. RQ 1.2 introduced a simple but reliable calculation method, as the CV and is later supported by an interpretation scale of it.

The following RQ 1.3a illustrates the stimulus of Nickel prices on the stock prices of firms in the value chain of stainless steel. The impact of the raw materials on the profit of the companies is researched in RQ 1.3b. The bias of Nickel prices on companies in the stainless steel business is striking. This finding is in line with previous findings of the Oil & Gas industry worldwide.

The possibility of predicting the Nickel price is proven. It is rooted in the connection between raw materials and their influence on stock prices. The relationship between Nickel and share prices offers the opportunity to gain a time advantage. This competitive advantage is the opportunity to lessen raw material price risks in the stainless steel business. The initial pillar is the strong existing relationship between Nickel and stainless steel mills. Further elaborated by the ARDL model, the close connection between the Compound and the mills. These reiterate the prior connections established with the correlation and multiple regression analysis.

The first contribution to knowledge is the confirmation of volatility and the pragmatic method to measure it. However, the more important conclusion is the strong linkage between the raw materials and influence on the stock price changes.
The forecast of the Nickel price change with the regression analysis the anticipates future prices. This, on its own, gives the industry leverage on the current price levels. The subjective judgment of price evolution and the inherent "herd behaviour" is avoided and statistics are predicting the future price development to a significant level. The auto-regression, the forecast based on historic values, with or without correction terms, is the opportunity to mitigate CPV risk in the future. GARCH models are a form to model volatility, taking the moving average into the equation. Henceforth, the increased statistical knowledge eases CPV risks.

6.2.2 Research Group 2

The literature review revealed numerous risk minimisations options (RQ 2.1). The applicability of the viable options (theoretical) was compared with the answers to the questionnaire. By including the view of the stainless steel producers (interviews), these results were reordered with the relevant experience and common practice. However, the personal experience of the author added to the findings. These three strands, the literature review, questionnaire, and interviews, ensured the finding that the above price risk strategies are applied in the industry. As a side result, these findings facilitated the triangulation.
These price risk mitigation scenarios were identified, presented and in a later step divided into four categories. These are financial, sourcing, contractual and extended with the strategic risk mitigation options (RQ 2.2).
However, there is a need to stress the importance of strategic mitigation schemes, including the clarification of the risk appetite of a company.
First, the risk appetite of the individual companies and its ability to cope on its own with the material price risks and the consequences. However, the supplier network cooperation, like the Japanese keiretsu idea, challenges the first approach. The opportunity to invest in RSI to spread the risks on several pillars, see the effects of swarm intelligence. Thus, venturing out on one's own in risk avoidance is a non-preferable option to avoid the impact of global and local commodity price volatility. The concept of swarm intelligence and the cooperative approach offer the opportunity to master the commodity price volatility risk.
Founded on the literature review, the ERM should include the input (raw) material price risk. The findings of the questionnaires and the interviews demonstrate the need for a raw material price mitigation strategy. Over 2/3 of the participants consider price volatility as the major

business risk. Therefore, it is surprising that price risk mitigation is still in its infancy (Fischl et al., 2014). Despite similarities with the Oil & Gas industry.

This thesis illustrates the strategic component of commodity price volatility. Even though it is often treated as an operational risk. However, CPV should be present more prominently in the ERM. The frequency of the words mentioned in the interviews reveals the impact of the word “price”, it is the most frequent expression. This suggests that pricing and pricing risks reached the executive agenda.

Henceforth, the mitigation of price volatility should be lifted to the executive’s agenda, so its steering is on an executive level. The example of the exhaust system industry as the major consumer of stainless steel in the automotive sector highlights this need. The global exposure of the industry demands active strategic price management as part of the efforts to secure the long-term profitability of the company. Knowing that they are exposed in a sandwich position in between mills and automotive producers.

For the global automotive exhaust manufacturers, the profitability, and the risk control of raw material is one of the decisive factors in the long-term view. Sales prices are often not entirely linked to the volatility of stainless steel. Therefore, the risk management of pricing, the mastering of price volatility minimises the exposure and limits the potential margin threat and loss of profitability.

An active price mitigation strategy is not limited to the stainless steel industry, like appliances (white good) producers, food processing equipment manufacturers, furniture companies like *IKEA*. All industries that are exposed to *VUCA* situations can profit from the conclusions of this thesis.

6.2.3 Research Group 3

The third group of research questions examines the practical applicability of the previous research questions. Two past events verified the statistical predictability of Nickel price volatility. At the example of trade restrictions (US 232) and the world financial crisis in 2008 (RQ 3.2) are elaborated.

The research results are verified by the two exogenous events. The results of the computations and possible mitigation strategies are demonstrated. The testing of the conclusions of the previous results constitutes the necessity of managing and incorporate an active ERM.

The calculations in the event of the world financial crisis allowed us to predict the Nickel price with statistical significance. The utmost important finding was the distinction of the price direction. The outcomes of the calculations demonstrate the pragmatic predictive element of statistics in the mitigation process. The calculations suggest that an active commodity price risk management is feasible, the prediction allows for generating a time advantage. Hence, countering price movements with an anticyclical buying pattern or selling pattern. The limitation of the calculations is the time horizon, the statistical accuracy of predicting future price movements worsens with each additional period. Which is statistic inherent and does not depend on the researched industry.

The statistical results reflect the predictive power of the following period. For the following periods, the accuracy of the predictions decreases, as suggested by the ARDL calculation. The results and the accuracy of the calculations can be improved with greater computer power and including further variables, such as interest rate levels, inflation trends, exchange rate fluctuations. In this thesis, it was important to show the connection between the price changes of the raw materials (Nickel, Ferrochrome) and the possibility of predicting the price direction.

This research advocates the necessity to mitigate strategic price risks (CPV) with strategic mitigation scenarios rather than the handling on an operational level. Thus, this finding contradicts the recent business sentiment to mitigate strategic risks by operational measures. Subsequently, the strategic elements of customer selection, lobbying, diversification and active role in the shaping of the supplier network are stressed.

6.3 Economic importance

This research conveys insights into the CPV management in the stainless steel business. This research concludes with the economic impact. Therefore, the opportunity to lessen the negative impact is examined. The opposite is within reach of an opportunistic commercial decision.

Raw material prices influence, to a significant extent, the share prices of the researched companies. However, this obvious assumption is proven by statistics. The comments on the influence of Oil prices on the transport sector initiated the investigation into existing raw material dependencies in the stainless steel sector. There is a similar dependence rate of 2/3. Nickel and Oil are dominant raw materials for specific industries. The interdependence is identical between Oil & transport and mining & steel companies.

Nickel influences both the special properties of the material and its value. Price fluctuations exist. Like other raw materials, prices are very volatile. Hedging these fluctuations is therefore in the interest of the companies so that it can exclude negative impacts. However, it is not the mitigation strategy of choice for the raw material prices, despite the common use of hedging for currency fluctuations.

This thesis supports the assumption that mitigation scenarios can avert or alleviate the negative impacts of raw material price volatility.

The economic importance of steel mills in particular for the local economies gives rise to a further mitigation strategy. Based on the local importance and partially for the entire domestic economy, steel has unprecedented importance for the economy. Hence, several interests and stakeholders are affected, when a producers' outlook is at stake. Lobbyism is henceforth incorporated into the DNA of these discussions.

A new aspect is the ecological CO_2 footprint that might increase costs distort historic trade, and cost relationships. This comprises introducing trade barriers for the import of steel as carbon border taxation values and respective compensation penalties. In recent years, lobbying has led to many trade barriers. The current global economic situation is fuelling these assumptions. World stainless steel trade is increasingly restricted. For Europe, it is a throwback to the beginning of the ECSC. But for the local steel industry, compartmentalisation is an appropriate defensive measure. The same tendencies are observed in the export of raw materials. Geopolitical or government interests impact market prices beyond supply and demand.

In sum, for all value creation levels, the influence and the possibility of avoiding the impacts of raw material price volatility are presented. Despite other influencing factors, the impact of the raw material side is evident and significant.

However, there are limitations to these findings. The specific risk appetite of an organisation is an unknown component. Exploring this qualitative component is crucial to understanding root causes. It is beyond this study. The willingness and the acceptance of certain risks in the ERM enable or disables certain opportunities and risks. Therefore, the individual risk appetite is the differentiator for the organisation, despite the same range of mitigation scenarios.

The alignment between commodity price volatility, the impact on the organisation and the mitigation schemes are the base for an ERM. However, the decision making about the expected action (mitigation) relies on the individual risk appetite. It is the entrepreneurial decision to adjust the accepted risk level.

However, this research advocates the strategic importance of commodity price volatility mitigation in the ERM. The steel industry faces new major tasks as the CO_2 neutral production legislations and rising energy costs.

6.4 Future research

Future research might want to explore the tie between the commodities themselves or between the stock prices of similar or different value creation levels. Similar upstream activities exist for certain other products, e.g., carbon steel, plastic industry, wood, or furniture industry.
Another wish is an exploration of a longitudinal study. This captures the diverse sentiments towards the major business risks in the stainless steel business. The replication of the questionnaire at diverse points in time might capture distinct aspects and principal thoughts. Ideally, this occurs, after a financial crisis or a similar exogenous event that impacts the business routine of the industry apart from the deployed survey strategy.
The impact of the time horizon of the data series might initiate future research. This research deploys monthly averages for the calculations. It might be an option to use daily prices to capture the subtle difference and to detail the ARDL findings. If quarterly results of the mills are offering a deeper insight into the time-varying aspect of the raw material price swings and their impacts.
Following these financial impacts, other economic data series might offer a diverse understanding. Incorporating of interest or currency rates GDP figures or diverse early bird indicators might add to the granulation of the price prediction. Hence, the mitigation of the price risks and a widening opportunity.
The depth of production and specialisation of some companies could be an opportunity for future research. Exploring the reasons for or against a broader product portfolio, as a buffer against raw material price fluctuations. Is a connection between these activities and the geographical region existing or is it a coincidence that it took place, particularly in Europe?
In this context, the diversification is driven by producers like *Acerinox* and *Aperam*. They are aiming to control the route to the end customer and to concentrate on niche products. Based on the clustering of the mitigation scenarios the overwhelming part of the price mitigation management is strategic and not operational.

Risk appetite

Regardless of the mitigation strategies described a consideration of the organisation's risk appetite is recommended. This risk appetite is crucial to understanding the selection of the preferred measure. This thesis will touch on this aspect; however, this research cannot explain this psychological-social phenomenon.

The distinction between risk and uncertainty goes back to Knight (1921) and his work "Risk, Uncertainty and Profit" who defined risk as a predictable probability. In contrast to uncertainty, where the outcome is unknown.
Almost 100 years later, these terms are often used equivalently (Groot & Thurik, 2018; Toma et al., 2012), despite the fundamental differences. The choice of mitigation is a decision in the presence of uncertainty. Hence, the outcome cannot be predicted with statistics. Uncertainty in corporate decisions is the responsibility of the "Risk" Board with steel mills and mine operators, although it should be an “Uncertainty Panel” in Knight's sense.
Therefore, this board sets the "virtual" guard rails for the management. It details the risk allowances for business decisions. Like *Outokumpu* and the decision to hedge Nickel (Outokumpu 2020, p.85; Anonymous 2019b), for *Aperam* to substitute pure elements like Nickel by stainless steel scrap with an appropriate Nickel content, among others.
Noteworthy that under these compliance conditions, the freedom and the speed of decision-making might not meet the speed of business requirements. Which favours smaller companies, where decision making is less restrictive. *AST* is a smaller stainless steel plant, although part of *ThyssenKrupp*, the CEO has a final say in the decisions concerning raw materials (AST, personal communication, 2019). The decision-making authority and purchasing sovereignty of the management can be a significant advantage in deadlocked situations. In this way, far-reaching, strategic points can also be considered, it can set the course for many years to come This is a negotiation advantage in smaller units (i.e., *AST*). In contrast to the management-led negotiation teams at other plants, such as *AKSteel* in the USA. Another example is *Aperam*, where the CEO agrees on the scrap purchases (APS, personal communication, 2019). This approach is inconceivable in a company like *AK Steel* or *Acerinox*.
In both cases, the internal regulations for limiting risk must be observed and adopted. Hence, it minimises the risk/uncertainty with listed companies. In smaller or non-listed companies, the preparedness to take risks/uncertainties might be higher. The non-existent control body cannot intervene. There is also a greater willingness to take risks if there is no financial interdependence between the company's management and its capital. However, a financial link favours the aspect of security, since a personal interest in the company exists (Callahan, 2002; Tufano, 1996).
Hence, the ability and willingness to accept and allow uncertainty in the business decision sets the base for the selection. In the example of a low tolerance band for uncertainty/ risk, the exposure to raw material price swings is limited. Hence, the tolerance band reduces the risk experience. The strategies of choice might hedge, price/risk passing, or index-based price

finding regulations. With a higher tolerance band in a *VUCA* world, the mitigation strategies like forwarding buying, price setting might be the methods of choice.
However, it might be of interest for future research to rank the risk/uncertainty through a domain-specific risk-taking (Dospert Scale) (Weber et al., 2002). It may evaluate the specific amount of risk and uncertainty that is allowed or accepted by the decision makers.
The impact of the risk willingness of the company has a pivotal role. It is hence obligatory to investigate this aspect. The Dospert scale is an appropriate tool to measure the risk attitude of the individual decision-makers in the organisation in its certain domains (Blais & Weber, 2006; Weber et al., 2002). The willingness to accept or neglect risks is an impact that is almost not recognised in the academic world (Fischl et al., 2014; Gaudenzi et al., 2017; Pellegrino et al., 2019) despite the financial instrument of hedging, as it is a common tool in the currency exchange rate environment (Pindyck, 2001).
About the clustering of volatility, subsequent research might want to explore a scale that adopts measured volatility. The severity of the volatility depends on interpreting a standardised scale (Table 71, p.236). The severity of volatility varies not only on price swings, but also on the time horizon. The SD measure the variation from the mean of the data series. It is an absolute value. However, the CV measures the relative value of change. However, the interpretation is subjective. Depending on the CPV, the ranking might have to be adjusted, which reflects the focus on the respective time horizon.

Mitigation strategies in the cause of industrialisation

The transformation of the manufacturing of stainless steel about the aspects of the concept of the value chain is a challenging research topic. Reviewing the various stages of the manufacturing concepts, the ERM focus might alter in the cause of time. Risk management faces changing requirements. Each industry sector experiences different risks. Hence, the business is becoming more complex (*VUCA*) and shifting, hence the focus on commodity price volatility risk. The same risk is regarded from different angles in different time periods (Agrawal & Hurriyet, 2004):

- Mass Production Era (1930-1970)
- Lean Production Era (1970-1990)
- Agile Production Era (1990-2000)
- Organic & Ecological Era (2000 onwards)

The relevance and the development of commodity price volatility risks compared with other business risks that impact the profitability and the business prospect. The evaluation of new risk themes is rooted in the diverse industrial eras. The examples are compliance breaches cybercrime attacks or a loss of reputation (CSR topics) that have not had relevance in the past decades. Altering price risks are challenging, therefore the ERM is fundamental for strategic risk management. It is vital to deal with the $VUCA$ world. Despite the financial risks of the "old economy" extra risks have the potential to derail the companies' earnings and financial stability.

Future research might wish to explore the changing requirements of raw material price volatility management in different time periods. The time of the economies of scale is terminated, hence is not the primary driver of profitability anymore.

Stainless steel future demand

The latest emission legislation, including the CO_2 restrictions, is enormous pressure on the steel-industry. The competitiveness of the commodity product steel will be challenged from a cost perspective and the increasing environmental awareness of the consumer. These implications have the potential to change the market position of the producers. If the CO_2 emissions of steel production and transport are considered the global trade of a commodity product, steel and stainless steel might have to obey new competitive forces (Horvath, 2001; Mouton et al., 2002). Entry barriers are shifting from manufacturing and capital costs to ecological environmental aspects. The value chain proposition is under enormous pressure. The era of the economies of scale would lose its grip on the "old economy". These implications are an aspect that should attract future research.

Another aspect is mergers and acquisitions in the different industries. The mining industry is a global business, whereas the stainless steel industry is because of trade protective measures regional orientated. 4-6 major players in the world dominate the exhaust system sector. The market position, the cost effects, the entrance barriers are impacting the profitability of the companies.

Causality and time-varying aspect

This thesis deploys the correlation analysis to research the linkage between variables. To secure these findings, it is recommended that future research want to expand this approach. The Granger causality test might distinguish whether one variable can predict the upcoming value of the other. Granger (1969) introduced it. The difference between ordinary regression calculations is the ability to predict the future value of a time series with historical data. The term is "Granger causality". For the selection of the mitigation scenarios, predictability is of mere

importance. The ability to limit the predictors is crucial in the ease of use for the commodity price volatility calculations (Lütkepohl & Krätzig, 2004, pp. 144–150). This approach might lead to an approach that deploys the opportunities of artificial intelligence (AI). From a supply chain risk approach incorporating a Hidden-Markov-Modell (HMM) is of interest for future research identifying the unknown parameters (Stamp, 2017). In an HMM, the system modelled is supposed to be a Markov process. It comprises unknown parameters, and the task is to discover the hidden parameters from the observed parameters (Franzese & Iuliano, 2019, p. 753).
The prisoner's dilemma is a takeaway of the game theory and a reference to the Nash Equilibrium. This angle might divulge new insights into the optimal choice of a mitigation strategy. Where the optimum outcome is where there is no incentive to deviate from the initial (mitigation) strategy.

6.5 Contribution to knowledge

The research gaps raised in section 3.6 are answered within this thesis. However, the academic journey of this research led to new challenges and future research opportunities. The parallel between the Oil & Gas prices and their influence on the processing industries and the researched raw material and stainless steel market. This research proves the pivotal aspect of the raw material prices for the stainless steel business. Therefore, the strong and considerable influence of Nickel prices is reiterated. The calculations and the answers of the interviews suggest that Nickel pricing is <u>the</u> influencing variable for the stainless steel business. Hence, it is a seismograph for the respective industry like the Oil & Gas price to the processing and transportation industries. Thus, this research examined and confirmed this relationship by statistical and qualitative means. However, it might sound obvious, but the stainless steel industry depends on the price movement of the input materials to an enormous extent. After the global financial crisis, this became apparent for the enterprises. So, there was a push to cope with the commodity price volatility risk in a more sophisticated manner. This research adds to the existing ERM and adds to the price prediction methods and the business advantage of information generation.
The influence of stainless steel scrap is not trivial to answer, unlike carbon steel scrap. The principal differentiator is the Nickel content. The price is determined by the price of Nickel and not always by the supply and demand function, like for carbon steel. However, future research might want to explore the share between the supply and demand function and the alloy contents in the price setting of stainless steel scrap. Taking the ecological discussions into

account, scrap might limit the emission of greenhouse gases like CO_2. It is assumed that the melting process with EAF furnaces emits fewer emissions than the conventional blast furnace production route (Fraunhofer Institut, 2019). Therefore, scrap will become more prominent as raw material, as it lowers the carbon footprint and hence the cost for the emission of CO_2.
The CPV of the raw materials has been displayed. The research gap to rank this price volatility is explained. The scale to interpret the CV is elaborated. Hence, the independent measurement of different data series allows scaling the volatility. Therefore, the CV calculation permits the ranking that allows the interpretation of the severity. Depending on the researched time, the ranking enables the mitigation of the negative impacts for an organisation. The objectivity of the ranking compared with the willingness to accept risks of the organisation allows connecting the price volatility to the ERM. The risk management system provides generic strategies or guidelines for the mitigation of the (risk) impacts. The risk-averse organisation might want to react to lower volatility levels than a company that is prepared to accept higher risk positions in its portfolio.
The objectivity of the statistics paired with the volatility level is the pragmatic discovery. The ranking scale might be adjusted however, the interpretation is possible, hence the ability to react to it. The linkage to the risk appetite supports the assumption that interpreting the CV is a subjective task. It enables objective risk management. Therefore, it impacts the profitability and the share price of the companies with a delay.
It is a question of time, not a question of whether it will affect the companies of the succeeding value creation level and the mills.

Selection of mitigation strategies

The selection of the mitigation strategy is a process. The lessons learned from this research can be summarised in the selection process for the combination of strategies.
The most essential component of ERM is the continuous monitoring of the relevant raw material and supplier markets. This consists not only of price curves but also of qualitative information. It is important for the assessment of future supply and demand and price trends. This foundation is essential to classify the relationships in the relevant market. The price volatility of the relevant raw materials must be under constant observation. For the stainless steel sector, these are Nickel, Ferrochrome and Iron ore. The volatility must be evaluated and classified using the CV. An evaluation of different time periods provides an initial classification of how volatility is developing in the markets. With the scale presented a comparison is possible, with the corresponding option to interpret and rank the severity of volatility.

The prediction of the expected price and price evolution is possible with a significant statistical probability. Note the answers to research questions 1.1 and 1.3.
The continuous screening of the commodity market is the beginning of market understanding and marketing intelligence. Information and content providers offer this service, such as *Bureau van Dijk*.
Subsequently. these basic principles of market intelligence are decisive for a competent and constructive exchange within this case, the stainless steel manufacturer. Communication on the same level enables the next level of knowledge acquisition. However, it requires information about the capacity utilisation of steel plants or the availability of scrap quantities to form a market judgement. Scrap is one of the most frequent ingredients in stainless steel production, as this is EAF (electric-arc furnace) based. Therefore, the literature review stresses the importance of the scrap situation. It was Alain Greenspan's favourite. The procurement functions organise the internal communication. The management process and evaluation of this information so it can be used as market intelligence and deployed as decision-making tool. Thus, knowledge management within the company is the foundation for a holistic decision regarding the mitigation of the negative consequences or the opportunities for commodity price volatility.
The exploitation of the information, forecasts and market assessment can be used in the ERM to select mitigation strategies. The steel mills and the mine operators have risk boards (Acerinox, 2019, p. 70; Aperam, 2020, p. 35; BHP Billiton, 2020, p. 35; Glencore, 2020, p. 98; Nornickel, 2020, p. 221; Outokumpu, 2020, p. 85; Vale, 2020, p. 122) to reduce the corporate risk appetite. This risk board secures the exposure and determines the limits up to which a business risk may be taken. The establishment of a structure that enables quick decisions to be made. This speed can be decisive. This is affirmed by the interviews with experts (APS, personal communication, 2019; AST, personal communication, 2019).
The qualitative data collection revealed the combination of long-term price hedging (up to 12 months or up to 24 months) and potential spot market purchases (Table 53, p.171). Thus, this strategy is the most common method to pair stability and flexibility (i.e., spot buys). The data of the questionnaire suggests that this strategy combines the price of a security with the opportunity to outpace the concluded contract. The calculations indicate that there is no apparent monetary difference between the diverse contracts. The “herd behaviour” of the market participants can exaggerate price movements. It plays an essential role according to the literature and the experience of the author.

The actual selection of a mitigation strategy to defend the company's position from negative impacts is like taking advantage of market opportunities. It involves several functions in the organisation, the procurement, finance, and logistic department. The section process and this is learning from the primary and secondary data deployed in this research is divided into a short term and a strategic branch. The initiation of the mitigation strategy to protect the company's earnings is a process that involves different business areas and is strategic.

The selection process is divided into an operational and a strategic component. It is an immediate operational decision, taken without delay, as time is the key success factor. Provided that the available financial and supply chain factors (storage space, merchantability, FIFO requirements, etc.) are accessible.

The strategic component, the decision to extend the value chain, are mid to long-term initiatives. It may comprise integrating the distribution channel, niche products, long products, welding wire production, etc... It ties up the company's resources and cannot be changed instantly. This strategic component can be observed at *Acerinox* and *Aperam*. Raw material prices do not affect *Outokumpu* in the Ferrochrome sector, as it's mine secures the supply.

As described, the exhaust manufacturers do not have the possibilities to pass on the raw material price risk completely to the automotive industry. For this reason, the portfolio of the measures might be limited but is existing. Market intelligence allows purchasing decisions to be made - under the existing restrictions - which can have a positive impact. In rising price situations, it can make sense to allocate material in the SC and suspend JIT deliveries from the supplier network. Or the changes in AS values can be brought forward or postponed around the end of the month to capture the more helpful one. It can be agreed with the steel mills that the AS invoicing occurs at various times in between the production and the physical delivery. Like the AS system introduced by *Outokumpu* for the trading sector. It offers the customer the opportunity to decide. The mills make their own decision. The plant offers the possibility, binds the customer to itself and shifts the price risk to the customer (Outokumpu, 2020, p. 240). The customer might see this as an opportunity to limit the raw material price of unpredicted exposure. From the mill's perspective, it is a risk- and price passing from the producer to the customer. In recent years, the Nickel prices, hence the AS is relatively stable, see Figure 31, p.154.

Apart from the stable price situation, the communication and the market knowledge about global price fluctuations is accessible for market participants. The customers and the producers are better informed, as news is travelling fast. There is a certain market transparency. The joint coordination between the steelworks, the exhaust gas manufacturer and the customer has created a relationship of trust. This allows an understanding and acceptance of these price risks and foster's a working relationship of trust. The unity prevailed and the partnership idea had a positive influence on TCE´s introduced by Coase (1937) further developed by Williamson (2005, 2007). Both authors see the relationship between supplier production and customer as an area to decrease costs through close cooperation. The RSI approach (Anderson, 2003; Crawford, 1990) suggest that, from the longer-term perspective, the positive development of the Japanese way (Dyer et al., 2018; Dyer & Chu, 2011; Fruin, 2008) of supplier network cooperation leads the way to a sustainable commodity price volatility mitigation for the participants along the value chain.

6.6 Limitations

However, this thesis cannot capture the complete value and supply chain of the product (i.e., exhaust system). Value creation and value capture are different in different industries. It is also a market power issue as suppliers and buyers negotiate along the supply chain. However, as technology develops and environmental circumstances change, the negotiation power in the value chain can shift from one industry to another. The complete value chain comprises more segments than the three mentioned in this research. In the value chain of not solely of stainless steel, there are six industries that influence the price the consumer (end-user) pays for an automobile:

1. Governments (issue mining licences and receive contractual and tax revenues)
2. Mining companies (produce and sell metals and minerals)
3. Steel companies (manufacture and sell stainless steel)
4. Tier 1 Automotive components/systems manufacturers
5. Automotive OEMs (design, assemble and sell automobiles)
6. Automotive retailers (buy and sell automobiles)

The captured industries 2,3 & 4 include the price risk of the raw materials. These are exposed to CPV, and the researched industries. The governmental and political aspect is partway captured as trade restrictions. However, the effects of industries 1,5 & 6 might lead to future research.

Many of the companies are multi-product firms, hence the aggregated numbers might dilute a one-to-one impact of the raw material price movements. However, a more diversified view is not possible for all researched companies. The exception is the "pure" stainless steel producers. Hence, these are the principal focus of this research. The result section carves out the influencing raw materials for the steel producers. The production mix (carbon versus stainless steel) points to the influencing raw materials. The nucleolus of this research is the stainless steel mills with a diversified shareholder structure. The steel industry is considered an “old economy”; therefore, some simplistic assumptions can be made without stressing the results. The value chain price volatility is linked to the company’s profit under the assumption that the mills are rational economic actors.

The principal aim is the maximation of profit. This is essential to assume that other profit influencing factors are to be neglected. In Germany, often the unions and the family ownership distress the simple assumption of profit maximisation. Examples with a focus besides the rational economic profit rationalisation are Bosch (employees), SMEs (who cannot tax arbitrage), or Japanese competitors (disproportional reinvestment in CAPEX and customer markets). However, for none of the stainless steel mills, this assumption is relevant.
This thesis covers the old economy of steel production and is hence closer to the profit interest than other industries or other ranks in the value creation. Therefore, the limitations exist and are dealt with in the results and conclusion sections.

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Appendix No. 1

Background information

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Background information

1 Mining market

The global mining and metals industry are expecting a stronger demand nonetheless accompanied by a volatile pricing situation. The expected future increase in demand is anticipated with investments to expand the production (Moghaddam, 2018). This increase in Global production/ excavation capacities of base metals happened for most metals in the 2000s (Arezki, 2015). As an important industrial raw material, the price volatility of base metals has an important influence on the macro economy (Wu & Hu, 2016, p. 2784f) and therefore for the consumers, transformers and producers of the products made from these raw materials. The steel and aluminium industry are consuming most of these base metals. The stainless-steel industry in particular as it is the main receiver of the primary and secondary Nickel market. The share of 65% for the production of stainless-steel and another 20% for other special steel grades is a strong evidence of the bond and interdependency between these two markets (White, 2019). The automotive production consumes 12% of the Global steel production in general is the third largest consumer for steel in the World (Basson, 2019). Which implications does the commodity price volatility have to the profitability and sourcing strategies in this industry and in particular and for other commodity orientated industries as well? The consequences in the supply chain and the procedures that trigger the appropriate mitigation strategy(-ies) and practises and solutions to balance the commodity price volatility in the stainless-steel segment are being examined. This research is to the best of the authors knowledge the only research that will investigate and bridge the gap between commodity price volatility in the stainless-steel market. Extensive research has been completed on the commodity raw materials and on the statistical approaches to forecast and to predict and to manage price volatility risk but have so far not been linked to this particular industry.

The base materials, such as -Iron Ore, Nickel, Ferrochrome, Copper, Aluminium- sometimes referred to as precious metals are referred to in this report as commodities, see section 1.1. Despite the availability of these materials and the inherent criticality (Achzet & Helbig, 2013), the price fluctuations are an important driver of profitability. In the initial stage of the value creation chain is the mining industry.

The mining industry is very capital intensive. The base metals referred to in this report are the “ferrous” metals (Iron Ore) and the “non-ferrous” metals (Nickel, Aluminium, Copper, Zinc), both are base metals that are “low” in value by weight. Precious metals are “higher” in value by weight like Gold and Palladium or Rhodium. The Iron Ore market is dominated by three companies that dominate approximately 75% of it (Rio Tinto, Vale, BHP Billiton). The “non-ferrous” metals are excavated by smaller mining companies and some of these are “by-products” (Poitras, 2013, pp. 32–34). The mining industry is characterized as high capital-intensive, thus higher prices are generally directly exposing a better profitability. Higher prices might open the opportunity to excavate commodities in areas with a higher excavation cost base. This might if the increased supply is not finding a ready market result in a lower profitability.

The customer of these commodities is on the other hand suffering from higher commodity prices as these are affecting their profitability in an opposing direction (increased cost for the base metals). The price swings are not solely attributed to the demand and supply function of an ideal market. Further examples will be given in chapter 5.3. These price fluctuations are referenced as commodity price volatility in this report.

2 Stainless steel market

Stainless steel was invented in the early years of the 20th century. On October 17th in the year 1912, *Krupp* engineers Benno Strauss and Eduard Maurer patented austenitic stainless steel as Nirosta in Germany. Shortly before, Harry Brearley of the Brown-Firth research laboratory in Sheffield, England, while seeking a corrosion-resistant alloy for gun barrels, discovered and subsequently industrialized a martensitic stainless-steel alloy. The discovery was announced two years later in a January 1915 newspaper article in The New York Times ('Stainless steel', 2017).

In general steel is a combination or alloy of iron and carbon. The carbon content is below 2% of carbon, below 1% of manganese and small contents of silicon, phosphorus, sulphur and oxygen (Basson, 2019). In metallurgy, stainless steel, also known as inox steel or inox from French inoxydable, is a steel alloy with a minimum of 10.5% chromium content by mass. Stainless steel is notable for its corrosion resistance, and it is widely used for food handling and cutlery among many other applications (Cobb, 2010, p. 5).

To produce one ton of steel via the blast furnace production route it takes:

- 1.37 tons of iron ore
- 0.78 tons of coal
- 0.27 tons of limestone
- 0.125 tons of steel scrap

The second production possibility is via the electric arc furnaces (EAF):

- 710 kg of steel scrap
- 586 kg of iron ore
- 150 kg of coal
- 88 kg of limestone and
- 2.3 GJ of electricity

Iron ore is thus the main ingredient in the production via the blast furnace route and if recycled via the same route or the EAF melting iron ore is used again for the production of a steel or stainless-steel (Basson, 2019).

Stainless steel does not readily corrode, rust or stain with water as ordinary steel does. However, it is not fully stain-proof in low-oxygen, high-salinity, or poor air-circulation environments. There are various grades and surface finishes of stainless steel to suit the environment the alloy must endure. Stainless steel is used where both the properties of steel and corrosion resistance are required (Basson, 2019).

2.1 Stainless-steel compounds

The main characteristics of the material are the impacts of certain alloys in the chemical composition of the material. The main alloys in these grades are Nickel, Ferrochrome, Titanium and Manganese for the commonly used grades. The grades are defined as ferritic, austenitic and duplex grades.

The material is resistant to corrosion and heat, but it is not immune to it. This means that the choice of the material grades is dependent on the application. Temperature and mediums involved are having an impact to the corrosion resistance.

2.2 Stainless-Steel market size and main players

In the year 2015 and 2017, the global stainless-steel market was dominated in terms of production capacity and production tonnage by twenty suppliers. This report focusses on the flat products, the sheets, and coils not the long products, the bars, and profiles of the product spectrum of the mills. The flat products represent slightly above 80% of the global stainless-steel market (Rowe, 2020) according to the International Stainless Steel Forum (ISSF). From this perspective the production capacities and the headquarters of the main producers are in Asia, more specifically in China. Eleven of the top 20 producers are headquartered in China. Another four (2018 data) are headquartered in Asia (Taiwan, Japan, and Korea). Fifteen or 75% of the top 20 producers are in Asia. The sole American owned producer AK steel dropped out of the equation lately. Despite the restrictive trade environment of the national government, see chapter 1.2 and 5.3.1 (Moll, 2016, 2018, 2020).

Table 1 Mayor stainless steel producers in 2015, 2017 and 2018, Source SMR, Stainless steel mills

Stainless steel Producer 2015	Country of HQ	Stainless steel Producer 2017	Country of HQ	Stainless steel Producer 2018	Country of HQ
Tsingshan Group	China	Tsingshan Group	China	Tsingshan Group	China
TISCO	China	TISCO	China	TISCO	China
POSCO Group	Korea	POSCO Group	Korea	POSCO Group	Korea
Baosteel Stainless Steel	China	Hong Wang Group	China	Chengde Group	China
Outokumpu Group	Finland	Outokumpu Group	Finland	Outokumpu Group	Finland
Acerinox Group	Spain	Chengde Group	China	Acerinox Group	Spain
Aperam Group	France	Acerinox Group	Spain	Aperam Group	France
LISCO	Taiwan	Aperam Group	France	Jindal Stainless	India
Jinguang Group	China	Baosteel Stainless Steel	China	Jiangsu Delong	China
Chengde Group	China	LISCO	Taiwan	LISCO	Taiwan
JISCO	China	Jindal Stainless	India	Acciai Speciali Terni	Italy
Acciai Speciali Terni	Italy	JISCO	China	Baosteel Stainless Steel	China
Jindal Stainless	India	Acciai Speciali Terni	Italy	JISCO	China
NSSC (Nippon Stainless Steel Corp)	Japan	NSSC (Nippon Stainless Steel Corp)	Japan	NSSC	Japan
Shandong Taishan Stainless Steel	China	Lianyungang Huale Alloys	China	Henan Xinjinhui	China
AK Steel	USA	YUSCO	China	Fujian Fuxin	China
Zhenshi Group Eastern Special Steel	China	Henan Xinjinhui	China	YUSCO	China
YUSCO	China	Jiangsu Delong	China	Lianyungang Huale Alloys	China
Lianyungang Huale Alloys	China	Fujian Fuxin	China	Nisshin Steel HD	Japan
Henan Xinjinhui	China	AK Steel	USA	Shandong Taishan Stainless Steel	China

Table 2 Summary Stainless steel producers per geographical region, Source SMR, Stainless steel mills

Summary per region	No. of Mills 2015	No. of Mills 2017	No. of Mills 2018
China	11	11	11
Europe	4	4	4
USA	1	1	0
Korea	1	1	1
India	1	1	1
Japan	1	1	2
Taiwan	1	1	1

In 2015 the global production output reached a level of 41.5 million metric tons. According to the production figures 75% of the world stainless steel production was manufactured in Asia , 52% in China and 23% in Asia excluding China. In 2018 the global production reached 50.7 million metric tons. The average annualized growth rate since 1980 is 5.4% according the ISSF 2019. This growth rate is compared to other industry metals like Aluminium (3.7%) or Copper (2.6%) and more than double the growth rate of carbon steel (2.5%) (Rowe, 2020). The share of the Chinese producers remained at 53%, the Asian share excluding China decreased to 16.2%. Thus, the Asian share reduced to one the first glimpse to close to 70% of the world stainless-steel production. But if South Korea´s Posco and Tsingshan with the production unit in Indonesia are accumulated to the Asian share it increases by almost 10% to 80%.

The Finnish Outokumpu merged with British company Avesta in 2001. Avesta was part of British Steel. In 2012 Outokumpu merged with the stainless-steel division of ThyssenKrupp, called Inoxum, formerly known as ThyssenKrupp Nirosta. A similar approach was taken when the stainless-steel activities of ArcelorMittal have been separated in 2011. These activities have been brought together to the newly formed company called Aperam. ArcelorMittal is by capacity and quantity output the most important steel producer for carbon steel products in the world. The European stainless-steel producers are purely dedicated to this product. Globally there are just two mayor stainless-steel producers that are “pure” producers, the largest producer in the world Tsingshan Holding in China and Indonesia and Jindal in India. The Chinese producer, with almost 7,5 Million metric tons of crude stainless-steel production in 2017 and intentions to expand to a production capacity of 10 million tons. In India the operations of Jindal stainless is dedicated to this product. All other mayor stainless-steel producers are part of carbon steel manufacturers, like AK Steel, Posco, Nippon or JFE.

2.3 Market restrictions

The stainless industry developed in Europe and later in North America until 1990. Thereafter the Chinese government decided to invest in the steel industry in general and as part of it into the stainless-steel industry. The focus of the production was and is on the most common austenitic grades. These grades are easier to produce- less production time and less equipment abrasion- for the same amount of tonnage. These production capacities are influencing the stainless-steel production and the pricing tendencies in the stainless-steel market. Due to the installed stainless-steel production capacities, the market is experiencing overcapacities. The most recent stainless-steel production installations have been in Asia, in particular in China. The production capacities in China are exceeding the stainless-steel demand in China. This overcapacity was the initial rational to start to export into more developed countries with a higher stainless-steel demand like Europe and into the United States of America. Both economic regions did protect the domestic stainless-steel producers with the introduction of tariff barriers. These trade restrictions have been imposed in 2015 for the European community (Commission implementing regulation (EU) 2015/1429 of 26 August 2015 imposing a definitive anti-dumping duty on imports of stainless-steel cold-rolled flat products originating in the People's Republic of China and Taiwan) and 2016 in the USA. Other examples are the trade barriers imposed by the relatively small stainless-steel mills in South Africa (Columbus of *Acerinox*) and *Aperam* in Brazil. Both countries have imposed legislation to prevent the import of stainless steel to protect the domestic producer. The stainless-steel market is therefore not a free trade market from the perspective of a free flow of goods and materials.

The other perspective is partly a self-imposed restriction. The grades produced in the different regions differ from grades in others. The main austenitic grades like 304/ 1.4301, 316/ 1.4571 / 1.4404 are widely available but the 309/1.4828 and the different grades of heat-resistant materials are not. Sometimes there is no equivalent in EN –AISI or JIS standard to name the main steel grades standardization institutional systems. For historical reasons the mills in Europe, the United States of America and Japan developed slightly different grades for similar applications. From a production point of view all grades are similar in the recipe but the usage is not matching the minimum production lots of the heavy industry. Production minimum lot sizes can be as important as 360 tons. Which might often be too much for the end user, the exhaust gas treatment sector.

These trade regulations are stressing the supply chain as a free material flow and availability of stainless-steel materials are not given. Chinese stainless-steel material which is typically competitively priced is excluded from the US and the European market. From Asian production locations (China, Japan, Malaysia, and Taiwan) not all material grade selections are available. These restrictions are concluding into an export of materials around the globe to satisfy the Automotive producer's requirements. Material produced at one location must be shipped and transported at competitive levels around the globe. One of the main reasons for the competitive advantage and the cost leadership of the Chinese mills is the usage of Nickel Pick Iron (NPI) and the most recent production equipment. Most of the Chinese stainless-steel production sites are greenfield investments. Based on western or Japanese melting and rolling production equipment. The Chinese producers in specific Tsiangshan are using NPI as the main source for Nickel alloys in the material. This process is giving the stainless-steel producer a competitive advantage of up to 300$/ ton on a standard 304 material grade as flat material in cold rolled condition (CR 2B-condition) according to the market research institute SMR.

2.4 Route to the market

Stainless-steel is sold typically from the mills to trading companies and distribution companies. In some cases, if the quantity or for specific material the material is sold directly to the customer base. The main exhaust gas treatment system producers are supplied usually on a mill-direct base. Stainless-steel is not traded at any metal exchange and therefore this product is not considered a commodity from a trading point of view. Carbon steel billets for example are traded at the London Metal Exchange (LME). Irrespectively from the higher value proposition of stainless-steel. To the best of the authors knowledge no research has been dedicated to the commercial stainless-steel market.

2.5 Stainless the niche market

The stainless-steel market is compared to the carbon/mild- steel market small in size which is measured in tonnage. The global carbon steel market in 2016 represented 1,682 billion tons (World Steel Association, 2018) and the global stainless-steel represents 48 Million tons of annualized production (Rowe, 2017) which is quantity wise a 3% share of the global steel market.

In 2018 the carbon steel production reached 1,817 billion tons (World Steel Association, 2020) and the stainless-steel production reached 51 million tons (Rowe, 2020) The share fell to below 3% of the global steel production. Therefore, it is to be considered a niche market. The definition of a niche market is according to the literature. Many of the definitions of “niche” discussed in the literature reviews by (Toften & Hammervoll, 2009, pp. 1378–1380) bear clear resemblances to traditional definitions of “segment”. A niche can be seen as a “specific market segment” and “firms can choose to produce a single market offering targeted to a specific market segment (i.e., a niche strategy)” (Dalgic & Leeuw, 1994, pp. 39–43; Hunt & Arnett, 2004, pp. 7–10) consider a niche to be “a small market consisting of an individual customer or a small group of customers with similar characteristics or needs”. In general, the definitions emphasize that a niche is a smaller, more focused and often narrower (Toften & Hammervoll, 2009, pp. 1378–1380) segment of a wider referral market. Kotler is stating that customers within a niche market typically poses of certain requirements and hence are willing to pay a premium to the enterprise that is offering a solution to fulfil these requirements (Kotler & Pfoertsch, 2007, pp. 357–360). Niches are therefore not static but can constantly be developed by identifying new needs of potential customers, needs that are currently not being satisfied by other market offerings. For example, (Skarp & Gadde, 2008) demonstrate that niche steel companies can grow their specific niches by offering upgraded steel offerings to customers currently using standard steel. For the purpose of this paper, a niche is treated as a specific (as in focused, smaller, and narrower) market segment targeted by a firm's offerings (Ottosson & Kindstrom, 2016).

Due to the specific constellation of a niche market segment paired with a commodity price volatility makes it a unique market. The ability to substitute the material grade or the material supplier is limited. The ability of the producers to design the material price volatility into the price mechanism is unique. The ability of the next production level to pass on the commodity price volatility to the end consumer is limited as described before. Therefore the cost-/price management of stainless-steel and the respective alloy price volatility is or should be part of the Enterprise Risk Management (ERM) as it has a direct impact to the profitability of the consumer or company that uses these material in their bill of material for serial production, like an exhaust gas treatment system manufacturer. "The ERM is the process by which companies identify, measure, manage and disclose all key risks to increase value to stakeholders." (Segal, 2011, p. 13). In literature the definition might be expanded to the "process of planning, organizing, leading, and controlling the activities of an organization to minimize the impact of risks in an organization including financial risks, operational and strategic risks. ERM expands the process to include not just risks associated with accidental losses" (Torode, 2017). Enterprise risk management is a process, effected by an entity's board of directors, management and other personnel, applied in strategy setting and across the enterprise, designed to identify potential events that may affect the entity, and manage risk to be within its risk appetite, to provide reasonable assurance regarding the achievement of entity objectives (Nason & Fleming, 2018, p. 4) .

The alloys used in stainless steel are mainly Nickel, Ferrochrome, Titanium, Molybdenum, partly traded at the London Metal Exchange (LME) and therefore volatile.

The alloy surcharge is used to price in the volatile alloys (Crucini & Davis, 2016) only in Asia an effective pricing is applied. This pricing includes the cost of the volatile alloys.

3 Stainless Market- Exhaust treatment segment

The exhaust gas treatment system environment is likely to increase due to stricter environmental legislation in countries like North America, Japan and Europe and the upcoming demand for environmental protection solutions in the emerging markets. The fact that the exhaust treatment system is exposed to higher temperature and higher pressures of the turbo chargers are influencing the material choice within the stainless-steel grades. The newest developments reflecting on the increasing share of hybrid engine solutions to power the car. The exhaust systems for the type of engine are increasingly complex and are designed with material grades that are more expansive and due to the complexity, the weight is not reduced. One reason is the need for an exhaust gas heat exchanger and valve solutions to channel the gas flow.

The material selection is based on the customer and internal requirements by the exhaust gas treatment system manufacturer. The material selection is driven by the application as the part must be functional and the system must fulfil the customer and legal requirements. The exhaust gas treatment system producer which is in most cases as well the developer of the system is responsible for the usability, the correct function and the warranty imposed by law or/and by the customer. This warranty or guarantee might be as far-reaching as 10 years or 1 million kilometres for commercial vehicle / truck applications. This warranty period is granted by the Tier 1 supplier towards the vehicle manufacturer. The final customer/ consumer of the automobile is faced with a much shorter warranty period. The costs for the warranty are passed over from the Automotive producer to the supplier panel. This shift has implications for the producer of the exhaust gas treatment system segment.

3.1 Stainless-steel grades deployed

The selection of the material grades is hence influenced by the technical departments, by material warranty, and by the commercial team. Each group has a different view of the material selection, ranging from durability, mechanical material characteristics like elongation, weldability as the main emphasis points and finally from the commercial perspective. The selection of a grade that includes fewer alloys, which is, therefore, less expensive will have an immediate effect on the profitability of the complete project and most likely on the potential price volatility of the grade involved. The typical application of grade classes is depicted in Figure 1.

Figure 1 Exhaust system hot to cold end

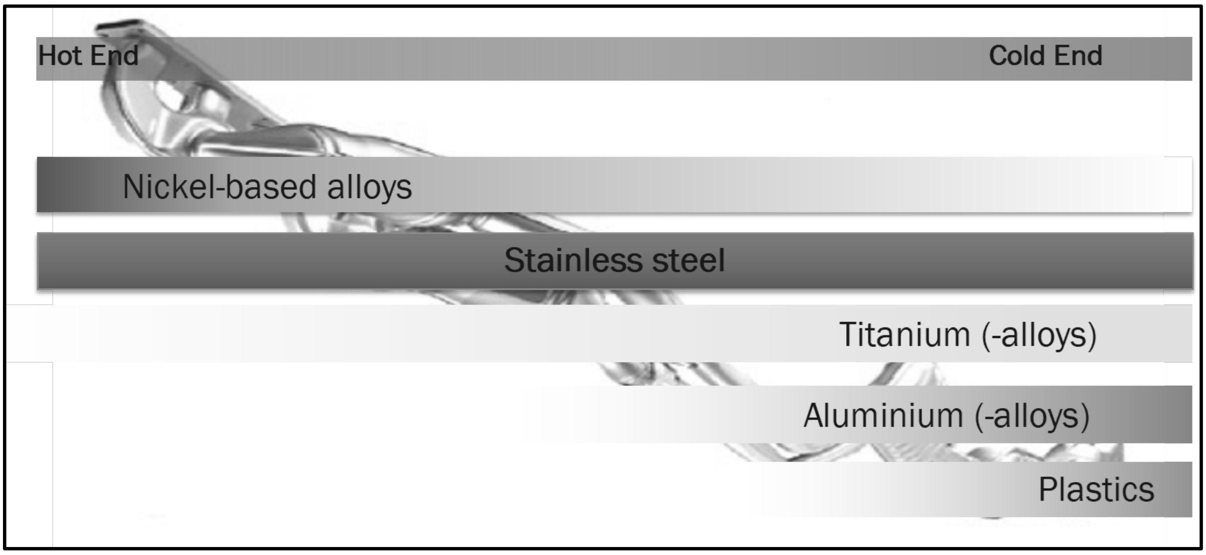


Figure 2 displays the typical grades that are part of an exhaust system in the automotive industry and represent the current application. The Nickel containing grads are deployed in the so-called hot end of the exhaust gas treatment system. This is the part of the system that is close to the engine and the turbocharger, hence heat and pressure are a given. The heat often reaches > 1000 degrees Celsius. The new generations of engines are smaller (i.e., less cylinder capacity) but turbo charged to reach the required performance. Therefore a substitution with Nickel free grades is almost impossible.

Figure 2 Exhaust system grades deployed (2019)

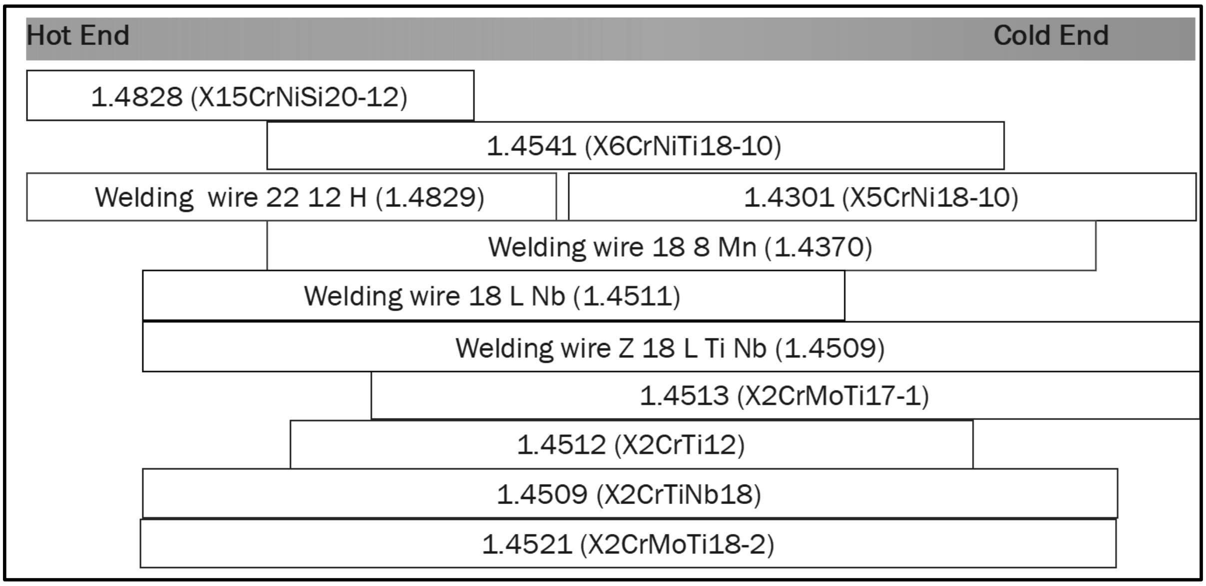


Table 3 Average Chemical composition, Source Chemical analysis stainless-steel

Average Chemical composition (in %)														
Grade	Type	C	Si	Mn	P	S	N	Cr	Ni	TI	Nb	Mo	SUM	Iron Ore
304 / 1.4301	austenitic	0.07	1.00	2.00	0.05	0.02	0.11	18.25	9.25				30.7	69.3
309 / 1.4828	austenitic	0.20	1.75	2.00	0.05	0.02	0.11	20.00	0.12				24.2	75.8
441 / 1.4509	ferritic	0.03		1.00				18.00		0.35	0.65		20.0	80.0
409 / 1.4512	ferritic	0.03	1.00	1.00	0.04	0.02		11.50		0.00			13.6	86.4
439 / 1.4510	ferritic	0.05		1.00		0.00		17.00		0.38			18.4	81.6
436 / 1.4513	ferritic	0.03	1.00	1.00	0.04	0.02		17.00		0.45		1.00	20.5	79.5

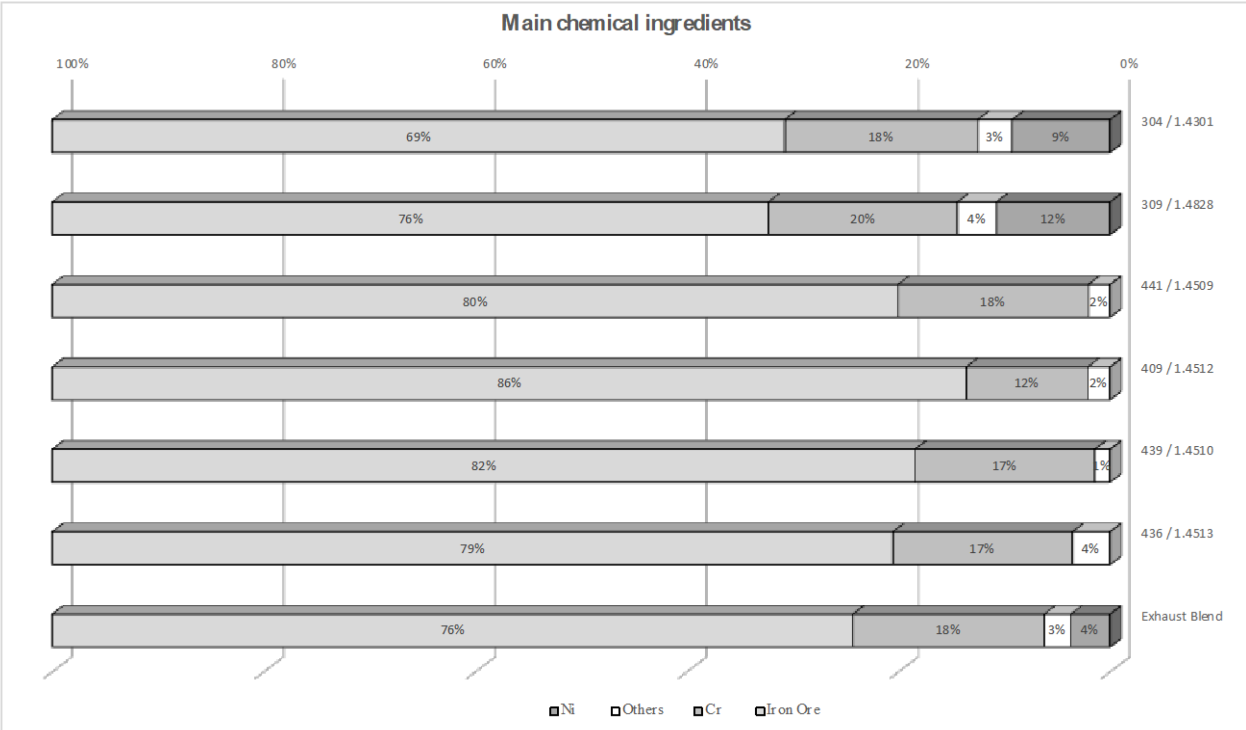
Table 4 Exhaust Blend, Source Chemical analysis stainless-steel

Blended material : 40 % Austenitic in grade 304 / 1.4301 & 60% ferritic in grade 441 / 1.4509														
Grade	Type	C	Si	Mn	P	S	N	Cr	Ni	TI	Nb	Mo	SUM	Iron Ore
Exhaust Blend	n.a.	0.05	0.40	1.40	0.02	0.01	0.04	18.10	3.70	0.21	0.39	0.00	24.3	75.7

Deviations or substitution requests of a given grade selection in a program life are typically not granted or permitted for the Tier 1 supplier. The automobile manufacturer would claim that the validation for the complete system would have to be redone. This would involve resources, costs, and time. The sourcing of the material can be challenging to cover all the different requirements. The restrictions are the availability, price, minimum order quantities from the local steel mills. The material costs impact the competitiveness of the producer in the acquisition phase and after the nomination, the material costs are one of the key drivers of profitability of an awarded production program. The selection of the material grade is, therefore, a key-decision for the exhaust gas treatment system producer with wide-reaching impact on the profitability.

The costs of the grades vary due to the specific ingredients of the raw material – stainless steel. In Europe, North & South America, Africa the producers introduced a variable price component to reflect these changes in the raw material alloy segment. In Asia, mainly China, India the mills are offering one price that includes the cost of the alloy elements already. Typically, these prices can be agreed for a price validity of 3-6 months due to the fluctuation of the alloys typically not longer than 12 months.

Figure 3 Main chemical ingredients for materials used in the exhaust industry (Source Chemical analysis)



The exhaust blend that consists of 40% of the ingredients of the grade 304/1.4301 and 60% of the ferritic grade 441/1.4509. This imaginary blend represents the typical exhaust manufacturing material grade. It contains:

- 76% of Iron ore
- 17% of Ferrochrome
- 4% of Nickel
- 4% of other elements

This is the content of the specific elements in the material. The value of the elements will be demonstrated with the monthly average value of January 2008, 2013, and 2018. The 3% of the other elements will be anticipated with a value of 1 $ / kg.

Table 5 Value of Exhaust blend, Source Chemical analysis

Grade	Cr	Ni	Others	Iron Ore	Sum
Exhaust Compound	17%	4%	4%	76%	100%
in kg	181	37	25	757	1000
Jan 2008	$ 838	$ 1,025	$ 25	$ 146	$ 2,034
Jan 2013	$ 414	$ 647	$ 25	$ 114	$ 1,200
Jan 2018	$ 471	$ 476	$ 25	$ 58	$ 1,029
Average	$ 574	$ 716	$ 25	$ 106	$ 1,421
Average in % of value	40%	50%	2%	7%	100%

Even though the Ferrochrome and the Nickel content do represent 22% of the material the value of these two portions is adverse. The value represents approximately 90% of the total material value. The Iron ore portion that is assumed with 76% is accounting for an average of 7% of the material value. Hence the commodity price volatility is an important aspect to understand and to manage the price volatility of stainless-steel material.

These price movements have been captured in the alloy surcharge, that is implied in Europe and the Americas the system has been referenced in chapter 1.1 Stainless steel market – Background information. It is displayed in the two following graphs that are displaying the monthly development since the year 2000. The alloy surcharge for the ferritic grade increased from vertically 0 to 650€/to. The price development for the main austenitic grade tripled from 500€/to to 1500€/to. These add-ons to the base price are an important factor, as the current base price (January 2020) is 1020€/to. The alloy surcharge is hence 50% than the base price for the 304 grade. Which will be explained later in detail.

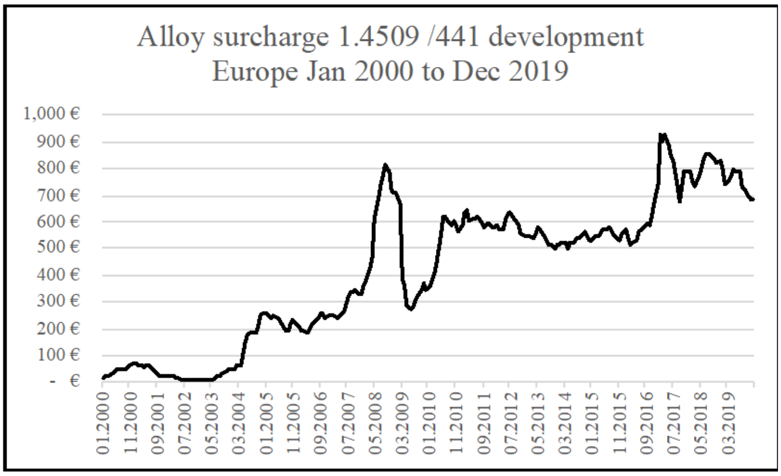


Figure 4 Alloy surcharge development 441 / Source: Own data

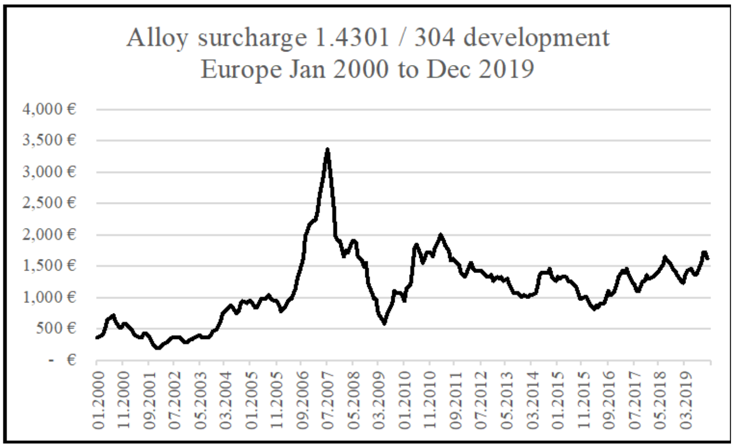


Figure 5 Alloy surcharge development 304 / Source: Own data

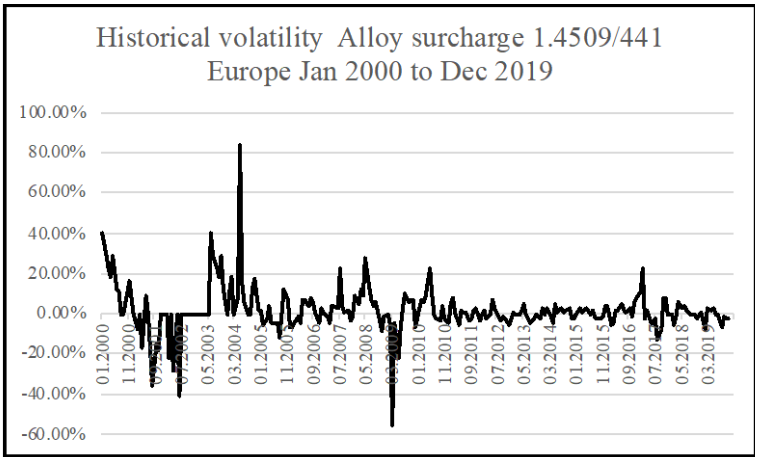


Figure 6 Historical volatility alloy surcharge 441, Source Own data

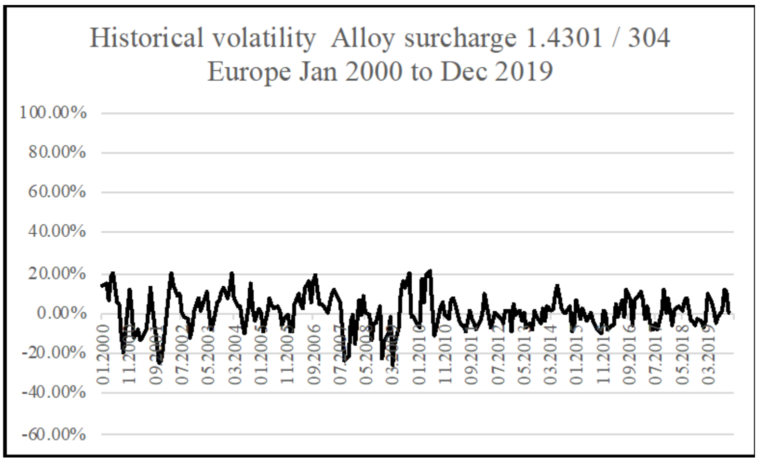


Figure 7 Historical volatility alloy surcharge 304, Source Own data

3.2 Price volatility

Traditionally the costs of the alloy surcharge were paid in full by the automotive producer. In recent years, a switch in legacy was noted. The long-term experience is showing a different approach. The automotive producer is “mitigating” the risk of the price volatility of the material completely or partly to the supply base. Different thoughts seek to explain this mitigation from a customer perspective:

- Cost reduction
- Avoidance of volatility of the alloy surcharges
- Reduced administration costs
- Price stability
- Long-term cost reduction (LTC) including alloy surcharge costs

The automotive producer is usually requesting an LTC over the lifetime of the product lifecycle. The typical LTC is in a range of 3 x 3% per annum. This means that the Tier 1 supplier must grant cost savings of guaranteed 3% of the total cost for 3 consecutive years. LTC agreements of 3 x 4% or 5% have been seen in the industry already.

Price stability and a fixed alloy surcharge are typically applied if the price maintenance is involving special efforts in the administration of the automotive producer. Another method of minimizing administration cost is the self-billing process. This process is generating an invoice when the material is accepted by the supplier, which is typically not the date of delivery but a later date. This process is involving immense efforts if corrections are needed. The supplier is not able to generate an invoice anymore.

In addition to the mentioned approaches, the OEM reserves the right to initiate cost-saving workshops. If cost reduction potentials are identified the customer is entitled to claim these potential or realistic savings from the Tier 1 supplier. The variable costs of the raw material, in majority the stainless-steel portion– excluding the costs of the monoliths of the catalytic converters- exhaust gas system is not paid by the final customer. There is no addendum for these costs at the final consumer’s price. The price of a car is the price of the car and is not changing daily or monthly due to the changes of the volatile materials. The suppliers’ ability to adapt to these price risks are part of the overall competitiveness. A competitiveness that embraces and actively manages the business price risks including the material price volatility which will be researched in this report. The linkage between the price volatility of the raw materials and the continuous effect of it to the next levels of the value chain. The raw material prices that are charged to the OEM and the implications of it in the value chain measured in the share price development of the companies.

3.3 Challenges

This report studies also the influence that might occur from the decreasing market share of “Diesel” powered engines and what might be the impact of the “E-mobility”. The traditional automotive industry is threatened by new players in E- Mobility and the conquers from Asia. The combination of new technologies and new entries of powerful market players can “disrupt” this traditional mobility industry. The increasing trend of electrical vehicles and the trend of that are and industry might stand at the edge of a disruptive evolution that might end up in the decreasing share of internal combustion engines for individual transport purposes.

The “Dieselgate” scandal did jeopardize the sales and thus the production quantities of these engine types. The industry is moving away from internal combustion engines (ICE) towards electrical powertrain application that are either full battery vehicles or Hybrid concepts. Automotive suppliers that have a long tradition of serving the ICE market are faced with a major business disruption-a risk- originated in the stricter environmental protection jurisdictions across the globe. These companies are witnessing a change in paradigms that hit the traditional automotive industry and supply base (Tier1) as a Tsunami. The focus on ICE powertrain concepts represents an immanent business risk that has the potential to jeopardize the long-term existence.

Appendix No. 2

Findings of Interviews after coding short

1. Aperam / Eric Haekens

- SSC are used by mills to amend stock levels
- Particular in Italy the private owned ones are using the stock to sell and adopt
- Tsingshan is not on the same playing field (safeguard, CO2 emissions, HSE, CSRT) Mill is at the place of the raw materials (same as Columbus in RSA)
- Unique model not reproducible – target 8 Mio tons (global market is 53Mio tons) Tsingshan is facing trade barriers everywhere is limited in the selection of the markets
- Import of CR is about 30-40% (1,2 Mio tons), which is the production of one mill
- Import of HR goes basically only to one customer Marcegaglia
- Consolidation with VDM was denies as the EU commission took the stand that it is too strong for EU, but global view was not taken into consideration
- Consumption of stainless-steel is increasing therefore investments are needed
- Regulate capacities within the group
- Central location is an advantage despite the different production plants and the transport costs in between
- Europe is 4,5 Mio tons compared to the global market of 53 Mio tons
- Lessons learned: over the last years that capacity-wise, Europe has, in order to serve the local markets, sufficient capacity and doesn't need to invest heavily into new capacities in order to respond to the European demand

2. AK Steel/Dan Lebherz

- River location is a cost advantage AK has longer Supply chains
- Ak is holding stock, the others doon not
- RM demand from China for scrap and commodities
- No NPIG use different technology
- US focused- no idea about the goal cost structures
- Approves the NO Tsingshan – ATI deal due to unfair trading
- Risky SC – producer / mill has high fixed costs
- Expects further consolidation—unclear in the US or globally
- Long term no restriction but only if the same base conditions are used everywhere – domestic industry has to be rebuilt

3. Acerinox / Anonymous

- Investment stops in China
- Tsingshan might be a snow ball effect, have to become bigger to keep running
- ATI JV is generating losses but helps ATI to maximize the usage of the rolling lines
- ACX is using slabs of Tsingshan as well in Bahruj and potentially in Spain
- Performance output is 2 times better compared to OTK and 1,3 times better than to Aperam
- ACX is producing similar grades as the other mills – same grade offering perceived from Daniel
- Local differences 429 in US only
- Volatile market situations are the new normal

4. Outokumpu / Anonymous

- Cost advantage due to integration
- Customers asking for the same price
- China is driving technology as there seems to be no financial restriction
- Global market pricing trends
- Potentially big slab producer in Asia and rerolling in other regions
- Transparent AS system desirable

5. AST /Dr Schlüter

- European mills did restructure and drive efficiency already but no there are no gains possible anymore
- Us facilities very old and not modernized since decades, some exception Rockport and the AP Line at ATI
- NAS is best in class as they control the raw material supply _ river location-
- Grade selection no 200 series
- Tsingshan – fair competition how to grow so fast in a market that is characterized by overcapacity
- Cost advantage due to integration
- One slab producer for the rest – with very efficient melting
- Tsingshan excluded from China – mischievousness at Dr. Schlüter

Appendix No. 3

Metals and Statistics

Contents

1. Definition of the raw materials / commodities used in this report

Aluminium (LME) London Metal Exchange, unalloyed primary ingots, high grade, minimum 99.7% purity, settlement price beginning 2005; previously cash price. The Source for this price is the World Bank Global Economic Report. This report refers to Platts Metals Week, Thomson Reuters Datastream; (World Bank, 2018).

Iron Ore in this report is defined in the World Bank report as the Iron ore (Brazil), VALE (formerly CVRD) Carajas sinter feed, contract price, f.o.b. Ponta da Madeira. The Unit is a dry metric ton unit (dmtu). Prior to the year 2010 annual contract prices. The source for this commodity used by the World Bank are the producers: Vale; CVRD and UNCTAD (World Bank, 2018).

Nickel is "Nickel (LME), cathodes, minimum 99.8% purity, settlement price beginning 2005; previously cash price". The sources for the Global commodity report are Platts Metals Week, Thomson Reuters Datastream (World Bank, 2018).

Copper is referred to as "Copper (LME), grade A, minimum 99.9935% purity, cathodes and wire bar shapes, settlement price". The source for the price notations as indicated by the World Bank is Platts Metals Week, Engineering and Mining Journal; Thomson Reuters Datastream (World Bank, 2018).

Ferro-Chrome is listed separately as it is essential for the characteristics of stainless-steel. Stainless-steel is defined by a minimum Chromium content of typically 18-20% for austenitic grades ('Austenitic stainless steel', 2017). The Ferrochrome in this report is the Chrome, Ferro-Chrome. Delivered Consumers' Works in US Dollars. The primary name of this grade is "bgrcaes0030" and further described with a Carbon content of 6-8 % C. basis 60 % Cr. max. 1.5 % Si. It is published by the Commodity Price List from the Federal Institute for Geosciences & Natural Resources in Hannover. For this report, I received the data from the Hamburg Institute of International Economics (HWWI).

The *stainless-steel scrap with the origin USA* in this report is the brand “Detroit 304 solids, clips, broker buying $/gross ton” the source is the American metal market (AMM) organization. Further price descriptions are “Broker 304 solids, clips, Brooker buying price, Delivered at the place (American Metall, 2018). The stainless steel *scrap (304) notation Europe* is published by the industry magazine Focus Rostfrei, a German-based publisher with branches and publications across Europe. The scrap is categorized as “Schrott-Preis, Einkaufspreise größerer Händler, (Deutschland für Blechabfälle, 17 % Cr, 9 % Ni - typisch für 1.4301)“ Scrap price, buying price for bigger traders (Germany for sheet scrap, consisting of 17 % Cr, 9 % Ni – typical for 1.4301/304) (Focus Rostfrei, 2018)

The Inflation rate is the rate published in the Statistical data warehouse of the ECB. The title of the used inflation rate for the Eurozone is “The Harmonised Index of Consumer Prices (HICP). Overall inflation rate (annual rate of change)”. The HICP is produced by Eurostat, the statistical office of the European Union, together with the national statistical institutes. It measures the average change over time in the prices paid by households for a basket of consumer goods and services (European Central Bank - Data Warehouse, 2018)(European Central Bank - Data Warehouse, 2018).

The interest rate of the ECB is the rate on the main refinancing operations (MRO), which provide the bulk of liquidity to the banking system (European Central Bank, 2018). It is one of the Key interest rates in the Euro Zone. For this purpose, it is used in this report.

2. Statistics- basics

Statistical methods

In literature typically, the following statistical methods are used to measure volatility.

The mean is the measure of central tendency that you are most likely to have heard of because it is simply the average score and the media are full of average scores. To calculate the mean we simply add up all of the scores and then divide by the total number of scores we have. We can write this in equation form as:

$$\overline{\mathrm{X}} = \frac{\sum_{i=1}^{n} x_i}{n}$$

The median is another way to quantify the centre of a distribution. It is the middle value when the scores are ranked in order to magnitude. The median relatively unaffected by extreme scores at either end of the distribution: the median changed only from 98 to 95.5

when the extreme score is removed. The median is also relatively unaffected by skewed distributions and can be used with ordinal, interval and ratio data (it cannot, however, be used with nominal data because these data have no numerical order).

$$\text{Median} = \frac{(n+1)}{2}$$

<u>The Variance</u> in a population of data is the Greek symbol (σ^2). The variance is, therefore, the average error between the mean and the observations made (and so is a measure of how well the model fits the actual data). The specific about the variance as a measure: it computes measure in units squared (because each error in the calculation is squared).

$$\text{Variance } (s^2) = \frac{\sum(x_i - \bar{x})^2}{N-1}$$

For this reason, the square root of the variance (which ensures that the measure of average error is in the same units as the original measure) is applied. This measure is known as the standard deviation and is simply the square root of the variance.

$$s = \sqrt{\frac{\sum(x_{i-}\bar{x})^2}{N-1}}$$

The sum of squares, variance and standard deviation are all, therefore, measures of the 'fit' (i.e. how well the mean represents the data). Small standard deviations (relative to the value of the mean itself) indicate that data points are close to the mean. A large standard deviation (relative to the mean) indicates that the data points are distant from the mean (i.e. the mean is not an accurate representation of the data). This explanation is the reason why the standard deviation is a measure of how well the mean represents the data. In the case of volatility, a large standard deviation means a higher volatility and range of the data records.

To measure the dispersion in a distribution the initial thought is to quantify the spread or dispersion of the data. The simplest way to measure dispersion is to look at the largest and the smallest score. The **<u>range</u>** is the largest score subtracted by the smallest score. The problem with the range is that because it uses the highest and the lowest score it is influenced tremendously by the extreme score.

To balance this problem is to calculate the range when values at the extremes of the distribution are excluded. One convention is to cut off the top and bottom 25% of scores and calculate the range of the middle 50% of scores – known as the **interquartile range** (Field, 2013).

To demonstrate that the values might show a volatility. There are two main ways in which a distribution can deviate from a normal distribution kurtosis and skewness. These values are of importance as this report is investigating volatility thus a distribution of the scores that are not or potentially not a normal distribution (Gaussian distribution). The skewness is defined as the lack of symmetry. The kurtosis is the "pointiness" of a distribution. These two values will allow a "measurement" of volatility. This measurement is the degree of deviation from the standard distribution of scores. Skewness and kurtosis the values are "0" if it describes a normal distribution. Hence every deviation is an initial hint to volatility.

This research will use these values. The values are more useful when converted into z scores. A z score is a score from a distribution that has a mean of 0 and a standard deviation of 1. The conversion of these values (skewness and kurtosis) is conducted by dividing the values by their standard errors. The result is the z- score. The main advantages are that these values can now be compared even they are from different samples. The likelihood of occurrence for the for the values of skewness and kurtosis. The following formula to transform any score to a z -score. Subtraction of the mean of the distribution (in this case zero) and then divided by the standard deviation of the distribution (in this case the standard error). This calculation is used by Rabah Arezki in his article about "The relative volatility of commodity prices" and used by Andy Fields in the publication "Discovering statistics using IBM SPSS statistics" (Arezki, Lederman, & Zhao, 2014; Field, 2013)

Z skewness = $\frac{S-0}{SE\ skewness}$ Z kurtosis = $\frac{K-0}{SE\ kurtosis}$

In the above equations, the values of S (skewness) and K (kurtosis) and their respective standard errors are produced by SPSS. These z-scores can be compared against values that would occur by chance alone. For the interpretation of these values, the following values according to Fields are outlined.

- An absolute value greater than 1.96 is significant at $p < .05$,
- above 2.58 is significant at $p < .01$ and
- absolute values above about 3.29 are significant at $p < .001$.

However large samples will give rise to small standard errors and so when sample sizes are big, significant values arise from even small deviations from normality. In smallish samples it is acceptable that values are > 1.96; however, in large samples, this criterion should be increased to the 2.58 one and in very large samples, because of the problem of small standard errors that described, no criterion should be applied! If the sample size is large (200 or more) it is more important to look at the shape of the distribution visually and to look at the value of the skewness and kurtosis statistics rather than calculate their significance (Field, 2013).

In finance, volatility (symbol σ) is the degree of variation of a trading price series over time as measured by the standard deviation of logarithmic returns. Historic volatility is derived from time series of past market prices. An implied volatility is derived from the market price of a market traded derivative (in particular an option).

The calculation of the mathematically, historical volatility, which is the (usually annualized) standard deviation of returns. The monthly returns are based on 21 trading days assumption and the annualized calculation is defined with 252 days. The calculation method is: Calculating the returns. The return of a stock in a given period can be defined as the **natural log**, ln, of the closing price of a stock at the end of the period divided by the closing price of the stock at the end of the previous period. In equation form, this is:

$$Rn = \ln\left(\frac{Cn}{Cn-1}\right)$$

where Rn is the return of a given stock over the period, ln is the natural log function, Cn is the closing price at the end of the period, and C(n-1) is the closing price at the end of the last period. The natural log is used to convert the numerical change in the value of the stock over the period to an approximation of the percent change between days (Macroption Website, 2017).

The next calculation step is the calculation of the standard deviation of the returns calculated as Rn. The standard deviation is the square root of the variance, which is the average squared deviation from the mean.

$$R_{avg} = \frac{\sum_{i=1}^{n} R_i}{n}$$

$$\left(R_i - R_{avg}\right)^2$$

$$\sigma^2 = \frac{\sum_{i=1}^{n}(R_i - R_{avg})^2}{n-1}$$

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(R_i - R_{avg})^2}{n-1}}$$

Historical volatility (the calculation method used in this report) is calculated as the standard deviation of logarithmic returns (Macroption Website, 2017). The standard deviation of the continuously compounded return on an asset, measured using historical prices ('Encyclopedia of Finance | SpringerLink', n.d.; 'Historical Volatility', 2006).

Historical annualized volatility = $\sigma * \sqrt{252}$

Z skewness = (S-0)/(SE skewness) Z kurtosis = (K-0)/(SE kurtosis)

In the above equations, the values of S (skewness) and K (kurtosis) and their respective standard errors are produced by SPSS. These z -scores can be compared against values that would occur by chance alone. For the interpretation of these values reference is made to Andy Fields.

An absolute value greater than 1.96 is significant at $p < .05$,

above 2.58 is significant at $p < .01$ and

absolute values above about 3.29 are significant at $p < .001$.

However large samples will give rise to small standard errors and so when sample sizes are big, significant values arise from even small deviations from normality. In smallish samples it is acceptable that values are > 1.96; however, in large samples this criterion should be increased to the 2.58 one and in very large samples, because of the problem of small standard errors that described, no criterion should be applied! If the sample size is large (200 or more) it is more important to look at the shape of the distribution visually and to look at the value of the skewness and kurtosis statistics rather than calculate their significance (Field, 2013).

Appendix No. 04a

Raw Material (1960-2021)

Month	Nickel	Aluminium	Iron Ore	Copper
1960.01	$ 1.631	$ 511	$ 11	$ 715
1960.02	$ 1.631	$ 511	$ 11	$ 728
1960.03	$ 1.631	$ 511	$ 11	$ 685
1960.04	$ 1.631	$ 511	$ 11	$ 723
1960.05	$ 1.631	$ 511	$ 11	$ 685
1960.06	$ 1.631	$ 511	$ 11	$ 692
1960.07	$ 1.631	$ 511	$ 11	$ 702
1960.08	$ 1.631	$ 511	$ 11	$ 676
1960.09	$ 1.631	$ 511	$ 11	$ 647
1960.10	$ 1.631	$ 511	$ 11	$ 613
1960.11	$ 1.631	$ 511	$ 11	$ 642
1960.12	$ 1.631	$ 511	$ 11	$ 637
1961.01	$ 1.711	$ 511	$ 11	$ 607
1961.02	$ 1.711	$ 511	$ 11	$ 617
1961.03	$ 1.711	$ 511	$ 11	$ 621
1961.04	$ 1.711	$ 511	$ 11	$ 632
1961.05	$ 1.711	$ 511	$ 11	$ 668
1961.06	$ 1.711	$ 511	$ 11	$ 652
1961.07	$ 1.711	$ 511	$ 11	$ 633
1961.08	$ 1.711	$ 511	$ 11	$ 636
1961.09	$ 1.711	$ 511	$ 11	$ 633
1961.10	$ 1.711	$ 511	$ 11	$ 630
1961.11	$ 1.711	$ 511	$ 11	$ 632
1961.12	$ 1.711	$ 511	$ 11	$ 635
1962.01	$ 1.761	$ 511	$ 11	$ 635
1962.02	$ 1.761	$ 505	$ 11	$ 648
1962.03	$ 1.761	$ 496	$ 11	$ 648
1962.04	$ 1.761	$ 496	$ 11	$ 646
1962.05	$ 1.761	$ 496	$ 11	$ 646
1962.06	$ 1.761	$ 496	$ 11	$ 646
1962.07	$ 1.761	$ 496	$ 11	$ 646
1962.08	$ 1.761	$ 496	$ 11	$ 646
1962.09	$ 1.761	$ 496	$ 11	$ 646
1962.10	$ 1.761	$ 496	$ 11	$ 646
1962.11	$ 1.761	$ 496	$ 11	$ 646
1962.12	$ 1.761	$ 496	$ 11	$ 646

Month	Nickel	Aluminium	Iron Ore	Copper
1963.01	$ 1.741	$ 496	$ 11	$ 646
1963.02	$ 1.742	$ 496	$ 11	$ 646
1963.03	$ 1.742	$ 496	$ 11	$ 646
1963.04	$ 1.741	$ 496	$ 11	$ 646
1963.05	$ 1.742	$ 496	$ 11	$ 646
1963.06	$ 1.742	$ 496	$ 11	$ 646
1963.07	$ 1.741	$ 496	$ 11	$ 646
1963.08	$ 1.742	$ 496	$ 11	$ 646
1963.09	$ 1.742	$ 496	$ 11	$ 646
1963.10	$ 1.741	$ 507	$ 11	$ 646
1963.11	$ 1.742	$ 507	$ 11	$ 646
1963.12	$ 1.742	$ 507	$ 11	$ 650
1964.01	$ 1.741	$ 507	$ 10	$ 656
1964.02	$ 1.742	$ 507	$ 10	$ 694
1964.03	$ 1.742	$ 525	$ 10	$ 745
1964.04	$ 1.741	$ 529	$ 10	$ 862
1964.05	$ 1.742	$ 529	$ 10	$ 828
1964.06	$ 1.742	$ 529	$ 10	$ 808
1964.07	$ 1.741	$ 529	$ 10	$ 855
1964.08	$ 1.742	$ 529	$ 10	$ 999
1964.09	$ 1.742	$ 529	$ 10	$ 1.162
1964.10	$ 1.741	$ 529	$ 10	$ 1.358
1964.11	$ 1.742	$ 529	$ 10	$ 1.400
1964.12	$ 1.742	$ 540	$ 10	$ 1.269
1965.01	$ 1.735	$ 540	$ 10	$ 1.001
1965.02	$ 1.735	$ 540	$ 10	$ 1.180
1965.03	$ 1.735	$ 540	$ 10	$ 1.237
1965.04	$ 1.735	$ 540	$ 10	$ 1.348
1965.05	$ 1.735	$ 540	$ 15	$ 1.379
1965.06	$ 1.735	$ 540	$ 10	$ 1.309
1965.07	$ 1.735	$ 540	$ 10	$ 1.134
1965.08	$ 1.735	$ 540	$ 10	$ 1.210
1965.09	$ 1.735	$ 540	$ 10	$ 1.328
1965.10	$ 1.735	$ 540	$ 10	$ 1.402
1965.11	$ 1.735	$ 540	$ 10	$ 1.469
1965.12	$ 1.735	$ 540	$ 10	$ 1.518

Month	Nickel	Aluminium	Iron Ore	Copper
1966.01	$ 1.739	$ 540	$ 10	$ 1.679
1966.02	$ 1.739	$ 540	$ 10	$ 1.874
1966.03	$ 1.739	$ 540	$ 10	$ 1.875
1966.04	$ 1.739	$ 540	$ 10	$ 1.907
1966.05	$ 1.739	$ 540	$ 10	$ 1.664
1966.06	$ 1.739	$ 540	$ 10	$ 1.696
1966.07	$ 1.739	$ 540	$ 10	$ 1.568
1966.08	$ 1.739	$ 540	$ 10	$ 1.195
1966.09	$ 1.739	$ 540	$ 10	$ 1.128
1966.10	$ 1.739	$ 540	$ 10	$ 1.275
1966.11	$ 1.739	$ 540	$ 10	$ 1.302
1966.12	$ 1.739	$ 540	$ 10	$ 1.215
1967.01	$ 1.936	$ 540	$ 9	$ 1.244
1967.02	$ 1.936	$ 540	$ 9	$ 1.220
1967.03	$ 1.936	$ 540	$ 9	$ 1.098
1967.04	$ 1.936	$ 540	$ 9	$ 995
1967.05	$ 1.936	$ 540	$ 9	$ 1.036
1967.06	$ 1.936	$ 540	$ 9	$ 1.015
1967.07	$ 1.936	$ 540	$ 9	$ 997
1967.08	$ 1.936	$ 540	$ 9	$ 1.045
1967.09	$ 1.936	$ 540	$ 9	$ 1.060
1967.10	$ 1.936	$ 540	$ 9	$ 1.138
1967.11	$ 1.936	$ 540	$ 9	$ 1.444
1967.12	$ 1.936	$ 540	$ 9	$ 1.324
1968.01	$ 2.075	$ 540	$ 9	$ 1.409
1968.02	$ 2.075	$ 540	$ 9	$ 1.720
1968.03	$ 2.075	$ 540	$ 9	$ 1.701
1968.04	$ 2.075	$ 540	$ 9	$ 1.255
1968.05	$ 2.075	$ 540	$ 9	$ 1.097
1968.06	$ 2.075	$ 562	$ 9	$ 1.137
1968.07	$ 2.075	$ 562	$ 9	$ 1.054
1968.08	$ 2.075	$ 562	$ 9	$ 1.056
1968.09	$ 2.075	$ 562	$ 9	$ 1.110
1968.10	$ 2.075	$ 562	$ 9	$ 1.080
1968.11	$ 2.075	$ 562	$ 9	$ 1.100
1968.12	$ 2.075	$ 562	$ 9	$ 1.185

Month	Nickel	Aluminium	Iron Ore	Copper
1969.01	$ 2.363	$ 573	$ 10	$ 1.256
1969.02	$ 2.363	$ 584	$ 10	$ 1.285
1969.03	$ 2.363	$ 584	$ 10	$ 1.278
1969.04	$ 2.363	$ 584	$ 10	$ 1.388
1969.05	$ 2.363	$ 584	$ 10	$ 1.392
1969.06	$ 2.363	$ 584	$ 10	$ 1.483
1969.07	$ 2.363	$ 584	$ 10	$ 1.454
1969.08	$ 2.363	$ 584	$ 10	$ 1.607
1969.09	$ 2.363	$ 584	$ 10	$ 1.579
1969.10	$ 2.363	$ 602	$ 10	$ 1.554
1969.11	$ 2.363	$ 606	$ 10	$ 1.631
1969.12	$ 2.363	$ 606	$ 10	$ 1.700
1970.01	$ 2.846	$ 606	$ 10	$ 1.626
1970.02	$ 2.846	$ 606	$ 10	$ 1.657
1970.03	$ 2.846	$ 606	$ 10	$ 1.754
1970.04	$ 2.846	$ 613	$ 10	$ 1.742
1970.05	$ 2.846	$ 617	$ 10	$ 1.598
1970.06	$ 2.846	$ 617	$ 10	$ 1.458
1970.07	$ 2.846	$ 617	$ 10	$ 1.367
1970.08	$ 2.846	$ 617	$ 10	$ 1.267
1970.09	$ 2.846	$ 617	$ 10	$ 1.247
1970.10	$ 2.846	$ 617	$ 10	$ 1.142
1970.11	$ 2.846	$ 617	$ 10	$ 1.085
1970.12	$ 2.846	$ 617	$ 10	$ 1.046
1971.01	$ 2.932	$ 617	$ 10	$ 1.010
1971.02	$ 2.932	$ 617	$ 10	$ 1.020
1971.03	$ 2.932	$ 617	$ 10	$ 1.144
1971.04	$ 2.932	$ 617	$ 10	$ 1.252
1971.05	$ 2.932	$ 617	$ 10	$ 1.114
1971.06	$ 2.932	$ 617	$ 10	$ 1.074
1971.07	$ 2.932	$ 617	$ 10	$ 1.115
1971.08	$ 2.932	$ 628	$ 10	$ 1.098
1971.09	$ 2.932	$ 639	$ 10	$ 1.056
1971.10	$ 2.932	$ 639	$ 10	$ 1.041
1971.11	$ 2.932	$ 642	$ 10	$ 1.014
1971.12	$ 2.932	$ 666	$ 10	$ 1.038

Month	Nickel	Aluminium	Iron Ore	Copper
1972.01	$ 3.080	$ 670	$ 10	$ 1.078
1972.02	$ 3.080	$ 670	$ 10	$ 1.112
1972.03	$ 3.080	$ 670	$ 10	$ 1.108
1972.04	$ 3.080	$ 670	$ 10	$ 1.133
1972.05	$ 3.080	$ 600	$ 10	$ 1.106
1972.06	$ 3.080	$ 567	$ 10	$ 1.063
1972.07	$ 3.080	$ 538	$ 10	$ 1.035
1972.08	$ 3.080	$ 540	$ 10	$ 1.047
1972.09	$ 3.080	$ 538	$ 10	$ 1.061
1972.10	$ 3.080	$ 538	$ 10	$ 918
1972.11	$ 3.080	$ 540	$ 10	$ 1.007
1972.12	$ 3.080	$ 540	$ 10	$ 1.024
1973.01	$ 3.373	$ 542	$ 10	$ 1.119
1973.02	$ 3.373	$ 558	$ 10	$ 1.244
1973.03	$ 3.373	$ 571	$ 10	$ 1.510
1973.04	$ 3.373	$ 571	$ 10	$ 1.588
1973.05	$ 3.373	$ 582	$ 10	$ 1.552
1973.06	$ 3.373	$ 602	$ 10	$ 1.749
1973.07	$ 3.373	$ 635	$ 10	$ 2.021
1973.08	$ 3.373	$ 619	$ 10	$ 2.123
1973.09	$ 3.373	$ 604	$ 10	$ 1.936
1973.10	$ 3.373	$ 622	$ 10	$ 2.065
1973.11	$ 3.373	$ 650	$ 10	$ 2.273
1973.12	$ 3.373	$ 633	$ 10	$ 2.244
1974.01	$ 3.572	$ 604	$ 13	$ 2.032
1974.02	$ 3.572	$ 619	$ 13	$ 2.292
1974.03	$ 3.572	$ 688	$ 13	$ 2.743
1974.04	$ 3.572	$ 752	$ 13	$ 3.032
1974.05	$ 3.572	$ 765	$ 13	$ 2.876
1974.06	$ 3.572	$ 756	$ 13	$ 2.440
1974.07	$ 4.079	$ 761	$ 13	$ 1.919
1974.08	$ 4.079	$ 849	$ 13	$ 1.803
1974.09	$ 4.079	$ 838	$ 13	$ 1.461
1974.10	$ 4.079	$ 844	$ 13	$ 1.399
1974.11	$ 4.079	$ 842	$ 13	$ 1.417
1974.12	$ 4.079	$ 860	$ 13	$ 1.289

Month	Nickel	Aluminium	Iron Ore	Copper
1975.01	$ 4.431	$ 895	$ 17	$ 1.211
1975.02	$ 4.431	$ 908	$ 17	$ 1.267
1975.03	$ 4.431	$ 917	$ 17	$ 1.344
1975.04	$ 4.431	$ 897	$ 17	$ 1.329
1975.05	$ 4.431	$ 904	$ 17	$ 1.254
1975.06	$ 4.431	$ 904	$ 17	$ 1.193
1975.07	$ 4.431	$ 864	$ 17	$ 1.222
1975.08	$ 4.431	$ 838	$ 17	$ 1.277
1975.09	$ 4.852	$ 827	$ 17	$ 1.210
1975.10	$ 4.852	$ 816	$ 17	$ 1.179
1975.11	$ 4.852	$ 814	$ 17	$ 1.180
1975.12	$ 4.852	$ 838	$ 17	$ 1.151
1976.01	$ 4.850	$ 853	$ 23	$ 1.193
1976.02	$ 4.850	$ 851	$ 23	$ 1.219
1976.03	$ 4.850	$ 816	$ 23	$ 1.329
1976.04	$ 4.850	$ 820	$ 23	$ 1.510
1976.05	$ 4.850	$ 825	$ 23	$ 1.512
1976.06	$ 4.850	$ 805	$ 23	$ 1.550
1976.07	$ 4.850	$ 904	$ 23	$ 1.647
1976.08	$ 4.850	$ 939	$ 23	$ 1.539
1976.09	$ 4.938	$ 996	$ 23	$ 1.459
1976.10	$ 5.313	$ 948	$ 23	$ 1.285
1976.11	$ 5.313	$ 948	$ 23	$ 1.279
1976.12	$ 5.313	$ 974	$ 23	$ 1.287
1977.01	$ 5.313	$ 1.058	$ 23	$ 1.396
1977.02	$ 5.313	$ 1.078	$ 23	$ 1.426
1977.03	$ 5.313	$ 1.082	$ 23	$ 1.515
1977.04	$ 5.187	$ 1.082	$ 23	$ 1.429
1977.05	$ 5.282	$ 1.082	$ 23	$ 1.371
1977.06	$ 5.313	$ 1.102	$ 23	$ 1.312
1977.07	$ 5.313	$ 1.171	$ 23	$ 1.248
1977.08	$ 5.313	$ 1.184	$ 23	$ 1.160
1977.09	$ 5.313	$ 1.184	$ 23	$ 1.195
1977.10	$ 4.586	$ 1.204	$ 23	$ 1.210
1977.11	$ 4.586	$ 1.237	$ 23	$ 1.182
1977.12	$ 4.586	$ 1.261	$ 23	$ 1.261

Month	Nickel	Aluminium	Iron Ore	Copper
1978.01	$ 4.586	$ 1.316	$ 21	$ 1.261
1978.02	$ 4.586	$ 1.321	$ 21	$ 1.217
1978.03	$ 4.586	$ 1.299	$ 21	$ 1.254
1978.04	$ 4.696	$ 1.259	$ 21	$ 1.285
1978.05	$ 4.696	$ 1.237	$ 21	$ 1.303
1978.06	$ 4.645	$ 1.248	$ 21	$ 1.333
1978.07	$ 4.586	$ 1.290	$ 21	$ 1.337
1978.08	$ 4.586	$ 1.321	$ 21	$ 1.426
1978.09	$ 4.586	$ 1.382	$ 21	$ 1.442
1978.10	$ 4.586	$ 1.425	$ 21	$ 1.506
1978.11	$ 4.586	$ 1.394	$ 21	$ 1.481
1978.12	$ 4.586	$ 1.409	$ 21	$ 1.533
1979.01	$ 4.586	$ 1.265	$ 24	$ 1.659
1979.02	$ 4.546	$ 1.442	$ 24	$ 1.944
1979.03	$ 4.819	$ 1.542	$ 24	$ 2.050
1979.04	$ 5.379	$ 1.569	$ 24	$ 2.100
1979.05	$ 5.968	$ 1.576	$ 24	$ 1.926
1979.06	$ 6.519	$ 1.597	$ 24	$ 1.878
1979.07	$ 6.614	$ 1.534	$ 24	$ 1.814
1979.08	$ 6.614	$ 1.562	$ 24	$ 1.976
1979.09	$ 6.614	$ 1.616	$ 24	$ 2.096
1979.10	$ 6.614	$ 1.786	$ 24	$ 2.076
1979.11	$ 6.614	$ 1.833	$ 24	$ 2.090
1979.12	$ 6.945	$ 1.913	$ 24	$ 2.214
1980.01	$ 6.585	$ 2.055	$ 28	$ 2.601
1980.02	$ 6.979	$ 2.131	$ 28	$ 2.918
1980.03	$ 6.734	$ 1.978	$ 28	$ 2.306
1980.04	$ 6.233	$ 1.932	$ 28	$ 2.070
1980.05	$ 6.001	$ 1.776	$ 28	$ 2.037
1980.06	$ 6.295	$ 1.669	$ 28	$ 2.006
1980.07	$ 6.622	$ 1.758	$ 28	$ 2.176
1980.08	$ 6.585	$ 1.784	$ 28	$ 2.082
1980.09	$ 6.655	$ 1.655	$ 28	$ 2.060
1980.10	$ 6.692	$ 1.626	$ 28	$ 2.040
1980.11	$ 6.453	$ 1.504	$ 28	$ 2.010
1980.12	$ 6.391	$ 1.431	$ 28	$ 1.879

Month	Nickel	Aluminium	Iron Ore	Copper
1981.01	$ 6.404	$ 1.431	$ 28	$ 1.869
1981.02	$ 6.371	$ 1.452	$ 28	$ 1.801
1981.03	$ 6.292	$ 1.443	$ 28	$ 1.818
1981.04	$ 6.307	$ 1.369	$ 28	$ 1.821
1981.05	$ 6.352	$ 1.297	$ 28	$ 1.742
1981.06	$ 6.169	$ 1.232	$ 28	$ 1.700
1981.07	$ 6.150	$ 1.175	$ 28	$ 1.682
1981.08	$ 5.999	$ 1.231	$ 28	$ 1.787
1981.09	$ 5.579	$ 1.169	$ 28	$ 1.710
1981.10	$ 5.217	$ 1.140	$ 28	$ 1.666
1981.11	$ 5.100	$ 1.082	$ 28	$ 1.651
1981.12	$ 5.496	$ 1.131	$ 28	$ 1.655
1982.01	$ 5.629	$ 1.113	$ 33	$ 1.611
1982.02	$ 5.717	$ 1.088	$ 33	$ 1.598
1982.03	$ 5.653	$ 1.029	$ 33	$ 1.510
1982.04	$ 5.394	$ 996	$ 33	$ 1.522
1982.05	$ 5.212	$ 973	$ 33	$ 1.528
1982.06	$ 5.187	$ 919	$ 33	$ 1.300
1982.07	$ 5.069	$ 958	$ 33	$ 1.441
1982.08	$ 4.953	$ 959	$ 33	$ 1.452
1982.09	$ 4.310	$ 960	$ 33	$ 1.427
1982.10	$ 3.917	$ 952	$ 33	$ 1.461
1982.11	$ 3.434	$ 965	$ 33	$ 1.444
1982.12	$ 3.576	$ 987	$ 33	$ 1.473
1983.01	$ 3.797	$ 1.077	$ 29	$ 1.572
1983.02	$ 4.228	$ 1.230	$ 29	$ 1.647
1983.03	$ 4.832	$ 1.302	$ 29	$ 1.598
1983.04	$ 4.818	$ 1.364	$ 29	$ 1.675
1983.05	$ 5.032	$ 1.453	$ 29	$ 1.766
1983.06	$ 4.883	$ 1.466	$ 29	$ 1.701
1983.07	$ 4.804	$ 1.520	$ 29	$ 1.704
1983.08	$ 4.853	$ 1.604	$ 29	$ 1.640
1983.09	$ 4.911	$ 1.614	$ 29	$ 1.561
1983.10	$ 4.674	$ 1.566	$ 29	$ 1.435
1983.11	$ 4.585	$ 1.517	$ 29	$ 1.389
1983.12	$ 4.657	$ 1.549	$ 29	$ 1.415

Month	Nickel	Aluminium	Iron Ore	Copper
1984.01	$ 4.671	$ 1.549	$ 26	$ 1.376
1984.02	$ 4.640	$ 1.491	$ 26	$ 1.430
1984.03	$ 4.781	$ 1.456	$ 26	$ 1.501
1984.04	$ 4.912	$ 1.370	$ 26	$ 1.533
1984.05	$ 4.811	$ 1.289	$ 26	$ 1.421
1984.06	$ 4.773	$ 1.275	$ 26	$ 1.367
1984.07	$ 4.640	$ 1.163	$ 26	$ 1.331
1984.08	$ 4.736	$ 1.136	$ 26	$ 1.338
1984.09	$ 4.706	$ 1.012	$ 26	$ 1.294
1984.10	$ 4.750	$ 1.028	$ 26	$ 1.273
1984.11	$ 4.748	$ 1.152	$ 26	$ 1.345
1984.12	$ 4.859	$ 1.095	$ 26	$ 1.321
1985.01	$ 4.947	$ 1.075	$ 27	$ 1.359
1985.02	$ 5.051	$ 1.098	$ 27	$ 1.389
1985.03	$ 5.212	$ 1.095	$ 27	$ 1.390
1985.04	$ 5.490	$ 1.106	$ 27	$ 1.502
1985.05	$ 5.604	$ 1.105	$ 27	$ 1.531
1985.06	$ 5.553	$ 1.032	$ 27	$ 1.432
1985.07	$ 5.091	$ 1.012	$ 27	$ 1.475
1985.08	$ 4.908	$ 1.019	$ 27	$ 1.420
1985.09	$ 4.570	$ 985	$ 27	$ 1.366
1985.10	$ 4.240	$ 971	$ 27	$ 1.385
1985.11	$ 4.035	$ 950	$ 27	$ 1.370
1985.12	$ 4.090	$ 1.039	$ 27	$ 1.391
1986.01	$ 4.035	$ 1.119	$ 26	$ 1.418
1986.02	$ 3.988	$ 1.115	$ 26	$ 1.406
1986.03	$ 4.123	$ 1.168	$ 26	$ 1.445
1986.04	$ 3.999	$ 1.164	$ 26	$ 1.435
1986.05	$ 4.043	$ 1.164	$ 26	$ 1.419
1986.06	$ 4.087	$ 1.183	$ 26	$ 1.413
1986.07	$ 3.911	$ 1.123	$ 26	$ 1.344
1986.08	$ 3.807	$ 1.129	$ 26	$ 1.303
1986.09	$ 3.724	$ 1.206	$ 26	$ 1.347
1986.10	$ 3.644	$ 1.162	$ 26	$ 1.317
1986.11	$ 3.642	$ 1.132	$ 26	$ 1.303
1986.12	$ 3.572	$ 1.133	$ 26	$ 1.336

Month	Nickel	Aluminium	Iron Ore	Copper
1987.01	$ 3.525	$ 1.171	$ 25	$ 1.346
1987.02	$ 3.717	$ 1.283	$ 25	$ 1.380
1987.03	$ 3.772	$ 1.367	$ 25	$ 1.466
1987.04	$ 3.898	$ 1.401	$ 25	$ 1.484
1987.05	$ 4.436	$ 1.412	$ 25	$ 1.520
1987.06	$ 4.436	$ 1.472	$ 25	$ 1.572
1987.07	$ 4.753	$ 1.653	$ 25	$ 1.695
1987.08	$ 5.307	$ 1.810	$ 25	$ 1.756
1987.09	$ 5.333	$ 1.746	$ 25	$ 1.811
1987.10	$ 5.692	$ 1.963	$ 25	$ 1.967
1987.11	$ 5.937	$ 1.681	$ 25	$ 2.524
1987.12	$ 7.661	$ 1.824	$ 25	$ 2.869
1988.01	$ 8.073	$ 2.002	$ 24	$ 2.663
1988.02	$ 8.667	$ 2.138	$ 24	$ 2.330
1988.03	$15.497	$ 2.526	$ 24	$ 2.359
1988.04	$18.012	$ 2.508	$ 24	$ 2.286
1988.05	$17.025	$ 2.988	$ 24	$ 2.448
1988.06	$15.590	$ 3.578	$ 24	$ 2.540
1988.07	$14.591	$ 2.582	$ 24	$ 2.214
1988.08	$14.187	$ 2.701	$ 24	$ 2.201
1988.09	$11.878	$ 2.387	$ 24	$ 2.436
1988.10	$11.558	$ 2.309	$ 24	$ 2.940
1988.11	$13.342	$ 2.382	$ 24	$ 3.305
1988.12	$16.920	$ 2.503	$ 24	$ 3.499
1989.01	$17.725	$ 2.398	$ 28	$ 3.394
1989.02	$18.524	$ 2.183	$ 28	$ 3.097
1989.03	$17.157	$ 2.074	$ 28	$ 3.264
1989.04	$15.261	$ 2.126	$ 28	$ 3.118
1989.05	$13.454	$ 2.259	$ 28	$ 2.739
1989.06	$12.143	$ 1.914	$ 28	$ 2.546
1989.07	$12.275	$ 1.756	$ 28	$ 2.505
1989.08	$12.910	$ 1.798	$ 28	$ 2.762
1989.09	$11.222	$ 1.718	$ 28	$ 2.884
1989.10	$10.425	$ 1.820	$ 28	$ 2.861
1989.11	$ 9.793	$ 1.736	$ 28	$ 2.591
1989.12	$ 8.809	$ 1.633	$ 28	$ 2.419

Month	Nickel	Aluminium	Iron Ore	Copper
1990.01	$ 7.056	$ 1.528	$ 33	$ 2.367
1990.02	$ 6.977	$ 1.454	$ 33	$ 2.360
1990.03	$ 9.267	$ 1.567	$ 33	$ 2.626
1990.04	$ 8.940	$ 1.526	$ 33	$ 2.686
1990.05	$ 8.698	$ 1.527	$ 33	$ 2.742
1990.06	$ 8.422	$ 1.566	$ 33	$ 2.585
1990.07	$ 9.318	$ 1.571	$ 33	$ 2.769
1990.08	$10.957	$ 1.782	$ 33	$ 2.957
1990.09	$10.844	$ 2.067	$ 33	$ 3.031
1990.10	$ 9.145	$ 1.946	$ 33	$ 2.744
1990.11	$ 8.587	$ 1.618	$ 33	$ 2.586
1990.12	$ 8.158	$ 1.522	$ 33	$ 2.485
1991.01	$ 8.569	$ 1.515	$ 35	$ 2.449
1991.02	$ 8.672	$ 1.505	$ 35	$ 2.449
1991.03	$ 8.701	$ 1.496	$ 35	$ 2.410
1991.04	$ 9.021	$ 1.392	$ 35	$ 2.472
1991.05	$ 8.452	$ 1.296	$ 35	$ 2.306
1991.06	$ 8.280	$ 1.275	$ 35	$ 2.219
1991.07	$ 8.541	$ 1.297	$ 35	$ 2.236
1991.08	$ 8.145	$ 1.256	$ 35	$ 2.233
1991.09	$ 7.681	$ 1.212	$ 35	$ 2.325
1991.10	$ 7.443	$ 1.150	$ 35	$ 2.364
1991.11	$ 7.245	$ 1.135	$ 35	$ 2.380
1991.12	$ 7.118	$ 1.098	$ 35	$ 2.223
1992.01	$ 7.517	$ 1.177	$ 33	$ 2.139
1992.02	$ 7.862	$ 1.267	$ 33	$ 2.206
1992.03	$ 7.418	$ 1.280	$ 33	$ 2.227
1992.04	$ 7.421	$ 1.317	$ 33	$ 2.215
1992.05	$ 7.327	$ 1.307	$ 33	$ 2.217
1992.06	$ 7.193	$ 1.276	$ 33	$ 2.299
1992.07	$ 7.498	$ 1.313	$ 33	$ 2.520
1992.08	$ 7.268	$ 1.305	$ 33	$ 2.522
1992.09	$ 6.918	$ 1.270	$ 33	$ 2.414
1992.10	$ 6.305	$ 1.174	$ 33	$ 2.249
1992.11	$ 5.565	$ 1.159	$ 33	$ 2.158
1992.12	$ 5.724	$ 1.207	$ 33	$ 2.207

Month	Nickel	Aluminium	Iron Ore	Copper
1993.01	$ 5.931	$ 1.207	$ 29	$ 2.257
1993.02	$ 6.039	$ 1.202	$ 29	$ 2.213
1993.03	$ 5.971	$ 1.151	$ 29	$ 2.153
1993.04	$ 5.972	$ 1.109	$ 29	$ 1.950
1993.05	$ 5.763	$ 1.124	$ 29	$ 1.795
1993.06	$ 5.532	$ 1.165	$ 29	$ 1.853
1993.07	$ 5.036	$ 1.202	$ 29	$ 1.927
1993.08	$ 4.722	$ 1.172	$ 29	$ 1.947
1993.09	$ 4.353	$ 1.115	$ 29	$ 1.862
1993.10	$ 4.449	$ 1.087	$ 29	$ 1.646
1993.11	$ 4.634	$ 1.040	$ 29	$ 1.630
1993.12	$ 5.119	$ 1.094	$ 29	$ 1.724
1994.01	$ 5.578	$ 1.175	$ 26	$ 1.805
1994.02	$ 5.825	$ 1.270	$ 26	$ 1.866
1994.03	$ 5.588	$ 1.289	$ 26	$ 1.915
1994.04	$ 5.408	$ 1.279	$ 26	$ 1.882
1994.05	$ 6.087	$ 1.323	$ 26	$ 2.151
1994.06	$ 6.282	$ 1.401	$ 26	$ 2.364
1994.07	$ 6.227	$ 1.492	$ 26	$ 2.458
1994.08	$ 5.860	$ 1.455	$ 26	$ 2.406
1994.09	$ 6.365	$ 1.569	$ 26	$ 2.506
1994.10	$ 6.748	$ 1.698	$ 26	$ 2.548
1994.11	$ 7.556	$ 1.893	$ 26	$ 2.802
1994.12	$ 8.556	$ 1.878	$ 26	$ 2.985
1995.01	$ 9.593	$ 2.061	$ 28	$ 3.009
1995.02	$ 8.505	$ 1.916	$ 28	$ 2.878
1995.03	$ 7.532	$ 1.805	$ 28	$ 2.924
1995.04	$ 7.398	$ 1.849	$ 28	$ 2.904
1995.05	$ 7.232	$ 1.763	$ 28	$ 2.773
1995.06	$ 7.872	$ 1.780	$ 28	$ 2.995
1995.07	$ 8.597	$ 1.860	$ 28	$ 3.076
1995.08	$ 8.945	$ 1.888	$ 28	$ 3.037
1995.09	$ 8.405	$ 1.761	$ 28	$ 2.916
1995.10	$ 8.062	$ 1.674	$ 28	$ 2.814
1995.11	$ 8.506	$ 1.654	$ 28	$ 2.977
1995.12	$ 8.091	$ 1.657	$ 28	$ 2.926

Month	Nickel	Aluminium	Iron Ore	Copper
1996.01	$ 7.862	$ 1.589	$ 30	$ 2.616
1996.02	$ 8.216	$ 1.592	$ 30	$ 2.538
1996.03	$ 8.022	$ 1.612	$ 30	$ 2.561
1996.04	$ 8.043	$ 1.587	$ 30	$ 2.596
1996.05	$ 8.027	$ 1.589	$ 30	$ 2.658
1996.06	$ 7.709	$ 1.482	$ 30	$ 2.173
1996.07	$ 7.204	$ 1.459	$ 30	$ 1.986
1996.08	$ 7.054	$ 1.463	$ 30	$ 2.009
1996.09	$ 7.318	$ 1.407	$ 30	$ 1.941
1996.10	$ 7.031	$ 1.336	$ 30	$ 1.961
1996.11	$ 6.943	$ 1.450	$ 30	$ 2.231
1996.12	$ 6.581	$ 1.500	$ 30	$ 2.268
1997.01	$ 7.072	$ 1.576	$ 30	$ 2.435
1997.02	$ 7.735	$ 1.580	$ 30	$ 2.406
1997.03	$ 7.896	$ 1.632	$ 30	$ 2.421
1997.04	$ 7.316	$ 1.561	$ 30	$ 2.391
1997.05	$ 7.483	$ 1.625	$ 30	$ 2.514
1997.06	$ 7.062	$ 1.568	$ 30	$ 2.613
1997.07	$ 6.836	$ 1.592	$ 30	$ 2.450
1997.08	$ 6.761	$ 1.711	$ 30	$ 2.251
1997.09	$ 6.504	$ 1.611	$ 30	$ 2.107
1997.10	$ 6.380	$ 1.608	$ 30	$ 2.052
1997.11	$ 6.140	$ 1.599	$ 30	$ 1.917
1997.12	$ 5.945	$ 1.531	$ 30	$ 1.762
1998.01	$ 5.492	$ 1.486	$ 31	$ 1.688
1998.02	$ 5.387	$ 1.466	$ 31	$ 1.665
1998.03	$ 5.396	$ 1.438	$ 31	$ 1.748
1998.04	$ 5.394	$ 1.418	$ 31	$ 1.801
1998.05	$ 5.020	$ 1.365	$ 31	$ 1.733
1998.06	$ 4.476	$ 1.307	$ 31	$ 1.661
1998.07	$ 4.325	$ 1.309	$ 31	$ 1.651
1998.08	$ 4.081	$ 1.311	$ 31	$ 1.621
1998.09	$ 4.102	$ 1.342	$ 31	$ 1.648
1998.10	$ 3.872	$ 1.304	$ 31	$ 1.586
1998.11	$ 4.132	$ 1.295	$ 31	$ 1.574
1998.12	$ 3.878	$ 1.249	$ 31	$ 1.474
1999.01	$ 4.269	$ 1.218	$ 28	$ 1.431
1999.02	$ 4.626	$ 1.187	$ 28	$ 1.411
1999.03	$ 5.011	$ 1.182	$ 28	$ 1.378
1999.04	$ 5.103	$ 1.278	$ 28	$ 1.466
1999.05	$ 5.399	$ 1.323	$ 28	$ 1.511
1999.06	$ 5.195	$ 1.315	$ 28	$ 1.422
1999.07	$ 5.700	$ 1.404	$ 28	$ 1.640
1999.08	$ 6.449	$ 1.431	$ 28	$ 1.648
1999.09	$ 7.028	$ 1.492	$ 28	$ 1.750
1999.10	$ 7.321	$ 1.474	$ 28	$ 1.724
1999.11	$ 7.950	$ 1.473	$ 28	$ 1.728
1999.12	$ 8.083	$ 1.554	$ 28	$ 1.765
2000.01	$ 8.310	$ 1.680	$ 29	$ 1.844
2000.02	$ 9.653	$ 1.670	$ 29	$ 1.801
2000.03	$10.280	$ 1.577	$ 29	$ 1.739
2000.04	$ 9.728	$ 1.457	$ 29	$ 1.679
2000.05	$10.130	$ 1.467	$ 29	$ 1.786
2000.06	$ 8.411	$ 1.506	$ 29	$ 1.753
2000.07	$ 8.164	$ 1.564	$ 29	$ 1.799
2000.08	$ 8.007	$ 1.528	$ 29	$ 1.856
2000.09	$ 8.638	$ 1.601	$ 29	$ 1.960
2000.10	$ 7.678	$ 1.500	$ 29	$ 1.899
2000.11	$ 7.340	$ 1.474	$ 29	$ 1.795
2000.12	$ 7.314	$ 1.565	$ 29	$ 1.851
2001.01	$ 6.995	$ 1.616	$ 30	$ 1.788
2001.02	$ 6.524	$ 1.604	$ 30	$ 1.766
2001.03	$ 6.134	$ 1.509	$ 30	$ 1.739
2001.04	$ 6.330	$ 1.497	$ 30	$ 1.664
2001.05	$ 7.061	$ 1.539	$ 30	$ 1.682
2001.06	$ 6.641	$ 1.466	$ 30	$ 1.608
2001.07	$ 5.937	$ 1.416	$ 30	$ 1.525
2001.08	$ 5.521	$ 1.377	$ 30	$ 1.464
2001.09	$ 5.027	$ 1.345	$ 30	$ 1.426
2001.10	$ 4.825	$ 1.283	$ 30	$ 1.377
2001.11	$ 5.078	$ 1.327	$ 30	$ 1.428
2001.12	$ 5.264	$ 1.345	$ 30	$ 1.472
2002.01	$ 6.043	$ 1.369	$ 29	$ 1.504
2002.02	$ 6.029	$ 1.369	$ 29	$ 1.562
2002.03	$ 6.538	$ 1.405	$ 29	$ 1.605
2002.04	$ 6.958	$ 1.370	$ 29	$ 1.590
2002.05	$ 6.761	$ 1.343	$ 29	$ 1.596
2002.06	$ 7.120	$ 1.354	$ 29	$ 1.648
2002.07	$ 7.143	$ 1.338	$ 29	$ 1.589
2002.08	$ 6.717	$ 1.292	$ 29	$ 1.480
2002.09	$ 6.640	$ 1.301	$ 29	$ 1.479
2002.10	$ 6.804	$ 1.311	$ 29	$ 1.484
2002.11	$ 7.314	$ 1.372	$ 29	$ 1.582
2002.12	$ 7.193	$ 1.375	$ 29	$ 1.596
2003.01	$ 8.026	$ 1.378	$ 32	$ 1.648
2003.02	$ 8.623	$ 1.422	$ 32	$ 1.684
2003.03	$ 8.379	$ 1.389	$ 32	$ 1.659
2003.04	$ 7.910	$ 1.332	$ 32	$ 1.587
2003.05	$ 8.331	$ 1.398	$ 32	$ 1.648
2003.06	$ 8.875	$ 1.410	$ 32	$ 1.687
2003.07	$ 8.797	$ 1.436	$ 32	$ 1.710
2003.08	$ 9.351	$ 1.456	$ 32	$ 1.760
2003.09	$ 9.965	$ 1.416	$ 32	$ 1.790
2003.10	$11.047	$ 1.474	$ 32	$ 1.921
2003.11	$12.087	$ 1.508	$ 32	$ 2.055
2003.12	$14.163	$ 1.555	$ 32	$ 2.201
2004.01	$15.327	$ 1.606	$ 38	$ 2.424
2004.02	$15.145	$ 1.686	$ 38	$ 2.760
2004.03	$13.715	$ 1.656	$ 38	$ 3.009
2004.04	$12.848	$ 1.730	$ 38	$ 2.949
2004.05	$11.118	$ 1.623	$ 38	$ 2.734
2004.06	$13.534	$ 1.678	$ 38	$ 2.687
2004.07	$15.023	$ 1.709	$ 38	$ 2.808
2004.08	$13.680	$ 1.692	$ 38	$ 2.846
2004.09	$13.271	$ 1.724	$ 38	$ 2.895
2004.10	$14.404	$ 1.820	$ 38	$ 3.012
2004.11	$14.045	$ 1.814	$ 38	$ 3.123
2004.12	$13.769	$ 1.849	$ 38	$ 3.145

Month	Nickel	Aluminium	Iron Ore	Copper
2005.01	$14.505	$ 1.834	$ 65	$ 3.170
2005.02	$15.350	$ 1.883	$ 65	$ 3.254
2005.03	$16.191	$ 1.980	$ 65	$ 3.379
2005.04	$16.142	$ 1.894	$ 65	$ 3.394
2005.05	$16.932	$ 1.744	$ 65	$ 3.249
2005.06	$16.160	$ 1.731	$ 65	$ 3.524
2005.07	$14.581	$ 1.779	$ 65	$ 3.614
2005.08	$14.893	$ 1.868	$ 65	$ 3.798
2005.09	$14.228	$ 1.840	$ 65	$ 3.858
2005.10	$12.403	$ 1.929	$ 65	$ 4.060
2005.11	$12.116	$ 2.051	$ 65	$ 4.269
2005.12	$13.429	$ 2.247	$ 65	$ 4.577
2006.01	$14.555	$ 2.378	$ 67	$ 4.734
2006.02	$14.979	$ 2.455	$ 65	$ 4.982
2006.03	$14.897	$ 2.429	$ 67	$ 5.103
2006.04	$17.942	$ 2.621	$ 67	$ 6.388
2006.05	$21.077	$ 2.861	$ 67	$ 8.046
2006.06	$20.755	$ 2.477	$ 69	$ 7.198
2006.07	$26.586	$ 2.513	$ 71	$ 7.712
2006.08	$30.744	$ 2.460	$ 70	$ 7.696
2006.09	$30.131	$ 2.473	$ 70	$ 7.602
2006.10	$32.703	$ 2.655	$ 72	$ 7.500
2006.11	$32.114	$ 2.703	$ 74	$ 7.029
2006.12	$34.570	$ 2.814	$ 74	$ 6.675
2007.01	$36.811	$ 2.809	$ 78	$ 5.670
2007.02	$41.184	$ 2.832	$ 83	$ 5.676
2007.03	$46.325	$ 2.762	$ 89	$ 6.452
2007.04	$50.267	$ 2.815	$ 91	$ 7.766
2007.05	$52.179	$ 2.793	$ 102	$ 7.681
2007.06	$41.719	$ 2.677	$ 103	$ 7.474
2007.07	$33.426	$ 2.732	$ 106	$ 7.973
2007.08	$27.652	$ 2.516	$ 122	$ 7.514
2007.09	$29.538	$ 2.391	$ 149	$ 7.649
2007.10	$31.055	$ 2.442	$ 168	$ 8.008
2007.11	$30.610	$ 2.507	$ 195	$ 6.967
2007.12	$25.992	$ 2.382	$ 190	$ 6.588

Month	Nickel	Aluminium	Iron Ore	Copper
2008.01	$27.690	$ 2.446	$ 193	$ 7.061
2008.02	$27.955	$ 2.777	$ 186	$ 7.888
2008.03	$31.225	$ 3.005	$ 197	$ 8.439
2008.04	$28.763	$ 2.959	$ 196	$ 8.685
2008.05	$25.735	$ 2.903	$ 193	$ 8.383
2008.06	$22.549	$ 2.958	$ 184	$ 8.261
2008.07	$20.160	$ 3.071	$ 181	$ 8.414
2008.08	$18.928	$ 2.764	$ 179	$ 7.635
2008.09	$17.795	$ 2.526	$ 140	$ 6.991
2008.10	$12.140	$ 2.121	$ 89	$ 4.926
2008.11	$10.702	$ 1.852	$ 65	$ 3.717
2008.12	$ 9.686	$ 1.490	$ 70	$ 3.072
2009.01	$11.307	$ 1.413	$ 73	$ 3.221
2009.02	$10.409	$ 1.330	$ 76	$ 3.315
2009.03	$ 9.696	$ 1.336	$ 64	$ 3.750
2009.04	$11.166	$ 1.421	$ 60	$ 4.407
2009.05	$12.635	$ 1.460	$ 63	$ 4.569
2009.06	$14.960	$ 1.574	$ 72	$ 5.014
2009.07	$15.985	$ 1.668	$ 84	$ 5.216
2009.08	$19.642	$ 1.934	$ 98	$ 6.165
2009.09	$17.473	$ 1.834	$ 81	$ 6.196
2009.10	$18.525	$ 1.879	$ 87	$ 6.288
2009.11	$16.991	$ 1.949	$ 99	$ 6.676
2009.12	$17.066	$ 2.180	$ 105	$ 6.982
2010.01	$18.439	$ 2.235	$ 126	$ 7.386
2010.02	$18.976	$ 2.049	$ 127	$ 6.848
2010.03	$22.461	$ 2.206	$ 140	$ 7.463
2010.04	$26.031	$ 2.317	$ 172	$ 7.745
2010.05	$22.008	$ 2.041	$ 161	$ 6.838
2010.06	$19.389	$ 1.931	$ 144	$ 6.499
2010.07	$19.518	$ 1.988	$ 126	$ 6.735
2010.08	$21.413	$ 2.118	$ 145	$ 7.284
2010.09	$22.643	$ 2.162	$ 141	$ 7.709
2010.10	$23.807	$ 2.347	$ 148	$ 8.292
2010.11	$22.909	$ 2.333	$ 156	$ 8.470
2010.12	$24.111	$ 2.351	$ 163	$ 9.147

Month	Nickel	Aluminium	Iron Ore	Copper
2011.01	$25.646	$ 2.440	$ 179	$ 9.556
2011.02	$28.252	$ 2.508	$ 187	$ 9.868
2011.03	$26.710	$ 2.556	$ 169	$ 9.503
2011.04	$26.408	$ 2.678	$ 179	$ 9.493
2011.05	$24.237	$ 2.596	$ 177	$ 8.960
2011.06	$22.421	$ 2.558	$ 171	$ 9.067
2011.07	$23.848	$ 2.525	$ 173	$ 9.650
2011.08	$21.845	$ 2.379	$ 178	$ 9.001
2011.09	$20.378	$ 2.293	$ 177	$ 8.300
2011.10	$19.039	$ 2.181	$ 150	$ 7.394
2011.11	$17.873	$ 2.080	$ 136	$ 7.581
2011.12	$18.267	$ 2.022	$ 136	$ 7.565
2012.01	$19.855	$ 2.144	$ 140	$ 8.040
2012.02	$20.394	$ 2.208	$ 140	$ 8.441
2012.03	$18.661	$ 2.184	$ 145	$ 8.471
2012.04	$17.940	$ 2.050	$ 148	$ 8.289
2012.05	$17.068	$ 2.008	$ 137	$ 7.956
2012.06	$16.549	$ 1.890	$ 135	$ 7.423
2012.07	$16.128	$ 1.876	$ 128	$ 7.584
2012.08	$15.735	$ 1.845	$ 108	$ 7.516
2012.09	$17.288	$ 2.064	$ 99	$ 8.088
2012.10	$17.169	$ 1.974	$ 114	$ 8.062
2012.11	$16.335	$ 1.949	$ 120	$ 7.711
2012.12	$17.449	$ 2.087	$ 129	$ 7.966
2013.01	$17.473	$ 2.038	$ 150	$ 8.047
2013.02	$17.690	$ 2.054	$ 155	$ 8.061
2013.03	$16.725	$ 1.910	$ 140	$ 7.646
2013.04	$15.673	$ 1.862	$ 137	$ 7.234
2013.05	$14.948	$ 1.832	$ 124	$ 7.249
2013.06	$14.280	$ 1.815	$ 115	$ 7.000
2013.07	$13.750	$ 1.770	$ 127	$ 6.907
2013.08	$14.315	$ 1.818	$ 137	$ 7.193
2013.09	$13.801	$ 1.761	$ 134	$ 7.159
2013.10	$14.118	$ 1.815	$ 133	$ 7.203
2013.11	$13.684	$ 1.748	$ 136	$ 7.071
2013.12	$13.925	$ 1.740	$ 136	$ 7.215

Month	Nickel	Aluminium	Iron Ore	Copper
2014.01	$14.101	$ 1.727	$ 128	$ 7.291
2014.02	$14.204	$ 1.695	$ 121	$ 7.149
2014.03	$15.678	$ 1.705	$ 112	$ 6.650
2014.04	$17.374	$ 1.811	$ 115	$ 6.674
2014.05	$19.401	$ 1.751	$ 101	$ 6.891
2014.06	$18.629	$ 1.839	$ 93	$ 6.821
2014.07	$19.118	$ 1.948	$ 96	$ 7.113
2014.08	$18.600	$ 2.030	$ 93	$ 7.002
2014.09	$18.035	$ 1.990	$ 82	$ 6.872
2014.10	$15.812	$ 1.946	$ 81	$ 6.737
2014.11	$15.807	$ 2.056	$ 74	$ 6.713
2014.12	$15.962	$ 1.909	$ 68	$ 6.446
2015.01	$14.849	$ 1.815	$ 68	$ 5.831
2015.02	$14.574	$ 1.818	$ 63	$ 5.729
2015.03	$13.756	$ 1.774	$ 58	$ 5.940
2015.04	$12.831	$ 1.819	$ 52	$ 6.042
2015.05	$13.511	$ 1.804	$ 60	$ 6.295
2015.06	$12.825	$ 1.688	$ 63	$ 5.833
2015.07	$11.413	$ 1.640	$ 52	$ 5.457
2015.08	$10.386	$ 1.548	$ 56	$ 5.127
2015.09	$ 9.938	$ 1.590	$ 57	$ 5.217
2015.10	$10.317	$ 1.516	$ 53	$ 5.216
2015.11	$ 9.244	$ 1.468	$ 47	$ 4.800
2015.12	$ 8.708	$ 1.497	$ 41	$ 4.639
2016.01	$ 8.507	$ 1.481	$ 42	$ 4.472
2016.02	$ 8.299	$ 1.531	$ 47	$ 4.599
2016.03	$ 8.717	$ 1.531	$ 56	$ 4.954
2016.04	$ 8.879	$ 1.571	$ 61	$ 4.873
2016.05	$ 8.660	$ 1.551	$ 55	$ 4.695
2016.06	$ 8.928	$ 1.594	$ 52	$ 4.642
2016.07	$10.263	$ 1.629	$ 57	$ 4.865
2016.08	$10.336	$ 1.639	$ 61	$ 4.752
2016.09	$10.192	$ 1.592	$ 58	$ 4.722
2016.10	$10.260	$ 1.666	$ 59	$ 4.731
2016.11	$11.129	$ 1.737	$ 73	$ 5.451
2016.12	$10.972	$ 1.728	$ 80	$ 5.660

Month	Nickel	Aluminium	Iron Ore	Copper
2017.01	$ 9.971	$ 1.791	$ 80	$ 5.755
2017.02	$10.643	$ 1.861	$ 89	$ 5.941
2017.03	$10.205	$ 1.901	$ 88	$ 5.825
2017.04	$ 9.609	$ 1.921	$ 70	$ 5.684
2017.05	$ 9.155	$ 1.913	$ 62	$ 5.600
2017.06	$ 8.932	$ 1.885	$ 57	$ 5.720
2017.07	$ 9.491	$ 1.903	$ 68	$ 5.985
2017.08	$10.890	$ 2.030	$ 76	$ 6.486
2017.09	$11.216	$ 2.096	$ 72	$ 6.577
2017.10	$11.336	$ 2.131	$ 62	$ 6.808
2017.11	$11.972	$ 2.097	$ 64	$ 6.827
2017.12	$11.495	$ 2.080	$ 72	$ 6.834
2018.01	$12.865	$ 2.210	$ 76	$ 7.066
2018.02	$13.596	$ 2.182	$ 77	$ 7.007
2018.03	$13.393	$ 2.069	$ 70	$ 6.799
2018.04	$13.938	$ 2.255	$ 66	$ 6.852
2018.05	$14.366	$ 2.300	$ 66	$ 6.825
2018.06	$15.106	$ 2.238	$ 65	$ 6.966
2018.07	$13.794	$ 2.082	$ 65	$ 6.251
2018.08	$13.411	$ 2.052	$ 67	$ 6.051
2018.09	$12.510	$ 2.026	$ 68	$ 6.051
2018.10	$12.315	$ 2.030	$ 73	$ 6.220
2018.11	$11.240	$ 1.939	$ 73	$ 6.196
2018.12	$10.835	$ 1.920	$ 69	$ 6.075
2019.01	$11.523	$ 1.854	$ 76	$ 5.939
2019.02	$12.685	$ 1.863	$ 88	$ 6.300
2019.03	$13.026	$ 1.871	$ 86	$ 6.439
2019.04	$12.773	$ 1.845	$ 94	$ 6.438
2019.05	$12.016	$ 1.781	$ 100	$ 6.018
2019.06	$11.944	$ 1.756	$ 109	$ 5.882
2019.07	$13.546	$ 1.797	$ 120	$ 5.941
2019.08	$15.749	$ 1.741	$ 93	$ 5.709
2019.09	$17.657	$ 1.754	$ 93	$ 5.759
2019.10	$17.046	$ 1.726	$ 89	$ 5.757
2019.11	$15.172	$ 1.775	$ 85	$ 5.860
2019.12	$13.829	$ 1.771	$ 93	$ 6.077

Month	Nickel	Aluminium	Iron Ore	Copper
2020.01	$13.507	$ 1.773	$ 96	$ 6.031
2020.02	$12.716	$ 1.688	$ 88	$ 5.688
2020.03	$11.846	$ 1.611	$ 89	$ 5.183
2020.04	$11.804	$ 1.460	$ 85	$ 5.058
2020.05	$12.180	$ 1.466	$ 94	$ 5.240
2020.06	$12.727	$ 1.569	$ 103	$ 5.755
2020.07	$13.402	$ 1.644	$ 109	$ 6.372
2020.08	$14.538	$ 1.737	$ 121	$ 6.499
2020.09	$14.857	$ 1.744	$ 124	$ 6.705
2020.10	$15.239	$ 1.806	$ 120	$ 6.714
2020.11	$15.808	$ 1.935	$ 124	$ 7.069
2020.12	$16.823	$ 2.015	$ 155	$ 7.772
2021.01	$17.863	$ 2.004	$ 170	$ 7.972

Appendix No. 04b

Share Prices (2000-2021)

Month	Outokumpu	Aperam	Acerinox	Yieh	AK Steel	Posco	Jindal Stainless	Nippon Steel	JFE
2000.01	$ 272,3		$ 93,5						
2000.02	$ 297,4		$ 103,3		$ 83,1	$ 251,3			
2000.03	$ 287,6		$ 109,5		$ 103,8	$ 275,0			
2000.04	$ 263,1		$ 91,0		$ 110,6	$ 211,3			
2000.05	$ 228,8		$ 75,8		$ 96,9	$ 205,0			
2000.06	$ 249,4		$ 81,0		$ 80,0	$ 240,0			
2000.07	$ 249,4		$ 82,5		$ 100,6	$ 216,9			
2000.08	$ 200,2		$ 75,0		$ 108,8	$ 212,5			
2000.09	$ 181,4		$ 82,1		$ 93,8	$ 186,3			
2000.10	$ 195,6		$ 74,3		$ 92,5	$ 158,1			
2000.11	$ 173,7		$ 81,3		$ 91,3	$ 144,4			
2000.12	$ 172,5		$ 88,3		$ 87,5	$ 155,6			
2001.01	$ 228,8		$ 88,8		$ 93,6	$ 210,0			
2001.02	$ 228,8		$ 87,3		$ 95,3	$ 224,0			
2001.03	$ 218,5		$ 83,0		$ 100,5	$ 179,5			
2001.04	$ 231,1		$ 92,5		$ 129,7	$ 200,1			
2001.05	$ 234,5		$ 82,0		$ 133,9	$ 203,5			
2001.06	$ 217,4		$ 79,0		$ 125,4	$ 197,2			
2001.07	$ 220,8		$ 78,8		$ 131,1	$ 168,8			
2001.08	$ 201,3		$ 65,5		$ 130,2	$ 174,1			
2001.09	$ 215,1		$ 87,0		$ 84,5	$ 157,0			
2001.10	$ 247,1		$ 87,5		$ 91,0	$ 171,5			
2001.11	$ 271,1		$ 93,9		$ 106,0	$ 212,0			
2001.12	$ 290,6		$ 97,0		$ 113,8	$ 230,0			
2002.01	$ 306,6		$ 98,4		$ 137,8	$ 246,2			
2002.02	$ 291,7		$ 100,3		$ 139,9	$ 277,2			
2002.03	$ 291,9		$ 106,3		$ 143,0	$ 261,5			
2002.04	$ 283,7		$ 107,0		$ 122,6	$ 244,5			
2002.05	$ 279,1		$ 106,1		$ 139,7	$ 282,5			
2002.06	$ 265,4		$ 104,4		$ 128,1	$ 272,7			
2002.07	$ 258,5		$ 95,4		$ 93,8	$ 245,4			
2002.08	$ 224,2		$ 77,8		$ 91,0	$ 228,5			1.364
2002.09	$ 228,8		$ 89,7		$ 73,1	$ 215,8			1.496
2002.10	$ 213,9		$ 97,5		$ 72,4	$ 231,3			1.441
2002.11	$ 189,9		$ 87,5		$ 81,0	$ 258,3			1.441
2002.12	$ 191,0		$ 85,6		$ 80,0	$ 247,3			1.533
2003.01	$ 177,1		$ 90,1		$ 63,5	$ 255,0			1.717
2003.02	$ 183,0		$ 82,5		$ 54,9	$ 231,0			1.500
2003.03	$ 174,6		$ 83,5		$ 32,5	$ 197,0			1.437
2003.04	$ 161,8		$ 80,5		$ 29,2	$ 205,5			1.404
2003.05	$ 175,9		$ 83,2		$ 29,6	$ 229,6			1.800
2003.06	$ 185,5		$ 93,2		$ 36,2	$ 261,9			2.000
2003.07	$ 191,3		$ 96,5		$ 24,0	$ 305,0			2.350
2003.08	$ 226,5		$ 90,8		$ 26,4	$ 300,0			2.440
2003.09	$ 237,0		$ 93,6		$ 20,0	$ 286,0			2.810
2003.10	$ 257,4		$ 96,5		$ 24,0	$ 289,8	$ 774,5		2.565
2003.11	$ 246,4		$ 93,5		$ 30,0	$ 298,5	$ 969,2		2.925
2003.12	$ 249,4		$ 89,6		$ 51,0	$ 339,7	$ 868,2		2.730
2004.01	$ 250,5		$ 92,3		$ 49,0	$ 341,8	$ 856,6		2.760
2004.02	$ 259,7		$ 99,6		$ 48,6	$ 372,9	$ 702,5		2.845
2004.03	$ 300,9		$ 107,6		$ 58,7	$ 353,9	$ 639,0		2.475
2004.04	$ 281,2		$ 112,7		$ 47,0	$ 307,5	$ 520,5		2.385
2004.05	$ 300,9		$ 117,0		$ 45,8	$ 318,0	$ 506,0		2.675
2004.06	$ 291,0		$ 115,1		$ 52,7	$ 335,1	$ 704,0		2.665
2004.07	$ 291,5		$ 111,4		$ 66,3	$ 362,8	$ 711,5		2.980
2004.08	$ 300,9		$ 111,2		$ 60,9	$ 361,8	$ 818,0		3.140
2004.09	$ 319,4		$ 108,9		$ 81,6	$ 378,5	$ 806,0		2.845
2004.10	$ 315,7		$ 110,3		$ 95,3	$ 373,9	$ 828,5		2.960

Month	Outokumpu	Aperam	Acerinox	Yieh	AK Steel	Posco	Jindal Stainless	Nippon Steel	JFE
2004.11	$ 297,0		$ 118,1		$ 129,1	$ 472,4	$ 901,0		2.925
2004.12	$ 308,0		$ 116,8		$ 144,7	$ 445,3	$ 884,5		2.865
2005.01	$ 316,9		$ 131,0		$ 145,1	$ 450,0	$ 1.011,0		3.220
2005.02	$ 309,6		$ 126,5		$ 175,5	$ 542,5	$ 955,0		2.990
2005.03	$ 249,4		$ 115,0		$ 110,6	$ 493,6	$ 964,5		2.910
2005.04	$ 256,2		$ 117,3		$ 72,5	$ 455,3	$ 996,0		2.735
2005.05	$ 243,2		$ 112,7		$ 76,5	$ 449,2	$ 1.227,5		2.740
2005.06	$ 259,7		$ 117,4		$ 64,1	$ 439,7	$ 1.158,5		2.910
2005.07	$ 274,1		$ 118,7		$ 92,2	$ 499,0	$ 1.212,0		3.200
2005.08	$ 251,7		$ 115,6		$ 79,0	$ 522,5	$ 1.459,5		3.690
2005.09	$ 245,0		$ 109,3		$ 85,7	$ 565,6	$ 1.185,0		3.590
2005.10	$ 257,2		$ 112,9		$ 69,9	$ 512,9	$ 1.112,0		3.800
2005.11	$ 288,5		$ 122,9		$ 82,9	$ 497,6	$ 974,0		3.960
2005.12	$ 324,4		$ 132,2		$ 79,5	$ 495,1	$ 910,0		4.210
2006.01	$ 326,0		$ 128,7		$ 115,1	$ 573,9	$ 956,5		4.320
2006.02	$ 389,9		$ 135,1		$ 111,0	$ 584,4	$ 1.143,5		4.750
2006.03	$ 445,2		$ 133,3		$ 150,0	$ 638,0	$ 1.171,0		4.420
2006.04	$ 417,8		$ 131,0		$ 149,1	$ 704,7	$ 872,0		4.820
2006.05	$ 418,7		$ 135,6		$ 134,5	$ 643,0	$ 949,5		4.850
2006.06	$ 434,7		$ 147,2		$ 138,3	$ 669,0	$ 927,5		4.580
2006.07	$ 458,7		$ 147,0		$ 129,2	$ 617,4	$ 970,0		4.780
2006.08	$ 442,3		$ 152,1		$ 126,1	$ 621,1	$ 1.085,0		4.630
2006.09	$ 548,2		$ 184,0		$ 121,4	$ 649,3	$ 1.238,5		4.700
2006.10	$ 574,3		$ 206,3		$ 149,3	$ 705,2	$ 1.206,5		5.340
2006.11	$ 686,4		$ 230,5		$ 164,9	$ 788,6	$ 1.190,5		6.130
2006.12	$ 701,5		$ 205,0		$ 169,0	$ 826,7	$ 1.246,0		6.690
2007.01	$ 644,3		$ 201,1		$ 210,4	$ 881,8	$ 1.296,5		7.290
2007.02	$ 609,7		$ 189,5		$ 231,3	$ 927,0	$ 1.223,0		6.970
2007.03	$ 582,0		$ 174,2		$ 233,9	$ 1.039,5	$ 1.497,0		6.620
2007.04	$ 594,9		$ 189,3		$ 305,2	$ 1.047,4	$ 1.540,0		7.400
2007.05	$ 584,6		$ 181,4		$ 347,2	$ 1.193,0	$ 1.424,0		7.670
2007.06	$ 526,2		$ 176,7		$ 373,7	$ 1.200,0	$ 1.653,0		8.210
2007.07	$ 456,4		$ 184,6		$ 399,7	$ 1.424,5	$ 1.645,0		7.560
2007.08	$ 576,3		$ 205,2		$ 400,0	$ 1.533,1	$ 1.696,0		8.140
2007.09	$ 589,1		$ 203,6		$ 439,5	$ 1.787,7	$ 1.666,5		6.690
2007.10	$ 472,7		$ 180,0		$ 501,3	$ 1.837,5	$ 2.177,0		6.050
2007.11	$ 485,3		$ 170,2		$ 445,7	$ 1.578,7	$ 2.342,0		5.660
2007.12	$ 477,7		$ 158,4		$ 462,4	$ 1.504,1	$ 1.685,0		4.910
2008.01	$ 579,1		$ 162,5		$ 477,6	$ 1.355,0	$ 1.572,5	$ 53,7	4.740
2008.02	$ 659,1		$ 160,0		$ 526,2	$ 1.353,0	$ 1.411,5	$ 46,0	4.420
2008.03	$ 652,5		$ 174,0		$ 544,2	$ 1.189,8	$ 1.473,0	$ 45,1	5.700
2008.04	$ 657,8		$ 168,5		$ 627,8	$ 1.234,0	$ 1.380,0	$ 50,0	5.960
2008.05	$ 509,1		$ 146,3		$ 710,0	$ 1.366,5	$ 1.233,0	$ 55,6	5.350
2008.06	$ 339,1		$ 123,0		$ 690,0	$ 1.297,8	$ 1.306,5	$ 48,0	5.290
2008.07	$ 370,6		$ 127,1		$ 635,0	$ 1.326,5	$ 1.230,0	$ 49,8	4.660
2008.08	$ 250,5		$ 125,1		$ 526,1	$ 1.071,0	$ 1.091,0	$ 41,9	3.180
2008.09	$ 185,3		$ 92,8		$ 259,2	$ 933,7	$ 385,0	$ 34,4	2.445
2008.10	$ 169,5		$ 98,5		$ 139,2	$ 671,9	$ 291,0	$ 29,7	2.315
2008.11	$ 171,6		$ 113,6		$ 78,8	$ 577,5	$ 356,5	$ 27,8	2.335
2008.12	$ 209,3		$ 118,5		$ 93,2	$ 752,5	$ 378,5	$ 29,5	2.285
2009.01	$ 189,4		$ 91,2		$ 80,7	$ 635,2	$ 363,5	$ 26,2	2.155
2009.02	$ 186,7		$ 96,8		$ 61,8	$ 501,7	$ 388,5	$ 23,5	2.145
2009.03	$ 258,3		$ 114,5		$ 71,2	$ 668,3	$ 590,5	$ 23,9	2.675
2009.04	$ 309,8		$ 127,4		$ 130,1	$ 769,7	$ 952,0	$ 29,7	3.180
2009.05	$ 288,3		$ 132,1		$ 143,0	$ 838,9	$ 776,0	$ 33,6	3.250
2009.06	$ 305,4		$ 133,9		$ 191,9	$ 826,7	$ 797,5	$ 33,4	3.810
2009.07	$ 342,3		$ 150,7		$ 196,7	$ 1.010,7	$ 799,5	$ 35,1	3.250
2009.08	$ 294,2		$ 151,4		$ 203,2	$ 914,6	$ 852,0	$ 34,9	3.080

Month	Outokumpu	Aperam	Acerinox	Yieh	AK Steel	Posco	Jindal Stainless	Nippon Steel	JFE
2009.09	$ 258,3		$ 150,1		$ 197,3	$ 1.039,4	$ 994,0	$ 32,7	3.030
2009.10	$ 264,0		$ 138,5		$ 158,7	$ 1.021,2	$ 1.091,5	$ 34,0	2.840
2009.11	$ 300,9		$ 141,8		$ 200,0	$ 1.192,0	$ 1.235,0	$ 32,8	3.650
2009.12	$ 296,5		$ 149,6		$ 213,5	$ 1.311,0	$ 1.041,5	$ 35,8	3.160
2010.01	$ 296,1		$ 125,5		$ 203,4	$ 1.129,5	$ 1.002,5	$ 32,2	3.305
2010.02	$ 368,4		$ 145,8		$ 215,3	$ 1.154,6	$ 1.084,0	$ 33,1	3.765
2010.03	$ 365,6		$ 150,1		$ 228,6	$ 1.170,1	$ 1.172,5	$ 34,5	3.385
2010.04	$ 299,3		$ 129,3		$ 167,5	$ 1.121,6	$ 1.043,0	$ 31,4	3.065
2010.05	$ 300,9		$ 128,3		$ 149,6	$ 963,7	$ 1.014,0	$ 30,8	2.780
2010.06	$ 308,2		$ 131,9		$ 119,2	$ 943,2	$ 1.039,5	$ 29,8	2.675
2010.07	$ 294,7		$ 122,6		$ 139,9	$ 1.040,1	$ 1.050,0	$ 29,9	2.481
2010.08	$ 326,5		$ 130,6		$ 127,4	$ 1.009,6	$ 1.282,0	$ 29,1	2.553
2010.09	$ 295,4		$ 117,8		$ 138,1	$ 1.139,8	$ 1.218,5	$ 30,4	2.512
2010.10	$ 289,2		$ 114,6		$ 125,9	$ 1.039,4	$ 1.041,5	$ 27,5	2.661
2010.11	$ 317,6		$ 131,3		$ 132,8	$ 984,4	$ 1.083,0	$ 29,1	2.828
2010.12	$ 320,1	$ 299,5	$ 124,3		$ 163,7	$ 1.076,9	$ 923,5	$ 31,5	2.635
2011.01	$ 297,7	$ 299,7	$ 137,5		$ 159,0	$ 1.021,4	$ 862,0	$ 30,2	2.575
2011.02	$ 286,2	$ 283,5	$ 139,3		$ 159,8	$ 1.030,8	$ 827,5	$ 32,2	2.434
2011.03	$ 250,5	$ 284,2	$ 135,7		$ 157,8	$ 1.142,9	$ 887,5	$ 28,4	2.206
2011.04	$ 235,0	$ 254,3	$ 132,8		$ 162,5	$ 1.103,0	$ 1.073,5	$ 27,9	2.030
2011.05	$ 194,7	$ 223,3	$ 125,8		$ 153,0	$ 1.020,2	$ 977,5	$ 26,8	2.204
2011.06	$ 175,9	$ 194,3	$ 115,3		$ 157,6	$ 1.086,2	$ 1.005,0	$ 28,8	2.100
2011.07	$ 147,1	$ 128,0	$ 100,0		$ 121,5	$ 1.098,0	$ 909,0	$ 30,0	1.768
2011.08	$ 117,1	$ 109,8	$ 84,7		$ 89,9	$ 951,4	$ 1.000,5	$ 26,5	1.577
2011.09	$ 140,7	$ 125,3	$ 96,2		$ 65,4	$ 760,1	$ 936,5	$ 25,6	1.512
2011.10	$ 114,6	$ 119,4	$ 100,4	$ 92,0	$ 83,3	$ 859,2	$ 703,5	$ 23,7	1.389
2011.11	$ 116,2	$ 109,0	$ 99,1	$ 92,0	$ 84,6	$ 856,5	$ 726,0	$ 21,8	1.394
2011.12	$ 168,3	$ 156,4	$ 108,2	$ 92,0	$ 82,6	$ 821,0	$ 747,0	$ 22,3	1.360
2012.01	$ 119,4	$ 154,8	$ 107,2	$ 92,0	$ 94,4	$ 917,6	$ 765,5	$ 23,0	1.751
2012.02	$ 133,6	$ 138,8	$ 96,4	$ 92,0	$ 79,2	$ 925,0	$ 796,5	$ 25,4	1.778
2012.03	$ 112,8	$ 127,5	$ 91,8	$ 92,0	$ 75,6	$ 837,0	$ 776,5	$ 24,8	1.511
2012.04	$ 72,4	$ 91,2	$ 80,3	$ 92,0	$ 74,2	$ 832,5	$ 737,5	$ 22,1	1.272
2012.05	$ 63,2	$ 103,6	$ 88,2	$ 90,5	$ 60,3	$ 757,3	$ 722,0	$ 19,9	1.318
2012.06	$ 62,8	$ 111,6	$ 81,1	$ 79,0	$ 58,7	$ 804,4	$ 693,5	$ 20,5	1.041
2012.07	$ 61,1	$ 103,8	$ 85,1	$ 83,5	$ 53,2	$ 795,3	$ 679,0	$ 18,0	988
2012.08	$ 72,5	$ 125,6	$ 87,3	$ 89,5	$ 52,2	$ 815,0	$ 676,0	$ 17,5	1.030
2012.09	$ 58,0	$ 111,8	$ 80,4	$ 90,5	$ 48,0	$ 815,4	$ 661,0	$ 18,7	1.125
2012.10	$ 62,6	$ 111,1	$ 78,2	$ 90,0	$ 50,4	$ 783,8	$ 699,0	$ 19,7	1.277
2012.11	$ 69,7	$ 114,1	$ 83,5	$ 92,0	$ 40,1	$ 743,9	$ 710,0	$ 21,0	1.602
2012.12	$ 70,2	$ 106,9	$ 89,2	$ 87,8	$ 46,0	$ 821,5	$ 636,0	$ 22,2	1.949
2013.01	$ 62,7	$ 101,6	$ 82,6	$ 92,0	$ 40,0	$ 814,6	$ 551,0	$ 24,8	1.987
2013.02	$ 52,2	$ 95,9	$ 80,0	$ 86,8	$ 37,5	$ 806,9	$ 475,5	$ 24,4	1.767
2013.03	$ 43,7	$ 93,2	$ 81,8	$ 87,7	$ 33,1	$ 737,1	$ 583,5	$ 22,9	2.108
2013.04	$ 48,6	$ 104,5	$ 78,6	$ 86,3	$ 33,5	$ 719,9	$ 543,5	$ 23,9	2.145
2013.05	$ 44,6	$ 83,4	$ 71,5	$ 80,1	$ 34,7	$ 706,5	$ 489,0	$ 23,8	2.177
2013.06	$ 37,8	$ 92,8	$ 77,0	$ 77,9	$ 30,4	$ 650,8	$ 444,0	$ 24,7	2.217
2013.07	$ 42,9	$ 102,4	$ 78,6	$ 79,3	$ 34,0	$ 716,8	$ 385,5	$ 26,4	2.178
2013.08	$ 43,1	$ 113,9	$ 79,6	$ 79,3	$ 33,6	$ 720,2	$ 375,5	$ 25,6	2.543
2013.09	$ 38,3	$ 126,2	$ 97,2	$ 79,3	$ 37,5	$ 736,4	$ 377,5	$ 31,0	2.222
2013.10	$ 34,2	$ 135,7	$ 98,3	$ 83,6	$ 44,0	$ 744,6	$ 374,5	$ 30,3	2.302
2013.11	$ 35,5	$ 134,3	$ 92,5	$ 82,0	$ 56,6	$ 774,9	$ 375,0	$ 29,4	2.502
2013.12	$ 37,8	$ 133,4	$ 96,4	$ 79,3	$ 82,0	$ 780,0	$ 335,0	$ 30,9	2.160
2014.01	$ 37,4	$ 163,0	$ 105,6	$ 80,3	$ 70,7	$ 679,9	$ 323,0	$ 27,5	2.070
2014.02	$ 48,2	$ 192,8	$ 116,6	$ 80,4	$ 62,1	$ 665,6	$ 359,5	$ 26,4	1.943
2014.03	$ 55,0	$ 187,4	$ 126,0	$ 80,5	$ 72,2	$ 694,1	$ 390,0	$ 24,9	1.890
2014.04	$ 64,6	$ 239,3	$ 125,9	$ 80,3	$ 70,0	$ 736,0	$ 484,0	$ 24,0	1.931
2014.05	$ 73,5	$ 246,5	$ 129,4	$ 79,6	$ 61,2	$ 707,9	$ 591,0	$ 26,1	2.091
2014.06	$ 62,8	$ 251,8	$ 124,3	$ 82,3	$ 79,6	$ 744,4	$ 486,5	$ 29,5	2.187

Month	Outokumpu	Aperam	Acerinox	Yieh	AK Steel	Posco	Jindal Stainless	Nippon Steel	JFE
2014.07	$ 63,2	$ 245,1	$ 116,5	$ 82,9	$ 91,0	$ 808,3	$ 446,5	$ 28,1	2.104
2014.08	$ 54,6	$ 247,2	$ 121,7	$ 79,2	$ 109,2	$ 828,0	$ 370,0	$ 26,0	2.189
2014.09	$ 45,1	$ 229,2	$ 118,4	$ 80,2	$ 80,1	$ 759,0	$ 338,0	$ 23,8	2.176
2014.10	$ 47,9	$ 257,7	$ 122,3	$ 80,3	$ 75,7	$ 715,6	$ 313,0	$ 24,8	2.526
2014.11	$ 48,8	$ 245,8	$ 125,1	$ 79,9	$ 59,2	$ 680,0	$ 432,0	$ 23,9	2.696
2014.12	$ 48,0	$ 232,4	$ 132,0	$ 78,1	$ 59,4	$ 638,1	$ 333,5	$ 23,1	2.612
2015.01	$ 58,6	$ 317,0	$ 145,6	$ 78,1	$ 37,9	$ 582,3	$ 339,0	$ 21,6	2.988
2015.02	$ 74,1	$ 373,5	$ 156,3	$ 78,1	$ 44,2	$ 606,4	$ 349,0	$ 24,8	2.654
2015.03	$ 64,1	$ 341,2	$ 130,6	$ 77,5	$ 44,7	$ 546,6	$ 361,5	$ 23,3	2.710
2015.04	$ 49,5	$ 376,8	$ 139,0	$ 76,0	$ 50,8	$ 590,8	$ 415,0	$ 24,3	3.037
2015.05	$ 45,2	$ 360,7	$ 124,1	$ 74,7	$ 52,6	$ 547,6	$ 394,0	$ 25,6	2.717
2015.06	$ 42,1	$ 336,0	$ 114,0	$ 71,8	$ 38,7	$ 490,9	$ 416,5	$ 24,2	2.326
2015.07	$ 39,6	$ 301,4	$ 99,2	$ 70,2	$ 29,5	$ 415,2	$ 370,5	$ 21,9	1.883
2015.08	$ 20,6	$ 240,7	$ 79,8	$ 70,3	$ 30,9	$ 404,0	$ 382,5	$ 19,0	1.563
2015.09	$ 31,0	$ 280,9	$ 98,4	$ 69,9	$ 24,1	$ 391,8	$ 529,5	$ 17,8	1.916
2015.10	$ 28,2	$ 321,9	$ 101,8	$ 69,9	$ 28,9	$ 400,3	$ 223,0	$ 19,0	1.942
2015.11	$ 27,3	$ 328,9	$ 94,2	$ 70,9	$ 23,8	$ 364,1	$ 287,0	$ 19,1	1.920
2015.12	$ 22,5	$ 287,7	$ 82,7	$ 70,3	$ 22,4	$ 353,6	$ 229,0	$ 18,8	1.606
2016.01	$ 31,4	$ 314,4	$ 101,0	$ 70,8	$ 20,4	$ 370,9	$ 180,5	$ 16,5	1.352
2016.02	$ 34,3	$ 335,6	$ 101,8	$ 70,3	$ 28,6	$ 403,7	$ 168,0	$ 16,3	1.516
2016.03	$ 36,6	$ 343,3	$ 103,2	$ 69,3	$ 41,3	$ 473,3	$ 169,5	$ 18,4	1.580
2016.04	$ 37,6	$ 358,2	$ 104,0	$ 69,7	$ 46,8	$ 520,2	$ 151,0	$ 20,2	1.492
2016.05	$ 37,6	$ 315,6	$ 99,3	$ 66,8	$ 42,8	$ 436,4	$ 158,5	$ 19,3	1.315
2016.06	$ 51,5	$ 374,2	$ 119,6	$ 66,7	$ 46,6	$ 445,0	$ 200,0	$ 18,3	1.357
2016.07	$ 49,0	$ 370,0	$ 111,2	$ 67,0	$ 65,6	$ 506,8	$ 235,5	$ 17,8	1.607
2016.08	$ 61,2	$ 402,1	$ 117,8	$ 67,0	$ 44,6	$ 509,7	$ 246,5	$ 20,2	1.461
2016.09	$ 63,5	$ 414,0	$ 112,2	$ 68,2	$ 48,3	$ 510,8	$ 415,0	$ 19,6	1.507
2016.10	$ 72,9	$ 422,5	$ 118,5	$ 67,0	$ 52,0	$ 519,5	$ 365,5	$ 18,9	1.670
2016.11	$ 85,1	$ 434,7	$ 126,1	$ 67,0	$ 91,3	$ 534,3	$ 377,5	$ 20,8	1.780
2016.12	$ 82,8	$ 436,9	$ 127,0	$ 67,3	$ 102,1	$ 590,5	$ 477,5	$ 20,9	1.982
2017.01	$ 93,5	$ 480,1	$ 134,2	$ 70,0	$ 80,8	$ 578,8	$ 582,5	$ 23,2	2.125
2017.02	$ 91,4	$ 468,5	$ 131,3	$ 65,3	$ 83,3	$ 620,3	$ 711,5	$ 23,8	1.909
2017.03	$ 88,2	$ 462,2	$ 128,2	$ 65,2	$ 71,9	$ 645,0	$ 724,0	$ 22,0	1.901
2017.04	$ 70,8	$ 426,7	$ 120,3	$ 69,6	$ 63,4	$ 590,2	$ 703,5	$ 22,6	1.847
2017.05	$ 69,9	$ 407,0	$ 119,9	$ 68,3	$ 61,0	$ 628,8	$ 715,0	$ 20,7	1.951
2017.06	$ 71,1	$ 410,6	$ 108,7	$ 67,3	$ 65,7	$ 625,9	$ 884,0	$ 21,9	2.133
2017.07	$ 86,8	$ 443,3	$ 119,8	$ 68,3	$ 56,6	$ 751,2	$ 942,5	$ 24,0	2.172
2017.08	$ 87,9	$ 443,3	$ 122,0	$ 65,3	$ 56,0	$ 756,2	$ 1.118,5	$ 23,2	2.198
2017.09	$ 81,2	$ 461,9	$ 123,4	$ 64,7	$ 55,9	$ 694,0	$ 1.191,0	$ 22,6	2.420
2017.10	$ 72,6	$ 429,5	$ 113,0	$ 66,0	$ 45,9	$ 729,8	$ 1.111,5	$ 23,7	2.642
2017.11	$ 77,4	$ 429,2	$ 119,2	$ 67,7	$ 48,7	$ 762,4	$ 1.043,5	$ 23,3	2.706
2017.12	$ 69,0	$ 479,0	$ 118,5	$ 68,3	$ 56,6	$ 781,3	$ 1.122,0	$ 25,0	2.589
2018.01	$ 66,6	$ 428,2	$ 121,8	$ 68,5	$ 50,6	$ 894,8	$ 1.012,0	$ 24,9	2.488
2018.02	$ 55,4	$ 390,5	$ 113,5	$ 67,0	$ 51,6	$ 822,4	$ 783,5	$ 23,3	2.144
2018.03	$ 53,8	$ 403,7	$ 116,5	$ 69,1	$ 45,3	$ 788,5	$ 922,5	$ 21,9	2.329
2018.04	$ 55,6	$ 404,7	$ 114,4	$ 67,1	$ 45,9	$ 848,5	$ 801,0	$ 21,5	2.252
2018.05	$ 54,3	$ 397,0	$ 116,1	$ 65,7	$ 44,7	$ 806,4	$ 838,5	$ 21,0	2.096
2018.06	$ 52,8	$ 362,7	$ 112,9	$ 65,3	$ 43,0	$ 710,0	$ 685,0	$ 19,4	2.266
2018.07	$ 58,0	$ 397,4	$ 123,1	$ 68,7	$ 46,4	$ 738,5	$ 585,0	$ 19,7	2.525
2018.08	$ 50,6	$ 388,0	$ 115,6	$ 69,0	$ 43,7	$ 690,5	$ 679,5	$ 20,5	2.538
2018.09	$ 50,6	$ 394,0	$ 123,5	$ 66,8	$ 49,9	$ 662,6	$ 545,0	$ 19,2	2.593
2018.10	$ 36,8	$ 300,2	$ 99,2	$ 65,2	$ 37,8	$ 580,5	$ 524,5	$ 21,2	2.136
2018.11	$ 38,2	$ 262,0	$ 90,2	$ 65,2	$ 31,9	$ 581,5	$ 380,5	$ 18,5	2.048
2018.12	$ 32,0	$ 230,5	$ 86,6	$ 68,4	$ 21,8	$ 530,3	$ 336,0	$ 18,6	1.757
2019,01	$ 37,7	$ 266,5	$ 95,3	$ 67,6	$ 29,6	$ 602,5	$ 272,5	$ 16,9	1.901
2019,02	$ 35,4	$ 286,0	$ 94,1	$ 68,0	$ 30,5	$ 585,4	$ 353,5	$ 18,0	1.921
2019,03	$ 32,3	$ 252,6	$ 87,7	$ 68,3	$ 27,8	$ 560,8	$ 397,0	$ 18,1	1.877

Month	Tenneco	Faurecia	Futaba	Sejong	BHP Billiton	Norilsk	Vale	Glencore	VIX
2000.01		$ 384,9		$ 34.500					
2000.02	$ 73,8	$ 350,7		$ 31.200	$ 2.270				
2000.03	$ 79,4	$ 377,9		$ 25.000	$ 2.579				
2000.04	$ 88,8	$ 412,1		$ 23.000	$ 2.090				
2000.05	$ 73,1	$ 377,0		$ 22.700	$ 1.989				
2000.06	$ 52,5	$ 364,2		$ 26.900	$ 2.357				
2000.07	$ 58,8	$ 370,8		$ 20.900	$ 2.226				
2000.08	$ 71,3	$ 341,9		$ 20.600	$ 2.375				
2000.09	$ 51,9	$ 391,6		$ 24.800	$ 2.119				
2000.10	$ 43,1	$ 419,4		$ 25.700	$ 2.305				
2000.11	$ 39,4	$ 382,9		$ 20.000	$ 2.016				
2000.12	$ 30,0	$ 464,1	$ 37.700	$ 22.200	$ 2.261				
2001.01	$ 39,5	$ 509,2	$ 30.600	$ 22.600	$ 2.489				
2001.02	$ 31,5	$ 510,6	$ 35.500	$ 20.500	$ 2.791				
2001.03	$ 28,0	$ 536,1	$ 35.400	$ 23.000	$ 2.791				
2001.04	$ 30,0	$ 573,9	$ 33.700	$ 27.000	$ 3.015				
2001.05	$ 31,7	$ 606,3	$ 33.100	$ 28.800	$ 3.144				
2001.06	$ 32,6	$ 587,2	$ 30.500	$ 23.600	$ 3.104				
2001.07	$ 48,5	$ 565,3	$ 30.500	$ 22.200	$ 2.874				
2001.08	$ 37,2	$ 455,2	$ 28.850	$ 20.000	$ 2.857				
2001.09	$ 21,0	$ 517,9	$ 29.350	$ 23.500	$ 2.452				
2001.10	$ 18,0	$ 530,6	$ 29.550	$ 26.400	$ 2.563				
2001.11	$ 15,6	$ 537,9	$ 29.600	$ 26.300	$ 2.953				
2001.12	$ 20,4	$ 546,1	$ 26.350	$ 26.200	$ 3.058				
2002.01	$ 24,5	$ 518,8	$ 28.700	$ 34.700	$ 3.326				
2002.02	$ 24,2	$ 508,7	$ 33.100	$ 36.700	$ 3.505				
2002.03	$ 40,0	$ 490,5	$ 38.500	$ 34.400	$ 3.457		$ 22,8		
2002.04	$ 55,9	$ 446,7	$ 38.900	$ 37.000	$ 3.216		$ 22,7		
2002.05	$ 61,7	$ 395,7	$ 35.000	$ 32.200	$ 3.418		$ 25,0		
2002.06	$ 66,0	$ 456,8	$ 30.900	$ 30.000	$ 3.133		$ 23,1		
2002.07	$ 79,9	$ 421,0	$ 34.200	$ 29.000	$ 2.826		$ 20,4		
2002.08	$ 60,8	$ 319,1	$ 30.500	$ 22.400	$ 2.840		$ 21,3		
2002.09	$ 42,1	$ 378,4	$ 28.650	$ 22.400	$ 2.747		$ 19,0		
2002.10	$ 57,5	$ 381,1	$ 26.200	$ 23.350	$ 2.910		$ 22,0		
2002.11	$ 41,2	$ 357,4	$ 23.600	$ 20.500	$ 3.180		$ 22,5		
2002.12	$ 40,4	$ 365,2	$ 22.350	$ 17.900	$ 3.094		$ 24,1		
2003.01	$ 34,4	$ 323,8	$ 23.200	$ 18.500	$ 2.649		$ 23,0		
2003.02	$ 23,5	$ 253,3	$ 22.850	$ 16.850	$ 3.078		$ 24,2		
2003.03	$ 22,6	$ 348,4	$ 23.200	$ 19.500	$ 2.956		$ 22,5		
2003.04	$ 39,1	$ 478,7	$ 24.850	$ 25.000	$ 2.984		$ 23,3		
2003.05	$ 38,4	$ 528,8	$ 28.050	$ 34.900	$ 2.961		$ 25,0		
2003.06	$ 36,0	$ 571,7	$ 27.350	$ 32.000	$ 2.975		$ 24,7		
2003.07	$ 51,5	$ 539,7	$ 27.050	$ 34.300	$ 3.462		$ 29,0		
2003.08	$ 59,3	$ 501,4	$ 29.350	$ 26.700	$ 3.875		$ 31,2		
2003.09	$ 62,9	$ 506,9	$ 27.400	$ 30.850	$ 3.726		$ 34,0		
2003.10	$ 59,6	$ 515,1	$ 23.900	$ 36.300	$ 4.316		$ 38,1		
2003.11	$ 55,5	$ 451,9	$ 23.400	$ 36.750	$ 4.066		$ 36,5		
2003.12	$ 66,9	$ 606,3	$ 24.800	$ 31.400	$ 4.551		$ 48,8		
2004.01	$ 106,2	$ 534,7	$ 25.700	$ 33.900	$ 4.211		$ 44,7		16,10
2004.02	$ 133,9	$ 524,2	$ 29.400	$ 30.500	$ 4.607		$ 48,3		16,00
2004.03	$ 126,9	$ 559,3	$ 28.950	$ 30.000	$ 4.626		$ 45,8		17,69
2004.04	$ 138,0	$ 488,7	$ 29.200	$ 25.350	$ 4.202		$ 37,9		15,70
2004.05	$ 127,7	$ 515,1	$ 29.900	$ 27.300	$ 4.281		$ 42,3		17,71
2004.06	$ 132,3	$ 547,0	$ 29.100	$ 25.450	$ 4.463		$ 39,6		15,36
2004.07	$ 139,1	$ 532,4	$ 26.800	$ 28.400	$ 4.673		$ 44,9		15,50
2004.08	$ 134,4	$ 533,4	$ 26.200	$ 29.900	$ 4.878	$ 54,5	$ 48,1		16,68
2004.09	$ 131,0	$ 492,8	$ 25.200	$ 32.200	$ 5.423	$ 62,8	$ 56,2		14,08
2004.10	$ 127,4	$ 512,4	$ 24.150	$ 33.800	$ 5.162	$ 61,5	$ 52,9		14,97

Month	Tenneco	Faurecia	Futaba	Sejong	BHP Billiton	Norilsk	Vale	Glencore	VIX
2004.11	$ 155,0	$ 527,0	$ 26.600	$ 31.800	$ 5.708	$ 57,8	$ 62,1		13,58
2004.12	$ 172,4	$ 578,9	$ 26.500	$ 39.500	$ 5.694	$ 55,4	$ 72,5		12,46
2005.01	$ 161,4	$ 604,5	$ 27.550	$ 45.200	$ 6.128	$ 56,5	$ 75,6		13,44
2005.02	$ 151,9	$ 556,2	$ 30.000	$ 47.500	$ 7.242	$ 63,2	$ 87,5		11,71
2005.03	$ 124,6	$ 547,0	$ 29.750	$ 40.200	$ 6.631	$ 57,5	$ 79,0		13,13
2005.04	$ 128,3	$ 555,7	$ 29.500	$ 45.700	$ 5.960	$ 56,2	$ 67,4		14,46
2005.05	$ 150,0	$ 529,7	$ 30.000	$ 45.900	$ 6.193	$ 59,5	$ 72,6		13,97
2005.06	$ 166,4	$ 537,9	$ 28.150	$ 46.100	$ 6.640	$ 61,3	$ 73,2		11,87
2005.07	$ 188,6	$ 544,3	$ 28.150	$ 47.600	$ 7.522	$ 68,5	$ 81,4		11,05
2005.08	$ 181,3	$ 573,5	$ 28.400	$ 65.100	$ 7.685	$ 72,0	$ 86,0		12,95
2005.09	$ 175,1	$ 532,4	$ 27.250	$ 57.400	$ 8.543	$ 83,3	$ 109,7		12,63
2005.10	$ 165,2	$ 506,9	$ 27.200	$ 75.500	$ 7.746	$ 73,6	$ 103,3		14,94
2005.11	$ 173,7	$ 469,1	$ 26.950	$ 64.600	$ 8.081	$ 86,5	$ 108,4		12,15
2005.12	$ 196,1	$ 480,9	$ 27.600	$ 48.000	$ 8.855	$ 94,0	$ 102,9		11,26
2006.01	$ 219,5	$ 478,7	$ 31.100	$ 45.700	$ 9.686	$ 90,3	$ 128,2		12,04
2006.02	$ 226,5	$ 492,3	$ 30.400	$ 47.200	$ 8.953	$ 90,0	$ 116,1		12,47
2006.03	$ 216,9	$ 476,4	$ 30.800	$ 46.500	$ 9.807	$ 97,5	$ 121,3		11,69
2006.04	$ 240,5	$ 458,6	$ 29.750	$ 45.100	$ 10.530	$ 132,5	$ 128,8		11,85
2006.05	$ 238,4	$ 449,1	$ 29.350	$ 44.250	$ 9.793	$ 121,3	$ 116,5		14,45
2006.06	$ 260,0	$ 382,2	$ 28.500	$ 41.400	$ 9.783	$ 130,0	$ 120,2		16,92
2006.07	$ 232,3	$ 442,1	$ 31.000	$ 43.700	$ 9.457	$ 138,0	$ 116,0		15,33
2006.08	$ 227,5	$ 445,2	$ 31.400	$ 46.950	$ 9.336	$ 136,8	$ 107,2		13,35
2006.09	$ 233,9	$ 422,1	$ 30.700	$ 44.000	$ 8.599	$ 127,0	$ 107,8		12,18
2006.10	$ 227,0	$ 469,5	$ 27.000	$ 44.700	$ 9.429	$ 149,0	$ 127,2		11,31
2006.11	$ 235,8	$ 447,5	$ 27.850	$ 54.500	$ 9.000	$ 157,5	$ 138,8		10,82
2006.12	$ 247,2	$ 490,1	$ 28.800	$ 44.200	$ 8.716	$ 160,0	$ 148,7		10,96
2007.01	$ 232,5	$ 467,3	$ 27.700	$ 42.300	$ 8.842	$ 169,0	$ 169,7		11,04
2007.02	$ 243,0	$ 476,8	$ 28.100	$ 58.500	$ 9.527	$ 177,8	$ 170,5		11,16
2007.03	$ 254,6	$ 517,8	$ 29.150	$ 58.600	$ 10.567	$ 191,3	$ 185,0		15,16
2007.04	$ 299,5	$ 522,6	$ 24.700	$ 60.500	$ 10.530	$ 193,3	$ 203,1		12,93
2007.05	$ 326,1	$ 531,1	$ 26.350	$ 62.800	$ 11.472	$ 192,5	$ 227,3		13,30
2007.06	$ 350,4	$ 557,7	$ 25.050	$ 79.000	$ 12.964	$ 222,6	$ 222,8		14,95
2007.07	$ 353,0	$ 516,5	$ 25.700	$ 66.400	$ 13.738	$ 236,0	$ 245,0		17,27
2007.08	$ 317,5	$ 499,2	$ 25.300	$ 66.900	$ 13.607	$ 222,0	$ 246,7		25,03
2007.09	$ 310,1	$ 542,5	$ 25.550	$ 53.700	$ 16.321	$ 271,0	$ 339,3		22,20
2007.10	$ 306,1	$ 469,6	$ 23.100	$ 49.500	$ 17.077	$ 315,0	$ 376,8		19,12
2007.11	$ 295,9	$ 424,9	$ 21.600	$ 50.500	$ 14.988	$ 286,0	$ 345,8		25,58
2007.12	$ 260,7	$ 319,1	$ 18.520	$ 49.500	$ 14.419	$ 271,4	$ 326,7		21,65
2008.01	$ 264,7	$ 309,2	$ 18.600	$ 57.000	$ 13.775	$ 244,0	$ 300,1		25,82
2008.02	$ 252,5	$ 301,8	$ 17.140	$ 50.000	$ 15.202	$ 290,0	$ 348,4		25,46
2008.03	$ 279,4	$ 296,3	$ 17.860	$ 51.300	$ 13.943	$ 277,5	$ 346,4		27,10
2008.04	$ 255,8	$ 291,8	$ 18.520	$ 54.500	$ 16.788	$ 272,0	$ 390,8		21,56
2008.05	$ 239,8	$ 244,7	$ 18.220	$ 50.200	$ 17.851	$ 298,5	$ 397,8		18,30
2008.06	$ 135,3	$ 236,1	$ 18.860	$ 45.850	$ 17.907	$ 251,5	$ 358,2		22,11
2008.07	$ 144,2	$ 236,6	$ 18.430	$ 52.000	$ 15.790	$ 216,5	$ 300,3		24,32
2008.08	$ 146,1	$ 184,9	$ 18.480	$ 51.600	$ 16.023	$ 193,7	$ 265,5		20,70
2008.09	$ 106,3	$ 97,8	$ 14.670	$ 39.900	$ 11.742	$ 137,9	$ 191,5		30,24
2008.10	$ 49,1	$ 106,9	$ 12.510	$ 30.600	$ 9.821	$ 104,5	$ 131,2		61,18
2008.11	$ 32,8	$ 90,1	$ 11.360	$ 30.200	$ 11.089	$ 72,0	$ 119,4		62,64
2008.12	$ 29,5	$ 92,4	$ 12.400	$ 34.800	$ 12.068	$ 63,0	$ 121,1		52,41
2009.01	$ 18,4	$ 81,8	$ 13.670	$ 32.100	$ 11.015	$ 42,0	$ 141,1		44,68
2009.02	$ 13,6	$ 73,0	$ 15.420	$ 38.000	$ 10.315	$ 46,2	$ 128,9		45,57
2009.03	$ 16,3	$ 84,0	$ 17.460	$ 48.300	$ 12.917	$ 61,0	$ 133,0		44,80
2009.04	$ 30,6	$ 68,2	$ 18.830	$ 55.100	$ 13.281	$ 82,5	$ 165,1		38,06
2009.05	$ 61,2	$ 64,3	$ 17.710	$ 46.550	$ 13.766	$ 113,7	$ 191,5		31,98
2009.06	$ 106,0	$ 86,3	$ 16.640	$ 48.550	$ 12.721	$ 91,0	$ 176,3		29,14
2009.07	$ 161,7	$ 96,1	$ 16.020	$ 60.000	$ 14.577	$ 100,3	$ 197,3		26,16
2009.08	$ 157,0	$ 148,3	$ 14.650	$ 60.400	$ 15.183	$ 105,4	$ 192,1		25,34

Month	Tenneco	Faurecia	Futaba	Sejong	BHP Billiton	Norilsk	Vale	Glencore	VIX
2009.09	$ 130,4	$ 132,1	$ 14.200	$ 59.900	$ 15.930	$ 125,0	$ 231,3		24,93
2009.10	$ 136,2	$ 140,0	$ 14.190	$ 61.200	$ 15.328	$ 128,2	$ 254,9		24,25
2009.11	$ 144,2	$ 154,0	$ 16.390	$ 65.400	$ 17.324	$ 136,8	$ 286,7		23,78
2009.12	$ 177,3	$ 153,1	$ 15.610	$ 65.000	$ 18.606	$ 143,5	$ 290,3		21,24
2010.01	$ 176,8	$ 127,9	$ 15.540	$ 83.800	$ 17.403	$ 153,0	$ 257,9		20,64
2010.02	$ 201,6	$ 148,8	$ 18.460	$ 89.000	$ 18.718	$ 152,5	$ 278,6		22,54
2010.03	$ 236,5	$ 152,7	$ 19.150	$ 87.100	$ 21.078	$ 184,4	$ 321,9		17,77
2010.04	$ 257,7	$ 126,5	$ 15.760	$ 116.500	$ 18.891	$ 192,0	$ 306,2		17,42
2010.05	$ 221,6	$ 132,2	$ 14.920	$ 122.000	$ 17.842	$ 158,5	$ 271,9		31,93
2010.06	$ 210,6	$ 150,7	$ 15.620	$ 122.500	$ 16.363	$ 144,5	$ 243,5		29,92
2010.07	$ 276,0	$ 137,0	$ 12.980	$ 119.000	$ 18.201	$ 162,8	$ 278,0		25,57
2010.08	$ 247,2	$ 172,0	$ 13.870	$ 142.500	$ 17.082	$ 168,8	$ 267,5		24,75
2010.09	$ 289,7	$ 193,6	$ 14.140	$ 137.500	$ 18.886	$ 169,5	$ 312,7		22,52
2010.10	$ 326,2	$ 182,6	$ 14.470	$ 126.500	$ 20.644	$ 186,5	$ 321,4		20,37
2010.11	$ 364,6	$ 216,3	$ 15.810	$ 122.000	$ 21.311	$ 197,7	$ 316,8		20,10
2010.12	$ 411,6	$ 253,3	$ 16.180	$ 129.000	$ 23.792	$ 240,4	$ 345,7		17,57
2011.01	$ 413,3	$ 281,7	$ 16.210	$ 118.500	$ 22.197	$ 258,0	$ 348,3		17,32
2011.02	$ 398,8	$ 258,0	$ 15.990	$ 139.500	$ 22.696	$ 242,5	$ 342,3		17,43
2011.03	$ 424,5	$ 278,5	$ 15.070	$ 203.500	$ 22.943	$ 262,8	$ 333,5		20,72
2011.04	$ 462,1	$ 295,5	$ 14.280	$ 195.500	$ 23.545	$ 278,5	$ 334,0	$ 5.311	16,24
2011.05	$ 417,5	$ 295,4	$ 14.780	$ 205.000	$ 22.412	$ 252,1	$ 322,6	$ 4.910	16,91
2011.06	$ 440,7	$ 270,3	$ 14.070	$ 199.500	$ 22.869	$ 260,7	$ 319,5	$ 4.757	19,15
2011.07	$ 399,4	$ 205,0	$ 14.690	$ 145.500	$ 21.199	$ 270,4	$ 324,4	$ 4.215	19,23
2011.08	$ 328,1	$ 162,2	$ 15.990	$ 135.000	$ 19.642	$ 248,5	$ 282,4	$ 4.029	35,03
2011.09	$ 256,1	$ 193,1	$ 14.970	$ 159.000	$ 16.209	$ 215,0	$ 228,0	$ 4.380	36,53
2011.10	$ 327,2	$ 155,4	$ 13.190	$ 140.000	$ 18.350	$ 192,5	$ 254,1	$ 3.985	32,83
2011.11	$ 289,6	$ 146,5	$ 12.280	$ 115.500	$ 18.177	$ 176,3	$ 232,5	$ 3.920	31,94
2011.12	$ 297,8	$ 190,8	$ 12.600	$ 117.000	$ 17.511	$ 153,3	$ 214,5	$ 4.112	25,05
2012.01	$ 321,0	$ 210,0	$ 13.620	$ 122.000	$ 19.800	$ 191,7	$ 253,0	$ 4.320	20,23
2012.02	$ 385,0	$ 202,2	$ 11.820	$ 121.000	$ 19.003	$ 196,2	$ 251,4	$ 3.894	18,42
2012.03	$ 371,5	$ 162,4	$ 12.500	$ 129.500	$ 17.790	$ 183,5	$ 233,3	$ 4.256	16,17
2012.04	$ 308,3	$ 132,4	$ 11.110	$ 129.500	$ 18.415	$ 177,1	$ 222,0	$ 3.405	17,82
2012.05	$ 271,5	$ 130,5	$ 12.380	$ 133.500	$ 15.804	$ 149,2	$ 183,1	$ 2.955	21,00
2012.06	$ 268,2	$ 129,6	$ 11.710	$ 122.500	$ 16.844	$ 166,2	$ 198,5	$ 3.201	21,13
2012.07	$ 292,9	$ 146,5	$ 10.060	$ 126.500	$ 17.431	$ 154,0	$ 180,5	$ 3.850	17,57
2012.08	$ 303,7	$ 128,9	$ 10.100	$ 149.000	$ 17.123	$ 148,6	$ 163,7	$ 3.431	15,69
2012.09	$ 280,0	$ 115,8	$ 9.420	$ 124.500	$ 17.953	$ 158,1	$ 179,0	$ 3.430	15,28
2012.10	$ 305,5	$ 120,8	$ 8.880	$ 114.000	$ 18.518	$ 151,7	$ 183,2	$ 3.455	16,28
2012.11	$ 320,7	$ 117,2	$ 9.730	$ 118.500	$ 18.299	$ 158,2	$ 174,3	$ 3.513	16,70
2012.12	$ 351,1	$ 129,9	$ 9.710	$ 111.500	$ 19.861	$ 189,4	$ 209,6	$ 3.935	17,31
2013.01	$ 349,6	$ 137,0	$ 10.260	$ 115.500	$ 20.117	$ 198,7	$ 201,7	$ 3.875	13,51
2013.02	$ 354,3	$ 124,0	$ 9.950	$ 135.500	$ 19.483	$ 175,7	$ 189,9	$ 3.561	14,07
2013.03	$ 393,1	$ 141,0	$ 13.570	$ 125.000	$ 17.860	$ 169,1	$ 172,9	$ 3.170	13,03
2013.04	$ 386,7	$ 174,0	$ 12.750	$ 145.500	$ 16.704	$ 152,7	$ 170,9	$ 3.231	13,97
2013.05	$ 443,6	$ 170,0	$ 11.830	$ 152.000	$ 17.865	$ 145,2	$ 144,0	$ 2.721	13,49
2013.06	$ 452,8	$ 198,4	$ 11.500	$ 165.000	$ 15.687	$ 143,7	$ 131,5	$ 2.775	17,27
2013.07	$ 483,3	$ 192,5	$ 11.370	$ 166.000	$ 17.524	$ 134,9	$ 137,2	$ 3.052	13,97
2013.08	$ 461,3	$ 214,0	$ 12.570	$ 171.000	$ 17.515	$ 129,9	$ 144,1	$ 3.367	14,21
2013.09	$ 505,0	$ 215,4	$ 13.580	$ 166.500	$ 16.974	$ 143,5	$ 156,1	$ 3.400	14,69
2013.10	$ 530,7	$ 248,0	$ 12.800	$ 179.500	$ 18.005	$ 151,7	$ 160,2	$ 3.099	15,41
2013.11	$ 574,0	$ 277,1	$ 13.730	$ 152.000	$ 17.338	$ 150,8	$ 153,2	$ 3.127	12,92
2013.12	$ 565,7	$ 292,6	$ 12.810	$ 164.500	$ 17.431	$ 167,1	$ 152,5	$ 3.225	14,19
2014.01	$ 568,4	$ 322,8	$ 16.160	$ 158.500	$ 16.746	$ 154,0	$ 136,0	$ 3.292	14,24
2014.02	$ 602,4	$ 306,8	$ 17.800	$ 170.500	$ 17.986	$ 167,2	$ 141,7	$ 3.088	15,47
2014.03	$ 580,7	$ 324,0	$ 16.040	$ 173.500	$ 17.198	$ 167,5	$ 138,3	$ 3.185	14,84
2014.04	$ 598,7	$ 301,7	$ 15.050	$ 166.500	$ 17.898	$ 180,3	$ 132,2	$ 3.234	14,20
2014.05	$ 637,5	$ 275,6	$ 17.350	$ 170.000	$ 17.422	$ 192,9	$ 127,5	$ 3.255	12,48
2014.06	$ 657,0	$ 264,7	$ 16.980	$ 179.000	$ 17.622	$ 199,1	$ 132,3	$ 3.600	11,54

Month	Tenneco	Faurecia	Futaba	Sejong	BHP Billiton	Norilsk	Vale	Glencore	VIX
2014.07	$ 637,0	$ 256,1	$ 16.020	$ 191.000	$ 18.923	$ 194,3	$ 143,5	$ 3.624	12,30
2014.08	$ 640,8	$ 253,2	$ 16.480	$ 180.000	$ 17.790	$ 195,7	$ 130,6	$ 3.432	13,49
2014.09	$ 523,1	$ 257,9	$ 15.600	$ 150.000	$ 15.995	$ 185,8	$ 110,1	$ 3.199	13,47
2014.10	$ 523,6	$ 295,1	$ 16.080	$ 151.500	$ 15.020	$ 186,9	$ 100,9	$ 3.204	18,06
2014.11	$ 543,5	$ 309,2	$ 17.590	$ 128.000	$ 14.148	$ 175,7	$ 90,1	$ 2.988	13,41
2014.12	$ 566,1	$ 358,2	$ 19.090	$ 135.500	$ 12.950	$ 138,2	$ 81,8	$ 2.489	16,29
2015.01	$ 514,2	$ 407,2	$ 19.230	$ 127.000	$ 13.458	$ 169,5	$ 70,3	$ 3.003	19,12
2015.02	$ 582,4	$ 407,0	$ 19.350	$ 117.000	$ 15.076	$ 183,0	$ 74,2	$ 2.859	15,90
2015.03	$ 574,2	$ 423,8	$ 20.030	$ 134.500	$ 13.743	$ 177,5	$ 56,5	$ 3.103	14,81
2015.04	$ 584,5	$ 409,7	$ 24.290	$ 117.000	$ 14.559	$ 185,1	$ 76,8	$ 2.880	13,49
2015.05	$ 587,2	$ 368,9	$ 22.180	$ 104.000	$ 13.795	$ 175,7	$ 63,0	$ 2.553	13,34
2015.06	$ 574,4	$ 349,7	$ 21.960	$ 102.500	$ 12.490	$ 169,5	$ 58,9	$ 2.080	14,34
2015.07	$ 498,1	$ 321,7	$ 16.600	$ 93.600	$ 11.825	$ 153,3	$ 52,6	$ 1.454	14,35
2015.08	$ 458,5	$ 277,7	$ 15.410	$ 118.000	$ 11.025	$ 163,9	$ 50,0	$ 916	19,43
2015.09	$ 447,7	$ 360,3	$ 15.750	$ 110.500	$ 10.050	$ 143,7	$ 49,8	$ 1.125	24,38
2015.10	$ 565,9	$ 355,3	$ 17.120	$ 99.900	$ 10.405	$ 149,0	$ 43,6	$ 967	16,79
2015.11	$ 538,8	$ 370,1	$ 16.360	$ 100.500	$ 7.969	$ 134,5	$ 33,7	$ 905	16,21
2015.12	$ 459,1	$ 334,0	$ 15.100	$ 95.000	$ 7.600	$ 127,0	$ 32,9	$ 895	18,03
2016.01	$ 382,1	$ 313,6	$ 14.660	$ 93.100	$ 6.764	$ 115,3	$ 24,5	$ 1.333	23,72
2016.02	$ 455,2	$ 332,9	$ 15.940	$ 98.000	$ 7.280	$ 120,6	$ 29,4	$ 1.573	22,52
2016.03	$ 515,1	$ 360,7	$ 16.830	$ 99.000	$ 7.828	$ 129,6	$ 42,1	$ 1.629	15,85
2016.04	$ 533,0	$ 357,5	$ 20.190	$ 92.900	$ 9.331	$ 147,7	$ 56,7	$ 1.311	14,30
2016.05	$ 537,2	$ 287,4	$ 19.400	$ 97.500	$ 8.230	$ 137,9	$ 39,3	$ 1.529	14,85
2016.06	$ 466,1	$ 352,9	$ 19.180	$ 110.000	$ 9.428	$ 133,7	$ 50,6	$ 1.868	17,77
2016.07	$ 565,2	$ 357,9	$ 15.510	$ 118.500	$ 9.447	$ 147,2	$ 57,5	$ 1.741	13,16
2016.08	$ 558,3	$ 349,0	$ 16.400	$ 116.500	$ 9.899	$ 150,2	$ 52,7	$ 2.121	12,40
2016.09	$ 582,7	$ 335,1	$ 17.160	$ 103.000	$ 11.625	$ 160,5	$ 55,0	$ 2.500	14,22
2016.10	$ 550,7	$ 338,2	$ 17.820	$ 95.600	$ 12.345	$ 151,4	$ 69,2	$ 2.793	14,59
2016.11	$ 589,5	$ 368,3	$ 19.620	$ 94.700	$ 13.135	$ 167,2	$ 84,9	$ 2.774	15,24
2016.12	$ 624,7	$ 401,7	$ 19.700	$ 99.800	$ 13.065	$ 169,2	$ 76,2	$ 3.265	12,47
2017.01	$ 674,5	$ 414,9	$ 20.310	$ 101.500	$ 14.375	$ 161,8	$ 101,8	$ 3.220	11,61
2017.02	$ 643,1	$ 445,8	$ 19.620	$ 98.000	$ 12.975	$ 159,8	$ 103,5	$ 3.131	11,53
2017.03	$ 624,2	$ 448,2	$ 20.010	$ 93.800	$ 12.340	$ 156,9	$ 95,0	$ 3.036	11,90
2017.04	$ 630,3	$ 467,3	$ 19.140	$ 95.100	$ 11.750	$ 153,9	$ 85,8	$ 2.851	13,14
2017.05	$ 568,5	$ 444,7	$ 19.700	$ 91.100	$ 11.730	$ 139,2	$ 83,7	$ 2.872	10,86
2017.06	$ 578,3	$ 469,3	$ 20.230	$ 85.500	$ 11.760	$ 137,3	$ 87,5	$ 3.341	10,51
2017.07	$ 553,0	$ 488,6	$ 20.340	$ 78.800	$ 13.780	$ 150,2	$ 100,3	$ 3.595	10,26
2017.08	$ 542,0	$ 587,3	$ 21.240	$ 72.600	$ 14.765	$ 167,9	$ 110,7	$ 3.420	11,98
2017.09	$ 606,7	$ 624,1	$ 22.390	$ 77.800	$ 13.145	$ 172,0	$ 100,7	$ 3.630	10,44
2017.10	$ 581,1	$ 642,8	$ 23.370	$ 81.100	$ 13.625	$ 184,6	$ 97,9	$ 3.396	10,13
2017.11	$ 594,1	$ 651,3	$ 23.520	$ 75.800	$ 13.450	$ 173,4	$ 107,0	$ 3.900	10,54
2017.12	$ 585,4	$ 723,8	$ 24.160	$ 74.500	$ 15.225	$ 189,1	$ 122,3	$ 4.037	10,26
2018.01	$ 580,1	$ 692,8	$ 23.050	$ 81.300	$ 15.640	$ 206,1	$ 130,9	$ 3.864	11,06
2018.02	$ 525,5	$ 657,2	$ 21.810	$ 81.500	$ 14.842	$ 197,5	$ 137,3	$ 3.538	22,46
2018.03	$ 548,7	$ 678,0	$ 22.720	$ 78.900	$ 14.036	$ 187,0	$ 127,2	$ 3.507	19,02
2018.04	$ 446,9	$ 737,4	$ 20.860	$ 79.100	$ 15.440	$ 170,4	$ 138,4	$ 3.775	18,27
2018.05	$ 467,0	$ 718,8	$ 19.600	$ 74.900	$ 16.952	$ 177,9	$ 140,3	$ 3.750	14,12
2018.06	$ 446,2	$ 604,8	$ 19.680	$ 69.400	$ -	$ 181,0	$ 137,9	$ 3.554	13,68
2018.07	$ 431,5	$ 584,6	$ 20.430	$ 71.400	$ -	$ 181,8	$ 125,3	$ 3.279	13,15
2018.08	$ 459,7	$ 525,6	$ 20.660	$ 79.200	$ -	$ 171,3	$ 143,1	$ 3.146	12,55
2018.09	$ 425,9	$ 517,8	$ 20.480	$ 76.600	$ -	$ 163,9	$ 128,2	$ 3.312	12,91
2018.10	$ 429,4	$ 426,9	$ 17.590	$ 52.400	$ -	$ 173,2	$ 148,1	$ 3.189	19,35
2018.11	$ 347,1	$ 368,9	$ 17.850	$ 49.000	$ -	$ 168,6	$ 152,6	$ 3.150	19,39
2018.12	$ 346,9	$ 330,7	$ 15.820	$ 77.900	$ -	$ 192,1	$ 142,2	$ 2.914	24,95
2019,01	$ 267,9	$ 385,7	$ 17.160	$ 81.000	$ -	$ 185,5	$ 129,4	$ 3.051	19,57
2019,02	$ 346,8	$ 423,6	$ 17.880	$ 62.300	$ -	$ 207,2	$ 124,7	$ 3.050	15,23
2019,03	$ 349,4	$ 374,0	$ 16.960	$ -	$ -	$ 214,6	$ 120,4	$ 3.170	14,49

Appendix No. 04c

Scrape Ferro-Chrome Prices (2006-2019)

Month	Stainless 304 scrap Europe	Stainless 304 scrap USA	Ferro-Chrome
2006.01			$ 1.200
2006.02			$ 1.200
2006.03			$ 1.270
2006.04			$ 1.330
2006.05			$ 1.330
2006.06			$ 1.340
2006.07			$ 1.460
2006.08			$ 1.460
2006.09			$ 1.430
2006.10			$ 1.430
2006.11			$ 1.470
2006.12			$ 1.470
2007.01			$ 1.720
2007.02			$ 1.530
2007.03			$ 1.790
2007.04			$ 2.090
2007.05			$ 2.270
2007.06			$ 2.870
2007.07			$ 3.030
2007.08			$ 3.030
2007.09			$ 3.200
2007.10			$ 3.420
2007.11			$ 3.970
2007.12			$ 2.670
2008.01	€ 1,85	$ 2,44	$ 4.630
2008.02	€ 1,80	$ 2,51	$ 5.290
2008.03	€ 1,95	$ 2,89	$ 6.170
2008.04	€ 1,80	$ 3,02	$ 6.280
2008.05	€ 1,50	$ 2,86	$ 4.460
2008.06	€ 1,42	$ 2,18	$ 5.570
2008.07	€ 1,40	$ 2,10	$ 5.290
2008.08	€ 1,30	$ 1,85	$ 5.290
2008.09	€ 1,20	$ 2,03	$ 5.130
2008.10	€ 1,05	$ 2,03	$ 4.410
2008.11	€ 0,50	$ 2,03	$ 3.140
2008.12	€ 0,45	$ 2,03	$ 2.430
2009.01	€ 0,45	$ 2,03	$ 2.200
2009.02	€ 0,55	$ 2,03	$ 1.760
2009.03	€ 0,68	$ 2,03	$ 1.430
2009.04	€ 0,72	$ 2,03	$ 1.430
2009.05	€ 0,75	$ 2,03	$ 1.630
2009.06	€ 0,80	$ 2,03	$ 1.760
2009.07	€ 0,80	$ 1,66	$ 1.950
2009.08	€ 1,07	$ 1,89	$ 2.090
2009.09	€ 1,00	$ 1,82	$ 2.090
2009.10	€ 1,00	$ 1,73	$ 1.980
2009.11	€ 0,90	$ 1,61	$ 1.980
2009.12	€ 0,88	$ 1,55	$ 2.090
2010.01	€ 1,00	$ 1,80	$ 2.090
2010.02	€ 1,25	$ 1,89	$ 2.380
2010.03	€ 1,30	$ 2,20	$ 2.700
2010.04	€ 1,60	$ 2,49	$ 3.140
2010.05	€ 1,40	$ 2,24	$ 2.930

Month	Stainless 304 scrap Europe		Stainless 304 scrap USA		Ferro-Chrome	
2010.06	€	1,25	$	1,70	$	2.860
2010.07	€	1,00	$	1,75	$	2.750
2010.08	€	1,75	$	2,00	$	2.640
2010.09	€	1,70	$	2,14	$	2.860
2010.10	€	1,40	$	2,23	$	2.860
2010.11	€	1,40	$	2,13	$	2.750
2010.12	€	1,40	$	2,05	$	2.750
2011.01	€	1,65	$	2,30	$	2.750
2011.02	€	1,75	$	2,61	$	2.760
2011.03	€	1,60	$	2,56	$	3.310
2011.04	€	1,65	$	2,37	$	2.980
2011.05	€	1,50	$	2,04	$	2.730
2011.06	€	1,30	$	1,94	$	2.590
2011.07	€	1,45	$	2,00	$	2.620
2011.08	€	1,20	$	1,97	$	2.620
2011.09	€	1,20	$	1,84	$	2.580
2011.10	€	1,30	$	1,60	$	2.480
2011.11	€	1,25	$	1,60	$	2.480
2011.12	€	1,30	$	1,60	$	2.380
2012.01	€	1,50	$	1,77	$	2.540
2012.02	€	1,50	$	1,95	$	2.600
2012.03	€	1,50	$	1,91	$	2.600
2012.04	€	1,40	$	1,75	$	2.620
2012.05	€	1,40	$	1,75	$	2.580
2012.06	€	1,30	$	1,66	$	2.470
2012.07	€	1,30	$	1,57	$	2.250
2012.08	€	1,22	$	1,55	$	2.180
2012.09	€	1,33	$	1,67	$	2.120
2012.10	€	1,25	$	1,57	$	2.090
2012.11	€	1,20	$	1,46	$	2.160
2012.12	€	1,20	$	1,67	$	2.120
2013.01	€	1,22	$	1,72	$	2.290
2013.02	€	1,27	$	1,65	$	2.240
2013.03	€	1,22	$	1,50	$	2.290
2013.04	€	1,18	$	1,42	$	2.310
2013.05	€	1,08	$	1,39	$	2.170
2013.06	€	1,05	$	1,30	$	2.150
2013.07	€	0,90	$	1,19	$	2.040
2013.08	€	0,95	$	1,30	$	2.050
2013.09	€	0,95	$	1,33	$	2.070
2013.10	€	0,93	$	1,34	$	2.190
2013.11	€	0,97	$	1,38	$	2.190
2013.12	€	0,99	$	1,39	$	2.250
2014.01	€	0,97	$	1,52	$	2.280
2014.02	€	1,00	$	1,53	$	2.300
2014.03	€	0,88	$	1,61	$	2.310
2014.04	€	0,95	$	1,76	$	2.340
2014.05	€	1,15	$	1,91	$	2.340
2014.06	€	1,15	$	1,87	$	2.340
2014.07	€	1,20	$	1,86	$	2.380
2014.08	€	1,20	$	1,73	$	2.370
2014.09	€	1,07	$	1,59	$	2.380
2014.10	€	0,95	$	1,30	$	2.310
2014.11	€	1,00	$	1,35	$	2.280

Month	Stainless 304 scrap Europe		Stainless 304 scrap USA		Ferro-Chrome	
2014.12	€	1,00	$	1,47	$	2.270
2015.01	€	1,05	$	1,32	$	2.220
2015.02	€	1,02	$	1,27	$	2.260
2015.03	€	1,08	$	1,21	$	2.260
2015.04	€	1,08	$	1,18	$	2.180
2015.05	€	1,10	$	1,28	$	2.180
2015.06	€	1,10	$	1,22	$	2.090
2015.07	€	1,05	$	1,13	$	2.090
2015.08	€	1,03	$	1,09	$	2.120
2015.09	€	0,97	$	0,98	$	1.970
2015.10	€	0,90	$	0,94	$	1.970
2015.11	€	0,87	$	0,93	$	1.820
2015.12	€	0,80	$	0,82	$	1.810
2016.01	€	0,80	$	0,85	$	1.790
2016.02	€	0,80	$	0,90	$	1.790
2016.03	€	0,80	$	0,93	$	1.770
2016.04	€	0,80	$	0,95	$	1.810
2016.05	€	0,85	$	1,01	$	1.940
2016.06	€	0,88	$	1,04	$	1.920
2016.07	€	0,90	$	1,12	$	1.880
2016.08	€	0,92	$	1,11	$	1.850
2016.09	€	0,88	$	1,02	$	1.840
2016.10	€	0,89	$	1,02	$	1.850
2016.11	€	0,95	$	1,06	$	1.880
2016.12	€	1,05	$	1,19	$	1.970
2017.01	€	1,08	$	1,25	$	2.080
2017.02	€	1,11	$	1,27	$	2.190
2017.03	€	1,11	$	1,26	$	2.290
2017.04	€	1,10	$	1,22	$	2.390
2017.05	€	1,00	$	1,16	$	2.480
2017.06	€	0,92	$	1,00	$	2.550
2017.07	€	1,00	$	1,03	$	2.425
2017.08	€	1,05	$	1,21	$	2.425
2017.09	€	1,00	$	1,35	$	2.425
2017.10	€	1,02	$	1,30	$	3.064
2017.11	€	1,02	$	1,34	$	3.064
2017.12	€	1,05	$	1,23	$	3.064
2018.01	€	1,11	$	1,34	$	2.601
2018.02	€	1,17	$	1,41	$	2.601
2018.03	€	1,17	$	1,41	$	2.601
2018.04	€	1,22	$	1,45	$	3.131
2018.05	€	1,22	$	1,45	$	3.131
2018.06	€	1,21	$	1,46	$	3.131
2018.07	€	1,15	$	1,41	$	3.042
2018.08	€	1,13	$	1,34	$	3.042
2018.09	€	1,09	$	1,14	$	3.042
2018.10	€	1,04	$	1,10	$	2.888
2018.11	€	0,96	$	1,04	$	2.734
2018.12	€	0,87	$	0,97	$	2.601
2019.01	€	0,90	$	1,00	$	2.469
2019.02	€	1,00	$	1,00	$	2.469
2019.03	€	1,04	$	1,00	$	2.469

Appendix No. 5

ARDL Calculations

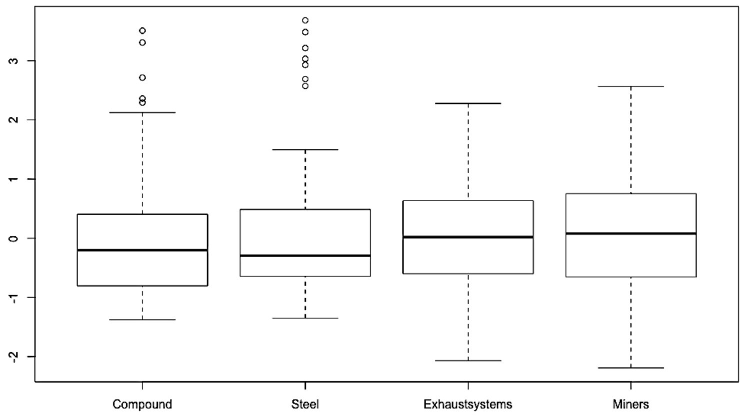
Contents

1 The data set

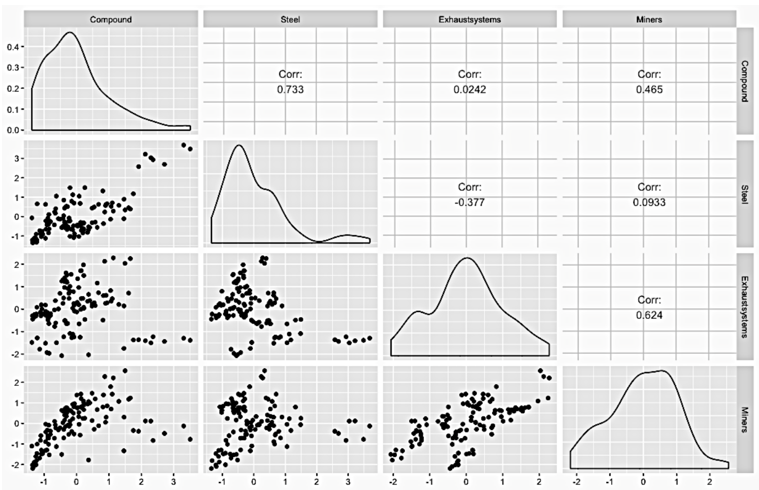
We have four variables:

- Compound (4% Nickel + 1% Aluminium + 76% Iron Ore +1% Copper+ 17% Ferrochrome),
- Miners,
- Steel Manufactures,
- Exhaust system providers

1.1 Box plot (scaled data)

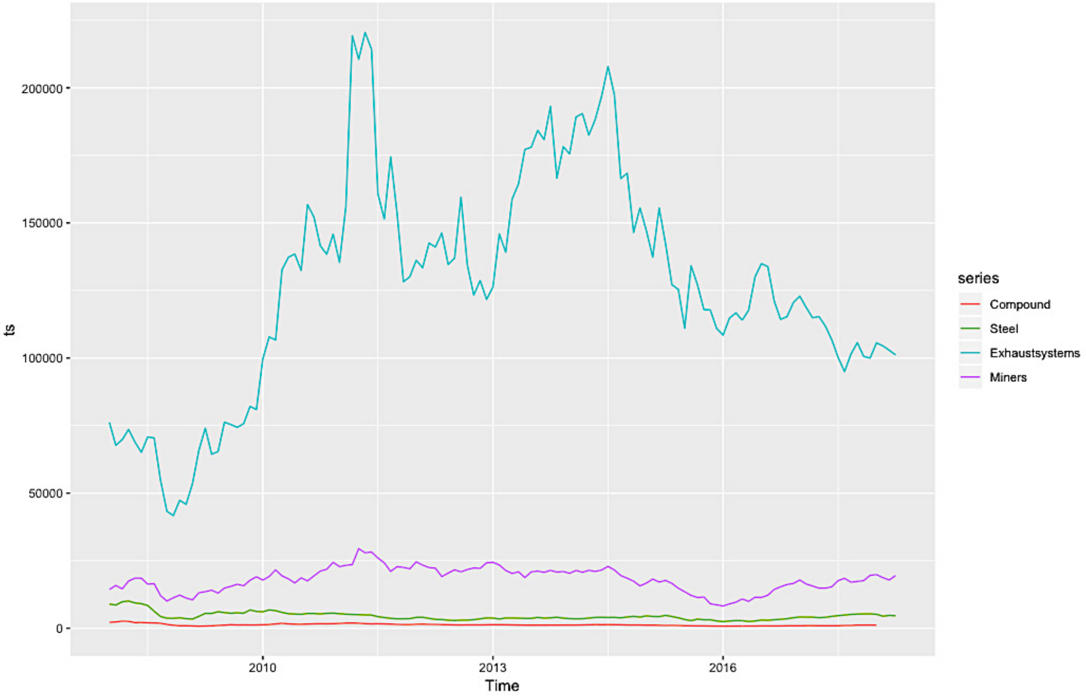


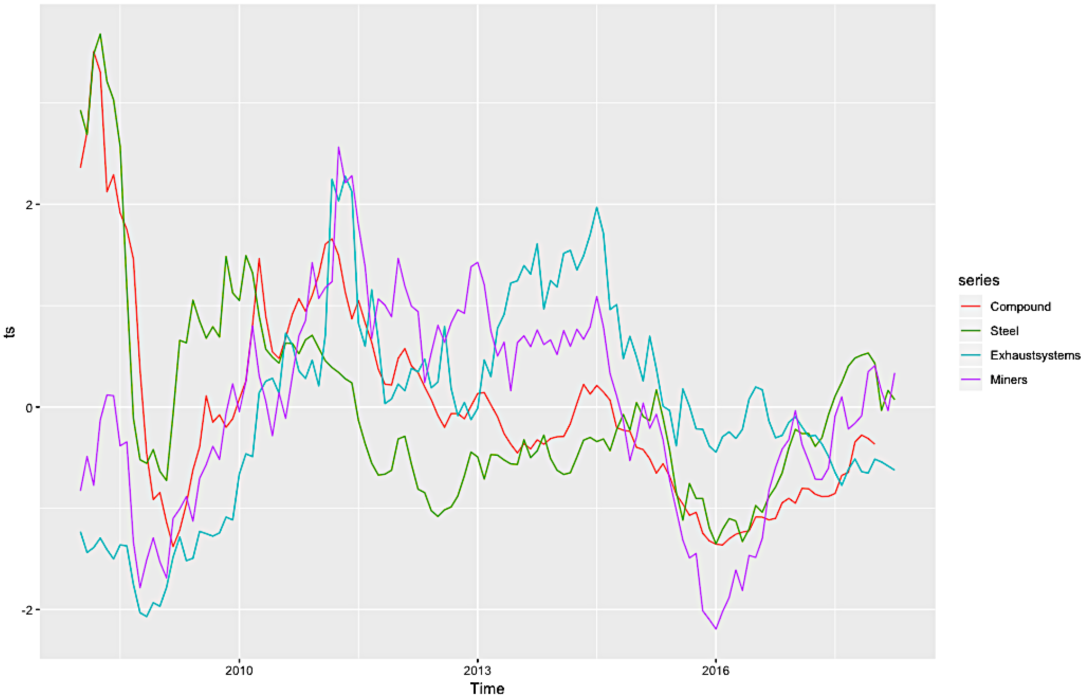
1.2 Matrix scatterplot (scaled data)



We recognise a strong correlation between steel manufacturers and compound.

1.3 Time series (unscaled vs. scaled data)





1.4 Differencing

One basic assumption to work with time series data is stationarity which means time series data must not be explosive, nor trending, nor wandering. → mean, variance and other statistical properties remain constant over time. A test for differencing suggests one degree of differencing. We perform a unit root test to determine the number of differences required for time series to be made stationary.

2 ARDL

We have a dynamic model with lagged values of both the dependent and independent variables of the following form:

$$y_t = f(y_{t-1}, x_t, x_{t-1}, x_{t-2}, \ldots)$$

Notes regarding Dynamic Linear Models (dynlm) package: the main function used to estimate our model is the dynlm function. Within this function:

- d() is used to specify the difference in a variable
- L() is used to compute the desired lag of the variable (lag length q)

For example, by setting L(g, 0:3) we are specifying the coefficients for variable g of the current period and the past three periods. Setting d(u, 1) means we wish to calculate the difference in u from the previous one period.

Autocorrelation in the error term can arise from an autocorrelated omitted variable, or it can arise if a dependent variable y is autocorrelated and this autocorrelation is not adequately explained by the x's and their lags that are included in the equation. The presence of autocorrelation can lead to misleading results as they violate the assumptions of least squares.

2.1 Miners

Miners is a function of miners at t-1 and compound at lag = 0

No autocorrelation left in the errors, as the errors do not exceed the tolerance band

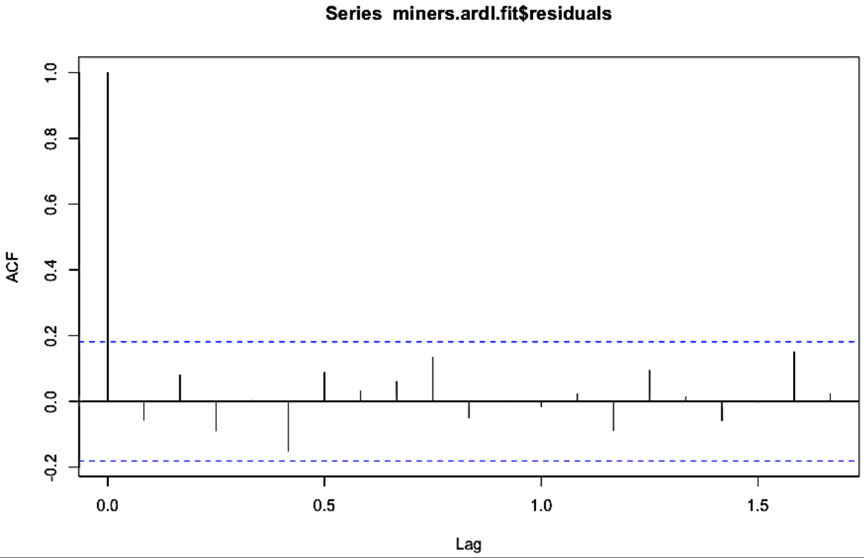
```
Time series regression with "ts" data:
Start = 2008(8), End = 2018(4)

Call:
dynlm(formula = Miners ~ L(Miners, 1) + L(d(Compound, 1), 0:6),
   data = ts)

Residuals:
   Min     1Q  Median     3Q    Max
-3602.2  -983.4    24.7  932.7  5966.4

Coefficients:
                        Estimate Std. Error t value Pr(>|t|)
(Intercept)           1251.54520  602.76487   2.076   0.0402 *
L(Miners, 1)             0.93457    0.03192  29.277   <2e-16 ***
L(d(Compound, 1), 0:6)0  4.15731    1.82825   2.274   0.0249 *
L(d(Compound, 1), 0:6)1 -2.65513    1.99853  -1.329   0.1868
L(d(Compound, 1), 0:6)2  2.85734    1.85826   1.538   0.1271
L(d(Compound, 1), 0:6)3  0.69548    1.62281   0.429   0.6691
L(d(Compound, 1), 0:6)4  1.24236    1.62446   0.765   0.4461
L(d(Compound, 1), 0:6)5 -1.68696    1.57236  -1.073   0.2857
L(d(Compound, 1), 0:6)6  0.41780    1.46642   0.285   0.7763
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1469 on 108 degrees of freedom
Multiple R-squared:  0.9035,  Adjusted R-squared:  0.8964
F-statistic: 126.4 on 8 and 108 DF,  p-value: < 2.2e-16
```



2.2 Steel manufacturers

Steel is a function of steel at t-1 and compound at lag = 0

There is room for a little bit of optimisation due to autocorrelation at lag 1

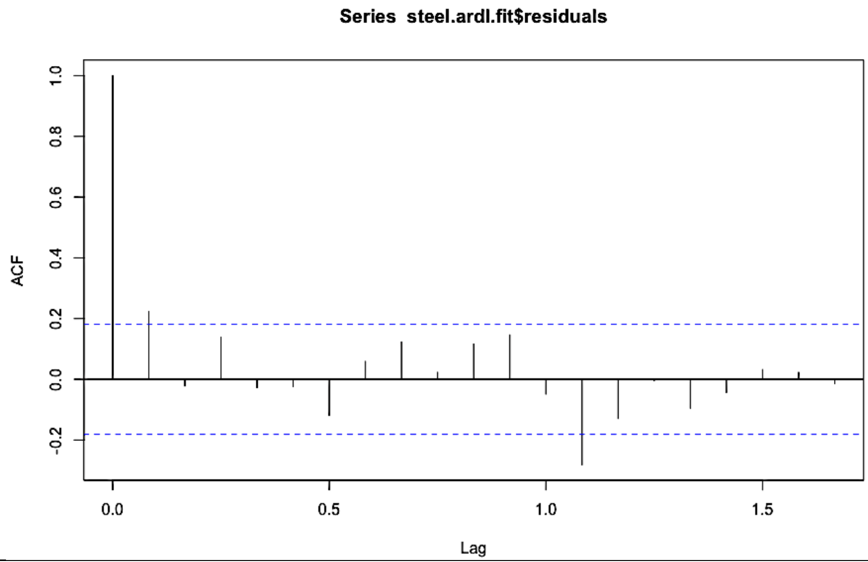
```
Time series regression with "ts" data:
Start = 2008(8), End = 2018(4)

Call:
dynlm(formula = Steel ~ L(Steel, 1) + L(d(Compound, 1), 0:6),
   data = ts)

Residuals:
    Min      1Q  Median      3Q     Max
-1187.94  -207.06  -12.16  185.21  1330.73

Coefficients:
                    Estimate Std. Error t value Pr(>|t|)
(Intercept)          563.38245  155.85084  3.615 0.000458 ***
L(Steel, 1)            0.86284    0.03517  24.533  < 2e-16 ***
L(d(Compound, 1), 0:6)0  0.96336    0.46838   2.057 0.042117 *
L(d(Compound, 1), 0:6)1  0.47422    0.50816   0.933 0.352798
L(d(Compound, 1), 0:6)2 -0.47879    0.48292  -0.991 0.323689
L(d(Compound, 1), 0:6)3  0.73731    0.41164   1.791 0.076071 .
L(d(Compound, 1), 0:6)4  0.59021    0.41117   1.435 0.154047
L(d(Compound, 1), 0:6)5 -0.53313    0.40243  -1.325 0.188038
L(d(Compound, 1), 0:6)6 -0.70848    0.37455  -1.892 0.061227 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 374.2 on 108 degrees of freedom
Multiple R-squared:  0.8716,  Adjusted R-squared:  0.8621
F-statistic: 91.62 on 8 and 108 DF,  p-value: < 2.2e-16
```



2.3 Exhaust systems

Exhaust systems is a function of exhaust systems at t-1

There is room for a little bit of optimisation due to autocorrelation at lag 1 (2 outliers)

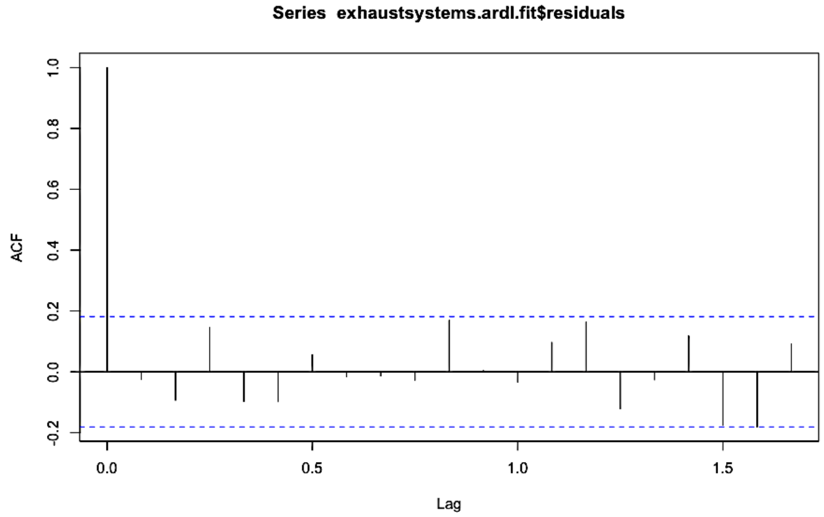
```
Time series regression with "ts" data:
Start = 2008(8), End = 2018(4)

Call:
dynlm(formula = Exhaustsystems ~ L(Exhaustsystems, 1) + L(d(Compound,
    1), 0:6), data = ts)

Residuals:
   Min     1Q Median     3Q    Max
-43820  -7313   -981   6499  59696

Coefficients:
                        Estimate Std. Error t value Pr(>|t|)
(Intercept)            1.112e+04  4.525e+03   2.456   0.0156 *
L(Exhaustsystems, 1)   9.201e-01  3.282e-02  28.037   <2e-16 ***
L(d(Compound, 1), 0:6)0  4.135e+00  1.636e+01   0.253   0.8009
L(d(Compound, 1), 0:6)1  1.780e+01  1.783e+01   0.998   0.3204
L(d(Compound, 1), 0:6)2  2.132e+01  1.661e+01   1.283   0.2021
L(d(Compound, 1), 0:6)3  2.962e+00  1.460e+01   0.203   0.8396
L(d(Compound, 1), 0:6)4 -1.328e+00  1.460e+01  -0.091   0.9277
L(d(Compound, 1), 0:6)5  6.550e+00  1.402e+01   0.467   0.6414
L(d(Compound, 1), 0:6)6  3.764e+00  1.317e+01   0.286   0.7756
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 13130 on 108 degrees of freedom
Multiple R-squared:  0.8991,  Adjusted R-squared:  0.8916
F-statistic: 120.2 on 8 and 108 DF,  p-value: < 2.2e-16
```



3 VAR

Vector autoregressive (VAR) models allow predicting multiple time series variables using a single model. VAR models extend the idea of univariate autoregression (AR) to k time series regressions, where the lagged values of all k series appear as regressors. → we regress a vector of time series variables on lagged vectors of these variables.

$$\mathrm{Y_t} = \beta_{10} + \beta_{11}\mathrm{Y_{t-1}} + \cdots + \beta_{1p}\mathrm{Y_{t-p}} + \cdots + \gamma_{11}\mathrm{X_{t-1}} + \cdots + \gamma_{1p}\mathrm{X_{t-p}}$$
$$\mathrm{X_t} = \beta_{20} + \beta_{21}\mathrm{Y_{t-1}} + \cdots + \beta_{2p}\mathrm{Y_{t-p}} + \cdots + \gamma_{21}\mathrm{X_{t-1}} + \cdots + \gamma_{2p}\mathrm{X_{t-p}}$$

3.1 Miners ←→ Compound

```
> # robust coefficient summaries
> coeftest(VAR_EQ1, vcov. = sandwich)

t test of coefficients: Compound

             Estimate Std. Error t value  Pr(>|t|)
Intercept    39.0153677 30.2482298 1.2898   0.19965
Compound_t-1  1.2208465  0.1444037  8.4544 9.077e-14 ***
Compound_t-2 -0.3161713  0.1419703 -2.2270   0.02786 *
Miners_t-1    0.0204842  0.0079576  2.5742   0.01130 *
Miners_t-2   -0.0163601  0.0085323 -1.9174   0.05762 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

> coeftest(VAR_EQ2, vcov. = sandwich)

t test of coefficients: Miners

              Estimate  Std. Error t value Pr(>|t|)
Intercept    1049.672744  579.879768  1.8102  0.07284 .
Compound_t-1    1.031951    1.415150  0.7292  0.46733
Compound_t-2   -0.889625    1.175923 -0.7565  0.45085
Miners_t-1      0.946274    0.083714 11.3036  < 2e-16 ***
Miners_t-2     -0.012379    0.082162 -0.1507  0.88050
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
Linear hypothesis test
Hypothesis:
Miners_t - 0
Miners_t - 2 = 0

Model 1: restricted model
Model 2: ts[, "Compound"] ~ L(ts[, "Compound"], 1:2) + L(ts[, "Miners"],
    1:2)

Note: Coefficient covariance matrix supplied.

  Res.Df Df      F  Pr(>F)
1    119
2    117  2 4.1634 0.01792 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
Linear hypothesis test
Hypothesis:
Compound_t - 0
Compound_t - 2 = 0

Model 1: restricted model
Model 2: ts[, "Miners"] ~ L(ts[, "Compound"], 1:2) + L(ts[, "Miners"],
    1:2)

Note: Coefficient covariance matrix supplied.

  Res.Df Df      F Pr(>F)
1    119
2    117  2 0.2888 0.7497
```

3.2 Steel ←→ Compound

```
> # robust coefficient summaries
> coeftest(VAR_EQ1, vcov. = sandwich)

t test of coefficients: Compound

             Estimate Std. Error t value  Pr(>|t|)
Intercept    50.915089  59.644303  0.8536   0.39505
Compound_t-1  1.172560   0.152923  7.6676 5.677e-12 ***
Compound_t-2 -0.283008   0.148077 -1.9112   0.05842 .
Steel_t-1     0.062751   0.030503  2.0572   0.04189 *
Steel_t-2    -0.044090   0.028305 -1.5577   0.12201
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

> coeftest(VAR_EQ2, vcov. = sandwich)

t test of coefficients: Steel

             Estimate Std. Error t value Pr(>|t|)
Intercept    387.51447  181.02789  2.1406  0.03438 *
Compound_t-1   0.37509    0.50065  0.7492  0.45524
Compound_t-2  -0.44957    0.44798 -1.0036  0.31766
Steel_t-1      1.23400    0.12341  9.9994  < 2e-16 ***
Steel_t-2     -0.30376    0.13806 -2.2002  0.02976 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
Linear hypothesis test

Hypothesis:
Steel_t - 0
Steel_t - 2 = 0

Model 1: restricted model
Model 2: ts[, "Compound"] ~ L(ts[, "Compound"], 1:2) + L(ts[, "Steel"],
   1:2)

Note: Coefficient covariance matrix supplied.

  Res.Df Df     F  Pr(>F)
1    119
2    117  2 2.679 0.07284 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
Linear hypothesis test

Hypothesis:
Compound_t - 0
Compound_t - 2 = 0

Model 1: restricted model
Model 2: ts[, "Steel"] ~ L(ts[, "Compound"], 1:2) + L(ts[, "Steel"], 1:2)

Note: Coefficient covariance matrix supplied.

  Res.Df Df      F Pr(>F)
1    119
2    117  2 0.8172 0.4442
```

3.3 Exhaust systems ←→ Compound

```
> # robust coefficient summaries
```

```
> coeftest(VAR_EQ1, vcov. = sandwich)

t test of coefficients: Compound

                 Estimate  Std. Error t value  Pr(>|t|)
Intercept         71.51958091 36.36434841  1.9667   0.05158 .
Compound_t-1       1.27909128  0.15483227  8.2611 2.531e-13 ***
Compound_t-2      -0.35198359  0.15578543 -2.2594   0.02571 *
Exhaustsystems_t-1  0.00034075  0.00061643  0.5528   0.58147
Exhaustsystems_t-2 -0.00022913  0.00055238 -0.4148   0.67905
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

> coeftest(VAR_EQ2, vcov. = sandwich)

t test of coefficients: Exhaustsystems

                 Estimate  Std. Error t value Pr(>|t|)
Intercept          6.9984e+03  5.7220e+03  1.2231  0.22377
Compound_t-1       2.6284e+01  1.1380e+01  2.3097  0.02266 *
Compound_t-2      -2.5126e+01  1.0125e+01 -2.4817  0.01450 *
Exhaustsystems_t-1  9.2875e-01  9.0862e-02 10.2215  < 2e-16 ***
Exhaustsystems_t-2  8.6931e-03  9.2579e-02  0.0939  0.92535
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

>
```

```
Linear hypothesis test

Hypothesis:
Exhaustsystems_t - 0
Exhaustsystems_t - 2 = 0

Model 1: restricted model
Model 2: ts[, "Compound"] ~ L(ts[, "Compound"], 1:2) + L(ts[, "Exhaustsystems"],
   1:2)

Note: Coefficient covariance matrix supplied.

  Res.Df Df      F Pr(>F)
1    119
2    117  2 0.1759 0.8389
```

```
Linear hypothesis test

Hypothesis:
Compound_t - 0
Compound_t - 2 = 0

Model 1: restricted model
Model 2: ts[, "Exhaustsystems"] ~ L(ts[, "Compound"], 1:2) + L(ts[, "Exhaustsystems"],
   1:2)

Note: Coefficient covariance matrix supplied.

  Res.Df Df      F  Pr(>F)
1    119
2    117  2 3.1257 0.04759 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Appendix No. 6

Questionnaire

University of Salford MANCHESTER

1967-2017 50 YEARS

Organisational solutions to manage commodity price volatility: A comparison of ‘financial instruments’, ‘diversification’ and ‘Keiretsu Gaisha’

Introduction to the survey "Organisational solutions to manage material price volatility of stainless steel".

Dear Participant

I am adressing you today with a request to participate at my research thesis I am conducting at the Salford Business School, University of Salford, Manchester UK.
My research is centered around the commodity price volatility in the stainless-steel segment. I am researching the potential organizational opportunities to deal with commodity price volatility. The research is investigating different effects of the stainless-steel price volatility and potential solutions to manage or avoid the effects of material price volatility. The research title is:

"Organisational solutions to manage commodity price volatility: A comparison of ‘financial instruments’, ‘diversification’ and ‘Keiretsu Gaisha’"

Your participation would make a vital difference to my research, as you have an immense experience in the field of the stainless-steel market. Your professional knowledge and past learnings in this particular industry segment will be an important contribution. Your participation is completely voluntary and you have the right to withdraw at any time from this research at any point during the survey process without providing reasons for doing so.

Your responses will be treated in strictly confidential.

The research is supervised from the Salford Business School. The name of the supervisor is Christos Papanagnou which is available for any additional information you might want to ask about this research.

Allow me to thank you in advance for your kindness to participate in my research.

Your sincerely

Pascal M. Heckmann

Business Segment

Your business is in which business segment? *

- ☐ Stainless Producer / Stainless Steel mill
- ☐ Stainless Steel cold rolling
- ☐ Steel Trader
- ☐ Stainless Steel Service Center
- ☐ Processing/ Machining of stainless steel to produce other products
- ☐ End customer/ consumer of stainless steel
- ☐ Other business segment

Basic business data

The Headquarter of your business is in which geographical region? *

- ○ North America
- ○ Latin America
- ○ Europe
- ○ Australia
- ○ Asia
- ○ Africa

Is your business predominately buying or selling stainless-steel? *

- ○ Buying
- ○ Selling
- ○ Neither

The yearly quantity / metric tons your business is handling is

- ◯ < 100.000 metric tons
- ◯ > 100.000 metric tons
- ◯ > 250.000 metric tons
- ◯ > 500.000 metric tons
- ◯ > 1.000.000 metric tons
- ◯ > 2.000.000 metric tons

The ownership of your business is ... *

- ◯ privately owned
- ◯ stock listed
- ◯ company with limited liability

Strategy

What are the main business risks/ threats for your business in regard to the usage of Stainless Steel? *

Multiple answers are possible.

- ☐ Supply Chain disruption
- ☐ Price volatility
- ☐ Fixed prices
- ☐ Demand volatility
- ☐ Single sourcing
- ☐ Natural catastrophes
- ☐ Political risks
- ☐ Material availability
- ☐ Others, please state ____________

What are the different buying/selling strategies your business is using to cope with Stainless Steel price volatility? *

Multiple answers are possible (max. 3 answers).

- [ ] Fixed prices
- [ ] Longterm contracts
- [ ] Spot buying
- [ ] Combination of Longterm contracts and spot buying
- [ ] Hedging of alloys (e.g. Nickel)
- [ ] Inventory control
- [ ] No procurement strategy is used or existing
- [ ] Other strategy ____________

Strategy & Exposure

Did you consider one or both of the following strategies to mitigate the Stainless steel price volatility? *

- ○ No
- ○ Diversification into other business segments (e.g. stainless steel and rubber)
- ○ Vertical integration into the supply or value chain (e.g. stamping, welding, automation)
- ○ If yes please describe ____________

Which percentage of your turnover is related to the price of Stainless Steel? *

Please indicate a percentage share (e.g. 0; 50 or 60)

____________ %

What are the key decision factors that determine the commodity buying/selling strategy? *

Multiple answers are possible.

- [ ] Product characteristics (quality)
- [ ] Processing capability of the product
- [ ] Base price (without any surcharges)
- [ ] Total (effective) price
- [ ] Price stability
- [ ] Material availability (short lead times)
- [ ] Financial impact
- [ ] Others, please state

Strategy & Exposure part 2

Stainless steel price volatility represents for your business? *

- ○ an opportunity
- ○ a risk
- ○ neither

Is the price risk (price volatility risk) involved in your procurement decision?

Do you take the volatility of stainless steel into consideration, if you procure (BUY OR SELL) stainless steel?

- ○ yes
- ○ no
- ○ Please state the main factors

Are quality specifications of the commodity involved in a procurement decision?

Multiple answers are possible.

- [ ] yes
- [ ] no
- [ ] sometimes
- [ ] how/why

Outlook

Do you expect that your commodity buying or selling strategies will change to reflect a price volatility risk in the next 5 years?

Are there potential events, opportunities, risks or other factors that might impact your buying strategy?

- ○ yes
- ○ no
- ○ Please explain what change is expected.

Are financial restrictions involved in the procurement/ sales of volatile products in your organization? *

Do you have to involve Finance before a sales/ purchase transaction, because it is a volatile product?

- ○ yes
- ○ no

Which service do you expect from your commodity supplier? *

What is the key decision driver? -------- Multiple answers are possible.

- [ ] Price competitiveness
- [ ] Price stability
- [ ] Deep understanding of the commodity market
- [ ] Market overview
- [ ] Material availability
- [ ] Material quality
- [ ] Geographical coverage
- [ ] Technical support
- [ ] Value add services
- [ ] Other reasons

Open questions / Outlook

If there is a very limited supply of a specific quality of a commodity what type of strategy does this generally lead to?

Please state briefly what your organisation does if there is a risk of material shortage.

Are there any other major factors that you consider when making commodity procurement decisions?

Appendix No. 7

Interview questions

INTERVIEW / QUESTIONS

COMMODITY PRICE MITIGATION STRATEGIES IN THE STAINLESS-STEEL INDUSTRY

PASCAL HECKMANN (PG)

UNIVERSITY OF SALFORD

Contents

1 Interview reasons and type of interview

Target group: Top executives of the stainless-steel industry

Type: Semi structured, non- standardised and an in-depth interview

Reasons: Explore and map mitigation strategies for material price volatility in answering the Research questions of the report of Pascal Heckmann

2 Opening

1. Overview of purpose of the study
2. Confidentially assurance/permission to audiotape
3. Brief description of Title/responsibility/role of interview participants

3 General Questions

4. What types of price volatile commodities does your organization directly purchase?
5. How important are these commodities to your organization? -----Why?
6. Approximately what percent of your organization's overall spend is accounted for by these commodities?

4 Risk Assessment and mitigation

7. The company you are representing is potentially experiencing market risks? Which are the risks you are expecting in the near future?
   a. How did these risks change in recent years?
   b. Examples: Competition from Asia, economic uncertainty, price volatility, worsening of the own cost base
   c. Which substitution developments have you experienced?
8. Does your organization have a standardized process for managing commodity price risk? ----------If so, please describe the process.

9. What approaches / Which methods does your company use to manage commodity price risk?
    a. Note: After the initial answer ask about other approaches that were not mentioned: substitute of qualified materials, passing/sharing with suppliers, passing/sharing with customers, forward buying, hedging (futures, options, other derivatives)
10. How do you determine which approaches to use?
11. Are different approaches used for different commodities? <u>-------If so, why?</u>
12. How do you measure the effectiveness and monitor the results of these approaches?
13. What does you company do really well when managing price risk? <u>--------Why?</u>
14. What are the greatest challenges your company faces when managing commodity price risk? <u>--------Why?</u>
15. Over the last three years, what trends have you seen in the approaches used to manage price risk? <u>---------Why?</u>
16. What trends do you think will occur in the next three years? <u>-------Why?</u>

5 Price, volatility

17. Compared to your competitor do you think you are managing price volatility in a special way and if so, what is different?
18. The purchase of raw material is handled by which function in your organization?
    a. What could be the task/role of the top management?
    b. Why could it be a task for the CEO? (example Aperam)
19. Which influence has a stable price situation versus a volatile price situation for your company?
20. Why would commodity price volatility influence the profitability of the company you are representing?
21. Which could be the influence of producers like Tshinshan – who controls the mining / excavation costs- will they play a more important role in the future? (backward integration)
    a. What could be the reason for stainless-steel producers to integrated backwards?
        i. <u>Which costs implications could this have?</u>

b. Will the LME pricing continue to be a reference for the raw material costs -(Nickel?)- the alloy surcharge?
   i. <u>Why do you think so?</u>
   ii. <u>Why not?</u>
   iii. <u>Which challenges/ limitations could this system face in the future?</u>

22. Will the price volatility change the consumption of stainless-steel?
    i. <u>Explain the role of Substitution</u>
    ii. <u>Innovation</u>

6 Development & challenges of the stainless-steel industry

23. Thinking about the current implementation of trade barriers like Anti-dumping cases and the section 232 in the USA what are you expecting for future developments?
    i. <u>Pricing</u>
    ii. <u>Availability</u>
    iii. <u>Mill investments</u>
    iv. <u>Longterm planning</u>
24. To conclude this interview, I would like to have your input for the following question.
    a. What will be the consequences of the increased Asian production capacities?
    b. Are you expecting the stainless-steel industry to be dominated by companies from China/ Asia?
       i. <u>Why do you think so?</u>
25. From your perspective what are the dominating trends & developments in the future for the stainless-steel business environment?
    a. Are you expecting further limitations to the free flow of products?
    b. Are you expecting further tariff barriers for the company you are representing?
    c. Are you welcoming stricter protection laws for domestic producers? Or are you expecting a more liberal view on the tariff legislation?

7 Strategic questions

26. The purchase of raw material is handled by which function in your organization?
    a. Do you think it should be a top management task?
    b. Do you think it should be handled by the CEO? (example Aperam)

27. Do you think the influence of producers like Tshinshan – who controls the mining / excavation costs will play a pivotal role in the future?
    a. Do you expect any implications for the other regions besides Asia?
    b. Should the stainless-steel producers integrated backwards, to control the raw material costs better?
    c. Will the LME pricing continue to be a reference for the raw material costs (Nickel?)
28. From your perspective what is / could be an appropriate method to mitigate the price volatility risk in the stainless-steel industry?
    i. <u>Why is it a risk and not an opportunity?</u>
    ii. <u>What could be the answer?</u>
    iii. <u>What could be a method to offset the price swings?</u>
29. What are situations that have been critical for your company in regard to price volatility?
    i. <u>Natural disasters?</u>
    ii. <u>Financial crisis (interest rates, x rates)?</u>
30. Could you recommend a mix of tools or methods to offset these price swings?
31. Would you recommend any literature or topics that should be considered in this research?

8 Farewell questions

Would you want to read and approve your answers in this interview (the transcript) prior the use in my research?

Are you interest in a copy of the final report?

Appendix No. 8

Interview transcripts

Transkripts of interviews

Contents

Interview Outokumpu

Interview with mill representative July 25th 2019
Respondent
Senior sales position
Member of the Executive Board

PMH: So, thank you very much for your participation. I'd like to ask you a couple of questions concerning price volatility and potential mitigation strategies from your point of view, from the point of view of a manufacturer. One of the first questions would be question number four. What type of price volatile commodities do you have to deal with? (#00:00:29-6#)
R1: I think we have a couple of volatile price items. First of all, we have the exchange rate. Furthermore, we have our raw material especially Ferrochromium, nickel, you know? That would be the most important one. (#00:01:02-3#)PMH: Would iron-ore still be one of these commodities? (#00:01:05-2#)
R1: Of course, iron as well. (#00:01:08-1#)PMH: How important are these ones for your organisation? (#00:01:15-2#)
R1: They are very important. As you know, we are dealing normally with the best price and the alloy surcharge, but more and more customers are asking for effective price. That means that alloy surcharge is included. And that means that we have to find yeah, a price model where raw material is included. (#00:01:52-8#)PMH: Is this because of the Asian influence where it's very common to have an effective price or is this? (#00:01:59-4#)
R1: One issue is Asia but also United States. (#00:02:07-1#)PMH: Okay, thank you. Approximately what percentage of your organisation's overall spent is accounted for by these commodities? (#00:02:17-4#)
R1: Commodities, I would say around 80 percent. (#00:02:29-4#)
PMH: 80 percent? Thank you. Then we would kind of move into risk assessment and mitigation. The company you're representing is potentially experiencing market risk and this is more market price risks. Which are the risks you're expecting in the near future? (#00:02:49-2#)
R1: One risk could be the availability of raw material. (#00:02:59-7#)PMH: Do you have a certain one in mind if you say that's very hard to get? (#00:03:06-8#)
R1: Yeah, in the near future maybe not but in the longer run I could imagine that we have some issues with this Ferrochromium for example. (#00:03:23-9#)PMH: Okay. And why Ferrochromium? (#00:03:26-3#)
R1: The demand is increasing and the sources are more and more limited. (#00:03:38-3#)PMH: Okay. How did these risks change over the recent years? Did you see that these risks are changing or was it always Ferrochromium and it always will be Ferrochromium? (#00:03:54-4#)
R1: Mhm. No changes. (#00:03:56-7#)PMH: No changes? (#00:03:57-3#)
R1: No. (#00:03:57-8#)PMH: If we would take an example, the competition from Asia. Would this change something? (#00:04:06-6#)
R1: I would say no. Why no? I think all manufacturers have more or less the same sources. Okay? As you know now Outokumpu has an own mine for Ferrochromium. (#00:04:30-6#)
PMH: Do you think that the price volatility will increase for these items? For Ferrochromium, for nickel? (#00:04:41-4#)
R1: For Ferrochromium, I think we have and we had in the past a huge volatility when you compare Ferrochromium prices maybe ten years back or 20 years back up to now. So, it was never really, really flat. (#00:05:07-2#)PMH: Okay. And you expect that this is going? (#00:05:09-3#)
R1: Yeah. Absolutely, yeah. (#00:05:10-7#)PMH: Okay. (#00:05:11-5#)
R1: Typically going on. Yeah. (#00:05:12-6#)PMH: Is ongoing in the future? (#00:05:13-6#)
R1: Yeah. (#00:05:13-5#)PMH: Do you - you mentioned that Outokumpu has their own ferrochrome mine. (#00:05:19-5#)
R1: Mhm. (#00:05:20-1#)PMH: Do you see a tendency that more stainless steel producers are backwards integrating? (#00:05:26-9#)
R1: No. (#00:05:29-3#)PMH: Into the mining industry? (#00:05:30-3#)
R1: No. (#00:05:30-6#)PMH: No? (#00:05:30-8#)
R1: No, definitely not. Because the investment is really, really huge. And in addition, you know you have the problem with also with - with the market, with the availability of mines. For Outokumpu, we have some historical issues because the mine is very close you know, to Outokumpu. (#00:05:58-8#)PMH: So, it's pure coincidence? (#00:06:01-5#)
R1: Yeah. Yeah. (#00:06:02-2#)PMH: Never planned? It just happened this way? (#00:06:06-6#)
R1: No. No. (#00:06:08-4#)PMH: Okay. Does your-? (#00:06:11-5#)

R1: Yeah. I think I would say more the opposite now. We had also done some thoughts to sell the mine. Okay. (#00:06:22-6#)PMH: Why? (#00:06:23-2#)
R1: Yeah. Why? Outokumpu is or was not in a very comfortable you know (laughs) financial situation and-, (#00:06:36-0#)PMH: So, that's more from a financial? (#00:06:37-1#)
R1: Absolutely, yeah. (#00:06:38-0#)PMH: Restriction? (#00:06:38-4#)
R1: Absolutely, yeah. (#00:06:39-3#)PMH: But from, I mean from a production point of view, this must be great because you've got your own ferrochrome, you only have to dig into the ground and-, (#00:06:46-8#)
R1: Absolutely, yeah. And we have a lot of capacities now. That means that we also sell Ferrochromium to our competitors. (#00:06:56-1#)PMH: Question number eight. Does your organisation have a standardised process for managing commodity price risks? Because we've got-, (#00:07:10-7#)
R1: Yes, we have. Yeah. (#00:07:11-4#)PMH: Could you explain a little bit more - in a little bit more detail? (Laughs) (#00:07:16-6#)

R1: I think first you have to know now which price parts do we have now. We have a (scrap? #00:07:43-1#) price, we have iron price, we have prices for Ferrochromium and the other raw materials. And therefore, we have a well-managed purchasing department with managing the risk process. That could mean that we also secure a limited volume in nickel. (#00:08:20-0#)PMH: Ja. (#00:08:20-8#)
R1: We have a separate process for Ferrochromium. Also with our own mine but in (projects? #00:08:33-0#), we have also a risk management there that we also secure a limited volume now for a limited time. (#00:08:40-5#)PMH: Which is more from a perspective of supply chain or price-driven? (#00:08:48-4#)
R1: Both. Supply chain but also price. The background is very, very easy. When we are running business specific to prices, you know for example for white goods, our customers asking for a one-year or two-year contract price and there is everything included. That means that we have to secure also our Ferrochromium price, you know? (#00:09:20-7#)PMH: But you would only do this against a specific contract? (#00:09:24-6#)
R1: Yeah. (#00:09:24-9#)PMH: Not because you think the time for buying is good? So, speculation? (#00:09:30-6#)
R1: Okay. For our speculation, maybe from time to time but I think that we're not very focused on speculation. (#00:09:43-5#)PMH: Ja. A little bit we touched on this. What approaches, which methods does your company use to manage the commodity price risk? (#00:09:57-2#)
R1: What do you mean? (#00:09:59-3#)PMH: Do you have a - how do you measure the? (#00:10:03-0#)
R1: Okay. (#00:10:03-7#)PMH: The price risk? Because you could say the price is volatile. Yes? (#00:10:07-7#)
R1: Yeah. (#00:10:07-9#)PMH: But this is good, this is bad. And prices go up and down. (#00:10:13-6#)
R1: Yeah. (#00:10:14-2#)PMH: On approaches side? Presumably they go up and down on the sales side. (#00:10:20-1#)
R1: When you're running automotive, it's going only in one direction. (#00:10:25-8#)PMH: Ja (laughs). But was it just you bought what you need and you tried to secure against a given contract? Or is this something where you say okay, if, let's say nickel grows up to 15,000 you would try to secure for a lower price because you would think prices go up? (#00:10:49-2#)
R1: Yeah. (#00:10:49-2#)PMH: Or? (#00:10:50-5#)
R1: Normally, we are buying only when we have a contract. It can happen now that we are also now speculating a little bit. You know? But that is not our - not our core business to speculate with raw material. (#00:11:12-7#)PMH: And hedging was used at all? (#00:11:15-5#)R1: Hedging, it's a common process especially for nickel. (#00:11:25-2#)PMH: And there's always a time gap between your purchase-, (#00:11:33-5#)
R1: And production time. (#00:11:36-2#)PMH: And then you've got the production, the service centre cycle, stocking cycle and then you sell the product? (#00:11:43-8#)
R1: Mhm. (#00:11:44-4#)
PMH: In the time in-between should be as short as possible? But typically it's somewhere three months maybe. And how do you calculate this - the price risk of these three months? (#00:11:57-6#)R1: It's an internal process from our purchasing department and it's a supply chain. We have a time gap between purchasing and production. It's normally not three months I would say we are talking about maybe six to eight weeks. (#00:12:30-6#)PMH: And maybe a stupid question. Would you buy your raw materials or would you have to pay your raw materials when you physically get them or when you physically sell them? (#00:12:45-4#)
R1: We are paying when material when we see the material intake. (#00:12:53-8#)
PMH: Would you work with consignment stocks? (#00:12:58-6#)
R1: Yeah. Do we mean for raw material or for? (#00:13:05-7#)PMH: Yes. Yes, yes. (#00:13:05-9#)
R1: Yeah. (#00:13:06-7#)

PMH: Ja, okay. I mean we just touched on different methods like hedging, consignment stock. When do you decide and who is deciding which method to use? So, when would you go for hedging? When would you go for consignment? When would you go for nothing? (#00:13:28-8#)
R1: That is the job of our supply chain department. Of course, when we are maybe deciding to purchase a higher volume, it's also on our CFO or our CEO included. (#00:13:53-2#)
PMH: The purchase department reports to whom? CEO or CFO? (#00:14:00-4#)
R1: CEO. (#00:14:01-6#)
PMH: Would he be involved in these purchase decisions? Not on a really regular base? Or this is more important? (#00:14:14-9#)
R1: More and more - let me say in really important decisions. Yes. That means when we're thinking about to purchase you know a higher volume. (#00:14:28-7#)
PMH: Because of your market expectation? (#00:14:32-3#)
R1: Absolutely, yeah. (#00:14:33-1#)
PMH: Okay. How do you measure the effectiveness of the different methods? Because for me this is the question because the prices are volatile and sometimes you decide to hedge, sometimes you say, "I buy more than, because my gut feeling or my market intelligence is giving me signs that price is going up or down." But how do you measure how effective you buy raw materials? (#00:15:05-6#)
R1: It's really, really difficult to say. (#00:15:11-0#)
PMH: How did you? (#00:15:14-4#)
R1: We have a regular meeting between our financial guys and also our sales department. And there we are discussing about market expectations, about competition, about possibly contract. (#00:15:47-3#)
PMH: Was this kind of a weekly thing or monthly? (#00:15:51-6#)
R1: It's I would say monthly meetings. Okay, when we see some extraordinary market developments so then we have also more meetings. So - and there we are discussing our common strategy and for the purchasing and the volatility. (#00:16:21-6#)
PMH: From your perspective, what is your company doing really, really well when managing commodity price risk compared to others? (#00:16:33-7#)
R1: To others? (#00:16:35-2#)
PMH: Mhm. (#00:16:35-5#)
R1: (Laughs) Difficult - really difficult questions because we are not really involved and have not the knowledge about the others in the internal process of the others. And therefore it's very difficult to comment. (#00:16:59-2#)
PMH: But do you think you manage it well? (#00:16:59-6#)
R1: I would say yes, well. But-, (#00:17:08-5#)
PMH: But (laughs)? (#00:17:09-7#)
R1: I think every time you have room for improvement. And to really a good comment, I think you need more knowledge about the others now. How is the process here and how do they manage the volatility of several materials? (#00:17:34-5#)
PMH: How do you secure the market intelligence? This is just-, (#00:17:39-4#)
R1: Mhm. (#00:17:39-9#)
PMH: I mean you can read for sure a lot of publications but how do you really come to your view? (#00:17:48-5#)
R1: I think the most important is beside market information maybe by reporting and so on, is a good change in the internal sales organisation worldwide. And also the communication and to our key customers. (#00:18:13-9#)
PMH: Okay. Just trying to dig a little bit deeper. What are the greatest challenges for your company when facing commodity price risks? (#00:18:32-1#)
R1:Yeah, most difficult and maybe most important challenge is to foresee (laughs) the price development of nickel and Ferrochromium. And as you know, now it can happen, I don't want to say overnight but in a very short period, you have prices now up and down and nobody knows really why. (#00:19:17-2#)
PMH: We had last week we came from whatever, eleven or twelve thousand up to 15,000. (#00:19:22-0#)
R1: Yeah. Yeah, and ask - and ask the specialist why? (#00:19:26-4#)
PMH: Tsingshan? Because one out of nickel pig iron? (#00:19:30-2#)
R1: Yeah. (#00:19:30-1#)
PMH: And they're in the market for apparently 20,000 tons of nickel. That's why it peaked but everyone kind of, within two weeks, everybody is expecting it goes down again. (#00:19:41-1#)

R1: Yeah. But I think the most important issue is, to know is it enough for a short period or one, two, or four weeks or is it for a longer time of maybe you know some quarters? (#00:19:55-4#)
PMH: (laughs). I know. (#00:19:59-7#)
R1: And I think you have the same problem in your own forecasting, you know? And I think when you make a one-year plan or you know whatever maybe also for longer term, I think you have also you know to speculate and also to forecast a total price. That means you know best price and alloy surcharge, you know? And how do you calculate your low risk? Yeah. It's the - it's a crystal ball you know? But in our calculation now also in our one-year focus, you know, we have to forecast a nickel price for example and yeah. (#00:20:47-2#)
PMH: Yes, but you are physically a nickel buyer? (#00:20:49-3#)
R1: Yeah. (#00:20:49-7#)
PMH: And you could physically also hedge the nickel for one year? You could. The question is why should you? (#00:20:55-5#)
R1: Maybe, okay, make it sense now and-, (#00:20:57-3#)
PMH: And for us as consumer, it's ja. (#00:21:01-7#)
R1: Yeah. But we know some competitors you know in your market also fixing nickel. (#00:21:09-2#)
PMH: Yes. We're not allowed to. (#00:21:11-4#)
R1: Yeah. (#00:21:11-9#)
PMH: I know. I know. I know. I'd like to do that. (#00:21:17-1#)
R1: Yeah. (#00:21:18-3#)
PMH: Over the last three years, what trends have you seen in the approaches to manage commodity price risks? Did anything change from your perspective? I mean you said within your company not really but did you see something outside of your company? (#00:21:36-6#)
R1: Not really. I see the trend in price in general but that means that more and more customers are asking for a total price for a total contract price and not anymore to split it in a best price in the alloy surcharge. (#00:22:05-9#)
PMH: We - I will come back to this one. (#00:22:12-5#)
R1: Okay. (#00:22:13-1#)
PMH: Because there's some more focus on the effective pricing later on. (#00:22:20-2#)
R1: Okay. (#00:22:20-3#)
PMH: Maybe one last question about mitigation strategies. Do you see that anything in the next years is going to change? (#00:22:30-6#)
R1: I would say from today I don't see it. (#00:22:43-3#)
PMH: Okay. Okay. We had this one. And now we - I would come back to your thought of the effective price. Just imagine the prices would be stable. Would this be good or bad for you as a producer? (#00:23:04-3#)
R1: When we are talking about the best price? (#00:23:11-9#)
PMH: Effective price. (#00:23:13-8#)
R1: Effective price. Yeah, it's depending because the developed - the price development of the raw material. (#00:23:23-0#)
PMH: Yes, but for you as a producer just imagine the prices stay the same for twelve months. (#00:23:28-0#)
R1: Yeah, that would be fine. Absolutely. (#00:23:30-8#)
PMH: So, it would be a benefit to you? (#00:23:33-4#)
R1: Yeah, absolutely. Yeah. (#00:23:34-5#)
PMH: You wouldn't fear that the consumer would only benchmark then on as you say this transformation cost? Because everything is stable? The one with the lowest transformation cost would ruin the business? (#00:23:53-4#)
R1: Mhm. I don't think so. (#00:23:56-8#)
PMH: And why do you think a lot of people are moving into the direction of effective price? (#00:24:07-1#)
R1: One reason definitely is to reduce the price risk and especially for the alloy surcharge part. (#00:24:29-4#)
PMH: Okay. Maybe very, very simple question but I think it's not so simple to answer. (#00:24:43-0#)
R1: Yeah. (#00:24:43-2#)
PMH: Why would commodity price volatility influence the profitability of your company? (#00:24:48-9#)
R1: Again? (#00:24:51-5#)
PMH: Why would commodity price volatility influence the profitability of your company? (#00:24:57-6#)
R1: Well-, (#00:24:59-3#)
PMH: So, if the prices go up and down? (#00:25:00-5#)
R1: Yeah, okay. As I said before, commodities have a percentage of around 80 percent. So, it's main part of our business. So, any price up and downs are influencing our result. (#00:25:22-7#)

PMH: Did you measure this specifically? Is this kind of windfall profits and windfall losses? (#00:25:29-6#)
R1: Yeah. (#00:25:30-0#)
PMH: So, there was a separate? (#00:25:31-2#)
R1: Yeah. Absolutely. It's a very important part in our company. (#00:25:36-6#)
PMH: Okay. And now moving a little bit to Asia, Tsingshan is a big one which is doing everything different which has, is completely backward integrated. Which could be the influence of producers like Tsingshan who control everything from the mining to the cold rolling? (#00:26:13-5#)
R1: It's a very, very big competitor for us, have more or less the same role like Outokumpu who is also completely integrated and from the mining up to the cold rolling process. And-, (#00:26:43-3#)
PMH: Do you think there will be more companies going this way despite high investment costs? So that-, (#00:26:57-8#)
R1: The question is where companies are located and we are talking about China, where money is unlimited, available, could be possible. But I think in Europe not because you know, we have more than enough capacities in Europe. And therefore, I don't think that we will go more in this direction. (#00:27:34-4#)
PMH: Do you think they will set pricing trends because they don't have to take care of the LME? (#00:27:40-7#)
R1: Of course, especially in Asia. But when they're dealing in Asia and also in overseas or in Europe that we have also an influence for European price as well. (#00:27:56-9#)
PMH: Could you think about a situation where I mean they control all the mining, they control, apparently they've got very cheap electricity costs? That they would become the number one slab producer and they're only selling stainless steels slabs to other stainless steel companies? (#00:28:18-3#)
R1: When they have capacities, of course. Why not? Yeah. (#00:28:21-3#)
PMH: Do you think the other producers are inclined to do so? Because they would give up a little bit of their value chain. (#00:28:32-3#)
R1: So, for Europe especially in short terms, I don't see the trend because slab capacities is enough available. Look to AST for example, you know, they have more than enough capacities. And for our company, for Outokumpu I would say we have also enough capacities. (#00:29:11-0#)
PMH: Do you think the CO2 emission wide and do you have to sell or to buy the CO2 certificates? This could make a change? (#00:29:21-5#)
R1: In the long run, I could imagine. (#00:29:27-6#)
PMH: Okay. Kind of the overall question is of stainless not of this interview, the price volatility of stainless steel which is given. Does this have an influence on the consumption? So, because when we talked about nickel of 50,000, a couple of decades back, a lot of people had the fear that people are moving away from stainless. Do you still think this might be a trend or is this driven by application? (#00:30:06-3#)
R1: I would say it's driven by the application but we had such times you know maybe 15 years ago where we had a nickel price of around 50 and this time we had more and more discussions about alternatives in stainless you know? And that means from austenitics to ferritics. (#00:30:36-5#)
PMH: So, it's more substitution within stainless? (#00:30:40-7#)
R1: Absolutely, yeah. (#00:30:41-7#)
PMH: For austenitic, ferritic, and ja? (#00:30:43-5#)
R1: Yeah. (#00:30:43-4#)
PMH: Okay. And now, going a little bit more helicopter view, the development and challenges of the stainless steel industry. If you would think about the current implementation of the trade barriers. (#00:31:00-3#)
R1: Mhm. (#00:31:01-4#)
PMH: Like the anti-dumping cases, we have in Europe, the quota system we have and of course U.S. trade sanctions 232.
PMH: Are you expecting any further developments like this in the future? (#00:31:18-7#)
R1: No. (#00:31:20-0#)

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PMH: Okay. Question 28. From your perspective, what is - could be an appropriate method to mitigate the price volatility risk in the stainless steel industry? The holy grail (laughs) because you said price - if prices are stable it's great, price volatility is not so good. So, what could be the holy grail? (#00:00:28-6#)
R1: The holy what? (#00:00:32-9#)
PMH: Holy grail. (Foreign language #00:00:34-2#)
R1: (Foreign language #00:00:35-2#) Okay. You know we are more interested in a stable price because also our investors are not interested in volatility and prices up and downs because it's very difficult to forecast also for

our stock price. And when we have more stable prices with our customers especially long-term contract prices, we are also able to fix and to find contracts with our raw material suppliers. (#00:01:31-2#)
PMH: You mentioned a very interesting topic which is the long-term contracts, your customers. Is this also a strategy to mitigate the price risk? (#00:01:44-3#)
R1: Yeah, of course. Indeed. (#00:01:46-9#)
PMH: And you're looking into special segments? (#00:01:49-6#)
R1: We are looking in special segments. And the question is where we find or where we have our long-term contracts. Of course, so now we have it in our automotive industry. (#00:02:09-7#)
PMH: White goods? (#00:02:13-6#)
R1: But also in white goods and domestic-, (#00:02:17-4#)
PMH: Domestic appliances? (#00:02:21-3#)
R1: Appliance, yeah. (#00:02:22-5#)
PMH: If you would guess, how much is long-term contract versus spot business? (#00:02:30-5#)
R1: At least 50/50. You can say when we are dealing with NGOs business, we're talking almost about contract prices. And when we're talking about business distributors, stockholders and so on. We have prices of maybe one month for spot business. (#00:03:02-5#)
PMH: Ja. Also more and more effective prices? (#00:03:09-0#)
R1: I would say yes. Yes, especially when we are talking about ferritic grades. (#00:03:20-4#)
PMH: And Outokumpu introduced the dust daily alloy surcharge, what was the motivation to do so? Why did you introduce your daily alloy surcharge or the surcharge where you can choose between? (#00:03:46-5#)
R1: I think the idea was to find a fair price model for our customers and also to reduce our risk. Because when you are publishing the daily alloy surcharge customer can really fix the nickel price, the actual nickel price and not nickel price what is maybe two or three months old in the old price model. (#00:04:31-5#)
PMH: Was it successful? (#00:04:33-1#)
R1: For short-term business, it was successful. And in the meantime, I would say it's a price model where a lot of customers are working with. (#00:04:55-2#)
PMH: So, more than 25 percent of? (#00:04:57-9#)
R1: Yeah. (#00:04:58-2#)
PMH: Okay. Thank you. Do you think this is also the tool or the method to work together in the future between a producer and customer? This kind of a more reality or transparent alloy surcharge system? (#00:05:24-5#)
R1: Yes - I would say yes, of course. Especially for the short-term business, it's important to have the transparency. And we are offering transparency with the dust and yes. (#00:05:46-8#)
PMH: Okay. Then moving back to risk, have there been critical situations for your company? Like natural disasters or financial crises? That have been really critical for your company? (#00:06:02-6#)
R1: Yeah. We, I think we had two critical times. One was in - I think in 2006 or 2007. We had a big fire here in Krefeld. We had a fire in the cold rolling mill. So, the cold rolling mill was more or less completely destroyed here in Krefeld. And therefore, we had a lack of capacity for around five to six months. And so, that was very, very difficult to manage because also in this time in 2006, we had very, very strong market with best prices maybe you remember it was 2000 Europe best price and that was also the time the 50,000 Europe you know? (#00:07:11-6#)
PMH: Ja. (#00:07:11-9#)
R1: Nickel price and so on. Yeah. (#00:07:15-2#)
PMH: And did you have any backup plans? Until this accident? And the second question would be after this? (#00:07:24-7#)
R1: I think we had a backup - let me say to be more transparent, we have created in a very short time a backup plan (laughs). (#00:07:37-6#)
PMH: Ja, sure. (#00:07:38-0#)
R1: Because in this time we were not Outokumpu, we were just (ThyssenKrupp? #00:07:46-7#) and we had also a very strong mill in Shanghai, a cold rolling mill. And this time we have qualified Shanghai (unclear #00:08:03-9#) in a very short time to supply also the European market. So, we have supplied hot end to China or we have also bought hot end from Asian competitors to roll it in cold material. (#00:08:28-2#)
PMH: So, this was also by coincidence? This was not really your backup plan you had but you were lucky you had some, another cold rolling line? (#00:08:41-2#)
R1: We had another cold rolling line in China, we had another one in U.S. So, we were in a very lucky situation that we had you know several mills worldwide, not only in Germany. (#00:09:02-7#)
PMH: But when you did build the cold rolling lines in China and in the U.S., it was never meant as a backup for Germany, it's just? (#00:09:11-1#)

R1: Yeah, definitely. (#00:09:11-9#)
PMH: That was extra capacity? (#00:09:13-3#)
R1: Absolutely, yeah. (#00:09:13-9#)
PMH: Ja, okay. Financial crisis, was this close to a breaking point for your company? (#00:09:22-7#)
R1: Yes, of course. Because overnight, market prices were more or less destroyed. And I remember, right? We had in 2007-2008 market prices close - for spot prices close to 2,000 Europe best price. And I would say in a timeline of three or four months, it was reduced by maybe 40 percent or something, that's it. And also the other stock came also from 120 percent maybe to 50 or something. That's it. (#00:10:17-9#)
PMH: You mentioned in the beginning two critical times. One was a fire and the second one? (#00:10:25-5#)
R1: The financial crisis. (#00:10:27-0#)
PMH: Okay. (#00:10:27-5#)
R1: Mhm. (#00:10:27-6#)
PMH: So, I think that's it. Last question for me would be could you recommend any literature for me on this topic? Yes? No? No? No? Nobody did until now? Nobody did? (#00:10:43-2#)
R1: No. (#00:10:43-2#)
PMH: (Laughs) But my doctor father he says you have to ask these questions. (#00:10:50-9#)
R1: Okay. (#00:10:51-2#)
PMH: I'll do. (#00:10:52-0#)
R1: Okay. (#00:10:52-5#)
PMH: Okay. So, thank you very much (laughs). (#00:10:54-5#)
R1: Yeah, okay. (#00:10:55-4#)

(End of interview) (#00:10:56-1#)

Interview Acerinox

Sales Global (Mill anonymous)

In Madrid Acerinox HQ, 17-07-2019

Introduction conversation, we touched on the general situation in the stainless-steel market, particular on Tsingshan and the situation in China. It was explained that there is an investment stop for new capacity in China. There are some doubts that Bao will reopen the stainless-steel activities in the south of the country.
Tsingshan might be a snowball effect situation where they have to "turn" a bigger wheel to fund and finance the old debts. Daniel doubts that they are earning any money at all. It might be in situation that eh trade to China is completely restricted for them. The JV with ATI in the US is generating losses. It is speculated if ATI is rolling the slabs in order to bring down the costs for the rolling production lines in the USA. The estimated costs to ship the material from Indonesia to Pittsburgh is estimated at 100$/to plus a freight cost internally from 60$/to (x2). So, to be commercially successful the slabs would have to offer a price advantage that includes the transport cost of approx. 220$/to and the 25% import duty.
(Autor's Note: if CR coil is sold for 1,1$/kg the transformation estimated at 270$/to the costs of the slab 730

CR price	1100 $/to plus AS 1330$/to (0,6044/lbs)
Transformation cost:	270
Transport costs:	220
Scrap:	50
Duties 25%	378
Slab cost estimated:	182$/to plus AS of 1330$/to (1512$/to)

From a production perspective this calculation is not possible to roll slabs at this pricing level. The costs must be coming from the AS; thus, the potentially cheaper alloys are funding the CR price. The recent scrap notations are close to 900-1000$/to)
The general market was discussed the low pricing levels in Europe and Asia. The special situation in the USA. The stainless-steel business is very lucrative for the domestic producers. As the imports are restricted due to quotas, antidumping measures and the Us trade sanction 232 (see below). For the ACERINOX group is a challenging market environment as the other production sites (Spain, Columbus in South Africa and Bahru in Malaysia are loss making operations. The Bahru operations are using slabs/hotband from Tsingshan to be I position to compete in the Asian market.

The Chinese market is almost closed for Bahru products due to the low-price levels and the import restrictions. Niche products are the commercial focus in this market (heat resistant grades).
Interview Questions & Answers
PMH:I will refer a couple of times to the question number, so it is a little bit easier for me to track it down. #00:00:11-8#
MILL ANONYMOUS Okay. #00:00:12-6#
PMH So, if we come to let us say the general questions, what type of price volatile commodity do you have in your organization, and which ones are you buying directly? #00:00:25-7#MILL ANONYMOUS Okay. The highest volatility in our business comes from nickel. Which as you know is a raw material listed in the London Metal Exchange with a very high volatility, and represents approximately 60% of our cost. #00:00:48-9#
PMH Or not 60% of volume, not of quantity? #00:00:54-4#MILL ANONYMOUS No, it is in the typical grade that we produce, which is 304. Nickel is 8%. #00:01:04-9#
PMH Ja. And let me just ask you one more question about this typical grade. If you go to typical grades, you refer to304? #00:01:17-5#
MILL ANONYMOUS Ja. #00:01:19-4#
PMH And is this the typical grade, or is this just a very common grade? Meaning if you would take all grades together and make one big mixture of the year, will it still be kind of 304? #00:01:35-8#
MILL ANONYMOUS 304 is the main grade we produce. Yes, with no doubt. And is the main grade that is consumed. And from my point of view, it is the perfect stainless steel. It is a wonderful thing. Because it has first of all anticorrosive properties, but is easy to weld, and has very nice mechanical properties. And the Metallurg of the grade is good.

So, the 304 is the grade that you can use in most of the applications, either because of anticorrosive properties, because of mechanical properties, or because of aesthetical properties. #00:02:34-2#
PMH Is it also easy to produce? #00:02:36-4#
MILL ANONYMOUS What do you mean with easy? #00:02:45-8#
PMH For your production sites, is it because it is the most common grade you sell? #00:02:51-0#
MILL ANONYMOUS Ja. #00:02:53-2#
PMH Or is it also the easiest grade to produce, so with less, or with only few production topics? Because if you compare this to fluidics, I think ferritic grades are a little bit more tricky more difficult to produce. #00:03:06-9#
MILL ANONYMOUS It is the grade. I do not really know if the reason is it is the grade. We have the most or the biggest expertise because it is the one that we produce most, or because it is the easiest to produce. But for us, we have the biggest expertise in producing 304 for sure. #00:03:30-1#
PMH Okay. And how important are these commodities? You mentioned nickel, but I think there are other commodities that are price volatile as well? #00:03:41-4#
MILL ANONYMOUS Yes. #00:03:41-9#
PMH Ferrochrome? #00:03:44-2#
MILL ANONYMOUS Mainly in the last couple of years we have seen that ferrochromium has become also very volatile. So, coming from history, it had a quite stable price, and also predictable price. It had to do with the electricity price in South Africa. This was the main driver for the current price. Since the Chinese became the biggest ferrochrome producers worldwide, and they are typically speculating with things, it has become very volatile. #00:04:19-4#
PMH And volatile because of speculation, or really of supply and demand? #00:04:26-7#
MILL ANONYMOUS I think it has to do I would not say maybe not speculation, but I mean in the past, South Africa was the biggest oil producer, and also the biggest ferrochrome producer. Due to the availability or lack of availability of electricity in South Africa, they started to export iron-ore rather than produce ferrochrome mainly to China because of the big increase in stainless steel production in China. The Chinese typically tried to buy cheap and sell/. #00:05:16-2#
PMH Higher? #00:05:18-2#
MILL ANONYMOUS High, I mean. So, they started to buy a lot of iron-orefrom South Africa to produce the ferrochrome. And they are driving the price. So, it is today's ferrochrome price is really driven by the supply and demand situation in China. #00:05:40-2#
PMH Okay. Are there other commodities that are volatile for yourself? #00:05:49-0#
MILL ANONYMOUS One of a very important one is exchange rate. I do not know. It is not a commodity, but it is a volatile, it has to do a lot with volatility. Most of the raw materials that we buy are priced in dollars. And we have our profit and loss account in the group in euro’s but in European euro’s, in South Africa rand’s, and in Malaysia in ringgits, and in all the different countries where we sell in the respective rate. #00:06:34-4#

PMH Ja. I am not quite sure if I may ask this question, but the currency impact is a major one for x-rate? #00:06:49-1#
MILL ANONYMOUS It is, yes. #00:06:50-4#
PMH Okay. So you are basically becoming a bank? #00:06:53-5#
MILL ANONYMOUS No. #00:06:54-7#
PMH Traders? #00:06:55-6#
MILL ANONYMOUS No, but look it in this way. We are a global company, and we have around 35% of our sales are more or less in euro's, and 60% of our sales are in dollars. #00:07:14-7# so, it has a double effect in pricing our sales, and then consolidating the results. So, with a strong dollar, the results coming from America or from the dollar countries improve our group performance and the other way around.
This is on the profit and loss account, but also on the balance sheet as a lot of our actives are in dollar countries, it depends on the exchange rate as we consolidate in euro's our company increases the balance sheet or decreases it. #00:08:11-8#
PMH Ja. And question number six would be, approximately what percentage of your organization's overall spend is accounted for by these commodities? If you say nickel, ferrochrome, iron-ore, is that something you could reveal? #00:08:28-3#
MILL ANONYMOUS We typically do not do that. And as I am on the sales side, I do not have this. But you can really check this in our annual report /. #00:08:41-7#
PMH Okay. I will have a look in the annual report/. #00:08:43-4#
MILL ANONYMOUS In the yearly report. #00:08:45-7#
PMH Annual report. #00:08:46-0#
MILL ANONYMOUS Yes. #00:08:47-0#
PMH We move to the risk assessment and mitigation, and you are experiencing market risks? #00:09:01-1#
MILL ANONYMOUS Ja. #00:09:02-0#
PMH In general, which are the risks you are expecting in the near future? #00:09:05-9#
MILL ANONYMOUS In our risk metrics, the very first one is the overcapacity, then mainly in the last couple of years, traders. And then I would say typically not for the sector, but for us it is strategic risk. I mean there are a lot of things going on in the world now with new technologies and new ways of producing.
And if you have the wrong technology and this has to do with strategy, then you may be out of the business. I refer to different sources, different kinds of raw materials that we do not use and some of our competitors they use, for example nickel pig iron (NPI). #00:10:22-1#
PMH Yes, but you do not think that the melting process itself will be completely #00:10:25-9#
MILL ANONYMOUS I do not see that there is no for the time being no new technology available, but the technology is the same, but or similar. But the vertical integration of some of our competitors may give them advantages that we do not have due to our strategic approach to the market. #00:10:56-1#
PMH Ja, okay. Is price volatility for use on this risk matrix? #00:11:10-8#
MILL ANONYMOUS Price volatility yes, we were in the past and you know us since many, many years, you know that we were the ones that in good times we earned a lot, and in bad times we never lost money. So, we always said that we can live with the other market situations. And I think price volatility is a big headache in our case, mainly because of the amount of working capital we have on hands.
And of course this is a risk that we tried to mitigate with you know with we had this conversation before. We tried to have as few working capital as possible. #00:12:15-0#
PMH Ja, on the commodity side, on the input side, do you see any substitution? I guess nickel you cannot substitute, ferrochrome you cannot substitute? #00:12:25-8#
MILL ANONYMOUS The last element that came into our world and this is what I think 20 years ago was the manganese, which was known before since the very beginning of the development of stainless-steels, but was developed mainly in China and in India 20 years ago as a substitute for nickel. Manganese has also similar properties to nickel and can give the material also on the corrosive and properties like nickel.

This is the last one. We do not see or we have not seen within the stainless steel world many new developments. In substitution, we always speak about duplex, but duplex is something we know also since more than 20 years, and is still only 2% of the (#00:13:25-5#) world production. So, it is becoming I mean as the demand is growing, duplex is growing also, but it is not becoming a substitute for the traditional standard steel grades.

And substituting materials we find many times in different sectors, for example aluminum, where we may find in some applications, carbon steel, coated steel in some cases plastic, and in very special cases composites. These would be the substituting materials, but we are not feeling so much that because what we have seen in the last couple of years is that the demand increase in stainless steel has been always been faster or higher than in those materials.

So, I think it will be the other way around (#00:14:25-2#). Stainless steel is getting applications from these materials. According to the last (unclear#00:14:33-0#) but the compound annual growth rate of metals in this case from beginning 1980, stainless steel is doubling all the others, and bringing around 20% faster growing than aluminum. So, in this sense I think we are taking pieces of the cake. #00:15:12-6#
PMH Okay, thank you. Then question number eight, does your organization have a standard process for managing commodity price risk? #00:15:22-3#
MILL ANONYMOUS But I think it is a part of our value chain in this case. And this is a strategic thing for material purchasing, and reports directly to the CEO. And we have very clear procedures how to buy and what to buy and how to compare the different raw material resources in every single moment. #00:16:02-6#
PMH Ja. So, and it is centralized for all plans or for Spain and for the US, or is this/. #00:16:10-5#
MILL ANONYMOUS It is the purchasing is done locally. The strategy is done centralized. And we have a daily coordination among the different names, generally speaking. Then we have the special agreements. Ferrochromium we buy on global basis for example. And pure nickel also and do in scrap. We do the negotiation for scrap. We do the negotiation centrally. #00:16:47-3#
PMH Globally. #00:16:50-0#
MILL ANONYMOUS Globally, yes. #00:16:52-5#
PMH I think then we touched already online what approaches, which messages do you use to manage commodity price risk area, you described is as very close alignment and it is going directly to the CEO. Is Bernardo also in these meetings, or is this just reporting to him? #00:17:17-6#
MILL ANONYMOUS Is reporting and direct influence. I mean the important decisions are done by him. #00:17:27-2#
PMH Ja. And for me, one of the questions is and at times you will have different approaches how to procure these metals, when do you decide which one to use? Or sometimes you are in a situation where it is very hard to find these metals, for example scrap. And sometimes there is an excess of scrap. Would you buy on stock, would you/. #00:18:01-2#
MILL ANONYMOUS No, we do not speculate. In purchases we try, and this is in our strategy to have as less working capital as possible. So, we try to have our target is to have less than two weeks of raw materials generally speaking. And we work a lot with consignment stocks with our suppliers. And when you say comparable prices, we have a very I think after 50 years in the business we have a very good knowledge how to evaluate and price each of the materials included in the raw materials for use for our scrap.

Scrap for us it is the perfect raw material, because it has already everything that we need. It has iron-ore, chromium, nickel. So, perfect we put it into the furnace method and that is it (#00:19:01-2#). But we have I think a very good expertise in order to evaluate for each scrap price. At what real price, we have the nickel, the chromium, the iron-ore.

And we compare this with other sources where we get the same raw materials with ferronickel, with pure nickel, with ferrochromium, and ferro-silicon, ferro-silicon Magnesium, all those different grades. And each time, all the quotations we become and we compare. Even NPI is a source that we put into this benchmark of all the raw materials. And in some cases we have put also NPI. #00:19:51-4#
PMH Is this an approach which is purely done by purchase procurement, or do the mills who have to manufacture also a word in this? Because they might say, “I love my stainless steel scraps” or “Please bring me only scrap.” And from a cost side you say, “No, not this month.” #00:20:13-6#
MILL ANONYMOUS I mean only for your information, our purchasing manager is also the strategic director of the group. #00:20:23-9#
PMH Okay. #00:20:26-4#
MILL ANONYMOUS He has a very good knowledge about both sides you know, and not only price is important, but also production, ja. #00:20:37-2#
PMH Requirement needs you mean. Okay. #00:20:40-2#
MILL ANONYMOUS But we think or we like to think that we are quite innovative and quite open for the alternative sources for that material. So, we were the first for example to melt. Something that you are doing in Germany, you are emptying the batteries? #00:21:09-7#
PMH Yes. #00:21:11-5#

MILL ANONYMOUS And what remains is nickel. And we were the first to melt this kind of material coming from Germany. #00:21:19-2#
PMH Okay. #00:21:21-4#
MILL ANONYMOUS So, we are quite innovative, our people in the (unclear#00:21:25-1#) also quite willing to try new things. #00:21:28-9#
PMH Okay, good. If you have these different approaches, keeping in mind there is price volatility, how do you measure which one is the most profitable one for Acerinox? #00:21:45-3#
MILL ANONYMOUS In raw materials? #00:21:47-1#
PMH Yes. #00:21:48-9#
MILL ANONYMOUS It depends. As I told you, we do it constantly. So, we have the needs according to our orderbook what we need, how many units of nickel, of chromium, of iron-ore we need. We go to the market ask for quotations. And then we make constantly the comparison. And in some time/. #00:22:10-3#
[End of transcribed interview] #00:22:10-3#

Authors note: From this point the remaining part is not transcribed but written from the notes made during the interview.
4. What types of price volatile commodities does your organization directly purchase?
5: How important are these commodities to your organization?
Very important this might range up to 80% or 60% depending of the material grades and other variables
6. Approximately what percent of your organization's overall spend is accounted for by these commodities?
It is a very high share in particular if energy is included as well. It is not possible to hedge energy completely (see above for percentages)
7: The company you are representing is potentially experiencing market risks? Which are the risks you are expecting in the near future?

a. How did these risks change in recent years?
b. Examples: Competition from Asia, economic uncertainty, price volatility, worsening of the own cost base
c. Which substitution developments have you experienced?

13 What does you company do really well when managing price risk?
There is no single truth method available. The different markets are making the difference. ACERINOX is fast in the production and short in lead times that is what is giving them an advantage in the market.
For all markets in particular in the USA and Europe the alloy surcharge (AS) system is rigoursly followed- to pass on the commodity price volatility to the next in the supply chain.
The As is the tool to pass on the price volatility risk. Depending on the sector it might as well be a long-term agreement that is fixing the price for a certain period. (Authors note: this is typically used in the white good and appliances industry.)
The longer-term customer contracts are allowing the mill a certain margin. This margin is partly in the fact that it allows the mill to budget and forecast the production schedule in advance. In particular in the segment in which the bright annealed material is used (white goods/ appliances) longer-term agreements are an advantage for both the stainless-steel producer and the customer. (Authors note: the surface is special and fragile and needs special attention and due to the fact that the final product appearance should look always the same supplier changes or spot buy is not an option for this particular industry)
The financial comparison to the two main European competitors reveals that ACERINOX is producing twice as much per employee as Outokumpu and 1,3 times more than Aperam.
The comparison on the EBIT/staff is factor 2 for Outokumpu and approx. 1,5 for Aperam.

The production range of the grades is similar between the mills. ACERINOX is exposed with 8% to the automotive – mainly exhaust market-, roughly 20% are ferritic grades. The main grade by far is the 304/1.4301 and to a smaller extent the moly grades and the duplex grades. Outokumpu is stronger in the duplex grades (2% of the world stainless-steel demand less than 2 Mio tons) partly to the exposure in the OCTG environment.
The main difference might be that the other mills are approaching the customer what they want, and they will produce this grade. ACERINOX in contrast is not the first mover or the innovator it will follow when there is a market requirement that allows to produce the grades at competitive pricing. The product offering is not so much tailored made. In contrast the Japanese mills are offering a much wider product portfolio. It seems that the innovation rate is higher. Even some grades are offered in the USA, like the 429, this grade is commercially not available in Europe. This might be due to the fact that it is used by the Japanese and Korean automotive exhaust gas treatment system producers in North America.

14: What are the greatest challenges your company faces when managing commodity price risk?
The main challenges are the management of the trade working capital (TWC), the purchase strategy, the budget demand planning, to meet the budget.
The price volatility and the availability of the raw materials is secured by consignment stock agreements with the suppliers, supply agreements in general and the sometimes long-term agreements with customers and suppliers. An additional challenge is the market intelligence that is needed to generate a reliable forecast- to plan the production needs. Overall it is a question of production costs and hence profitability of the group.

15: Over the last three years, what trends have you seen in the approaches used to manage price risk?

The event that changed the raw material management was the financial crisis in 2008. Prior to this date it was the common standard to book orders to fill the mill. This had an implication on the big raw material stock that had to be available at any given point in time as the order book had to be filled.
After 2008 the focus shifted to “produce to order” approach in the mill. The production had to increase the efficacy. Additionally, this is the possibility to run the mill at utilization rates below 80% even down to 60% in a profitable manner.
16: What trends do you think will occur in the next three years?
Volatile market situations are the new normal situation. There is no mayor change or trend that will be any different from the current situation.
17: Compared to your competitor do you think you are managing price volatility in a special way and if so, what is different?

Acerinox is just better, comparing the financial results are good, the share price development is better than of the peers and the market capitalization/ evaluation of the finance community is better.
18. The purchase of raw material is handled by which function in your organization?

The raw material purchases are handled by a centralized function in the HQ in Madrid. This is headed by the Groups strategy Director, who heads the procurement department as well. The communication is defined as a standard and daily routines are used to evaluate and re-evaluate the current situation.
In the mayor negotiations is could as well be that the CEO is participating at negotiations with the critical raw material suppliers.
The raw materials besides stainless-steel scrap is handled by a few mining companies. The supply side on the scrap side is slightly wider but for the EU & the US a scrap dealer has to be certified by the government to secure that the environmental protection requirements are met. This certification is reducing the potential offer of scrap.
19. Which influence has a stable price situation versus a volatile price situation for your company?

In the price stable environment, the focus is definitely on production expertise and the best cost production method

20. Why would commodity price volatility influence the profitability of the company you are representing?
see the answers earlier in this interview

21: Which could be the influence of producers like Tsingshan – who controls the mining / excavation costs- will they play a more important role in the future? (backward integration)

a. What could be the reason for stainless-steel producers to integrated backwards?
b. Will the LME pricing continue to be a reference for the raw material costs -(Nickel?)- the alloy surcharge?

The question that was discussed internally at ACERINOX whether to buy a scrap dealer as scrap is the best ingredient to run the mill operation efficiently. Stainless-steel scrap already contains a certain amount of Nickel, Ferrochrome and Iron Ore. It would be like a marriage. The ties to the open market would be partly locked. This would be a disadvantage as the continuous benchmark of the raw materials is of essence to leverage the own bargaining power.
Backward investments have been discussed and are continuously reviewed. Initial discussions with traders and miners have been held. In particular in South Africa, the main exporter of Ferrochrome and partly Iron Ore.

If the ME remains as a reference is heavily dependent on the business attitude of the new players in the market that are backwards integrated. If players like Tsingshan are offering long-term pricing deals for austenitic grades

this will have an impact on the pricing negotiations between ACERINOX and the mining industry and the scrap dealers.
The scrap dealers typically have the costs of stockholding and transport and financing. They are not in the classical sense producing scrap. They might be blending the scrap.

If the LME will still be THE reference is unknown, it might become a different index. The LME (Nickel) is fulfilling a market need for a transparent pricing for the industry right now

22. Will the price volatility change the consumption of stainless-steel?

Most of the industrial products but for sure metal or aluminium, copper, plastic products are volatile in price the consumer is used to this volatility. This will not change the buying pattern nor will it trigger substitution as such. In most of the applications of stainless steel but for sure in the exhaust gas treatment system segment the final price of the vehicle is influenced only marginally by a price change. If for example the exhaust system is priced at 110€/ part and contains 25kg of stainless-steel with a value of 2€/kg the material value is 50€. This price even if fluctuations of 10-15% are experienced will not change the price of the car.
There is no roof for the Nickel price, stainless-steel will always be sold due to the material properties and the aesthetic reasons and the longevity of the product.

23. Thinking about the current implementation of trade barriers like Anti-dumping cases and the section 232 in the USA what are you expecting for future developments?

- Pricing
- Availability
- Mill investments
- Long-term planning

Stainless-steel is produced in 22 countries, 21 one of these implemented trade barriers of any kind. The one country without trade barriers is Japan. Japan is a relatively close market with special niche grades and hence protected in a very special manner. Partly because of the longer-term relationships between the Japanese mills and the consumers. (Authors note: It is affair assumption that the Japanese market is a closed market for non-domestic producers. A similar attitude is reported for South Korea)

The situation cannot be betting worse than it is right now.
Mainly it is China that is not open to the free trade agreements. No Chinese stainless-steel producer is publishing any results or any hint about government aides in form of financing or e.g. cheaper electricity costs. These companies are not under the same regulations as private companies in western countries. No annual report is available. (Authors note: Tisco mentioned that they are loss making in the past two years, same would be applicable for the last years of Bao stainless-steel production).

No transparency does exist in the financing, nor capital structure, nor the production costs. The electricity costs particular in Europe with the trend to renewable energy is driving these costs up tremendously. Another important topic are the CO_2 emission certificates. According to ACERINOX research the mills in China are emitting 30% more emissions than the world stainless-steel average. Another mayor driver behind the Co_2 emissions are the transport ones. These add up to 50% to the already higher emissions of the domestic Chinese production. These costa re not reflected in the prices from Chinese stainless-steel producers.
According to Mill anaonymous it is not an even playing field as the costs and the regulations differ. (The Author made the comment that in particular this argument was used by the American producers)
24: I would like to have your input for the following question.

a. What will be the consequences of the increased Asian production capacities?
b. Are you expecting the stainless-steel industry to be dominated by companies from China/ Asia?
i. Why do you think so?

The overcapacity in Asia is a topic that has to be addressed properly. The balance between supply and demand ii not given. Taking into account the Co2 emissions there have to be consequences and an even playing field must be available to all stainless-steel producers.
(Authors note see comments of previous answer)

25: From your perspective what are the dominating trends & developments in the future for the stainless-steel business environment?

a. Are you expecting further limitations to the free flow of products?
b. Are you expecting further tariff barriers for the company you are representing?
c. Are you welcoming stricter protection laws for domestic producers? Or are you expecting a more liberal view on the tariff legislation?

The material properties, like aesthetic and mechanical properties and other technological advantages like allow support the increased demand of stainless-steel. The production excellence of Acerinox is allowing to produce material that is thinner and very homogenous from the microstructure. These properties will allow to drive the demand. On example is the use of stainless-steel reinforcement bars in the building and infrastructure environment. Even in the automotive segment there is potential for a wider usage.

Trade restrictions is more a capacity restriction. Economically it is not beneficial to transport iron ore and ferrochrome from South Africa to China. These shipments contain high amounts of dirt water and air. The ferrochromium content compared to the mass is low and hence bigger quantities of unrefined material are sent across the globe. Comment again about the Co2 emissions of the transport. This unbalanced relation between producing countries and consumption/ demanding industrial countries is obviously not in balance. If the stainless-steel mill production capacity is in balance again no trade restrictions are needed.

26: The purchase of raw material is handled by which function in your organization?

a. Do you think it should be a top management task?
b. Do you think it should be handled by the CEO? (example Aperam)

The purchase functions are under the responsibility of the raw material procurement and this person is the Strategy Director as well. There is a direct reporting line to the Group CEO.

27. Do you think the influence of producers like Tsingshan – who controls the mining / excavation costs will play a pivotal role in the future?

a. Do you expect any implications for the other regions besides Asia?
b. Should the stainless-steel producers integrated backwards, to control the raw material costs better?
c. Will the LME pricing continue to be a reference for the raw material costs (Nickel?)

See previous answers – therefore left out

28: From your perspective what is / could be an appropriate method to mitigate the price volatility risk in the stainless-steel industry?

i. Why is it a risk and not an opportunity?
ii. What could be the answer?
iii. What could be a method to offset the price swings?

The unlevelled demand and supply situation on the raw material side is a challenge. A link between the raw material stocks and the real consumption is needed to prevent an opportunistic buy/production pattern. This approach should link the mining industry as “producers” of Ferrochrome, Iron Ore and Nickel. These raw materials markets are dominated by a few global mining companies. The market can be declared as an oligopoly.

The material “production” side for scrap is slightly different. There are principally sufficient players in the market, but the scrap dealer has to be certified and comply with regulations mainly regarding the environmental

protection and or the good storage of the scrap that might contain contents of oil or other liquid decontaminations from the previous production step.
29: What are situations that have been critical for your company in regard to price volatility?

i. Natural disasters?
ii. Financial crisis (interest rates, x rates)?

There have been two critical points in time for the ACERINOX Group in recent years. The initial one was the financial crisis in 2008. The demand dropped significantly, and the business model was still centred about the best capacity utilization level at the mill. A high utilization was regarded as mandatory to earn money. The mill had to be filled (feed the beast mentality, see prior answers). The cost of the production sites was too high, and no real option existed to adapt short term to the decreased production levels.

The other critical situation started at the beginning of 2014. The nickel notations decreased for 21 consecutive months until mid 2016. This is an unfavourable situation as the raw material purchased was always more expensive when at the beginning of the supply chain than when the material was sold approximately eight weeks later. The difference in cost had to be offset by the mill.
It was mentioned that the USD ($) is the main currency for the group, despite the fact that the consolidation in Madrid for the annual report (balance sheet) is done in Euro (€). This is important to be pointed out. The main currency in the business is the USD ($), as the raw material costs are typically traded in $, the main sales transaction due to the group exposure in the US and in Asia (Malaysia) is handled in USD ($). The main raw materials besides electricity are mainly directly or indirectly linked to USD ($). Electricity and wages are always paid in local currency in Spain in Euro (€) in Malaysia in (Ringgit) in the US in USD ($).

The hedging of the USD ($) is of utmost importance. The hedging in handled in the Group HQ in Madrid.

30: Could you recommend a mix of tools or methods to offset these price swings?

No answer was discussed in detail

31. Would you recommend any literature or topics that should be considered in this research?
No literature was named explicitly,
This interview transcription will be sent to Mill anonymous for review and approval.
(…) this is indicating comments and additional information from the interviewer

Interview Aperam

<u>Interview with Eric Haekens (EHK) / Aperam in Gent/ Belgium, May 3rd 2019</u>

PMH: [German] No, we have to speak English. The interview for me, has the purpose to validate my research questions. Because I'm trying to explore which mitigation strategies for price volatility do exist in the stainless steel industry. Because we have a lot of ups and downs in the price, mainly due to nickel but not only. My question is, is there something that can smooth out these price ups and downs, these hikes #00:01:00-0# because one of the big people in the steel industry, the biggest steel maker in the industry says, "Volatility is killing the business." This was Mr. Mittal . He did say that in an interview in the 80s or something like this. We come to this a little bit later, if people think about volatility, very often they only think about financial solutions. Then there's for me the difference between strategic topics which is price volatility. And you know how this price hikes they can go up very tremendously. Is it a strategic topic, or is it a tactical topic? For me that is sometimes not clear. #00:02:00-0# For me it's just to get the understanding. Do mitigation strategies exist, yes or no? And if they exist, in which situation can I use them? It's kind of the holy grail. But it's not kind of the prediction of the nickel in two or three years. #00:02:23-2#
EHK: Just the management of the different risks or how this is deployed and how this is done. #00:02:29-0#
PMH: And if there's a natural catastrophe, what will happen? What could happen? Is it just something from the shelf, take this strategy or this plan? Or is it really let's wait and see? I will have a look later on in my research which strategy might be the best one. Is there one that can fit all? #00:03:00-0# Or is it always dependent on the situation? For example, if stainless steel or nickel goes up and down. If nickel is, for example, five percent of your

value add, then most likely you're not too concerned. But if it's 95, you might be very, very well concerned. So that's for me testing waters. Where do I want to go? And to understand from a practical view, how does that fit to literature? That's the purpose of the study. Secondly, confidentiality. We will make it absolutely anonymous. We will give you the typed version so you can wipe out whatever you want to. #00:04:00-0# If you're not okay with it, then I will not use it. Brief description and a title of yourself. I could take this from your business card. #00:04:17-1#
EHK: My name is Eric Haekens, I'm the chief sales officer of Aperam, responsible of sale for all the commercial activities that are linked with the production and the entities of Aperam in Europe. That's from mill perspective. Within the responsiblity, it's as well commercial as technical commercial topics and product development topics that are under my direct responsibility. #00:04:52-2#
PMH: So a very wide scope for one person. #00:04:56-2#
EHK: A wide scope but working on different areas of the business which can go from pure sales up to marketing and development purposes. So, looking at the short, middle and long term and the wider scope. It's more a function that is interacting between the different components of our organisation. That can be production. That can be R & D. That can be pure business development. And on the other hand, making the and linking the goods with the external world. Which are for us in the most case, our customers in the different segments that we are targeting. For Aperam, just to give that context, when you take our business #00:06:00-0# portfolio, it's quite diverse and mixed. On the one hand contract business, and what we call spot business. With contract business, that can be week contracts up to contracts of three months or six months directly by the mill. Or what we do through our service centers that are under Aperam stainless steel services and solutions and that we do directly from the mill. On the spot business, it's mostly linked with the business that we have with the classical distribution centers and tube mills which are moulding with the day-to-day spot marketing in that sense. But be aware that compared to other of our competitors that Aperam that are part of the contract and project business #00:07:00-0# really linked with end-users. Contract business is for more than two thirds of our business. Up to 70 percent of our business is linked with the end-user and contract business in there. #00:07:14-1#
PMH: So it's a longer term business. #00:07:16-1#
EHK: It's a longer term business. It's a business where you work with specific end-users and with specific contracts and where we are less exposed to the volatility. And that's coming to your point. The volatility of the stainless business. Which is mainly for the biggest part impacted by the stocking/de-stocking phases that are going with the classical spot business. And spot business with distribution and service centers and traders and tube producers (makers). #00:07:45-0#
PMH: Thank you. If you would come, let's say helicopter view, general questions. What type of price volatility commodities do you have in your organisation? It is stainless steel? #00:08:01-2#
EHK: It's stainless steel. But when we talk purely about this price volatility commodities, from a purchasing point of view where we are exposed to, it's raw material in all its forms. It can be scrap up to pure nickel or chrome, moly or whatever products we need for production. Energy which becomes more and more a kind of purchasing function where you're exposed to volatility of energy prices because we consume a lot of energy. And energy costs, specifically for our upstream organisations in Genk and Chatelet mill it's quite important. Third level of what we can call price volatility commodities is linked with the currency risk and how we deal with that. And for us it's the most part, is the dollar risk in #00:09:00-0# the business that we have. As well on the purchasing side as on the sales side, knowing that roughly for Aperam the main trading currency is euro. But then, let's say with the export business that we are doing, which is for Europe, Aperam Stainless Europe roughly 15 percent of our business is export business. Which is done in the majority part in US dollar, which is take a certain risk in the exchange rates and so on, and the way that we have contracts in dollars for longer term. And that is part beyond raw material of the risk that we have to manage and that we have to take into account. If you don't manage that risk, your contract at the end of the period could be under threat. #00:10:00-2#
PMH: And the raw material purchase, scrap, nickel, moly is in dollars or in euros? #00:10:08-1#
EHK: The majority-wise it's expressed in dollars. But when we buy the scrap, the negotiation is done let's say, it's euro. But the euro is always linked with when you have the major/ When you have nickel, when you have ferromoly, when you have ferrochromium, all these components are traded in, and as a reference you find it in dollars. It's very dollar-related, less than the euro-related. #00:10:47-0#
PMH: How important are these for your company? #00:10:53-0#
EHK: When you take energy, and you take raw material for a stainless steel company, this is the majority part of the spending. On a cost base, a significant part, which is going way beyond 50 percent of the spending that we have. I don't have the exact figure here. When you pure on a cost base, depending on the grade of course, it can go from 65 to 75, sometimes 80 percent of the cost base. Where the energy cost within the part is between six and eight percent. So it's an element that is even much more important than the cost of the salaries. #00:12:00-

0# I talk now about the cost-reduction. So it's an important part. That's why I mentioned it, beyond raw material. Energy is, after raw material, the second biggest spending and commodity-related component that we have to manage. Here I talk about Stainless Europe. I take Brazil out because that is not a reality there. Because it's not only stainless. It's other products. They have a different kind of production route. With eucalyptus and so on, green energy that they are using in their production facilities in Brazil. #00:12:44-0#
PMH: Six that was already mentioned, approximately what percentage of your organisation or expense accounts is commodities. We touched on this one. I would come to/ #00:12:59-1#
EHK: So it's over 50 percent of our spendings. That's without going too much into it. As I said, you go in the neighborhood of 60, 65, sometimes up to 75, 80 percent. #00:13:12-2#
PMH: And this depends then on the grade. #00:13:14-1#
EHK: It depends on the grade. It depends on the specificness of the greater structure. #00:13:24-0#
PMH: Is it a fair assumption to say if it's a lower grade, if it's a cheaper grade, then the material content is higher? #00:13:34-2#
EHK: You have to see between for instance ferritic, austenitic. In ferritic, it's different between ferritic standard, ferritic stabalised. It's different between a twelve percent chromium and an 18 percent chromium. When you have the higher alloy to steels in the range of the austenitics you're between a moly grade and a chrome-nickel grade. So the higher you go #00:14:00-0# into the chain and in the composition, the higher the part of the cost of the/ That's what I say between these. It's linked with the chemical composition. The richer the chemical composition, the higher the cost that we have in the/ And afterwards can further because you have finish product, and you have your melt. So you melt a certain volume. And out of that volume, depending on the grade, you have yield. And you don't have necessarily the same yield of every product. The yield can be high on some products and/ Which is a part of the equation. #00:14:47-0#
PMH: The company you are representing is currently experiencing market risk. Which are these risks? And which risks are you expecting in the near future? #00:15:01-0#
EHK: Classical, the risks that we are exposed to is the risk of, in our industry, about over-capacity. You've seen over the last year a very strong increase of the capacities worldwide. And this is not still yet come to an end with the Indonesia and Indonesian investments. This over-capacity is always have to be seen against the demand, and how this supply and demand balance influences the market. But we know that in terms of on the one hand you have the upstream capacity, which is in the melt shops. And the install capacity worldwide. On the other hand you have down-stream cold rolled. The over-capacity is much more present in the melt shop #00:16:00-0# capacity. To a lesser extent in the cold rolled capacity. Globally when you talk about the market risk, as I said it's a capacity situation. Over-capacity supply, demand. And it's more and more the trade defense, and cases, and protectionism policy where we see that more and more. Borders and trading is limited by increased level of trade defense cases that have been initiated by countries or by European Union. Everywhere in the world, we are more and more confronted with the lack of free trade that is influencing heavily our opportunities and way to maneuver around in the international market. #00:16:59-2#
PMH: Just try to stick to the manuscript because we will come to this later. Because I was tempted to jump in already. #00:17:09-2#
EHK: Yeah, I understand. #00:17:11-2#
PMH: You mentioned a couple of things. Did this change in the last couple of years? #00:17:20-0#
EHK: What changed in the last couple of years, specifically on the trade defense side where you see more and more cases that are coming there. And it's a kind of snowball effect when one region is starting the other region is following. On the over-capacity situation, this is very much linked with the new investments that have been done specifically in this case for Indonesia. Which are challenging some market equilibrium specifically linked with China. Where Indonesia becomes a bit into China of the stainless steel. #00:18:09-1#
PMH: But it is a Chinese company. #00:18:11-1#
EHK: Indeed. But then it's puzzling that the Chinese government is trying to block the import of a Chinese company. #00:18:23-1#
PMH: Then we come back again to trade defense. #00:18:27-0#
EHK: Exaclty. #00:18:28-0#
PMH: Do you see any kind of substitution coming up on the horizon? #00:18:35-2#
EHK: In the favour of stainless steel, we see that there is still a positive growth worldwide. In one way or another, we continue as stainless steel to take advantage of the properties and the advantage of stainless steel compared to carbon steel or other material. So the moment that stainless steel is becoming much more cost competitive in uses, a kind of positive substitution/ We see that we are still not at the end of that potential. But there I think for stainless steel, it lacks a bit a kind of ambitious way to position stainless steel against other products and to make an active promotion for the features and advantages of stainless steel. #00:19:40-1#

PMH: So you see more that substitution goes into the direction of stainless steel, and stainless steel is not being substituted. #00:19:46-1#
EHK: No, we don't see too much substitution. The only time when we had a kind of feeling that the attraction to stainless was diminishing was #00:20:00-0# the moment when you had the nickel just like ten years ago when it was above 40, 50 thousand dollars. Then you could see a kind of hesitation. Now the moment when it stays around the levels that we know today, stainless has quite some natural advantages compared to other products. Maybe the only side note we have to put into the substitution discussion is the internal substitution of stainless of austenitic, ferritic. In some cases, what happened in automotive world in certain areas. The substitution between duplex and 316. So we have a lot of internal substitution within stainless steel where this doesn't necessarily make the game bigger, but it makes it shift within the stainless steel application. In China and India between the 200 and 300 series and so on. That is something that is more cannibalising certain grades within the stainless steel family and is not contributing to focusing on making the game bigger for stainless. That is another component of the substitution. #00:21:20-0#
PMH: So you're not seeing plastic taking over or something like this? #00:21:24-1#
EHK: Not directly. Not to have the very concrete examples where we see that stainless steel is massively substituted by other products, on the contrary. We are more specifically substituting the carbon steel is quite obvious. #00:21:46-0#
PMH: Does your organisation have a standardised process for managing commodity price volatility? #00:22:03-1#
EHK: First of all, we have indeed internal processes that allow us to do risk management. We don't allow our company to step into any risk that could harm the profitability of our business. This means that when we talk about standardised procedures and commodity pricing, we always run from the sales side when we take orders and when we take business at pricing that goes beyond base and alloy surcharge or effective prices. We always are managing and have internal procedure to hedge the nickel. For the time being, it's the only commodity that you can hedge in a financial way. All the other commodity products like ferrochromium, ferromoly and others, you don't have a financial system there that allows you to manage that risk. There we take certain calculated risk. And in certain areas, depending on the size of the contracts that we take, we can consider to buy physically some raw materials against a certain contract. But that means that we need to have a substantial volume and an advantage, let's say a risk mitigation that we can have on the right side when we are today certain raw materials for longer term. And that's an assessment that we have to make together with our purchasing department. That's the way we take case by case the decision. #00:24:00-0# For the nickel, nickel is linked with euro, dollar, in that case. But for contract as such is expressed in foreign currency. This contract is always hedged from the currency side. #00:24:17-0#
PMH: But you would hedge nickel only on a contract base if you make a project sales? And this would be a fixed price, or you would hedge nickel as well for other customer? #00:24:37-0#
EHK: No, when it's base and alloy surcharge we have a natural hedge of the nickel, so we are not going to hedge nickel. The moment when we have every business that we are doing where nickel is involved and where we have an effective price, if it is for normal delivery time or for a longer delivery time, we have an internal procedure and a automatised system where automatically we are going to start hedging of the nickel against the contract that we have taken. #00:25:16-0#
PMH: But it's always against special, certain contract? #00:25:20-0#
EHK: It's always case by case. Always a contract, and every time when we have contract and effective price where the nickel is fixed, we always without exception. So we have numerous hedgings that we do everyday. But the system is as such is let`s say implemented to our system that this is done in a very process-driven way without having the case by case approach. #00:25:54-1#
PMH: Can I ask you one more question which is not on here? Is this the wish of the customer to have the effective price for the project, or is this your desire? #00:26:06-1#
EHK: It's always the decision of the customer that he wants to have a price on the contract that is valid for a certain period, an effective price. We always make clear that in terms of nickel hedging. We do that of course to mitigate our risk and to assure the customer that we can commit to that price for the duration of the contract. There specific to these customers, we have a clear expectation, commitment that he cannot come back to us within two or three months saying, "We don't anymore." But there we could open a discussion on the fact that when he wants to step out of the contract that he pays the cost of nickel hedging. Which already appeared in certain #00:27:00-0# cases, more exception than rule. But in 98, 99 percent of everything that we do in the framework of nickel hedging, this contract is respected. And we have internal systems when it's linked with delivery times and commitment to certain delivery to the customer. So there the customer has to respect the

certain volume and monthly production that we are launching. But we can discuss with them, it's deviating from one month to the other we have systems there to mitigate that. #00:27:33-2#
PMH: And this hedging is done in your purchasing department or in your finance department? #00:27:40-2#
EHK: Finance department. So we have in our treasury department is leading operationally that process. So they are doing the follow-up and the hedging towards our broker company that is working on behalf of us. So it's the treasury department which is under the responsibility of our CFO organisation within Aperam. #00:28:11-1#
PMH: Is this something which would be linked with the activities of the Mittal Group or is this purely Aperam
EHK: Purely Aperam. There is no link. And the treasury department in Luxembourg not only on behalf of the mill stainless steel factory of Europe. They work there for nickel alloys, which is a different kind of format – Imphy-. And when it's Brazil, it's done of the treasury department in Brazil, but linked to CFO. #00:28:42-1#
PMH: Would you use your nickel suppliers to go into price fixations, or is this always hedged? Can you go out and say, "Dear mister nickel supplier, give me a price for one year."? Is this something which is possible? #00:29:10-2#
EHK: Theoretically, you could do that. In practical terms, it can only be done when behind that fixed nickel contract for a certain period you have a customer contract that is requesting that. #00:29:30-0#
PMH: But you would then cut out the finance portion, the hedging if you would talk directly to the nickel producer and say, "Dear mister nickel producer, I'll take this 100, 200 tons a month for twelve months." So this is not/ #00:29:46-0#
EHK: This is not done due to the fact that you have the/ The nickel hedging, what we doing is a financial operation. And the supply of nickel is mostly done within a big part of the scrap supply that we get on a multi basis. So the purchase of pure nickel is done, but it doesn't represent the biggest portion of the physical supply. But it's used as a bargaining power between what you do purchasing of your scrap raw material and the discussion that you have with your scrap suppliers to make a certain mix with that with pure nickel in order to not to be at risk. It's a balance that's followed up on a more than regular basis. And it's part of the discussion that is done by sourcing. #00:30:59-0#
PMH: So they decide do we buy stainless steel scrap, and we buy less nickel, or they buy more nickel, and they buy standard scrap. #00:31:09-0#
EHK: Exactly. It's not only a matter of price. It's a matter of availability. When you have scrap availability that is scarce. Again, there is not only stainless scrap. There are different types of scrap of course that are there. And in these different sub-segments, you could have a different dynamic because when you make304 or you make 316 or you make duplex, it's a different supply of scrap that you have. And you have to buy. That's why there it's a matter of bargaining power, but it's a matter of being assured of a certain supply that you need to have in order to make your production in the melt shop. We cannot start the melt shop because we are lacking raw materials, then it's not so intelligent. #00:32:03-2#
PMH: For me very important is when do you use which approach? Who is determining? Is this purely based on price or technical? Or is it a board's decision whether we go and buy only stainless steel scrap? #00:32:32-1#
EHK: First of all, I think that there are some standard procedures. And I said before that we don't take any risk. So from the sales side we always having the procedure in order to hedge. On the sourcing purchasing side, they have a certain strategy that they follow. They have to make sure that within their purchasing policy that they build in a certain flexibility between the different parts for scrap or raw materials that they are buying. For us in terms of the organisation, the sourcing part of raw material is reporting directly to our CEO. So there is a very short link in the organisation because our CEO is directly involved into the strategy and policies that are linked with raw material. #00:33:40-2#
PMH: And this way of working to my knowledge is very unique in the industry. Because at Aperam the CEO knows about the scrap dealings. #00:33:55-0#
EHK: I cannot judge for the others, but I can affirm to you that for us, it's of crucial importance that with the money that is spent, and with the experience that our CEO has on the sales side, he has a very good knowledge of both sides of the equation, on the purchasing side, on the selling side. This type of organisation was already in place since more than seven or eight years where at the time, when our CEO was not yet CEO but was responsible for commercial and distribution network, already at that time, the sourcing part was within the organisation of our actual CEO. #00:34:52-2#
PMH: Do you think this gives you an advantage? #00:34:55-2#
EHK: I think this gives us a practical and pragmatic advantage in terms of market intelligence and knowing what is going on on the sales side and how to react to that on the purchasing side or vice versa. #00:35:12-2#
PMH: Scrap is often used as an early bird indicator, a kind of forewarning system. The previous president of the US Fed Bernake, when he started his career, he was scrap. For him scrap was the thing to judge where the global economy was going. Is this something Aperam thinks as an early bird indicator that it uses? #00:35:57-1#

EHK: No, we don't consider it as early because it's on the raw materials side you can follow what's happening with the nickel and scrap you can't do that. In terms of scrap anyway, it's a monthly negotiation. It's not something that is here. You don't settle the price of scrap for the whole year. It's done month by month by month. It's linked of course with the different indicators that you have. What is the nickel doing in the previous month? What is the ferrochromium doing? But the actual negotiation is a monthly negotiation. It's not a negotiation that is done for longer term. You cannot go to a scrap dealer today and say, "I want to buy my scrap at that price for the next six months." #00:36:44-2#
PMH: But you could tell him, "I'll take this and this quantity." #00:36:49-0#
EHK: You will always have a commitment for a certain quantity, but you need to discuss the conditions that supplier on a monthly basis. It's a bit when we are dealing with a distributor or service center where you have monthly pricing and you can tell them in beginning of the year, "We want to work for x thousand pounds per month." But you need every month to discuss on the pricing and find a kind of market conform pricing that is leading to a deal and a contract accepted by both parties. #00:37:26-0#
PMH: If I listen to this, a fair amount of time of your CEO is spent with purchasing. #00:37:34-0#
EHK: Yeah. I can confirm this. #00:37:38-0#
PMH: I think this is very unique to Aperam. #00:37:40-2#
EHK: But is that linked to how the organisation is structured? Because on the one hand purchasing raw material and you have another department that's non-raw material purchasing. But the non-raw material purchasing, they're two different organisations. #00:38:03-0#
PMH: The department that buys the equipment, they report to the CEO? #00:38:09-2#
EHK: No, they report to the CTO. #00:38:11-1#
PMH: Because this answers kind of the next question for me. Are different approaches used for different commodities? Everything which is production related is linked to the CEO, and the rest is CTO. #00:38:37-0#
EHK: Yeah. So the raw material, let's say there was a specific organisation that is handling all the purchase of raw material. And everything that's non-raw material, it's separate in the organisation for. #00:38:51-2#
PMH: Thank you. Another one which for my PhD is important, how do you measure the effectiveness and monitor the results of different approaches? One you mentioned is buy stainless steel scrap with is nickel to and less pure nickel. And the other one is buy carbon scrap and more pure nickel. Is this done on a monthly basis, or is this according availability? #00:39:27-2#
EHK: This is part of the measuring the efficiency of the purchasing of raw material combined with efficiencies that we have on the production level. What is the most optimum? What is the impact on that on quality? So there is a fair detailed follow up of the different performances from a technical point of view. This is then shared with our suppliers. You can look at efficiency or productivity of certain scrap supply coming from one producer to the other. And then you can measure the efficiencies. That's my point. There is a whole list or portfolio of purchase/production indicators that allow us to measure the effectiveness of the supply of scrap or different products that are coming in. #00:40:38-2#
PMH: So the decision of scrap is not only done by purchase. It's done by operations. #00:40:44-1#
EHK: Operations is involved there because they have to deal with what is purchased. I don't have to tell you that when you have certain suppliers, you have different qualities. Even if you have some purchasing advantage on product supply on one supplier, if afterwards the effectiveness rate is not according to that, you can lose more. There's a whole TCO approach that is linked with that, and it allows us to adjust the purchasing strategy on the middle and the long term. So that is in place. So it's not only about price and such. But there's a fair amount of intelligence and common sense that goes into that and linked with the TCO model that allows us to make a good judgement on the efficiency of the purchasing in that sense. #00:41:51-2#
PMH: Do you have the impression Aperam is doing this very, very well? Do you think you are better than your competitors? #00:42:02-0#
EHK: For me, that's difficult to judge. I don't know how competitors are organised. What I know internally from Aperam is that a lot of valuable data and intelligence that we have gathered over the last ten, maybe 15 years by deploying the TCO approach gives us good basic information about how we are doing or how we can improve our performance in that respect. I cannot judge how the others are doing that. It would be an interesting feedback that you can get maybe from your feelings. #00:42:49-2#
PMH: This would not be an internal benchmark from Aperam towards the other suppliers in Europe or worldwide. #00:42:57-1#
EHK: I would assume that we doing things the right way. Giving the results that Aperam is/ And I don't know how much the results are linked with that. It's part of it. And I don't know neither how this is. Depends a bit how far you are upstream integrated. When you take some of our competitors who have a ferrochromium mine like

Outokumpu, they have a different type of set-up compared to what we have when you take overseas supplies. It's a different type of material/#00:43:42-0#
PMH: We come to that. #00:43:44-0#
EHK: Exactly, yes. For us, it's there trying to measure that efficiency compared to much more integrated mills. But that's very difficult to measure in a very transparent and effective way. Of course you don't have that data available. #00:44:09-1#
PMH: Mittal - They know how this works because they have the experience. #00:44:16-0#
EHK: They have experience but mostly the carbon steel, maybe not on the stainless steel. Mittal is there with the carbon steel. They're sitting in the mining industry. So they are much more integrated than we are in that respect. #00:44:33-1#
PMH: Coming a little bit more to the helicopter view, what is the greatest challenges your company faces when managing commodity prices? #00:44:45-0#
EHK: Of course as we said before, the greatest risk is the volatility. The volatility is influencing for a big part the purchasing behaviour of our customers specifically in the stock market. That's then concept of having what's the apparent consumption? What's the real consumption? And what is the stocking, de-stocking and re-stocking? The challenge is there to have a very good reading and knowledge of what's really happening into the market. Because in one way, in order for your load of your mills is going to be determined by the purchasing behaviour of the market. That's why Aperam has a strategy of trying to find a good mix between contract, and spot business, and end-user business, and service center business. If you can move up the part of the contract and the end-user business, this give you much more stability. #00:46:20-1#
PMH: But this is production-wise, yes? #00:46:23-1#
EHK: This is production-wise, but it's part of the strategy to see that we are mitigating that volatility by deploying a commercial strategy where we try to ban out the maximum possible way the volatility of the market. And that is linked, as I said, with your contract business versus spot business and end-user business versus spot distribution business that is there. #00:47:00-0# In that respect, it's very much linked with your mix. Today when the most volatility is linked with nickel. When you take the global product portfolio of Aperam, at least Aperam Europe, we have roughly between 30 and 35 percent of our load is linked with ferritic products, ferritic and austenitic products. So we have a relatively high share of products that are without nickel. So already there shifting that to a higher level, you already take away. That is then linked with that we have more contract business in the more assured segments that are for the/ #00:47:58-0#
PMH: Could in times where you see or experience a high volatility, are you more in a position to take stock? Is your behaviour towards inventory different? #00:48:18-2#
EHK: We try to have a stability in our stock position. So we have a view. For us stock goes from raw material up to finished product. That is, what is in our mill up to what is in our service centers. There from a risk perspective, we try to know what is the percentage of nickel that is in there. What part of that nickel? How is it priced? Is it stock that is not yet sold? Is it linked with contracts that we already have where the nickel is already/ #00:49:00-0# So it's a very detailed exercise and follow-up that is done on to determine which part of your stock, from raw material up to finished product, is at risk. And for that risk you take a certain position in are going to cover that risk by treasury, by financial instrument like hedging that part of nickel and do a rollover different type of hedging procedures that can be done in order to review that position, sell or buy more. On top of what I said before about the risk management by having contracts with effective prices without an exception always having a financial hedge of the nickel, we parallel to that have a position hedging of the part of your stock that is not sold and where we are at risk on that. #00:49:58-2#
PMH: That's very, very detailed. Volatility for you is very, very much nickel. #00:50:10-0#
EHK: Volatility for us is very much nickel. And it's linked with the side effects of the nickel, the behaviour of the expectation of a market towards/ We all know the moment when you work in distribution, the moment when the nickel is increasing, automatically you have a kind of restocking that's taking place. People want to be ahead of the nickel rise. On the contrary, you have a tendency to slow down your purchasing the moment when feel that nickel is dropping. Although the last couple of months the swings of nickel have not been that important, but everybody is looking to what the nickel is doing and is making decisions based on that. Everybody has his #00:51:00-0# own convictions how to deal with that. But you have to say that our market is very much aware of the risks that are there. With all the trial and errors and all the things that have been experienced in the past. The market has been getting quite prudent. You don't see anymore these excessive speculative buying when people think that nickel is going to increase. So there is more discipline at least in Europe in the market coming from the producers. As from the market participants, in this case the service centers and distributors where we see that part of #00:52:00-0# that market is willing and asking us to be much more agile on lead times and stocks. They try to push the risk upstream and ask from our organisation or producers that we keep certain stocks

available. That's we see a shift into the supply that's part of the volatility and how you would deal with that to instead producing orders MTO, making to order, that you're going to have a system that you're going to make to stock. This means that for a commodity product, instead of a customer giving you what he needs for next two or three months that he expects from you, that you keep that in one way or another available and when he needs it, he takes it and that he reduces his stock and #00:53:00-0# his exposure. This is something that today, we already are deploying into our supply chain. Given the fact that we have our fair share of volume through our own integrated service centers, we have that kind of supply chain system already in place for our own integrated service centers. With that difference that it's more an optimisation in our global supply chain not to put stocks everywhere but to put stocks at the right place into the company. So overall it's not that when you take the stock, the raw material, black rolled or slabs and stock at the mill for the service center. At the end, compared to where we were in MTO system and the whole system should be used to stock over the chain within Aperam parameter with 20 or 30 percent. And that's the deal with volatility. That the #00:54:00-0# amount of stock that we have is rotating faster but is smaller. So they're beyond having risk management in terms of raw material. You need to have parallel to that adaptive supply chain systems that allow you to be much more reactive to the market and increase your rotation internally by having a supply chain system that is putting the stocks at the right/ So for that, we have worked on different concepts. The supply chain concepts are more and more in place in our organisation between melt shop and hot roll mill, cold roll mill and our service centers at this. #00:54:49-1#
PMH: So it's a combination of reducing lead times, and reducing stocks, and keep the stocks at the right place. #00:54:59-0#
EHK: One of the things is when you talk about risks, we talk about volatility. But you talk about the lack of having adequate and very accurate and trustworthy forecast coming from the customer base. We can ask customers that are in contract business will give us a forecast of what they need from us for the next six months or eight months. This can be fine-tuned. You always know that the forecast is always not exact science. It's not mathematics after the comma. There is so much volatility in the demand. I think you're well aware of that being in the automotive business. At the end of the day, nobody cares. The forecast is there, but at the end of the day, when you need to have it tomorrow, and you said that you did it before for next week. You need to have it tomorrow and not next week. So that is the kind of volatility that we are faced with. And that is why we need supply chains that are flexible. #00:56:12-2#
PMH: This is supply chain. But this is the part of the business where you basically don't have a volatility in price because of the contract business. Either it's fixed, or you have the alloy surcharge system. #00:56:25-0#
EHK: There you are protected on that way. But more and more when your spot customers are willing to reduce their risk, they ask you to keep certain things. To have to be honest today, when I look at the different independent service centers and distributors Europeanwide, everybody is discussing to say that they need to reduce their stock, and they need to rely on the supplier. In one way or another, #00:57:00-0# the stock of service center is their weapon, is their strong point. When they have it, it sells. When they don't have it, it does not sell. And they don't have enough trust to the reliability of their suppliers. It's more exception that we find today distribution customers that want to work with us on a very transparent way of helping them to help them into the rotation and to take away part of their stock risk with our supply chain system. The rule is most of the independent service centers, their main asset is their stock. And they don't want to give that away, or don't want to put that at risk by relying on the producer. #00:57:52-0#
PMH: Is this more just understanding who is the owner structure? Because to understand the risk appetite of these companies. Is this more an owner-driven type of/ #00:58:07-1#
EHK: Most of that is linked with the family that is owning the company and owns their money. When you go to organisations which have a more corporate structure, they are as such under a lot of pressure on working capital, on risk. So they are more open to discuss this. When you go to a family owned company where in most cases it's the owner and the CEO are the family who's corporately active, they are less eager to give up their stock. #00:58:53-2#
PMH: Do you see, just making a guess, in Scandinavia people are typically more open to new ideas, that they take on the idea as you proposed, and in the southern part, in Italy, it's/ #00:59:11-0#
EHK: Yes, you that's the very true. Because there the biggest family-owned service centers are located in the south, and they are much more traditionally convinced that having a decent and a high stock will help them to sell. #00:59:26-2#
PMH: For me, this is a typical Italian thing because they not only for stainless steel, but for other products stock is the asset. #00:59:37-1#
EHK: Exactly. They fiscal systems that can help them to manage that. I would say the real trigger is the moment when you have a family-owned company, you make your own decisions, they do that mostly based on protecting their business-model by having a big stock, which will only guarantee that they can maintain certain sales. And

the moment that you go into companies that hv a more corporate structure with established procedures and are being squeezed in terms of working capital and margin, they are more eager to discuss and be open to such kind of ideas to reduce their stocks. But then they need a supplier that's reliable that they can always be sure that when they need it, that it's there. #01:00:33-2#
PMH: I'm just taking a couple of detours here. #01:00:35-1#
EHK: No problem. #01:00:36-1#
PMH: I think question number 20, why would commodity price volatility influence the profitablity of the company you are representing. I guess we discussed this one. Now we come to the big elephant in the room, which is Tshingshan the pronunciation is right. #01:00:58-1#
EHK: I'm not a specialist either in Chinese. #01:01:01-0#
PMH: You mentioned this. So they're upstream integrated. In a way, they don't care about LME nickel prices because they have it all. It's all in their backyard. They control the production costs. They control the excavation costs. Do you think this will change the stainless steel world? #01:01:29-0#
EHK: I think it's seen as a big game changer. I don't know for you the first time that you heard about Tshingshan but it is stainless steel industry. And their impact is something that is not more than two, three, four years ago. It's relatively recent. They came on very fast. On that, it's clear that they have numerous #01:02:00-0# advantages compared to the classical, even Asian, producers in that way. On the other hand, this is coming more into the trade defense the part of the political area. Where you can ask yourself questions how a company like Tshingshan was able to position themselves very strongly into Indonesia in an industry that is in terms of ethics, labour rights, social rights, CO2, climate change and so on. They not necessarily are working with the same kind of constraints that #01:03:00-0# we have as a European-based stock exchange company who has to comply with a lot of rules which are not necessarily applicable for Tsingshan. That's an argument that can be used towards European commission to say this is a threat. That threat is coming into our market. What do we do about it? Today Tshingshan in Indonesia for instance is not into the safeguards due to the fact that they only recently started. But we need to build a strong case around the disruption that they could bring into the market. Is it fair trade? Is it a level playing field? There are some issues that we need to tackle on the political side. #01:03:57-1#
PMH: Corporate, social responsibility is one topic. Capacity is one. Another one for this research, it's more about the price setting because they have the price in their hands. And if we go back in the steel industry, not necessarily stainless, steel industry in Europe, everywhere, basically this was where the mining was. Because of the coal the energy. In the beginning, all of the mills have been basically backwards integrated. Then there was a big shift, like yourself. You don't have a mine. You don't have a scrap dealer, all these kind of things. You think this is going in the direction of being backwards integrated again? #01:04:48-2#
EHK: I don't think so. I think even if we would be interested to backwards integrate, I don't think we will have the financial means. Or the investment would be too big. You can invest into a nickel mine and chromium mines and so on. But that's not part of our today's portfolio. I'm afraid that this will be, at least I talk about Aperam, other European producers, it would from a financial point of view be a leap too high or too big to tackle. The model that has been put now in place by Tshingshan is really linked with the Indonesia because in the past Indonesia was a big export of nickel pig iron and so on. They said we have to value the raw material that is in our country, and that triggered that kind of discussions with Tsingshan that they said, "Okay. We're going to put our mills, or at least the production, in the place where you have the raw material." #01:06:02-2#
PMH: So it basically was a trade barrier? #01:06:07-1#
EHK: Trade barrier that created this push. I mean, I don't see that as realistic even not for certain Asian producers. Or at least not for European producers beside the ferrochromium mines of Outokumpu. There is nothing that today we will not dig here into the ground and will find some nickel. That will not be the case. But I personally don't think that this will lead to that we will find now new place coming in the market having the same business-model as Tsingshan. We know that Indonesia, they were beyond Tsingshan, there are some others that are considering investments there. This could go up to, today I think they have the capacity to be doing two and three million, maybe it could go up to five or six million. There are some two or three others that are investigating. #01:07:09-1#
PMH: I think Tsingshan they want to go into the direction of eight to ten million tons of capacity. #01:07:13-0#
EHK: That is a long term/ We'll see if they will be able to/ Anyway somewhere they could be with the trade barrier, anti-dumping that's now been developed by the Chinese government. But this could reduce a bit there in the sharp increase in the production that is taking place in Indonesia. #01:07:40-1#
PMH: So it's again trade barriers. #01:07:44-1#
EHK: In our industry, I said before when I mentioned the big challenges and risk, I think the political factor and the trade defense, and linked with that is going to play a much more important role in the future than it has done in the past. #01:08:00-0#

PMH: So it's the free flow of goods, we will not see anymore. #01:08:06-0#
EHK: We will be restricted. And you see clearly just an example of the safeguards in Europe that in one way or another, when these things are in place, the importers are somewhat trying to influence and to steer and manage their flows not to be on the risk side. #01:08:35-0#
PMH: I think into the European Union we have about 30 percent of imports right now. Do you think this is the right level for Europe? #01:08:43-1#
EHK: When you take in Europe, you take the figures of 2018 and you have to make the distinction between hot rolled and cold rolled. When you take hot rolled, including hot-rolled band, so the black coil, the import level was between I would say 35 to 40 percent. And the majority part of the imports are black coil and are coming from China, Indonesia and are going to basically one customer, which is Marcegaglia. Because they have shifted a big part of their black oil supply outside of Europe on top of what they already do with Terni. But that part is diminishing. And this is accounting for when you take the control market in Europe, about between 350 and 400 thousand tons a year. On the other part you have the cold rolled. And cold rolled, you have an import in 2018 that was between #01:10:00-0# around 25 and 30 percent low/high. And average is 27, 28 percent. Which means, the tons behind that, it's around 1.2 million tons a year, which is a big number. It's the production of a company practically as Aperam. Today, is that the maximum? Can they go beyond that? I think with the measures that have been taken now with the safeguards will diminish for a part the imports because they are much more capped. That is an indirect impact with the heavy imports. The pricing on the spot market in Europe has somewhat been #01:11:00-0# influenced by the import pricing. And the moment when you have a certain gap between import and European prices, and that gap is considered as correct by the local customers, they prefer to buy from Europe. I would think that there we have seen hopefully with the maximum that is feasible in terms of/ Because we already have seen when you go, we have already the figures from the first quarter of 2019. And you see that the global market in Europe, in terms of apparent consumption, compared to q1 2018, has dropped with practically ten percent. So this is indicating a kind of de-stocking phase in the apparent consumption. #01:12:00-0# Whereas when you take the, I talk about cold rolled now, about the market supply from the European domestic mills into the market, q1 has reduced with 3 to 4 percent when compared with q1 2018. And the import volumes coming from export have decreased with 30 to 35 percent compared to q1. So already there, the import part for the time being is significantly lower than we we one year ago. But that's q1. We'll pick up a bit i think during q2, but will not reach the same levels of 2018, linked partially with the safeguards, linked with the de-stocking in Europe, linked with demand. Today in the market that is less robust as we had it one year ago. And the safeguards are in place for minimum up to 2021 or 2022. So that will reshift a bit the balance between import and domestic supply. #01:13:12-2#
PMH: I will now make a second recording because otherwise/ #01:13:18-0#

<u>Internal hint, second recording</u>
PMH: We have the second recording now. So we have the LME, the challenges, the price volatility, changes in consumption of things, development and challenges of the stainless industry. We touched a lot on this. You gave a couple of hints already. Trade restrictions did increase. You forsee even more trade restrictions coming into the steel industry. #00:00:37-0#
EHK: We seem even more strict. So just as an example we have the trade restrictions that were applied in China for hot rolled, that Korea is considering having import restrictions going into the South Korean market. We have #00:01:00-0# within Europe the extension of the safeguards including Indonesia in that way. We the rediscussion on the anti-dumping tariffs in Europe existing today for China and #ave cont-n#d to have the section 232 into the US where there seems not to be any movement on the side of the governments as well in Europe commission or the Trump administration that there will be some relaxation on the issue. that will be there for longer than we exepected. We have, and this will only count in Brazil, #00:02:00-0# the market is traditionally protected and will continue to be protected going forward. Even if the actual government may be a little bit more liberal, there it seems that there will not be a big movement on that part. As I said, these trade defense mechanisms will be there for the next period. That's for sure. #00:02:27-1#
PMH: Question for you is, is this changing the investments you're long-term planning? #00:02:37-2#
EHK: Well there are two things about that to say. On the first hand, you know that Aperam was intending to widen the scope by the acquisition of VDM, which at the end was not done due to the fact that there were #00:03:00-0# too much restrictions imposed by the European commission which didn't make this a viable project. When you add it up the advantages was not a business case that would fulfill the expectations that we had with the planned investment. And this mainly linked with the fact in that day, European commission was too much focusing on the impact on the European market and less on the fact that this could create a kind of champion on the global level. There you see that the policy of the European commission is more going into the direction where

they block development of certain metal and steel companies into Europe by the fact that they are not willing to accept that we are #00:04:00-0# operating in a global market, rather than being only on the European market. So this was a dissapointment for Aperam in terms of widening the scope and having an interesting and intelligent investment by having a portfolio that was for us, much more interesting in terms of set up because you going much more to specialty markets and to growing markets. And that would help us to be better and help us to have a more interesting portfolio. Does that change in general? I would say that's the second part of the answer, the investment policy of the company. Not necessarily because we have maintained the investment that was already decided on the cold roll mill and the new pickling line in Genk. So that has been confirmed and that is in preparation. Because we think that the consumption with stainless steel will continue to grow. #00:05:09-2#
PMH: Even in Europe? #00:05:10-2#
EHK: Even in Europe. We still have consumption growth of between 1.5 and 2, 2.5 percent for that. The investment is not partly responding to a growing consumption of stainless steel. But building the future because when you do an investment like this, most of these investments are not investments that you have for five or ten years. These lines are mostly for a scope of a timeline that go beyond 30, 40 years. When look at the actual lines are in today in our mills, they have been investment in the 70s and 80s. Such kind of investments are longer term. So we have to look beyond with we consider #00:06:00-0# as being the short-term outlook because we need to see that with the investment all the capacities could be idled. Other capacities could be stopped within Aperam. That's important there to prepare the future. And this is not only adding capacity. This is more trying to regulate the capacities within the company and putting your money into the most efficient and the most cost competitive lines that we have within our mills. #00:06:47-2#
PMH: Would Aperam see themselves as a class leader in Europe from a production perspective? #00:07:00-1#
EHK: We strive to be the most cost competitive. We have one handicap is the fact that we are not fully integrated. So we have mills and between upstream and downstream, we have the four mills Genk, Charleroi,Isbuerges and Gueugnon. Between upstream and downstream, slabs have to be produced in Genk have to go to Chatelet for hot rolling, and then afterward being dispatched in the different cold roll mills. Compared to our competition with being an integrated mill. But on the other hand, that's not feasible to put everything in one spot. When you could start to begin from scratch, yes, that's what you would do. But that's the historical heritage #00:08:00-0# that you have, so there is no way to escape from that. Today it's important to know where is the market consumption of stainless steel in Europe? When you go from Catalunia and northern Italy and you go to eastern Europe and you go to the south of Sweden, and Denmark, and the UK. That's a radius of 700, 800 kilometers around our production facilities. So there you capture more than two third of the stainless steel consumption. Even the cost of having a non-integrated mill, extra cost on that is partially mitigated by the fact that the consumption of the final products are done within a fair distance of our production facilities. When you take our competition, when you take Algacieras, when you take Terni, when they have to come in these markets, the cost of bringing the material to the place where it should be is adding up to their advantage of being integrated. So there we have some advantage. In the stainless steel business that's our addition points. You have a capacity. You have the cost of maintaining that capacity. But the real trigger is, how do you use that capacity? Even if you have in your melt shop a capacity that is going beyond two million tons, we don't use the full capacity. So we have a structure that is using the capacity and the flexibility at the optimum. So we are having structure around that that allows us to not maintaining a capacity or structure that would produce 2.2 million #00:10:00-0# tons, but a structure that is using the capacity for the capacity that we need it for, 1.4, 1.5 million tons. Downstream you have capacities on the annealing and pickling and cold rolling lines. But we not using all these capacities because we have what we call core tools. These are the tools that are running seven days a week, 24 hours a day. And we have what we call swing tools. These tools are not used. They are used in the moment when the market is there, and you need to put there the flexibility to ramp it up and close it down. So this means that just as an example comparing it to last year, we have closed down compared to 2018 three lines that were active last year because we had a very higher demand due the market. But where we decided going into 2019, with a weaker demand #00:11:00-0# we were able then to reduce our footprint by shifting these swing tools from operation into mothball (keeping available but not actively using, remark PMH). That's important to underline that you need to use your capacity in a flexible and dynamic way. Using all the debt capacity that you really need. So the volume thinking is that we don't necessarily have to fill our melt shop with 100%. We don't have necessarily to fill our cold roll equipment with 100%. We just have to adapt flexibly enough as quickly as possible the footprint in order to respond to the needs of the market. #00:11:56-0#
PMH: This comes back to reducing lead times and keeping the inventory where it should be. #00:12:00-2#
EHK: That's a big part of that equation. #00:12:03-1#
PMH: Is this something sales would decide, or is this operational management? #00:12:11-1#

EHK: Well we have within Aperam what we call a “sales and operational planning. It's a process that is quite established where the process is adopted going from what we think we have in terms of demand management. And based on that, we are fitting that with what are our additional capabilities or our capacity. There see compared to what we think the market is doing, do we have enough or too much capacity? What do we do? This is mill by mill with #00:13:00-0# the loading of upstream. For instance, first we'll use the capacity that we have at the melt shop in Chatelet because it's close to the melt shop. And Genk has two melt shop. So we can use one melt shop fully and the other as a kind of buffer. So there is a whole process behind it to determine clearly what are the needs of the market and the best of our possibilities and how this is fit with the industrial capabilities. The needs of the market is expressed to what is contract business. How are these contracts running? We embed it into our budget. And then we have between 60 and 70 percent of distingtive with contracts, you know we have assured our stability. On the other hand how does it fit with the spot business? You have to arbitrate on that maybe 30 or 40 percent. This is a process that is quite embedded into our rituals. We have every week a follow-up of the longer term planning and the short-term plan. Every Tuesday morning, we have between sales and operations hang out, skype maybe 30 minutes where we are going into the very detailed planning of each mill. "This is what we have planned for the month of June. We have x tons by segment and by customer. Is the fill-up rate of that planning, is that according to plan? Or why is not according to plan? Why it's less? Why it's more?" So we have a very detailed for a lot of data. And we can adapt. #00:14:55-2#
PMH: And then you could go out and say, "We need some spot orders." #00:14:58-2#
EHK: It's possible to take some spot orders and function of your policy. Do we want to be aggressive, or do we want to support a market, or do we have an incident into our operations where we accumulating late orders? And then it's better not to sell capacity, but to use the capacity that is free to recuperate on the late orders. So it's all these kind of decisions that we did within that S&P process. Where we are trying to plan in function of the demand that we see. But then we have very strong micro-planning that allows us to follow-up if what we think will be the reality, if that is the reality on the front. #00:15:45-2#
PMH: I will speed up because I'm a little bit time-conscious here. I think we touched on the consequences of the increased Asian production capacities. But one thought I'd like to have from you, are you expecting that the stainless steel industry is dominated by companies from Asia and China in the future? #00:16:10-1#
EHK: Yes. Because today I think we always have to put things in perspective. Europe today with the consumption of 4.5 million tons, it's nothing compared to what's happening in Asia. And the production today in Asia is representing more than, when you take China and non China it's close to two third of worldwide consumptions. So that says everything. #00:16:42-2#
PMH: My next question would be perspective dominating trends and developments. You said you're expecting more limitations in the free flow of products. You're expecting more tariff barriers in your environment. Do you think you will take advantage of these trade barriers or disadvantaged in total? #00:17:09-1#
EHK: In our mindset, trade barriers will not help us to become a better company. We should always think into operation to what we do that there are no trade barriers. And trade barriers are just to create a level playing field. Because the disadvantage of having a strong trade defence and trade barriers is that you get lazy. And that's something that we have to avoid. The structure of the European rules are more liberal than what is happening in Brazil or the United States. So we don't count on these trade barriers to help us. But this can give us at least some advantages that we at least can fight one or the other with the same weapons. So we are not overly-convinced that these trade defense measures will double our profits, or will double our volume, or we never know. It's something that is only creating a level playing field. It's not something that will have such a positive effect that we can now do everything that we want to. #00:18:31-0#
PMH: For example in the US, it's kind of an open secret that AK Steel, they're the ones pushing for more trade restrictions. And even in their last year annual report in the first page they praised the President for the introduction of US 232 trade restrictions. So you don't see this happening for Aperam? #00:18:56-2#
EHK: With Aperam, not even for the European users. It's not in our cultural neither. The decision processes in Europe are quite complicated and looking, taking time and looking for consensus between the different member states. I don't know what will happen with the Brexit. It's another factor of insecurity, at least over the next/ month until October. How will that influence when they go out of the European Union? How will that influence the trade defense and mechanisms in Europe? #00:19:45-2#
PMH: But that's the interesting question because my perspective was it will not change much because they don't have a big industry to protect anymore. Because the British stainless steel industry is basically owned by Outokumpu and there's not much production left. But if there are safeguard measures, Great Britan could be victim of the safeguard measures if we trade union. #00:20:16-0#
EHK: Or they could be like Norway who's not on either in the European/ The could maybe rely more on imports. Those are possibilities. #00:20:24-1#

PMH: But another interesting point is not for flat products but for long products is Switzerland. They are not part of the European Union, but they're an important player for stainless steel and long products. So that was an interesting one. 26, we mentioned that your CEO was involved in these scrap purchases. And then we come now back again to price mitigation. Do you think the price volatility is a risk or an opportunity to the stainless steel industry? #00:21:09-2#

EHK: I think it's more a risk. Volatility could drive speculation, but that's more on the spot side and on the side of distribution and service center with these cycles, stock, de-stock, re-stocking cycles and so on. It's a risk side on the development of the user stainless steel because it could be seen as a kind of/ That's a bit what we have when we discuss about customers who want to go from another material to stainless. It's a much more easy discussion when you talk about ferritic because it's less volatile. It always comes down to nickel and how to mitigate that. #00:22:00-0# So this volatility is more a barrier in the further development of stainless steel in the industry. There the price volatility has more disadvantages than advantages. #00:22:28-0#

PMH: What could Aperam offer to smoothen this out? #00:22:38-2#

EHK: Basically what we do is we promote a ferritic offer for products where the properties of ferritic could reply to the technical specification. That's something that we have already done in the past #00:23:00-0# and we continue to do. Going more into a supply chain system that is taking away the risk from the customer and where we have taking part of the risk and manage that risk internally. That we keep the stock as much as possible, higher in the supply chain. But that comes down back to the fact that the availability could be assured. In one way or another, you price your material if it's coming from stock or it's going on order. One and all you have to, when the nickel is 15,000 dollar, you cannot sell it at 12,000 or 10,000. It's not possible. But as long as we continue to experience this volatility in #00:24:00-1# the nickel, our market will be driven by that. So the two things that are set, it's going into less nickel bearing products within stainless steel and having a supply chain that could maybe reduce the risk exposure of our customers. But that helps maybe for the end-users or the contracts. That's less evident to do with distribution. #00:24:37-2#

PMH: Talking about this alloy surcharge system, a company like Outokumpu is offering different systems. A daily alloy surcharge. Is this something that you think will change the market behaviour? #00:24:54-1#

EHK: It already changed the market behaviour in the past the moment Outokumpu published the “DAS” the daily surcharge. It already triggered a lot of other side effects that at the end has led to, in the spot market where instead of having base plus alloy, we more and more having effective prices. But influenced by the import price gap and the fact that customers are more expecting to have a price that is conformative with the global market. That's the topic. Today you have different types of how you price it and having a different kind of surcharge system. But basically for the majority part of the business that is done in the nickel bearing materials, you have or talking about the base price and have the alloy-surcharge that is published. Or you discuss at the moment when you take the order an effective price which is basically however you calculate, it's an effective price. Afterwards, you can't do whatever exercise with what is the “DAS” of the day, what is the multi-surcharge and so on. At the end of the day, it's an effective price that is discussed, and that is the reference for the customer who's buying it. #00:26:22-1#

PMH: Do you see this will take more share of your business having in mind companies like Tsingshan who control everything? #00:26:32-1#

EHK: This already has a big share of our business for the day. There is a big movement in the spot industry where you shift from base plus alloy to effective price. Our objective or goal is to go back into a certain, more normalised situation where you have a more base price and a surcharge. But with the different threats that we have in terms of import with the Tsingshan effect and with international pricing being much more driven by effective price than base plus alloy. We probably have turned a page in the industry where the effective price is more the standard. Because at the end of the day, that's the real reality. When we sell to a distribution or to a service center or to distributors, they're selling to their market on effective price. And that is a more reflection of how the market is ticking than a traditional way of pricing. #00:27:38-0#

PMH: Now going back into the helicopter view again, you say one of the situations that have been critical for your company in regard to price volatility. Can that be linked to either natural disasters, or financial crisises, or something like this? #00:27:59-0#

EHK: We have seen, but that's the case in more than ten years ago when you had the spike of the nickel and linked with the financial markets and the collapse of some financial institutions in the US. This has been a clear token and proof that there is a link between these commodities and speculation and the state of the financial market. #00:28:35-1#

PMH: Before this event with Lehmann Brothers financial crisis, did you have the same risk measurement procedures in place as before? #00:28:47-1#

EHK: No, it changed a lot. Following that experience that we have/ Because between 2008, 2009 and 2013, 2014, our industry was in a very bad shape. We went through a lot restriction. If I see only the footprint and the restriction that's taking place in the stainless steel industry, with the capacities that were in place before 2008 and now, you have seen a lot of rationalisation, close down of melt shops, close down of controlling equipment, close down of compete of mills. So we came to a rationalisation where today we don't see any new investments beside of what we're doing here. But the industry in Europe saying industry is rather consolidating what we have reather than that expanding, investing heavily into new/ #00:30:00-0# This is I think lessons learned over the last years that capacity-wise, Europe has, in order to serve the local markets, sufficient capacity and doesn't need to invest heavily into new capacities in order to respond to the European demand. #00:30:21-0#
PMH: Coming back to these financial crisis, you think this was for Aperam a trigger to introduce risk management in a completely different way? #00:30:32-0#
EHK: Yes. I think then we have installed, and have learned by doing trial and error, different procedures in order to measure your risk of stock, working capital, adopting supply chain systems that allow you to be much more reactive and much more efficient into the management of your operations. #00:31:00-0# Completely change the mentality on risk mangement in terms of nickel hedging, in terms of hedging of your risk in currency and so on. So all the things that we discussed before, and the more procedures that we put in place, is a direct result of the bad experience that was done since the last big crisis of 2008, 2009. Or the measures taken in terms of footprint and restriction has all been triggered by the bigger financial problems that were arising since 2008. #00:31:40-2#
PMH: If I go back to Aperam yourself you said you are pretty decentralised in a good or a bad way. I remember I don't know how many years back, you had a big fire. Is this something where you say this is now par? Did this change something in your risk management? Or was this already included in your risk management? #00:32:05-0#
EHK: Well the fire at the time, that was at the pickling line in Gueugnon. So there in terms of risk management and this part of when you do the certification for IATF. So they ask you what is your back-up plan when one of your lines is/ So we have in place indeed a formalised plan where the moment when we have a problem with a melt shop, with a hotstrip mill, the annealing and pickling line, cold rolled mill. And for each of these scenarios we have a plan ready to say this is the mitigation. So when we have a problem with the hot strip mill, we have a back-up plan. We had some problems in the past with Chatelet. There we have had a back-up plan we'd be broken. #00:33:04-0#
PMH: But was this after the disaster? Or was this already before the fire? Or was this because of the IATF certification? #00:33:13-2#
EHK: It was part of something not really to do with the financial crisis. It was an issue that was triggered with the fire in Guegnon. But it's part of a global risk management. Every year we have a routine where this triggered by our audit department and risk management department where we have to qualify the different risks that we see as for business that can go industry risks, that can go trade risks that can go among payment risks and so on. Part of that is reliability of tools. #00:33:57-2#
PMH: Is there company-wide risk mapping? #00:34:01-1#
EHK: Company-wide risk mapping, and based on that you need to build mitigation plans which allow you to manage that risk in an organised way. #00:34:15-2#
PMH: Was this Aperam risk mapping triggered by a special event? #00:34:22-1#

EHK: It was not triggered by a special event. It was more something that we had to adhere to the moment when we had a spinoff from ArcelorMittal in 2011. So we were not anymore within the ArcelorMittal group. We were on the stock exchange market, and there you have to comply with certain expectations of the financial markets that you manage your business risks. That started all the internal #00:35:00-0# procedures and initiatives in order to do that risk mapping. And that is much more linked with the fact that we went on our own and we were spinned off, and we had our own future in hands and our own responsibilities to take in terms of with our shareholders. That was more the trigger to continue to go. That linked with IATF and other organisms that push you to have that. #00:35:35-1#
PMH: The last two questions would be, could you recommend a mix of tools or methods to off set this price range? You mentioned the reduction of inventory. #00:35:51-0#
EHK: Business portfolio management where we talk about between spot and being contracts, between ferritic and austenitic products. And this comes back to the discussion of your product mix. We tend to go more and more to more specialised products. I wouldn't say niche products but higher range products where you find less volatility than when you are in a commodity field, commodity market. We call that de-commodisation of our portfolio. So through product development and putting more efforts into that part by extending our product

range by adding products that are on the market but we didn't produce before, like duplex, super duplex, 48, 38, a new product like K44X, all these kind of things. Let's say we worked diligently in improving our product offer. This is part of the mitigation plan in order to be less exposed to volatility of the commodity market. #00:37:17-2#
PMH: Last question would be, would you recommend any literature for me on price volatility? #00:37:28-2#
EHK: It's a good question, but I don't have any very specialised literature that is in place. I think the most valuable input, I think you will get through the different interviews you are doing and learning from the practice. #00:37:58-0#
PMH: Yeah. For me, it's as something out there, a mix of tool combined method a pure method that can help to mitigate it. Because price volatility, and this came from my questionnaires as well, for two thirds, it's a problem. This is their main risk. And for again about 60, 70 percent it is risk, not an opportunity. If you break it down, it comes to your findings. The distribution, they think it's an opportunity because they always think they can outpace the market. They're the clever ones. #00:38:36-1#
EHK: Thinking sometimes they make good decisions, sometimes they less good decisions. But I don't have in mind a kind of book that I have read where I say, "This you should read because then you have all the answers to your questions." But when I come across it, I will certainly share it with you, but I don't have it. I don't have any specific literature that I can recommend to you that is useful. #00:39:08-1#
PMH: Then again, thank you very much for your time. #00:39:11-0#
EHK: It's my pleasure. #00:39:12-1#
PMH: And would you be interested to have a copy of the report later? #00:39:17-2#
EHK: We very glad to have a copy of the report. It would for me be very useful to see what, based on the very extensive questionaire and the topics that you have raised, to see what comes out of that because those are very interesting for us. #00:39:33-1#
PMH: It will take a couple of weeks, months, years. #00:39:36-2#
EHK: No, no. I hope by the time that you are publishing your report, that the market hasn't changed that much that you can restart again. #00:39:46-0#
PMH: No, certainly not. Thank you very much. #00:39:50-2#
EHK: Yeah, my pleasure. #00:39:53-1#

Interview AK Steel

May 8th in West Chester / Ohio, USA
Interview with Dan W. Lebherz / AK Steel
Manger Speciality Products & Markets
PMH: Dan, how to avoid commodity price volatility?

Dan: To mitigate commodity price volatility AK Steel is offering annual contracts for some customers, the base price is fixed, and an alloy surcharge is applied. This is giving the advantage of price mitigation through the system of a variable and a fixed price element. The variable price part includes the alloy surcharge, the electrode surcharge and quarterly adjusted freight rates. This system is applicable for stainless-steel contracts only (not for carbon steel contracts)
There is no other exposure to mitigate the price risk besides by annual contracts. These always include the fluctuation of the alloy surcharge, only the mills AS is applicable. In Europe they might have done things differently from the US.
Remark of interviewer that the bigger stainless-steel trading corporations, like Thyssen and Klöckner are publishing a separate AS list. But the list is part of the negotiation and different options are available.

Interview Questions & Answers
4. What types of price volatile commodities does your organization directly purchase?
Dan: Nickel, scrap, Molybdenum, Ferrochrome, stainless-steel scrap and electrodes are price volatile elements of the raw materials used in the stainless-steel production. Not all of these commodities are purchased with a firm/fixed order or by an annual price agreement. Some are spot buys. Because you cannot fix the prices very well in advance. Only a portion of the actual consumption is locked in some not. It is like a hedging strategy.

5: How important are these commodities to your organization?
Dan:Very important this might range up to 80% or 60% depending of the material grades and other variables

6. Approximately what percent of your organization's overall spend is accounted for by these commodities?
Dan: It is a very high share in particular if energy is included as well. It is not possible to hedge energy completely (see above for percentages)

7: The company you are representing is potentially experiencing market risks? Which are the risks you are expecting in the near future?

d. How did these risks change in recent years?
e. Examples: Competition from Asia, economic uncertainty, price volatility, worsening of the own cost base
f. Which substitution developments have you experienced?

Dan: In February it was going down (the AS), Nickel is under decline, carbon scrap is down short-term. June prices (AS) prices are most likely down, this has a direct impact on the bottom line. But the mill is respecting the long-term contractual situation, there is a high base load in the mill (utilization rate). The mill has a good idea about the upcoming requirements due to the substantial amount of contractual business. The mill has a good visibility (due to contracts). The current material through put is 12-15 weeks. What it means is that mill carries quarter to quarter inventory (RM to finished product). Example Ferrochrome was high in Q2/2018 and went down 3 consecutive quarters- higher costs and lower selling prices (the input material is more expensive than at the invoicing date). Material melted in February is sold now.
NAS (Stainless-steel producer in Kentucky, part of ACX Group / Spain) at the river location can take large barges and might have shorter inventory cycles, better match between as the buying and selling price. AK is tight up with longer supply chains and has to connect these to the auto business. NAS & OTK have fewer contractual business, if steel is ordered they produce, if no orders are existing, they stop the production. AS example if they have orders of 5k tons and 10ktons capacity the utilization rate is 50%, there is no stock, they have to mitigate the cost of underutilization versus stock costs.

Remark of Dan:
OTK published the financial reports, the sales policy in the US is driven by carbon steel guys and thus follows this path.
(OTK stated lower sales base prices in the US Q1/2019 versus Q4/2018 which is not explainable with the current market conditions- see below US 232 etc.) This remark was added after the interview was conducted.

Example: Annual contracts for the white goods industry

Dan: The volatility of the RM is rooted in China, in total the RM did not change so much, but the timing and the locations of usage caused short term disruptions, if a new furnace is starting there is an immediate demand for RM. In the past the RM have been feed to Japan and South Korea time and value have been stable. Now there is a giant “sucking” (commodity demand) from China. The material flow (to China) & spot prices increased since the early 2000`s and continuous to go on. It was not a massive increase now, but the supply chain is in place to, there is a different buying pattern there is no pull from one to the other one, it seems to stabilize to an extent. Long-term (purchases of raw materials) are only possible with a (price) premium (as the mining companies are interested in the spot opportunities) as the complete risk is with the mining industry therefore there is a premium (to the price)
c) AK Steel is a victim of substitution (of primary Nickel) as the NPIG (Nickel pig iron) is substituting the prime Nickel for those who can use it in the production process (NPIG)

Remark of Dan: ATI is bringing slabs made from NPIG from Indonesia.
Dan: Ak Steel never used NPIG, it would be difficult to approve these deals (use of NPIG) as it would involve a different technology (production). Additionally, the “refining” of NPIG is energy intensive and is polluting the environment. As there is hardly any environmental protection in Indonesia (home base of Tsingshan) and this is the reason for a pollution of the environment.
(These aspects are not covered when considering the costs of making stainless-steel in Asia)
8: Does your organization have a standardized process for managing commodity price risk?
Dan: No answer initially. Certain hedging strategies are practically in place. The commercial department could recommend using a hedging strategy for special contracts but there is no guarantee that the purchase department will or has to follow this suggestion. In the past there have been commercial sales contracts with a hedge of the raw materials in the background.
9: What approaches / Which methods does your company use to manage commodity price risk?

Dan: Contract strategy is a part of it (to mitigate commodity price volatility), use of single versus multiple sourcing, the use of external indexes, like Platt´s or fixed prices, for Ferrochrome which index is used as multiple exist (decision of the mill to select an index that is in “favour” of the own requirements), same for carbon scrap and Iron Ore
The Dearborn plant is experiencing winter harbour closures (due to the cold climate) hence the plant is placing inventory on the ground is hence taking by this method a physical hedging position for approx. 3 months. (AK) owns now own coal mines some came from the acquisition of the US mills from Severstal. There is a coking coal strategy, there is currency hedging in place, but only for booked business to mitigate the price risk?
10: How do you determine which approaches to use?

Dan: No answer was “granted”
11: Are different approaches used for different commodities?
Dan: believes there is, because if nothing else as it differs from commodity to commodity.
12: How do you measure the effectiveness and monitor the results of these approaches?

Dan: Potentially, forecast versus actual of the annual costs
13 What does you company do really well when managing price risk?
Dan: Nothing, there is room for improvement
14: What are the greatest challenges your company faces when managing commodity price risk?
unanticipated natural disasters like the dam leakage in Brazil, mayor disruptions like earth quakes
15: Over the last three years, what trends have you seen in the approaches used to manage price risk?
Dan: As an organization, we have brought in people that better understands what the objectives are what hedging strategies should work, we as AK insourced expertise in the last 3-5 years.
16: What trends do you think will occur in the next three years?
Dan: Accounting – is the place to support, continue to utilize the current system
17: Compared to your competitor do you think you are managing price volatility in a special way and if so, what is different?

Dan: We have not been a company with a global footprint and have had little awareness other than the US perspective. This is as well applicable for the cost structure and - base and the input of raw material (Us perspective). 30 years ago, Avesta (now OTK) has had a global awareness, more than any other company (located and sales in several countries), it was different at that time.
18. The purchase of raw material is handled by which function in your organization?

Dan: No answer, from the procurement department, not from the CEO directly but he would be “heavily involved”
19. Which influence has a stable price situation versus a volatile price situation for your company?

This Q was not discussed in detail

20. Why would commodity price volatility influence the profitability of the company you are representing?

see the answers earlier in this interview

21: Which could be the influence of producers like Tsingshan – who controls the mining / excavation costs- will they play a more important role in the future? (backward integration)

c. What could be the reason for stainless-steel producers to integrated backwards?
d. Will the LME pricing continue to be a reference for the raw material costs -(Nickel?)- the alloy surcharge?

Dan: The exemptions request of ATI was denied (so they will have to pay 25% tariffs on the slab imports from Tsingshan of Indonesia authors note—ATI formed a JV with Tsingshan- to combine the “cheap” production costs in Indonesia and the processing of the slabs in the USA), there has been no tremendous impact in the last 2 years, looking into the longer-term future (decades) the environmental protection costs even in the developing countries will raise and will equalize. This will pay the price to balance the existing costs differences (Dan´s remark).
(Talking about the tariff differences in the NAFTA region (Mexico and Canada- authors note)
It was the idea of Nafta to have a common trade region with equal import tariffs, but Mexico did take advantage of the “cheap” labour costs. The raise in education, health and safety regulation and particular for the worker wages did not happen, that is why manufacturing jobs in the USA have moved to Mexico in particular. If the

labour forces would have experienced higher raise and could come to a similar level than the US wages, there would not have been a big switch from labour intensive manufacturing from the USA towards Mexico. This same situation does happen with the situation in Indonesia (Tsingshan) the “dirty” jobs have been moved to these countries to the disadvantage of the labour force. This development is, this cost advantage is possible “on the backs” of the working people.
(Back to Mexico situation)
It would be easier if the Mexican government would be able to restrict the imports (of steel) so the cost base would be the same (as in the US) . This is why there will be a push back (Dan expects the tariffs to be implemented for components as well- Steel can be imported to Mexico and manufactured to components and sold without tariffs to the USA. This is giving Mexico and Canada an additional cost advantages in the disfavour of US based companies).
Backward investments, this would mean huge investments in new markets and applications, cost advantages could go up to 50 to 75% that might cause/see substitution
The supply chain is still full of risks… The producer has high fixed costs on the stainless-steel slabs that have to meet market prices versus the costs of the excavation and processing costs (mining and the processing to ingredients ready to use in the stainless-steel production)
If the LME will still be THE reference is unknown, it might become a different index. The LME (Nickel) is fulfilling a market need for a transparent pricing for the industry right now
22. Will the price volatility change the consumption of stainless-steel?

see above
23. Thinking about the current implementation of trade barriers like Anti-dumping cases and the section 232 in the USA what are you expecting for future developments?

i. Pricing
ii. Availability
iii. Mill investments
iv. Long-term planning

Dan: Is the stainless-steel market more restrictive? In the next 2 years no major changes are expected, long-term there will be further consolidation in the industry.
The (free trade situation) will have to be more restrictive before it can become less restrictive again. The environmental protection has to be enforced and paid for at the same level (water consumption, particle emission…)
Canada and Mexico have to close in the borders as the policies have to “protect” the Nafta region. The current situation is misused as circumventions by these two countries. WE (the US) expect the same barriers for these regions to avoid this misalignment. It will become worse before it can become better again. The overcapacity has to be addressed (Nafta region).
24: I would like to have your input for the following question.

c. What will be the consequences of the increased Asian production capacities?
d. Are you expecting the stainless-steel industry to be dominated by companies from China/ Asia?
i. Why do you think so?

Dan: Yes, there will be (trade barriers) for Asian producers. Yes, there will be lesser trade barriers once the mills are playing on an even playing field
25: From your perspective what are the dominating trends & developments in the future for the stainless-steel business environment?

d. Are you expecting further limitations to the free flow of products?
e. Are you expecting further tariff barriers for the company you are representing?
f. Are you welcoming stricter protection laws for domestic producers? Or are you expecting a more liberal view on the tariff legislation?

Dan: Long-term there should not be restrictions, but first the domestic production has to be rebuilt before they can become competitive again

26: The purchase of raw material is handled by which function in your organization?

1. Do you think it should be a top management task?
2. Do you think it should be handled by the CEO? (example Aperam)

Dan: The purchase functions are under the responsibility of an VP, but the CEO is heavily involved in these activities. There are guidelines for the purchase & sales team, the approval board has to accept these major deals (no limits have been discussed), but there are rules if a longer-term deal (multiple quarters) is made, like capital projects are treated the same way and the need to be presented to the approval committee. These deals have to be pre cleared before these can be organised
27. Do you think the influence of producers like Tsingshan – who controls the mining / excavation costs will play a pivotal role in the future?

g. Do you expect any implications for the other regions besides Asia?
h. Should the stainless-steel producers integrated backwards, to control the raw material costs better?
i. Will the LME pricing continue to be a reference for the raw material costs (Nickel?)

Dan: left out
28: From your perspective what is / could be an appropriate method to mitigate the price volatility risk in the stainless-steel industry?

j. Why is it a risk and not an opportunity?
k. What could be the answer?
l. What could be a method to offset the price swings?

Dan: Ak has the appropriate measures and methods in place. They agree to arrangements and are still responsible that these longer-term deals) are coming in (booked into production) and sometimes the fixed costa ND the variable costs are passing the line. Not few only some companies are taking the risk of taking long-term positions (in Raw materials). The measurement of the measures is done versus budgeted values. The opportunity is that the actual costs beat the expectations, the risk is these costs do not beat the expectation (budget).Beyond raw material: equipment costs could be higher than anticipated and other contracts like insurances and mill supplies go up
29: What are situations that have been critical for your company in regard to price volatility?

m. Natural disasters?
n. Financial crisis (interest rates, x rates)?

Dan: Natural disaster to a lesser degree but a freeze up (winter conditions) or dropped bell (carrier of liquid steel) into one of the blast furnaces, a tap hole burn through, spares equipment outages as the production equipment is partially older than 50-70 years.
US Steel that is investing $1.2 B in Strip Casting that will replace a Hot Strip Mill built in 1936. Comment of Dan (" I was attempting to make the point that to revitalize the US industry, in general, significant investment in new technologies will be required over the coming decades"- after reviewing the written interview).
Outside risks could be a meltdown of the global economy.
War? as the US is active in several different regions in the world (Iran, North Korea ….)
The drop of the NASDAQ index due to the comments the US President Trump made on the trade restrictions towards (the NASDAQ dropped 3,5% on May 8th due to the comments, but it gained 20% since Jan1st 2019 – authors note)

(Personal note of Dan due to the current stock prices he decided to work for one more year)
30: Could you recommend a mix of tools or methods to offset these price swings?

Dan: Reliable suppliers and the awareness what are available on the market, like hedging, nowadays you do not have to be a mill (meaning the important size of a mill) to take a position in hedging in Nickel.
Steel scrap could be hedged using one of the LME traded steel slab contracts that are available (reverse hedge, extended hedge – alternative for the product that is not hedgeable)
Iron Ore and electricity can be hedged, Moly not as it traded at same exchanges only
32. Would you recommend any literature or topics that should be considered in this research?
No literature was named explicitly,
This interview will be sent to Dan for review.

West Chester, May 2019

Interview AST

Interview with Dr. Schlüter (SLT) CEO of Thyssen AST in Essen June 19th 2019

PMH (Interviewer): [Speaking in German #0:00:13.1#] Good morning, it is always a little bit strange to speak English to a German. #0:00:17.6#
DR. SLT (Responder): Yeah sometimes it is easier to do it in English .#0:00:22.9#
PMH: We just touched before on a couple of things. For Question 4, what types of price volatile commodities does your organisation buy? You mentioned you are buying nickel, you are buying ferrochrome, you are buying stainless steel scrub? #0:00:39.8#
DR. SLT: Let me say generally speaking we do have to consider all different kind of alloys for stainless steel production, with the main focus of course on chromium, nickel and molybdenum. #0:00:54.3#PMH: Okay moly as well? #0:00:56.6#
DR. SLT: Yeah. #0:00:58.7#
PMH: Okay and the ferrochrome, do you have there any preference where the material is coming from, or is this just a standard grade? #0:01:06.8#
DR. SLT: Let me say of course we have a fair mix between the different mines and of course, due to the fact that there is a kind of consolidation in the industry, we have our preferred resources but with a certain kind of flexibility so generally speaking we can say we have three main suppliers followed by some small alternatives as well. #0:01:37.3#
PMH: Okay. And that was mentioned before for Question 5 - how important are these commodities to your organisation, you mentioned about 1.25 billion purchased? #0:01:51.4#

DR. SLT: Okay the raw materials plus energy is the main constant driver for a stainless-steel product. #0:02:01.1#
PMH: Ja and the 1.5 billion does include energy as well? #0:02:04.3#
DR. SLT: No, it's only the pure raw material purchasing for the production of stainless-steel products. So this is let me say what is going into the melting shop. #0:02:16.6#
PMH: Yes and would you consider these, the ones you mentioned as the absolute main commodities also for the success of the company? #0:02:23.7#
DR. SLT: Yes. #0:02:23.7#
PMH: Okay. Question 6 would be approximately what percentage of your organisations overall spend is accounted for by these commodities, this is compared to your turnover? #0:02:43.0#
DR. SLT: Okay turnover is 2 billion, as you know in the stainless steel it is difficult to make a percentage depending on the share (share of alloys and the general price volatility) (#0:02:53.2#).
PMH: Yeah. #0:02:54.9#
DR. SLT: Ja if you compare this 2 billion of #0:02:58.6#
PMH: So it is more #0:02:59.3#
DR. SLT: It is more than 50%. #0:03:01.2#PMH: Than 50%? #0:03:01.2#
DR. SLT: Ja. Ja but it is fair to say it is, I think 60% is a good idea. #0:03:08.3#
PMH: Yeah and you mentioned energy. Do you see there an increase in energy costs over the last years? #0:03:19.9#
DR. SLT: Yes and no. Let me say generally speaking there is an increase and let me say this a main aspect in considering or judging the European steel industry in the global world, ja and here we really have a disadvantage but of course there are different models how to eliminate this effect. For example, in Italy, we have a special contract between big companies to bundle their energy demands and to buy certificates and to optimise it. It is a very complicated system; it is driven by the government but of course it helps a little bit to make companies more competitive in the global competition. #0:04:14.8#
PMH: Ja and in the steel industry a lot of people talk about these C02 emissions, is this something on the horizon or is this already there? #0:04:23.2#
DR. SLT: Let me say it's started to be implemented, not in the same way but in the way of thinking to let me say, to have limited resources and to sell them. #0:04:35.0#
PMH: Ja. #0:04:35.0#
DR. SLT: This idea already exists. #0:04:38.6#PMH: Okay. Okay then we would come to Question 7 - the company you are representing is potentially experiencing market risks - which are the risks you are expecting in the near future? #0:04:56.8#
DR. SLT: Okay here you speak about general risks? #0:04:58.0#PMH: General risks. #0:04:58.0#

DR. SLT: So of course there is an impact on let me say the trading policies as you know, all the discussions concerning anti-dumping and safeguard measures. #0:05:11.9#
PMH: Yeah. #0:05:11.9#
DR. SLT: Of course we have development concerning the future of the European Union. #0:05:19.6#PMH: Is Brexit something which? #0:05:20.3#
DR. SLT: Yeah of course. For some companies the impact is more or less but of course it will influence something. #0:05:29.7#
PMH: Ja but your exposure to England is not too big? #0:05:32.5#
DR. SLT: No we don't have. #0:05:33.7#
PMH: No. #0:05:33.7#
DR. SLT: Let me say of course we have our distributor business, for AST it is limited but for 40K it's an issue, with all the car producers and so on, it is. #0:05:46.3#
PMH: Ja but from a raw material supply side is? #0:05:49.3#
DR. SLT: Let me say the impact from the global economy for example yesterday the announcement concerning that B decisions immediately have an impact on the US dollar, so you always have this kind of impact, so furthermore, okay, in stainless steel, the main problem of the industry is over capacity. And this over capacity is driven by Asia, especially China and of course this is a big question mark how to handle this over capacity. #0:06:26.9#
PMH: Yip. Do you think that these risks are changing? #0:06:35.4#
DR. SLT: Ja I think they already changed because somewhere, last month for the steering committee of AST I presented a chart showing the global worth, what was protected in the past and what is protected nowadays, and then you have the answer to your question. #0:06:55.4#PMH: Yip. #0:06:58.1#
DR. SLT: And I would say it's an unforeseen development. #0:07:03.3#PMH: Okay. #0:07:05.4#
DR. SLT: Nobody would have expected that Europe starts safeguard measures or something like this. It is against our philosophy. #0:07:17.0#
PMH: Yes and the European Union was always very free, liberal trade area, maybe too liberal, but just question mark. #0:07:27.6#
DR. SLT: Yeah it's, I fully agree, it's a big question mark because generally speaking, I am not a friend of any kind of trade barriers because we are in a global world and we do have to respect it. And we have to prepare our companies to be competitive in this environment, as long as, and here I have my experience with AST, we run unique and remarkable restructuring program, but we do not have any further ideas how to decrease costs significantly. That means we are at the end and our would say our main European competitors did their homework as well and after all these measures, if your prices or your costs are still higher than Asian prices, then you do have to react. #0:08:21.4#
PMH: Yes. #0:08:21.4#
DR. SLT: This is let me say, it must be in a fair environment and competition so and if it comes to such constellations you need this kind of protection but I am against, because and this is what you are observing in the US, you can protect your market, but if you do not motivate your companies to further develop and solve the problems, then it's for nothing. #0:08:52.1#
PMH: Yes I am not quite sure how many stainless-steel mills you have seen in the US, the one I am referring to is for example AK Steel, for more that is a museum. Besides the Rockport (#0:09:08.1#) facility, which is I guess 10 years old, but the melting in Butler and so on is a museum. And okay, (Calvert? #0:09:23.0#), the former (#0:09:22.8#) ThyssenKrupp group now the (#0:09:24.0#) of course that is state of the art, but with their inherent problems, and you mentioned raw material production sales. I think where they struggle is the last bit, the sales, for sure. Production wise I cannot judge, but I would just imagine that this is state of the art, and it should be competitive. And then you have got NAS (#0:09:47.6#) which is for me the best in class because they control the raw material, they control production, and sales to a certain amount. They know exactly how they have to. #0:10:01.6#
DR. SLT: Let me say this was always the perl (juwel in the crown) oft eh Acerinox group (#0:10:04.6#)
PMH: Yes and there's stating this, unfortunately they stopped the individual profit and loss for all the steel mills, but I guess 5 or 6 years ago and now everything is consolidated but my estimation is with the, about 1 million tons, a little bit more they are doing there, they earn about 1 billion. Maybe 800 million but it's close to 1 billion and if you compare this to the results of Acerinox (#0:10:35.3#) they are eating up this profit. #0:10:40.5#
DR. SLT: Oh okay. #0:10:41.4#
PMH: We just touched on Asia and then which substitution developments have you experienced for stainless? Do you think stainless will substitute or is going to be substituted so? #0:10:55.8#
DR. SLT: A very good question. #0:10:57.7#

PMH: So have lunch or being lunch? #0:11:00.9#
DR. SLT: I say it has something to do with the status of the development of a country or a region. That means in Europe maybe let's say Germany, you have the car industry. You have maybe stainless steel with a sub, with a potential of substitution by aluminium not only stainless, carbon stainless. #0:11:26.1#
PMH: Ja, ja. #0:11:28.0#
DR. SLT: And so there is always in highly developed countries you have a kind of substitution process. If you look to other areas for example India, Vietnam, developing countries, you will observe that the share of stainless steel is increasing because as much as a region is developed, the consumption of stainless steel is increasing. #0:11:56.9#
PMH: And do you think a share of about 20kg per person which I guess it is little bit higher in Europe but India with 1 billion people I mean 20kg? #0:12:08.5#
DR. SLT: Ja, ja it's too much but let me say for developed countries, it is a good figure. #0:12:16.6#
PMH: Ja, ja, talking about India, India has from my perspective compared to China, a very huge domestic usage of stainless. #0:12:25.0#
DR. SLT: Ja correct and what you are observing for us in our definition it must be a 300 or 400 series. If you talk to these non-developed areas, they consider 200 series as stainless steel too, what is out of our scope ja. #0:12:44.6#
PMH: So you are not producing 200 at all? #0:12:46.9#
DR. SLT: No. #0:12:50.2#PMH: Then we come to Question 8 - does your organisation have a standard process for managing commodity price risk and this is more on the buying side? #0:13:07.1#
DR. SLT: What do you mean by managing prices? #0:13:15.9#
PMH: Do you have an influence on the commodity prices? You mentioned the negotiations you have had with let's say, I would presume the traders of the mining industry because they can set a certain price. #0:13:29.5#
DR. SLT: Ja okay you have let me say if it comes to this point, an influence first of all, you can define the pricing formula. There are a lot of different options behind. #0:13:48.6#
PMH: Ja. #0:13:48.6#
DR. SLT: To influence it yes, it is important to explain the situation of your own market that for example the raw material supplier gets a deep understanding. Of course you have an impact with your size, this is for sure. It gives negotiation power and of course, due to the fact that we have more than one supplier, you always can say to develop a new segment, customer, region or whatever, we want to grow in the segment, but we need the support from you, raw material supplier, otherwise the volumes go to Asia and you will not take part. So this is something of course you can let me say, put into the negotiations. #0:14:45.5#
PMH: Ja that is really actively coming to the supply chain network idea, is really taking them on board for the journey, for a common journey ja? #0:14:56.3#
DR. SLT: Correct, correct ja. #0:14:58.6#
PMH: But do you have a standard process for this? #0:15:00.0#
DR. SLT: Yes there is a process. #0:15:04.3#
PMH: Okay. And then Question 9 - what approaches or which approaches, which message does your company have to manage these commodity projects? It is a little bit the same but its more the, do you have a toolset, where you say if commodity prices go up, like nickel, like ferrochrome, is there something where you say eh, we are going to substitute, we are going to seek new suppliers, we #0:15:29.5#
DR. SLT: Ja this is something, and here we come to the point how to manage, this is something we implemented, and some minutes before my meeting I had alignment with my colleagues, a CFO of AST where we are discussing these things. For example today I had a negotiation of 30 000 tonnes with our main customer, and of course, here I need a clear overview of the real incoming raw material cost to get an understanding, what is the quality of what we are discussing in the market. #0:16:07.1#
PMH: Ja so fair assumption, before you take the sales decision, you will refer to what will be the, let's say the incoming raw material cost and this also mapping the time period. #0:16:22.3#
DR. SLT: Ja for example to give you an idea, we have a dashboard updated each week where we have all these raw material parameters where we analyse the past, the current situation, and what is the forecast for the future. #0:16:40.5#
PMH: Are you using that, and it's not on this questionnaire, artificial intelligence for this? #0:16:45.5#
DR. SLT: Not yet. #0:16:47.2#
PMH: Do you think about it? #0:16:53.9#
DR. SLT: Yes because some days ago here our trading division they introduced such a system for some areas, some days ago a friend of mine he's a head hunter and he explained me how he is using artificial intelligence in his area too, this was a little bit surprising, so you cannot avoid the discussion and I would say in the near future,

and next week I will discuss it with the Senior Sales Management team some adjustments in our organisation, where we want to optimise pricing and here we will start to establish such tools ja. #0:17:36.8#
PMH: Because one of the statistical calculations I will do for this research is called ARDL, Auto Regressive Deferred Logarithmic calculation and what it basically means is taking for example nickel or ferrochrome from the past, what happened, you can compare or you can calc, or you know the values. Does this have an impact on your share price, on the ferrochrome share price, on the nickel, on your profit, whatever. Just to say okay there's, just take into account three months of gap, how is this? So basically it is always comparing, and this will also be part for me, for me this is time variant. #0:18:30.7#
DR. SLT: Yeah we will come to this point, this is the most critical point you have to overcome if you want to reduce volatility in prices. #0:18:37.6#
PMH: Ja. If you have different tool sets, dashboard, negotiations, when do you use which approach? Market situation is like the English say, a gut feeling, is this? #0:18:53.0#
DR. SLT: Ja, and here you come to the point on which management level you are using the tools. We have some tools we only developed for the board and we do not communicate this kind of information to other labels. So there are, let me say, different tools for different levels. #0:19:16.5#PMH: Okay. Why would you do this? #0:19:21.2#
DR. SLT: It is a clear separation of purchasing and sales activities. #0:19:28.0#
PMH: Yes so who would lead the raw material purchase? Is this yourself? #0:19:37.3#
DR. SLT: Ja let me say for the time being it is myself, but this has something to do with our approach to bring more sales competencies into the negotiations ja. #0:19:50.0#
PMH: Okay but for the long term you would see this under the system? #0:19:52.8#
DR. SLT: No we separate it ja. #0:19:53.3#
PMH: Under the CFO? #0:19:55.5#
DR. SLT: CFO ja. #0:19:55.4#PMH: CFO, not yourself? #0:19:57.2#
DR. SLT: Let me say for the time being by myself, but officially it should be done by the CEO or the CFO. #0:20:08.7#
PMH: Okay. #0:20:08.7#
DR. SLT: For the time being it's officially the CFO. #0:20:12.1#
PMH: Ja okay I will come to that question later. If you have these different measures and tools, and if you say you have had a negotiation and you did use your dashboard, your market intelligence, when do you determine and how do you determine if this is efficient, good, was this a good result or not such a good result? #0:20:33.9#
DR. SLT: This is what we are doing in this rolling dashboard system ja. What is important to underline - at the end, we have a calculator for our pricing and let me say spot business ja. And at the end, the board decides which parameters we put into the system and then we have the breakdown to all levels ja. #0:21:03.1#
PMH: Ja and then they know exactly this is the rock bottom in (#0:21:04.8#) price, of course they always have to. #0:21:07.8#
DR. SLT: If there is a let me say an adjustment due to some political reasons or market reasons, this is something different but at the end it's based on our pure cost situation considering a mark-up. #0:21:26.7#
PMH: And would you have a different input for different regions? Yes okay. So yes ja? #0:21:32.5#
DR. SLT: Ja. #0:21:34.0#PMH: You know the industry also very well, Question 13 - what does your company do really well when you think about managing price risks, compared to the others? #0:21:52.1#
DR. SLT: You mean on the purchasing prices? #0:21:54.6#
PMH: Both, both. #0:21:55.4#
DR. SLT: Both okay generally speaking, it is extremely important to train your sales staff to describe and understand the pricing willingness of your customers. This is extremely challenging. Furthermore, coming to purchasing of course you try to hedge as much as possible, and this is for example, something AST has changed in the industry that for example, for chromium we are able to make a theoretical hedge. #0:22:47.8#PMH: Okay. #0:22:49.8#
DR. SLT: So for example in the future or in the past, if you had to quote for a project business with a duration of one year, it is almost impossible and you have to make assumptions and you really can lose, you can win, but you can lose as well. And to avoid this, meanwhile we get for these volumes a fixed volume too, so at the end, it is a kind of risk management, we cannot take part on positive development, but we will not lose. #0:23:23.3#
PMH: Yes which gives you a stable financial return. #0:23:28.3#
DR. SLT: Ja, ja, ja. #0:23:29.7#
PMH: And you would rate this higher as a potential windfall? #0:23:33.7#

R. SLT: Ja, ja and of course within the group, we have various hedging models how to eliminate risks. Then we involve insurance companies and all these things. There is a very strict policy behind and this is something that is really on the agenda of Tshingshan Group AG. #0:24:00.2#
PMH: Okay. Did this change in the past? #0:24:01.0#
DR. SLT: Ja. #0:24:01.7#
PMH: Because Tshingshan Group was the steel company. #0:24:05.7#
DR. SLT: Ja, not let me say it has something to do that we had our experiences and of course risk management became even more important, so let me say the policy became much more stricter than it was in the past. And of course, it reduced the room for speculative behaviour. #0:24:39.2#
PMH: Yip do you think this is giving you an advantage compared to your competitors? #0:24:43.2#
DR. SLT: Both is possible. You always know it at the end. The only thing is that again, the room for speculation is limited and to the group usually says, we are not a bank, or whatever, we are doing our business and immediately we hedge the currencies, the nickel and so on, so there is a clear policy behind it. #0:25:09.8#PMH: Yeah, understood. And we have to dig a little bit deeper into number 14. Still what do you think will change in the future, what is the big challenge in the future, if you think about? #0:25:28.0#
DR. SLT: You come to the point, at the very beginning, I described the current situation and the ideal scenario, and this is something we are working, is to bring the raw material purchasing production and point of sales theoretically together. #0:25:50.9#
PMH: When I think about Asia, in particular, India, it was very long, very common if you buy, this is the price, no adjustment afterwards. And a lot of imports they have been priced like this, so you make a contract and the purchase company, they try to make windfall profit, but they took the risk on the raw materials not the producer in China. #0:26:21.2#
DR. SLT: Ja let me say at the end it's a typical effective pricing. And of course, due to the fluctuations and so on, meanwhile in Europe, the share of effective prices has increased significantly, and it is not only let me say market driven, it's for example, internally driven by TK2 because we want to avoid any compliance risk with the alloy surcharge (#0:26:53.7#) I think you are aware of the topic and the problems and here we changed everything completely but the effective prices is let me say, something we do not like too much, because it's such a consolation you are immediately comparable with Asian prices, of course there is always the problem of different delivery times but you create a higher transparency in the market, ja, this is for sure. #0:27:34.7#
PMH: Okay. Then again over the last three years, Question 15, what trends have you seen in the approaches to use and manage price risk? Is this more going into effective price? Or is there more? #0:27:53.0#
DR. SLT: I do not know if you can manage the problem with an effective price because you have no chance to compensate any changes in the raw material markets, but you have the effective prices and you have the system base plus alloy. But there are different options in between, for example, with some customers we have an effective price with the exception of nickel. #0:28:34.9#
PMH: Okay, ja. #0:28:34.9#
DR. SLT: We have another system customers decide when we should hedge the nickel, it can be a moment of agreement on the contract, it can be during the production time, and the latest, the day of the delivery. So there are different models in between. #0:28:58.7#PMH: And is this really taking more share in the? #0:29:03.7#
DR. SLT: Ja definitely, ja. #0:29:05.3#
PMH: And what do you think is the motivation for your customers to do so? #0:29:12.0#
DR. SLT: The customer only has one target that they are in a position to roll over these kind of price increases. #0:29:21.5#
PMH: Yes, pass on. #0:29:21.5#
DR. SLT: They do not want to earn money with it because they have the same approach, we do not speculate, they only want to be in a fair constellation that they are convinced to make them roll over. #0:29:36.0#
PMH: Yeah and if you say so, I assume that your share of stock holding business is than, rather low? #0:29:45.0#
DR. SLT: Ja okay we have let me say the so-called end user strategy but to run a mill efficient, you need the commodities and stockholder business as well, but of course, the topics we are talking today is more or less focused on stock business, or spot business ja. The end consumer (#0:30:05.3#) business is a little bit different. #0:30:10.0#
PMH: Okay thanks. And then I am kind of going to conclude this, this happened in the past. Do you see more changes to come in the next three to five years? #0:30:22.9#
DR. SLT: Ja, ja this process is ongoing, it has something to do with the globalization, that meanwhile you find each stainless-steel producer in each region so there will be changes. I personally think that one day we will not have he alloy surcharge (#0:30:37.3#) anymore. #0:30:41.0#

PMH: Okay and this kind of, is it good? I would say which to a later topic which is then we are coming to Tshingshan, they might also be involved in this development. Question 17 - compared to your competitors, do you think you are managing price volatility in a special way? And if so, what is different? #0:31:09.8#
DR. SLT: Ja. #0:31:09.8#
PMH: Do you think the way you do this with the different pricing models is giving you an advantage? #0:31:17.4#
DR. SLT: Ja, definitely. #0:31:19.6#
PMH: Okay. And then we come, we leave the volatility now for a little bit, which influence would have stable price situation versus a volatile price situation for your company? Would, in an ideal world, would it be a stable pricing situation all the time? #0:31:42.1#
DR. SLT: I think this is almost impossible. Generally speaking, each market or healthy market is driven by supply and demand, and this is changing. #0:32:01.2#
PMH: So really the market forces. #0:32:04.6#
DR. SLT: Ja. #0:32:04.6#
PMH: So you don't think that very stable nickel, ferrochrome, scrap prices is not really an advantage? #0:32:14.2#
DR. SLT: No. Ja it would be an advantage, but it will not come to this point, because these are free markets too. #0:32:23.0#
PMH: Okay. Question 20 - why would commodity price volatility influence the profitability of the company; of the company you are representing? #0:32:33.6#
DR. SLT: Ja because we have different markets, we have the raw material market, we have the stainless-steel market and we have for example, the distributor market. And in case you are not able to roll over your cost increase is coming from raw materials, you have immediately a profit risk.#0:32:53.4#PMH: Is this profit risk more in declining markets so where the demand side is on the let's say stronger negotiation position? #0:33:03.1#
DR. SLT: Of course the impact is higher in these concentrations ja. #0:33:06.7#
PMH: Is it a fair assumption still when the commodities prices go up like nickel, ferrochrome, profitability typically goes up as well? #0:33:14.0#
DR. SLT: Ja at the end it's a, if you analyse a long time period you could come to this, but the problem is that the increase is always slower than the decrease. #0:33:26.8#
PMH: Okay. So you are suffering. #0:33:34.7#
DR. SLT: Ja. #0:33:39.0#
PMH: Ja. 21 - which could be the influence of producers, and now we come to famous Tshingshan who controls the mining excavation costs. Will they play a more important role in the future because they have done something which is basically the backward integration, they have all the mines, they control the nickel, they control the iron ore, ferrochrome and #0:34:02.6#
DR. SLT: Yeah okay this is let me say, one of the hot topics ja. Sometimes I have the impression that people overestimate the situation because you do have to distinguish between the short-term impact and the long-term strategy. What we are observing with Tshingshan is a short-term constellation, I think they will not be able to survive in this same constellation from a long-term point of view. Let me say the development of Tshingshan is remarkable and of course they have a new constellation, ja. But of course, I pointed out the topic of fair competition. How was it possible to grow in such a short time period to a level of 9 million on top, I do not know. First of all, then they have an advantage in raw materials, maybe energy, or whatever, so that means they have an advantage in melting. If it comes to rolling, they lose competitiveness. And they have their impacts from other countries to safeguard measures and so on. So, I do not know what the constellation or market position of Tshingshan in the future will be. What people think now they have the capacity and they sell it worldwide to lowest prices and then this will not come true. #0:35:53.9#
PMH: Partly because of safeguarding and anti-dumping measures? #0:35:57.8#
DR. SLT: Ja but let me say to make it more positive, why don't you think in a scenario where they say they focus on the melting of slabs and in all other regions where we have the competences for the rolling, to combine it and to shut down melting capacity. #0:36:20.5#
PMH: So coming back to the idea of what Columbus used to be. #0:36:23.4#
DR. SLT: For example ja. #0:36:25.0#
PMH: Basically the intention was, they have got a slab producer, maybe a hot band and that's it. #0:36:30.8#
DR. SLT: So let me say Tshingshan is the new player, they have their advantages but of course they have their challenges as well and maybe it would be possible that the setup and the function of the stainless steel is changing, and this could make sense. #0:36:46.8#PMH: Okay ja so take the cheap slabs, bring them to somewhere else. #0:36:50.8#

DR. SLT: Take the excess to raw materials, make very efficient melting, have the slabs and then sell the slabs and #0:37:00.5#
PMH: Ja and ATI in America they did this? #0:37:02.0#
DR. SLT: Ja. #0:37:02.0#
PMH: This is now going to this #0:37:04.3#
DR. SLT: Yeah but here you come to the point, due to the safeguard, they fail for the time being. #0:37:08.5#PMH: Yes but the product was very competitive. #0:37:11.4#
DR. SLT: Ja. So this underlines a little bit the idea. #0:37:16.8#PMH: Yes and I was four weeks ago in China, talking to for example, Tisco (Tisco? #0:37:21.8#) and they are really concerned, I would not say afraid, but they are really concerned about the Tshingshan, Tshingshan is excluded from China, they have the anti-dumping measures, but it is Chinese capital and Tshingshan for me, like yourself, I don't know where they can go because they are not allowed to go to China. China I learnt there is no capacity increase allowed by the government anymore, so they doubt that the Shanghai Bao (steel plant for stainless) (#0:37:56.6#) will open up again, so apparently China is reducing the capacity increase. #0:38:06.1#

DR. SLT: Ja okay but let me say and here we must be fair, the China can claim about Indonesia (#0:38:12.6#) and Tshingshan as much as they want yeah but at the end they build up 50 billion tonnes of capacity. Yeah so I am sorry for China, but this is their problem. #0:38:25.5#
PMH: Ja. The other observation I made is that the mills in China apparently want to have more customer I would say interaction because before it was just no, but they see that only by producing they will not sell the products, and but just piggy backing on Tshingshan again, do you think backward integration can be also an answer for yourself? Would you think about buying? #0:39:01.3#
DR. SLT: No. We are not the experts and let me say, I can imagine that we do it via partner but not directly. #0:39:19.6#
PMH: Ja okay, and then we just touched a little bit on this, the LME pricing because Tshingshan is not in this event (#0:39:26.7#), on the other hand, I don't know how much impact Tshingshan has in Europe? So do you think the LME nickel prices will still be one, will be important, because we talked about more or less effective pricing, different pricing methods and you mentioned this already, you do not see that the alloy surcharge will survive for the near future. #0:39:53.5#
DR. SLT: Ja with nickel we always have the special pricing via the LME price but of course we are not purchasing to the LME price, so it's always let me say a theoretical guideline or whatever. #0:40:08.9#
PMH: Not more, not less? #0:40:09.1#
DR. SLT: Ja. #0:40:12.5#
PMH: Ja if you see, we touched on stainless steel, Question 22 - is price volatile? Do you think this is driving substitution, only the price? Not the material characteristics, or is basically limiting the substitution? #0:40:34.1#
DR. SLT: Let me say the following. There is another point behind this(#0:40:37.5#), I think you can follow me (#0:40:38.7#) If you look to some areas, for example, white good industry, Miele (#0:40:45.0#), they are let me say quality, innovation driven or whatever. They need nice products, for example, our silver ice, anti fingerprint (#0:40:56.7#) and so on but meanwhile the cost pressure is so huge in their market environment that they cannot, that they do not get the price for these kinds of products so they need substitutes, for example, a layer on carbon steel, ja, the fake anti fingerprint (#0:41:15.1#) ja, so, but this is the driver of substitution, it's not the volatility of stainless steel. #0:41:23.6#
PMH: It's really the price pressure. #0:41:25.3#
DR. SLT: Cost pressure ja it is. #0:41:26.7#
PMH: Ja and but do you see that stainless steel will substitute different things because it is for mechanical reasons? #0:41:34.7#
DR. SLT: Ja I think stainless steel has some nice properties ja and if it comes to these corrosion resistance in areas or if it comes to aesthetical aspects, it is still valid ja. #0:41:55.8#P
MH: Just a general question, are you afraid that stainless steel demand will decrease? #0:41:59.8#
DR. SLT: I do not think so. #0:42:01.8#P
MH: It will increase? #0:42:02.2#
DR. SLT: Due to the fact that we have these huge number of populations in developing countries. #0:42:10.0#
PMH: Purely because from the growing emerging markets? #0:42:10.4#
DR. SLT: Ja. #0:42:12.2#
PMH: Ja and so, but in Europe, which is basically a very saturated environment, you do not foresee a huge increase in stainless steel demand? #0:42:25.0#

DR. SLT: A huge increase not, but there are opportunities for increases. We have a top-secret project where it would come to a significant substitution of carbon steel environments and if something like this would be successful it could have a significant impact ja. And as you know, if it comes to energy consumption, stainless steel has advantages compared to aluminium and so on, so let me say, I do not see the big increase, but I do not see a decrease too. Of course you know mobility is a topic, do we need exhaust systems in the future, so of course, these could have impacts ja. #0:43:14.3#
PMH: Yes the company I work for we think yes, for a couple of reasons because we cannot foresee that the immobility will take a share of more than 20%, maybe 25% for a lot of reasons, and partly because of raw material availability for the batteries. And you mentioned the emerging markets, there is a huge demand for internal combustion engines in these markets as well and they cannot start with a battery. #0:43:52.2#
DR. SLT: And this is why in the end I see it as a balance ja. #0:43:56.1#
PMH: Ja. And then we come to a topic we already touched, Question 23 - thinking about the trade barriers, are you expecting more trade barriers to come, or do you think in a couple of years this will all be falling apart, and it will be the free flow of material again? #0:44:24.1#
DR. SLT: It depends. If the world is able to find solutions how to manage over capacity. The second point is it's clear, it was mainly driven by the US decision and of course it depends a little bit on how long Trump will be in the responsibility so I personally see chances that it will come to a reduction of trade. #0:44:51.6#P
MH: Ja did this recent development, and we are talking about the last two years, impact your planning for the mill, for your capacities? #0:45:03.5#
DR. SLT: No. #0:45:03.8#
PMH: No? #0:45:03.8#
DR. SLT: No. #0:45:06.5#
PMH: Okay. And then we come to 25, so you mentioned that the, you expect a freer flow of the goods, so you are expecting a decrease in the safeguard of anti-dumping measures, trade barriers? #0:45:29.5#
DR. SLT: From a long-term point of view. #0:45:30.7#
PMH: Yes, long term means five years plus, something like this. Ja and which would then answer Question 25. #0:45:43.8#
DR. SLT: Ja and let me say one remark of course, we are observing a special development if it comes to political ja opinions ja so you know you are aware about all these changes in all European countries and so on and of course it depends on who will take over the majority in the future ja. If it really comes to a more national approach, it's possible that trade barriers will remain. #0:46:17.2#
PMH: Ja but is this more for Europe or globally? #0:46:25.7#
DR. SLT: It is more a European topic for the time being. #0:46:27.6#
PMH: Ja because your main exposure is Europe? #0:46:30.6#
DR. SLT: Ja, ja. #0:46:31.8#
PMH: So whatever Trump does in America is not really effecting you? #0:46:38.2#
DR. SLT: Ja. #0:46:38.5#
PMH: Question 6 - we touched on this already, the purchase of raw materials is handled by which function in your organisation? #0:46:45.0#
DR. SLT: Okay we have our own raw material department. #0:46:50.2#
PMH: It is also here central function in (Esne? #0:46:53.2#)
DR. SLT: No we have it in AST internally but due to the experience it is supported as a consultant fee of our raw material, it is the group materials trading, this is let me say the official organisation. #0:47:07.8#
PMH: Okay. Then 27 is basically what we have done. From your perspective, and that's really going again into the alloy surcharge effective pricing, 28, from your perspective, what would be the appropriate method to mitigate the price volatility within the stainless-steel industry? #0:47:36.7#
DR. SLT: As I said we do have to bring purchasing, production and sales poles together, theoretically. That means we need a new way of negotiating raw materials. The second point is we have to optimize our logistic chain. That means we need much more fast rules if it comes from production to our customers. The idea is to roll, to do the cold rolling in the last second at immediately the customer, especially the distributor gets the material ready, already has the order on the table. #0:48:25.0#PMH: This is really reducing the time and the #0:48:28.9#
DR. SLT: This is the only chance to manage it. Only to give you an example, to make it clear - in a scenario, we would buy slabs, AST. We have a capacity of 580 000 tonnes. Material services have a demand of 400 000 tonnes. Can you imagine AST would only produce for the materials organisation. They have their stocks with an artificially intelligence filling system. We get a clear indication when to produce, you do not have any windfall losses. This is now let me say, white, between black and white, there are a lot of things in between but this must

be the idea, to short of this period and to yeah let me say that the costs you get from raw material you always have let me say in your order to your accuser. #0:49:35.0#
PMH: Ja backed up and this not by hatching anymore but really by because by hatching, typically a third party is in between is getting a share of the #0:49:46.8#
DR. SLT: If someone has to make artificial decisions. So this is let me say, our answer to your question. #0:49:55.0#
PMH: 29 would be, what are the situations which you have been critical for your company with regards to price volatility, and this is more kind of natural disasters, financial? When did you really experience something really happened with? #0:50:13.2#
DR. SLT: Ah ja, okay from the past you know when we had the fire in (Nairoste? #0:50:16.5#) it immediately has an impact ja. Or we had a special event when we had the explosion in the chromium price, two years ago. Ja this was the typical event, and this was the moment when I stepped into the purchasing. #0:50:36.6#
PMH: Okay. #0:50:42.2#
DR. SLT: Ja, but this was a typical moment where I said to the chromium producer because they discussed what was the demand in China everything, even I said, if you are not able to give us another price, AST will shut down one furnace, and these volumes will be in China and you will not get any kilogram of chromium. Now you are the decision maker, and at that moment the relationship with the chromium producer changed completely. But all of my purchasing colleagues would not have been able to run this discussion. #0:51:15.8#
PMH: Yes because you could make the decision, they could not. #0:51:19.3#
DR. SLT: And this was let me say, the time where we see that we have to work into this, and that you can be successful. #0:51:27.6#
PMH: Yes with a really strong corporate, and not this American, they call it arm's length, stay away. #0:51:33.0#
DR. SLT: Correct ja. #0:51:34.3#
PMH: Because I have to punch you. And this is ja, and for me, this is really, really critical and is for me, in my negotiations, set up also changing because I grew up with the arm length, the punching negotiation style, which is done, it is history. #0:51:59.3#
DR. SLT: Ja, ja it is back (#0:52:00.9#)
PMH: Yes if the, also the customer cannot take you on the journey and this might be qualities, grades, quantities, if the customer is not attractive to you, you do not want to serve him and if you cannot take this journey together, ja, I would see this as a big advantage. Question 30 would be could you recommend a mix of tools or method to offset price ranks? #0:52:35.4#
DR. SLT: Yeah this is something I tried to explain with these various pricing models ja? #0:52:40.1#
PMH: Okay. Good. Couldn't you recommend any kind of literature for me? I mean you don't have to. #0:52:50.0#
DR. SLT: I do have to think about it because I am, I have to think about it. #0:53:03.1#
PMH: And then I would like to conclude this interview, once again, thank you very much. I will transcribe this, I will send it to you and then I will only use the parts which you agree on, and I think I can, once I have finished my research, I am allowed to give you one copy. #0:53:29.8#
DR. SLT: You can be convinced, I expect it.#0:53:33.4#PMH: Yeah that is what I thought yeah. Okay thank you very much. #0:53:39.4#
DR. SLT: No thank you and good luck for the next steps. #0:53:42.1#

(…) this is indicating comments and additional information from the interviewer

Appendix No. 9

Interview Nvivo nodes

Source / Interview	AK Steel	Aperam	Acerinox	Outokumpu	AST	∑
Market enviroment	14	19	12	12	13	**70**
Contractual situation	3	9	14	2	6	**34**
Costs / Production	3	13	24	20	5	**65**
CSR and Health & Safety	6	1	3	2	1	**13**
Mitigtation	11	20	50	12	14	**107**
Corporate Organization	5	10	64	7	5	**91**
Process topics	9	14	19	15	14	**71**
Overal risk	17	10	40	7	13	**87**
Backward integration/ Diversification	2	0	4	1	3	**10**
Production Overcapacity	1	2	5	4	0	**12**
Price volatility	15	14	39	13	12	**93**
Substitution	1	8	8	7	2	**26**
Trade restrictions	10	11	25	7	1	**54**
Scrap related topics	1	0	7	4	0	**12**
Spot business	2	1	5	0	2	**10**
∑	**100**	**132**	**319**	**113**	**91**	**755**

Source: Interview Nvivo nods matrix research 20190908

Source / Interview	AK Steel	Aperam	Acerinox	Outokumpu	AST	∑
A: Competition Market enviroment	14%	4%	11%	14%	14%	9%
B: contracts	3%	4%	2%	7%	7%	5%
C: costs	3%	8%	18%	5%	10%	9%
D: CSR HSE	6%	1%	2%	1%	1%	2%
E: mitigation	11%	16%	11%	15%	15%	14%
F: Organization	5%	20%	6%	5%	8%	12%
G: Process	9%	6%	13%	15%	11%	9%
H: risk	17%	13%	6%	14%	8%	12%
I: Backward integration Diversification	2%	1%	1%	3%	0%	1%
J: Overcapacity	1%	2%	4%	0%	2%	2%
K: Price volatility	15%	12%	12%	13%	11%	12%
L: substitution	1%	3%	6%	2%	6%	3%
M: trade restrictions	10%	8%	6%	1%	8%	7%
N: Scrap	1%	2%	4%	0%	0%	2%
O: spot biz	2%	2%	0%	2%	1%	1%
∑	**100%**	**100%**	**100%**	**100%**	**100%**	

Source: Interview Nvivo nods matrix research 20190908

Appendix No. 10

University of Salford

Informed Consent Form

Appendix A / <u>Informed Consent Form</u>

University of Salford MANCHESTER

Name: Daniel Azpitarte

Position: Commercial Director

Name of Firm: Acerinox

Address: S. Compostela 100, Madrid / Spain

Date: 17.07.2019

Request for Anonymity: **Yes (X)** No ( )

I, the above name participant, hereby confirm my willingness and readiness to participate in this research having been recruited by the researcher, Pascal M. Heckmann of Salford Business School, University of Salford, Manchester UK in the research: ***"Organisational solutions to manage commodity price volatility: A comparison of financial instruments, diversification and Keiretsu Gaisha".***

It is confirmed that the researcher has obtained the necessary permission needed for me to participate in this research from the employer. I also confirm that there are no known risks or hazards associated with this research and that my responses and/or input will be treated in strict confidence by the researcher.

I am aware that my participation is completely voluntary and that I have the right to withdraw from this research at any point during the interview or survey process without providing reasons for doing so.

I understand also that I may provide the information and/or data anonymously and will indicate so above. In this situation, the researcher will attach an unique identifier to my response to inform the researcher alone of the original source of the data.

I hereby give my consent, with the understanding, that the information I am giving would be used as data for the above research.

Participant's signature:.. **Date:** 3/6/2020

Appendix A / Informed Consent Form

University of Salford MANCHESTER

Name: Dan Lebherz

Position: Marketing Manager

Name of Firm: AK Steel

Address: West Chester/OH USA

Date: 19.05.2019

Request for Anonymity: Yes ( ) No (X)

I, the above name participant, hereby confirm my willingness and readiness to participate in this research having been recruited by the researcher, Pascal M. Heckmann of Salford Business School, University of Salford, Manchester UK in the research: ***"Organisational solutions to manage commodity price volatility: A comparison of financial instruments, diversification and Keiretsu Gaisha".***

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I hereby give my consent, with the understanding, that the information I am giving would be used as data for the above research.

Participant's signature:.................................... **Date:** 19th May 2019

Appendix A / Informed Consent Form

University of Salford MANCHESTER

Name: Eric Haekens

Position: Chief Sales officer

Name of Firm: Aperam

Address: Swinnenwijerweg 5. 3600 Genk/ Belgium

Date: 03.05.2019

Request for Anonymity: Yes ( ) No (X)

I, the above name participant, hereby confirm my willingness and readiness to participate in this research having been recruited by the researcher, Pascal M. Heckmann of Salford Business School, University of Salford, Manchester UK in the research: ***"Organisational solutions to manage commodity price volatility: A comparison of financial instruments, diversification and Keiretsu Gaisha".***

It is confirmed that the researcher has obtained the necessary permission needed for me to participate in this research from the employer. I also confirm that there are no known risks or hazards associated with this research and that my responses and/or input will be treated in strict confidence by the researcher.

I am aware that my participation is completely voluntary and that I have the right to withdraw from this research at any point during the interview or survey process without providing reasons for doing so.

I understand also that I may provide the information and/or data anonymously and will indicate so above. In this situation, the researcher will attach an unique identifier to my response to inform the researcher alone of the original source of the data.

I hereby give my consent, with the understanding, that the information I am giving would be used as data for the above research.

Participant's signature:........................ **Date:** 25-05-2020

Appendix A / Informed Consent Form

University of
Salford
MANCHESTER

Name: Thorsten Schlüter **Position: CEO** /CSO

Name of Firm: AST/ ThyssenKrupp **Address: ~~West Chester/OH USA~~** Essen, Germany

Date: 19.05.2019

Request for Anonymity: Yes ( ) No (X)

I, the above name participant, hereby confirm my willingness and readiness to participate in this research having been recruited by the researcher, Pascal M. Heckmann of Salford Business School, University of Salford, Manchester UK in the research: ***"Organisational solutions to manage commodity price volatility: A comparison of financial instruments, diversification and Keiretsu Gaisha".***

It is confirmed that the researcher has obtained the necessary permission needed for me to participate in this research from the employer. I also confirm that there are no known risks or hazards associated with this research and that my responses and/or input will be treated in strict confidence by the researcher.

I am aware that my participation is completely voluntary and that I have the right to withdraw from this research at any point during the interview or survey process without providing reasons for doing so.

I understand also that I may provide the information and/or data anonymously and will indicate so above. In this situation, the researcher will attach an unique identifier to my response to inform the researcher alone of the original source of the data.

I hereby give my consent, with the understanding, that the information I am giving would be used as data for the above research.

Participant's signature:.. **Date:** 19-05-10

Appendix A / Informed Consent Form

University of Salford MANCHESTER

Name: Christian Muschiol

Position: Sales Global - Automotive

Name of Firm: Outokumpu

Address: Oberschlesienstr 16, 47807 Krefeld/ Germany

Date: 24.07.2019

Request for Anonymity: **Yes (X)** No ()

I, the above name participant, hereby confirm my willingness and readiness to participate in this research having been recruited by the researcher, Pascal M. Heckmann of Salford Business School, University of Salford, Manchester UK in the research: ***"Organisational solutions to manage commodity price volatility: A comparison of financial instruments, diversification and Keiretsu Gaisha"***.

It is confirmed that the researcher has obtained the necessary permission needed for me to participate in this research from the employer. I also confirm that there are no known risks or hazards associated with this research and that my responses and/or input will be treated in strict confidence by the researcher.

I am aware that my participation is completely voluntary and that I have the right to withdraw from this research at any point during the interview or survey process without providing reasons for doing so.

I understand also that I may provide the information and/or data anonymously and will indicate so above. In this situation, the researcher will attach an unique identifier to my response to inform the researcher alone of the original source of the data.

I hereby give my consent, with the understanding, that the information I am giving would be used as data for the above research.

Participant's signature:.. **Date:**...24.5.20...........

Appendix No. 11

University of Salford

SBSR1718-02 approval letter

Research, Innovation and Academic Engagement Ethical Approval Panel

Research Centres Support Team
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7 November 2017

Dear Pascal Heckmann,

RE: ETHICS APPLICATION SBSR1718-02

Based on the information that you provided, I am pleased to inform you that your application SBSR1718-02 has been approved.

If there are any changes to the project or its methodology, please inform the Panel as soon as possible by contacting SBS-ResearchEthics@salford.ac.uk.

Yours sincerely,

Professor David F. Percy
Chair of the Staff and Postgraduate Research Ethics Panel
Salford Business School

Appendix No. 12

Research question 1-1

Statistical raw data; distributions

Source: Own data “3. Frequencies share prices monthly all for CV calculation 20180923. Xlsx”

Contents

1 Descriptive frequencies with the maximum amount of data history

Max 1960		Nickel	Iron Ore	Ferro-Chrome	Outokumpu	Aperam	Acerinox	AK Steel	Posco	Jindal Stainless	JFE
Data availability		1960 Jan	1960 Jan	2006 Jan	2000 Jan	2010 Dec	2000 Jan	2000 Jan	2000 Jan	2003 Oct	2002 Aug
N	Valid	700	700	145	220	89	220	220	220	175	193
	Missing	36	36	591	516	647	516	516	516	561	543
Mean		8.288,83	40,76	2.456,75	222,01	262,91	115,74	121,98	657,97	820,54	2.860,93
Std. Error of Mean		273,26	1,54	76,10	10,80	13,47	2,03	8,29	23,39	30,51	107,79
Median		5.969,65	28,09	2.280,00	222,50	254,30	113,53	83,01	644,00	806,00	2.481,00
Mode		1.742,00	10,33	2.090,00	300,86	83,44a	101,80a	56,60a	826,70a	377,50a	2.675,00
Std. Deviation		7.229,72	40,72	916,38	160,22	127,11	30,07	122,89	346,92	403,64	1.497,45
Variance		52.268.913,82	1.658,07	839.759,20	25.668,85	16.157,96	903,94	15.101,91	120.350,81	162.927,37	2.242.346,48
Skewness		2,16	2,08	2,13	0,91	0,10	1,12	2,75	0,65	0,62	1,67
Std. Error of		0,09	0,09	0,20	0,16	0,26	0,16	0,16	0,16	0,18	0,17
Kurtosis		6,46	3,76	5,44	0,52	- 1,42	1,44	8,05	0,22	0,66	2,54
Std. Error of Kurtosis		0,18	0,18	0,40	0,33	0,51	0,33	0,33	0,33	0,37	0,35
Range		50.548,05	188,35	5.080,00	680,87	396,66	165,05	690,00	1.693,13	2.191,00	7.222,00
Minimum		1.631,00	8,77	1.200,00	20,60	83,44	65,45	20,00	144,38	151,00	988,00
Maximum		52.179,05	197,12	6.280,00	701,47	480,10	230,50	710,00	1.837,50	2.342,00	8.210,00
Sum		5.802.181,32	28.531,42	356.229,20	48.841,49	23.398,76	25.463,16	26.835,05	144.752,35	143.595,00	552.158,75
Coefficient of variation		0,87	1,00	0,37	0,72	0,48	0,26	1,01	0,53	0,49	0,52

a. Multiple modes exist. The smallest value is shown

Max 1960		Tenneco	Faurecia	Futaba	Sejong	BHP Billiton	Norilsk	Vale
Data availability		2000 Jan	2000 Jan	2000 Dec	2000 Jan	2000 Jan	2004 Aug	2002 Mar
N	Valid	220	220	209	220	220	166	195
	Missing	516	516	527	516	516	570	541
Mean		280,53	362,30	21.136,32	77.965,23	11.347,23	159,58	145,95
Std. Error of Mean		13,48	10,86	483,59	3.310,20	412,29	4,46	7,15
Median		249,85	366,79	19.620,00	60.850,00	11.792,50	158,35	127,50
Mode		30,00a	136,95a	29350,00a	117000,00a	2791,16a	169,50a	25,00a
Std. Deviation		199,89	161,05	6.991,12	49.098,27	6.115,21	57,43	99,80
Variance		39.957,76	25.938,24	48.875.748,38	2.410.640.189,45	37.395.848,05	3.298,44	9.960,42
Skewness		0,33	- 0,07	0,32	0,66	- 0,04	0,19	0,71
Std. Error of Skewness		0,16	0,16	0,17	0,16	0,16	0,19	0,17
Kurtosis		- 1,22	- 0,97	- 0,90	- 0,64	- 1,22	0,10	- 0,52
Std. Error of Kurtosis		0,33	0,33	0,33	0,33	0,33	0,37	0,35
Range		660,90	673,12	30.020,00	188.150,00	21.802,60	273,00	378,84
Minimum		13,60	64,28	8.880,00	16.850,00	1.989,30	42,00	18,96
Maximum		674,50	737,40	38.900,00	205.000,00	23.791,90	315,00	397,80
Sum		61.717,67	79.707,10	4.417.490,00	17.152.350,00	2.496.390,28	26.491,01	28.459,39
Coefficient of variation (CV)		0,71	0,44	0,33	0,63	0,54	0,36	0,68

2 escriptive frequencies with data history 2008

2008	Nickel	Iron Ore	Ferro-Chrome	Stainless 304 scrap Europe	Stainless 304 scrap USA	Outokumpu	Aperam	Acerinox	Yieh	AK Steel	Posco	Jindal Stainless
Data availability							2010 dec		2011 Oct			
N Valid	124	124	121	121	118	124	89	124	79	125	125	124
Missing	1	1	4	4	7	1	36	1	46	0	0	1
Mean	16.094,25	108,44	2.547,51	1,13	1,64	149,51	262,91	115,10	76,92	117,65	797,09	694,67
Std. Error of Mean	482,83	4,00	82,52	0,03	0,04	12,70	13,47	1,99	1,01	12,23	21,55	30,72
Median	15.771,13	100,02	2.300,00	1,08	1,61	73,18	254,30	118,08	78,10	70,70	769,70	701,25
Mode	8298,50a	40,50a	2.090,00	1,00	2,03	250,53a	83,44a	101,80a	92,00	56,60	1.039,40	377,50a
Std. Deviation	5.376,52	44,54	907,71	0,29	0,47	141,43	127,11	22,20	8,95	136,73	240,99	342,08
Variance	28.906.960,38	1.983,40	823.941,25	0,08	0,23	20.001,81	16.157,96	492,83	80,03	18.694,95	58.075,01	117.017,79
Skewness	0,60	0,33	2,47	0,46	0,47	1,66	0,10	0,12	0,36	2,92	0,38	0,35
Std. Error of	0,22	0,22	0,22	0,22	0,22	0,22	0,26	0,22	0,27	0,22	0,22	0,22
Kurtosis	- 0,27	- 1,16	6,20	0,38	- 0,09	2,81	- 1,42	- 0,40	- 1,19	8,51	- 0,32	- 0,84
Std. Error of Kurtosis	0,43	0,43	0,44	0,44	0,44	0,43	0,51	0,43	0,53	0,43	0,43	0,43
Range	22.926,76	156,62	4.850,00	1,50	2,20	638,54	396,66	102,48	27,30	689,60	1.012,90	1.421,50
Minimum	8.298,50	40,50	1.430,00	0,45	0,82	20,60	83,44	71,52	64,70	20,40	353,60	151,00
Maximum	31.225,26	197,12	6.280,00	1,95	3,02	659,14	480,10	174,00	92,00	710,00	1.366,50	1.572,50
Sum	1.995.687,18	13.447,15	308.249,20	136,90	193,69	18.539,33	23.398,76	14.272,19	6.076,90	14.706,20	99.635,70	86.138,50
Coefficient of variation	0,33	0,41	0,36	0,26	0,29	0,95	0,48	0,19	0,12	1,16	0,30	0,49

a. Multiple modes exist. The smallest value is shown

2008	Nippon Steel	JFE	Tenneco	Faurecia	Futaba	Sejong	BHP Billiton	Norilsk	Vale	Glencore	Inflation rate ECB	ECB interst rate
Data availability												
N Valid	125	125	125	124	124	124	125	125	125	85	116	119
Missing	0	0	0	1	1	1	0	0	0	40	9	6
Mean	26,68	2.361,88	396,93	272,94	16.170,32	109.982,66	15.569,34	168,72	173,59	3.091,11	1,40	0,81
Std. Error of Mean	0,67	81,46	16,03	13,70	313,85	3.776,51	335,47	4,26	8,64	101,78	0,11	0,09
Median	24,77	2.178,00	424,50	257,00	16.005,00	114.750,00	15.929,60	167,10	144,10	3.225,00	1,35	0,75
Mode	16,29a	2145,00a	144,20	136,95a	15990,00a	117000,00a	17431,20a	169,50a	191,50	894,80a	1,6a	1,00
Std. Deviation	7,50	910,72	179,19	152,58	3.494,89	42.053,45	3.750,63	47,68	96,55	938,39	1,19	0,99
Variance	56,21	829.402,93	32.109,27	23.281,65	12.214.261,68	1.768.492.684,73	14.067.204,64	2.273,23	9.322,07	880.571,79	1,41	0,98
Skewness	1,70	1,70	- 0,47	1,12	0,16	0,12	- 0,17	0,30	0,47	- 0,65	0,30	2,00
Std. Error of Skewness	0,22	0,22	0,22	0,22	0,22	0,22	0,22	0,22	0,22	0,26	0,22	0,22
Kurtosis	3,57	3,92	- 0,85	1,13	- 0,40	- 0,56	- 0,30	1,00	- 0,83	0,40	- 0,92	3,99
Std. Error of Kurtosis	0,43	0,43	0,43	0,43	0,43	0,43	0,43	0,43	0,43	0,52	0,45	0,44
Range	39,34	4.972,00	660,90	673,12	15.410,00	174.800,00	17.027,90	256,50	373,30	4.416,20	4,80	4,00
Minimum	16,29	988,00	13,60	64,28	8.880,00	30.200,00	6.764,00	42,00	24,50	894,80	- 0,70	-
Maximum	55,63	5.960,00	674,50	737,40	24.290,00	205.000,00	23.791,90	298,50	397,80	5.311,00	4,10	4,00
Sum	3.334,85	295.235,25	49.616,10	33.844,83	2.005.120,00	13.637.850,00	1.946.166,89	21.089,60	21.698,90	262.744,20	162,10	96,10
Coefficient of variation (CV)	0,28	0,39	0,45	0,56	0,22	0,38	0,24	0,28	0,56	0,30	0,85	1,23

3 Descriptive frequencies with data history 2013

2013		Nickel	Iron Ore	Ferro-Chrome	Stainless 304 scrap Europe	Stainless 304 scrap USA	Outokumpu	Aperam	Acerinox	Yieh	AK Steel	Posco	Jindal Stainless
N	Valid	64	64	61	61	58	64	64	64	64	65	65	64
	Missing	1	1	4	4	7	1	1	1	1	0	0	1
Mean		12.801,61	82,97	2.204,09	1,01	1,28	54,80	303,31	111,08	73,91	52,77	637,00	499,79
Std. Error of Mean		385,90	3,91	37,00	0,01	0,04	2,30	15,20	2,31	0,86	2,47	17,63	33,44
Median		12.847,90	71,89	2.220,00	1,00	1,26	51,84	325,40	116,48	70,55	48,70	665,60	404,50
Mode		8298,50a	40,50a	1970,00a	1,00	1,27	20,60a	83,44a	101,80	67,00	56,60	353,60a	377,50a
Std. Deviation		3.087,20	31,25	288,99	0,12	0,27	18,43	121,60	18,47	6,88	19,89	142,13	267,51
Variance		9.530.825,26	976,37	83.517,00	0,01	0,07	339,58	14.786,19	341,02	47,27	395,60	20.201,81	71.564,24
Skewness		0,40	0,82	1,00	0,09	0,57	0,32	-0,41	-0,32	0,52	0,71	-0,41	1,10
Std. Error of		0,30	0,30	0,31	0,31	0,31	0,30	0,30	0,30	0,30	0,30	0,30	0,30
Kurtosis		-0,83	-0,61	2,02	-0,47	-0,15	-0,74	-1,08	-0,31	-0,81	0,17	-0,89	0,39
Std. Error of Kurtosis		0,59	0,59	0,60	0,60	0,62	0,59	0,59	0,59	0,59	0,59	0,59	0,59
Range		11.102,58	114,14	1.294,40	0,47	1,09	72,85	396,66	84,73	27,30	88,80	541,20	1.040,00
Minimum		8.298,50	40,50	1.770,00	0,80	0,82	20,60	83,44	71,52	64,70	20,40	353,60	151,00
Maximum		19.401,08	154,64	3.064,40	1,27	1,91	93,45	480,10	156,25	92,00	109,20	894,80	1.191,00
Sum		819.302,83	5.310,12	134.449,20	61,38	74,04	3.507,51	19.411,56	7.109,01	4.730,10	3.430,10	41.404,80	31.986,50
Coefficient of variation		0,24	0,38	0,13	0,11	0,21	0,34	0,40	0,17	0,09	0,38	0,22	0,54

a. Multiple modes exist. The smallest value is shown

2013		Nippon Steel	JFE	Tenneco	Faurecia	Futaba	Sejong	BHP Billiton	Norilsk	Vale	Glencore	Inflation rate ECB	ECB interst rate
N	Valid	65	65	65	64	64	64	65	65	65	64	56	59
	Missing	0	0	0	1	1	1	0	0	0	1	9	6
Mean		23,10	2.099,91	539,59	369,11	17.581,56	119.945,31	13.975,45	162,27	100,77	2.804,36	0,66	0,15
Std. Error of Mean		0,42	49,90	9,26	18,38	448,35	4.255,67	415,41	2,67	5,41	106,69	0,09	0,03
Median		23,27	2.125,00	558,30	349,33	17.255,00	110.250,00	14.036,00	163,90	100,70	3.100,50	0,50	0,05
Mode		16,29a	1315,00a	349,60a	124,00a	19620,00a	98000,00a	6764,00a	175,70	24,50a	894,80a	0,20	-
Std. Deviation		3,39	402,28	74,63	147,02	3.586,81	34.045,32	3.349,14	21,56	43,62	853,50	0,69	0,22
Variance		11,47	161.828,69	5.569,37	21.614,33	12.865.235,62	1.159.084.104,66	11.216.740,12	464,79	1.902,91	728.461,24	0,47	0,05
Skewness		0,25	0,10	-0,70	0,89	-0,12	0,50	-0,36	-0,01	0,13	-0,97	0,44	1,60
Std. Error of Skewness		0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,30	0,32	0,31
Kurtosis		-0,03	-0,35	0,08	0,46	-0,65	-1,09	-0,68	-0,75	-0,88	-0,13	-0,90	1,47
Std. Error of Kurtosis		0,59	0,59	0,59	0,59	0,59	0,59	0,59	0,59	0,59	0,59	0,63	0,61
Range		14,69	1.721,50	324,90	613,40	14.340,00	118.400,00	13.353,20	90,80	177,20	3.142,20	2,60	0,75
Minimum		16,29	1.315,00	349,60	124,00	9.950,00	72.600,00	6.764,00	115,30	24,50	894,80	-0,60	-
Maximum		30,98	3.036,50	674,50	737,40	24.290,00	191.000,00	20.117,20	206,10	201,70	4.037,00	2,00	0,75
Sum		1.501,58	136.494,00	35.073,10	23.623,20	1.125.220,00	7.676.500,00	908.404,00	10.547,80	6.549,90	179.479,20	37,20	9,10
Coefficient of variation (CV)		0,15	0,19	0,14	0,40	0,20	0,28	0,24	0,13	0,43	0,30	1,03	1,45

Max 1960	Data availability	N	Mean	Median	Mode	Std. Deviation	Skewness	z score Skewness	Kurtosis	z score Kurtosis	Range	Minimum	Maximum	Coefficient of variation (CV)
Nickel	1960 Jan	700	8.288,83	5.969,65	1.742,00	7.229,72	2,16	23,40	6,46	35,00	50.548,05	1.631,00	52.179,05	0,87
Iron Ore	1960 Jan	700	40,76	28,09	10,33	40,72	2,08	22,54	3,76	20,38	188,35	8,77	197,12	1,00
Ferro-Chrome	2006 Jan	145	2.456,75	2.280,00	2.090,00	916,38	2,13	10,56	5,44	13,60	5.080,00	1.200,00	6.280,00	0,37
Outokumpu	2000 Jan	220	222,01	222,50	300,86	160,22	0,91	5,57	0,52	1,58	680,87	20,60	701,47	0,72
Aperam	2010 Dec	89	262,91	254,30	83,44a	127,11	0,10	0,37	-1,42	-2,80	396,66	83,44	480,10	0,48
Acerinox	2000 Jan	220	115,74	113,53	101,80a	30,07	1,12	6,81	1,44	4,40	165,05	65,45	230,50	0,26
AK Steel	2000 Jan	220	121,98	83,01	56,60a	122,89	2,75	16,78	8,05	24,65	690,00	20,00	710,00	1,01
Posco	2000 Jan	220	657,97	644,00	826,70a	346,92	0,65	3,94	0,22	0,69	1.693,13	144,38	1.837,50	0,53
Jindal Stainless	2003 Oct	175	820,54	806,00	377,50a	403,64	0,62	3,36	0,66	1,82	2.191,00	151,00	2.342,00	0,49
JFE	2002 Aug	193	2.860,93	2.481,00	2.675,00	1.497,45	1,67	9,52	2,54	7,31	7.222,00	988,00	8.210,00	0,52
Tenneco	2000 Jan	220	280,53	249,85	30,00a	199,89	0,33	2,03	-1,22	-3,74	660,90	13,60	674,50	0,71
Faurecia	2000 Jan	220	362,30	366,79	136,95a	161,05	-0,07	-0,42	-0,97	-2,97	673,12	64,28	737,40	0,44
Futaba	2000 Dec	209	21.136,32	19.620,00	29350,00a	6.991,12	0,32	2,03	-0,90	-2,68	30.020,00	8.880,00	38.900,00	0,33
Sejong	2000 Jan	220	77.965,23	60.850,00	117000,00a	49.098,27	0,66	0,42	-0,64	-1,96	188.150,00	16.850,00	205.000,00	0,63
BHP Billiton	2000 Jan	220	11.347,23	11.792,50	2791,16a	6.115,21	-0,04	-1,89	-1,22	-3,73	21.802,60	1.989,30	23.791,90	0,54
Norilsk	2004 Aug	166	159,58	158,35	169,50a	57,43	0,19	4,05	0,10	0,28	273,00	42,00	315,00	0,36
Vale	2002 Mar	195	145,95	127,50	25,00a	99,80	0,71	0,25	-0,52	-1,50	378,84	18,96	397,80	0,68

a. Multiple modes exist. The smallest value is shown

2008	Data availability	N	Mean	Median	Mode	Std. Deviation	Skewness	z score Skewness	Kurtosis	z score Kurtosis	Range	Minimum	Maximum	Coefficient of variation (CV)
Nickel		124	16.094,25	15.771,13	8298,50a	5.376,52	0,60	2,77	-0,27	-0,63	22.926,76	8.298,50	31.225,26	0,33
Iron Ore		124	108,44	100,02	40,50a	44,54	0,33	1,53	-1,16	-2,70	156,62	40,50	197,12	0,41
Ferro-Chrome		121	2.547,51	2.300,00	2.090,00	907,71	2,47	11,21	6,20	14,19	4.850,00	1.430,00	6.280,00	0,36
Stainless 304 scrap Europe		121	1,13	1,08	1,00	0,29	0,46	2,07	0,38	0,87	1,50	0,45	1,95	0,26
Stainless 304 scrap USA		118	1,64	1,61	2,03	0,47	0,47	2,13	-0,09	-0,20	2,20	0,82	3,02	0,29
Outokumpu		124	149,51	73,18	250,53a	141,43	1,66	7,63	2,81	6,52	638,54	20,60	659,14	0,95
Aperam	2010 dec	89	262,91	254,30	83,44a	127,11	0,10	0,37	-1,42	-2,80	396,66	83,44	480,10	0,48
Acerinox		124	115,10	118,08	101,80a	22,20	0,12	0,57	-0,40	-0,94	102,48	71,52	174,00	0,19
Yieh	2011 Oct	79	76,92	78,10	92,00	8,95	0,36	1,35	-1,19	-2,22	27,30	64,70	92,00	0,12
AK Steel		125	117,65	70,70	56,60	136,73	2,92	13,50	8,51	19,80	689,60	20,40	710,00	1,16
Posco		125	797,09	769,70	1.039,40	240,99	0,38	1,75	-0,32	-0,74	1.012,90	353,60	1.366,50	0,30
Jindal Stainless		124	694,67	701,25	377,50a	342,08	0,35	1,60	-0,84	-1,95	1.421,50	151,00	1.572,50	0,49
Nippon Steel		125	26,68	24,77	16,29a	7,50	1,70	7,86	3,57	8,31	39,34	16,29	55,63	0,28
JFE		125	2.361,88	2.178,00	2145,00a	910,72	1,70	7,85	3,92	9,13	4.972,00	988,00	5.960,00	0,39
Tenneco		125	396,93	424,50	144,20	179,19	-0,47	-2,18	-0,85	-1,97	660,90	13,60	674,50	0,45
Faurecia		124	272,94	257,00	136,95a	152,58	1,12	5,16	1,13	2,61	673,12	64,28	737,40	0,56
Futaba		124	16.170,32	16.005,00	15990,00a	3.494,89	0,16	0,76	-0,40	-0,94	15.410,00	8.880,00	24.290,00	0,22
Sejong		124	109.982,66	114.750,00	117000,00a	42.053,45	0,12	0,53	-0,56	-1,29	174.800,00	30.200,00	205.000,00	0,38
BHP Billiton		125	15.569,34	15.929,60	17431,20a	3.750,63	-0,17	-0,80	-0,30	-0,70	17.027,90	6.764,00	23.791,90	0,24
Norilsk		125	168,72	167,10	169,50a	47,68	0,30	1,41	1,00	2,34	256,50	42,00	298,50	0,28
Vale		125	173,59	144,10	191,50	96,55	0,47	2,17	-0,83	-1,94	373,30	24,50	397,80	0,56
Glencore		85	3.091,11	3.225,00	894,80a	938,39	-0,65	-2,50	0,40	0,77	4.416,20	894,80	5.311,00	0,30

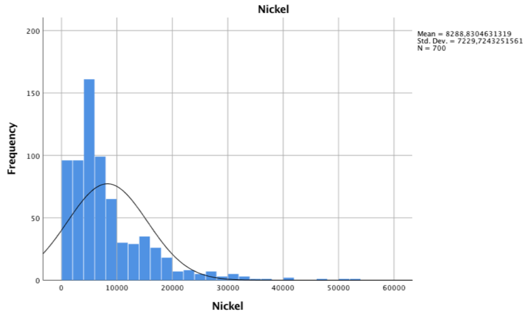
a. Multiple modes exist. The smallest value is shown

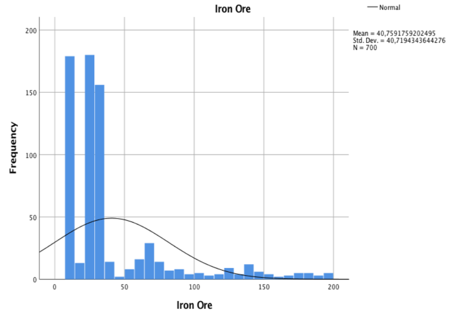
2013	Data availability	N	Mean	Median	Mode	Std. Deviation	Skewness	z score Skewness	Kurtosis	z score Kurtosis	Range	Minimum	Maximum	Coefficient of variation (CV)
Nickel		64	12.801,61	12.847,90	8298,50a	3.087,20	0,40	1,33	-0,83	-1,41	11.102,58	8.298,50	19.401,08	0,24
Iron Ore		64	82,97	71,89	40,50a	31,25	0,82	2,74	-0,61	-1,03	114,14	40,50	154,64	0,38
Ferro-Chrome		61	2.204,09	2.220,00	1970,00a	288,99	1,00	3,27	2,02	3,34	1.294,40	1.770,00	3.064,40	0,13
Stainless 304 scrap Europe		61	1,01	1,00	1,00	0,12	0,09	0,29	-0,47	-0,77	0,47	0,80	1,27	0,11
Stainless 304 scrap USA		58	1,28	1,26	1,27	0,27	0,57	1,82	-0,15	-0,24	1,09	0,82	1,91	0,21
Outokumpu		64	54,80	51,84	20,60a	18,43	0,32	1,08	-0,74	-1,26	72,85	20,60	93,45	0,34
Aperam		64	303,31	325,40	83,44a	121,60	-0,41	-1,36	-1,08	-1,83	396,66	83,44	480,10	0,40
Acerinox		64	111,08	116,48	101,80	18,47	-0,32	-1,08	-0,31	-0,52	84,73	71,52	156,25	0,17
Yieh		64	73,91	70,55	67,00	6,88	0,52	1,73	-0,81	-1,38	27,30	64,70	92,00	0,09
AK Steel		65	52,77	48,70	56,60	19,89	0,71	2,38	-0,17	-0,29	88,80	20,40	109,20	0,38
Posco		65	637,00	665,60	353,60a	142,13	-0,41	-1,37	-0,89	-1,52	541,20	353,60	894,80	0,22
Jindal Stainless		64	499,79	404,50	377,50a	267,51	1,10	3,66	0,39	0,67	1.040,00	151,00	1.191,00	0,54
Nippon Steel		65	23,10	23,27	16,29a	3,39	0,25	0,83	-0,03	-0,05	14,69	16,29	30,98	0,15
JFE		65	2.099,91	2.125,00	1315,00a	402,28	0,10	0,32	-0,35	-0,59	1.721,50	1.315,00	3.036,50	0,19
Tenneco		65	539,59	558,30	349,60a	74,63	-0,70	-2,37	0,08	0,14	324,90	349,60	674,50	0,14
Faurecia		64	369,11	349,33	124,00a	147,02	0,89	2,97	0,46	0,78	613,40	124,00	737,40	0,40
Futaba		64	17.581,56	17.255,00	19620,00a	3.586,81	-0,12	-0,40	-0,65	-1,11	14.340,00	9.950,00	24.290,00	0,20
Sejong		64	119.945,31	110.250,00	98000,00a	34.045,32	0,50	1,65	-1,09	-1,84	118.400,00	72.600,00	191.000,00	0,28
BHP Billiton		65	13.975,45	14.036,00	6764,00a	3.349,14	-0,36	-1,21	-0,68	-1,16	13.353,20	6.764,00	20.117,20	0,24
Norilsk		65	162,27	163,90	175,70	21,56	-0,01	-0,05	-0,75	-1,28	90,80	115,30	206,10	0,13
Vale		65	100,77	100,70	24,50a	43,62	0,13	0,44	-0,88	-1,51	177,20	24,50	201,70	0,43
Glencore		64	2.804,36	3.100,50	894,80a	853,50	-0,97	-3,24	-0,13	-0,22	3.142,20	894,80	4.037,00	0,30

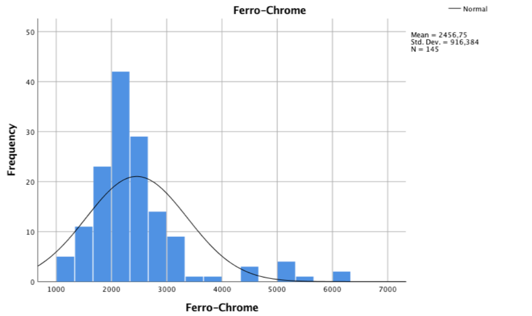
a. Multiple modes exist. The smallest value is shown

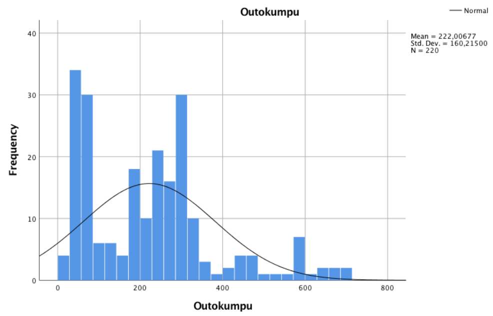
Source:3. Frequencies share prices monthly all for CV calculation 20180923, IBM SPSS

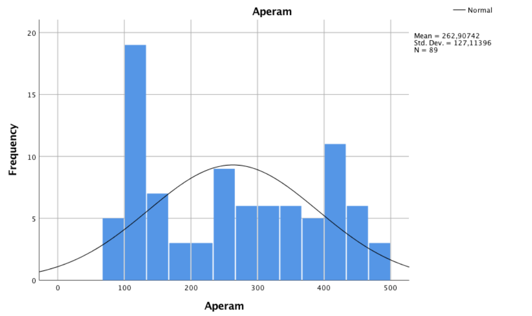
4 Histograms for Datasets 1960, 2008 and 2013

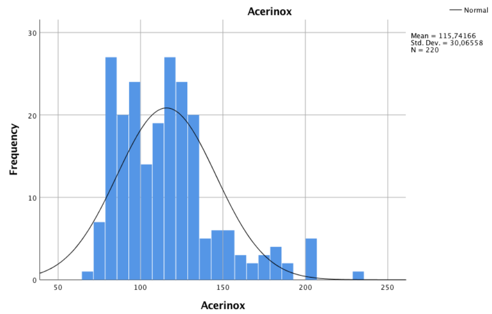


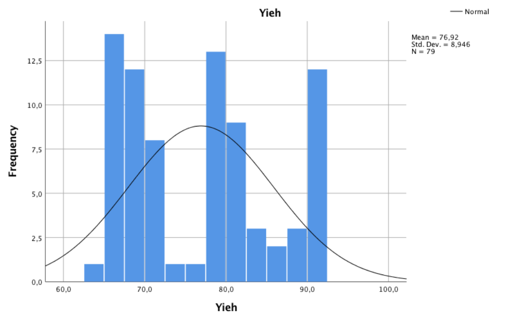


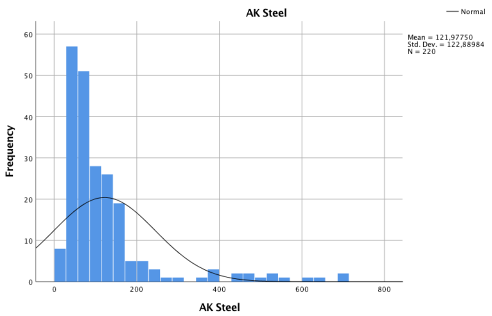


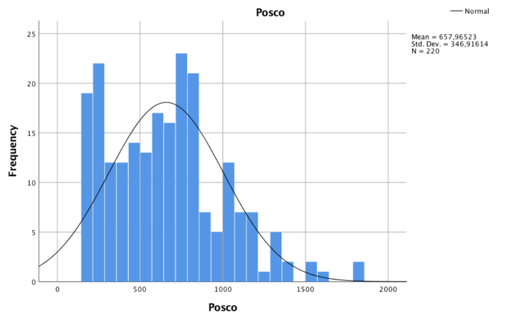


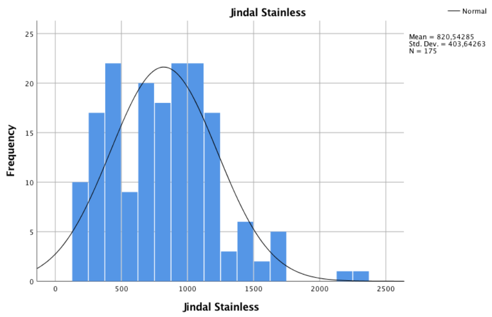


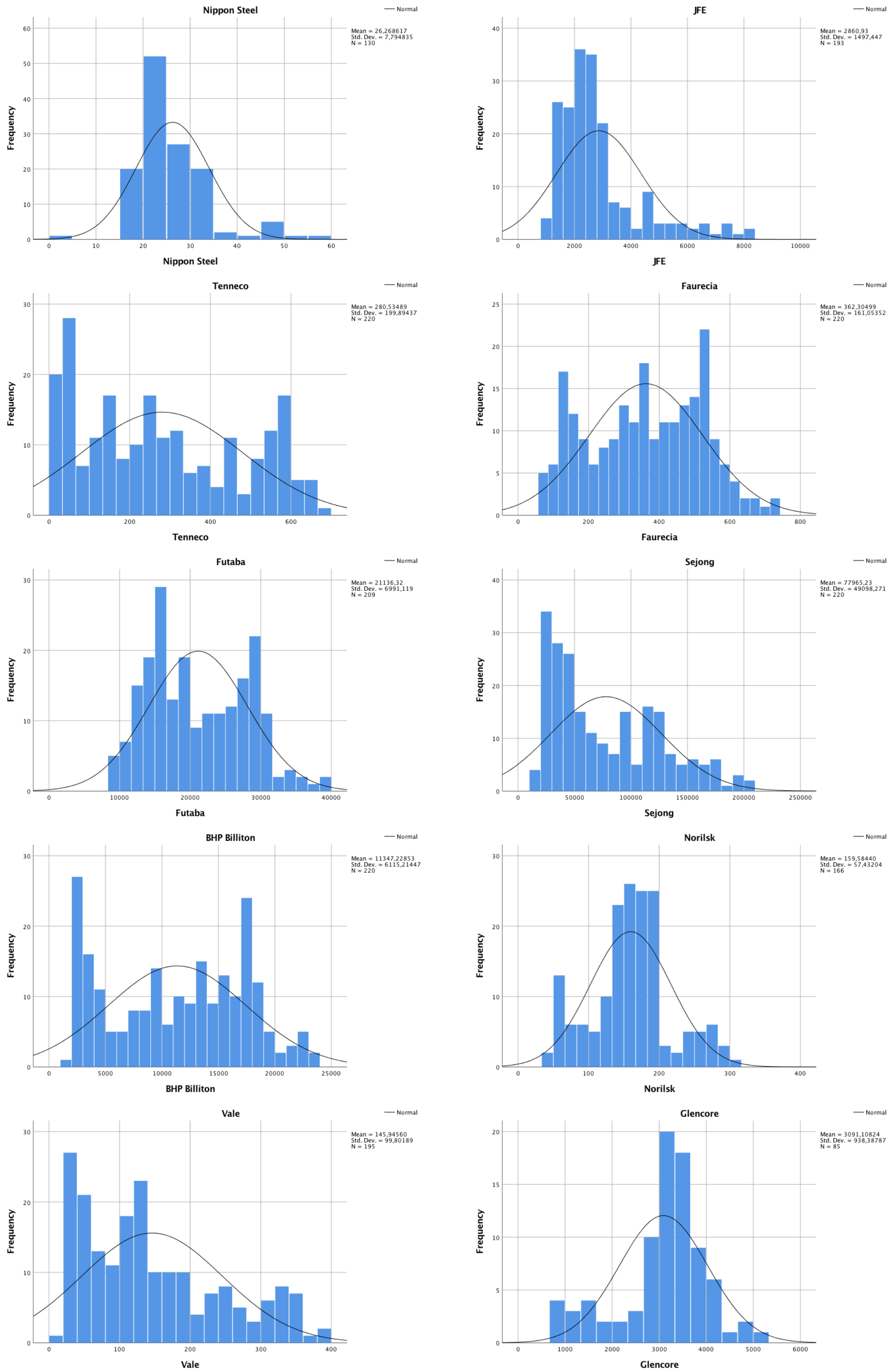




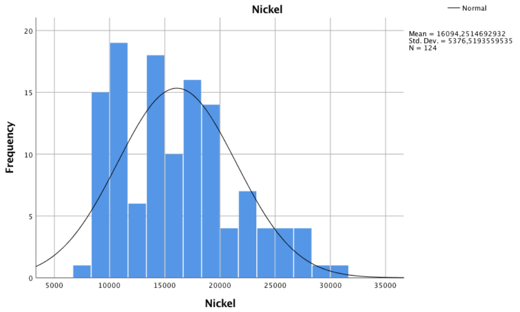


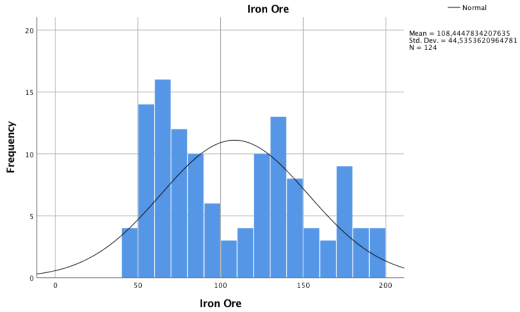


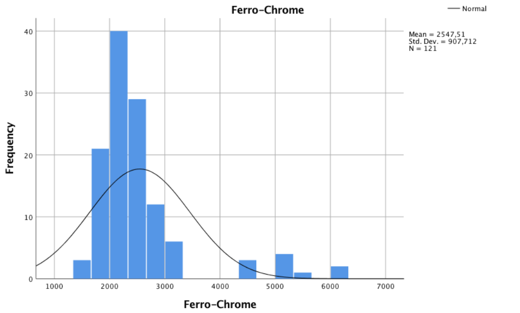


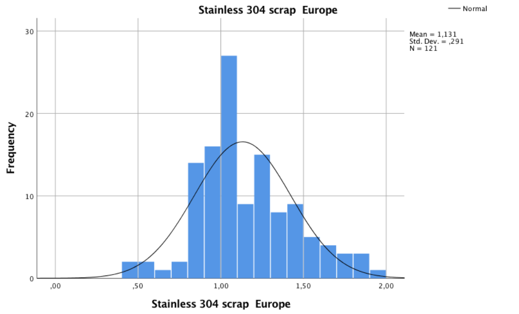


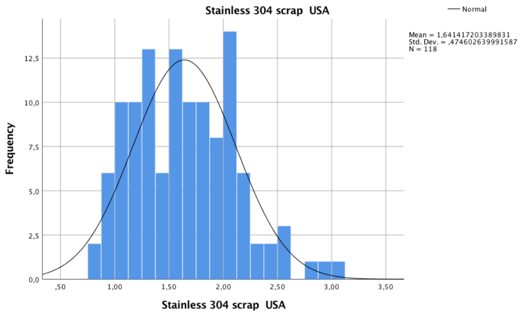
Data period 2008, Histograms

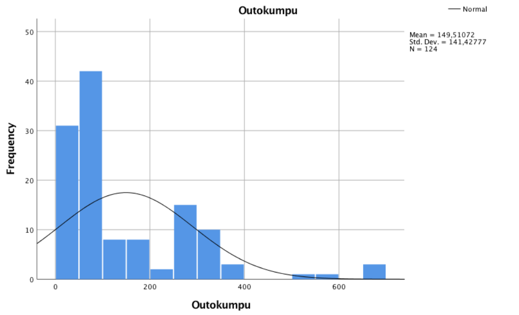

Nickel
Normal
Mean = 16094,2514692932
Std. Dev. = 5376,5193559535
N = 124
Frequency
Nickel

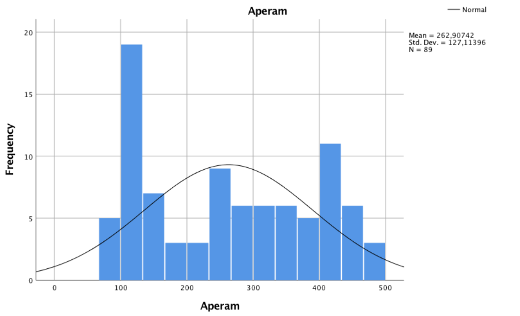

Iron Ore
Normal
Mean = 108,4447834207635
Std. Dev. = 44,5353620964781
N = 124
Frequency
Iron Ore

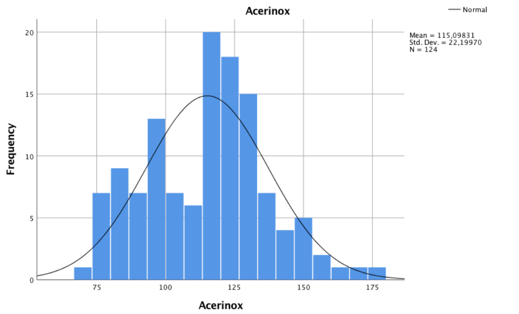

Ferro-Chrome
Normal
Mean = 2547,51
Std. Dev. = 907,712
N = 121
Frequency
Ferro-Chrome

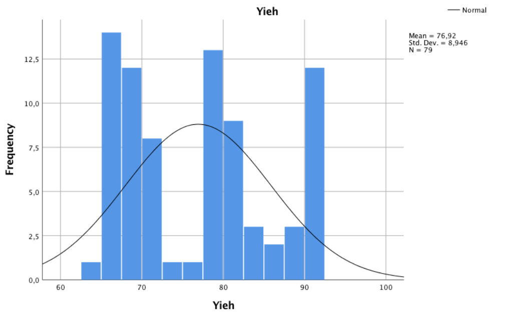

Stainless 304 scrap Europe
Normal
Mean = 1,131
Std. Dev. = ,291
N = 121
Frequency
Stainless 304 scrap Europe

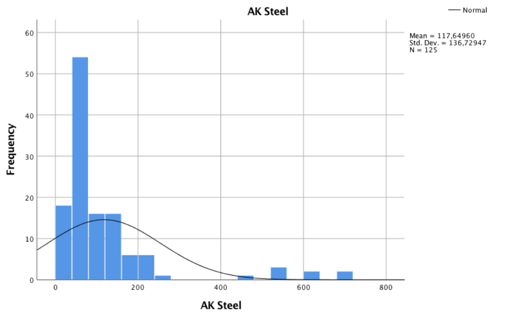

Stainless 304 scrap USA
Normal
Mean = 1,641417203389831
Std. Dev. = ,474602639991587
N = 118
Frequency
Stainless 304 scrap USA

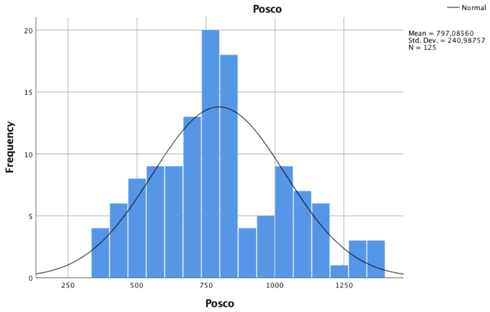

Outokumpu
Normal
Mean = 149,51072
Std. Dev. = 141,42777
N = 124
Frequency
Outokumpu

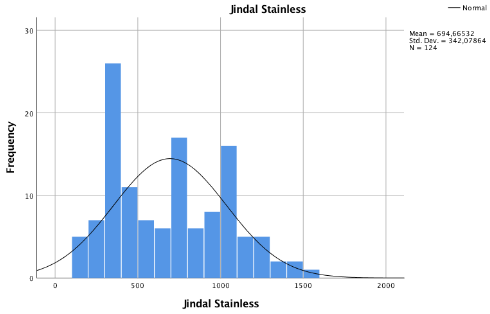

Aperam
Normal
Mean = 262,90742
Std. Dev. = 127,11396
N = 89
Frequency
Aperam

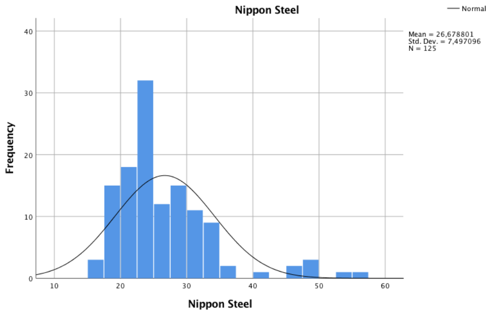

Acerinox
Normal
Mean = 115,09831
Std. Dev. = 22,19970
N = 124
Frequency
Acerinox

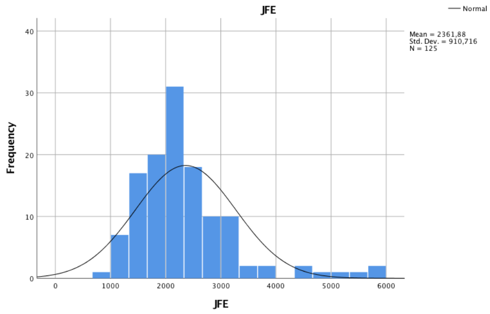

Yieh
Normal
Mean = 76,92
Std. Dev. = 8,946
N = 79
Frequency
Yieh

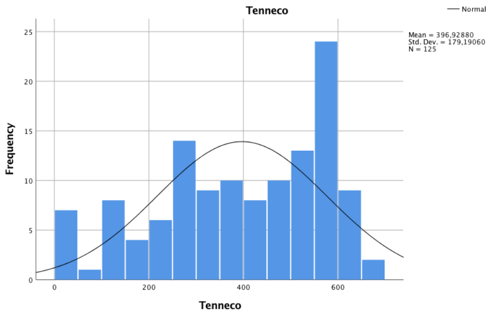

AK Steel
Normal
Mean = 117,64960
Std. Dev. = 136,72947
N = 125
Frequency
AK Steel

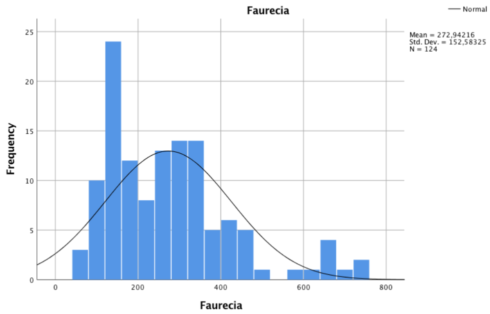

Posco
Normal
Mean = 797,08560
Std. Dev. = 240,98757
N = 125
Frequency
Posco

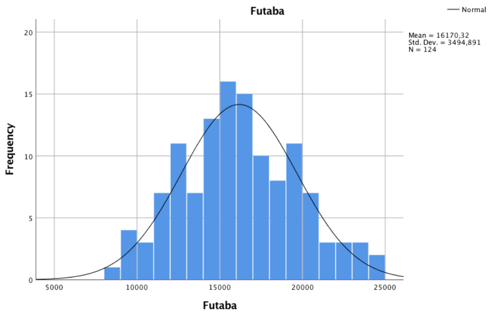

Jindal Stainless
Normal
Mean = 694,66532
Std. Dev. = 342,07864
N = 124
Frequency
Jindal Stainless

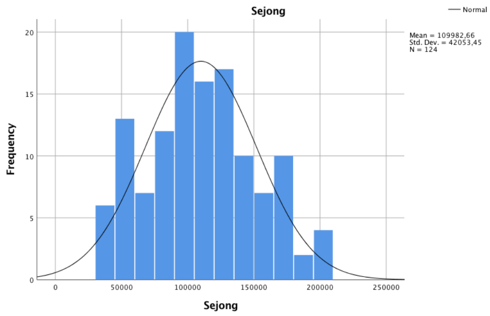

Nippon Steel
Normal
Mean = 26,678801
Std. Dev. = 7,497096
N = 125
Frequency
Nippon Steel

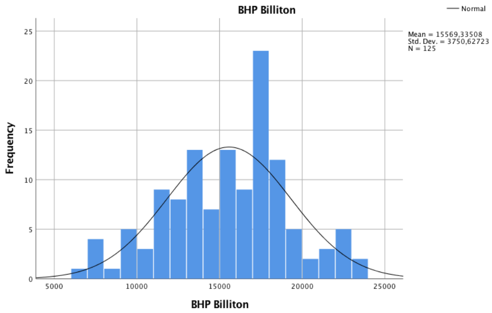

JFE
Normal
Mean = 2361,88
Std. Dev. = 910,716
N = 125
Frequency
JFE

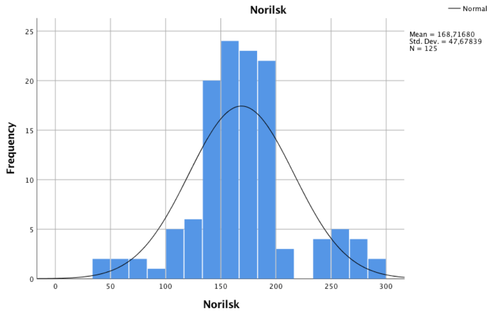

Tenneco
Normal
Mean = 396,92880
Std. Dev. = 179,19060
N = 125
Frequency
Tenneco

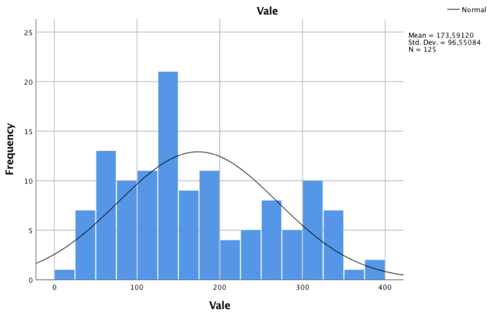

Faurecia
Normal
Mean = 272,94216
Std. Dev. = 152,58325
N = 124
Frequency
Faurecia

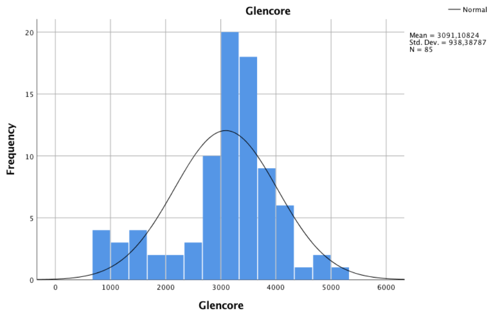

Futaba
Normal
Mean = 16170,32
Std. Dev. = 3494,891
N = 124
Frequency
Futaba


Sejong
Normal
Mean = 109982,66
Std. Dev. = 42053,45
N = 124
Frequency
Sejong

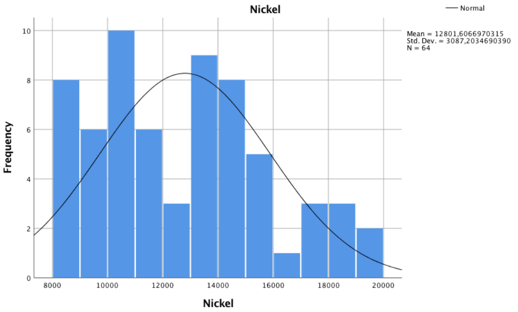

BHP Billiton
Normal
Mean = 15569,33508
Std. Dev. = 3750,62723
N = 125
Frequency
0
5
10
15
20
25
5000
10000
15000
20000
25000
BHP Billiton

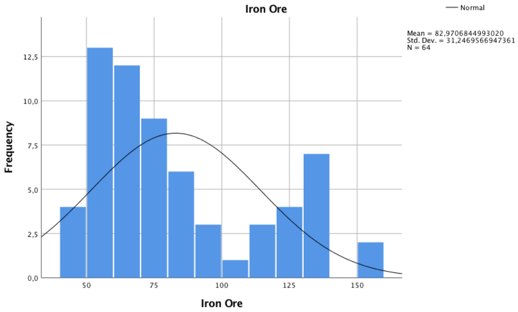

Norilsk
Normal
Mean = 168,71680
Std. Dev. = 47,67839
N = 125
Frequency
0
5
10
15
20
25
0
50
100
150
200
250
300
Norilsk

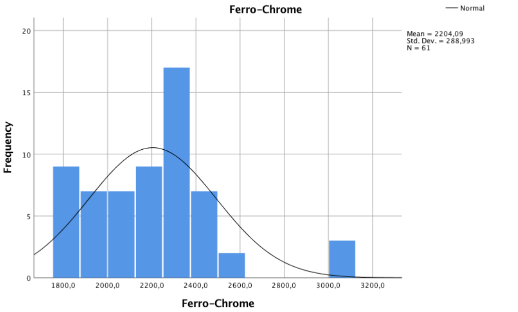

Vale
Normal
Mean = 173,59120
Std. Dev. = 96,55084
N = 125
Frequency
0
5
10
15
20
25
0
100
200
300
400
Vale

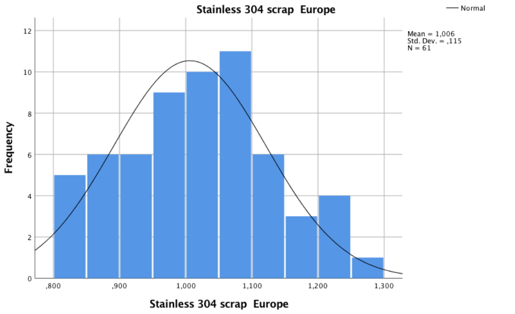

Glencore
Normal
Mean = 3091,10824
Std. Dev. = 938,38787
N = 85
Frequency
0
5
10
15
20
0
1000
2000
3000
4000
5000
6000
Glencore

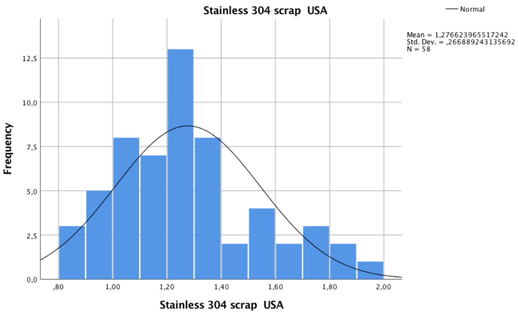
Data period 2013, Histograms

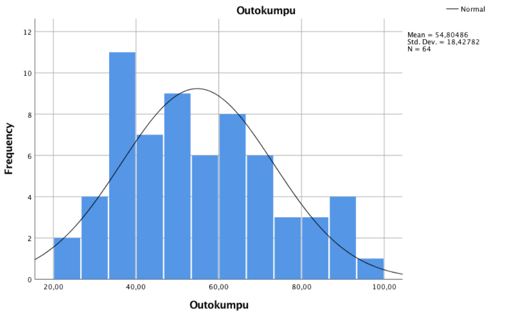


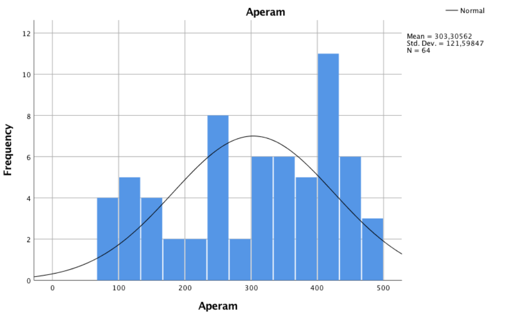


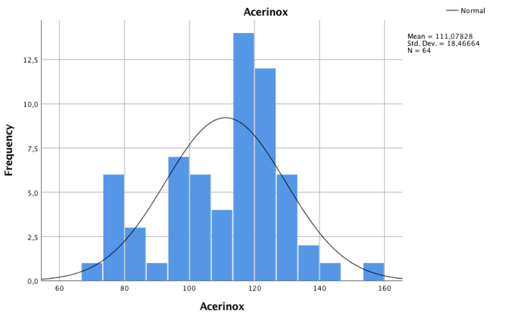


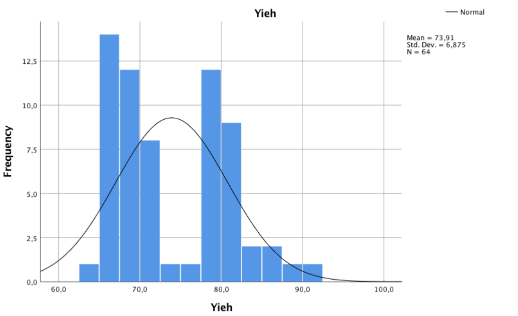


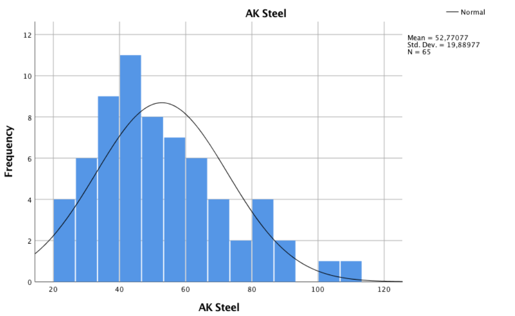


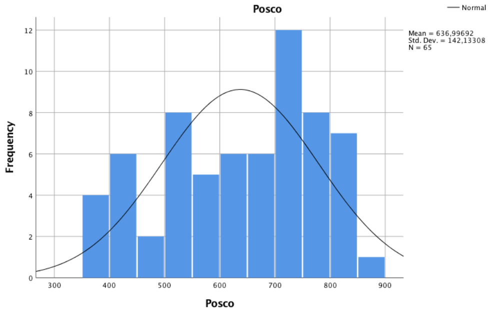


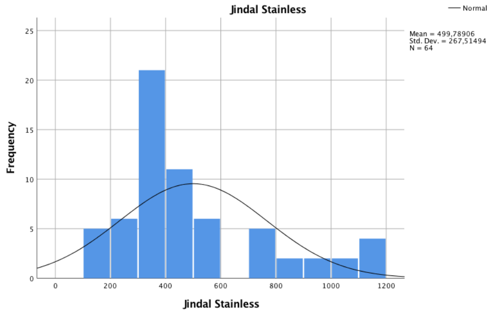


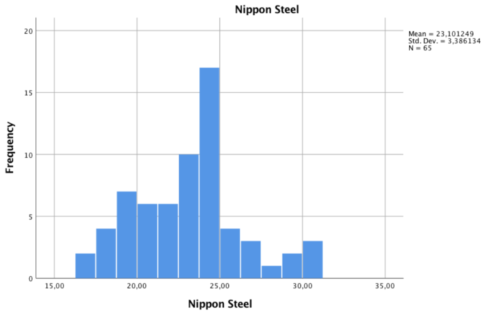


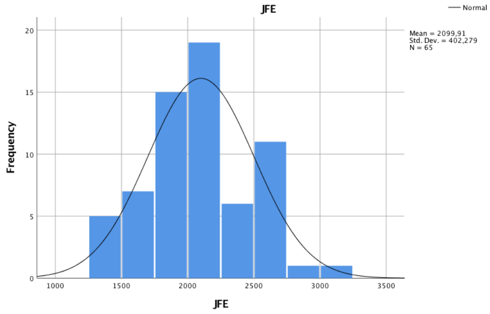


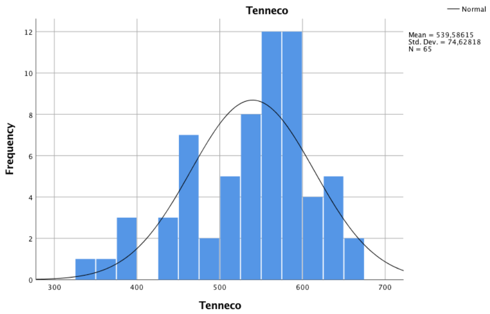


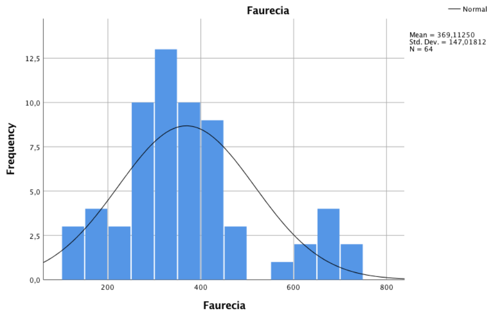

Posco
Normal
Mean = 636,99692
Std. Dev. = 142,13308
N = 65
Frequency
Posco

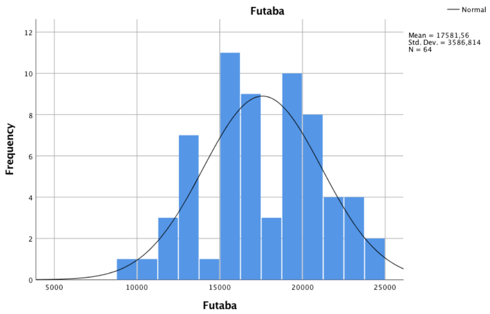

Jindal Stainless
Normal
Mean = 499,78906
Std. Dev. = 267,51494
N = 64
Frequency
Jindal Stainless

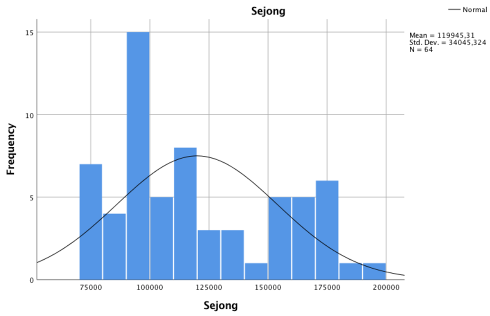

Nippon Steel
Mean = 23,101249
Std. Dev. = 3,386134
N = 65
Frequency
Nippon Steel

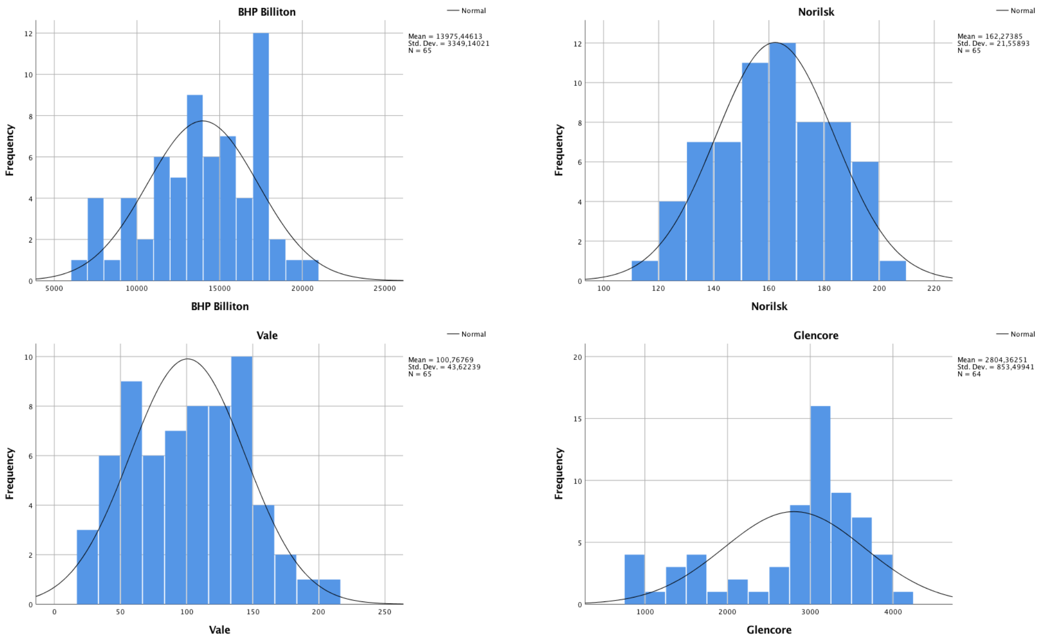

JFE
Normal
Mean = 2099,91
Std. Dev. = 402,279
N = 65
Frequency
JFE


Tenneco
Normal
Mean = 539,58615
Std. Dev. = 74,62818
N = 65
Frequency
Tenneco


Faurecia
Normal
Mean = 369,11250
Std. Dev. = 147,01812
N = 64
Frequency
Faurecia


Futaba
Normal
Mean = 17581,56
Std. Dev. = 3586,814
N = 64
Frequency
Futaba


Sejong
Normal
Mean = 119945,31
Std. Dev. = 34045,324
N = 64
Frequency
Sejong



5 Coefficient of variation Nickel 2018-2019,

Source: 3. Frequencies share price monthly all for CV calculations

2018-2019	ALUMINUM	COPPER	NICKEL
Mean	1951.48	6269.97	13513.99
Std. Deviation	185.68	430.46	1699.03
N	24	24	24
CV	0.10	0.07	0.13
2018			
Mean	2108.48	6529.80	13114.06
Std. Deviation	125.37	417.67	1237.53
N	12	12	12
CV	0.06	0.06	0.09
2019			
Mean	1794.49	6010.15	13913.91
Std. Deviation	50.94	256.29	2038.48
N	12	12	12
CV	0.03	0.04	0.15

Appendix No. 13

Calculations to answer research question 1-3

Contents

1 Correlation Nickel versus raw materials and share price

Period	Raw Materials	Correlation Coefficient	Sig. (2-tailed)	N	Strength of relation
1960-2018	Iron Ore	0.89	0.000	696	very strong
2000-2018	Iron Ore	0.83	0.000	216	very strong
2008-2018	Iron Ore	0.87	0.000	120	very strong
2000-2018	Ferro-Chrome	0.36	0.000	144	moderate
2008-2018	Ferro-Chrome	0.67	0.000	120	moderate
2000-2018	Stainless 304 scrap Europe	0.81	0.000	120	very strong
2008-2018	Stainless 304 scrap Europe	0.81	0.000	120	very strong
2000-2018	Stainless 304 scrap USA	0.81	0.000	118	very strong
2008-2018	Stainless 304 scrap USA	0.81	0.000	118	very strong

Period	Mining	Correlation Coefficient	Sig. (2-tailed)	N	Strength of relation
2000-2018	BHP Billiton	0.70	0.000	215	strong
2008-2018	BHP Billiton	0.80	0.000	120	strong
2000-2018	Norilsk	0.57	0.000	161	moderate
2008-2018	Norilsk	0.68	0.000	120	strong
2000-2018	Vale	0.82	0.000	190	very strong
2008-2018	Vale	0.89	0.000	120	very strong
2000-2018	Glencore	0.74	0.000	81	strong
2008-2018	Glencore	0.74	0.000	81	strong

Period	Stainless Steel Producer	Correlation Coefficient	Sig. (2-tailed)	N	Strength of relation
2000-2018	Outokumpu	0.38	0.000	216	moderate
2008-2018	Outokumpu	0.61	0.000	120	strong
2000-2018	Aperam		not sufficient data		
2008-2018	Aperam	-0.60	0.000	85	strong negative
2000-2018	Acerinox	0.62	0.000	216	strong
2008-2018	Acerinox	0.31	0.001	120	moderate
2000-2018	Yieh	0.84	0.000	75	very strong
2008-2018	Yieh	0.84	0.000	75	very strong
2000-2018	AK Steel	0.46	0.000	215	moderate
2008-2018	AK Steel	0.66	0.000	120	strong
2000-2018	Posco	0.86	0.000	215	very strong
2008-2018	Posco	0.87	0.000	120	very strong
2000-2018	Jindal Stainl.	0.65	0.000	171	strong
2008-2018	Jindal Stainl.	0.64	0.000	120	strong
2000-2018	Nippon Steel		not sufficient data		
2008-2018	Nippon Steel	0.65	0.000	120	strong
2000-2018	JFE	0.52	0.000	185	moderate
2008-2018	JFE	0.36	0.000	120	moderate

Period	Exhaust Producer	Correlation Coefficient	Sig. (2-tailed)	N	Strength of relation
2000-2018	Tenneco	0.37	0.000	215	moderate
2008-2018	Tenneco	-0.39	0.000	120	moderate negative
2000-2018	Faurecia	-0.31	0.000	216	weak negative
2008-2018	Faurecia	-0.39	0.000	120	moderate negative
2000-2018	Futaba	-0.32	0.000	205	weak negative
2008-2018	Futaba	-0.29	0.001	120	weak negative
2000-2018	Sejong	0.51	0.000	216	moderate
2008-2018	Sejong	0.28	0.002	120	weak

Source: 11. Correlation spearman K and S test of normality all periods

2 Model summary independent variable Nickel

Model summary, independent variable Nickel 1960-2018, Source: 11 Regression dependent variable nickel 20181021

Model Summary / Dependent Variable: Nickel monthly 1960-2018							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	Sig. F Change	
1	0.85	0.72	0.72	3,836	0.72	0.00	Copper
2	0.90	0.81	0.81	3,187	0.09	0.00	Copper, Aluminium
3	0.90	0.81	0.81	3,173	0.00	0.01	Copper, Aluminium, Iron Ore

Model summary, independent variable Nickel 2008-2018, Source: 11 Regression dependent variable Nickel 20181021

Model Summary / Dependent Variable: Nickel monthly 2008-2018							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	Sig. F Change	
1	0.87	0.75	0.75	2,675	0.75	0.00	Iron Ore
2	0.92	0.84	0.84	2,142	0.09	0.00	Iron Ore, Stainless 304 scrap USA
3	0.95	0.91	0.91	1,630	0.07	0.00	Iron Ore, Stainless 304 scrap USA, Copper
4	0.95	0.91	0.91	1,623	0.00	0.95	Stainless 304 scrap USA, Copper
5	0.96	0.92	0.92	1,519	0.01	0.00	Stainless 304 scrap USA, Copper, Stainless 304 scrap Europe

Model summary, independent variable Nickel 2013-2018, Source: 11 Regression dependent variable Nickel 20181021

Model Summary / Dependent Variable: Nickel monthly 2013-2018							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	Sig. F Change	
1	0.91	0.84	0.83	1,311	0.84	0.00	Stainless 304 scrap USA,
2	0.92	0.85	0.84	1,261	0.02	0.02	Stainless 304 scrap USA, Copper
3	0.93	0.87	0.87	1,173	0.02	0.00	Stainless 304 scrap USA, Copper, Ferro-Chrome
4	0.96	0.91	0.90	987	0.04	0.00	Stainless 304 scrap USA, Copper, Ferro-Chrome, Iron Ore

3 Coefficient analysis, independent variable Nickel

Coefficient Nickel, source own data 11. Regression dependent variable Nickel 20181021

Coefficients / Dependent variable Nickel 1960-2018								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval	
		B	Std. Error				Lower Bound	Upper Bound
1	(Constant)	694,12	230,98		3,005	0,003	240,63	1147,62
	Copper	2,73	0,06	0,848	42,242	0,000	2,60	2,86
2	(Constant)	-3404,42	300,47		-11,330	0,000	-3994,35	-2814,49
	Copper	1,58	0,08	0,489	18,677	0,000	1,41	1,74
	Aluminium	5,41	0,30	0,465	17,727	0,000	4,81	6,01
3	(Constant)	-3264,71	303,37		-10,761	0,000	-3860,35	-2669,07
	Copper	1,23	0,15	0,383	8,167	0,000	0,94	1,53
	Aluminium	5,38	0,30	0,462	17,717	0,000	4,78	5,98
	Iron Ore	20,89	7,61	0,118	2,744	0,006	5,94	35,84

Dependent Variable: Nickel

Coefficient Nickel, source own data 11. Regression dependent variable Nickel 20181021

Coefficients / Dependent variable Nickel 2008-2018								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval	
		B	Std. Error				Lower Bound	Upper Bound
1	(Constant)	4610,29	662,055		6,96	0,00	3.298,89	5.921,70
	Iron Ore	105,35	5,602	0,869	18,81	0,00	94,25	116,44
2	(Constant)	688,80	718,751		0,96	0,34	-735,04	2.112,64
	Iron Ore	66,24	6,598	0,546	10,04	0,00	53,17	79,32
	Stainless 304 scrap USA	5021,84	621,427	0,440	8,08	0,00	3.790,80	6.252,88
3	(Constant)	-7024,64	1003,927		-7,00	0,00	-9.013,60	-5.035,68
	Iron Ore	-0,52	8,849	-0,004	-0,06	0,95	-18,06	17,01
	Stainless 304 scrap USA	6357,67	494,772	0,557	12,85	0,00	5.377,44	7.337,90
	Copper	1,91	0,209	0,537	9,16	0,00	1,50	2,33
4	(Constant)	-6983,05	713,948		-9,78	0,00	-8.397,38	-5.568,73
	Stainless 304 scrap USA	6338,92	378,410	0,555	16,75	0,00	5.589,29	7.088,55
	Copper	1,90	0,118	0,535	16,13	0,00	1,67	2,14
5	(Constant)	-6904,62	668,749		-10,32	0,00	-8.229,54	-5.579,71
	Stainless 304 scrap USA	5809,63	376,804	0,509	15,42	0,00	5.063,12	6.556,15
	Copper	1,36	0,172	0,381	7,87	0,00	1,02	1,70
	Stainless 304 scrap Europ	3953,82	957,945	0,212	4,13	0,00	2.055,96	5.851,68

Dependent Variable: Nickel

Coefficient Nickel, source own data 11. Regression independent variable Nickel 20181021

Coefficients / Dependent variable Nickel 2013-2018								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval	
		B	Std. Error				Lower Bound	Upper Bound
1	(Constant)	-1417,97	864,311		-1,64	0,11	-3.150,08	314,15
	Stainless 304 scrap USA	11135,55	667,261	0,914	16,69	0,00	9.798,33	12.472,77
2	(Constant)	-3029,43	1080,435		-2,80	0,01	-5.195,57	-863,29
	Stainless 304 scrap USA	9142,65	1067,841	0,750	8,56	0,00	7.001,76	11.283,54
	Copper	0,68	0,291	0,205	2,34	0,02	0,10	1,26
3	(Constant)	115,72	1433,939		0,08	0,94	-2.760,40	2.991,84
	Stainless 304 scrap USA	9630,21	1005,561	0,790	9,58	0,00	7.613,31	11.647,11
	Copper	0,99	0,288	0,297	3,42	0,00	0,41	1,57
	Ferro-Chrome	-2,60	0,846	-0,197	-3,07	0,00	-4,30	-0,90
4	(Constant)	-1033,34	1230,314		-0,84	0,40	-3502,14	1435,47
	Stainless 304 scrap USA	9490,60	846,645	0,779	11,21	0,00	7791,68	11189,52
	Copper	2,88	0,465	0,868	6,20	0,00	1,95	3,82
	Ferro-Chrome	-5,39	0,920	-0,407	-5,85	0,00	-7,23	-3,54
	Iron Ore	-50,62	10,589	-0,500	-4,78	0,00	-71,87	-29,37

Dependent Variable: Nickel

4 Spearman´s ρ Nickel and Raw materials

Source: 11. Correlation spearman – K and S test of normality all periods.xlsx

Time Period	Nickel	Aluminium	Iron Ore	Copper	Ferro-chrome	Scrap 304 EU	Scrap 304 USA
1960-2018	1	0.93	0.89	0.90	No data availability		
2000-2010	1	0.89	0.86	0.93			
2000-2018	1	0.88	0.83	0.84			
2008-2018	1	0.81	0.87	0.83	0.67	0.81	0.81

5 Model Summary Commodities versus Share price

Model Summary / Independent variable: BHP Billiton share price							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	F Change	
1	0.77	0.59	0.59	2,466.59	0.59	169.14	Iron Ore
2	0.86	0.73	0.73	2,014.58	0.14	58.89	Iron Ore
3	0.89	0.79	0.79	1,774.60	0.06	34.21	Iron Ore, Ferro-Chrome, Nickel

Model Summary / Independent variable: Norilsk Nickel share price							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	F Change	
1	0.81	0.65	0.65	28.92	0.65	217.22	Stainless 304 scrap Europe
2	0.82	0.67	0.66	28.44	0.01	4.93	Stainless 304 scrap Europe, Nickel
3	0.84	0.71	0.71	26.49	0.05	18.54	Stainless 304 scrap Europe, Nickel, Stainless 304 scrap USA
4	0.86	0.74	0.73	25.40	0.03	11.02	Stainless 304 scrap Europe, Nickel, Stainless 304 scrap USA, Ferro-Chrome

Model Summary / Independent variable: Vale share price							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	F Change	
1	0.91	0.82	0.82	42.25	0.82	522.76	Nickel
2	0.93	0.86	0.85	37.91	0.04	29.08	Nickel, Iron Ore
3	0.94	0.88	0.88	33.93	0.03	29.58	Nickel, Iron Ore, Stainless 304 scrap USA

Model Summary / Independent variable: Glencore share price							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	F Change	
1	0.82	0.67	0.66	553.31	0.67	154.17	Stainless 304 scrap USA
2	0.85	0.72	0.71	511.73	0.05	14.02	Stainless 304 scrap USA, Ferro-Chrome
3	0.87	0.76	0.75	476.98	0.04	12.48	Stainless 304 scrap USA, Ferro-Chrome, Iron Ore

Model Summary / Independent variable: Outokumpu share price							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	F Change	
1	0.80	0.64	0.64	85.97	0.64	210.44	Stainless 304 scrap USA
2	0.83	0.68	0.68	81.64	0.04	13.63	Stainless 304 scrap USA, Ferro-Chrome
3	0.84	0.70	0.69	79.78	0.02	6.41	Stainless 304 scrap USA, Ferro-Chrome, Iron Ore

Model Summary / Independent variable: Aperam share price							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	F Change	
1	0.68	0.47	0.46	90.94	0.47	70.51	Iron Ore
2	0.75	0.57	0.56	82.43	0.10	18.59	Iron Ore, Ferro-Chrome

Model Summary / Independent variable: Acerinox share price							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	F Change	
1	0.42	0.17	0.17	20.77	0.17	24.33	Stainless 304 scrap USA
2	0.53	0.28	0.26	19.52	0.10	16.38	Stainless 304 scrap USA, Iron Ore
3	0.65	0.42	0.40	17.55	0.14	28.24	Stainless 304 scrap USA, Iron Ore, Nickel
4	0.69	0.47	0.46	16.77	0.05	11.80	Stainless 304 scrap USA, Iron Ore, Nickel, Ferro-Chrome
5	0.68	0.46	0.45	16.88	-0.01	2.48	Iron Ore, Nickel, Ferro-Chrome

Model Summary / Independent variable: Yieh share price							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	F Change	
1	0.89	0.79	0.78	4.13	0.79	263.37	Nickel
2	0.92	0.84	0.83	3.65	0.05	20.93	Nickel, Iron Ore
3	0.93	0.86	0.85	3.40	0.02	11.99	Ferro-Chrome, Stainless 304 scrap USA
4	0.93	0.87	0.86	3.28	0.01	5.98	Ferro-Chrome, Stainless 304 scrap USA, Stainless 304 scrap Europe

Model Summary / Independent variable: AK Steel share price							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	F Change	
1	0.85	0.72	0.71	74.78	0.72	292.34	Ferro-Chrome
2	0.86	0.74	0.74	71.59	0.03	11.55	Ferro-Chrome, Stainless 304 scrap USA
3	0.87	0.75	0.75	70.49	0.01	4.60	Ferro-Chrome, Stainless 304 scrap USA, Stainless 304 scrap Europe

Model Summary / Independent variable: JFE share price							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	F Change	
1	0.66	0.43	0.43	706.79	0.43	89.24	Ferro-Chrome
2	0.69	0.48	0.47	679.47	0.05	10.52	Ferro-Chrome, Stainless 304 scrap USA
3	0.73	0.54	0.52	645.38	0.05	13.47	Ferro-Chrome, Stainless 304 scrap USA, Iron Ore

Model Summary / Independent variable: Nippon Stainless share price							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	F Change	
1	0.75	0.56	0.56	5.10	0.56	147.20	Ferro-Chrome
2	0.82	0.67	0.67	4.42	0.11	39.47	Ferro-Chrome, Stainless 304 scrap USA
3	0.84	0.70	0.69	4.27	0.02	9.23	Ferro-Chrome, Stainless 304 scrap USA, Stainless 304 scrap Europe
4	0.85	0.73	0.72	4.05	0.03	13.76	Ferro-Chrome, Stainless 304 scrap USA, Stainless 304 scrap Europe, Nickel

Model Summary / Independent variable: Posco share price							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	F Change	
1	0.85	0.73	0.73	129.52	0.73	312.40	Nickel
2	0.87	0.76	0.75	123.50	0.03	12.58	Nickel, Stainless 304 scrap USA
3	0.88	0.77	0.76	121.21	0.01	5.39	Nickel, Stainless 304 scrap USA, Iron Ore

Model Summary / Independent variable: Jindal Stainless share price							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	F Change	
1	0.70	0.48	0.48	248.99	0.48	108.16	Nickel
2	0.72	0.51	0.51	242.21	0.03	7.59	Nickel, Ferro-Chrome

Model Summary / Independent variable: Tenneco share price							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	F Change	
1	0.58	0.34	0.33	147.34	0.34	59.91	Stainless 304 scrap USA
2	0.70	0.49	0.48	130.32	0.15	33.28	Stainless 304 scrap USA, Stainless 304 scrap Europe

Model Summary / Independent variable: Faurecia share price							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	F Change	
1	0.49	0.24	0.23	107.74	0.24	35.66	Stainless 304 scrap USA
2	0.60	0.36	0.35	99.00	0.12	22.38	Stainless 304 scrap USA, Ferro-Chrome
3	0.63	0.40	0.38	96.65	0.04	6.67	Stainless 304 scrap USA, Ferro-Chrome, Stainless 304 scrap Europe
4	0.69	0.48	0.46	90.06	0.08	18.29	Stainless 304 scrap USA, Ferro-Chrome, Stainless 304 scrap Europe, Iron Ore

Model Summary / Independent variable: Futaba share price							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	F Change	
1	0.35	0.12	0.11	3,050.91	0.12	15.88	Iron Ore
2	0.53	0.28	0.27	2,772.88	0.16	25.43	Iron Ore, Ferro-Chrome
3	0.56	0.31	0.29	2,727.21	0.03	4.88	Iron Ore, Ferro-Chrome, Stainless 304 scrap Europe

Model Summary / Independent variable: Sejong share price							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	F Change	
1	0.28	0.08	0.07	40,918.56	0.08	10.16	Ferro-Chrome
2	0.61	0.37	0.36	34,095.51	0.29	52.07	Ferro-Chrome, Iron Ore
3	0.67	0.45	0.43	31,978.29	0.08	16.73	Ferro-Chrome, Iron Ore, Stainless 304 scrap USA
4	0.73	0.53	0.52	29,488.91	0.09	21.06	Ferro-Chrome, Iron Ore, Stainless 304 scrap USA, Nickel

Source: 11. SPSS share price and commodities 20180805

6 Coefficient Analysis Commodities versus Share price

Coefficients / Dependent Variable: BHP Billiton

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	8296,21	605,633		13,70	0,00	7.096,68	9.495,75
	Iron Ore	66,17	5,088	0,770	13,01	0,00	56,10	76,25
2	(Constant)	10550,55	575,302		18,34	0,00	9.410,99	11.690,12
	Iron Ore	91,64	5,318	1,067	17,23	0,00	81,11	102,18
	Ferro-Chrome	-2,00	0,260	-0,475	-7,67	0,00	-2,51	-1,48
3	(Constant)	9156,94	559,994		16,35	0,00	8.047,60	10.266,29
	Iron Ore	55,73	7,723	0,649	7,22	0,00	40,43	71,03
	Ferro-Chrome	-2,23	0,232	-0,530	-9,58	0,00	-2,69	-1,77
	Nickel	0,37	0,063	0,518	5,85	0,00	0,24	0,49

Coefficients / Dependent Variable: Norilsk

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	16,30	10,612		1,54	0,13	-4,72	37,31
	Stainless 304 scrap Europe	133,61	9,066	0,807	14,74	0,00	115,66	151,57
2	(Constant)	19,29	10,523		1,83	0,07	-1,56	40,13
	Stainless 304 scrap Europe	102,17	16,738	0,617	6,10	0,00	69,02	135,33
	Nickel	0,00	0,001	0,224	2,22	0,03	0,00	0,00
3	(Constant)	48,62	11,937		4,07	0,00	24,97	72,26
	Stainless 304 scrap Europe	77,65	16,599	0,469	4,68	0,00	44,77	110,53
	Nickel	0,01	0,001	0,713	4,83	0,00	0,00	0,01
	Stainless 304 scrap USA	-44,17	10,259	-0,430	-4,31	0,00	-64,49	-23,85
4	(Constant)	52,61	11,508		4,57	0,00	29,82	75,41
	Stainless 304 scrap Europe	56,76	17,114	0,343	3,32	0,00	22,85	90,66
	Nickel	0,01	0,001	0,799	5,56	0,00	0,00	0,01
	Stainless 304 scrap USA	-58,40	10,729	-0,568	-5,44	0,00	-79,65	-37,14
	Ferro-Chrome	0,01	0,004	0,226	3,32	0,00	0,00	0,02

Coefficients / Dependent Variable: Vale

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-89,80	12,268		-7,32	0,00	-114,10	-65,50
	Nickel	0,02	0,001	0,905	22,86	0,00	0,01	0,02
2	(Constant)	-84,46	11,053		-7,64	0,00	-106,35	-62,57
	Nickel	0,01	0,001	0,562	7,73	0,00	0,01	0,01
	Iron Ore	0,86	0,160	0,392	5,39	0,00	0,55	1,18
3	(Constant)	-114,56	11,335		-10,11	0,00	-137,02	-92,11
	Nickel	0,01	0,001	0,294	3,59	0,00	0,00	0,01
	Iron Ore	0,85	0,143	0,388	5,96	0,00	0,57	1,14
	Stainless 304 scrap USA	67,12	12,342	0,323	5,44	0,00	42,67	91,57

Coefficients / Dependent Variable: Glencore								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-223,98	270,111		-0,83	0,41	-761,84	313,88
	Stainless 304 scrap USA	2317,23	186,626	0,817	12,42	0,00	1.945,61	2.688,85
2	(Constant)	-1885,60	509,219		-3,70	0,00	-2.899,80	-871,40
	Stainless 304 scrap USA	1609,36	255,980	0,567	6,29	0,00	1.099,53	2.119,19
	Ferro-Chrome	1,18	0,316	0,338	3,74	0,00	0,55	1,81
3	(Constant)	-1636,99	479,830		-3,41	0,00	-2.592,86	-681,12
	Stainless 304 scrap USA	754,95	339,762	0,266	2,22	0,03	78,10	1.431,79
	Ferro-Chrome	1,24	0,295	0,353	4,20	0,00	0,65	1,83
	Iron Ore	8,32	2,355	0,352	3,53	0,00	3,63	13,01

Coefficients / Dependent Variable: Outokumpu								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-244,84	28,60		-8,560	0,000	-301,49	-188,18
	Stainless 304 scrap USA	242,93	16,75	0,803	14,507	0,000	209,76	276,10
2	(Constant)	-265,42	27,73		-9,572	0,000	-320,35	-210,50
	Stainless 304 scrap USA	194,57	20,60	0,643	9,444	0,000	153,76	235,37
	Ferro-Chrome	0,04	0,01	0,251	3,693	0,000	0,02	0,06
3	(Constant)	-272,56	27,24		-10,004	0,000	-326,53	-218,59
	Stainless 304 scrap USA	229,92	24,50	0,760	9,385	0,000	181,39	278,46
	Ferro-Chrome	0,05	0,01	0,304	4,358	0,000	0,03	0,07
	Iron Ore	-0,65	0,26	-0,203	-2,533	0,013	-1,16	-0,14

Coefficients / Dependent Variable: Aperam								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	456,75	26,42		17,289	0,000	404,19	509,31
	Iron Ore	-1,98	0,24	-0,682	-8,397	0,000	-2,45	-1,51
2	(Constant)	153,17	74,37		2,059	0,043	5,16	301,18
	Iron Ore	-2,76	0,28	-0,949	-9,866	0,000	-3,31	-2,20
	Ferro-Chrome	0,17	0,04	0,415	4,311	0,000	0,09	0,25

Coefficients / Dependent Variable: Acerinox								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	82,23	6,911		11,90	0,00	68,54	95,92
	Stainless 304 scrap USA	19,96	4,046	0,416	4,93	0,00	11,94	27,97
2	(Constant)	81,16	6,499		12,49	0,00	68,29	94,04
	Stainless 304 scrap USA	36,90	5,656	0,770	6,52	0,00	25,70	48,11
	Iron Ore	-0,24	0,060	-0,478	-4,05	0,00	-0,36	-0,12
3	(Constant)	78,68	5,863		13,42	0,00	67,07	90,29
	Stainless 304 scrap USA	16,40	6,384	0,342	2,57	0,01	3,76	29,05
	Iron Ore	-0,51	0,074	-1,012	-6,92	0,00	-0,66	-0,37
	Nickel	0,00	0,001	0,975	5,31	0,00	0,00	0,01
4	(Constant)	74,25	5,749		12,92	0,00	62,86	85,64
	Stainless 304 scrap USA	10,05	6,375	0,210	1,58	0,12	-2,58	22,68
	Iron Ore	-0,57	0,073	-1,133	-7,86	0,00	-0,72	-0,43
	Nickel	0,00	0,001	0,999	5,69	0,00	0,00	0,01
	Ferro-Chrome	0,01	0,002	0,318	3,44	0,00	0,00	0,01
5	(Constant)	77,79	5,327		14,60	0,00	67,24	88,35
	Iron Ore	-0,58	0,073	-1,146	-7,92	0,00	-0,73	-0,44
	Nickel	0,00	0,001	1,162	8,14	0,00	0,00	0,01
	Ferro-Chrome	0,01	0,002	0,360	4,04	0,00	0,00	0,01

Coefficients / Dependent Variable: Yieh								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	46,95	1,953		24,04	0,00	43,06	50,85
	Nickel	0,00	0,000	0,888	16,23	0,00	0,00	0,00
2	(Constant)	47,76	1,735		27,53	0,00	44,30	51,22
	Nickel	0,00	0,000	0,633	8,61	0,00	0,00	0,00
	Iron Ore	0,09	0,019	0,337	4,57	0,00	0,05	0,12
3	(Constant)	51,95	2,016		25,77	0,00	47,93	55,97
	Nickel	0,00	0,000	1,012	7,84	0,00	0,00	0,00
	Iron Ore	0,10	0,018	0,393	5,59	0,00	0,06	0,13
	Stainless 304 scrap USA	-13,72	3,962	-0,451	-3,46	0,00	-21,63	-5,82
4	(Constant)	47,91	2,552		18,77	0,00	42,82	53,00
	Nickel	0,00	0,000	0,989	7,91	0,00	0,00	0,00
	Iron Ore	0,09	0,017	0,376	5,50	0,00	0,06	0,13
	Stainless 304 scrap USA	-16,98	4,053	-0,558	-4,19	0,00	-25,07	-8,90
	Stainless 304 scrap Europe	9,06	3,705	0,178	2,45	0,02	1,67	16,45

Coefficients / Dependent Variable: Ak Steel								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-205,56	20,341		-10,11	0,00	-245,84	-165,27
	Ferro-Chrome	0,13	0,008	0,846	17,10	0,00	0,11	0,14
2	(Constant)	-255,05	24,316		-10,49	0,00	-303,22	-206,89
	Ferro-Chrome	0,11	0,009	0,713	11,62	0,00	0,09	0,13
	Stainless 304 scrap USA	61,41	18,066	0,209	3,40	0,00	25,63	97,20
3	(Constant)	-226,49	27,396		-8,27	0,00	-280,76	-172,22
	Ferro-Chrome	0,12	0,010	0,764	11,77	0,00	0,10	0,14
	Stainless 304 scrap USA	76,67	19,159	0,260	4,00	0,00	38,72	114,63
	Stainless 304 scrap Europe	-64,72	30,170	-0,137	-2,15	0,03	-124,49	-4,96

Coefficients / Dependent Variable: JFE								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval for	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	652,15	192,270		3,39	0,00	271,33	1.032,96
	Ferro-Chrome	0,67	0,071	0,659	9,45	0,00	0,53	0,81
2	(Constant)	203,95	230,790		0,88	0,38	-253,20	661,10
	Ferro-Chrome	0,49	0,089	0,480	5,52	0,00	0,31	0,67
	Stainless 304 scrap USA	556,08	171,467	0,282	3,24	0,00	216,44	895,72
3	(Constant)	120,31	220,393		0,55	0,59	-316,28	556,91
	Ferro-Chrome	0,59	0,088	0,574	6,64	0,00	0,41	0,76
	Stainless 304 scrap USA	970,54	198,186	0,492	4,90	0,00	577,94	1.363,15
	Iron Ore	-7,61	2,073	-0,364	-3,67	0,00	-11,72	-3,50

Coefficients / Dependent Variable: Nippon								
Model		Unstandardized Coefficients		Standardized			95,0% Confidence Interval for	
		B	Std. Error	Coefficients	t	Sig.	Lower Bound	Upper Bound
1	(Constant)	11,05	1,388		7,96	0,00	8,30	13,80
	Ferro-Chrome	0,01	0,001	0,748	12,13	0,00	0,01	0,01
2	(Constant)	5,40	1,502		3,60	0,00	2,42	8,37
	Ferro-Chrome	0,00	0,001	0,471	6,81	0,00	0,00	0,01
	Stainless 304 scrap USA	7,01	1,116	0,435	6,28	0,00	4,80	9,22
3	(Constant)	7,85	1,660		4,73	0,00	4,56	11,14
	Ferro-Chrome	0,00	0,001	0,551	7,68	0,00	0,00	0,01
	Stainless 304 scrap USA	8,32	1,161	0,516	7,17	0,00	6,02	10,62
	Stainless 304 scrap Europe	-5,55	1,828	-0,214	-3,04	0,00	-9,18	-1,93
4	(Constant)	11,35	1,835		6,18	0,00	7,71	14,99
	Ferro-Chrome	0,00	0,001	0,598	8,63	0,00	0,00	0,01
	Stainless 304 scrap USA	3,46	1,711	0,215	2,02	0,05	0,07	6,85
	Stainless 304 scrap Europe	-13,37	2,729	-0,515	-4,90	0,00	-18,78	-7,97
	Nickel	0,00	0,000	0,542	3,71	0,00	0,00	0,00

Coefficients / Dependent Variable: Posco								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	165,63	37,607		4,40	0,00	91,14	240,11
	Nickel	0,04	0,002	0,854	17,67	0,00	0,03	0,04
2	(Constant)	94,31	41,111		2,29	0,02	12,87	175,74
	Nickel	0,03	0,004	0,596	6,93	0,00	0,02	0,03
	Stainless 304 scrap USA	159,34	44,921	0,305	3,55	0,00	70,36	248,32
3	(Constant)	102,23	40,493		2,52	0,01	22,01	182,44
	Nickel	0,02	0,005	0,411	3,53	0,00	0,01	0,03
	Stainless 304 scrap USA	158,06	44,091	0,303	3,58	0,00	70,72	245,40
	Iron Ore	1,19	0,512	0,215	2,32	0,02	0,17	2,20

Coefficients / Dependent Variable: Jindal Stainless								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-31,29	72,296		-0,43	0,67	-174,48	111,91
	Nickel	0,04	0,004	0,695	10,40	0,00	0,04	0,05
2	(Constant)	-105,44	75,303		-1,40	0,16	-254,60	43,72
	Nickel	0,04	0,005	0,557	6,80	0,00	0,02	0,05
	Ferro-Chrome	0,08	0,031	0,226	2,75	0,01	0,02	0,15

Coefficients / Dependent Variable: Tenneco								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	753,35	49,023		15,37	0,00	656,25	850,44
	Stainless 304 scrap USA	-222,14	28,700	-0,584	-7,74	0,00	-278,99	-165,30
2	(Constant)	602,45	50,640		11,90	0,00	502,14	702,75
	Stainless 304 scrap USA	-336,90	32,251	-0,885	-10,45	0,00	-400,78	-273,01
	Stainless 304 scrap Europe	299,40	51,902	0,489	5,77	0,00	196,59	402,21

Coefficients / Dependent Variable: Faurecia								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	457,43	35,848		12,76	0,00	386,43	528,43
	Stainless 304 scrap USA	-125,32	20,987	-0,485	-5,97	0,00	-166,89	-83,75
2	(Constant)	425,45	33,628		12,65	0,00	358,84	492,06
	Stainless 304 scrap USA	-200,45	24,984	-0,776	-8,02	0,00	-249,94	-150,96
	Ferro-Chrome	0,06	0,013	0,457	4,73	0,00	0,04	0,09
3	(Constant)	378,30	37,560		10,07	0,00	303,89	452,71
	Stainless 304 scrap USA	-225,65	26,268	-0,873	-8,59	0,00	-277,69	-173,61
	Ferro-Chrome	0,05	0,014	0,361	3,56	0,00	0,02	0,08
	Stainless 304 scrap Europe	106,86	41,364	0,257	2,58	0,01	24,92	188,80
4	(Constant)	309,10	38,558		8,02	0,00	232,71	385,49
	Stainless 304 scrap USA	-170,59	27,656	-0,660	-6,17	0,00	-225,38	-115,79
	Ferro-Chrome	0,05	0,013	0,398	4,20	0,00	0,03	0,08
	Stainless 304 scrap Europe	225,70	47,514	0,543	4,75	0,00	131,57	319,84
	Iron Ore	-1,53	0,357	-0,557	-4,28	0,00	-2,23	-0,82

Coefficients / Dependent Variable: Futaba								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	18606,15	749,103		24,84	0,00	17.122,46	20.089,85
	Iron Ore	-25,08	6,294	-0,347	-3,98	0,00	-37,54	-12,61
2	(Constant)	16567,27	791,847		20,92	0,00	14.998,77	18.135,76
	Iron Ore	-48,11	7,320	-0,666	-6,57	0,00	-62,61	-33,61
	Ferro-Chrome	1,80	0,358	0,511	5,04	0,00	1,10	2,51
3	(Constant)	15017,16	1048,103		14,33	0,00	12.940,88	17.093,45
	Iron Ore	-62,01	9,558	-0,858	-6,49	0,00	-80,94	-43,07
	Ferro-Chrome	1,60	0,364	0,453	4,40	0,00	0,88	2,32
	Stainless 304 scrap Europe	3179,77	1438,833	0,290	2,21	0,03	329,46	6.030,09

Coefficients / Dependent Variable: Sejong								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	144977,39	11131,152		13,02	0,00	122.930,74	167.024,04
	Ferro-Chrome	-13,16	4,127	-0,284	-3,19	0,00	-21,33	-4,98
2	(Constant)	123601,83	9736,605		12,69	0,00	104.315,49	142.888,17
	Ferro-Chrome	-32,97	4,400	-0,711	-7,49	0,00	-41,69	-24,25
	Iron Ore	649,50	90,007	0,685	7,22	0,00	471,21	827,79
3	(Constant)	148097,44	10920,391		13,56	0,00	126.464,23	169.730,65
	Ferro-Chrome	-27,05	4,373	-0,584	-6,19	0,00	-35,72	-18,39
	Iron Ore	888,94	102,727	0,938	8,65	0,00	685,44	1.092,44
	Stainless 304 scrap USA	-40168,62	9820,049	-0,449	-4,09	0,00	-59.622,06	-20.715,18
4	(Constant)	144091,23	10108,052		14,26	0,00	124065,35	164117,10
	Ferro-Chrome	-26,33	4,036	-0,568	-6,52	0,00	-34,32	-18,33
	Iron Ore	490,09	128,559	0,517	3,81	0,00	235,40	744,79
	Stainless 304 scrap USA	-70479,82	11208,524	-0,787	-6,29	0,00	-92685,93	-48273,71
	Nickel	5,90	1,286	0,758	4,59	0,00	3,35	8,45

Source: 11. SPSS share price and commodities 20180805

7 Correlation -Profit of the stainless-steel producers

Versus Raw materials, tonnage, turnover and number of employees.

Pearson Correlation/ Net profit	Nickel average	Chrome average	Iron Ore average	Tonnage	Turnover	Staff
Outokumpu	-0,474	0,037	-0,511	0,038	-0,025	-0,123
Acerinox	0,416	0,045	0,027	0,459	0,763	-0,124
Aperam	-0,074	0,268	-0,172	0,784	0,201	0,021
Posco	0,829	0,855	0,711	-0,534	-0,238	-0,202
Nippon	0,481	0,108	0,078	0,033	0,432	-0,199
JFE	0,673	0,566	0,274	0,525	0,138	-0,227

Source: 11. SPSS 2annual reports profit and commodities 20180820

8 Net profit of the stainless-steel producers.

Model Summary / Net Profit of the stainless steel producers							
Producer	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	F Change	
Outokumpu	0,893	0,797	0,492	278,844	0,797	2,617	Iron Ore average, OTK staff, OTK turnover, Chrome average, Nickel avergar, OTK tonnage
Acerinox	0,904	0,818	0,773	67,345	0,236	10,373	ACX turnover, ACX tonnage
Aperam	0,784	0,615	0,572	67,239	0,615	14,350	Aperam tonnage
Posco	0,855	0,732	0,678	0,413	0,732	13,631	Chrome average
Nippon	0,860	0,740	0,349	107,275	0,740	1,894	Nippon staff, Chrome average, Iron Ore average, Nippon turnover, Nickel avergar, Nippon tonnage
JFE	0,924	0,854	0,635	9,051	0,854	3,894	JFE staff, JFE tonnage, JFE turnover, Nickel avergar, Iron Ore average, Chrome average

Source: 11. SPSS 2annual reports profit and commodities 20180820

9 Test of normality Kolmogorov and Smirnov (K&S) One-Sample Kolmogorov-Smirnov Test

Descriptive Statistics and T test

Legend:

c) Lilliefors Significance Correction.

Time periods

- 1960- 2018
- 2000-2010
- 2000-2008
- 2008-2018

Source: 11. Correlation spearman K and S test of normality all periods

1960-2018		Nickel	Iron Ore	Ferro-Chrome	Stainless 304 scrap Europe	Stainless 304 scrap USA	BHP Billiton	Norilsk	Vale	Glencore	Outokumpu	Aperam	Acerinox	Yieh	AK Steel	Posco	Jindal Stainless	Nippon Steel	JFE	Tenneco	Faurecia	Futaba	Sejong
N		696	696	144	120	118	215	161	190	81	216	85	216	75	215	215	171	120	185	215	216	205	216
Normal Parameters	Mean	8259.18	40.58	2455.75	1.13	1.64	11253.40	158.71	146.24	3062.48	225.05	256.14	115.73	77.40	123.71	653.92	819.16	26.85	2883.98	275.11	356.21	21117.32	77923.84
	Std. Deviation	7239.81	40.76	919.50	0.29	0.47	6152.94	58.06	101.09	951.74	160.11	126.04	30.34	8.93	123.78	349.87	408.01	7.60	1525.08	198.83	156.05	7056.97	49551.67
Most Extreme Differences	Absolute	0.18	0.32	0.18	0.10	0.08	0.11	0.09	0.11	0.15	0.11	0.15	0.09	0.17	0.22	0.07	0.08	0.13	0.19	0.10	0.09	0.10	0.15
	Positive	0.18	0.32	0.18	0.10	0.08	0.11	0.09	0.11	0.07	0.11	0.15	0.09	0.17	0.22	0.06	0.08	0.13	0.19	0.10	0.07	0.10	0.15
	Negative	-0.18	-0.22	-0.11	-0.07	-0.04	-0.08	-0.08	-0.10	-0.15	-0.10	-0.09	-0.08	-0.09	-0.20	-0.07	-0.05	-0.09	-0.12	-0.09	-0.09	-0.08	-0.11
Test Statistic		0.18	0.32	0.18	0.10	0.08	0.11	0.09	0.11	0.15	0.11	0.15	0.09	0.17	0.22	0.07	0.08	0.13	0.19	0.10	0.09	0.10	0.15
Asymp. Sig. (2-tailed)		,000c	,000c	,000c	,003c	,097c	,000c	,001c	,000c	,000c	,000c	,000c	,000c	,000c	,000c	,008c	,013c	,000c	,000c	,000c	,000c	,000c	,000c

2000-2010		Nickel	Iron Ore	Ferro-Chrome	Stainless 304 scrap Europe	Stainless 304 scrap USA	BHP Billiton	Norilsk	Vale		Outokumpu		Acerinox		AK Steel	Posco	Jindal Stainless	Nippon Steel	JFE	Tenneco	Faurecia	Futaba	Sejong
N		120	120	48	24	24	119	65	94		120		120		119	119	75	24	89	119	120	109	120
Normal Parameters	Mean	15680.04	65.13	2676.25	1.08	2.10	7505.77	138.43	132.12		319.58		119.82		162.05	579.62	1059.29	36.97	3758.57	127.65	413.60	25690.00	39191.25
	Std. Deviation	10198.53	46.88	1501.99	0.46	0.39	4883.08	77.53	106.07		137.32		36.13		150.80	416.69	397.48	9.45	1743.62	92.81	150.17	6130.27	14463.29
Most Extreme Differences	Absolute	0.18	0.22	0.21	0.13	0.28	0.17	0.13	0.15		0.23		0.14		0.27	0.16	0.09	0.22	0.19	0.16	0.17	0.13	0.11
	Positive	0.18	0.22	0.21	0.13	0.28	0.17	0.13	0.15		0.23		0.14		0.27	0.16	0.09	0.22	0.19	0.16	0.10	0.10	0.11
	Negative	-0.14	-0.22	-0.16	-0.11	-0.13	-0.13	-0.11	-0.14		-0.13		-0.10		-0.17	-0.15	-0.06	-0.10	-0.08	-0.11	-0.17	-0.13	-0.06
Test Statistic		0.18	0.22	0.21	0.13	0.28	0.17	0.13	0.15		0.23		0.14		0.27	0.16	0.09	0.22	0.19	0.16	0.17	0.13	0.11
Asymp. Sig. (2-tailed)		,000c	,000c	,000c	,200c,d	,000c	,000c	,006c	,000c		,000c		,000c		,000c	,000c	,180c	,005c	,000c	,000c	,000c	,000c	,001c

2000-2018		Nickel	Iron Ore	Ferro-Chrome	Stainless 304 scrap Europe	Stainless 304 scrap USA	BHP Billiton	Norilsk	Vale	Glencore	Outokumpu	Aperam	Acerinox	Yieh	AK Steel	Posco	Jindal Stainless	Nippon Steel	JFE	Tenneco	Faurecia	Futaba	Sejong
N		216	216	144	120	118	215	161	190	81	216	85	216	75	215	215	171	120	185	215	216	205	216
Normal Parameters	Mean	15714.43	83.99	2455.75	1.13	1.64	11253.40	158.71	146.24	3062.48	225.05	256.14	115.73	77.40	123.71	653.92	819.16	26.85	2883.98	275.11	356.21	21117.32	77923.84
	Std. Deviation	8303.89	49.53	919.50	0.29	0.47	6152.94	58.06	101.09	951.74	160.11	126.04	30.34	8.93	123.78	349.87	408.01	7.60	1525.08	198.83	156.05	7056.97	49551.67
Most Extreme Differences	Absolute	0.11	0.16	0.18	0.10	0.08	0.11	0.09	0.11	0.15	0.11	0.15	0.09	0.17	0.22	0.07	0.08	0.13	0.19	0.10	0.09	0.10	0.15
	Positive	0.11	0.16	0.18	0.10	0.08	0.11	0.09	0.11	0.07	0.11	0.15	0.09	0.17	0.22	0.06	0.08	0.13	0.19	0.10	0.07	0.10	0.15
	Negative	-0.10	-0.13	-0.11	-0.07	-0.04	-0.08	-0.08	-0.10	-0.15	-0.10	-0.09	-0.08	-0.09	-0.20	-0.07	-0.05	-0.09	-0.12	-0.09	-0.09	-0.08	-0.11
Test Statistic		0.11	0.16	0.18	0.10	0.08	0.11	0.09	0.11	0.15	0.11	0.15	0.09	0.17	0.22	0.07	0.08	0.13	0.19	0.10	0.09	0.10	0.15
Asymp. Sig. (2-tailed)		,000c	,000c	,000c	,003c	,097c	,000c	,001c	,000c	,000c	,000c	,000c	,000c	,000c	,000c	,008c	,013c	,000c	,000c	,000c	,000c	,000c	,000c

2008-2018		Nickel	Iron Ore	Ferro-Chrome	Stainless 304 scrap Europe	Stainless 304 scrap USA	BHP Billiton	Norilsk	Vale	Glencore	Outokumpu	Aperam	Acerinox	Yieh	AK Steel	Posco	Jindal Stainless	Nippon Steel	JFE	Tenneco	Faurecia	Futaba	Sejong
N		120	120	120	120	118	120	120	120	81	120	85	120	75	120	120	120	120	120	120	120	120	120
Normal Parameters	Mean	16182.47	109.64	2547.07	1.13	1.64	15577.14	167.92	175.21	3062.48	152.57	256.14	115.05	77.40	120.57	795.63	688.50	26.85	2366.06	392.07	259.00	15972.33	110975.42
	Std. Deviation	5443.37	44.77	911.50	0.29	0.47	3823.32	48.43	98.22	951.74	142.76	126.04	22.56	8.93	138.80	245.77	345.64	7.60	928.98	180.99	133.99	3372.68	42391.98
Most Extreme Differences	Absolute	0.10	0.12	0.23	0.10	0.08	0.09	0.12	0.11	0.15	0.24	0.15	0.07	0.17	0.24	0.11	0.13	0.13	0.14	0.12	0.09	0.05	0.06
	Positive	0.10	0.12	0.23	0.10	0.08	0.05	0.12	0.11	0.07	0.24	0.15	0.06	0.17	0.24	0.11	0.13	0.13	0.14	0.07	0.09	0.05	0.06
	Negative	-0.07	-0.07	-0.17	-0.07	-0.04	-0.09	-0.09	-0.06	-0.15	-0.18	-0.09	-0.07	-0.09	-0.24	-0.05	-0.07	-0.09	-0.09	-0.12	-0.07	-0.03	-0.06
Test Statistic		0.10	0.12	0.23	0.10	0.08	0.09	0.12	0.11	0.15	0.24	0.15	0.07	0.17	0.24	0.11	0.13	0.13	0.14	0.12	0.09	0.05	0.06
Asymp. Sig. (2-tailed)		,007c	,000c	,000c	,003c	,097c	,016c	,000c	,002c	,000c	,000c	,000c	,182c	,000c	,000c	,002c	,000c	,000c	,000c	,000c	,019c	,200c,d	,200c,d

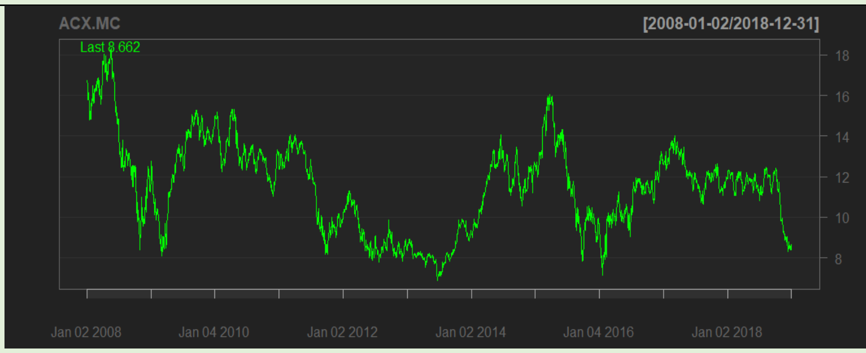
Appendix No. 14

GARCH statistics

Contents

Overview/ Share price developments 2008-2018

Miners	
BHP Group (BHP.AX)	
Norilsk Nickel (NILSY)	
Vale S.A. (VALE)	

Steel producers	
Outokumpu Oyj (OUT1V.HE)	
Aperam S.A. (APAM.AS)	
Acerinox, S.A. (ACX.MC)	
AK Steel Holding Corporation (AKS)	

POSCO (PKX)	
Nippon Steel Corporation (5401.T)	
JFE Holdings, Inc. (5411.T)	

Manufactures	
Faurecia S.E. (EO.PA)	
Tenneco Inc. (TEN)	
Futaba Corporation (6986.T)	

Sejong Industrial Co., Ltd. (033530.KS)

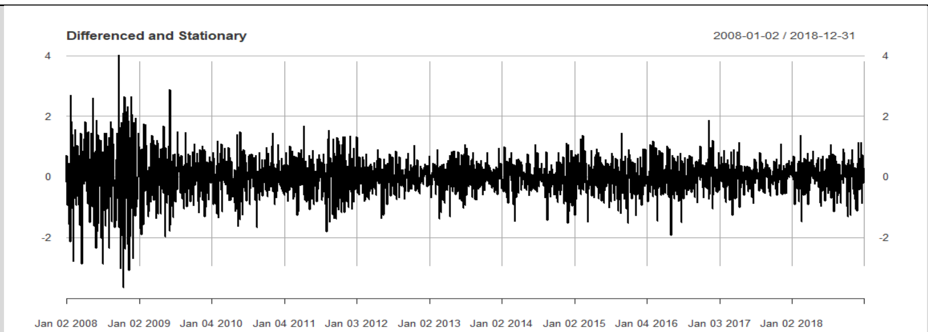
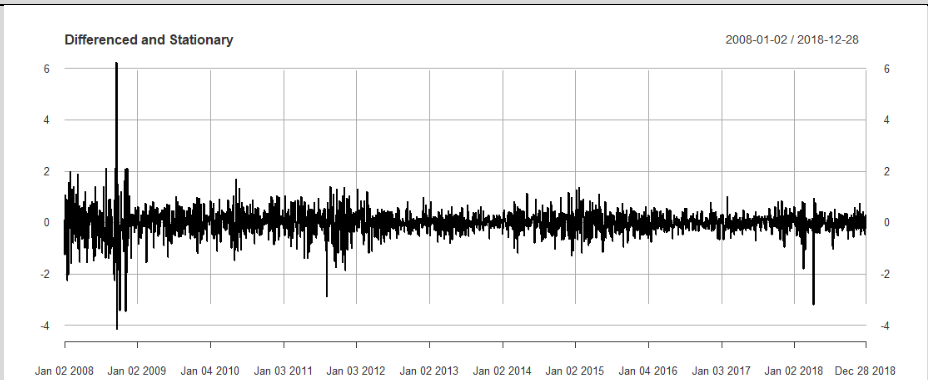
1 Data / Descriptive Statistics

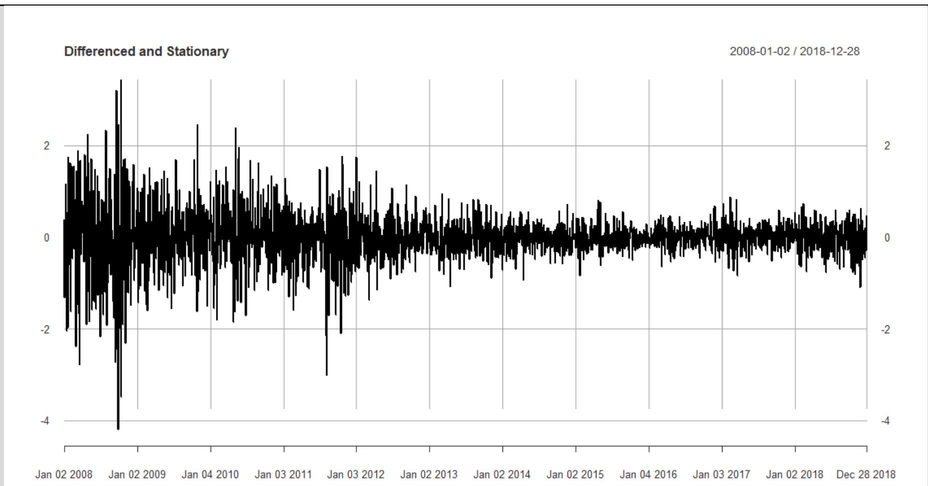
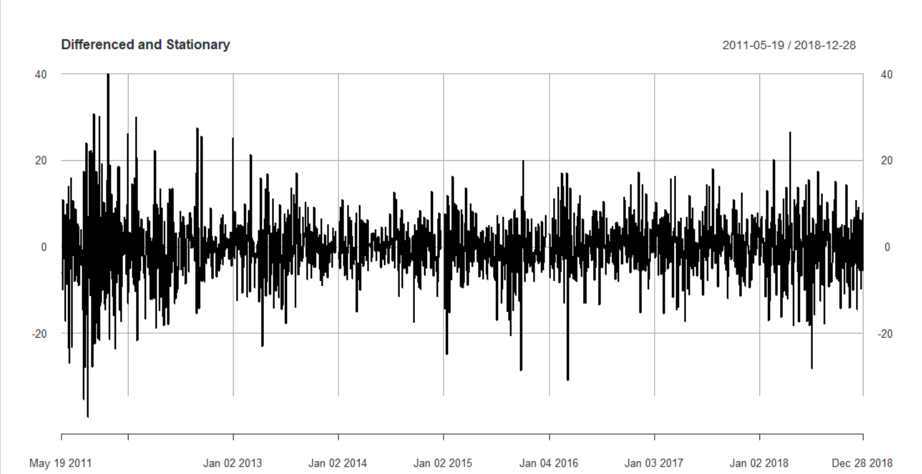
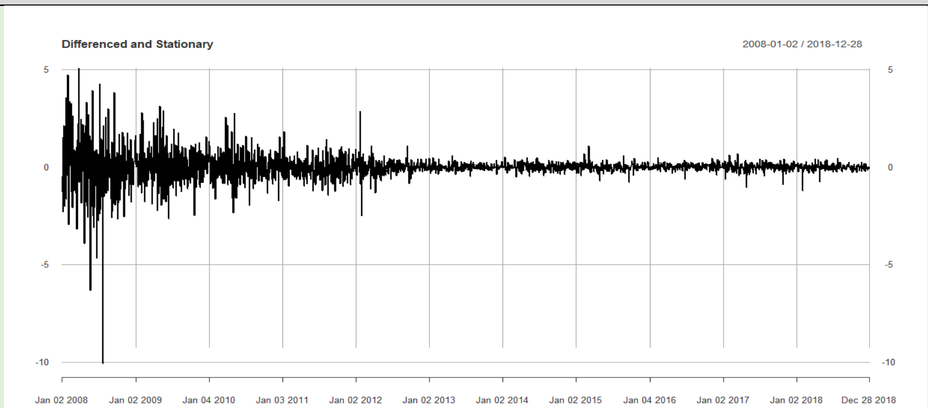
Company	N	Min	Mean	Max	Std. Dev.	CV
BHP.AX	2781	14.20	31.47	46.302	6.237	0.198
NILSY	2768	3.66	16.938	31.25	4.706	0.278
VALE	2768	2.15	17.235	43.91	9.388	0.545
GLEN.L	1925	68.62	310.013	531.1	89.492	0.289
OUT1V.HE	2766	2.06	14.978	77.766	14.526	0.97
APAM.AS	2027	7.985	26.829	50.8	12.622	0.47
ACX.MC	2809	6.90	11.517	18.32	2.221	0.193
AKS	2768	1.83	11.375	72.89	13.004	1.143
PKX	2768	32.31	79.3	147.74	24.226	0.305
JSLHISAR.BO	721	25.95	122.58	241.65	57.153	0.466
NIPST	2715	1451.15	2854.851	7030	919.171	0.322
JFE	2715	956	2381.95	6400	908.968	0.382
EO.PA	2811	5.657	28.46	75.9	15.605	0.548
TEN	2768	0.7	39.68	68.71	17.438	0.439
FUTBA	2715	836	1634.437	2527	343.961	0.21
SEJONG	2729	2790	10654.25	22200	4151.935	0.39

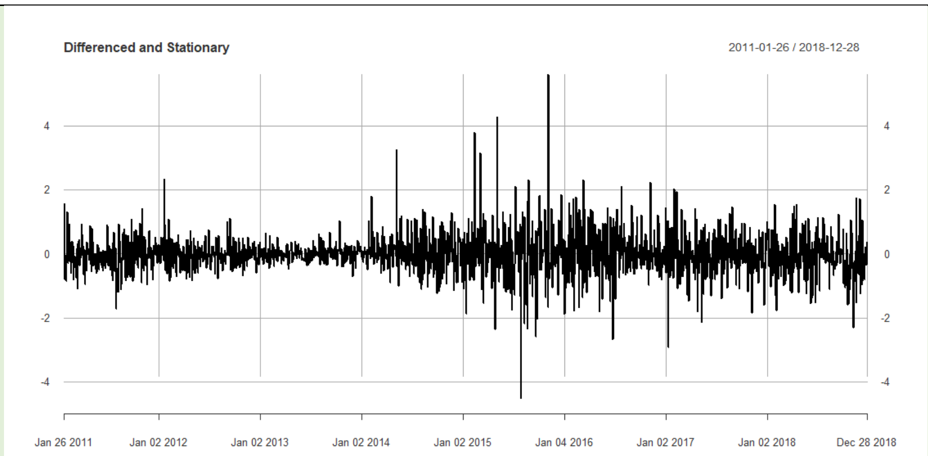
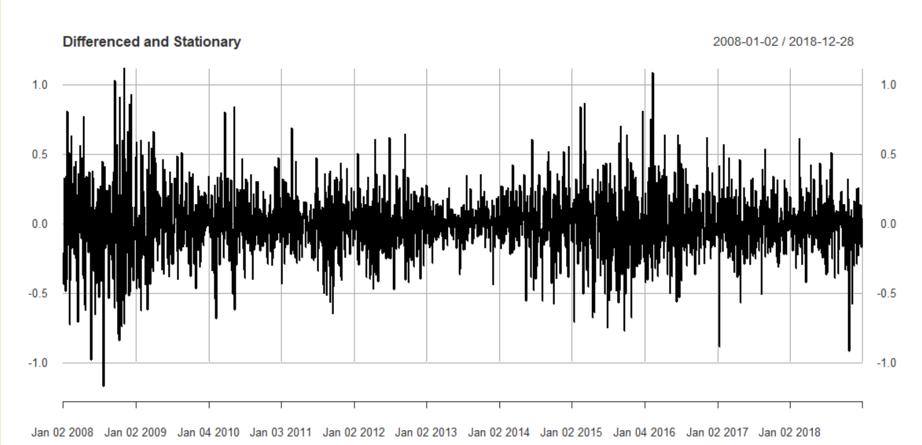
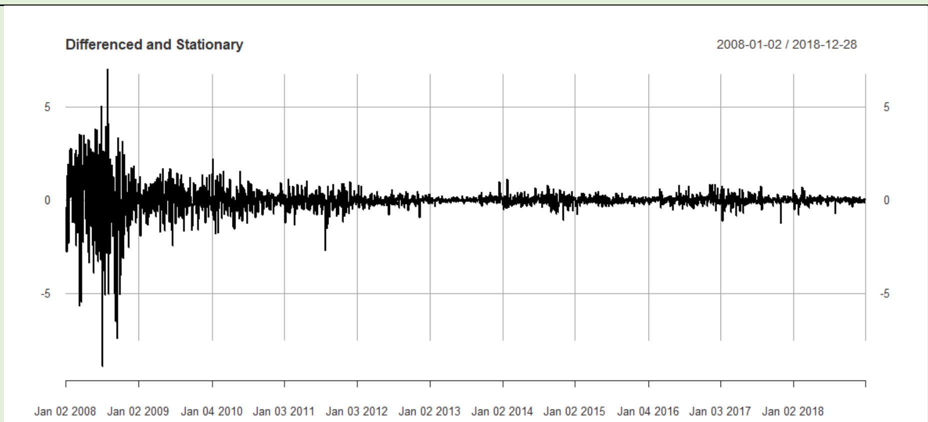
2 Price Model estimation

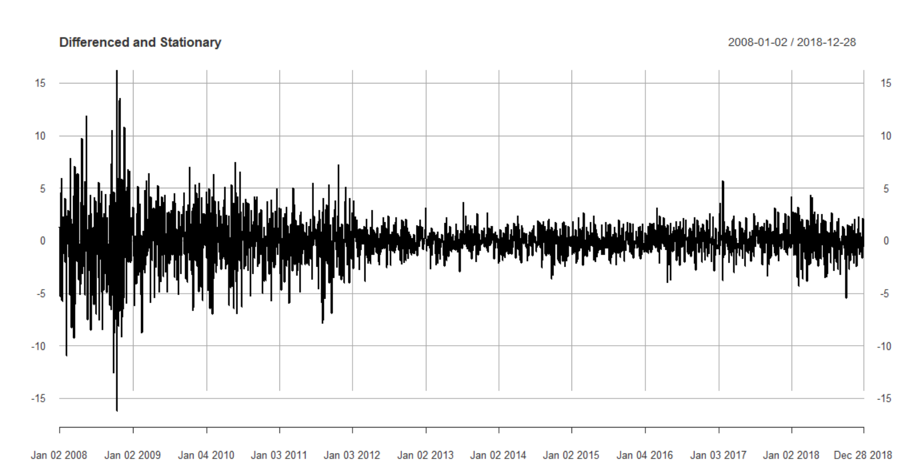
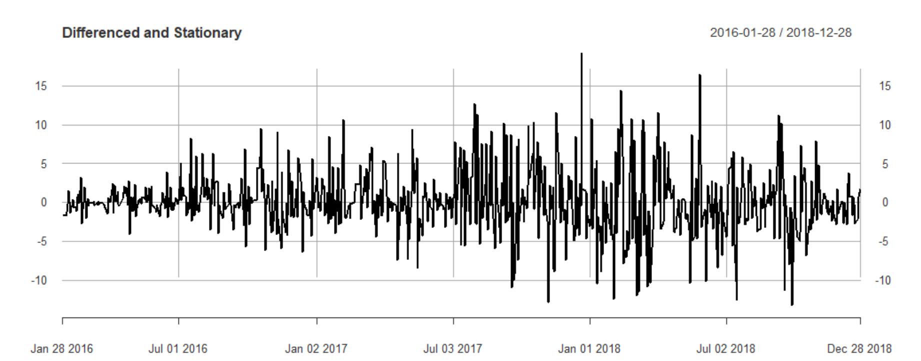
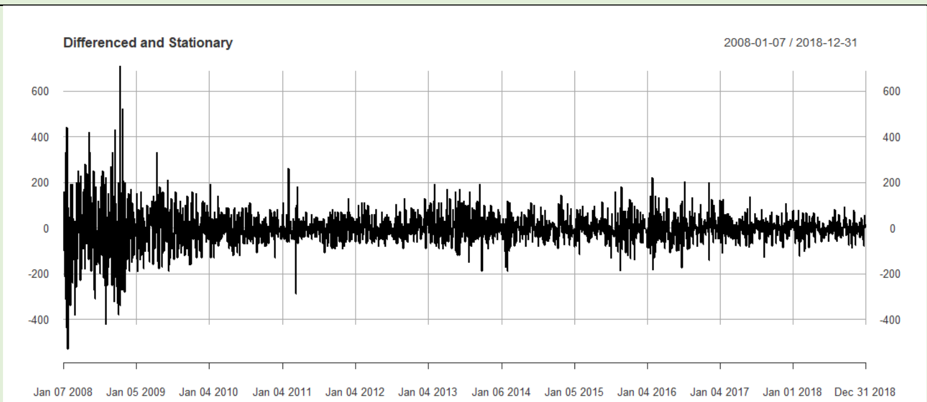
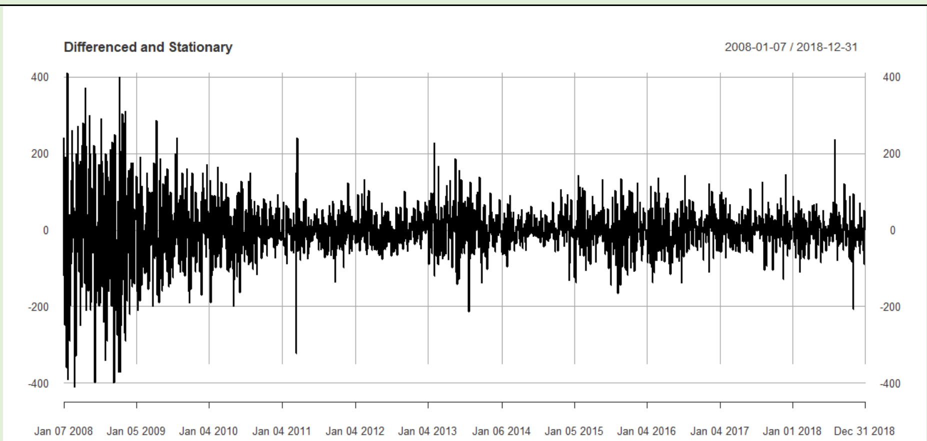
Company	Test statistic	p-value	p-value < 0.05
BHP.AX	2.2807	0.4595	
NILSY	-2.4438	0.3904	
VALE	-1.8818	0.6284	
GLEN.L	-2.2703	0.4639	
OUT1V.HE	-2.299	0.4517	
APAM.AS	-1.7987	0.6636	
ACX.MC	-2.7805	0.2479	
AKS	-2.4355	0.3939	
PKX	-2.7842	0.2463	
JSLHISAR.BO	-0.12945	0.99	
NIPST	-4.3292	0.01	**
JFE	-3.3511	0.06185	
EO.PA	-2.3165	0.4443	
TEN	-1.0185	0.9358	
FUTBA	-2.9576	0.1729	
SEJONG	-2.0858	0.542	

2.1 Differenciated and stationariety

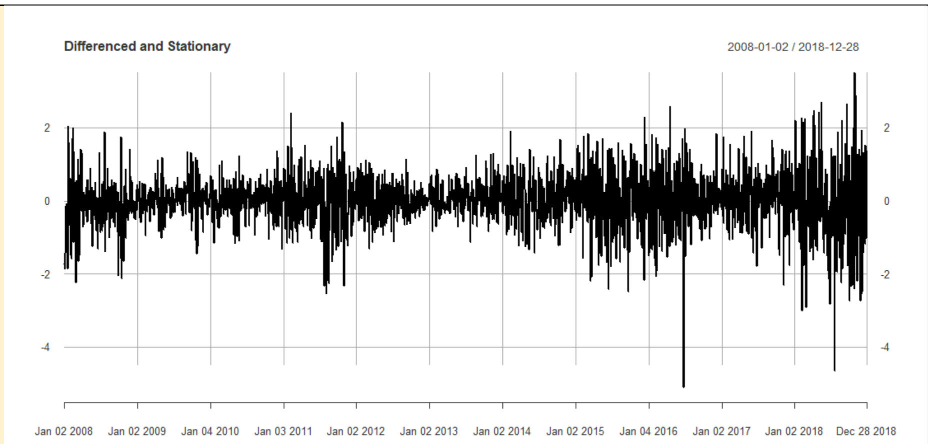
Company	
BHP.AX	
NILSY	

VALE	
GLEN.L	
OUT1V.HE	

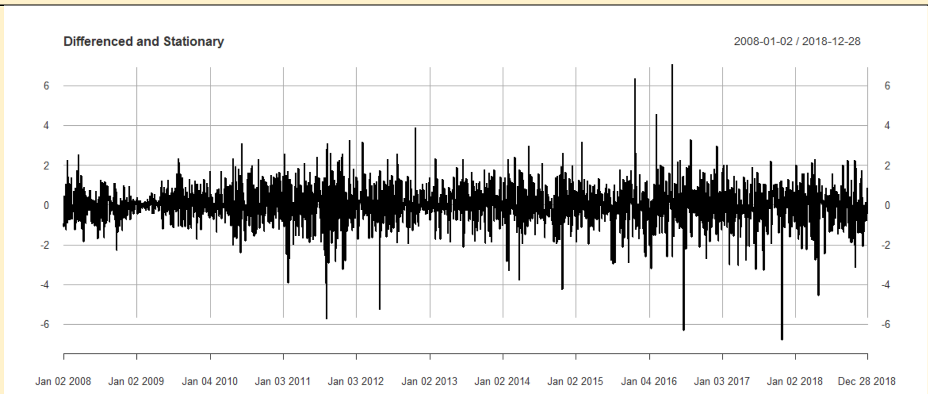
APAM.AS	
ACX.MC	
AKS	

PKX	
JSLHISAR.BO	
NIPST	
JFE	

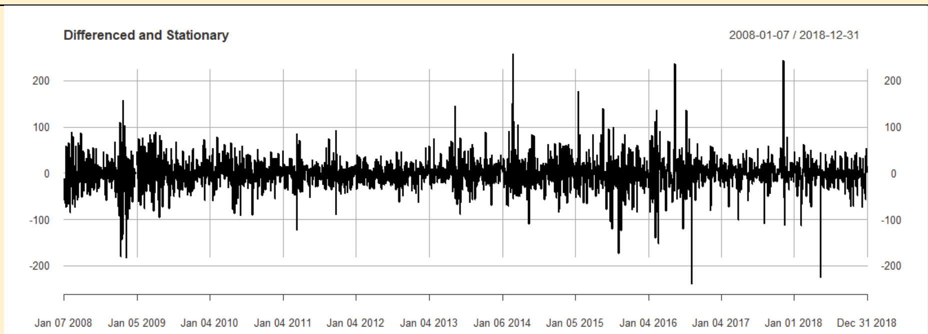
EO.PA



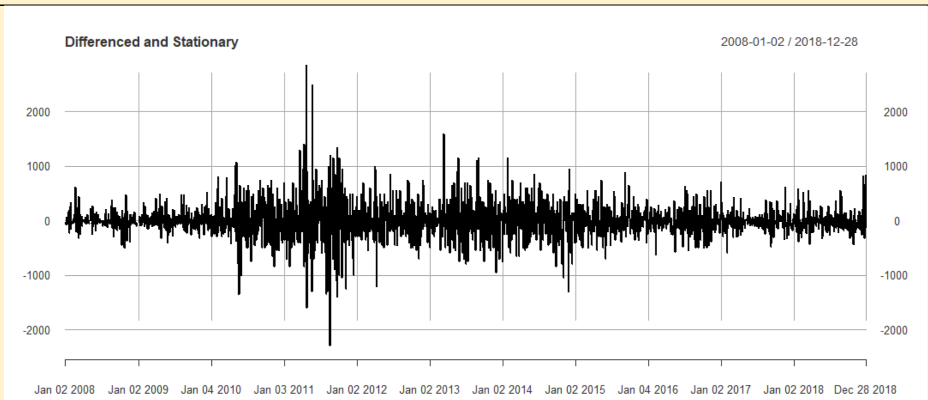
TEN



FUTBA



SEJONG



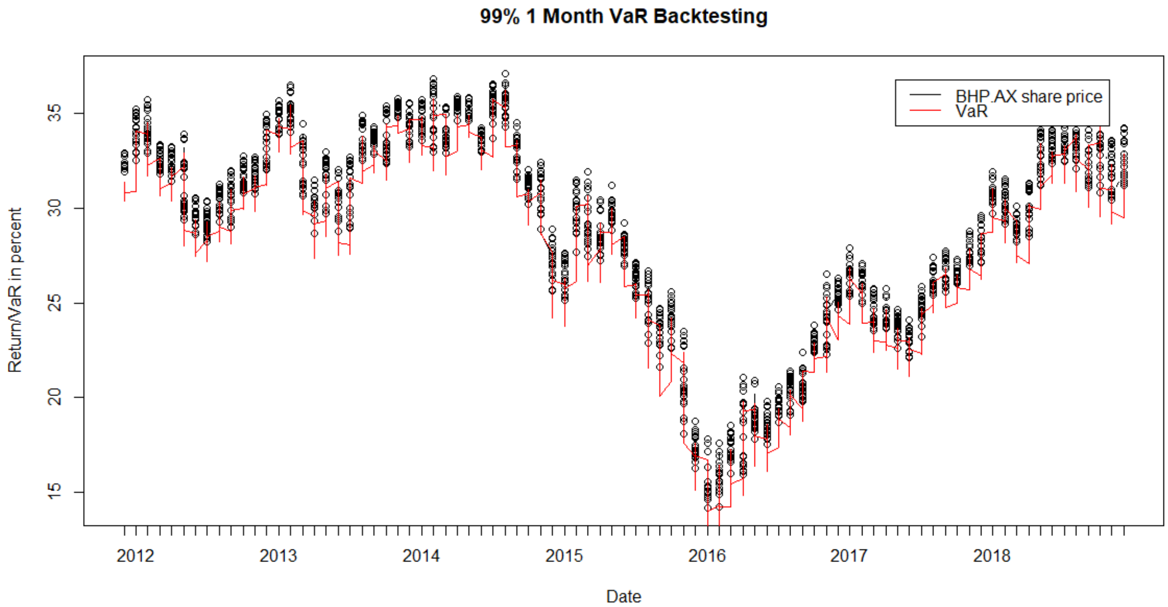
2.2 ARMA model

Company	Differencing	ARMA model
BHP.AX	1	ARMA(1,1)
NILSY	1	ARMA(2,2)
VALE	1	ARMA(2,0)
GLEN.L	1	ARMA(0,0)
OUT1V.HE	1	ARMA(5,1)
APAM.AS	1	ARMA(1,0)
ACX.MC	1	ARMA(1,2)
AKS	1	ARMA(4,3)
PKX	1	ARMA(2,0)
JSLHISAR.BO	1	ARMA(2,2)
NIPST	1	ARMA(5,0)
JFE	1	ARMA(3,0)
EO.PA	1	ARMA(1,1)
TEN	1	ARIMA(0,0)
FUTBA	1	ARMA(1,0)
SEJONG	1	ARMA(3,2)

2.3 Estimation results

	AR (0,0)	AR (1,1)	AR (2,2)	AR (2,0)	AR (5,1)	AR (1,0)	AR (1,2)	AR (4,3)	AR (5,0)	AR (3,0)	AR (3,2)
BHP.AX	5.28	1.53	1.53								
NILSY	4.31	0.94	0.94								
VALE	5.94	1.01	1.01	1.01							
GLEN.L	10.15	6.59	6.59								
OUT1V.HE	5.38	0.54	0.54		0.55						
APAM.AS	7.05	1.58	1.58			1.58					
ACX.MC	3.33	-0.38	-0.38				-0.39				
AKS	4.63	0.50	0.50					0.50			
PKX	7.83	3.71	3.71	3.71							
JSLHISAR.BO	9.90	5.30	5.30	5.30							
NIPST	14.7	10.9	10.9						10.9		
JFE	14.8	10.8	10.7							10.8	
EO.PA	7.08	1.84	1.84								
TEN	7.59	2.58	2.58								
FUTBA	13.5	9.56	9.56			9.56					
SEJONG	18.5	13.8	13.9								13.9

2.4 VAR



Appendix No. 15

Commodity price mitigation strategies

Number	Publication
1	Zsidisin, Managing commodity price risk ...- 2013
2	Borghesi, Risk Management, How to Assess, Transfer and Communicate Critical Risks-2013
3	Kouvelis, Handbook of Integrated Risk Management in Global Supply Chains-2011
4	Qazi, Supply chain risk network management: A Bayesian belief network and expected utility-based approach for managing supply chain risks-2018
5	Costantino, Commodity price volatility mitigation in SC- 2016
6	Poitras, Commodity Risk Management: Theory and Application- 2013
7	Piot-Lepetit, Methods to analyse agricultural-2011
8	Watanabe, The economics of interfirm networks- 2015
9	Buzzell, Is Vertical Integration Profitable-1983
10	Pellegrino, Supply Chain Finance: A supply chain-oriented perspective to mitigate commodity risk and pricing volatility-2018
11	Manuj und Mentzer, Global SC risk mgmt. strategies-2008
12	Delnooz, Commodity risk mitigation- 2014
13	Jüttner and Maklan, SC resilience in the global financial crisis.-2011
14	Xiarchos, Price and volatility transmission between primary and scrap metal markets-2009
15	Carter, A review of the literature on commodity risk management-2017
16	Matook, Supplier development with benchmarking as part of a comprehensive supplier risk management framework- 2009
17	Rutten and Youssef , An exploration of commodity income stabilization options for coffee farmers- 2007
18	Gaudenzi, An exploration of factors influencing the choice of commodity price risk mitigation strategies - 2017
19	Johnson, Supply organizations in North America: A 24-year perspective on roles and responsibilities 1987–2011-2014
20	Schiele / Journal of Purchasing & Supply Management 13 (2007) 274–293
21	Monczka, Purchasing & Supply Chain Management-2015, p 397
22	Bolandifar, Hedging through index-based price contracts in commodity-based supply chains-2020
23	Byrne, Exploring agency, knowledge, and power in an Australian bulk cereal supply chain-2014
24	Xiao, Price, and service competition of supply chains with risk-averse retailers under demand uncertainty -2006
25	Xie, Quality investment and price decision in a risk-averse supply chain - 2011
26	Shi, A portfolio approach to managing procurement risk using multi-stage stochastic programming, 2011

Appendix No. 16

Literature research according to Figure 10 & 11

Authors
Title
DOI Publication Year Total Citations Average per Year

Commodity and Price and Volatility and mitigation

Ben Abdallah, Marwa; Farkas, Maria Fekete; Lakner, Zoltan
Analysis of meat price volatility and volatility spillovers in Finland
10.17221/158/2019-AGRICECON 2020 0 0

Chevallier, Julien; Le Pen, Yannick; Sevi, Benoit
Options introduction and volatility in the EU ETS
10.1016/j.reseneeco.2011.07.002 2011 24 2,4

Michaelowa, Axel
Can insurance deal with negative effects arising from climate policy measures?
2006 0 0

Anupama; Malik, N. S.
Price Risk Mitigation in Agriculture through Future Trading
2010 0 0

Ni, Jian; Zhou, Wei; Yang, Dan
Procurement Risk Mitigation for Rebar Using Commodity Futures
10.1007/978-3-319-59280-0_124 2018 0 0

Oko-Isu, Anthony; Chukwu, Agnes Ugboego; Ofoegbu, Grace Nyereugwu; Igberi, Christiana Ogonna; Ololo, Kennedy Okechukwu; Agbanike, Tobechi Faith; Anochiwa, Lasbrey; Uwajumogu, Nkechinyere; Enyoghasim, Michael Oguwuike; Okoro, Uzoma Nnaji; Iyaniwura, Adeolu
Coffee Output Reaction to Climate Change and Commodity Price Volatility: The Nigeria Experience
10.3390/su11133503 2019 0 0

Sharma, Dinesh Kumar; Malhotra, Meenakshi
Impact of futures trading on volatility of spot market-a case of guar seed
10.1108/AFR-03-2014-0005 2015 1 0,17

de Kort, J.; Vellekoop, M. H.
Existence of optimal consumption strategies in markets with longevity risk
10.1016/j.insmatheco.2016.10.013 2017 1 0,25

Alshehri, Khaled; Bose, Subhonmesh; Basar, Tamer
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Appendix No. 17

Mining Risk reports 2018-2019

Company	Type	Item	Page in AR 2018	Page in AR 2019
Glencore	hedge	Currency / Trading positions / Commodity prices / Interst rates	27, 120, 196	78
Glencore	Main risks	Commodity prices / Volatility in prices	24	75
Glencore	Main risks	Currency ex change rates	24	75
Glencore	Main risks	Geoploitiacal permits / licences	25	75
Glencore	Main risks	Political Trading barriers		2
Glencore	Main risks	Global demand downturn		77
Glencore	Mitigation	Diversification/ Contractual terms/ Focus on growth areas / E Mobility	27	77
Glencore	Mitigation	Customer selection	24	77
Glencore	Mitigation	Active engagement with the governmental authorities	28	79
Glencore	Mitigation	Monitoring of risk appetite	100	98
Glencore	Mitigation	Brownfield investments preferred (costs)		8
Nornickel	hedge	Currency Russian Rubel against USD	199	223
Nornickel	hedge	no hedge instruments for products	265	311
Nornickel	Main risks	Commodity prices	196	223
Nornickel	Main risks	Currency ex change rates	196	223
Nornickel	Main risks	Gloabal demand downturn	196	223
Nornickel	Mitigation	Market monitoring	198	225
Nornickel	Mitigation	Longterm contracts	198	224
Nornickel	Mitigation	Active engagement in Commodity associations to increase demand	198	224
Nornickel	Mitigation	Customer selection across industries and geographic area´s	198	225
Nornickel	Mitigation	Product diversification	198	225
Nornickel	Mitigation	Strategic partnerships	198	225
Nornickel	Mitigation	Monitoring of risk appetite	196	221
BHP Billiton	hedge	Commodity prices and exchange rates are generally not hedges	34	
BHP Billiton	hedge	Commodity prices and exchange rates are hedged		86
BHP Billiton	Main risks	Commodity prices & volatility	34	29
BHP Billiton	Main risks	Global demand (China)	34	36/ 42
BHP Billiton	Main risks	Exchange rates	34	
BHP Billiton	Main risks	Governments actions	34	36
BHP Billiton	Main risks	Political events that risk long-term fiscal stability	34	
BHP Billiton	Mitigation	Product diversification	34	36/ 42
BHP Billiton	Mitigation	Market selection	34	36/ 42
BHP Billiton	Mitigation	Currency selection	34	36/ 42
BHP Billiton	Mitigation	Reduction of price volatility	34	36/ 42
BHP Billiton	Mitigation	Monitoring of risk appetite	113	29
BHP Billiton	Mitigation	Index pricing		205
VALE	Hedge	Currencies hedged EUR & USD& YUAN	94	100
VALE	Main risks	Commodity price changes	23	35
VALE	Main risks	Volatile demand pattern of global economy	23	35
VALE	Main risks	Price volatility	24	35
VALE	Main risks	Long-term investments and ROI	23	´-
VALE	Main risks	Overload on Iron Ore	23	32
VALE	Main risks	Quantity driven by China (42% of Vale turnover) 49% in 2019	23	33
VALE	Main risks	Dependency on USD	23	32
VALE	Main risks	Political and social environment	23	34
VALE	Main risks	Tariff barriers	27	32
VALE	Main risks	Low competivness		16
VALE	Main risks	Use of ss scrap will reduce demand / substitution	24	32
VALE	Mitigation	Production adjustments	25	17
VALE	Mitigation	Monitoring of risk appetite	181	122
VALE	Mitigation	may incorporate derivative instruments, predominantly forwards, futures and options.	303	312
VALE	Mitigation	Steel mill operation in Brazil & USA	75	75
VALE	Mitigation	Iron Ore beneficiation technologies	12	15
VALE	Mitigation	According to ISO 31000 & COSO ERM	119	122
VALE	Mitigation	Turnaround activities, assest utlization rates, increase productivity		16
VALE	Mitigation	Global customer selection		16
VALE	Mitigation	Direct customer contact / no traders inbetween		16
VALE	Mitigation	Production adjustments Sell of stakes		

Risks	Glencore		Nornickel		BHP		VALE	
Annual report	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**
Commodity price volatility	x	x	x	x	x	x	x	x
Currencies volatility	x	x	x	x	x	x	x	x
Trade barriers	x	x	x	x	x	x	x	x
Substitution							x	x
Global demand reduced	x	x	x	x	x	x	x	x
Dependency on one product							x	x
Mitigation	**Glencore**		**Nornickel**		**BHP**		**VALE**	
Annual report	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**	**2018**	**2019**
Hedging Currencies	x	x	x	x		x	x	x
Hedging Commodity prices	x	x				x	x	x
Hedging Interst rates	x	x			x	x		
Customer selection	x	x	x	x	x	x		
Market selection			x	x	x	x		
Diversification - Product	x	x	x	x				
Diversification- geographic	x	x	x	x	x	x		
Lobbying	x	x	x	x			x	x
Contracts	x	x	x	x	x	x		
Index Pricing					x	x		
Monitoring of risk appetite	x	x	x	x	x	x	x	x
Strategic partnerships			x	x				
Up stream business activities	x	x			x	x	x	x

Company	Type	Item	Category	2015	2017	2018	2019
Acerinox	Main risks	Raw material price volatility	Commodity price volatility	44	54	83	42
Acerinox	Main risks	Political trade barriers like export ban Indonesia for Nickel	Commodity price volatility				42
Acerinox	Mitigation	Contractual firm orders all have a known raw material risk	Contract / Price setting	102		125	128
Acerinox	Mitigation	AS passes the price changes to teh customer	Contractual/ sharing & passing of volatility	101	124	124	128
Acerinox	Mitigation	Risk commitee reports to oard all plants	Executive involvement	44	6	80	70
Acerinox	Hedge	Currencies	Financial / hedge	100	122	115	126
Acerinox	Main risks	Raw material volatility is 90% hedged with AS system of group sales, 10% other price settings	Contractual/ sharing & passing of volatility	101	124	124	28
Acerinox	Mitigation	Nickel natural hedge by Alloy surcharge	Contractual/ sharing & passing of volatility	101	124		128
Acerinox	Mitigation	Valuation at average costs help to decrease impact of Nickel price volatility on margins	Financial/ cost setting		125	125	129
Acerinox	Main risks	Cyclical nature of apparent consumption due to volatility in raw materials	Macro		125	125	128
Acerinox	Mitigation	10% Nickel change means less than 1% gross margin on sales	Strategic	101			
Acerinox	Main risks	Overcapacity to decrease prices -- China	Strategic / capacity utilization	44	6	83	3
Acerinox	Main risks	Sales policies of competitors with decrease of prices to maintain market share- highly competitive market	Strategic / customer base	45	187		3
Acerinox	Main risks	market is largely controlled by independent wholesalers leads to volatility in apparent consumption, reflecting their expectations regarding nickel price trends their strategies to stockpile or realise inventories.	Strategic / customer base	100	124	124	128
Acerinox	Mitigation	short term orders	Strategic / customer base	102	125	126	129
Acerinox	Mitigation	Plants and sales networks across the globe reduce exposure to on especific area	Strategic / customer base	100	124	6	8
Acerinox	Mitigation	own sales network to channel the production and to have a tighter grip on the market price	Strategic / customer base	101	125	125	129
Acerinox	Mitigation	Competitive position through continous investments	Strategic / customer base			6	11
Acerinox	Mitigation	Sales to end customers	Strategic / customer base			125	129
Acerinox	Mitigation	Product mix	Strategic / diversification			6	3
Acerinox	Mitigation	shortening of production cycle	Strategic / operational	102	124	125	11

Acerinox	Mitigation	Inventory control	Strategic / operational	102	124	125	11
Acerinox	Mitigation	Reduce production cycle to two weeks	Strategic / operational	101	124	124	128
Acerinox	Mitigation	Strategic partnerships	Strategic / operational			184	11
Acerinox	Main risks	EU Safeguard measures not enough to protect the stainless industry	Strategic / tariffs				128
Acerinox	Main risks	politicl instability	Strategic / tariffs			2	10
Acerinox	Mitigation	Trade barriers US 232 to protect the US market / EU SAFEGUARD	Strategic / tariffs			3	3
Acerinox	Mitigation	Acqusition of VDM long products, greater value added opportunity to grow in new markets	Strategic/ vertical				47
Aperam	Main risks	Nickel price changes (demand driven, speculation driven)	Commodity price volatility	24	55	62	65
Aperam	Main risks	Nickel price dcerease	Commodity price volatility	181	55	22	65
Aperam	Main risks	Nickel price changes	Commodity price volatility		3	22	65
Aperam	Main risks	Ferrochrome and Iron Ore volatility	Commodity price volatility		3	22	65
Aperam	Main risks	As system is not covering all teh price volatility of Alloys	Contractual/ sharing & passing of volatility			22	23
Aperam	Main risks	Currency fluctuations	Currency volatility	25	56	63	66
Aperam	Main risks	Inflation in Brazil that triggers x rate changes to USD	Currency volatility	182	56	63	66
Aperam	Mitigation	Risk Board reports to Boaard and consists partly of Board members	Executive involvement	25	27	32	35
Aperam	Hedge	Nickel hedging	Financial / hedge	39	43	48	53
Aperam	Hedge	Currencies	Financial / hedge	141	150	165	53
Aperam	Main risks	Raw material uncertainity	sourcing	182	3	62	65
Aperam	Main risks	Aperams profitability correlates amongst othrs with nickel prices	Strategic	181	56	62	65
Aperam	Main risks	Overcapacity	Strategic / capacity utilization	181	55	62	65
Aperam	Main risks	Cost per employee is too high compared to competitors	Strategic / capacity utilization	182	56	63	66
Aperam	Mitigation	Innovative services to teh customer / Products innovations	Strategic / customer base	7	4	17	17

Aperam	Mitigation	Customer loyalty	Strategic / customer base		4	16	26
Aperam	Mitigation	one of teh largest distribution networks in the world	Strategic / customer base			16	17
Aperam	Mitigation	Diversified customer base	Strategic / customer base			16	17
Aperam	Mitigation	Development of more profitable products	Strategic / diversification	7	4	20	19
Aperam	Mitigation	wide product offering flat, long, Nickel alloys	Strategic / diversification	14	13	16	17
Aperam	Mitigation	Geographically diversified in Brazil and EU	Strategic / diversification			15	16
Aperam	Mitigation	Operational excellence	Strategic / operational	5	4	5	3
Aperam	Mitigation	AD measures in EU but not sufficient	Strategic / tariffs	4		26	25
Aperam	Main risks	geoplolitical risks	Strategic / tariffs	181	55	26	65
Aperam	Main risks	Soft AD measures for imports into teh EU	Strategic / tariffs		23	26	26
Aperam	Mitigation	Soft safeguard measures	Strategic / tariffs			26	26
Aperam	Main risks	US 232 is diverting quantities to EU	Strategic / tariffs			26	26
Aperam	Main risks	Material from China and Indonesia (Tshingshan)	Strategic / tariffs			26	26
Aperam	Mitigation	Import duties in Brasil to protect local market	Strategic / tariffs			29	31
Aperam	Main risks	Political Risk BREXIT	Strategic / tariffs			62	65 / no risks
Aperam	Mitigation	Charcioal from own forests in Brazil	Strategic/ vertical		3	14	66
Outokumpu	Main risks	Commodity prices / Volatility in prices (Nickel, Moly, iron Ore	Commodity price volatility	25	127	84	85
Outokumpu	Main risks	Ferrochrome mine related to USD/EUR sales -- X rate risk is significant, steel contribution margin impacted by USD	Commodity price volatility	68	127	124	85
Outokumpu	Main risks	Nickel price changes	Commodity price volatility	70	127	125	87
Outokumpu	Main risks	fixed purchase prices, fixed sales prices, inventory of priced alloys Nickel...	Contactual / price setting		127	124	85
Outokumpu	Main risks	Metals short- longterm or spot contracts	Contactual / price setting	107	127		
Outokumpu	Mitigation	AS Systems passes on partly the raw material/ volatilty costs to customerrs	Contractual/ sharing & passing of volatility		128	125	130

Outokumpu	Main risks	Currency ex change rates EUR/SEK/USD/YUAN/GBP	Currency volatility	25	84	124	85
Outokumpu	Main risks	Different Environmental standards in EU / USA / ASIa - Co2 rights /// Carbon border adjustment	Environment				7
Outokumpu	Mitigation	Board approves RM	Executive involvement	67	46	82	85
Outokumpu	Mitigation	Metal desk / treasury responsible for metal price risk	Executive involvement	67		82	85
Outokumpu	Mitigation	new way to deal with metals board presentation in 2018	Executive involvement			84	
Outokumpu	Mitigation	Purchasing management model introduction	Executive involvement				240
Outokumpu	Hedge	Nickel hedging	Financial / Hedge	25	88	84	85
Outokumpu	Hedge	Molybdenum hedging just partly	Financial / Hedge	109	84	125	85
Outokumpu	Hedge	Propane gas hedging	Financial / Hedge	25	86	84	85
Outokumpu	Hedge	Currency hedging	Financial / Hedge	41	84	83	62
Outokumpu	Mitigation	Nickel forwards	Financial / hedge		88	84	87
Outokumpu	Mitigation	Objectives of financial risk management is to reuce the impact of price fluctuations	Financial / several	67	86	82	87
Outokumpu	Main risks	Import from Third countries 30% in EU in 2019	Strategic / tariffs				7
Outokumpu	Main risks	Highly cyclical business, significant exposure to underlying market risks	Macro	67	84	82	85
Outokumpu	Main risks	No established financial market for Chrome	Strategic		86	85	87
Outokumpu	Main risks	Capacity utilization rate due to supresses low price levels	Strategic / capacity utilization	109	127	125	129
Outokumpu	Main risks	Overcapacity	Strategic / capacity utilization	108	126	124	11
Outokumpu	Mitigation	Customer orientation & effiency	Strategic / customer base		127	124	8
Outokumpu	Main risks	Trade barriers & Antidumping measure	Strategic / tariffs	108	127	124	6
Outokumpu	Mitigation	Protection by AD measures	Strategic / tariffs	68	127	124	6
Outokumpu	Main risks	iron ore exposure similar to that of nickel, ut lower exposure due to part of iron ore from own ferrochrome mine	Strategic/ vertical			84	85
Outokumpu	Mitigation	Use of own Ferrochrome mine, no x rates	Strategic/ vertical	108			85

Appendix No. 18

VIX vs Nickel 2017-2019
US Trade 232

Content

1 Correlation analysis Spearman´s rho Nickel and VIX

Source: Regression TrumpUSA232_20201028 .xlsx

Correlation analysis 2007 to 2019 February (n =26)

Spearman's rho	Nickel	VIX
Nickel	1.000	0.461*
VIX	0.461*	1.000
Aluminium	0.714**	0.024
Iron Ore	-0.080	0.268
Copper	0.744**	0.101
Stainless 304 scrap Europe	0.645**	0.164
Stainless 304 scrap USA	0.653**	-0.011
Ferrochrome	0.703**	0.150
Outokumpu	-0.536**	-0.741**
Aperam	-0.462*	-0.803**
Acerinox	-0.246	-0.512**
Yieh	-0.050	-0.036
AK Steel	-0.595**	-0.651**
Posco	0.519**	-0.211
Jindal Stainless	-0.082	-0.683**
Nippon Steel	-0.261	-0.645**
JFE	0.432*	-0.429*
Tenneco	-0.486*	-0.711**
Faurecia	0.542**	-0.267
Futaba	0.190	-0.556**
Sejong	-0.474*	-0.283
BHP Billiton	0.059	-0.335
Norilsk	0.646**	0.380
Vale	0.703**	0.711**
Glencore	0.430*	-0.319

** Significant at 0.001 level / *Significant at 0.05 level, two tailed

2 Regression analysis, linear- VIX- Base metals

Model Summary / Dependent Variable: VIX 2017-201902 (US232)							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	Sig. F Change	
1	0.48	0.23	0.08	4	0.23	1.55	Ferro-Chrome, Iron Ore, Aluminium, Nickel

Anova/ Dependent Variable: VIX 2017-201902 (US232)							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	102	4	25	1.546	0.225	Ferro-Chrome, Iron Ore, Aluminium, Nickel
	Residual	346	21	16.5			
	Total	448	25				

Coefficients / Dependent Variable VIX 2017-201902 (US232)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	34.58	23.80		1.45	0.161
	Nickel	0.00	0.00	0.88	2.26	0.035
	Aluminium	-0.01	0.01	-0.49	-1.40	0.176
	Iron Ore	-0.09	0.16	-0.17	-0.56	0.585
	Ferro-Chrome	0.00	0.01	-0.28	-0.72	0.479

A multiple regression was run to predict VIX of the monthly average price notations of the base materials. These variables could not statistically significantly predict VIX, $F(4, 21) = 1.546$, $p < 0.001$, $R^2 = 0.23$. No value added statistically significantly to the prediction, $p < 0.05$.

3 Regression analysis, linear- VIX- Miners

Model Summary / Dependent Variable: VIX 2017-201902 (US232)							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	Sig. F Change	
1	0.83	0.68	0.62	3	0.68	11.34	Glencore, Vale , Norilsk, BHP Billiton

Anova/ Dependent Variable: VIX 2017-201902 (US232)							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	306	4	77	11.345	0.000	Glencore, Vale , Norilsk, BHP Billiton
	Residual	142	21	6.7			
	Total	448	25				

Coefficients / Dependent Variable VIX 2017-201902 (US232)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	13.11	6.51		2.01	0.057
	BHP Billiton	0.00	0.00	0.44	2.20	**0.039**
	Norilsk	0.03	0.04	0.15	0.91	0.375
	Vale	0.19	0.04	0.92	4.69	**0.000**
	Glencore	-0.01	0.00	-0.69	-3.86	**0.001**

A multiple regression was run to predict VIX of the monthly average share prices of the mining companies. None of the variables added statistically significantly predicted VIX, $F(4, 21) = 11.35$, $p < 0.001$, $R^2 = 0.68$. Three variables (BHP Billiton, Glencore, Vale) did added statistically significantly to the prediction, $p < 0.05$.

4 Regression analysis, linear- VIX- Stainless producers

Model Summary / Dependent Variable: VIX 2017-201902 (US232)							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	Sig. F Change	
1	0.87	0.75	0.62	3	0.75	5.47	JFE, AK Steel, Yieh, Posco, Nippon Steel, Jindal Stainless, Outokumpu, Acerinox,

Anova/ Dependent Variable: VIX 2017-201902 (US232)							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	338	9	38	5.475	0.002	JFE, AK Steel, Yieh, Posco, Nippon Steel, Jindal Stainless, Outokumpu, Acerinox, Aperam
	Residual	110	16	6.9			
	Total	448	25				

Coefficients / Dependent Variable VIX 2017-201902 (US232)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	20.87	26.29		0.79	0.439
	Outokumpu	-0.12	0.09	-0.53	-1.34	0.199
	Aperam	-0.05	0.06	-0.87	-0.90	0.380
	Acerinox	0.14	0.19	0.41	0.75	0.463
	Yieh	-0.10	0.39	-0.04	-0.25	0.806
	AK Steel	-0.02	0.16	-0.06	-0.11	0.911
	Posco	0.01	0.01	0.21	0.85	0.408
	Jindal Stainless	0.00	0.01	-0.14	-0.29	0.777
	Nippon Steel	0.98	0.60	0.51	1.65	0.119
	JFE	-0.01	0.00	-0.38	-1.75	0.099

A multiple regression was run to predict VIX of the monthly average share prices of the stainless-steel producers. These could not variables statistically significantly predict VIX, $F(9, 16) = 5.48$, $p < 0.001$, $R^2 = 0.75$. None of the variables added statistically significantly to the prediction, $p < 0.05$.

5 Regression analysis, linear- VIX- Exhaust Producer

Model Summary / Dependent Variable: VIX 2017-201902 (US232)							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	Sig. F Change	
1	0.70	0.49	0.40	3	0.49	5.09	Sejong, Futaba, Tenneco, Faurecia

Anova/ Dependent Variable: VIX 2017-201902 (US232)							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	220	4	55	5.088	0.005	Sejong, Futaba, Tenneco, Faurecia
	Residual	227	21	10.8			
	Total	448	25				

Coefficients / Dependent Variable VIX 2017-201902 (US232)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	38.13	9.80		3.89	0.001
	Tenneco	-0.02	0.01	-0.44	-1.48	0.153
	Faurecia	0.01	0.01	0.33	1.12	0.277
	Futaba	0.00	0.00	-0.54	-1.46	0.158
	Sejong	0.00	0.00	0.05	0.22	0.826

A multiple regression was run to predict VIX of the monthly average share prices of the share prices of the Exhaust producers. These could not variables statistically significantly predict VIX, $F(4, 21) = 5.09$, $p < 0.001$, $R^2 = 0.49$.

None of the variables added statistically significantly to the prediction, $p < 0.05$.

6 Regression analysis, linear- Nickel- Base metals

Model Summary / Dependent Variable: Nickel 2017-201902 (US232)							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	Sig. F Change	
1	0.87	0.76	0.71	919	0.76	16.23	Ferro-Chrome, Copper, Iron Ore, Aluminium

Anova/ Dependent Variable: Nickel 2017-201902 (US232)							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	54,783,650	4	13,695,913	16.23	0.000	Ferro-Chrome, Copper, Iron Ore, Aluminium
	Residual	17,725,782	21	844,085			
	Total	72,509,432	25				

Coefficients / Dependent Variable Nickel 2017-201902 (US232)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-16,340	4,165		-3.92	**0.001**
	Aluminium	6.5	3.3	0.54	1.95	0.065
	Iron Ore	97.4	30.8	0.47	3.16	**0.005**
	Copper	0	1	0.00	0.02	0.984
	Ferrochrome	2.9	1.0	0.56	3.07	**0.006**

A multiple regression was run to predict Nickel of the monthly average prices of the base metal. These variables partly statistically significantly predicted Nickel, $F(4, 21) = 16.23$, $p < 0.001$, $R^2 = 0.76$.

The variables “Iron Ore and Ferrochrome” added statistically significantly to the prediction, $p < 0.05$. The others did not.

7 Regression analysis, linear- Nickel- Miners

Model Summary / Dependent Variable: Nickel 2017-201902 (US232)							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	Sig. F Change	
1	0.82	0.68	0.62	1,052	0.68	11.12	Glencore, Vale , Norilsk, BHP Billiton

Anova/ Dependent Variable: Nickel 2017-201902 (US232)							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	49,259,320	4	12,314,830	11.123	0.000	Glencore, Vale , Norilsk, BHP Billiton
	Residual	23,250,113	21	1,107,148			
	Total	72,509,432	25				

Coefficients / Dependent Variable Nickel 2017-201902 (US232)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-2,091	2,638		-0.79	0.437
	BHP Billiton	0.0	0.1	-0.11	-0.57	0.573
	Norilsk	21.3	15.2	0.23	1.40	0.175
	Vale	40.3	16.2	0.49	2.49	**0.021**
	Glencore	1.7	0.9	0.33	1.81	0.085

A multiple regression was run to predict Nickel of the monthly average share prices of the mining companies. These variables partly statistically significantly predicted Nickel, $F(4, 21) = 11.12$, $p < 0.001$, $R^2 = 0.68$.

One of the variables (Vale) added statistically significantly to the prediction, $p < 0.05$. The others did not.

8 Regression analysis, linear- Nickel- Stainless Mills

Model Summary / Dependent Variable: Nickel 2017-201902 (US232)							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	Sig. F Change	
1	0.92	0.84	0.75	855	0.84	9.25	JFE, AK Steel, Yieh, Posco, Nippon Steel, Jindal Stainless, Outokumpu, Acerinox, Aperam

Anova/ Dependent Variable: Nickel 2017-201902 (US232)							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	60,822,057	9	6,758,006	9.252	0.000	JFE, AK Steel, Yieh, Posco, Nippon Steel, Jindal Stainless, Outokumpu, Acerinox, Aperam
	Residual	11,687,375	16	730,461			
	Total	72,509,432	25				

Coefficients / Dependent Variable Nickel 2017-201902 (US232)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	19911	8,579		2.32	**0.034**
	Outokumpu	-77.39	29.24	-0.85	-2.65	**0.018**
	Aperam	9.90	19.12	0.41	0.52	0.612
	Acerinox	90.76	61.03	0.65	1.49	0.156
	Yieh	-304.53	127.62	-0.28	-2.39	**0.030**
	AK Steel	-56.96	53.20	-0.50	-1.07	0.300
	Posco	8.99	3.53	0.52	2.55	**0.022**
	Jindal Stainless	-2.93	2.51	-0.45	-1.17	0.260
	Nippon Steel	51.62	195	0.07	0.26	0.795
	JFE	0.30	1.08	0.05	0.28	0.784

A multiple regression was run to predict Nickel of the monthly average share prices of the stainless-steel producers. These variables partly statistically significantly predicted Nickel, $F(9, 16) = 9.25$, $p < 0.001$, $R^2 = 0.84$.

Three of the variables (Outokumpu, Posco, Yieh) added statistically significantly to the prediction, $p < 0.05$. The others did not.

9 Regression analysis, linear- Nickel- Exhaust producer

Model Summary / Dependent Variable: Nickel 2017-201902 (US232)							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	Sig. F Change	
1	0.85	0.72	0.66	989	0.72	13.28	Sejong, Faurecia, Tenneco, Futaba

Anova/ Dependent Variable: Nickel 2017-201902 (US232)							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	51,969,297	4	12,992,324	13.283	0.000	Sejong, Faurecia, Tenneco, Futaba
	Residual	20,540,135	21	978,102			
	Total	72,509,432	25				

Coefficients / Dependent Variable Nickel 2017-201902 (US232)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	14421.12	2945.47		4.90	**0.000**
	Tenneco	-7.35	3.53	-0.46	-2.08	0.050
	Faurecia	13.50	3.06	0.98	4.42	**0.000**
	Futaba	-0.28	0.23	-0.35	-1.24	0.227
	Sejong	-0.01	0.02	-0.04	-0.24	0.816

A multiple regression was run to predict Nickel of the monthly average share prices of the Exhaust producers. These variables statistically significantly predicted Nickel, $F(4, 21) = 13{,}28$, $p < 0.001$, $R^2 = 0.72$.

One of the variables (Faurecia) added statistically significantly to the prediction, $p < 0.05$.

10 Influence towards share price time period 2017-201902

10.1 Mining Companies

Model Summary / Dependent Variable: BHP 2017-201902 (US232)					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.85	0.72	0.63	4,153	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel

Anova/ Dependent Variable: BHP 2017-201902 (US232)							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	841,217,863	6	140,202,977	8.13	0.000	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel
	Residual	327,629,332	19	17,243,649			
	Total	1,168,847,194	25				

Coefficients / Dependent Variable BHP 2017-201902 (US232)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-49,440	26,106		-1.89	0.074
	Nickel	-3.2	1.1	-0.79	-2.87	**0.010**
	Aluminium	47.8	17.0	0.98	2.80	**0.011**
	Iron Ore	46.5	171.1	0.06	0.27	0.789
	Copper	5.0	3.9	0.34	1.28	0.215
	Ferro-Chrome	-12	5	-0.56	-2.22	**0.039**
	VIX	-330.4	224.3	-0.20	-1.47	0.157

Model Summary / Dependent Variable: Norilsk 2017-201902 (US232)					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.88	0.77	0.70	10	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel

Anova/ Dependent Variable: Norilsk 2017-201902 (US232)							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	6,252	6	1,042	10.51	0.000	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel
	Residual	1,884	19	99			
	Total	8,136	25				

Coefficients / Dependent Variable Norilsk 2017-201902 (US232)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	29	63		0.47	0.643
	Nickel	0.0	0.0	0.41	1.63	0.119
	Aluminium	-0.1	0.0	-0.77	-2.41	**0.026**
	Iron Ore	0.4	0.4	0.16	0.86	0.399
	Copper	0.0	0.0	0.99	4.08	**0.001**
	Ferro-Chrome	0	0	0.10	0.44	0.668
	VIX	0.8	0.5	0.19	1.47	0.158

Model Summary / Dependent Variable: Vale 2017-201902 (US232)					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.91	0.82	0.77	10.11	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel

Anova/ Dependent Variable: Vale 2017-201902 (US232)							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	8,953	6	1,492	14.60	0.000	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel
	Residual	1,942	19	102			
	Total	10,895	25				

Coefficients / Dependent Variable Vale 2017-201902 (US232)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-61	64		-0.96	0.350
	Nickel	0.0	0.0	0.38	1.72	0.101
	Aluminium	0.0	0.0	-0.11	-0.38	0.710
	Iron Ore	0.6	0.4	0.25	1.52	0.145
	Copper	0.0	0.0	-0.02	-0.08	0.939
	Ferro-Chrome	0	0	0.48	2.38	**0.028**
	VIX	2.5	0.5	0.50	4.54	**0.000**

Model Summary / Dependent Variable: Glencore 2017-201902 (US232)					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.88	0.78	0.71	179	Copper, Nickel, Iron Ore, Aluminium

Anova/ Dependent Variable: Glencore 2017-201902 (US232)							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	2,135,925	6	355,988	11.13	0.000	Copper, Nickel, Iron Ore, Aluminium
	Residual	607,466	19	31,972			
	Total	2,743,391	25				

Coefficients / Dependent Variable Glencore 2017-201902 (US232)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	47	1,124		0.04	0.967
	Nickel	0.0	0.0	-0.20	-0.82	0.423
	Aluminium	0.0	0.7	-0.02	-0.06	0.952
	Iron Ore	-2.8	7.4	-0.07	-0.37	0.713
	Copper	0.7	0.2	0.94	3.95	**0.001**
	Ferro-Chrome	0	0	0.07	0.33	0.748
	VIX	-22.7	9.7	-0.29	-2.35	**0.030**

10.2 Vix / Scrap EU and USA

Model Summary / Dependent Variable: VIX 2017-201902 (US232)					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.49	0.23	0.04	4.14	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel

Anova/ Dependent Variable: VIX 2017-201902 (US232)							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	105	5	21	1.23	0.333	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel
	Residual	343	20	17			
	Total	448	25				

Coefficients / Dependent Variable VIX 2017-201902 (US232)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	37	25		1.48	0.154
	Nickel	0.0	0.0	0.88	2.21	**0.039**
	Aluminium	0.0	0.0	-0.67	-1.23	0.232
	Iron Ore	-0.1	0.2	-0.22	-0.66	0.518
	Copper	0	0	0.19	0.44	0.667
	Ferro-Chrome	0.0	0.0	-0.28	-0.71	0.485

Model Summary / Dependent Variable: Stainless Scrap EU 304 2017-201902 (US232)					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.85	0.73	0.65	0.06	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel

Anova/ Dependent Variable: Stainless Scrap EU 304 2017-201902 (US232)							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	0	6	0	8.57	0.000	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel
	Residual	0	19	0			
	Total	0	25				

Coefficients / Dependent Variable Stainless Scrap EU 304 2017-201902 (US232)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0	0		0.48	0.635
	Nickel	0.0	0.0	0.68	2.54	**0.020**
	Aluminium	0.0	0.0	1.10	3.21	**0.005**
	Iron Ore	0.0	0.0	0.25	1.22	0.238
	Copper	0.0	0.0	-0.72	-2.73	**0.013**
	Ferro-Chrome	0	0	-0.36	-1.44	0.166
	VIX	0.0	0.0	-0.27	-2.01	0.059

Model Summary / Dependent Variable: Stainless Scrap USA 304 2017-201902 (US232)					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.87	0.75	0.68	0.09	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel

Anova/ Dependent Variable: Stainless Scrap USA 304 2017-201902 (US232)							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	0	6	0.08	9.67	0.000	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel
	Residual	0	19	0.01			
	Total	1	25				

Coefficients / Dependent Variable Stainless Scrap USA 304 2017-201902 (US232)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0	1		-0.09	0.932
	Nickel	0	0	0.56	2.16	**0.044**
	Aluminium	0	0	0.91	2.78	**0.012**
	Iron Ore	0.0	0.0	-0.05	-0.25	0.806
	Copper	0.0	0.0	-0.22	-0.89	0.386
	Ferro-Chrome	0	0	-0.54	-2.28	**0.035**
	VIX	0.0	0.0	-0.33	-2.50	**0.022**

10.3 Stainless-steel producers

Model Summary / Dependent Variable: Outokumpu 2017-201902 (US232)					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.89	0.80	0.74	9.6	Copper, Nickel, IronVIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel Ore, Aluminium

Anova/ Dependent Variable: Outokumpu 2017-201902 (US232)							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	7,028	6	1,171	12.66	0.000	Copper, Nickel, IronVIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel Ore, Aluminium
	Residual	1,757	19	92			
	Total	8,785	25				

Coefficients / Dependent Variable Outokumpu 2017-201902 (US232)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	60	60		0.99	0.333
	Nickel	0	0	-0.40	-1.75	0.096
	Aluminium	0	0	0.53	1.79	0.089
	Iron Ore	0.2	0.4	0.09	0.51	0.613
	Copper	0.0	0.0	0.05	0.22	0.832
	Ferro-Chrome	0	0	-0.49	-2.31	**0.032**
	VIX	-2.8	0.5	-0.62	-5.31	**0.000**

Model Summary / Dependent Variable: Aperam 2017-201902 (US232)					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.86	0.74	0.66	40.93	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel

Anova/ Dependent Variable: Aperam 2017-201902 (US232)							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	89,790	6	14,965	8.93	0.000	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel
	Residual	31,833	19	1,675			
	Total	121,623	25				

Coefficients / Dependent Variable Aperam 2017-201902 (US232)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	148	257		0.57	0.573
	Nickel	0	0	-0.23	-0.88	0.392
	Aluminium	0	0	0.72	2.13	**0.047**
	Iron Ore	1.1	1.7	0.13	0.63	0.535
	Copper	0.0	0.0	-0.07	-0.25	0.803
	Ferro-Chrome	0	0	-0.37	-1.54	0.141
	VIX	-11.6	2.2	-0.71	-5.27	**0.000**

Model Summary / Dependent Variable: Acerinox 2017-201902 (US232)					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.83	0.69	0.59	7.88	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel

Coefficients / Dependent Variable Acerinox 2017-201902 (US232)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	98	50		1.98	0.062
	Nickel	0	0	0.20	0.69	0.501
	Aluminium	0	0	0.85	2.30	**0.033**
	Iron Ore	0.2	0.3	0.13	0.62	0.543
	Copper	0.0	0.0	-0.49	-1.72	0.102
	Ferro-Chrome	0	0	-0.55	-2.05	0.054
	VIX	-2.1	0.4	-0.73	-4.95	**0.000**

Anova/ Dependent Variable: Acerinox 2017-201902 (US232)							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	2,577	6	429	6.92	0.001	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel
	Residual	1,180	19	62			
	Total	3,756	25				

Model Summary / Dependent Variable: Yieh 2017-201902 (US232)					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.50	0.25	0.02	1.6	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel

Anova/ Dependent Variable: Yieh 2017-201902 (US232)							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	16	6	3	1.07	0.414	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel
	Residual	47	19	2			
	Total	63	25				

Coefficients / Dependent Variable Yieh 2017-201902 (US232)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	92	10		9.26	**0.000**
	Nickel	0.0	0.0	0.71	1.58	0.131
	Aluminium	0.0	0.0	-0.99	-1.73	0.100
	Iron Ore	-0.1	0.1	-0.70	-2.08	0.051
	Copper	0.0	0.0	0.30	0.68	0.507
	Ferro-Chrome	0	0	-0.45	-1.10	0.283
	VIX	0.0	0.1	-0.12	-0.52	0.612

Model Summary / Dependent Variable: AK Steel 2017-201902 (US232)					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.83	0.69	0.59	9.5	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel

Anova/ Dependent Variable: AK Steel 2017-201902 (US232)							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	3,770	6	628	6.95	0.000	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel
	Residual	1,717	19	90			
	Total	5,487	25				

Coefficients / Dependent Variable AK Steel 2017-201902 (US232)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-297	48		-6.24	**0.000**
	Nickel	0.0	0.0	-0.07	-0.75	0.461
	Iron Ore	2.2	0.4	0.56	5.93	**0.000**
	Aluminium	0	0	0.20	1.50	0.144
	Copper	0.0	0.0	0.32	2.70	**0.011**

Model Summary / Dependent Variable: Posco 2017-201902 (US232)					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.88	0.77	0.69	54	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel

Anova/ Dependent Variable: Posco 2017-201902 (US232)							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	183,409	6	30,568	10.37	0.000	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel
	Residual	56,004	19	2,948			
	Total	239,413	25				

Coefficients / Dependent Variable Posco 2017-201902 (US232)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-323	341		-0.95	0.356
	Nickel	0.0	0.0	0.04	0.16	0.877
	Aluminium	0.4	0.2	0.61	1.91	0.072
	Iron Ore	-1.2	2.2	-0.10	-0.54	0.592
	Copper	0.1	0.1	0.43	1.74	0.098
	Ferro-Chrome	0	0	-0.33	-1.44	0.167
	VIX	-5.6	2.9	-0.24	-1.92	0.070

Model Summary / Dependent Variable: Jindal Stainless 2017-201902 (US232)					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.94	0.88	0.84	105	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel

Anova/ Dependent Variable: Jindal Stainless 2017-201902 (US232)							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	1,496,890	6	249,482	22.63	0.000	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel
	Residual	209,421	19	11,022			
	Total	1,706,311	25				

Coefficients / Dependent Variable Jindal Stainless 2017-201902 (US232)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1,131	660		-1.71	0.103
	Nickel	-0.1	0.0	-0.61	-3.38	**0.003**
	Aluminium	1.0	0.4	0.54	2.33	**0.031**
	Iron Ore	-4.5	4.3	-0.14	-1.05	0.309
	Copper	0.4	0.1	0.65	3.68	**0.002**
	Ferro-Chrome	0	0	-0.29	-1.71	0.103
	VIX	-28.2	5.7	-0.46	-4.98	**0.000**

Model Summary / Dependent Variable: Nippon Steel 2017-201902 (US232)					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.84	0.70	0.61	1	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel

Anova/ Dependent Variable: Nippon Steel 2017-201902 (US232)							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	85	6	14	7.41	0.000	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel
	Residual	36	19	2			
	Total	121	25				

Coefficients / Dependent Variable Nippon Steel 2017-201902 (US232)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0	9		-0.05	0.963
	Nickel	0.0	0.0	-0.86	-3.05	**0.007**
	Aluminium	0.0	0.0	0.70	1.95	0.066
	Iron Ore	0.1	0.1	0.24	1.15	0.264
	Copper	0.0	0.0	0.47	1.69	0.108
	Ferro-Chrome	0	0	-0.18	-0.70	0.492
	VIX	-0.2	0.1	-0.34	-2.38	**0.028**

Model Summary / Dependent Variable: JFE 2017-201902 (US232)					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.86	0.73	0.65	164	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel

Anova/ Dependent Variable: JFE 2017-201902 (US232)							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	1,390,750	6	231,792	8.59	0.000	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel
	Residual	512,491	19	26,973			
	Total	1,903,241	25				

Coefficients / Dependent Variable JFE 2017-201902 (US232)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1,702	1,033		1.65	0.116
	Nickel	0.0	0.0	0.22	0.81	0.430
	Aluminium	-1.1	0.7	-0.58	-1.68	0.109
	Iron Ore	-8.0	6.8	-0.24	-1.19	0.250
	Copper	0.4	0.2	0.69	2.62	**0.017**
	Ferro-Chrome	0	0	0.40	1.64	0.118
	VIX	-35.3	8.9	-0.54	-3.98	**0.001**

10.4 Exhaust gas treatment system producer

Model Summary / Dependent Variable: Tenneco 2017-201902 (US232)					
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**	**Predictors**
1	0.84	0.70	0.61	66.97	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel

Anova/ Dependent Variable: Tenneco 2017-201902 (US232)							
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	**Predictors**
1	Regression	202,403	6	33,734	7.52	0.000	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel
	Residual	85,206	19	4,485			
	Total	287,610	25				

Coefficients / Dependent Variable Tenneco 2017-201902 (US232)						
Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
		B	**Std. Error**	**Beta**		
1	**(Constant)**	256	421		0.61	0.550
	Nickel	0.0	0.0	-0.51	-1.81	0.086
	Aluminium	0.5	0.3	0.70	1.96	0.065
	Iron Ore	0.8	2.8	0.06	0.31	0.762
	Copper	0.0	0.1	0.07	0.26	0.800
	Ferro-Chrome	0	0	-0.50	-1.92	0.070
	VIX	-13.0	3.6	-0.51	-3.58	**0.002**

Model Summary / Dependent Variable: Faurecia 2017-201902 (US232)					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.93	0.87	0.83	51	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel

Anova/ Dependent Variable: Faurecia 2017-201902 (US232)							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	329,455	6	54,909	21.42	0.000	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel
	Residual	48,713	19	2,564			
	Total	378,169	25				

Coefficients / Dependent Variable Faurecia 2017-201902 (US232)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-832	318		-2.61	**0.017**
	Nickel	0.0	0.0	0.00	-0.01	0.996
	Aluminium	0.5	0.2	0.54	2.28	**0.034**
	Iron Ore	-1.3	2.1	-0.09	-0.63	0.533
	Copper	0.1	0.0	0.47	2.60	**0.018**
	Ferro-Chrome	0	0	-0.15	-0.88	0.388
	VIX	-8.5	2.7	-0.29	-3.10	**0.006**

Model Summary / Dependent Variable: Futaba 2017-201902 (US232)					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.86	0.74	0.66	1,215	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel

Anova/ Dependent Variable: Futaba 2017-201902 (US232)							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	80,210,091	6	13,368,349	9.05	0.000	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel
	Residual	28,064,709	19	1,477,090			
	Total	108,274,800	25				

Coefficients / Dependent Variable Futaba 2017-201902 (US232)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8,965	7,641		1.17	0.255
	Nickel	-0.2	0.3	-0.19	-0.74	0.468
	Aluminium	-0.8	5.0	-0.06	-0.17	0.870
	Iron Ore	-34.2	50.1	-0.13	-0.68	0.503
	Copper	3.8	1.1	0.86	3.35	**0.003**
	Ferro-Chrome	-1	2	-0.11	-0.47	0.644
	VIX	-273.0	65.6	-0.56	-4.16	**0.001**

Model Summary / Dependent Variable: Sejong 2017-201902 (US232)					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.68	0.46	0.30	10,184	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel

Model Summary / Dependent Variable: Sejong 2017-201902 (US232)					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.68	0.46	0.30	10,184	VIX, Aluminium, Iron Ore, Ferro-Chrome, Copper, Nickel

Coefficients / Dependent Variable Sejong 2017-201902 (US232)						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	139,586	64,028		2.18	**0.042**
	Nickel	0.0	2.7	-0.01	-0.01	0.988
	Aluminium	57.8	41.8	0.67	1.38	0.183
	Iron Ore	-142.2	419.7	-0.10	-0.34	0.739
	Copper	-12.6	9.5	-0.49	-1.32	0.201
	Ferro-Chrome	-28	13	-0.76	-2.20	**0.040**
	VIX	-814.1	550.1	-0.28	-1.48	0.155

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Model Summary / Dependent Variable: Nickel 2017-201902 (US232)							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	Sig. F Change	
1	0.98	0.97	0.95	373	0.72	13.28	Yieh, Nippon Steel, Ferro-Chrome, Norilsk, Stainless 304 scrap Europe, Sejong, Vale , JFE

Anova/ Dependent Variable: Nickel 2017-201902 (US232)							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	51,969,297	4	12,992,324	13.283	0.000	Yieh, Nippon Steel, Ferro-Chrome, Norilsk, Stainless 304 scrap Europe, Sejong, Vale , JFE
	Residual	20,540,135	21	978,102			
	Total	72,509,432	25				

Coefficients / Dependent Variable Nickel 2017-201902 (US232)								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	548.56	3556.68		0.15	0.879		
	Nippon Steel	-229.01	48.98	-0.31	-4.68	<u>0.000</u>	0.44	2.30
	JFE	1.13	0.45	0.19	2.52	<u>0.021</u>	0.34	2.93
	Sejong	0.00	0.01	0.06	0.93	0.364	0.53	1.89
	Norilsk	33.94	5.49	0.39	6.19	<u>0.000</u>	0.47	2.12
	Vale	16.26	5.71	0.20	2.85	<u>0.011</u>	0.39	2.56
	Stainless 304 scrap Europe	9577.47	910.24	0.54	10.52	<u>0.000</u>	0.72	1.38
	Ferro-Chrome	0.67	0.41	0.13	1.62	0.123	0.30	3.36
	Yieh	-97.37	49.69	-0.09	-1.96	0.066	0.87	1.15

A multiple regression was run to predict the Nickel price of the monthly average share prices of the stainless-steel producers and the base metal prices. Three variables (Nippon Steel, Norilsk and Stainless Scrap EU) added statistically significantly to predict the Nickel price, $F(4, 21) = 13.3$, $p < 0.001$, $R^2 = 0.95$. Two variables additional variables (JFE and Vale) added statistically significantly to the prediction, $p < 0.05$. Multicollinearity was considered.

Appendix No. 19

VIX vs Nickel 2007-2009 World financial crisis

Content

1 Spearman´s rho Nickel and VIX

Source: Regression 2007 to 2009 World Financial crisis.xlsx

Spearman's rho	Nickel	VIX
Nickel	1.000	- 0.816**
VIX	- 0.816**	1.000
Aluminium	0.775**	- 0.669**
Iron Ore	0.546**	- 0.362*
Stainless 304 scrap Europe	0.952**	- 0.623**
Stainless 304 scrap USA	0.454*	0.042
Ferrochrome	0.257	-0.032
Outokumpu	0.833**	- 0.634**
Acerinox	0.854**	- 0.709**
AK Steel	0.662**	- 0.546**
Posco	0.623**	- 0.541**
Jindal Stainless	0.819**	- 0.645**
Nippon Steel	0.910**	- 0.755**
JFE	0.897**	- 0.772**
Tenneco	0.892**	- 0.702**
Faurecia	0.936**	- 0.790**
Futaba	0.811**	- 0.732**
Sejong	0.482**	- 0.562**
BHP Billiton	0.004	-0.176
Norilsk	0.741**	- 0.571**
Vale	0.485**	- 0.439**

** Significant at 0.001 level / *Significant at 0.05 level

2 egression analysis, linear- VIX- Base metals

Model Summary / Dependent Variable:VIX 2007-2009							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	Sig. F Change	
1	0.85	0.72	0.68	7	0.72	19.97	Nickel, Iron Ore, Copper, Aluminium

Anova/ Dependent Variable:VIX 2007-2009							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	4,213	4	1,053	19.975	0.000	Nickel, Iron Ore, Copper, Aluminium
	Residual	1,635	31	52.7			
	Total	5,848	35				

Coefficients / Dependent Variable VIX 2007-2009						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	59.22	5.92		10.01	0.000
	Iron Ore	0.04	0.05	0.16	0.95	0.350
	Copper	-0.01	0.00	-0.79	-3.67	0.001
	Aluminium	0.01	0.01	0.33	1.35	0.188
	Nickel	0.00	0.00	-0.56	-3.35	0.002

A multiple regression was run to predict VIX of the monthly average price notations of the base materials. These variables statistically significantly predicted VIX, $F(4, 31) = 19.98$, $p < 0.001$, $R^2 = 0.72$. Two variables (Copper and Nickel) added statistically significantly to the prediction, $p < 0.05$.

3 Regression analysis, linear- VIX- Miners

Model Summary / Dependent Variable:VIX 2007-2009							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	Sig. F Change	
1	0.64	0.40	0.35	10	0.40	7.25	Vale, BHP Billiton, Norilsk

Anova/ Dependent Variable:VIX 2007-2009							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	2,365	3	788	7.246	0.001	Vale, BHP Billiton, Norilsk
	Residual	3,482	32	108.8			
	Total	5,848	35				

Coefficients / Dependent Variable VIX 2007-2009						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	51.55	12.97	0.00	3.98	0.000
	BHP Billiton	0.00	0.00	-0.23	-0.69	0.494
	Norilsk	-0.15	0.07	-0.95	-2.14	0.040
	Vale	0.07	0.10	0.49	0.78	0.441

A multiple regression was run to predict VIX of the monthly average share prices of the mining companies. One of the variables (Norilsk) statistically significantly predicted VIX, $F(3, 32) = 7.25$, $p < 0.001$, $R^2 = 0.40$. The other variables (BHP, Vale) did not add statistically significantly to the prediction, $p < 0.05$.

4 Regression analysis, linear- VIX- Stainless producers

Model Summary / Dependent Variable:VIX 2007-2009							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	Sig. F Change	
1	0.87	0.75	0.65	8	0.75	7.01	JFE, Acerinox, Posco, Outokumpu, Nippon Steel, Jindal Stainless, AK Steel

Anova/ Dependent Variable:VIX 2007-2009							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	2,881	7	412	7.007	0.001	JFE, Acerinox, Posco, Outokumpu, Nippon Steel, Jindal Stainless, AK Steel
	Residual	940	16	58.7			
	Total	3,821	23				

Coefficients / Dependent Variable VIX 2007-2009						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	70.29	18.00		3.90	0.001
	Outokumpu	0.04	0.03	0.43	1.33	0.201
	Acerinox	-0.16	0.17	-0.30	-0.96	0.352
	AK Steel	-0.02	0.03	-0.32	-0.60	0.555
	Posco	-0.03	0.02	-0.59	-1.56	0.137
	Jindal	-0.01	0.01	-0.39	-0.99	0.336
	Nippon Steel	0.43	0.71	0.32	0.61	0.550
	JFE	0.00	0.00	0.00	0.00	0.998

A multiple regression was run to predict VIX of the monthly average share prices of the stainless-steel producers. These variables statistically significantly predicted VIX, $F(7, 16) = 7.01$, $p < 0.001$, $R^2 = 0.75$.

BUT <u>None</u> of the variables added statistically significantly to the prediction, $p < 0.05$.

5 Regression analysis, linear- VIX- Exhaust Producer

Model Summary / Dependent Variable:VIX 2007-2009							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	Sig. F Change	
1	0.89	0.79	0.76	6	0.79	29.29	Sejong, Futaba, Tenneco, Faurecia

Anova/ Dependent Variable:VIX 2007-2009							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	4,624	4	1,156	29.294	0.000	Sejong, Futaba, Tenneco, Faurecia
	Residual	1,223	31	39.5			
	Total	5,848	35				

Coefficients / Dependent Variable VIX 2007-2009						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	84.67	7.90		10.72	0.000
	Tenneco	-0.12	0.03	-1.05	-3.94	0.000
	Faurecia	0.09	0.03	1.19	3.20	0.003
	Futaba	0.00	0.00	-0.92	-3.98	0.000
	Sejong	0.00	0.00	-0.19	-1.56	0.130

A multiple regression was run to predict VIX of the monthly average share prices of the Exhaust producers. These variables statistically significantly predicted VIX, $F(4, 31) = 29.29$, $p < 0.001$, $R^2 = 0.79$.

Three of the variables added statistically significantly to the prediction, $p < 0.05$. The share price of Sejong did not.

6 Regression analysis, linear- Nickel- Base metals

Model Summary / Dependent Variable: Nickel 2007-2009							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics: R Square Change	Change Statistics: Sig. F Change	Predictors
1	0.97	0.94	0.93	1,706	0.95	64.58	Ferro-Chrome, Stainless 304 scrap USA, Stainless 304 scrap Europe, Iron Ore

Anova/ Dependent Variable: Nickel 2007-2009							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	939,185,562	5	187,837,112	64.57	0.000	Ferro-Chrome, Stainless 304 scrap USA, Stainless 304 scrap Europe, Iron Ore
	Residual	52,358,933	18	2,908,830			
	Total	991,544,496	23				

Coefficients / Dependent Variable Nickel 2007-2009						
Model		Unstandardized Coefficients: B	Unstandardized Coefficients: Std. Error	Standardized Coefficients: Beta	t	Sig.
1	(Constant)	-2,885	3,766		-0.77	0.453
	Aluminium	3.3	2.4	0.30	1.34	0.197
	Iron Ore	25.8	27.9	0.21	0.93	0.367
	Stainless 304 scrap Europe	11,685	2,172	0.82	5.38	0.000
	Stainless 304 scrap USA	2,228	1,496	0.13	1.49	0.154
	Ferro-Chrome	-1.9	0.6	-0.50	-3.05	0.007

A multiple regression was run to predict Nickel of the monthly average prices of the base metal. These variables partly statistically significantly predicted Nickel, $F(5, 18) = 64.57$, $p < 0.001$, $R^2 = 0.94$. Two of the variables (Ferrochrome and Scrap EU) added statistically significantly to the prediction, $p < 0.05$. The others did not.

6.1 Nickel calculated with Regression analysis

Deviation	Nickel Month average	Date	Nickel calculated	Average Month value multiplied with unstandardized coefficient				
-12%	27,690	Jan 08	31,134	7,959	4,983	21,617	5,437	-8,862
-9%	27,955	Feb 08	30,339	9,036	4,802	21,033	5,593	-10,125
-3%	31,225	Mar 08	32,280	9,778	5,086	22,786	6,440	-11,809
-6%	28,763	Apr 08	30,431	9,629	5,060	21,033	6,729	-12,020
-9%	18,525	Oct 09	20,110	6,114	2,246	11,685	3,855	-3,790
Unstandardized Coefficients		(Constant)		Aluminium	Iron Ore	Stainless 304 scrap Europe	Stainless 304 scrap USA	Ferro-chrome
		B	-2,885	3.3	25.8	11,685	2,228	-1.9
		Std. Error	3,766	2.4	27.9	2,172	1,496	0.6
		Sig.	0.453	0.197	0.367	0.000	0.154	0.007

Source Annex 4 and 6, “Korrel complete data 1960”

7 Regression analysis, linear- Nickel- Miners

Model Summary / Dependent Variable: Nickel 2007-2009							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	Sig. F Change	
1	0.81	0.65	0.62	7,287	0.65	19.91	Vale , BHP Billiton, Norilsk

Anova/ Dependent Variable: Nickel 2007-2009							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	3,172,480,664	3	1,057,493,555	19.914	0.000	Vale , BHP Billiton, Norilsk
	Residual	1,699,295,386	32	53,102,981			
	Total	4,871,776,050	35				

Coefficients / Dependent Variable Nickel 2007-2009						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	29,931	9,058		3.30	0.002
	BHP Billiton	-1.3	1.2	-0.29	-1.12	0.272
	Norilsk	181.8	49.1	1.26	3.70	0.001
	Vale	-81.5	67.0	-0.59	-1.22	0.232

A multiple regression was run to predict Nickel of the monthly average share prices of the mining companies. These variables partly statistically significantly predicted Nickel, $F(3, 32) = 19.91$, $p < 0.001$, $R^2 = 0.65$.

One of the variables (Norilsk share price) added statistically significantly to the prediction, $p < 0.05$. The others did not.

8 Regression analysis, linear- Nickel- Stainless Mills

Model Summary / Dependent Variable: Nickel 2007-2009							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	Sig. F Change	
1	0.95	0.91	0.86	2,426	0.91	21.78	JFE, Acerinox, Posco, Outokumpu, Nippon Steel, Jindal Stainless, AK Steel

Anova/ Dependent Variable: Nickel 2007-2009							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	897,387,956	7	128,198,279	21.785	0.000	JFE, Acerinox, Posco, Outokumpu, Nippon Steel, Jindal Stainless, AK Steel
	Residual	94,156,539	16	5,884,784			
	Total	991,544,496	23				

Coefficients / Dependent Variable Nickel 2007-2009						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	626	5,699		0.11	0.914
	Outokumpu	19.85	8.42	0.48	2.36	0.032
	Acerinox	52.37	54.21	0.19	0.97	0.348
	AK Steel	14.08	9.80	0.48	1.44	0.170
	Posco	2.95	5.56	0.12	0.53	0.603
	Jindal	-0.16	3.95	-0.01	-0.04	0.968
	Nippon Steel	40.04	224	0.06	0.18	0.860
	JFE	-1.36	1.48	-0.25	-0.92	0.372

A multiple regression was run to predict Nickel of the monthly average share prices of the stainless-steel producers. These variables partly statistically significantly predicted Nickel, $F(7, 16) = 21.79$, $p < 0.001$, $R^2 = 0.91$.

One of the variables (Outokumpu) added statistically significantly to the prediction, $p < 0.05$. The others did not.

9 Regression analysis, linear- Nickel- Exhaust producer

Model Summary / Dependent Variable: Nickel 2007-2009							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	Sig. F Change	
1	0.92	0.85	0.83	4,847	0.85	44.10	Sejong, Futaba, Tenneco, Faurecia

Anova/ Dependent Variable: Nickel 2007-2009							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	4,143,544,812	4	1,035,886,203	44.097	0.000	Sejong, Futaba, Tenneco, Faurecia
	Residual	728,231,238	31	23,491,330			
	Total	4,871,776,050	35				

Coefficients / Dependent Variable Nickel 2007-2009						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	84.67	7.90		10.72	0.000
	Tenneco	-0.12	0.03	-1.05	-3.94	0.000
	Faurecia	0.09	0.03	1.19	3.20	0.003
	Futaba	0.00	0.00	-0.92	-3.98	0.000
	Sejong	0.00	0.00	-0.19	-1.56	0.130

A multiple regression was run to predict VIX of the monthly average share prices of the Exhaust producers. These variables statistically significantly predicted VIX, $F(4, 31) = 29.29$, $p < 0.001$,

$R^2 = 0.79$.

Three of the variables added statistically significantly to the prediction, $p < 0.05$. The share price of Sejong did not.

10 Influence of Nickel 2007-2009

10.1 Mining companies

Model Summary / Dependent Variable: BHP 2007-2009					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.89	0.79	0.77	1,263	Copper, Nickel, Iron Ore, Aluminium

Anova/ Dependent Variable: BHP 2007-2009							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	190,126,229	4	47,531,557	29.80	0.000	Copper, Nickel, Iron Ore, Aluminium
	Residual	49,446,534	31	1,595,049			
	Total	239,572,763	35				

Coefficients / Dependent Variable BHP 2007-2009						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	9,959	1,029		9.67	**0.000**
	Nickel	-0.1	0.0	-0.44	-3.03	**0.005**
	Iron Ore	9.4	7.8	0.18	1.20	0.239
	Aluminium	-4	1	-0.84	-4.02	**0.000**
	Copper	2.2	0.3	1.39	7.51	**0.000**

Model Summary / Dependent Variable: Norilsk 2007-2009					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.95	0.91	0.90	26	Copper, Nickel, Iron Ore, Aluminium

Anova/ Dependent Variable: Norilsk 2007-2009							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	212,782	4	53,196	76.65	0.000	Copper, Nickel, Iron Ore, Aluminium
	Residual	21,514	31	694			
	Total	234,296	35				

Coefficients / Dependent Variable Norilsk 2007-2009						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-53	21		-2.49	**0.019**
	Nickel	0.0	0.0	0.40	4.22	**0.000**
	Iron Ore	1.1	0.2	0.65	6.52	**0.000**
	Aluminium	0	0	-0.15	-1.11	0.274
	Copper	0.0	0.0	0.27	2.19	**0.036**

Model Summary / Dependent Variable: Vale 2007-2009					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.95	0.89	0.88	29	Copper, Nickel, Iron Ore, Aluminium

Anova/ Dependent Variable: Vale 2007-2009							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	225,044	4	56,261	64.71	0.000	Copper, Nickel, Iron Ore, Aluminium
	Residual	26,952	31	869			
	Total	251,996	35				

Coefficients / Dependent Variable Vale 2007-2009						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	37	24		1.54	0.134
	Nickel	0.0	0.0	0.09	0.87	0.392
	Iron Ore	1.1	0.2	0.66	6.21	**0.000**
	Aluminium	0	0	-0.55	-3.65	**0.001**
	Copper	0.0	0.0	0.74	5.58	**0.000**

10.2 Vix / Scrap EU and USA

Model Summary / Dependent Variable: VIX 2007-2009					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.85	0.72	0.68	7	Copper, Nickel, Iron Ore, Aluminium

Anova/ Dependent Variable: VIX 2007-2009							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	4,213	4	1,053	19.97	0.000	Copper, Nickel, Iron Ore, Aluminium
	Residual	1,635	31	53			
	Total	5,848	35				

Coefficients / Dependent Variable VIX 2007-2009						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	59	6		10.01	**0.000**
	Nickel	0.0	0.0	-0.56	-3.35	**0.002**
	Iron Ore	0.0	0.0	0.16	0.95	0.350
	Aluminium	0	0	0.33	1.35	0.188
	Copper	0.0	0.0	-0.79	-3.67	**0.001**

Model Summary / Dependent Variable: Stainless Scrap EU 304 2007-2009					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.97	0.94	0.93	0.12	Copper, Nickel, Iron Ore, Aluminium

Anova/ Dependent Variable: Stainless Scrap EU 304 2007-2009							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	5	4	1	77.52	0.000	Copper, Nickel, Iron Ore, Aluminium
	Residual	0	19	0			
	Total	5	23				

Coefficients / Dependent Variable Stainless Scrap EU 304 2007-2009						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0	0		-1.04	0.311
	Nickel	0.0	0.0	0.66	4.09	**0.001**
	Iron Ore	0.0	0.0	0.25	1.09	0.288
	Aluminium	0	0	0.11	0.45	0.657
	Copper	0.0	0.0	-0.03	-0.15	0.879

Model Summary / Dependent Variable: Stainless Scrap USA 304 2007-2009					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.84	0.70	0.64	0	Copper, Nickel, Iron Ore, Aluminium

Anova/ Dependent Variable: Stainless Scrap USA 304 2007-2009							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	2	4	1	11.06	0.000	Copper, Nickel, Iron Ore, Aluminium
	Residual	1	19	0			
	Total	3	23				

Coefficients / Dependent Variable Stainless Scrap USA 304 2007-2009						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2	0		5.71	**0.000**
	Nickel	0.0	0.0	1.12	3.04	**0.007**
	Iron Ore	0.0	0.0	0.29	0.54	0.596
	Aluminium	0	0	0.74	1.32	0.202
	Copper	0.0	0.0	-1.49	-3.42	**0.003**

10.3 Stainless-steel producers

Model Summary / Dependent Variable: Outokumpu 2007-2009					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.88	0.77	0.74	86,18	Copper, Nickel, Iron Ore, Aluminium

Anova/ Dependent Variable: Outokumpu 2007-2009							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	750,541	4	187,635	25.26	0.000	Copper, Nickel, Iron Ore, Aluminium
	Residual	230,229	31	7,427			
	Total	980,770	35				

Coefficients / Dependent Variable Outokumpu 2007-2009						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	86	70		1.22	0.232
	Nickel	0.0	0.0	0.88	5.71	**0.000**
	Iron Ore	1.3	0.5	0.40	2.50	**0.018**
	Aluminium	0	0	-0.13	-0.60	0.551
	Copper	0.0	0.0	-0.08	-0.39	0.696

Model Summary / Dependent Variable: Acerinox 2007-2009					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.83	0.69	0.65	19.22	Copper, Nickel, Iron Ore, Aluminium

Anova/ Dependent Variable: Acerinox 2007-2009							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	25,190	4	6,298	17.05	0.000	Copper, Nickel, Iron Ore, Aluminium
	Residual	11,451	31	369			
	Total	36,641	35				

Coefficients / Dependent Variable Acerinox 2007-2009						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	97	16		6.22	**0.000**
	Nickel	0.0	0.0	0.87	4.91	**0.000**
	Iron Ore	0.0	0.1	-0.02	-0.10	0.922
	Aluminium	0	0	-0.45	-1.75	0.089
	Copper	0.0	0.0	0.44	1.95	0.060

Model Summary / Dependent Variable: AK Steel 2007-2009					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.96	0.92	0.91	58	Copper, Nickel, Iron Ore, Aluminium

Anova/ Dependent Variable: AK Steel 2007-2009							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	1,175,626	4	293,906	86.08	0.000	Copper, Nickel, Iron Ore, Aluminium
	Residual	105,845	31	3,414			
	Total	1,281,470	35				

Coefficients / Dependent Variable AK Steel 2007-2009						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-297	48		-6.24	**0.000**
	Nickel	0.0	0.0	-0.07	-0.75	0.461
	Iron Ore	2.2	0.4	0.56	5.93	**0.000**
	Aluminium	0	0	0.20	1.50	0.144
	Copper	0.0	0.0	0.32	2.70	**0.011**

Model Summary / Dependent Variable: Posco 2007-2009					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.88	0.77	0.74	171	Copper, Nickel, Iron Ore, Aluminium

Anova/ Dependent Variable: Posco 2007-2009							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	2,941,069	4	735,267	25.27	0.000	Copper, Nickel, Iron Ore, Aluminium
	Residual	902,030	31	29,098			
	Total	3,843,099	35				

Coefficients / Dependent Variable Posco 2007-2009						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	391	139		2.81	**0.009**
	Nickel	0.0	0.0	0.40	2.64	**0.013**
	Iron Ore	3.3	1.1	0.50	3.13	**0.004**
	Aluminium	0	0	-0.77	-3.45	**0.002**
	Copper	0.2	0.0	0.84	4.28	**0.000**

Model Summary / Dependent Variable: Jindal Stainless 2007-2009					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.88	0.78	0.75	259	Copper, Nickel, Iron Ore, Aluminium

Anova/ Dependent Variable: Jindal Stainless 2007-2009							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	7,181,251	4	1,795,313	26.77	0.000	Copper, Nickel, Iron Ore, Aluminium
	Residual	2,079,200	31	67,071			
	Total	9,260,451	35				

Coefficients / Dependent Variable Jindal Stainless 2007-2009						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	264	211		1.25	0.221
	Nickel	0.0	0.0	0.86	5.71	**0.000**
	Iron Ore	5.5	1.6	0.53	3.45	**0.002**
	Aluminium	-1	0	-0.78	-3.58	**0.001**
	Copper	0.1	0.1	0.48	2.50	**0.018**

Model Summary / Dependent Variable: Nippon Steel 2007-2009					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.94	0.87	0.85	4	Copper, Nickel, Iron Ore, Aluminium

Anova/ Dependent Variable: Nippon Steel 2007-2009							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	1,795	4	449	32.84	0.000	Copper, Nickel, Iron Ore, Aluminium
	Residual	260	19	14			
	Total	2,055	23				

Coefficients / Dependent Variable Nippon Steel 2007-2009						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	16	4		3.83	**0.001**
	Nickel	0.0	0.0	0.15	0.64	0.531
	Iron Ore	0.1	0.1	0.75	2.17	**0.043**
	Aluminium	0	0	-0.25	-0.69	0.500
	Copper	0.0	0.0	0.31	1.09	0.290

Model Summary / Dependent Variable: JFE 2007-2009					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.90	0.81	0.79	901	Copper, Nickel, Iron Ore, Aluminium

Anova/ Dependent Variable: JFE 2007-2009							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	110,234,197	4	27,558,549	33.93	0.000	Copper, Nickel, Iron Ore, Aluminium
	Residual	25,179,622	31	812,246			
	Total	135,413,819	35				

Coefficients / Dependent Variable JFE 2007-2009						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	138	735		0.19	0.852
	Nickel	0.1	0.0	0.77	5.62	**0.000**
	Iron Ore	-3.3	5.6	-0.08	-0.58	0.565
	Aluminium	0	1	0.03	0.17	0.864
	Copper	0.2	0.2	0.20	1.16	0.255

10.4 Exhaust gas treatment system producer

Model Summary / Dependent Variable: Tenneco 2007-2009					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.94	0.88	0.86	40	Copper, Nickel, Iron Ore, Aluminium

Anova/ Dependent Variable: Tenneco 2007-2009							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	359,693	4	89,923	55.57	0.000	Copper, Nickel, Iron Ore, Aluminium
	Residual	50,164	31	1,618			
	Total	409,856	35				

Coefficients / Dependent Variable Tenneco 2007-2009						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-70	33		-2.12	**0.042**
	Nickel	0.0	0.0	0.83	7.51	**0.000**
	Iron Ore	0.5	0.2	0.23	1.98	0.057
	Aluminium	0	0	-0.44	-2.75	**0.010**
	Copper	0.0	0.0	0.49	3.43	**0.002**

Model Summary / Dependent Variable: Faurecia 2007-2009					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.92	0.85	0.83	73	Copper, Nickel, Iron Ore, Aluminium

Anova/ Dependent Variable: Faurecia 2007-2009							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	912,771	4	228,193	42.55	0.000	Copper, Nickel, Iron Ore, Aluminium
	Residual	166,251	31	5,363			
	Total	1,079,023	35				

Coefficients / Dependent Variable Faurecia 2007-2009						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-80	60		-1.35	0.188
	Nickel	0.0	0.0	0.92	7.41	**0.000**
	Iron Ore	0.3	0.5	0.08	0.64	0.526
	Aluminium	0	0	-0.06	-0.31	0.761
	Copper	0.0	0.0	0.03	0.17	0.863

Model Summary / Dependent Variable: Futaba 2007-2009					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.86	0.74	0.70	2,682	Copper, Nickel, Iron Ore, Aluminium

Anova/ Dependent Variable: Futaba 2007-2009							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	624,616,999	4	156,154,250	21.71	0.000	Copper, Nickel, Iron Ore, Aluminium
	Residual	223,014,390	31	7,194,013			
	Total	847,631,389	35				

Coefficients / Dependent Variable Futaba 2007-2009						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	11,400	2,186		5.21	**0.000**
	Nickel	0.4	0.1	0.86	5.30	**0.000**
	Iron Ore	-13.3	16.7	-0.13	-0.80	0.430
	Aluminium	0	2	0.05	0.21	0.837
	Copper	-0.1	0.6	-0.02	-0.10	0.923

Model Summary / Dependent Variable: Sejong 2007-2009					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	0.83	0.69	0.64	6,590	Copper, Nickel, Iron Ore, Aluminium

Anova/ Dependent Variable: Sejong 2007-2009							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	2,931,888,098	4	732,972,024	16.88	0.000	Copper, Nickel, Iron Ore, Aluminium
	Residual	1,346,447,666	31	43,433,796			
	Total	4,278,335,764	35				

Coefficients / Dependent Variable Sejong 2007-2009						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	35,844	5,371		6.67	**0.000**
	Nickel	0.4	0.2	0.46	2.60	**0.014**
	Iron Ore	-114.7	40.9	-0.51	-2.80	**0.009**
	Aluminium	-18	5	-0.93	-3.61	**0.001**
	Copper	9.6	1.5	1.45	6.33	**0.000**

11 GARCH Volatility

11.1 Miners

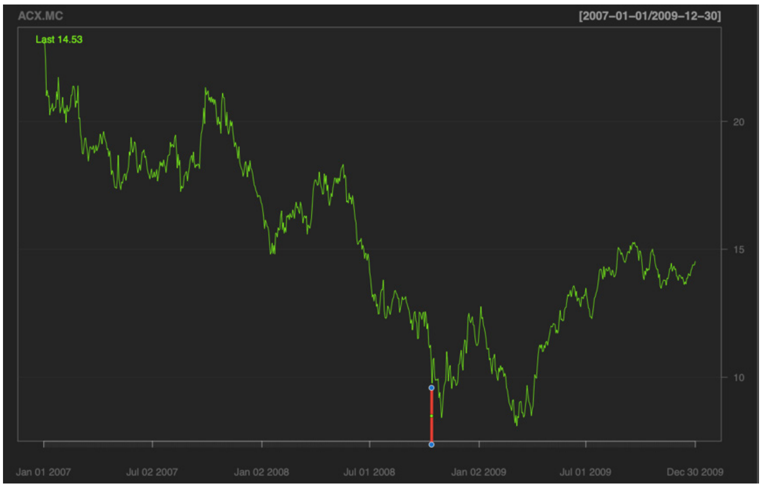
BHP Billiton

Norilsk

Vale

11.2 Stainless Producers

Acerinox

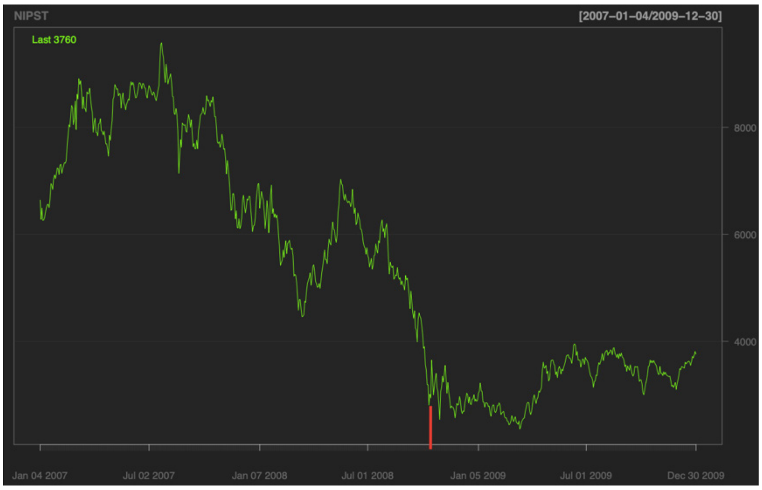


AK Steel

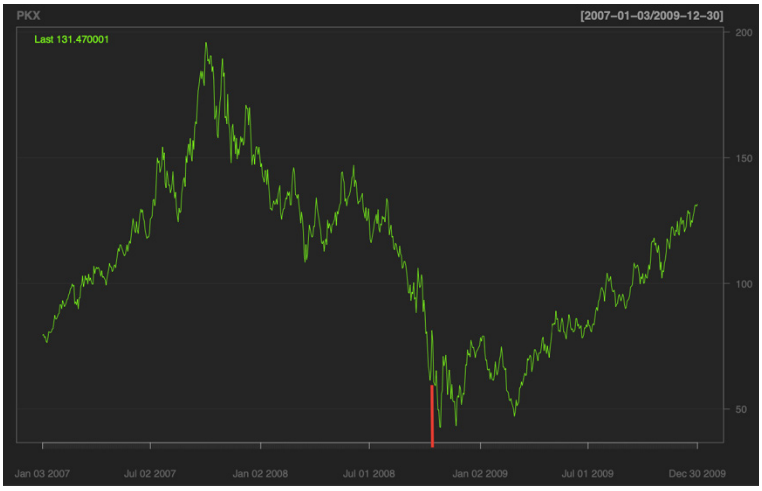
JFE

Outokumpu

Nippon Steel

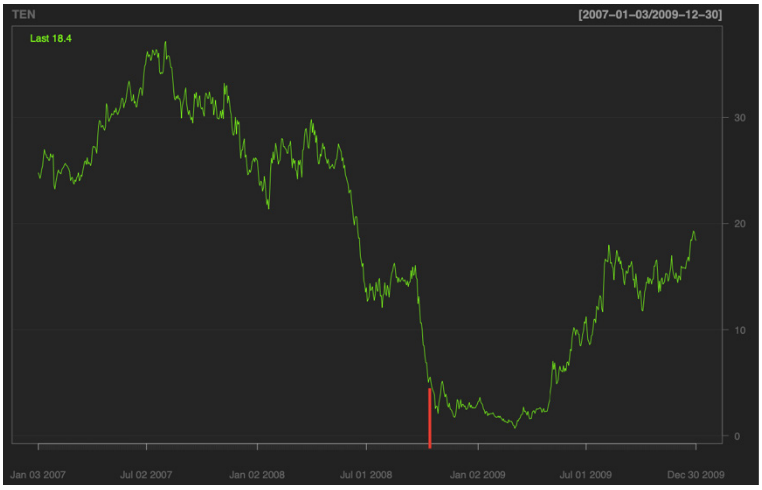


Posco

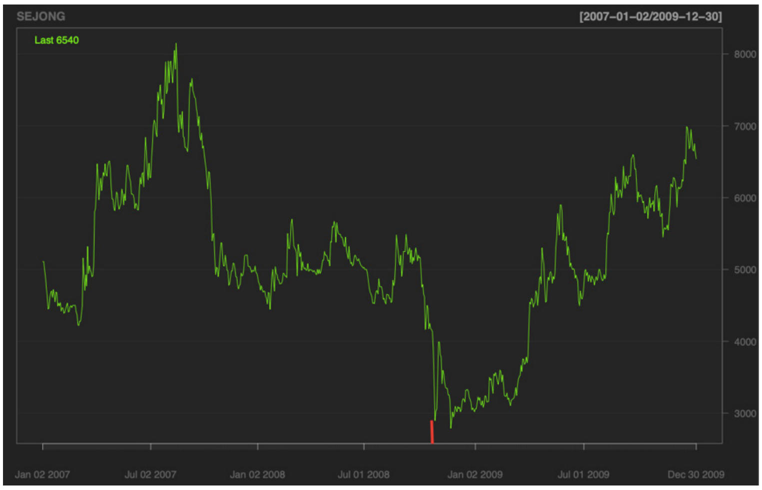


11.3 Exhaust Manufacturers

Tenneco

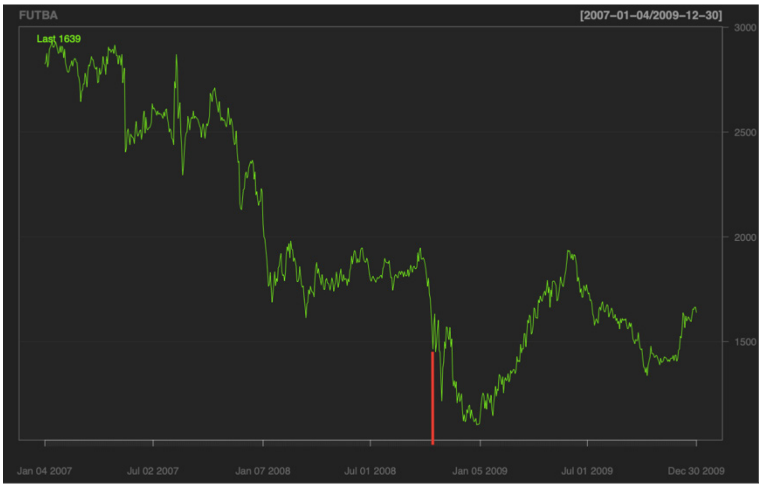


Sejong



Faurecia

Futaba


FUTBA
[2007–01–04/2009–12–30]
Last 1639
3000
2500
2000
1500
Jan 04 2007
Jul 02 2007
Jan 07 2008
Jul 01 2008
Jan 05 2009
Jul 01 2009
Dec 30 2009

Appendix No. 20

Calculations to answer research question 1.3b

Content

1 Descriptive Statistics

Source: 11. SPSS 2 annual reports profit and commodities 20201122

Descriptive Statistics Annual reports 2007 to 2018

Value	N	Minimum	Maximum	Mean	Std. Deviation	CV
OTK tonnage	13	1030	2797	2068	628	0.30
ACX tonnage	13	1806	2475	2202	200	0.09
Aperam tonnage	13	1447	2000	1813	149	0.08
OTK turnover	13	2641	6913	5705	1292	0.23
ACX turnover	13	2993	6901	4585	879	0.19
Aperam turnover	13	4077	9349	5578	1592	0.29
OTK staff	13	1161	16649	9884	3488	0.35
ACX staff	13	6506	7510	7013	386	0.06
Aperam staff	13	9400	13086	10185	1136	0.11
OTK net profit	13	-1003	392	-194	373	-1.92
ACX net profit	13	-229	312	73	143	1.96
Aperam net profit	13	-150	286	77	116	1.51
Nickel average	12	9595	37230	17681	7556	0.43
Chrome average	12	1858	4841	2574	785	0.31
Iron Ore average	12	56	168	107	40	0.37
Scrap 304 EU average	11	0.80	1.43	1.13	0.21	0.19
Scrap 304 USA average	11	1.02	2.33	1.60	0.43	0.27

2 Correlation Spearman's rho

Source: 11. SPSS 2 annual reports profit and commodities 20201122

Correlation analysis Annual reports 2007 to 2018

Value	OTK Net Profit	Acerinox Net Profit	Aperam Net Profit
OTK tonnage	0.052	0.107	0.149
ACX tonnage	,691**	0.404	,655*
Aperam tonnage	0.522	0.549	,659*
OTK turnover	0.077	,566*	0.484
ACX turnover	0.033	0.368	0.434
Aperam turnover	-0.423	0.379	-0.088
OTK staff	0.060	-0.077	0.126
ACX staff	-,630*	0.036	-0.292
Aperam staff	-0.380	0.017	-0.263
OTK net profit	1.000	0.308	,626*
ACX net profit	0.308	1.000	0.516
Aperam net profit	,626*	0.516	1.000
Nickel average	-,608*	0.028	-0.252
Chrome average	0.028	0.329	0.434
Iron Ore average	-,587*	-0.245	-0.273
Scrap 304 EU average	-0.245	0.082	0.064
Scrap 304 USA average	-0.555	-0.382	-0.255

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

2.1 Spearman's Rho in regard to Profit , illustrated

Spearman´s Rho / Net profit	Outokumpu	Acerinox	Aperam
Nickel average	-0.61	0.03	-0.3
Ferrochrome average	0.03	0.33	0.4
Iron Ore average	-0.59	-0.24	-0.3
Scrap 304 EU average	-0.25	0.08	0.1
Scrap 304 USA average	-0.55	-0.38	-0.3
Tonnage	0.05	0.40	0.66
Turnover	0.08	0.37	-0.09
Staff	0.06	0.04	-0.26
Profit	1.00	1.00	1.00

3 Regression analysis linear: Outokumpu Net Profit

Model Summary / Dependent Variable: Outokumpu Profit 2007-2019							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	Sig. F Change	
1	0.83	0.68	0.47	0	0.68	3.19	Scrap 304 EU average, OTK turnover, Chrome average, Iron Ore average

Anova/ Dependent Variable: Outokumpu Profit 2007-2019							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	970,978	4	242,745	3.191	0.099	Scrap 304 EU average, OTK turnover, Chrome average, Iron Ore average
	Residual	456,459	6	76,076			
	Total	1,427,437	10				

Coefficients / Dependent Variable: Outokumpu Profit 2007-2019								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-644.81	637.49		-1.01	0.351	Average	2.590
	OTK turnover	-0.04	0.07	-0.15	-0.61	0.566	0.84	1.187
	Chrome average	0.16	0.14	0.34	1.16	0.289	0.61	1.637
	Iron Ore average	-13.55	4.05	-1.49	-3.34	**0.016**	0.27	3.732
	Scrap 304 EU average	1551.16	800.50	0.87	1.94	0.101	0.26	3.804

A multiple regression was run to predict the Net Profit based on the annual report data and the average annual price notations of the base materials. These variables partly statistically significantly predicted Outokumpu Profit , $F(4, 10) = 3.191$, $p < 0.001$, $R^2 = 0.68$.

The variables “Iron ore” added statistically significantly to the prediction, $p < 0.05$. The others did not.

Multicollinearity might bias the calculation.

4 Regression analysis linear: Acerinox Net Profit

Model Summary / Dependent Variable: Acerinox Profit 2007-2019							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	Sig. F Change	
1	0.60	0.36	0.12	134	0.36	1.49	Iron Ore average, Chrome average, ACX tonnage

Anova/ Dependent Variable: Acerinox Profit 2007-2019							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	80,817	3	26,939	1.494	0.288	Iron Ore average, Chrome average, ACX tonnage
	Residual	144,226	8	18,028			
	Total	225,043	11				

Coefficients / Dependent Variable: Acerinox Profit 2007-2019								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-1148.89	614.35		-1.87	0.098	Average	1.679
	ACX tonnage	0.49	0.24	0.72	2.04	0.076	0.64	1.562
	Chrome average	0.01	0.06	0.05	0.16	0.874	0.71	1.411
	Iron Ore average	1.14	1.46	0.32	0.78	0.457	0.48	2.065

A multiple regression was run to predict the Net Profit based on the annual report data and the average annual price notations of the base materials. These variables partly statistically significantly predicted Acerinox Profit , $F(3, 11) = 1.494$, $p < 0.001$, $R^2 = 0.36$.

None of the variables added statistically significantly to the prediction, $p < 0.05$. Multicollinearity might bias the calculation in addition.

5 Regression analysis linear: Aperam Net Profit

Model Summary / Dependent Variable: Aperam Profit 2007-2019							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	Sig. F Change	
1	0.84	0.71	0.60	75	0.71	6.58	Aperam staff, Aperam tonnage, Chrome average

Anova/ Dependent Variable: Aperam Profit 2007-2019							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	110,978	3	36,993	6.582	0.015	Aperam staff, Aperam tonnage, Chrome average
	Residual	44,963	8	5,620			
	Total	155,941	11				

Coefficients / Dependent Variable: Aperam Profit 2007-2019								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-798.22	328.49		-2.43	**0.041**	Average	1.527
	Chrome average	0.01	0.04	0.06	0.23	0.821	0.56	1.785
	Aperam tonnage	0.66	0.17	0.86	3.95	**0.004**	0.76	1.311
	Aperam staff	-0.03	0.02	-0.33	-1.43	0.191	0.67	1.486

A multiple regression was run to predict the Net Profit based on the annual report data and the average annual price notations of the base materials. These variables partly statistically significantly predicted Acerinox Profit , $F(3, 11) = 6.582$, $p < 0.001$, $R^2 = 0.71$.

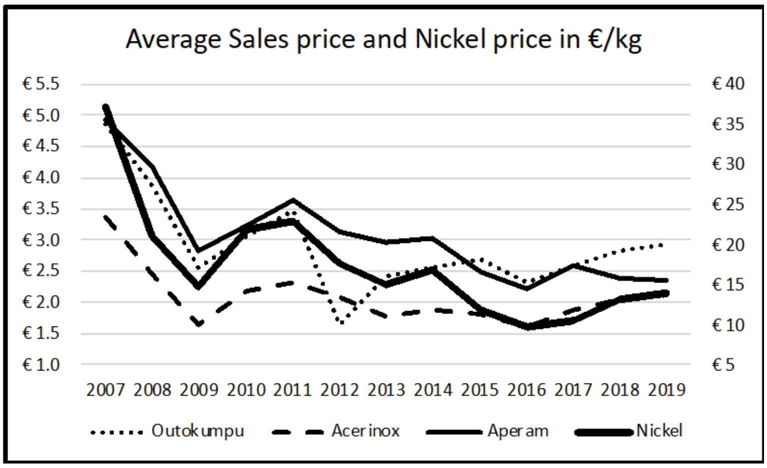
The variable “Aperam tonnage” added statistically significantly to the prediction, $p < 0.05$. The others did not.

Multicollinearity might have been treated by excluding variables that might have the same “trend” as the other variables. The values are above one and hence not a concern.

6 Average Sales price 2007 to 2019

Source 11. SPSS 2 annual reports profit and commodities20201122.xlsx

Average Nickel & Sales price per annum in €/kg				
Year	Nickel	Outokumpu	Acerinox	Aperam
2007	37.23 €	4.86 €	3.38 €	4.92 €
2008	21.11 €	3.89 €	2.47 €	4.17 €
2009	14.65 €	2.56 €	1.66 €	2.82 €
2010	21.81 €	3.06 €	2.18 €	3.22 €
2011	22.91 €	3.46 €	2.31 €	3.63 €
2012	17.55 €	1.63 €	2.08 €	3.13 €
2013	15.03 €	2.41 €	1.78 €	2.96 €
2014	16.89 €	2.55 €	1.88 €	3.02 €
2015	11.86 €	2.68 €	1.82 €	2.50 €
2016	9.60 €	2.33 €	1.60 €	2.22 €
2017	10.41 €	2.60 €	1.89 €	2.60 €
2018	13.11 €	2.83 €	2.05 €	2.39 €
2019	13.91 €	2.92 €	2.13 €	2.35 €



6.1 Index of Change

Average Nickel & Sales price per annum in €/kg / Index of change				
Year	Nickel	Outokumpu	Acerinox	Aperam
2007	100%	100%	100%	100%
2008	57%	80%	73%	85%
2009	39%	53%	49%	57%
2010	59%	63%	65%	65%
2011	62%	71%	68%	74%
2012	47%	33%	62%	64%
2013	40%	50%	53%	60%
2014	45%	52%	56%	61%
2015	32%	55%	54%	51%
2016	26%	48%	47%	45%
2017	28%	54%	56%	53%
2018	35%	58%	61%	48%
2019	37%	60%	63%	48%

7 Regression analysis linear – multicollinearity not corrected-

Source: Excel Annexes PMD Report, data – 11. SPSS 2 annual reports profit and commodities 20201122. xlsx

Model Summary / Dependent Variable: Outokumpu Profit 2007-2019							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics R Square Change	Change Statistics Sig. F Change	Predictors
1	,982	0.96	0.82	161	0.96	6.67	Scrap 304 USA average, OTK staff, Chrome average, OTK turnover, Scrap 304 EU average, Iron Ore average, OTK tonnage, Nickel average

Anova/ Dependent Variable: Outokumpu Profit 2007-2019							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	1,375,903	8	171,988	6.675	,137	Scrap 304 USA average, OTK staff, Chrome average, OTK turnover, Scrap 304 EU average, Iron Ore average, OTK tonnage, Nickel average
	Residual	51,534	2	25,767			
	Total	1,427,437	10				

Coefficients / Dependent Variable: Outokumpu Profit 2007-2019								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-1963.32	1296.54		-1.51	0.269	Average	101.532
	OTK tonnage	-2.45	0.91	-4.24	-2.69	0.115	0.01	**137.837**
	OTK turnover	0.78	0.27	2.74	2.83	0.106	0.02	**51.983**
	OTK staff	0.25	0.12	2.50	2.07	0.174	0.01	**80.981**
	Nickel average	-0.41	0.16	-4.99	-2.51	0.129	0.00	**219.288**
	Chrome average	-1.11	0.45	-2.42	-2.45	0.134	0.02	**54.391**
	Iron Ore average	-13.21	3.49	-1.45	-3.78	0.063	0.12	8.180
	Scrap 304 EU average	3514.48	1132.36	1.98	3.10	0.090	0.04	**22.476**
	Scrap 304 USA average	4368.93	1808.77	5.00	2.42	0.137	0.00	**237.118**

Model Summary / Dependent Variable: Acerinox Profit 2007-2019							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	Sig. F Change	
1	,936	0.88	0.38	102	0.88	1.77	Scrap 304 USA average, ACX turnover, Iron Ore average, Chrome average, ACX staff, ACX tonnage, Scrap 304 EU average, Nickel average

Anova/ Dependent Variable: Acerinox Profit 2007-2019							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	147,350	8	18,419	1.769	,411	Scrap 304 USA average, ACX turnover, Iron Ore average, Chrome average, ACX staff, ACX tonnage, Scrap 304 EU average, Nickel average
	Residual	20,829	2	10,414			
	Total	168,178	10				

Coefficients / Dependent Variable: Acerinox Profit 2007-2019								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	-2914.63	4959.12		-0.59	0.616	Average	64.047
	ACX tonnage	0.33	0.79	0.55	0.42	0.713	0.04	**26.980**
	ACX turnover	0.38	0.37	1.68	1.03	0.411	0.02	**42.853**
	ACX staff	0.23	0.68	0.64	0.33	0.773	0.02	**61.721**
	Nickel average	0.03	0.08	0.89	0.30	0.795	0.01	**144.773**
	Chrome average	-0.11	0.16	-0.70	-0.68	0.566	0.06	**17.249**
	Iron Ore average	0.13	3.94	0.04	0.03	0.977	0.04	**25.800**
	Scrap 304 EU average	-838.88	1115.43	-1.37	-0.75	0.530	0.02	**53.960**
	Scrap 304 USA average	-102.96	880.56	-0.34	-0.12	0.918	0.01	**139.044**

Model Summary / Dependent Variable: Aperam Profit 2007-2019							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		Predictors
					R Square Change	Sig. F Change	
1	,993	0.99	0.93	34	0.99	17.11	Scrap 304 USA average, Aperam tonnage, Scrap 304 EU average, Aperam staff, Iron Ore average, Chrome average, Aperam turnover, Nickel average

Anova/ Dependent Variable: Aperam Profit 2007-2019							
Model		Sum of Squares	df	Mean Square	F	Sig.	Predictors
1	Regression	153,669	8	19,209	17.112	,056	Scrap 304 USA average, Aperam tonnage, Scrap 304 EU average, Aperam staff, Iron Ore average, Chrome average, Aperam turnover, Nickel average
	Residual	2,245	2	1,123			
	Total	155,914	10				

Coefficients / Dependent Variable: Aperam Profit 2007-2019								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	36.52	591.78		0.06	0.956	Average	27.725
	Aperam tonnage	1.02	0.29	1.32	3.51	0.073	0.05	**19.589**
	Aperam turnover	-0.10	0.04	-0.94	-2.43	0.135	0.05	**20.696**
	Aperam staff	-0.21	0.04	-1.36	-5.05	0.037	0.10	**10.074**
	Nickel average	-0.02	0.02	-0.81	-1.36	0.308	0.02	**49.926**
	Chrome average	0.15	0.07	1.01	2.21	0.158	0.03	**28.872**
	Iron Ore average	1.19	0.95	0.40	1.26	0.336	0.07	**13.903**
	Scrap 304 EU average	0.72	147.16	0.00	0.00	0.997	0.11	8.714
	Scrap 304 USA average	433.95	205.15	1.50	2.12	0.169	0.01	**70.021**

Appendix No. 21

Training list

Course ID	Date	Title
A1	Nov 2017	Research/ Experimental design planning
A2	Nov 2017	Literature search
A6	Nov 2017	Managing your research data
A7	Nov 2017	Writing like a researcher
B3	Nov 2017	What to do when your supervisor corrects your work
B4	Nov 2017	Writing retreat /Pomodoro Technique
C1	Nov 2017	Strategies to manage your literature
D2	Nov 2017	Your thesis Structure
D3	Nov 2017	Your thesis , The thesis of your thesis
D4	Nov 2017	Formatting and submitting your thesis
WU Dresden	Sep 2017	Research Methods of the Social Sciences - Practical aspects of scientific work
	Oct 2018	Researcher Development Day / Strategies to develop your thesis
	Oct 2018	Researcher Development Day - Strategies for managing your literature and reading effectively
	Oct 2018	Researcher Development Day - The literature review, your critical voice and writing for research
	Oct 2018	Researcher Development Day - You have your data – what to do with it?
	Oct 2018	Researcher Development Day - Publishing whilst doing your PhD
	Oct 2018	Researcher Development Day - Insider insights - Tailoring your writing for publication
	Oct 2018	Researcher Development Day - Managing your research data – strategies and tools
WU Dresden	Oct 2018	Research Methods of the Social Sciences - Practical aspects of scientific work
	Dec 2019	Libary and IT
	Dec 2019	Personal meeting with Christos
	Oct 2019	Methodology with C Papanagnou
	Nov 2020	Formatting your dissertation or thesis - PART 1 of 2
	Nov 2020	Formatting your dissertation or thesis - PART 2 of 2