A BRIEF HISTORY OF THE CONCEPT OF WASTE IN PRODUCTION

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ABSTRACT

Purpose: The concept of waste has been used in relation to production since the beginning of the 20th century. As it is well-known, it is a foundational notion for the Toyota Production System and its derivatives, like lean production. However, waste is not a prevalent concept in the mainstream literature on economics, operations management, construction management or management. The reasons for this apparent aversion to the concept of waste are not well-understood. In view of this, we present an overview on the historical development and diffusion of the concept of waste. It is anticipated that such a long-term view would contribute to the current discussion of the place of this concept in the theory and practice of production.

Method: The historical method is followed.

Findings: The history of the concept of waste can naturally be divided into a number of periods: nascence up to the end of the 18th century, emergence of the classical notion in the 19th century, flourishing during scientific management, decline starting in the second quarter of the 20th century, and re-emergence in last quarter of that century. From these, especially the emergence of the classical notion of waste as well as its decline have been poorly understood. It is also an important insight that across the different periods, waste has been understood in two dimensions: instrumentally and intrinsically (morally).

Implications: Through an historical account, the relevance and texture of the concept of waste can be better appreciated. The focus can be directed to critically assessing the justification of the arguments that led to the decline of waste. All in all, the need for the revival of waste as a basic concept in managerial discourse is illuminated.

KEYWORDS: waste, production, economics, management**.**

INTRODUCTION

This paper is a contribution to the history of ideas, focusing on the concept of waste. This concept has been used in relation to production since the beginning of the 20th century. As is well-known, it is a foundational notion for the Toyota Production System and its derivatives, like lean production. However, waste is not a prevalent concept in the mainstream literature on economics, operations management,

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construction management or management. The reasons for this apparent aversion to the concept of waste are not well-understood.

In view of this, we present an overview on the historical development and diffusion of the concept of waste. It is anticipated that such a long-term view would contribute to the current discussion of the place of this concept in the theory and practice of production.

A historical method is followed, using both primary (reports from participants) and well-researched secondary sources. The paper is structured according to the different stages that can be perceived in the evolution of the concept of waste.

EMERGENCE OF THE CLASSICAL WASTE CONCEPT

The English word waste has its origin in the Latin word *vastum*, which was used in the Domesday book prepared for William the Conqueror, in the meaning of "land which was either unusable or uncultivated, and not taxed" (The Domesday Book Online). This English word started to be used around 1200, in that original meaning "desolate regions"; the meaning "useless expenditure" is recorded from circa 1300 and the sense of "refuse matter" from early 15th century (Online Etymology Dictionary). Waste was also a legal term in common law, more or less equivalent to destruction (Blackstone et al. 1827).

The concept of waste became to be well developed in the views of political economists, scientists and engineers in the 19th century. M. Norton Wise (1989) provides an in-depth analysis of the ways in which waste was understood to occur in physical, mechanical and production processes. For the purpose of the analysis, he distinguishes between the influence of moral and material dynamics.

MORAL DYNAMICS

Moral dynamics is a view of the world in which moral (sociological, sometimes theological) force is perceived to act as a driving force for change in the world. Norton Wise selected three academics and scholars, William Whewell, Thomas Chalmers and John Stuart Mill, to represent this cross-section of British scientific culture.

Whewell, a professor of mathematics and natural science at Cambridge, considered the world to be in a state of change. He rejected the notion of equilibrium in economics, such as the ideas proposed by Ricardo and Malthus, who saw machinery as increasing the national wealth, but unable to fundamentally change the poverty of the working classes (they held that the development of industry would not break the natural balance: "the natural rate of wages is the cost of subsistence"). Instead, Whewell challenged the notion of systems finding equilibria in response to disturbances, such as the general idea that market forces of supply and demand produce an equilibrium value. He led to the idea that disturbances and variations become primary phenomena and that economic systems never approached equilibrium. "Not some external laws of human nature, but the state of moral development of a people, their customs, defined the political economy in which they lived" (Norton Wise 1989, p. 397). The basic idea of Whewell's political economy was that a continual input of moral force was needed to maintain and enrich the nation in front of natural dissipation and irreversible waste, caused by the universal law of decay. Specifically, in 1850, Whewell observed that as friction dissipates

energy in physical systems, so there are losses in manufacturing systems. “In every process of economic exchange,” Whewell maintained, “there are losses, rendering invalid the principle that capital and labour can be transferred, without loss, from the production of one commodity to another” (Norton Wise 1989, p. 400). Economic 'waste' is inevitable, just as friction wastes the labour-force in a mechanical system.

Thomas Chalmers, a clergyman of the Presbyterian Church of Scotland, believed that a moral and religious education could enable any man, even peasants and labourers, "to transcend their state of depravity and thereby escape its condemnation to a subsistence level existence" (Norton Wise 1989, p. 400). “The labouring classes, once imbued with middle-class morality and respect for property, would turn the laws of political economy to their own advantage, as the proprietary classes had always had done. Labour would become property, equivalent to capital” (Norton Wise 1989, 402).

John Stuart Mill is Norton Wises’ third representative of moral dynamics. He held that social states are the result of the immediately prior social state, and move dynamically forward, without repeating cycles. He too believed that societies could be transformed by education, but by economic education, not moral or religious education.

MATERIAL DYNAMICS

Material dynamics represents the idea that physical systems are in and of themselves a force for change in the world. Norton Wise cites Charles Babbage’s views of production to explain material dynamics. Like Adam Smith and other economists of the early 19th century, Babbage too considered the division of labour to be essential, but not only for the reasons of direct productivity increase, which is obtained through expertise and learning of a simple process. He saw in the very nature of manufacturing – and in the way specialized factories were organized in the broader economy – that the manufacturer could for the first time buy only the exact amount needed of any given input. In this sense, they could buy the product, without paying for the 'downtime' cost of the service. As quoted by Norton Wise (1989) and by (Lewis 2007), he explained that (Babbage 1832, pp.175–6):

> “..the master manufacturer by dividing the work to be executed into different processes, each requiring different degrees of skill or of force can purchase exactly that precise quantity of both which is necessary for each process; whereas, if the whole work were to be executed by one workman, that person must possess sufficient skill to perform the most difficult, and sufficient strength to execute the most laborious of the operations into which the art is divided”

This idea extended beyond physical work to include mental work and organization as well. Babbage held that all kinds of resources should be allocated to minimize the cost of production. Babbage made a direct comparison between machines and economies at different scales. He posited that a production system (factory, mine, etc.) could be considered to function as a machine functions. The implication is that the workers can be considered to be parts of the machine. There is no consideration, however, of the will and intent of the people, at the operational level.

In terms of waste, Babbage was more concerned with the loss of energy in machines, which he saw as a more important waste than wasted human labour. For example, he devised a way to separate oxygen from air, so that it could be

compressed and blown into a furnace to drastically increase the energy that could be obtained from coal. His thinking was that compressing the air was wasteful, because 4/5 of it was not oxygen, and so it must be more efficient to remove the nitrogen first.

WORK, LABOUR-FORCE AND WASTE

Norton Wise provides a lengthy discussion of the meaning of the terms 'work' and 'labour-force' in English usage at the time (mid-19th century) as it appeared in the writings of Whewell (at Cambridge) and Gordon (the first professor of engineering; the chair was instituted at the University of Glasgow in 1840). Whewell considered the 'labour-force' as a component of production cost. Labour-force included productive and non-productive expenditure of effort. When the labour-force was not productive, such as when expended to overcome friction, it constituted Waste. Work, on the other hand, was considered as actually producing something of value.

Both Whewell and Babbage viewed large-scale production as being uniquely suited to overcoming the wastes of small-scale trade production. The wasted materials, time, power and skill that were unavoidable in a small shop could be used to produce by–products of value in a large-scale factory. The size of the operation is an important factor here. Economies of scale meant that only large-scale production could treat the wastes and make them productive or eliminate them.

Babbage placed value on knowledge and skill – he replaced the notion of being able to measure the value of all work using a common unit of physical labour, based on force x time, with the idea that the value of work should be based on force x skill x time, i.e. there was not a linear or simplistic way to relate the work of lower skilled workers to that of higher skilled workers. However, in the engineering sense, work began to be measured as force x distance, rather than force x time. The removal of the notion of time from the definition of work meant that it became a useful engineering measure, but could no longer express work as a function of time, which could be wasted.

Whewell and Babbage considered the labouring force to be consumed over time, so that the rate of doing work was important. But Whewell considered the sources of energy (sun, wind, water flows in rivers, coal) to be finite resources that were being consumed over time, regardless of human endeavour. In this sense, not using them constituted waste, because it was a waste of time. For him, waste was therefore a moral issue. Norton Wise explains: “[Waste] is not simply the failure to turn available resources into saleable commodities, or the waste of an individual’s time on earth; it is the waste of TIME absolutely, for all of humanity and for all of time.” Thus Whewell believed that moral dynamics must guide mechanical dynamics – avoiding waste was a moral imperative. Babbage and Mill, on the other hand, subjected moral dynamics to mechanical laws.

For our purposes, this allows classification of work and waste in three categories:

1. Work – expense of labouring force to change the composition of materials and produce products of value.
2. Waste – expense of labouring force to overcome resistance, such as friction, which is necessary due to physical or mechanical phenomena, but does not produce value.
3. Waste – expense of time, or waste of the potential labouring force.

Note that none of them consider at all the result of expense of labouring force that does produce results (products), but the products themselves have reduced or no value. In their view, the price of a product was composed of the cost of the labouring-force, the payment for the stored labouring-force embodied in the machines (i.e. payment of capital cost) and rent for land. There is no discussion of value to the user/client or its relationship to price, or of the waste of unrealized potential value.

CONCLUDING REMARKS

Based on the account given, there are two issues to emphasize. First, the instrumental and the intrinsic (moral or theological) dimension of the concept of waste were tightly interlinked in the considered period. Second, the power and range of the concept of waste in this period were so extraordinary that it is difficult to grasp from the perspective of today.

FLOURISHING OF WASTE IN SCIENTIFIC MANAGEMENT

This period, roughly 1880 – 1930, saw the growth of the 'Efficiency Movement', which was dedicated to the removal of waste not only from production systems, but from other spheres of life, such as education, services, and government. Frederick W. Taylor was one of its key engineering thinkers and practitioners; civic leaders like President Teddy Roosevelt and Justice Louis Brandeis promoted it through government. In the introduction to his seminal paper "The Principles of Scientific Management", Taylor (1911) wrote:

> "We can see our forests vanishing, our water-powers going to waste, our soil being carried by floods into the sea; and the end of our coal and our iron is in sight. But our larger wastes of human effort, which go on every day through such of our acts as are blundering, ill-directed, or inefficient, and which Mr. Roosevelt refers to as a, lack of "national efficiency," are less visible, less tangible, and are but vaguely appreciated."
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> "We can see and feel the waste of material things. Awkward, inefficient, or ill-directed movements of men, however, leave nothing visible or tangible behind them. Their appreciation calls for an act of memory, an effort of the imagination. And for this reason, even though our daily loss from this source is greater than from our waste of material things, the one has stirred us deeply, while the other has moved us but little."

In other words, Taylor's view of waste was that labour waste in production was the difference between the optimal production that might have been achieved using a 'one best way' identified and managed by scientific management, on the one hand, and the given current level of production, on the other hand. Henry Ford had a similar view of waste as the lost production potential when a sub-optimal method is used. The following passage is revealing (Ford and Crowther 1922):

> "A farmer doing his chores will walk up and down a rickety ladder a dozen times. He will carry water for years instead of putting in a few lengths of pipe. His whole idea, when there is extra work to do, is to hire extra men. He thinks of putting money into improvements as an expense. Farm products at their lowest prices are dearer than they ought to be. Farm profits at their highest are lower than they ought to be. It is waste motion - waste effort - that makes farm prices high and profits low."

The influence of the 19th century thinking of waste as the misuse of work (or the 'labour-force', as discussed in the previous section), is evident in a paragraph from

the first chapter of Ford's autobiography. His words seem to echo the moral dynamics of Chalmers and Whewell (Ford and Crowther 1922):

> "Everything was given us to use. There is no evil from which we suffer that did not come about through misuse. The worst sin we can commit against the things of our common life is to misuse them. "Misuse" is the wider term. We like to say "waste," but waste is only one phase of misuse. All waste is misuse; all misuse is waste."

Note also his view that the way to remove waste is through fundamental treatment of the production system (Ford and Crowther 1922):

> "The underlying causes of poverty, as I can see them, are essentially due to the bad adjustment between production and distribution, in both industry and agriculture--between the source of power and its application. The wastes due to lack of adjustment are stupendous. All of these wastes must fall before intelligent leadership consecrated to service. So long as leadership thinks more of money than it does of service, the wastes will continue. Waste is prevented by far-sighted not by short-sighted men. Short-sighted men think first of money. They cannot see waste."

Ford was concerned with waste in all of its forms, including wasted materials and wasted labour. The Ford production plants sought economy by recycling waste materials and energy as far as possible. But the waste of materials and energy were seen as secondary to the waste of labour potential (Ford and Crowther 2003):

> "My theory of waste goes back of the thing itself into the labour of producing it. We want to get full value out of labour so that we may be able to pay it full value. It is use – not conservation – that interests us. We want to use material to its utmost in order that the time of men may not be lost. Materials cost nothing. It is of no account until it comes into the hands of management …Saving material because it is material, and saving material because it represents labour might seem to amount to the same thing. But the approach makes a deal of difference. We will use material more carefully if we think of it as labour."

Frank G. Woollard was an early pioneer of flow production systems, well before Taichi Ohno. His approach was conceived during the First World War and applied more fully in the 1920s in the UK at the Morris motor car manufacturing company (Woollard and Morris 1925). His views on waste in production were no different to those of Taylor or Ford; for example, the 15th of his 18 principles states that "Every activity must be studied for the economic application of power." However, Woollard's view of the role of the worker in production differed sharply with Taylor's view. Taylor held that managers must take full responsibility for planning and directing the work, because manual labourers were not capable of understanding the scientific principles behind the optimum method for executing their work. Woollard, on the other hand, "…viewed factory workers as part of the production system, not separate from it, and gave them responsibilities that would have normally be handled by supervisors. He also allowed workers to participate in efforts to improve production processes..." (Emiliani and Seymour 2011).

Thus it is apparent that during this period, the concept of waste in production was central to the thinking of leading practitioners like Taylor and Ford. But the concept was also widely understood among academics; Taylor, Carl Barth and others gave lectures on the subject at the Harvard Business School already in 1908, and most business schools required courses in production management (Sprague 2007).

DECLINE OF THE CONCEPT OF WASTE

Although the concept of waste was commonly used in the first three decades of the 20th century, in the second quarter of that century a surprising thing happened. Waste started to disappear from scholarly and professional literature. For example, production management textbooks with no substantive discussion on waste and its causes emerged in the 1930s. Why did this concept decline so abruptly?

To our knowledge, no research has been done on this interesting question. However, it is possible to identify plausible reasons. Our hypothesis is that a novel set of concepts emerged into managerial and social sciences, in relation to which the concept of waste was not only old-fashioned and incompatible, but sometimes even dangerous and toxic. In the following, we give a concise overview on our initial hypotheses on the reasons for the decline of waste.

First, the intellectual and social atmosphere grew to demand a separation of moral considerations and instrumental rationality, of theological and secular arguments; thus the intrinsic understanding of waste was rejected. It may be that the instrumental and intrinsic understandings of waste were so tightly intertwined, that a rejection of one led to the rejection of the whole concept.

Second, the conceptualization of production as transformation, which had been proposed by Walras (1952) in economics at the end of the 19th century, gained foothold. As this is a black box conceptualization, waste is not visible at all.

Third, the idea of economics as concerning decision making under scarcity, and especially the related assumption of optimal decision-making by economic agents acting rationally and in their own best interest, suppressed the incompatible idea of waste, which awkwardly reminded about the distance of this assumption from reality.

Fourth, the disciplines related to management and organization shifted their emphasis away from the machine metaphor to behavioural issues, and the idea of technical efficiency (or inefficiency) was lost.

Fifth, the significance of waste reduction was diminished when a new widely usable alternative for productivity improvement emerged, namely electrification of factories and the associated innovations in the layout and organization of production (these led, among other things, to the development of mass production). The major productivity advances that are measured in the 1920s have been associated with the electrification of industry (Goldfarb 2002).

Sixth, waste reduction, popular in the times of recession and depression, may have attracted a reputation of an idea belonging to difficult times, pushed aside and forgotten when good times returned.

RE-EMERGENCE OF WASTE

TOYOTA PRODUCTION SYSTEM

The centrality of waste in Japanese thinking about production appears to have originated with Kiichirō Toyoda's injunction in 1945 to "Catch up with America in three years. Otherwise the automobile industry in Japan will not survive." (Ohno 1988) Ohno Taiichi's reaction to this was to wonder how workers in the US could be nine times more efficient than those in Japan. Japanese people, he concluded, must be wasting something.

However, the two strategies which Ohno identifies as central to Toyota's efforts to combat waste, just-in-time and autonomation, originated in Toyoda's previous efforts to compete with England in the textile industry. Toyoda Spinning and Textiles was dissolved in 1942 to concentrate efforts on the Toyota car manufacturing branch of the business (Ohno 1988). By 1945, the position of the company seems to have been desperate. It was clear that the Japanese could not emulate the successful US model, based on economies of scale and standardisation of product. Ford's mass production concept relied on increasing volumes so that each work station could be dedicated to the production of a single part, obviating the need for time consuming change-overs (Shingo 1985). The system was further simplified and volumes increased by reducing the product range. With a shortage of capital and restricted sales in an already competitive market, Toyota needed a new approach.

While mass production is based on the eliminating the waste involved in craft based production, the subsequent emphasis on increasing volumes diverts attention away from this goal. The particular conditions that Toyota faced required a deeper analysis of waste.

From 1959 to 1974, the Japanese economy experienced rapid growth under favourable global conditions and it was not until the oil crisis on the mid 1970s, when Ohno's obsession with waste and the just-in-time idea enabled Toyota to sustain earnings in conditions that were again unfavourable, that the difference between Toyota and other Japanese companies became apparent. By the 1980's, continuing problems in the US and other Western economies led observers to ask what it was that the Japanese were doing right. The subsequent diffusion of the ideas of the Toyota Production System, including the concept of waste, to the rest of the world under the banner of “lean” is now well known.

ENVIRONMENTAL CONCERNS

Meanwhile a second important concern with waste was emerging through the environmental movement. Two primary concerns can be identified: first, the problem of maximising the utility of finite resources under conditions of increasing demand; second, the negative environmental and social effects of pollution caused by waste. Here, the concern is often with waste as conventionally defined, an unwanted physical by-product of a process. Some examples are the problem of land-fill, storage of radioactive materials, or the release of toxic chemicals in either liquid or gaseous form. However, concerns with energy conservation also signify. The recycling of waste materials, for instance, is often less energy intensive than extraction from raw materials: for aluminium, the saving is 95%, for plastic 70% and for paper 40% (The Economist 2007). The problem of pollution goes beyond the question of efficiency savings to address the problem of unintended negative effects outside the production system, as in the case of toxic chemicals. Something that is the waste product of one system will often become a pollutant in another.

Food waste falls into both categories. In the affluent West, the chief problem is pollution when waste by consumers which is either dumped or burned. This has led to the introduction of food waste recycling schemes. In countries where hunger can be a problem consumer waste is minimal, but problems often arise from post-harvest waste which results in food spoiling before it reaches the consumer. As food loss and

waste is up to 30-50 % from all food produced, waste reduction has emerged as a major policy element (Foresight 2011).

The severe social and ecological consequences of these forms of environmental waste lend them an additional moral force.

CONCLUDING REMARKS

Again today – as 100 years earlier – both the instrumental and intrinsic dimension are present in the discourse on waste. However, whereas these two dimensions were integrated into one concept in scientific management, now the term waste does not necessarily carry this dual message.

CONCLUSIONS

A historical account of the concept of waste – its emergence in the 19th century as a scientifically grounded notion, the subsequent flourishing both as an instrumental and intrinsic concept across all human endeavours and then in scientific management of production, its decline, almost total vanishing from the stage, in the second quarter of the 20th century and its revival towards the end of that century – provides a fascinating and revealing view on the intellectual movements and shifts in the last two centuries. Our main conclusions are as follows.

First, the concept of waste has been found to be useful and fecund across times and across contexts; there is a full reason to take seriously, to clarify and define it and to adopt it into the conceptual framework and terminology of disciplines dealing especially with production but also more generally with human affairs.

Second, the concept of waste has been used in lean production and lean construction, but without much reflection and conceptual analysis. This concept deserves being sharpened and the full consequences of the acknowledgement of waste on our views on decision-making, organization and management merit to be clarified. The prospect is that waste will evolve to the central, mainstream idea for developing design and production, rather than being just in the vocabulary of "lean".

Third, in the light of the history of the concept of waste, the ahistorical nature of the managerial sciences and its counterproductive impacts become visible. Not aware of the process having led to the current orthodoxy, the community of management scholars seems to have been incapable of appreciating historical concepts, like waste, which bounce back due to practical needs. Once again, the significance of historical understanding and knowledge is proven.

Fourth, the historical oscillation between and the intertwinement of the intrinsic, moral view on waste and the instrumental view on waste bring the Aristotelian notions of *phronesis* and *techne* into the limelight. Especially the sustainability agenda implies that the relations between moral and instrumental values require a new assessment.

Fifth, the many arguments and concepts that led to the decline and defeat of the concept of waste seem to invite a critical re-assessment. The accepted wisdoms of management, such as viewing "achieving through people" as the essence of management, optimal decision-making, rationality, etc., merit challenge.

All in all, the examination of the history of the concept of waste has been an eye-opener for the authors: it has convincingly shown that production management is not an isolated and self-sufficient engineering endeavour, but rather it is in many ways

embedded in the totality of scientific, technical and moral pursuits of humankind. In relation to this totality, production management seems to have been largely on the receiving end, for good or bad. However, there are no barriers in principle for production management to contribute to this totality.

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