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Developing a Resilient Supply Chain Strategy by Exploiting ICT

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Abstract

Managing the supply chain is now a major concern in most organizations due to uncertainties and unpredictable circumstances and or incidents that may have a negative impact on the supply chain itself. Hence, it is vital for organizations to have appropriate strategies that will enable them to be resilient and flexible enough to react to any form of disturbances that may affect the flow of materials, products, information and money anywhere along the supply chain. The aim of this article is to develop an effective strategy in collaboration with ICT in order for an organization to be able to predict and most probably avoid the aforementioned circumstances by utilizing a simulation model where different scenarios could be tested.

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Keywords: Supply chain risks; Resilient strategy; ICT; Discrete-event simulation

1. Introduction

This article discusses the core value and benefits of supply chain management and the risks it faces today due to incidents like natural disasters, terrorism, cyber-attacks, credit crunch etc. that could lead to a drastic loss in productivity, revenue, competitive advantage, profitability etc., if not managed appropriately. In order to deal with these risks, it is vital for organizations to be resilient so that they would be able to avoid or bounce back and start operations in the shortest possible time after disruptions anywhere along the supply chain. Hence, a theoretical

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approach to developing a resilient supply chain strategy incorporated with an ICT (Information and Communication Technology) platform is introduced. The research methods are generally qualitative in which scientific publications, journals, relevant literatures, as well as the authors' professional lecturing experiences in the field of management and modelling and simulation are exploited. The objective of the research is to develop a resilient supply chain strategy with a shared ICT infrastructure in order to help organizations avoid disruptions and or start operations in the shortest possible time if these disruptions occur. The paper is divided into four sections namely, the supply chain management-value and benefits, the supply chain risks, developing a resilient strategy and exploiting ICT in implementing a resilient strategy. The first section discusses the core value and benefits of supply chain management. The type of risks that an organization may come across are highlighted in the second section, whilst a resilient strategy in order to counter these risks and help an organization bounce back and start operations in the shortest possible time is given in the third section. The last section incorporates the resilient strategy with a shared ICT platform with respect to discrete event simulation and its framework.

2. The Supply Chain Management –Value and Benefits

The literature surrounding supply chain management explores the diversity and the recognition of creating value. Craighead et al.[1] states that "Supply chain" refers to the activities, functions, and entities that are connected via product and information flow from source to consumer. Particularly, over the past decade a sufficient amount of work has emerged on the identification in this field[1]. The importance of value creation and utilising core resources looks beyond the processes of suppliers, manufacturers and customers[2]. The stakeholders of different components in the supply chain process are expected to highlight superior levels of performance once carried out correctly. Henderson and Kim[3] argue that achieving individual firms to invest in mechanisms, fosters integration, collaboration, and coordination across the supply chain members. Supply chain management can also offer a company implementation and value on planning and long term profitability once they understand the core value of what it can deliver. The key benefits are addressed below:

- *Improved Supply chain network* – where managers are able to monitor and manage the holistic view of all activities across the suppliers, factories, storage facilities and distribution centres. Enabling effective monitoring systems and management of all related processes such as buying and acquiring in raw materials, manufacturing and shipping processes, finished goods to customers and retail, warehouses and distributors outlets.
- *Reducing delays* – as systems are closely monitored and tracked enhancing the relationships, vendors and distribution channels can reduce delays;
- *Enhanced collaboration and partnerships* – understanding and improving relationships with key supply chain partners and participants who are likely to have an impact on the smooth transition of the process. This enhancement improves the process of sharing information and knowledge management in an effective way;
- *Reduced Costs* – streamlining and improving inventory management in the long run can help an organisation to reduce its costs. Organisations can then begin to effectively use financial resources on E-Systems enhancing the successful implementation of just-in-stock models and other processes.

Although the key benefits discussed above seem impressive, the supply chain is still vulnerable to risks that could have a negative impact on the productivity of an organization. The risks are discussed in the next section.

3. Risks in the Supply Chain

These risks include terrorism, cyber-attacks, credit crunch, shrinking product lifecycles, volatile and unpredictable markets, natural disasters etc., may result in a serious loss in competitive advantage, revenue, profitability and productivity etc., if not managed accordingly. In fact, as the numbers of threats that can undermine a supply chain are now greater, organizations are facing greater challenges in managing risks[4]. For example, as manufacturers today are adopting low-cost-country sourcing and supplier initiatives, they are exposed and vulnerable to the risk of supply chain disruptions and delays. Consequently, this would have an impact on the speed and quality of goods and services. Some of the main risks are given below:

- *Strategy Risk* – choosing the appropriate supply management strategy is pivotal to understanding the core objectives of an organisation. Making sure there are a pool of global suppliers and the organisation is not reliant on a couple of key local suppliers especially as the market grows. This risk can become a big issue for an organisation if they are not using reliable market intelligence to drive decision making and leadership;
- *Market Risk* – this risk looks at Brand, compliance, financial and market exposure. When organisations are outsourcing part production or even entire product lines, company's like High Street retailers such as Next plc, Top Shop and Zara are placing their organisations at the mercy of the suppliers. If they deliver a sub -par product, or fail to deliver completely, customers will be placing the blame on the organisation and not on the suppliers;
- *Implementation Risk* – this looks at implementing effective lead-times and production performances. If the organisation does not have the capacity and a legal binding contract they may find themselves at the bottom of the pecking order. Understanding new suppliers quickly can gain early visibility into any risk factors that might hinder production, lead-times and initial performance;
- *Demand Risk* – looks at how demand and inventory changes fluctuate and cause problems for production. Closely monitoring suppliers is an important factor as delays and performance issues may lead to other factors. Supplies may be facing bankruptcies, ownership changes, geographical changes etc.

In order for organizations to avoid and or be able to bounce back and start operations immediately after disruptions, it is then necessary to be resilient by implementing an appropriate resilient strategy in order to manage their supply chain. Hence, developing a resilient strategy is introduced in the next section.

4. Developing a Resilient Strategy

4.1. Defining Resilient

Before developing a resilient strategy, it is vital to understand the definition of 'resilience'. According to the Oxford Advance Learner's Dictionary[5], resilience is defined as 'the ability of a substance to return to its original shape after it has been bent. From a business perspective, Cranfield School of Management[6] states that resilience is 'the ability of a system to return to its original or desired state after being disturbed', and Sheffi[4] defines resilient as 'the ability to bounce back from large-scale disruptions'. All of these definitions have something in common which is: *getting back to the original state after some distortions*. How this could be practised within the supply chain is now a new area of study that needs attention to in order to develop a resilient supply chain strategy.

4.2. Resilient Strategy

Currently, when developing risk and business continuity management, a lot of organisations are still not aware that it is important to consider a resilient supply chain as part of their strategy. In fact, Christopher and Peck[7] stated that 'many organisations still lack the awareness that it is necessary to take into consideration a resilient supply chain as part of their strategy when developing their risk and business continuity management'. Hence, as a result of their studies in *'Building the Resilient Supply Chain'*, Christopher and Peck[7] came up with certain strategies that would enable organizations to develop and or improve the overall level of the supply chain resilience. The strategies include:

- Re-engineering the supply chain to build resilience into the system in advance of a potential disruption;
- Establishing a high level of collaboration with supply chain parties to identify and manage risk;
- Achieving the agility necessary to respond quickly to the unexpected;
- Embedding a culture of risk management.

From another perspective, Mensah and Merkurjev[8] highlighted that organizations would be able to develop a more resilient supply chain by:

- Planning and implementing six sigma practices;

- Implementing lean production with just in time (JIT) delivery and low inventory;
- Increasing supply chain flexibility;
- Developing a strong corporate culture.

Planning and implementing the six sigma practices does not only bring the benefit of having 3.4 defects per million activities or opportunities, but organizations can also stop and or prevent problems from happening. In addition, managers will be able to solve problems effectively as they have solid grasps on the problems of their organizations. Companies like Ford, General Electric, and Allied Signal have been able to solve supply chain issues through six sigma practices.

Implementing lean production with just in time (JIT) delivery and low inventory minimizes waste and inefficiency due to continuous improvements in quality, productivity and responsiveness. It also allows tight control over production processes, and product developing process cycles can be shortened.

Increasing supply chain flexibility allows organizations to respond better to a change in demand, and will also be capable in reallocating resources when needed. Developing good relationship with suppliers is another advantage of flexibility.

Developing a strong corporate culture will improve information flow along the supply chain where employees would be well informed about the organization's activities through continuous communication. Empowering employees to make quick decisions as a result of strong corporate culture helps to lead to quick recovery after disruptions. Consequently, organizations implementing any of the above strategies would be able to bounce back and start operations in the shortest possible time after any form of disruption along its supply chain. Furthermore, as technology is advancing rapidly, the above strategies could be implemented within an ICT platform as discussed in the next section.

5. Exploiting ICT in implementing a Resilient Strategy

A shared ICT infrastructure consisting of a six sigma software solution like the Fishbone Diagram and the FMEA (Failure Modes and Effects Analysis), an Enterprise Resource Planning (ERP) function to facilitate lean production processes, as well as a social intranet component to help develop a strong corporate culture could be established in order to effectively implement the resilient strategy given above. This will make it possible for all the nodes of the supply chain to be 'intelligent' as they will be able to learn, store data and distribute necessary and accurate information.

Reflecting on the six sigma, the Fishbone Diagram and the FMEA (Failure Modes and Effects Analysis) are the most common sigma tools exploited today in many organizations as they enable them to make the necessary amendments in their production processes. Alternatively, Modelling and Simulation could be used as an application technique to support supply chain design, management and optimization[9] as any network of supply chain[10] can be easily represented by a simulation model. Furthermore, simulation can be used as decision support tool in order to improve the supply chain management, reduce risks and vulnerability[9].The discrete event simulation is briefly considered next.

5.1. Discrete Event Simulation

Discrete event simulation makes it possible to study, analyse and understand the whole supply chain process of an existing system from the upper to the lower level including its nodes and links through graphics and or animation. According to Lee et al.[11], 'most supply chain problems are solved using discrete event simulation modelling'. Hence, models could be developed especially within areas of concern where uncertainties are high so that the impact of these uncertainties could be studied and understood in order to minimize risks. This could be supported with the statement that modelling tools are required for threat assessment; identification of infrastructure vulnerabilities and interdependencies; and planning and decision making'[12]. In the case of a system that has not yet been developed, an abstract model can be designed where its performance is analysed and evaluated by utilizing various scenarios that

would yield to better decision making when developing the real system. During the development of a simulation model, it is necessary to understand the concept of the framework for modelling and simulation as described below.

5.2. Framework for Modelling and Simulation

The entities of the framework for modelling and simulation are namely the source system, behaviour database, experimental frame, model and simulator. The source system is the real or virtual environment, or artificial source of data that the modeller is interested in. The related system specification is level 0 according to the related level of system specification illustrated in table 1. From a practical point of view, if for example the problem of a logging company is considered to be the closure of roads that might affect delivery, it is vital for the modeller to know what variables to measure and how to observe them. The variables to measure in the case of road closure could be given as a mathematical structure:

$$\bar{X}=\{x1, x2, x3, x4, x5\}; \quad (1)$$

where:

- x1 – heavy rainfall
- x2 – heavy snow
- x3 – foggy
- x4 – road works
- x5 – accidents

In case any of the above variables are true, there would be a road closure that would negatively affect the system in which the organization might not be able to supply the goods on time. This could lead to frustration along the supply chain affecting both the organization and customers. The next stage of the basic entity is the behaviour database where data is gathered from the source system which is observed at level 1 in the related system specification level. Historical data, if available, will be collected for a considerable period of time with respect to the structure $\overline{X}$.

Table 1. Basic Entities in Modelling and Simulation and their Levels of Specification

Basic Entity	Definition	Related system specification levels
Source system	What variables to measure and how to observe them	Observed at level 0
Behaviour database	Collection of gathered data	Observed at level 1
Experimental frame is observed or experimented with	Specifies the conditions under which the system	Constructed at levels 3 and 4
Model	Instructions for generating data	Constructed at levels 3 and 4
Simulator	Computational device for generating behaviour of the model	Constructed at level 4

The experimental frame, constructed at levels 3 and 4, specifies the condition under which the system is observed or experimented with[13].The frame consists of a generator, an acceptor, and a transducer. The generator is responsible for generating input segments to the system, whilst the function of the acceptor is to monitor an experiment in order to make sure that the desired experimental conditions are met. The output segment of the system is being observed and analysed by the transducer. Zeigler[14], states that 'the structure of the model is its set of instructions and may be expressed in a mathematical language called a formalism'. The model, defined as an instruction for generating data, is constructed at levels 3 and 4 of the related system specification levels that. Therefore, a set of instructions, rules,

equations, or constraints for generating I/O behaviour could be described as the most common concept of a simulation model. Finally, constructed at level 4, is the simulator which is a computational device for generating the behaviour of the model. Software packages like Arena, Simul8 WITNESS etc. could be used to execute the model developed in order to run different scenarios for observation and decision making.

6. Conclusion

This paper has introduced a resilient strategy that organizations may be able to adopt when planning and managing their supply chain in order to avoid incidents that might have a negative impact on the whole supply chain. On the other hand, in the case of disruptions anywhere along the supply chain, these organizations will be able to bounce back and start operations in the shortest possible time.

The strategies include a study conducted by Christopher and Peck[7] in 'Building the Resilient Supply Chain' that recommended reengineering and establishing a high level of collaboration with supply chain parties, whilst Mensah and Merkurjev[8] highlighted that organizations would be able to develop a more resilient supply chain by planning and implementing six sigma practices, implementing lean production with just in time (JIT) delivery and low inventory, Increasing supply chain flexibility and developing a strong corporate culture. For better results, the above given strategies could be integrated with a shared ICT infrastructure consisting of a six sigma software like the Fishbone Diagram and the FMEA (Failure Modes and Effects Analysis), an Enterprise Resource Planning (ERP) function to facilitate lean production processes, as well as a social intranet component to help develop a strong corporate culture.

As a result, it will make it possible for all the nodes of the supply chain to be 'intelligent' as they will be able to learn, store data and distribute necessary and accurate information. Alternatively, Modelling and Simulation could be used as an application technique to support supply chain design, management and optimization. This is where the discrete event simulation is effective as models could be developed especially within areas of concern where uncertainties are high so that the impact of these uncertainties could be studied and understood in order to minimize risks. It was also highlighted that during the development of a simulation model, it is necessary to understand the concept of the framework for modelling and simulation.

Finally, the strategies and techniques given are more from a theoretical point of view. It is now necessary to implement the recommended strategies in a real organization most probably in the forestry industry in order to test how effective the strategies are.

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