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A Literature Review of Disruption and Sustainability in Supply Chains

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Abstract *A search was conducted for peer-reviewed academic literature in the management and business field that relates to the topics of disruption and sustainability in supply chains. A limited set of relevant papers were identified that are dominated by a single journal (the International Journal of Production Economics) suggesting that the reviewed area is still in its early stages of development. Where sustainability features in the literature the discussion tends to concentrate on trade-offs between economic and environmental aspects, with social aspects, on the whole, ignored.*

1. Introduction

One of the key features of the modern world economy is the reliance on supply chains that span the globe. However, with this reliance comes increased recognition that such widespread supply chains are vulnerable to disruption and that these important economic structures impact on other areas of importance such as the environmental and social fabric of our world, i.e. the issue of sustainability. In this paper we aim to take stock of how this extended interest in disruption and sustainability in supply chains has fed through to the academic literature for business and management by carrying out an analysis of peer-reviewed journal and conference papers. Our main findings show that although there is a great deal of interest in the topic, this has not yet resulted in a substantial literature dealing with the impact of supply chain disruption on sustainability. Where the literature does deal with sustainability, it tends to concentrate on the interaction between economic and environmental aspects and displays little, if any, contact with the social aspect. The paper's structure is as follows: to begin with, some background points are made regarding disaster, sustainability and resilience, then a summary of the methodology is provided; continuing from this, the main themes of disruption and sustainability are reviewed and the paper ends with a conclusion.

2. Background

Disruption can take form in numerous ways, either being natural such as earthquakes and hurricanes or man-made such as terrorist attacks or wars. Although some academics have sought to define supply chain disruption such as, Schmidt and Raman [31] who define it as 'an unplanned event that adversely affects a firm's normal operations' there is no one universally-accepted definition of disruption to date. Although there is no universally-accepted definition of disruption till date, the effects of disruption on business and society are evident; for example, a UN report [37] on disaster risk and resilience states that in the past thirteen years, natural-hazards-related deaths have surpassed 1.1 million and more than 2.7 billion people have been affected by natural hazards. Although every country is prone to disruptions -as evidenced by the 9/11 terrorist attack on America and the 2011 earthquake in Japan which the Japan International Cooperation Agency - JICA [16] states resulted in 19,864 deaths and estimated damage of US$ million 210,000 - the UN 2012 report on disaster risk and resilience declares that disruptions will have a more significant impact on the least-developed countries and could destroy development gains which have been built up over decades. The effects of disasters vary and the uncertainty and unexpectedness makes a disaster and its potential damage difficult to predict and quantify. For example, hurricane Katrina left 1,800 dead people in New Orleans and thousands homeless [27]; whereas the South-East Asian tsunami killed 228,000 people across 14 countries and destroyed homes, infrastructure, and industry [16].

Sustainability has received enormous attention from researchers, practitioners, government and society as a whole. The recognition of sustainability as an important research and practical issue has been established since the 1987 Brundtland report [36] and recognition has expanded not only to governments and industry, but to individuals in society. Sustainability can be seen to be interconnected with disasters as one cause of some natural disasters could be the unsustainable practices that are carried out every day around the world thereby bringing about negative changes in the natural ecological system.

The notion of resilience can be seen as a sub-section of sustainability, as defined at the Centre for Resilience at the Ohio State University [28] "The capacity of a system to survive, adapt, and grow in the face of unforeseen changes, even catastrophic incidents." On the other hand, the Dow Jones Sustainability index defines sustainability as "a business approach that creates long-term shareholder value by embracing opportunities and managing risks deriving from economic, environmental and social developments" [28]. Thereby resilience could be viewed as providing a functioning tool for acknowledging, improving and measuring sustainability [28]. Recently, academics and industrialists have become increasingly interested in the notion of resilience and its importance in improving

the quality of supply management. Studies have included issues of how to make a supply chain more resilient [5], [8], [11], [12], [17], [32].

3. Methodology

To identify the literature, we searched initially the key academic database 'Web of Science'. This academic database was used because it is the premier bibliographical database which is prominent for its gold standard and citation indexing thereby providing high quality reliable papers. We used the search term '(Disruption OR disaster OR emergenc* OR crisis*) AND (sustainab* OR resilience OR robustness) AND ((supply OR value) AND (network OR chain))'. This search term was used because three key elements; disruption being the causal factor, resilience being the system type response required and supply chain being the context in which they take place; were required conjunctively. Searching for the above phrase in the full text of papers within the Web of Science database produced 449 hits. This search was further refined to the two research domains of science technology and social sciences which reduced the results to 371. After this step, the search was refined further to the research area of operations research management due to this being the nearest relevant category in the Web of Science to the area of interest which yielded 88 results. For these 88 results, the titles were manually scanned for relevant titles such as 'Sustainable supply management: An empirical study' and the abstracts for the relevant titles were read in order to decide if they were suitable for this literature review. This step led us to 18 academic peer-reviewed journal and conference papers that were considered to be particularly relevant to our review. Conference papers were used because this is a topic in its early stages thereby there is emerging literature which is coming out through conference papers. We added to these 18 papers 19 other relevant peer-reviewed academic papers under the topics of disaster, crisis and sustainability that had been collected over a one-year period leading up to the review. Further to this, we used the snowballing effect whereby we also added 11 additional, relevant papers which were cited and referenced in the papers found in our initial search process (See Table 1). This search process culminated in a pool of 48 academic papers; however after thorough reading and analysis, only 5 out of those 11 papers were deemed relevant to include within the text of this paper. Thus, the total number of references in this paper was 42.

***Table 1:** Collection of papers*

Source of Papers	Number of Papers
Collection of peer reviewed papers over a one year period	19
Web of Science	18
Snowballing effect and conferences	5
Total	**42**

4. Results

The immaturity of the field is signalled by a single journal dominating the set of papers – the International Journal of Production Economics -with 14 papers. This predominance is partially explained by a special issue on improving disaster supply chain management. The next frequently-occurring journal is Production and Operations Management with four papers.

4.1 Disruption

Early literature regarding disruption emphasises the need to prevent and protect one's company against facing disruption. However, this emphasis has now shifted to a longer-term approach which is to recognise disruptions and strengthen the company's preparedness in order to build resilience towards disruption risks [5], [12], [18], [32], [37]. Researchers have recognised that supply chains are becoming increasingly interconnected which therefore means the effects of disruptions can surpass the actual point of disruption, potentially, across entire supply chains thereby having far-reaching effects [13], [18]. A number of researchers [4], [11], [17], [35], [39] believe that the phenomenon of just-in-time (JIT) has worsened the effects of disruption. The use of JIT to reduce cost and improve competitiveness may be effective in a stable environment but can be destructive if a disaster strikes due to the JIT system being less flexible [32]. Barker and Santos [5] added to the belief that JIT worsens the effect of disruptions by using quantitative modelling to investigate how different risk management strategies that involve inventory will affect recovery after a disruption. Their results evidenced that having inventory available can ease some of the burden which the physical disruption has caused to production; whereas this option would not be available if a JIT approach was being adopted by a company. For example, a calculation from one of their studies found a $2.2 million economic loss in the sector being investigated over the span of thirty days; however, if inventory worth $400,000 was at hand, this would have covered one day's worth of the total sector's output and the economic loss would not have been as severe [5].

Other researchers such as Schmitt and Singh [31] have also added to the literature with a similar point made. By using a two-echelon model, these authors argued that when disruptions may be present inventory should be flexible and should be increased regardless of the cost structure of the company, as the effect of disruptions can be worse and last for a longer duration if inventory levels are not increased and flexible. Their studies also show that inventory should be closer to the customer as this allows disruptions which are more upstream in the network to not disrupt the inventory delivery to customers.

The literature further provides theoretical ideas which are aimed at preparing a company to reduce the effects of risky events by making a supply chain resilient. One frequently-occurring idea is collaboration by sharing information between the entire supply chain [9], [13], [14], [32], [34]. For example, Lanza et al. [25] believe that there are many desirable outcomes if firms in the supply chain engage in relevant information sharing such as being able to quantify risk and improved decision making by reducing the complexity of decision making. Adding to this, Lanza et al. [25] have gone as far as to say that the weakness in existing business models is because of the reluctance to share information. Despite the current literature recognising the need for information sharing to enhance a company's preparedness towards risks, the technicalities in the current literature are limited or non-existent on: how to share information, the channel through which it should be communicated; the method in which it should be used, shared and stored effectively and the difficulties involved in the sharing of information, such as privacy issues. This can be evidenced by the New Orleans hurricane Katrina for which Moynnihan [27] believes there was enough warning yet responders did not successfully convert the information of warning into an appropriate level of preparation for the scope of the disaster.

Cohen and Kunreuther [9] contributed to the literature of preparing for low frequency and high impact disasters with a conceptual framework which incorporates three steps: (1) Risk assessment and vulnerability analysis along with risk perception (2) Risk Management strategies and (3) Evaluation of strategies. Other such risk identification processes have also been produced by researchers such as Neiger et al. [29] and Knemeyer et al. [20]. Knemeyer et al.'s [20] four-step proactive process for risk identification is recognised as an extension of Kleindorfer's conceptual framework (see Figure 1). Despite this being a practical process, the use of such a practical process in order to deal with risks that can cause disruptions to supply chains in the real business world is still questionable as a Zurich report [42] states that although 47% of organisations surveyed claim to review or monitor risk in their supply chain, over 55% of organisations studied have not reviewed this risk within the last six months due to unavailability of time. Inevitably, the process designed by Knemeyer et al. [20] is not a one-day process

but a cross-functional process which requires the on-going time and expertise of each functional department in an organisation as the nature of risk is unpredictable and potential risks can alter from day to day. Such practical processes may also be difficult to follow in reality due to the increasing interconnectedness of organisations; this point is reinforced by Brintrup et al. [7] which state that a supply chain is complex with many lateral connections and thereby a firm is indirectly dependent on all its suppliers right down to the bottom of the supply chain, not just its immediate suppliers. Therefore this means that for an accurate evaluation of risk, this process would need to be followed up by all the critical suppliers in the supply chain as an organisation does not operate in isolation – such an intensive process is seemingly unmanageable.

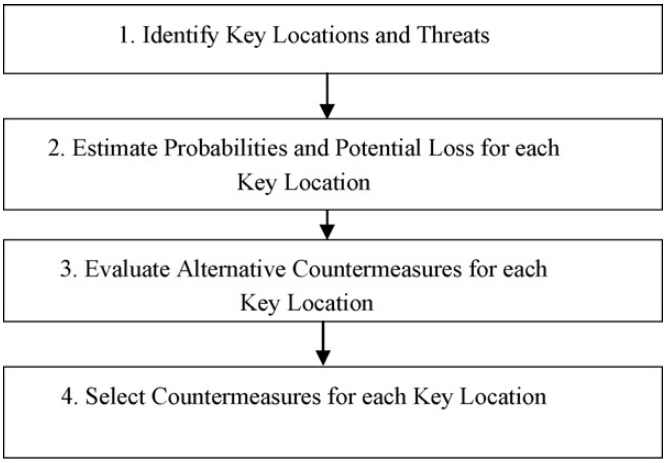

***Figure 1**. A proactive process for identifying and planning for catastrophic events [20]*

4.2 Sustainability

Research on the relationship between supply chain capabilities and sustainability is growing; the literature regarding sustainability has shifted from being viewed as a trade-off between expenses and economic growth to an essential practice for industry which aids the growth of an organisation [19]. Companies are beginning to realise the impact they can have on sustainability metrics; as an example, the proportion of the top 250 companies drawn from the Fortune Global 500 list that report on their social and environmental performance has increased from about 80 per cent in 2008 to 95 per cent in 2011 [21]. Having said this, some academics are of the opinion that organisations engage in sustainability as a marketing mechanism to improve their image with their customers and other stakeholders, and not for any of the triple bottom line reasons such as cost reduction [1].

Academics have found a positive relationship between sustainable supply chain management and economic growth of a company [2], [39]. For example, a model-testing study by Zhu et al. [41] of 341 manufacturers demonstrated a positive correlation between green supply chain management and factors such as environmental and economic performance. A study by Liu et al. [26] also confirms this by using a survey and calculating the regression line to indicate a positive relationship between specific supply chain capabilities and the implementation of green logistics which leads to improved environmental performance for an organisation. However, both these studies have limitations as Zhu et al. [41] used convenience sampling, thereby limiting the purity of the data, and Liu et al. [26] used a (relatively) small sample of 122 questionnaires thereby limiting the generalizability of the results obtained.

Due to organisations looking to become more environmentally-friendly and to use their materials more economically, a recent trend in sustainable supply chain literature is the discussion of the reverse supply chain [3], [15], [23]. Kusumastuti et al. [24] extended on previous studies by Krikke et al. [23] and Santibanez-Gonzalez and Luna [15] who provided models for closed-loop supply chains, by incorporating location and other complexities which are present in a supply chain system. Their study investigates the difficulties of reverse supply chains due to supply chains being dispersed as organisations seek to manufacture in low-cost countries such as China. They contributed to the literature by providing a proposed facility-location model which can be used by manufacturers of multi-level products to redesign their supply network [24].This study shows that manufacturers can reduce costs, mainly transportation costs, (by 11.2% in the case they studied) by redesigning their distribution network to cover different countries. The contribution by Kusumastuti et al. [24] could encourage organisations to pay more attention to their reverse supply chain as it provides economic benefits associated with doing so. This paper appears unique in that it provides a quantified benefit of a reverse supply chain. However, as Piotrowicz et al. [30] state, the economic benefits dominate in the majority of green supply chain studies and there is a lack of environmental and social benefit, as is the case with the study by Kusumastuti et al. [24].

The topic of resilience has emerged in the literature regarding sustainability as a pivotal topic in order to make supply chains more dynamic, flexible and to improve the sustainability of a supply chain [5], [11], [12], [33]. The literature is generally limited to strategies to improve the resilience of an organisation [8], [17]. The study by Christopher and Peck [8], which was primarily focused on the following industries; food retailing, oil and petrochemicals, pharmaceutical, packaging, electronics and transport services and distribution of automotive spares, provides four different strategies for improving the resilience within an organisation. These

four strategies are: (1) supply chain (re) engineering which includes supply base strategy which states that although an organisation may have one lead supplier, back up suppliers are required in case of disruptions; (2) supply chain collaboration which includes the sharing of information which should in practice create greater visibility of upstream and downstream risk profiles in the supply chain thereby creating a high level of 'supply chain intelligence'; (3) agility which includes visibility within the entire supply chain thereby allowing a quicker response to demand changes or supply disruptions within the supply chain; (4) creating a supply chain risk management culture which should allow improved business continuity and more informed decision making.

A study by Ji and Zhu [17] added to this by stating that although having more than one back-up supplier could be beneficial, the ability of this strategy (i.e. 1 above) to improve the supply chain is limited if the core supplier is affected, other suppliers downstream in the supply chain could also be affected to a certain extent which will reduce overall supply. Therefore a superior strategy to this, they explain, would be one called a 'real options strategy' which is based on the practice that an organisation will pay some money to its supplier for possible future supplies that may not be required. If there is a disruption in the future, suppliers will have to provide the redundant supply thereby improving resilience of the buyer and overall system. Ji and Zhu [17] further add to the literature by providing other strategies such as demand postponement strategies which basically allows an organisation to deliver their products or services in a delayed period for a discounted price. Although the literature provides strategies on how to improve resilience in a company, quantifiable results that show the effects of these strategies on resilience are lacking and neither has a method to measure resilience yet been fully developed. It is also questionable whether organisations will use these strategies in practice if they, for example, lead to higher costs for them as the gains from a more resilient supply chain are difficult to quantify.

5. Conclusions

The main issues found in the literature regarding disruptions are; factors which worsen the effects of disruption such as the use of the just-in-time manufacturing method and the way in which organisations can respond to reducing the negative effect of disruption such as by information sharing. Regarding sustainability, the literature makes clear that sustainability should not be viewed as a trade-off, rather, as a tool which can aid the functioning of an organisation. The main topic found in the literature regarding sustainability is the concept of the reverse supply chain and how it can help an organisation, mainly, through economic benefits. Another main issue in the literature regarding sustainability, which is evident, is the need to make the organisations supply chain more resilient by, for example, having back-up suppliers.

It is apparent from the literature review that the topics of disruptions and sustainability in supply chains are of high concern to academics; however, there is little evidence of these two topics being combined despite there being a clear relationship between the disruptions as causes of effects on sustainability metrics. The early development of this area of literature is demonstrated by the dominance of one particular journal, the International Journal of Production Economics. The majority of the literature regarding sustainability concerns the interaction between the economic and environmental aspects of sustainability while the social aspect appears to be ignored. Due to there being limited research on both disruptions and sustainability combined together, this provides a perfect opportunity to fill this gap in order to further advance knowledge and management practices on sustainability and supply chain disruptions.

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