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The role of visibility in supply chain resilience:

A Resource-based approach

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ABSTRACT: *Today, supply chains are becoming more complex due to globalisation and its effects. This complexity is compounded when strategies such as lean and agile are applied to improve efficiency and flexibility in supply chains. Resilience is required to overcome supply chain disruptions. Many resilience antecedents have been identified in the supply chain literature, but many researchers focus on visibility to improve resilience. However, there is a limited research relative to firm's resources that contribute in improving supply chain resilience through visibility. As an early stage study, using Resource-based view, this paper aims to identify two main organisational resources for improving supply chain resilience and proposes a conceptual model to improve supply chain resilience through visibility.*

Key words: Supply chain, Resilience, Resource-based view, Visibility.

INTRODUCTION

Within the last three decades, business environment has witnessed an increase in supply chain network complexity in terms of number of tiers (vertical complexity) as well as the number of members in each tier (horizontal complexity) and increasing geographic distances (spatial complexity) (Bode & Wagner, 2015). In addition, a supply chain's complexity is intensified by the speed and flexibility requirements of globalisation (Masson, Iosif, MacKerron, & Fernie, 2007) and business modes such as mergers, acquisition, collaboration, joint ventures, outsourcing etc. (Isik, 2010). This increase in supply chain complexity has generally led to improved quality, enhanced customer satisfaction, increased market share, better delivery performance and cost reduction (Milgate, 2001). Nevertheless, firms have also been impacted with a surge of disruptions to their global network due to natural and man-made disasters which are results of increase in network complexity (Pereira, Christopher, & Silva, 2014). Bode and Wagner (2015) show that there is a positive relationship among vertical, horizontal and spatial complexity and the frequency of supply chain disruptions. On the other hand, each member of supply chain will have diverse tiers and processes with different

vulnerabilities and risk potential (Hearnshaw & Wilson, 2013). Hence, tight couplings in this network complexity are considered as a cause of increasing supply chain susceptibility to various disruptions (Gölgeci & Ponomarov, 2015). These disruptions culminate in immediate as well as long-term negative impacts on firms' performance and reputation (Blackhurst, Dunn, & Craighead, 2011).

Research challenge

In current globalised supply chains, which are traversing diverse countries or even continents, disruptive events even if they occur in a remote place to a member inevitably would jeopardise the smooth flow of material (Blackhurst et al., 2011). Recent findings from a survey of 525 respondents from 71 countries show 81% of participating companies experienced at least one disruption through their global supply chain in the last 12 months (Alcantara, 2014). Due to the network structure of the supply chains, all disruptions are being propagated and amplified causing drastic negative effects on the firms' abilities to meet their objectives. As a consequence of Japan's earthquake in 2011(Oskin, 2015), which was a recent catastrophic global event, Toyota was forced to suspend several manufacturing sites in different regions due to the shortage of raw material. As a result, Toyota lost its competitive position in the marketplace in 2011 (Ivanov, Sokolov, & Dolgui, 2014). Another severely affected firm following a major supply chain disruption is Intel which lost $ 1 billion of its potential revenue during Thailand's flood (Ivanov et al., 2014). Such incidents like these demonstrate that OEMs (original equipment manufacturers) or the supply chain at large require the capability to overcome disruptions to ensure the network remains operational both upstream and downstream.

It is frequently mentioned in the literature that a supply chain disruption impacts negatively upon the financial performance of the supply chain (Craighead, Blackhurst, Rungtusanatham, & Handfield, 2007; Hendricks & Singhal, 2003; Hendricks & Singhal, 2005). A random sample of 519 disruption announcements from 1989 to 2000 was analysed by Hendricks and Singhal (2003) to investigate how disruptions impact on a supply chain's long-term performance. They revealed that those companies which had a major disruption in their supply chains experienced a decline of 10% in their shareholder value after public announcement of the disruption.

Escalating pressure on margins have increased the tendency of firms towards employing lean and agile strategies aiming at reducing costs, through process improvement and waste elimination (Christopher & Towill, 2001). Although, lean and low-cost solutions help firms achieving better margins, but they may lead to vulnerable supply chains (Azevedo, Machado, Barroso, & Cruz-Machado, 2008; Peck, 2005). Christopher and Peck (2004) argue that resilience implies flexibility and agility, hence, it is necessary to develop agility capabilities to be a resilient supply chain. Consequently, it is clear that the main factors to survive in this business environment are not only the low cost, high quality and short delivery times but also the ability to overcome disturbances that may jeopardise the performance of a supply chain (Carvalho, Azevedo, & Cruz-Machado, 2012). Building a capability to absorb shocks or quickly recovering from drastic disruptions within a supply chain is crucial due to the fact that the success of a firm depends on the flow of material through its supply network (Sheffi & Rice Jr, 2005) even if information on the disruption is shared among supply chain members (Blackhurst et al., 2011).

Supply chain resilience

Despite the fact that much research has been done in the area of supply chain risk management, conventional supply chain risk management methods and tools would be only successful when potential disruptive risks can be identified (Pettit, Croxton, & Fiksel, 2013). These type of risks are influenced by the complexity of the production process and emerging new manufacturing methods such as 3D printing as well. Some studies had been done to predict the manufacturing techniques behaviour using numerical methods (Nikoukar, Patil, Pal, & Stucker, 2013; Pal et al., 2013) to prevent possible disruption, but the unpredictable environmental factors may not be predicted and should be taken into account in the planning.

Extant research (Ambulkar, Blackhurst, & Grawe, 2015; Gölgeci & Ponomarov, 2015; Pereira et al., 2014) and anecdotal evidence show that not all risks can be prevented or even foreseen in advance; therefore, supply chains need a new capability by which they could proactively be prepared for risks without requiring risk identification (Scholten, Scott, & Fynes, 2014). In supply chain literature, resilience is defined within two schools of thought: ability to respond and ability to

reach a better level. Some researchers consider supply chain resilience is a capability to either respond to or overcome an unexpected disruptive event (Blackhurst et al., 2011; Carvalho et al., 2012; Rice & Caniato, 2003); while others state supply chain resilience is a firm's ability to recover to better level after an disruptive event (Christopher & Peck, 2004; Tukamuhabwa, Stevenson, Busby, & Zorzini, 2015). Although firms cannot survive after a major disruption without being resilient, there is a lack of consensus among authors in the existing literature on the definition of a resilient supply chain (Mensah & Merkuryev, 2014; Tukamuhabwa et al., 2015). Some of the different definitions of supply chain resilience from the literature are summarised in Table 1.

Based on the various definitions identified, the majority of researchers agree that resilience can provide an ability for a supply chain to quickly recover to its original level of performance (Allen, Datta, & Christopher, 2006; Rice & Caniato, 2003; Sheffi & Rice Jr, 2005) or even to a desired higher level (Christopher & Peck, 2004; Christopher & Rutherford, 2004; Nikookar, Takala, Sahebi, & Kantola, 2014; Ponomarov & Holcomb, 2009; Tukamuhabwa et al., 2015). On the other hand, the ultimate goal of every supply chain is delivering the final product to end users at the right time, with the right quantity and in the right quality with the possible lowest cost to improve customer satisfaction (Elmuti, 2002; Koskinen, Sahebi, Nikookar, & Zhan, 2013; Levi, Kaminsky, & Levi, 2003; Schönsleben, 2007; Stock & Boyer, 2009). Since, a supply chain is defined as a 'set of three or more entities (organisations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer' (Mentzer et al., 2001). Further, in current business environment, firms do not individually compete against each other, but rather through their supply chains (Mills, Schmitz, & Frizelle, 2004).

Insert Table 1 here

Hence, we believe that a definition of resilient supply chain should encompass commitment of the supply chain to deliver the final products and /or services to the end-users. Therefore, we define the best resilience of a supply chain as ***the capability of a supply chain to deliver its commitments to the end customers at the right time, with the right quantity, in the same quality, and possibly with the same cost both during and after a disruptive situation.***

Resilient capability of supply chains is generally gained by increased resilience of their constituents. Therefore, resilience is more meaningful if it is jointly developed, deployed and utilised by all supply chain members rather than through discrete and possibly ineffective efforts of individual firms within a system that includes weak members (Gölgeci & Ponomarov, 2015). Although resilience is frequently mentioned in the literature as a strategic necessity of current business environment, but existing literature only provide a general overview on resilience in supply chain management (Blackhurst et al., 2011).

While disruptive events are inevitable in complex supply chains, firms can deploy mechanisms to improve their resilience and reduce their vulnerability to disruption (Sheffi & Rice Jr, 2005). A resilience enhancer is defined as the capability of firms to react to and recover from disruptions efficiently (Blackhurst et al., 2011). Flexibility, redundancy, agility, collaboration innovation are some of the supply chain resilience antecedents reported in the literature (Ambulkar et al., 2015; Blackhurst et al., 2011; Gölgeci & Ponomarov, 2015; Mandal, 2014; Marley, Ward, & Hill, 2014; C. R. Pereira et al., 2014; Scholten et al., 2014; Wieland & Marcus Wallenburg, 2013). One of the most reported capabilities to improve the resilience of a supply chain is visibility (Alcantara, 2014; Blackhurst et al., 2011; Brandon-Jones, Squire, Autry, & Petersen, 2014). However, to the best of our knowledge with the exception of a study by Brandon-Jones et al. in 2014, the literature lacks empirical support for the relationship between visibility and resilience. A review of existing literature by Moberg et al. (2002) shows that quality of information and trust among supply chain members play a dominant role in improving value of information in terms of validity and reliability. Therefore, this research examines two dominant antecedents of visibility: trust and information quality on resilience.

In our proposed model, trust and information are combined to create visibility (a capability) through which firms are able to improve resilience (Figure 1).

Insert Figure 1 here

In this paper, first we look at the literature on Resource-based view (RBV) and explore the application of this RBV to formulate resilience capability of a supply chain. Then we review the current literature on supply chain visibility and discuss the factors that influence visibility and hypothesise the relationships among these factors and supply chain resilience. We then present a potential methodology to test this conceptual model.

THEORITICAL BACKGROUND

The principle aim of this early stage study is to help supply chains to function efficiently both in normal and disruptive situations. To reach this goal, this study uses RBV (Barney, 1991; Barney, Wright, & Ketchen, 2001; Wernerfelt, 1984) to improve our understanding on improving resilience of supply chains and shape our future resilience assessment model. RBV argues that a firm is a combination of resources including tangible resources (e.g. equipment) and intangible resources (e.g. knowledge). Organisations bundle their resources to create new capabilities which may culminate in competitive advantage (Wernerfelt, 1984) and improvement in performance (Barney, 1991).

Resource- Based View

Sheffi and Rice (2005) argue that disruptions inevitably occur in global supply chains, but firms can invest on developing capabilities to help sustain smooth flow of material or recover quickly in the event of many disruptions. On the other hand, RBV relies on the assumption that a firm is a set of different resources which can be utilised individually or combined to create capabilities that may culminate in achieving a sustained competitive advantage (Wernerfelt, 1984). In this regard, our study applies RBV to develop a preliminary conceptual model, which is illustrated in Figure 1, based on

firm's resources to deal with supply chain disruption and improve the overall performance of the supply chain.

Nevertheless, that some resources of a firm may have no effect or negative effect on a firm's performance or even prevent the firm from implementing efficient strategies (Barney, 1986) However, in our RBV approach, we consider solely the resources which facilitate the implementation of strategies that help improve the firm's performances. Various authors have classified a firm's resources in various groups (Blackhurst et al., 2011; Brandon-Jones et al., 2014). For example, Grant (1991) proposes classification in terms of financial, technological and reputational aspects of firms.

Barney (1991) categorised a firms resources into three categories:

1. Physical capital resources
2. Human capital resources
3. Organisational capital resources

We adopt Barney's (1991) classification for the purpose of this study. Physical capital resources are tangible assets of a firm including equipment, plants and all its infrastructure, raw materials and others (Williamson, 1975). Human capital resources include intangible possessions of a firm related to human resources such as experience, individual differences, knowledge, trust and others (Becker, 2009). Organisational capital resources are also intangible and relevant to organisational behaviour such as groups, organisational climate and culture.

Various types of resources should be combined to create organisational capability. The organisational capability enables a firm to reach competitive advantage in the marketplace. Blackhurst et al (2011) state that different types of resources have to be bundled together in order to develop an efficient capability for mitigating the drastic consequence of risks in supply chains. Trust, which is a human capital resource, and quality of information, which is an organisational capital resource, as two prominent capital resources have been investigated by different supply chain researchers (Chu, Chang, & Huang, 2012; McDowell, Harris, & Gibson, 2013; Petersen, Ragatz, & Monczka, 2005; Tsanos, Zografos, & Harrison, 2014). Hong et al. (2012) illustrate, within a supply chain, high level

of trust is an organisational resource among supply chain partners that leads to improving joint operational activities. Lin (2014) considers trust and quality of information as two intangible resources that ehance supply chain integration. Hence, we also consider trust and quality of information as two important capital resources which can be combined to improve the resilience of a supply chain

Visibility

Visibility has received much attention in literature as a useful cure for supply chain disruption (Alcantara, 2014) and a number of proposed conceptual frameworks present visibility as a resilience enabler for enhancing the resilience of a supply chain (Blackhurst et al., 2011; Brandon-Jones et al., 2014). For example Wieland & Wallenburg (2013) propose visibility is a critical factor in improving agility and resilience of any supply chain. They argue that sensing and gaining knowledge on actual changes that are happening in the environment will improve the preparedness of a firm in the event of any major change such as disruption in the flow of material and implore the need of visibility to achieve that knowledge.

Visibility in the supply chain context is defined as ’the extent to which actors within a supply chain have access to or share information which they consider as key or useful to their operations and will be of mutual benefit‘ (Barratt & Oke, 2007, P 1218). Therefore, a higher level of visibility can be achieved depending on accuracy, usefulness and timeliness of the shared information among supply chain partners. Improved visibility within a supply chain allows supply chain members to see the actual state of the supply chain in terms of the level of inventory, demand and the potential risk throughout the supply chain. Improved visibility also helps firms to trace disruptions and its pattern of propagation. Incorporating these factors in the decision-making process can help managers effectively deal with disruptions (Blackhurst et al., 2011). Hence, it is hypothesised that:

Hypothesis 1: Supply chain visibility has a positive influence on supply chain resilience.

Quality of information

Although transmission of information forms the basis of visibility, it is particularly important to determine how information transmission provides supply chain with visibility or even enhance visibility. Brandon-Jones et al. (2014) claim that 'supply chain connectivity' and 'supply chain information sharing' are two organisational resources which can be combined to improve supply chain resilience. They argue that 'information sharing' and 'supply chain connectivity' improves the level of visibility in a supply chain and consequently, resilience of the supply chain is enhanced by improved visibility.

Visibility is created in a supply chain, when supply chain partners share information among them, but this visiblity can enhance the performance of the supply chain if the transmitted information is incorporated into the decision-making process of the recipient only (Barratt & Oke, 2007). Thus, not only the ways the information is shared are important and have to be considered but also the value of information should be taken into account as well. Validity and reliability of information determine the value of information. Information is considered invaluable, if it has poor validity and reliability (Moberg, Cutler, Gross, & Speh, 2002). Hence, there is a need to determine what resources contribute in providing valuable information which may result in improving visibility through a supply chain and assessing what is a valuable information.

The quality of information is considered in terms of accuracy, timeliness and formatting of the information (Moberg et al., 2002). For managers to incorporate the received information into a decision-making process the information quality must be of an acceptable level. Transmitted information would significantly impact upon supply chain performance only if the shared information is at the right time and right type with a right person (Holmberg, 2000). Therefore, the second hypothesise is formed as:

Hypothesis 2: Quality of information has a positive influence on supply chain visibility.

Trust

A considerable volume of research in trust in organisational science shows the prominent role of trust in inter-organisational as well as intra-organisational relationships. Trust, which is similar to other organisational constructs, has been investigated in varying levels of analysis including individual-level, team-level, organisational level, and inter-organisational level. In this study, trust is investigated as an inter-organisational resource among supply chain members.

In management science, trust is defined as 'a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behaviour of another' (Rousseau, Sitkin, Burt, & Camerer, 1998). Based on this definition, trust in a supply chain context is considered as the eagerness of supply chain partners to rely on each other in whom at least one has confidence (Li & Lin, 2006). Rousseau et al. (1998) state that trust has different levels and it accumulates over time. Trust is enhanced or undermined as relationships between two parties advance (Brinkhoff, Özer, & Sargut, 2015) and is cited as one of the crucial factors that help forms productive relationship among supply chain members (Wilson & Vlosky, 1998).

Similar to information quality, trust as an organisational resource can be combined to create a competitive advantage (Barney & Hansen, 1994; Kraaijenbrink, Spender, & Groen, 2010) and also has a significant role on supply chain visibility due to the fact that trust determines the kind of information the firms are willing to share with their partners through a supply chain (Özer, Zheng, & Chen, 2011). Brinkhoff et al. (2015) argue that trust is the main determinant in sharing the level of critical information among supply chain members. Hence, levels of trust become very important in the event of disruption. For example, transaction data is regarded as highly confidential data in every firm since competitors' access to this data can jeopardise a firm's competitive position in the marketplace. On the other hand in an event of supply chain disruption in upstream level, it is essential for downstream members to have access to transaction data to assess the impact of this disruption and to decide on alternate plans to mitigate the impact, if possible. Transaction data allow downstream partners to determine status of the material flow from their suppliers and apply suitable strategies to either survive or overcome the crisis. Li and Lin (2006) explain that a supply chain react more

effectively in the case of difficulties such as disruption when all members trust each other. Therefore we hypothesise that:

Hypothesis 3: Trust has a positive influence on supply chain visibility.

PROPOSED RESEARCH METHOD

Our research aims to examine the relationship between visibility and resilience of supply chains as well as testing the relationships between two proposed organisational resources as antecedents of visibility within the supply chain context. The level of analysis employed in this study is at the system level, with data collected from a group of firms including manufacturing companies, particularly OEMs, and their immediate upstream and downstream partners. The main respondents of our study will be supply managers as well as sales managers due to their knowledge in the area of interest including supply chain, supply chain disruption, information sharing in supply chain context and supply chain resilience. A cross-sectional survey is proposed as the instrument to collect data. If all members of the population have access to the internet, a web-based survey followed by a surface mail notification can achieve a considerably greater response rate than a paper-based survey sent by regular mail (Couper, Traugott, & Lamias, 2001; Kaplowitz, Hadlock, & Levine, 2004). Due to the availability, popularity and easiness of email, we propose to use an internet-based survey along with an email notification.

The items of the survey are being adopted from existing scales in the literature. We expect that for some of our variables, there is no suitable measure in the literature. In this case, in line with Brandon-Jones et al. (2014), we will apply Churchill's (1979) procedure for developing a new scale. According to Churchill (1979) the procedure of developing a better measure of variable starts with a comprehensive literature review, followed by pretesting with academics and professionals.

Brandon-Jones et al. (2014) propose confirmatory factor analysis (CFA) to analyse and estimate multi-scale variables. Since our potential constructs will be multi-scale, we also planned to use CFA to estimate properties of our constructs.

CONCLUSION

From a comprehensive review of the extant literature on supply chain resilience, it is found that there is lack of empirical studies to test relationships between supply chain resilience and its antecedents. The goal of the proposed study is to overcome this gap and provide a basis for a future empirical research. The relationships between trust and information quality as two main antecedents of visibility and resilience in supply chain management had been conceptualised. Toward this goal, three hypothesises are to be tested in an empirical research. Further, our proposed new definition on the level of resilience of a supply chain is in the process of getting validated in a separate empirical study and we are in the process of assessing the level of resilience of a supply chain as well. However, the research framework described in this paper, once validated, will offer two helpful managerial implications in the area of supply chain management. Firstly, the outcomes of this study will help managers to improve the resilience of supply chains by improving visibility. Secondly this study aims to find new ways which are more affordable, to improve the level of information quality to improve the visibility of supply chain thus enhancing resilience of a supply chain.

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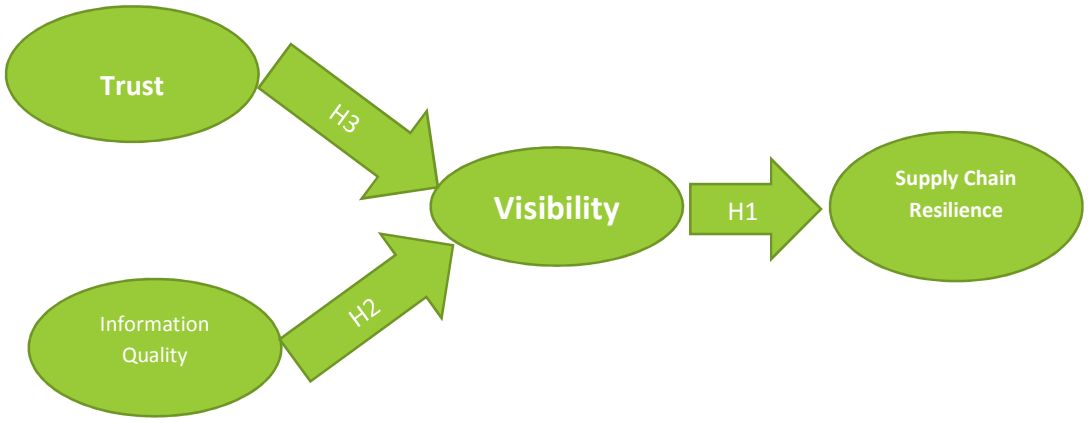
Figure 1: Conceptual model



Definition	Resource
"The capability of the firm to be alert to, adapt to, and quickly respond to changes brought by a supply chain disruption."	(Ambulkar et al., 2015)
"an adaptive capability of a supply chain to prepare for and/or respond to disruptions, to make a timely and cost effective recovery, and therefore progress to a post-disruption state of operations – ideally, a better state than prior to the disruption"	(Tukamuhabwa et al., 2015)
"Supply chain resilience is defined here as the capability of supply chains to respond quickly to unexpected events so as to restore operations to the previous performance level or even to a new and better one."	(C. R. Pereira et al., 2014)
"Resilience is the ability of a system to return to its original state, within an acceptable period of time, after being disturbed."	(Brandon-Jones et al., 2014)
"The adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function."	(Ponomarov & Holcomb, 2009)
"The ability of a supply chain to bounce back from a disruption."	(Sheffi & Rice Jr, 2005)
"The ability of a system to return to its original state or move to new, more desirable state after being disturbed."	(Christopher & Peck, 2004)
"Resilience is the ability of a supply network to respond to unexpected disruptions and restore normal supply network operations."	(Rice & Caniato, 2003)

Table 1: Resilience supply chain definitions