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The Dynamics of Vulnerabilities and Capabilities in Improving Resilience within Malaysian Construction Supply Chain

Purpose - The dynamics and effects of interconnected risks among construction organisations tend to be overlooked across the Malaysian public project supply chains, making them highly vulnerable to supply chain disruptions. This study aims to investigate this dynamism by assessing the supply chain's critical vulnerabilities and capabilities that formulate the level of resilience in handling disruptive events in construction projects.

Design/methodology/approach - A comprehensive questionnaire survey was conducted with 105 construction professionals from two groups of respondents, the public and private organisations that work in public projects to identify their current vulnerabilities and capabilities. Data were analysed and compared using the Mann-Whitney U and Kruskal-Wallis tests.

Findings - The findings revealed that the top five critical vulnerability factors of the supply chain include political or regulatory changes, market pressures, management, financial and strategic vulnerability. Further comparisons highlighted that the public organisations faced significantly higher political threats compared to the private organisations whilst the private organisations faced significant market pressures. The survey also show that despite the private organisations' high capability in financial strength, the public organisations' financial vulnerability has destabilised the entire supply chain.

Originality/value – This study presents the construction supply chain's vulnerabilities in a layered framework approach that can provide managers a new perspective on the dynamics of the cascading impacts of these vulnerabilities when observed through several layers of supply chains.

Keywords – Resilience, Supply chain management, Supply chain disruptions, Risk management, Public projects, Construction organisations, Malaysian construction industry, Project management

Paper type – Research paper

Introduction

In today's world, with the growing scale and interdependence of the global economy through worldwide communications and advanced technology, key players in the global marketplace are highly interconnected than ever before. Although countless benefits arise from these advances, such as unprecedentedly high international trade and lean supply chains (Kosansky and Taus, 2014), the increasing volatility of the interdependent global economy have amplified the collective exposure of global supply chains to interconnected risks. The construction industry, which is driven by supply chains, is also no exception in being impacted from these interconnected risks. These risks such as supply chain disruptions, operational risks, regulatory risks and unforeseen events can arise from any parties within a supply chain and from any sectors of the economy. Indeed, the construction industry's supply chains have constantly been reported to have faced disruptions in their day-to-day operations that cause time and cost overruns of extreme magnitudes (Le-Hoai et al., 2008; Sambasivan and Soon, 2007). Construction projects also often feature multiple overlapping risks that include commercial, design, project, quality and safety that have to be dealt with at the same time (Zurich, 2014). This is evident not just in the developed countries, but also in various developing countries, with increasing reports on project performance deficiencies such as poor quality of work, technical defects, lack of training of the construction workforce and higher accident rates on site (Ofori, 2012; Abdul-Rahman et al., 2007).

One of the developing countries whose construction industry is highly impacted by disruptive supply chains is Malaysia. Research conducted by Mehdi-Riazi et al. (2011) and Pratt (2000) reveal that large local construction engineering projects have frequently ended up being delivered late due to the

incompetencies of supply chain members, causing cost overruns and poor project delivery. This was realised in the extreme within the MATRADE Exhibition and Convention Centre (MECC) building in Kuala Lumpur, which experienced nine years of delay and a 70% cost overruns due to disruptions arising from the first contractor that had abandoned the project, causing the appointment of another contractor (Mehdi-Riazi et al., 2011). Several cracks were detected on the floor, walls and staircase of the building due to the incompetency of the first contractor. The original cost of Ringgit Malaysia (RM) 167 million had increased to RM287.5 million, with RM64.8 million spent just on the repair works. It was later reported that the first contractor had four other projects, in which two projects had also faced delay (The STAR, 2006). This has resulted in the client raising question on any irregularities in the tendering process conducted by the public bodies that had led to the selection of the incompetent contractor in the first place. The client had also faced significant loss (approximately RM120 million) from the potential rental earnings from the exhibition space. Indeed, such disruption does not only affect one organisation but problems cascade across supply chain partners.

The recent national report also points out non-performance of some of the key engineering projects at several scales that led to catastrophic outcomes to the client and other public and private organisations (National Audit Department, 2014). The poor performance of the supply chain has resulted in the Government not getting the best value for money for the expenditure incurred, thus affecting the public's perception on the Government's credibility in managing public projects (National Audit Department, 2014). In this case, the supply chain as a concept and primarily how risks transcend organisational boundaries is not a well-understood concept in Malaysia and there are a lot of discontinuity of partnerships at the supply chain level in the local construction industry (Mehdi-Riazi et al., 2011). The lack of good quality empirical work in construction supply chain resilience in developing countries also presents a distinct knowledge gap that this study intends to address. Whilst previous studies typically assess resilience based on the point of view of an individual firm (Pettit et al., 2013; Zsidisin and Wagner, 2010; McManus, 2008), our research departs by investigating resilience as determined by impacts and cascading impacts across a supply chain within the Malaysian construction industry. The aim of the paper is therefore to assess the supply chain's perceptions on their vulnerabilities and capabilities that formulate the level of resilience in handling disruptive events in construction projects.

Supply Chain Disruptions in Construction Projects

Studies conducted on performance in construction often identify delays and cost overruns as affecting project outcomes (Osei-Kyei and Chan, 2017; Le-Hoai et al., 2008; Pratt, 2000). The factors that cause these delays and cost overruns suggest that they are contextually dependent although some commonalities could be identified from country to country. Whilst these studies add value to the existing body of knowledge in improving performance, the studies hardly concentrate on the modern day complexities related to supply chain risks and risks which are interdependent across the construction supply chain dominating within many countries. The interdependencies of the supply chain in the construction industry differ from other industries, such as the retail and manufacturing sector as it involves a project-based supply chain that is transient in nature with overlapping risks that are wider than their immediate contractual responsibilities (Loosemore, 2000). A typical construction supply chain consists of the construction clients and design team at the upstream linkage, conducting activities leading to preparation of the production on site, and the main contractor, subcontractors and suppliers at the downstream linkage, that carry out the tasks in the delivery of construction project (Akintoye et al,

2000). This fragmentation of the sequential design-construction process often results in construction organisations working in silos, reducing the organisations' visibility to detect any risk of disruptions that may occur along the supply chain network. Indeed, supply chain in the face of disturbances is a subject that, in recent years, has motivated the interest of numerous researchers and practitioners. Some researchers also refer to disturbances as "disruptions" (Ponomarov & Holcomb, 2009), while others refer to it as "risk" (Chopra & Sodhi, 2004), "errors" (Love and Smith, 2016), "uncertainty" (Mason-Jones & Towill, 1998) or even as "crisis" (Loosemore, 2000). In the context of this study, the term used to refer to such disturbances is disruption, which is defined as a foreseeable or unforeseeable event that affects the usual operation and stability of an organisation or a supply chain (Barroso et al., 2008). The interdependent nature of the supply chain partners causes these disruptive elements to transfer the impacts and consequences within the wider supply chain. From the point of view of this study, a typical supply chain network in the context of Malaysia can be represented in Figure 1.

[Insert Figure 1 here]

The public sector, indicated as supply chain A in Figure 1, includes public organisations that act as the project owner on behalf of their clients (i.e. local ministries), and are in charge of implementing the public projects funded under the Government's stipulated provisions. A majority of the contractors and consultants working in the public projects are from the private sector. In addition to the public sector work these consultants and contractors also serve private clients within the private sector supply chain, depicted as B, C and D in Figure 1. Due to the growing complexity of the structure, this research considers the public sector initiated supply chain (supply chain A) as highlighted in Figure 1 as the main focus in this study. It can be observed here how managing the complex interdependencies both within and between these several supply chains is indeed challenging as disruptions arising from any part of this chain will subsequently have a cascading impact on another, both locally and internationally. For instance, the failure of timely payment by the public organisations to the contractors in supply chain A will subsequently affect the contractors' cash flow and pre-planned programs for other private sector projects that they are involved in supply chain C. This will also lead to the contactors sacrificing time, cost and quality or in the extreme case, the abandonment of projects in order to survive financially in the business. In this case, practitioners often underestimate the interdependencies of this payment-related issue which can result in potential extreme consequences across the industry and the economy. Certainly, delayed payment and non-payment in the Malaysian construction industry had often led to disputes and financial problems for industry players (Judi and Abdul-Rashid, 2010), affecting the survival of the entire delivery chain. The interdependent nature of the supply chain has also resulted in the reported poor project delivery, including non-functional buildings due to improper execution of works (National Audit Department, 2014). This shows that managing the interdependencies of supply chain disruptions had constantly become an issue to the Government in meeting their development plans.

In managing supply chain disruptions, Sheffi (2005) find that the effects of disruption can be minimised if an organisation can foresee and prepare for disruption before it occurs. In the context of this study, this phase is equivalent to the risk management process before construction begins on site. This proactive approach of risk management is quite common in the Malaysian construction industry to handle disruptions in projects. However, despite being widely practised in Malaysia, as the nature of supply chain becomes more complex and the significant risks shift from one phase to another, it is difficult for

the associated risks to be mitigated by individual participants in the supply chain. Most research in the Malaysian construction industry (Goh and Abdul-Rahman, 2013; Siang and Ali, 2012) seem to focus on the risk management process at the pre-disruption stage, and there seems to be a paucity of literature on the supply chain's response following 'actual disruptions' in construction. Hence the supply chain's ability to learn from existing disruptions and utilise their current capabilities to overcome such problems have not received much attention in literature, which this study intend to address. Furthermore, during disruptions, Sheffi (2005) argues that in some cases, the pre-planned contingency measures might not be able to contain the disruptions from spreading, hence alternative responses are usually required to handle such disruptions. As it is still questionable whether having a Formal Management System to Reduce Disruptions (FMSRD) can improve supply chain resilience, this study will also consider whether the current management approach adopted by the supply chain can improve their resilience to disruptions or not. In this case, the disruptions faced by both the public organisations and the respective supply chain partners (referred to as the private organisations from hereon) are included in this study to obtain a balanced perspective on their resiliency to disruptions in public projects.

Supply Chain Resilience, Vulnerabilities and Capabilities

Based on Barroso et al (2008) the authors arrive at a working definition for resilience in the case of supply chains, where this paper posits resilience to mean 'supply chain's ability to react to the negative effects caused by disruptions that occur at a given moment in order to maintain the supply chain's objectives or recover to a better state'. Most supply chain resilience literature (Pettit et al., 2013; McManus, 2008) however seem to cover multi sectoral issues and the literature's coverage of construction per se is very limited. A more industry-specific research, such as in the context of the construction industry is required to address this theoretical gap. In assessing supply chain resilience, Pettit et al (2010) most importantly suggested that it can be assessed in terms of two dimensions; vulnerabilities and capabilities, which are taken forward further in this study. Supply chain vulnerability here can be defined as "the existence of random disruptions that lead to deviations in the supply chain operations from normal or planned activities, all of which cause negative consequences for the involved construction parties" (Svensson, 2000, p.732). Pettit et al. (2010) argued that a 'vulnerability' could be targeted by a set of successfully employed capabilities. Capabilities here are related to the "attributes that enable an enterprise to anticipate and overcome disruptions" (Pettit et al., 2010. p.6). These capabilities can prevent an actual disruption, mitigate the effects of a disruption or enable adaptation following a disruption.

However, despite the importance of these capabilities, past researchers (Wedawatta and Ingirige, 2016; Juttner and Maklan, 2011) argued that improving resilience against one threat might increase the vulnerability to another. For instance, improving collaboration among supply chain partners may cause additional threats due to sharing sensitive information (Jüttner and Maklan, 2011). On the other hand, increasing flexibility through sub-contracting may increase the susceptibility of the construction supply chain to severe weather conditions at different geographic regions (Wedawatta and Ingirige, 2016). Hence, the fact that the resilience strategies are interrelated suggest that it is important to understand the trade-offs between the right capabilities to mitigate particular critical areas of vulnerability. The effects of an organisation's vulnerabilities and capabilities to another organisations' resiliency to disruptions in a supply chain however are under-researched and tend to be overlooked by previous researchers (Pettit et al., 2013; Zsidisin and Wagner, 2010; McManus, 2008). It is therefore important for this study to

investigate the dynamics of the effects between the Malaysian public and private organisations' vulnerabilities and capabilities to overcome disruptive events collectively in public projects.

In determining the vulnerability and capability parameters to be assessed in this study, extensive review of past research was undertaken. For instance, Christopher and Peck (2004) and Einarsson and Rausand (1998) highlighted that supply chain vulnerability may arise from factors within the organisation and its supply chain network, or from factors external to the supply chain network that are beyond their control. Further descriptions of these factors can be better understood from the synthesis in Table 1. In terms of capabilities, researchers from different disciplines (Pettit et al. 2010; Ponomarov and Hollcomb, 2009; Sheffi, 2005) had emphasised on factors such as flexibility, capacity, efficiency, visibility, adaptability and anticipation to create resilience to disruptions, as described in Table 2. Developing the concepts of how impacts cascade across a supply chain in the construction industry is investigated through the dynamism of these vulnerabilities and capabilities.

[Insert Table 1 here]

[Insert Table 2 here]

Research Method

The paper adopts a survey approach considering the range of project participants required which include the public and private organisations to investigate the overall supply chain's level of vulnerability and capability in dealing with disruptions in Malaysian public projects. The stratified random sampling was adopted in this paper, whereby the targeted population of construction professionals involved in Malaysian public sector projects is first separated into mutually exclusive, homogeneous groups (i.e. public and private organisations), and then a simple random sample is selected from each group (Trochim, 2005). A pilot survey was conducted beforehand to ensure the validity and clarity of the questionnaire. Subsequently, the self-administered questionnaires were distributed by hand and electronically, depending on the medium the respondents preferred. The same sets of questions were distributed to both the public and private organisations to cover the supply chain, ensuring consistency in the analysis of data later on in this study.

Overall, out of the 220 questionnaires distributed covering the targeted population, 105 responses were received (response rate 48%). This is in line with research in the construction field. For instance, useable response rates in the case of Fellows and Liu (2008) was ranging between 25% to 35%. Samples larger than 30 can also ensure the researcher the benefits of central limit theorem (see for example, Roscoe, 1975, p.163, or Abranovic, 1997, p.307-308). This is also accepted within the context of Malaysia from studies done by Sambasivan and Soon (2007), Alzan et al. (2011) and Abdul-Aziz and Ali (2004). Hence, it was established that an overall sample of 105 respondents were sufficient for the analysis of this study.

Out of the 105 respondents, 51% represented the public organisations and 49% represented the private organisations that are involved in delivering public projects. The fair distribution among these two groups enabled appropriate statistical comparisons in this study. In terms of the respondents' professions, more than half (52%) represented the engineering background. The possible reason is that more than half

civil engineers are employed by Malaysian public organisations (PWD, 2015). Some of these engineers also act as project managers who manage the supply chain during public projects delivery, making their insights valuable to this study. Further demographic statistics are given in Table 3.

[Insert Table 3 here]

The questionnaire survey was analysed using SPSS Version 22 (IBM Corp, 2013). Descriptive statistics were used to identify the respondents' general experiences in dealing with disruptions in public projects (i.e. the current FMSRD adopted by the organisation). The mean of the composite score and standard deviations were used to analyse questions entailing Likert scales, particularly the vulnerability and capability factors. Plus, as the questionnaire response follows a nonparametric distribution, the Mann-Whitney U and Kruskal-Wallis test were used with a confidence level of 95% to make judgments of the probability that an observed difference between two or more number of groups of respondents in this study is a dependable one or one that might have happened by chance (Field, 2009). The Spearman's coefficient of rank correlation was also used to test the level of agreement or disagreement among the different groups of respondents (the public organisations, consultants and contractors) in assessing the vulnerability and capability factors. The Spearman's correlation results range between the value of 1 and −1, whereby values closer to 1 indicate a perfect positive relationship (or high degree of agreement) and -1 implies a perfect negative relationship (or disagreement) (Assaf and Al-Hejji, 2006). The internal consistency and reliability of the survey measures were tested using Cronbach's Alpha Coefficient. For this study, an alpha value limit of 0.60 adopted by similar studies (Pettit et al., 2013; Sharma and Petosa, 2012) was used to demonstrate reliability. Table 4 presents the number of items and the Cronbach's alpha value for the vulnerability (V1 to V11) and capability (C1 to C12) factors. Overall, apart from the main factor V1 and V3, the remaining factors' reliability estimates ranges from 0.633 to 0.882, proving that the survey instrument is reliable and consistent to be further assessed.

[Insert Table 4 here]

Discussion of Findings

Level of Frequency and Severity of Disruptions in Public Projects

One of the key findings identified in the survey is the statistically significant differences in score on the perceptions of level of disruption frequency and impact among the public organisations, contractors and consultants, as shown through the Kruskal-Wallis test in Table 5. The highest ranking of frequency and severity of impact in this case was given by the contractors (mean rank = 70.08 and 70.92 respectively).

[Insert Table 5 here]

The discrepancy between the contractors' and the consultants' and public organisations' perceptions suggest that although all parties of the supply chain face disruptions in public projects, parties from the bottom tier of the supply chain, which in this case, the contractors, had faced more frequent disruptions during public projects delivery that had severely disrupted their operations. Considering the interdependencies of the design-construction process in a construction project, it might be the case that the inefficiencies earlier in the supply chain operation are realised at the construction phase, whereby the

contractors are mainly involved in. Hence, the fact that the consultants and public organisations do not acknowledge this suggests that the risks might have been transferred to the contractors during the subsequent construction phase. The higher repercussion of disruptions to the contractors compared to other parties in the supply chain also shows that majority of the risk of disruptions are borne by the contractors compared to the consultants and public organisations. It does not necessarily mean here that the contractors are more vulnerable to disruptions compared to other parties, in fact, this may be due to the current norms in the industry due to imbalances in risk sharing (Ahmed et al., 1999). However, it should be noted here that any disruptions affecting the contractors' work will eventually have an impact on the public organisations who will end up paying for the costs incurred from these disruptions. Hence, in building the resilience of the supply chain to disruptions, this interdependency is important to be considered as the risk of disruptions might later have a knock-on effect back to the upper tier of the supply chain (i.e. the consultants and public organisations) if it is not managed properly.

Current Disruption Management Approach Employed by the Organisations

In managing disruptions, majority of the respondents (42% public and 25% private organisations) reported that risk management is adopted by the firm to manage disruptions (see Table 6).

[Insert Table 6 here]

This is reasonable as risk management has been widely practiced in the Malaysian construction industry. Apart from the traditional risk management approach, 16% of the public organisations also have disaster management in place to deal with disruptive events. The major concern in the result here however is the fact that most of the private organisations (28%) do not employ any of the aforementioned strategies in the organisations' operations, suggesting that majority of the organisations have no FMSRD. Similar issue arises with the public organisations, whereby 15% of the respondents claimed to have no FMSRD. Apart from that, based on further detailed analysis of the Mann-Whitney U test, the vulnerability and capability scores were identified to be significantly different at the 95% confidence level between the organisations that have FMSRD and those who do not. Table 7 shows that organisations with no FMSRD were more vulnerable to majority of the factors compared to those adopting specific FMSRD. The organisations with explicit FMSRD on the other hand had higher capability scores, suggesting that having a formal management approach could help improve the resilience of the supply chain to disruptions in construction projects.

[Insert Table 7 here]

Supply Chain Vulnerability and Capability Assessment

Level of Agreement on the Vulnerability and Capability Factors

Table 8 presents the results of the Spearman's rank correlations and the significance level between the different pairs of groups of respondents, in testing their level of agreement or disagreement on the vulnerability and capability factors. The results show a significantly high level of agreement between the consultants and contractors in ranking the vulnerability and capability factors, approximately 82% and 89% respectively. This shows that the consultants and contractors have similar views on the ranking of these factors, thus the results by both parties can be treated as an adequate representation of the private

organisations involved in public projects in this paper. The public organisations also seem to have relatively good agreement with the consultants and contractors in ranking the vulnerability factors, approximately 78% with the consultants and 77% with the contractors. Considering that these parties are within the same public sector supply chain, it is reasonable to have positive agreement on the supply chain vulnerability factors.

[Insert Table 8 here]

However, there seem to be conflicting views on the capability factors, with the lowest degree of agreement between the public organisations and consultants in ranking the capability factors, approximately 59%. Similarly, contrary opinions on the capability factors could also be observed in Table 8 between the public organisations and contractors, approximately 67%. The results therefore imply that there are opposing views on the level of capability between the public and private organisations.

In assessing the supply chain vulnerability and capability factors, the top five critical vulnerability factors of the public and private organisations in Table 9 are discussed along with the relevant capabilities in Table 10 that could address these critical areas of vulnerability.

[Insert Table 9 here]

[Insert Table 10 here]

Political or Legal Pressures

Survey findings identified that the public organisations are significantly more vulnerable to 'political or legal pressures' (mean rank = 59.81) than the private organisations (mean rank = 45.79) as per Table 11.

[Insert Table 11 here]

Understandably, the public organisations have an obligation to spend the public's money properly and wisely, following a set of rules and regulations, hence making them even more vulnerable to any political disruptions or strict and changing Government rules. In this regard, the Malaysian public sector has frequently faced political interference especially during the awarding of projects to the contractors and consultants (Jaafar and Radzi, 2013), which could potentially have contributed to the higher significance of this score within the public projects. It was reported that regardless of the procurement system adopted, the strong tendency of political involvement in awarding public projects contributes to the increase in the number of contracting private firms that are only interested in winning the contracts. This has consequently led to the contracting firms sub-letting the total project to other contractors or sub-contractors, which then raises the issue of payment due to the multi-layered sub-contracting (Jaafar and Radzi, 2013). Hence, although the private organisations are not as vulnerable to political pressures compared to the public organisations, political pressures could ultimately affect the the private organisations' operations. Changes in government regulations that vary from one state to another had also affected the public projects delivery. Regulatory frameworks involving multiple authorities at the federal, state and local levels that govern the construction industry in Malaysia can be very complex and difficult to navigate (CIDB, 2015). It has also been reported that certain states place restrictions in

gaining planning permission during the design phase of a project (CIDB, 2015), causing significant delay in delivering public projects. Abdul-Aziz and Ali (2004) argued that quite often, the lack of knowledge of government regulations and procedures of the consultants engaged by the public organisations had also resulted in confusion over the terms in the regulations. This ultimately creates disputes between the public and private organisations that can be costly in terms of time, money and effort. In this case, although the public organisations are highly adaptable (the highest capability in earlier Table 10) to potential political and legal pressures, a degree of transparency in communicating information with not just the organisations' stakeholders, but the contractors and consultants engaged are important to facilitate collaborative decision-making (rated as the lowest capability) and counteract such political interference.

Market Pressures

On the contrary, the private organisations, being more commercially motivated, gave a significantly higher vulnerability score of 'market pressures' (mean rank = 59.70) compared to the public organisations (mean rank = 46.68), as shown in earlier Table 11. The volatility of the external environment was felt most by the private sector as expected. This includes strong price competition and severe price fluctuations caused by the construction market and economy. The result is quite surprising considering that the private organisations claimed to have good financial strength (a top three capability in Table 10) to cover such financial threats. This means that financial strength alone is not sufficient to overcome the unforeseen unfavorable economic conditions. Poor economic conditions especially in developing countries can affect a construction project in so many ways such as escalation of material prices (Sweis et al., 2008), increase in the cost of financing and lower returns on investment (Toor and Ogunlana, 2008). For instance, the knock-on effect on the falling Ringgit Malaysia (RM) during the first quarter of 2015 due to declining global oil prices had resulted in the cost of overseas materials and equipment to be more expensive. Consequently, this had led to the local suppliers raising the price of imported materials, causing the local contractors to face severe material price fluctuations in their operations. Aziz (2017) reported that building materials such as imported steel have increased up to 40% in the last two years. Indeed, the local steel suppliers are still dependent upon foreign steel players (Adnan, 2017), making the contractors highly vulnerable to severe price fluctuations. Furthermore, additional costs such as related taxes and levies had also increased the local contractors' overall operating cost (Aziz, 2017). This can ultimately have a cascading impact on the public project supply chain.

Management Vulnerability

In terms of the management vulnerability, both the public and private organisations reported to be highly susceptible to the delayed timing of making business decisions (a sub-factor of 'management vulnerability' in earlier Table 9). Delay has indeed been a significant issue generally in the construction industry worldwide (Osei-Kyei and Chan, 2017; Sweis et al., 2008) and specifically in Malaysia as one of the main factors that hamper the performances of the local construction projects (Sambasivan and Soon, 2007; Chan, 2001). Delay in decision making by the public organisations is prevalent at the pre-construction phase. Abdul-Karim (2008) reported that the public projects had faced delays associated with acquiring the list of projects from ministries, preparing resources and master plans, and inadequate design brief causing delay to the subsequent project delivery on-site. The late approvals of the scope of works and in finalising design were attributed to the ineffective bureaucracy practice and the

involvement of multiple decision makers (Mehdi-Riazi and Lamari, 2013) in the various levels of departments of the public organisations. The unclear roles and responsibilities of these departments also contribute to the delays and errors of public sector professionals across the states and federal organisations in delivering public projects. Moreover, further detailed analysis shows that the lengthy decision-making process in the case of the public organisations is also potentially due to the organisations' low dispersion of key resources in a highly dispersed market (ranked #4 of 12 capability factors in Table 10). Chan (2001) agrees that the use of resources such as skilled labour are less plentiful in the less developed areas compared to the capital city in Malaysia, suggesting that the non-uniform distribution of resources could cause slow decision-making in public projects located across different geographic regions. The private organisations' market on the other hand is not as geographically dispersed as the public organisations (ranked #7 of 12 capability factors), but dealing with a large number of supply chain members (ranked #8 of 11 vulnerability factors) with production operations that are very complex might contribute to the late decision-making on the private organisations' part.

Liquidity or Credit Vulnerability

Financial vulnerability is also a top threat to the public organisations, based on the significantly lower score in 'financial strength' (mean rank = 45.07), as per Table 12, compared to the private organisations (mean rank = 61.39). This includes vulnerability to any changes in financial and economic policies and the lack of financial resources to cover all potential needs.

[Insert Table 12 here]

The result is quite surprising considering that as a Government body, it is expected that the public organisations should have sufficient funds to deliver the public projects effectively in the interest of their stakeholders, particularly the public. Hence, it might be the case that the insufficient funds were due to the public sector clients' poor financial resources (i.e. local ministries). This is a great concern as the financial vulnerability of the public organisations could cascade as an impact towards private organisations. Abdul-Kadir et al. (2005) highlighted the detrimental effects of such late payment which had resulted in suppliers not getting paid on time by the contractors, causing frequent disruptions in material acquisition and the loss of trust by the suppliers to the contractors. Hence despite the private organisations' good financial strength, it does not guarantee that the organisations can overcome the effect of under payment or late payment by the public organisations due to this cascading impact from a different supply chain. Contractors also tend to mobilise financial resources across public and private projects to maintain some consistency in the progress of concurrent work, hence any delayed payment arising from the public projects will subsequently affect the resources the contractors have to carry out other relative private sector projects.

Strategic Vulnerability

In the Malaysian public sector, it is common that the pre-construction tasks (i.e. designing, brief preparation, tender evaluation) are outsourced to external consultants (Abdul-Aziz and Ali, 2004). Indeed, the survey results show that the public organisations have high degree of outsourcing, a sub-factor of 'strategic vulnerability' in earlier Table 9 (ranked #4 of 11 vulnerability factors). Although this strategic initiative of outsourcing provides opportunity for the private organisations to be engaged in public projects, the survey shows that the public organisations are facing the risks associated with this

effort. Unlike the private organisations, the public organisations seem to have lost control over the visibility of the organisations' supply chain (mean rank = 45.20), hindering the collection of information and collaborative data sharing among project team members (mean rank = 46.40), as shown in the earlier Table 12. The loss of control and visibility reflects the public organisations' uncertainty on the state of the public sector supply chain, making it harder for the organisations to detect any disruptions arising from their supply chain and obtain the full picture of the current situation affecting the project delivery. In this case, Sheffi (2005) pointed out that managing additional suppliers and having deep relationships with multiple suppliers are often too costly to maintain, which explains why the public organisations have inadequate management control over the supply chain members (a top three vulnerability factor in Table 9). Plus, when disruptions occur, the private organisations who serve only as an alternative source to the public organisations may not be inclined to take the risk to invest ahead of time to help the public organisations who chose not to do business with them in the first place (Sheffi, 2005). Hence, the public organisations should consider either to deepen the relationships with key suppliers or distribute the connections with multiple suppliers for the procurement strategy to be successful.

Synthesis and the Layered Framework Development

The research findings indicated that the top five critical vulnerability factors of the public and private organisations include political or regulatory changes, market pressures, management, financial and strategic vulnerability. The public organisations faced significantly higher political threats compared to the private organisations, whilst the private organisations faced significant market pressures, as depicted in Figure 2. The survey results further highlights how such vulnerability arising from any part of the chain could impact another supply chain network at a different level. As shown through the layered cascading impact (CI) channels in Figure 2, the increase of material price by the suppliers and manufacturers (CI 1) due to the identified market pressures in supply chain B and C caused the contractors and sub-contractors to face price fluctuation in their operation. This subsequently resulted in the escalation of the overall cost of both the public and private projects that the supply chain partners are involved in. This shows how poor performance in one supply chain can result in a set of organisations entering a vicious cycle of poor performance based on the organisations' vulnerability levels. Figure 2 indicates this poor performance through the cascading impact channels.

[Insert Figure 2 here]

The survey also reveals how vulnerabilities arising from one organisation could ultimately affect the capabilities of other parties in the supply chain. The result shows that despite the private organisations' high capabilities in financial strength (as per the abovementioned Table 12), the public organisations' financial vulnerability had destabilised the entire supply chain. Late payment to the contractors by the public organisations in Figure 2 (CI 2) had caused delayed payment to the suppliers by contractors, resulting in frequent stoppage of material delivery (Abdul-Kadir et al., 2005), which subsequently hinder the overall work progress. Considering the public organisations' high degree of outsourcing, the public organisations should not think in isolation and should take into account other parties engaged in their supply chain network during project delivery. This is due to the fact that some of the the public organisations' actions could have an impact on a different supply chain where there are only private sector players. Ultimately, collaboration between the public and private organisations (which are still

poor based on the lowest ranking of this factor), are important to overcome these critical vulnerabilities that will not only impact the organisations individually but on the basis of a network of supply chains.

Conclusion and The Way Forward

This paper has shed light on the effects of interdependent supply chains within the public and private sector construction organisations in Malaysia. More critically the survey findings revealed that some of the capabilities had worked against the organisations' operations which made the organisations more vulnerable to other factors. For instance, the public organisations' strategic initiative to outsource most of their work had caused poor visibility of the organisations over their supply chain's operations. In terms of the disruption impacts, the contractors were identified to have faced higher repercussion of disruptions from public projects compared to other parties in the supply chain, suggesting that the impact of inefficiencies is sometimes not immediate and are often realised later in the project. It was also a big concern that majority of the contractors do not employ any FMSRD, suggesting that the contractors might have adopted short-term solutions to fix problems as it occurs during project delivery. The survey further revealed that organisations with no FMSRD were in fact more vulnerable to majority of the main factors assessed in the survey compared to those who employed explicit FMSRD.

This study also identified how the critical vulnerabilities could subsequently send out cascading impacts across supply chain through the layered framework. The critical political pressures and financial vulnerability of the public organisations, along with the market pressures faced by the private organisations could ultimately affect the supply chain network's operations in both the public and private sector projects. Indeed, the framework shows that what appeared to be an impact on the supply chain is proven to be an impact that cascades down several concurrent supply chains affecting several directly and indirectly connected parties across multiple layers. Understanding the dynamics of this cascading impact is important to identify key problems that often arise in construction projects. Although this study concentrated on public projects in Malaysia, this layered framework approach of the construction supply chains may offer advantages in similar contexts in other countries in terms of understanding the dynamics of the cascading impacts of vulnerabilities when observed through several supply chains. Future studies should also consider including other supply chain members such as the private clients, subcontractors and suppliers in assessing their vulnerabilities and capabilities. Furthermore, future research can also take this study forward by considering the dynamics and interdependencies in assessing vulnerabilities across several layers of supply chains not just in the construction industry, but other industries as well.

Overall, this paper has provided managers in the Malaysian construction industry with the relevant insights into the public organisations' and their supply chain partners' critical vulnerabilities and current capabilities, where the impacts might not have been obvious to the managers before. Considering that the vulnerability of any parties of the supply chains can indeed dramatically degrade the overall supply chain's resilience, collaboration among supply chain members is important in responding to the identified critical vulnerabilities. The industry could benefit from the use of innovative Information Technology (IT) tools such as Building Information Modelling (BIM) to improve transparency in information flow and encourage collaborative decision-making. This will, in turn, increase the visibility of the status and resources of the construction supply chain and improve their productivity in the construction operations. Partnering with key players in the construction supply chain is also important to

foster long-term relationships and improve supply chain resilience to disruptions in construction projects. Ultimately, there should be a coherent strategy where all organisations within the supply chain all pull together in the same direction with better goal congruence.

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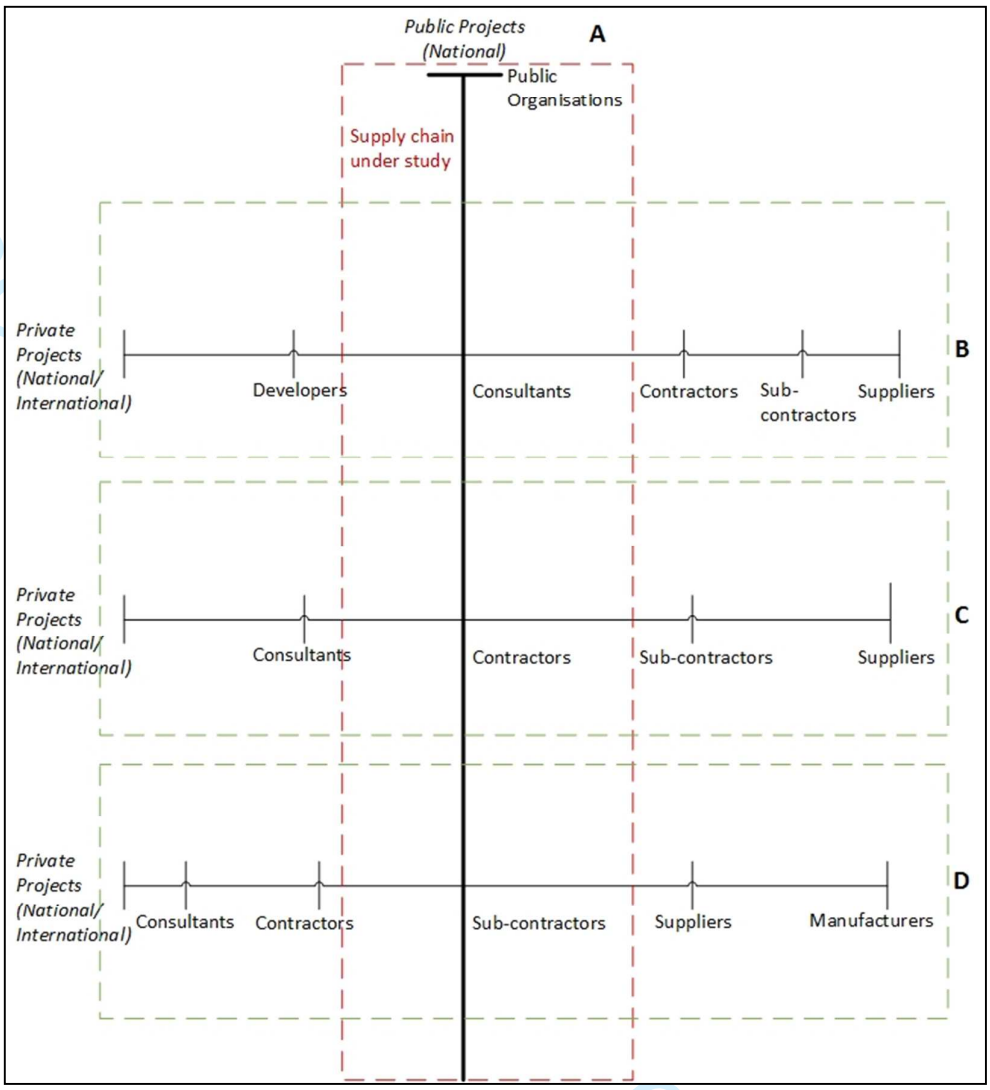

Fig. 1. Superimposing of the public and private supply chains in the Malaysian construction sector

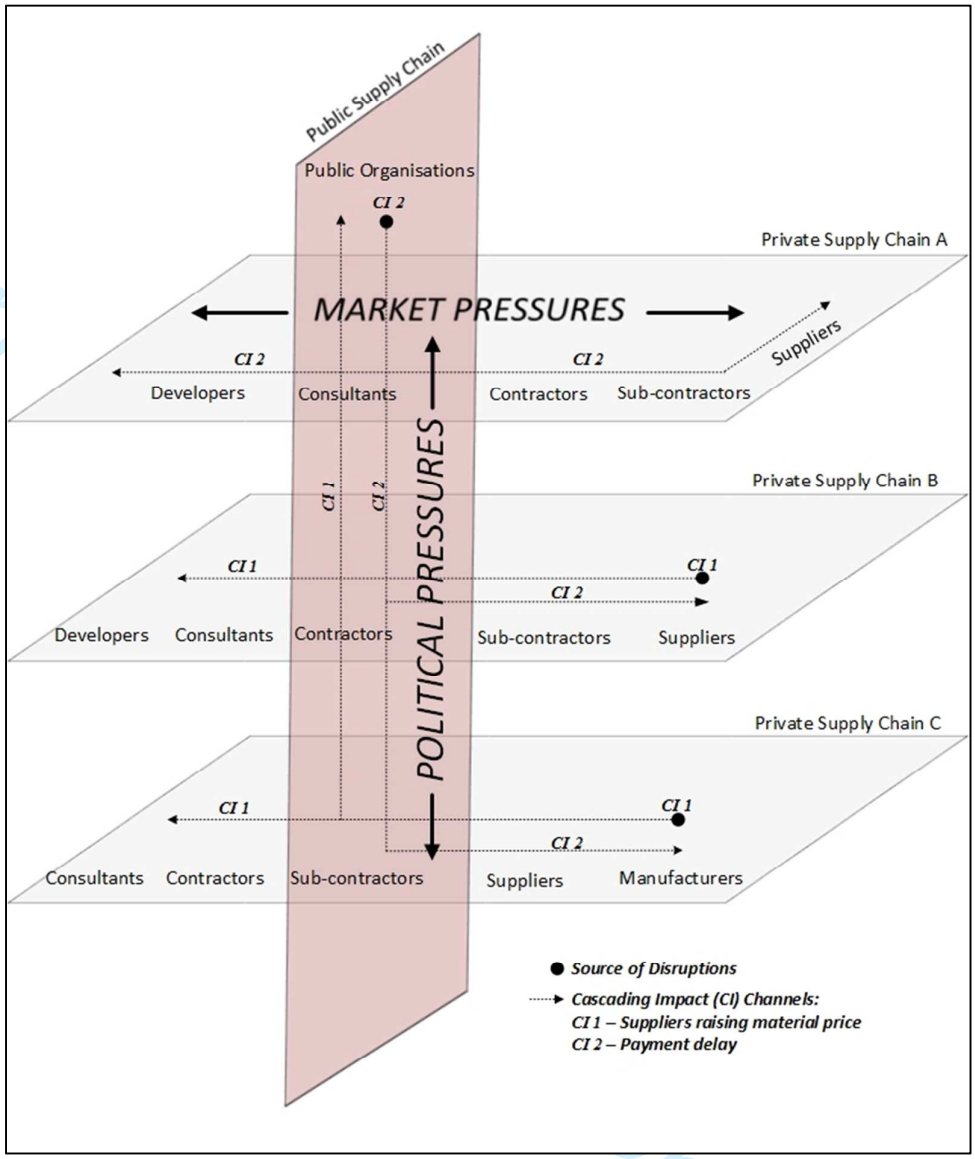

Fig. 2. Cascading impacts on supply chains represented through a layered framework

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Table 1. Definition of Main Vulnerability Factors

Main Vulnerability Factors	Definition	Chowdhury et al. (2012)	Pettit et al. (2010)	Blackhurst et al. (2008)	Sheffi (2005)	Christopher & Peck (2004)	Einarsson & Rausand (1998)
Strategic vulnerability	The inadequate strategic business decisions undertake by the firm on the products/services that the firm supplies.		X			X	
Management vulnerability	Vulnerability arising from poor management of the firm in executing the business decisions.				X	X	
Personnel vulnerability	Vulnerability arising from staff within the firm and human resources availability.		X				X
Process vulnerability	Vulnerability arising from the operation at any link of the supply-production-distribution chain.	X	X		X	X	
Supplier or customer disruptions	The susceptibility of suppliers and customers to disruptions.	X	X		X		
Technology disruptions	Disruption arising from technology changes in the industry.	X	X		X		
Political or legal pressures	Disruption arising from political or legal issues.		X				X
Environmental factors	Disruption due to external factors beyond the supply chain's control such as natural disaster.		X		X		X
Physical damage disruptions	Disruptions causing harm to the physical products, facilities or workers.		X	X	X		
Market pressures	Market influences that create business constraints or barriers.						X
Liquidity or credit vulnerability	Issues relating to money and poor management of monitory assets.				X		X

Table 2. Definition of Main Capability Factors

Main Capability Factors	Definition (adapted from Pettit et al., 2010)	Chowdhury et al. (2012)	Pettit et al. (2010)	Ponomarov & Holcomb (2009)	Blackhurst et al. (2008)	Sheffi (2005)	Christopher & Peck (2004)
Flexibility	Ability to quickly mobilise resources when required.	X	X	X	X	X	
Capacity	Availability of resources to enable continuous production levels.	X	X	X		X	X
Efficiency	Capability to produce outputs with minimum resources.	X	X	X		X	
Visibility	Knowledge of the status of current operating resources and the environment	X	X	X	X	X	
Adaptability	Ability to modify operations in response to disruptions or opportunities.	X	X	X		X	X
Anticipation	Ability to detect potential future disruptive events.	X	X	X	X	X	
Recovery	Ability to return to normal operational state promptly.	X	X			X	
Dispersion	Decentralisation of resources and customers.		X			X	
Collaboration	Ability to work effectively with other parties for mutual benefit.	X	X	X	X	X	
Market Position	Status of an organisation or its services/products in specific markets.	X	X	X			
Security	Defence against deliberate intrusions.	X	X			X	
Financial Strength	Capacity to absorb fluctuations in cash flow.		X				

Table 3. Respondents' Demographic Characteristics

Respondents' Demographic Characteristics		Number of respondents	Percent
1. Company	Public Organisations	54	51%
	Consultants (i.e. contract, engineering and architecture consultants)	26	25%
	Contractor	25	24%
	Total	105	100%
2. Profession	Project Manager	8	8%
	Engineer	55	52%
	Architect	7	7%
	Quantity Surveyor	5	5%
	Contractor	21	20%
	Other	9	8%
	Total	105	100%

Table 4. Internal Reliability of Vulnerability and Capability Factors

Main Factors (as per Table 1)	Number of Items	Cronbach's Alpha
V1. Strategic Vulnerability	6	0.520[a]
V2. Management Vulnerability	4	0.649
V3. Personnel Vulnerability	3	0.586[a]
V4. Process Vulnerability	8	0.872
V5. Supplier/ Customer Disruptions	5	0.819
V6. Technology Disruptions	2	0.734
V7. Political or Legal Pressures	2	0.683
V8. Environmental Factors	4	0.645
V9. Physical Damage Disruptions	3	0.785
V10. Market Pressures	2	0.737
V11. Liquidity/ Credit Vulnerability	2	0.699

[a] The mean inter-item correlation for V1 is 0.2 and V3 is 0.3 indicating that each item has good correlation with the domain (Briggs and Cheek, 1986)

Main Factors (as per Table 2)	Number of Items	Cronbach's Alpha
C1. Flexibility	5	0.829
C2. Capacity	3	0.715
C3. Efficiency	4	0.882
C4. Visibility	3	0.816
C5. Adaptability	4	0.825
C6. Anticipation	5	0.829
C7. Recovery	3	0.861
C8. Dispersion	4	0.747
C9. Collaboration	3	0.633
C10. Market Position	4	0.770
C11. Security	3	0.777
C12. Financial Strength	3	0.804

Table 5. Level of Frequency and Impact of Disruptions in Public Projects Perceived Differently by Public Organisations, Consultants and Contractors using Kruskal-Wallis Test

	Mean Rank			Test Statistics		
	Public Organisations	Consultants	Contractors	Chi-Square	*df*	*P*-value
Frequency of Disruptions	47.68	47.63	70.08	11.213	2	0.004
Severity of Impact of Disruptions	47.22	47.77	70.92	13.419	2	0.001

Table 6. Current management of disruptive events

Current Disruption Management Approach	Public Organisations	Private Organisations
Risk management	42%	25%
Crisis management	11%	13%
Emergency management	14%	21%
Business continuity management	3%	8%
Disaster management	16%	6%
None of the above	15%	28%

Table 7. Results of Vulnerability and Capability Factors Perceived Differently between Organisations with FMSRD and organisations without FMSRD using Mann-Whitney U Test

Vulnerability and Capability Factors	Mean Rank		Test Statistics		
	Organisations with FMSRD	Organisations without FMSRD	Mann-Whitney U	Z	*P*-value
Vulnerability Factors					
Personnel Vulnerability	48.64	62.52	874.00	-2.193	0.028
Process Vulnerability	48.90	61.94	893.00	-2.041	0.041
Supplier/Customer Disruptions	47.97	63.97	826.00	-2.514	0.012
Technology Vulnerability	48.88	61.98	891.50	-2.104	0.035
Political/Legal Pressures	48.99	61.74	899.50	-2.050	0.040
Environmental Factors	47.01	66.06	757.00	-3.000	0.003
Physical Damage Disruptions	48.07	63.76	833.00	-2.487	0.013
Liquidity/Credit Vulnerability	48.74	62.29	881.50	-2.212	0.027
Capability Factors					
Labor productivity	57.26	43.70	881.00	-2.290	0.022
Contingency planning	57.39	43.42	872.00	-2.419	0.016
Distributed decision-making	57.30	43.62	878.50	-2.292	0.022
Cyber-security	57.09	44.08	893.50	-2.250	0.024

Table 8: Spearman Rank Correlation

Groups of Respondents	Vulnerability		Capability	
	Spearman rank correlation coefficient	Significance level	Spearman rank correlation coefficient	Significance level
Consultants - Contractors	0.818	0.01	0.891	0.01
Public Organisations - Consultants	0.782	0.01	0.595	0.05
Public Organisations - Contractors	0.773	0.01	0.670	0.05

Table 9. Main Vulnerability Ranking and Scores of the Public and Private Organisations

Factor Label	Main Vulnerability Factors	Public Organisations			Private Organisations		
		Rank	Average Score	Standard Deviation	Rank	Average Score	Standard Deviation
V7	Political/Legal Pressures	1	3.66	0.78	4	3.33	0.66
V2	Management Vulnerability	2	3.58	0.48	2	3.44	0.74
V11	Liquidity/Credit Vulnerability	3	3.40	0.69	3	3.36	0.76
V1	Strategic Vulnerability	4	3.36	0.42	5	3.29	0.46
V10	Market Pressures	5	3.24	0.69	1	3.59	0.78
V6	Technology Disruptions	6	3.05	0.80	7	3.01	0.73
V4	Process Vulnerability	7	2.98	0.67	9	2.88	0.56
V8	Environmental Factors	8	2.96	0.63	6	3.11	0.63
V5	Supplier/Customer Disruptions	9	2.87	0.65	8	2.91	0.64
V3	Personnel Vulnerability	10	2.81	0.63	10	2.79	0.77
V9	Physical Damage Disruptions	11	2.62	0.65	11	2.63	0.77

Table 10. Main Capability Ranking and Scores of the Public and Private Organisations

Factor Label	Main Capability Factors	Public Organisations			Private Organisations		
		Rank	Average Score	Standard Deviation	Rank	Average Score	Standard Deviation
C5	Adaptability in Responding to Challenges	1	3.52	0.49	1	3.84	0.58
C11	Security against Deliberate Threats	2	3.47	0.58	4	3.62	0.51
C10	Market Position	3	3.44	0.58	6	3.60	0.50
C8	Dispersion of Resources & Customers	4	3.43	0.52	7	3.55	0.57
C4	Visibility of Supply Chain Operation	5	3.42	0.69	2	3.80	0.60
C7	Recovery from Disruptions	6	3.42	0.59	9	3.54	0.56
C6	Anticipation/Ability to Detect Potential Disruptions	7	3.38	0.56	8	3.54	0.52
C12	Financial Strength	8	3.36	0.55	3	3.72	0.52
C3	Efficiency in Operation	9	3.27	0.62	5	3.61	0.64
C1	Flexibility in Sourcing & Order Fulfillment	10	3.20	0.57	11	3.43	0.62
C2	Capacity of Resources	11	3.14	0.57	10	3.46	0.57
C9	Collaboration with Supply Chain Partners	12	3.12	0.55	12	3.27	0.53

Table 11. Results of Vulnerability Factors Perceived Differently between Public and Private Organisations using Mann-Whitney U Test

Vulnerability Factors	Mean Rank		Test Statistics		
	Public Organisations	Private Organisations	Mann-Whitney U	Z	*P*-value
Main Factors					
Political/Legal Pressures	59.81	45.79	1009.50	-2.425	0.015
Market Pressures	46.68	59.70	1035.50	-2.275	0.023
Sub-Factors					
Exposure to political disruptions	60.29	45.28	983.50	-2.692	0.007
Price pressures	47.17	59.18	1062.00	-2.165	0.030

Table 12. Results of Capability Factors Perceived Differently between Public and Private Organisations using Mann-Whitney U Test

Capability Factors	Mean Rank		Test Statistics		
	Public Organisations	Private Organisations	Mann-Whitney U	Z	*P*-value
Main Factors					
Visibility of Supply Chain Operation	45.20	61.25	956.00	-2.775	0.006
Financial Strength	45.07	61.39	949.00	-2.818	0.005
Sub-Factors					
Products, assets, people visibility	46.65	59.73	1034.00	-2.381	0.017
Collaborative information exchange	46.40	59.99	1020.50	-2.530	0.011
Financial reserves	46.17	60.24	1008.00	-2.632	0.008

	Reviewers Comments to Author	Authors Response to Reviewers Comments
	Reviewer 1 Comments:	
1.1	In the beginning of the paper, it was stated that there are a number of risks such as supply chain disruptions, geopolitical risks, cyber risks, natural catastrophes, etc. This paper seems to focus more supply chain disruptions and business/operational risks than other types of risks (such as natural disasters). If this is indeed the case, the scope should be more clearly stated in the beginning. Refining the scope is important because the ways in which organizations prepare and handles different types of risks would be different.	Necessary revisions have been included in the paper. Please refer to the highlighted texts in p.1 line 41 and line 49-51 of the paper.
1.2	This paper identified the main types of supply chain vulnerabilities facing public and private organizations in the context of Malaysia's construction industry through an industry survey. However, specific details are lacking in many places. For example, there was brief mention of the MATRADE project (p.2 line 3) but no project background and details were provided. What was this project? What were the specific supply chain problems? Were they related to logistics, supply of materials, conflict between stakeholders or other issues? What were the root causes?	More details of the MATRADE project added with background. Please refer highlighted texts in p.2 line 4-17 of the paper.
1.3	Disruptions were mentioned in many places of the paper but what exactly were these disruptions and what were the causes?	The inputs are provided under comments 1.2, 1.5, 1.6 and 1.15 in highlighting the causes of the supply chain disruptions.

1.4	The findings need to be presented in a more specific and targeted manner. Rather than just indicating public or private organizations, were they clients, consultants, contractors, sub-contractors or suppliers? Were they all aligned in their views on all of these issues? Seems unlikely. Different stakeholders within the chain may have different perceptions and thus respond differently or have different levels of susceptibility to certain types of vulnerabilities.	This is an important information by the reviewer. How we have tackled this is by adding a table with discussion on the levels of agreement between the public organisations, contractors and consultants in this study (refer p.7 line 48-56, and p.8 line 3-18). We hope this will be a good compromise in addressing the reviewer's comment considering the issue of space limitations of the paper. The data collected does not go into the level of granularity considering the suppliers and subcontractors. This will be highlighted as part of a future study.
1.5	P.7 line 35 - The findings show "public organisations are significantly more vulnerable to political or legal pressures". Were there previous incidents or events that led to this? What types of political and legal pressures do they face? Any specific examples?	This is an important observation by the reviewer. In fact, political pressures have affected the awarding of tender in public projects. Details of this have been added in the highlighted text in the paper (refer p.8 line 43-56 and p.9 line 3-8). References to such incidents have also been added (e.g. Jaafar and Radzi, 2013; CIDB, 2015; Abdul-Aziz and Ali, 2004).
1.6	P.8 line 22 - "... public and private organisations reported to be highly susceptible to the delayed timing of making business decisions ...". Again this is far too general. What types of decisions specifically? Decisions at what level?	Further details on this have been added in the highlighted text in the paper (refer p.9 line 51-56 and p.10 line 3-6).
1.7	P.10 line 40 - What does FMSRD stand for? The full term should be listed first before the abbreviation is repeatedly used.	The full term of the abbreviation FMSRD is listed in p.4 line 14.
1.8	More needs to be proposed for the conclusion and way forward. After these vulnerabilities were identified, then what? What recommendations can be proposed?	We have revised the paper and added our recommendations in the highlighted texts in p.12 line 33-39 and 49-56, and p.13 line 3.

1.9	P. 11 line 4 - If there are bottlenecks across the supply chain, it is more of a capacity problem rather than capability or vulnerability problem.	This has been revised accordingly in the highlighted text in p.12 line 41 of the paper.
1.10	10) As the name suggests, the journal has an emphasis on "innovation". What innovative solutions are there to tackle these vulnerability issues? Final Comment: There is a lot that need to be addressed and revised before this paper can be considered ready for publication in my opinion. Specifics and details are severely lacking in many places.	This is an important comment. We have included the potential innovative solution in p.12 line 49-56.
1.11	Additional Questions: Originality: Does the paper contain new and/or significant information adequate to justify publication?: There is significant information presented in this paper to certain degree. This paper identified the types of supply chain vulnerabilities in the context of Malaysia's construction industry through an industry survey with public and private organizations and using a layered framework approach but lacks specific details and investigation into the root causes.	We would like to thank the reviewer for the interests that this paper has generated, with regards to the comment on lack of specific details, we have added these specific details under our responses to comments 1.2, 1.5, 1.6 and 1.15 in this table.
1.12	Relationship to Seminal Literature: Does the paper demonstrate an adequate understanding of the relevant literature in the field and cite an appropriate range of literature sources? Is any significant work ignored?: Yes, the paper does demonstrate an adequate understanding of the literature in the field and a sufficient number of literature sources have been cited.	We would like to thank the reviewer for the comment on the literature review and synthesis.

1.13	Research Methodology: Is the paper's argument built on an appropriate base of theory, concepts, or other ideas? Has the research or equivalent intellectual work on which the paper is based been well designed? Are the methods employed, robust, defendable and appropriate?: Yes, based on a range of different vulnerabilities identified by other scholars and researchers in previous studies, an industry survey was conducted with public and private organizations in Malaysia, and followed by statistical analysis of the results. This was conducted in a manner comparable to other similar research work of this nature.	We appreciate the reviewer's acknowledgment of the appropriate research methods used in this paper.
1.14	Results: Are results presented clearly and analysed appropriately? Do the conclusions adequately tie together all elements of the paper?: The paper highlighted the main types of vulnerabilities (political/regulatory changes, market pressures, management, financial and strategic) facing public and private organizations. However, there is a lack of deeper analysis on the further breakdown of these organizations (i.e. clients vs. consultants vs. contractors vs. subcontractors vs. suppliers) as they are grouped together. Each stakeholder within the chain may have different perceptions on vulnerabilities and may prepare/react differently. The conclusions section needs to do a better job in highlighting more specifically what more can or should be done by the industry to address the problems. Right now, it is basically just a summary of the survey findings and leaves one wondering, "what next?" and "where do we go from here then?"	As highlighted in our response in comment 1.4, we have added Table 8 with discussion on the levels of agreement between the public organisations, contractors and consultants in this study (refer p.7 line 48-56, and p.8 line 3-18). These groups of respondents are the main representatives within the scope of this study. The data collected does not go into the level of granularity considering the suppliers and subcontractors. This will be highlighted as part of a future study. Conclusion has been revised accordingly under our response in comments 1.8 and 1.10.

1.15	Implications for research, practice and/or society: Does the paper identify clearly any implications for research, practice and/or society? Does the paper bridge the gap between theory and practice? How can the research be used in practice (economic and commercial impact), in teaching, to influence public policy, in research (contributing to the body of knowledge)? What is the impact upon society (influencing public attitudes, affecting quality of life)? Are these implications consistent with the findings and conclusions of the paper?: The five main types of vulnerabilities were repeatedly mentioned but again, it lacks specific actual examples and details. The root causes need to be further explained. For instance, were there any specific examples of political shocks (change of top-level leadership, filibustering, and/or particular policy changes) that brought significant disruptions in the construction supply chains)? The authors' mention of the falling Ringgit affecting cost of materials and equipment from overseas is one such example but much more is needed. Is the Malaysian construction industry heavily dependent on imported materials? Since the title of the paper indicates it is in the context of the Malaysia, I believe it would be of interest to readers if more specific examples from Malaysia can be drawn so we can learn more about the local industry.	The details on the political and legal pressures are added in the paper (refer p.8 line 43-56 and p.9 line 3-8). The vulnerability of the supply chain to material price fluctuations are also added in the highlighted texts in p.9 line 33-40 of the paper. We hope that this input provides further clarifications to the identified vulnerabilities.
1.16	Quality of Communication: Does the paper clearly express its case, measured against the technical language of the field and the expected knowledge of the journal's readership? Has attention been paid to the clarity of expression and readability, such as sentence structure, jargon use, acronyms, etc. Do the figures/tables aid the clarity of the paper?: In general, the technical language used in this paper is fine. It is readable and clear.	We would like to thank the reviewer for the comment on the quality of communication of the paper.

	Reviewer 2 Additional Questions:	
2.1	Originality: Does the paper contain new and/or significant information adequate to justify publication?: The paper provides some new insight into the level of resilience of construction supply chain in response to disruptive events in construction projects. The findings should help construction firms better identify their risks and prepare for the unexpected.	We would like to thank the reviewer for recognizing the new insights provided in this paper.
2.2	Relationship to Seminal Literature: Does the paper demonstrate an adequate understanding of the relevant literature in the field and cite an appropriate range of literature sources? Is any significant work ignored?: The literature review is rather comprehensive.	We appreciate the reviewer's comment on the literature review.
2.3	Research Methodology: Is the paper's argument built on an appropriate base of theory, concepts, or other ideas? Has the research or equivalent intellectual work on which the paper is based been well designed? Are the methods employed, robust, defendable and appropriate?: What was the sampling method? The findings show that some are from "public" and the other from "private". However, since this is about construction supply chain, it is paramount important to have the representation of a cross section of stakeholders in the industry including private client, subcontractor, suppliers, etc? Since they are not included in this study (by reading Table 3), how can one be sure of the representativeness of the results?	The sampling method is highlighted in the highlighted texts in p.5 line 29-34 of the paper. We have also added Table 8 in the paper along with the discussions in p.7 line 48-56, and p.8 line 3-18. The table gives analysed data on the different groups of respondents, but not necessary subcontractors and suppliers. The additional statistical analysis on the respondents' level of agreement in Table 8 shows that the contractors and consultants have high agreements on the ranking of the vulnerability and capability factors. The main scope of the paper was on public projects, whereby the three main groups identified in Table 8 are paramount. But we agree that a further extended study should include private projects and give further value and breakdown in terms of private client, subcontractors and suppliers. This will be therefore be included in future study. The conclusion has been amended accordingly (refer highlighted text in p.12 line 38-39).

2.4	Results: Are results presented clearly and analysed appropriately? Do the conclusions adequately tie together all elements of the paper?: How reliable are the results as the "private" group is represented by both consultant and contractor. Presumably their perception could be very different. Besides, it is difficult to compare the perception of the "public" sector and the that of the consultant and contractor (in the "private" group) in terms of their vulnerability and capability.	We have included Table 8 to clarify the level of agreement among the groups of respondents (refer response in comment 2.3). The contractors and consultants from the private organisations are respondents involved in the public projects, and are the supply chain partners of the public organisations. The private organisations' vulnerability and capability can be compared against the public organisations' to understand the dynamics of these capabilities and vulnerabilities and how they are affecting the other parties' operations, which this paper aims to address. We hope the additional Table 8 will be a good compromise in addressing the reviewer's comment.
2.5	Implications for research, practice and/or society: Does the paper identify clearly any implications for research, practice and/or society? Does the paper bridge the gap between theory and practice? How can the research be used in practice (economic and commercial impact), in teaching, to influence public policy, in research (contributing to the body of knowledge)? What is the impact upon society (influencing public attitudes, affecting quality of life)? Are these implications consistent with the findings and conclusions of the paper?: The research was based on a study in Malaysia, and it is not clear how can be results be generalised and applied to other countries.	This question relates to the replicability of findings to other contexts. Further clarifications on this have been added in the conclusion section (refer highlighted text in p.12 line 33-37) in the paper.

2.6	Quality of Communication: Does the paper clearly express its case, measured against the technical language of the field and the expected knowledge of the journal's readership? Has attention been paid to the clarity of expression and readability, such as sentence structure, jargon use, acronyms, etc. Do the figures/tables aid the clarity of the paper?: The paper should be proofread by native English speaker.	The full paper including the parts that have been highlighted have been checked for grammatical and typographical errors.