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Using ICT in Developing a Resilient Supply Chain Strategy

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Abstract

Supply chains in today's globalization are very vulnerable to risks such as natural disasters, terrorism, cyber attacks and credit crunch etc that could easily disrupt the flow of raw materials, finished products and information. Furthermore, these disruptions could yield to a drastic loss in productivity, competitive advantage and profitability that would most probably lead to bankruptcy if not managed appropriately. In fact, supply chain vulnerability is now a major concern in many organizations as some research programs have started to illustrate that modern supply chains are at greater risks than their supply chain managers could even recognise. The aim of this article is to analyse these risks and discuss how they could be prevented and/or managed. In addition, by implementing ICT in collaboration with certain strategies, a resilient supply chain could be developed. Moreover, in case any of these risks occur, the possibility for an organization to be able to bounce back and start operations in the shortest possible time is also considered.

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Keywords: Supply chain risks; Resilient strategy; ICT; Six Sigma; Simulation

1. Introduction

In today's competitive world where globalization now plays an important role in organizations, it is necessary to adopt a resilient strategy to overcome or prevent any form of disruption that may occur after an incident.

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In fact, according to the report of the Business Continuity Institute(BCI) where 519 organizations from 71 countries were surveyed, '75% of respondents still do not have full visibility of their supply chain disruption levels'[1]. The disruption includes mainly unplanned IT or telecom outages, adverse weather disruption, outsourcer service provision failure etc. This is just the top of the iceberg as other disruptions, discussed later on in the article, are of equal importance.

The aforementioned has motivated the authors to investigate this area further in order to build up resilient strategies of the supply chain. This article therefore exploits a theoretical approach to investigate the supply chain risks and their impacts, and recommends resilient strategies, with ICT as a platform enhancing the resilient strategy that may help organizations to resume operations in the shortest possible time after disruptions in any part of the supply chain.

The research methods are mainly qualitative involving various scientific publications, relevant literatures, journals as well as the authors' professional lecturing experiences in the field of management and modelling and simulation. Quantitative secondary resources are also exploited to illustrate the causes of disruption.

The objective of the research is to develop a supply chain resilient strategy in collaboration with ICT as a platform that would help organizations to resume normal operations in the shortest possible time after disruptions. The article is divided into four chapters namely, supply chain risks, developing a resilient strategy, the role of ICT and the role of simulation. The Supply Chain Risk chapter discusses different types of risks and their impacts on organizations with reference to various studies like that of the Business Continuity Institute, Grossman studies etc. The next chapter, which is Developing a Supply Chain Resilient Strategy, introduces strategies and tools that may help an organization to avoid these risks and or be able to bounce back into normal operations after disruptions. The Role of ICT and the Role of simulation are discussed next, and they portray how the resilient strategy developed could be more effective and efficient by integrating it into an ICT platform. Furthermore, it emphasizes that simulation can also be used to develop a resilient strategy by exploiting the Six Sigma methodology.

2. The supply chain risks

The supply chain in today's globalization, where the activities of many organizations could be linked to nearly all the continents of the world, faces a lot of risks that could have a negative impact on the productivity, competitive advantages and profitability etc if not managed accordingly. In fact, Christopher and Peck highlighted that 'in today's uncertain and turbulent markets, supply chain vulnerability has become an issue of significance for many companies'[2]. However, currently, it seems as if most of these organizations have fallen short of taking supply chain vulnerability into consideration. Moreover, according to the studies of the Business Continuity Institute (BCI) where 519 organizations from 71 countries were surveyed, '75% of respondents still do not have full visibility of their supply chain disruption levels'[1].

With reference to Figure 1, the result of the studies shows that 55% of the respondents experienced unplanned IT or telecom outages as their primary source of disruption, whilst 40 % of the respondents experienced adverse weather disruption, and 37% with outsourcer service provision failure[1].

Although the aforementioned are the most significant risks, the other risks according to the order of importance as loss of talent, skills, transport network disruption, new laws or regulations and cyber attack etc are of equal importance and should not be left out during a business continuity planning.

From another perspective, Tang[3], stresses that risks could be categorized as high profile and common. The high profile risks includes disasters like earthquake, terrorism, tsunami, SARS etc, whilst that of the common risks are mainly operational taking into account demand, supply, materials and information flow.

Referring back to the BCI studies, although it covered most of the possible risks that organizations may be vulnerable to, the risks of miscommunication was not considered. This is what, Mensah and Merkuryev[4] point out, in another development, that 'one area which can also have a significant impact on the supply chain is the risk of miscommunication'. It is also evident in the Holmes Report where miscommunication cost some 400 organizations in the UK and the US approximately US$37 billion[5]. Furthermore, in a recent incident, the French train operator SNCF purchased 2,000 new trains at a cost of €15 billion only to find out that they were too wide for the regional platform and they now have an additional cost of €50 million to widen the platforms[6]. Many other incidents have occurred recently with giant companies like Toyota and Ford Motors recalling thousands of newly manufactured

cars due to faulty brakes, airbags etc. These problems may have been prevented had there been a proper communication platform during the manufacturing process.

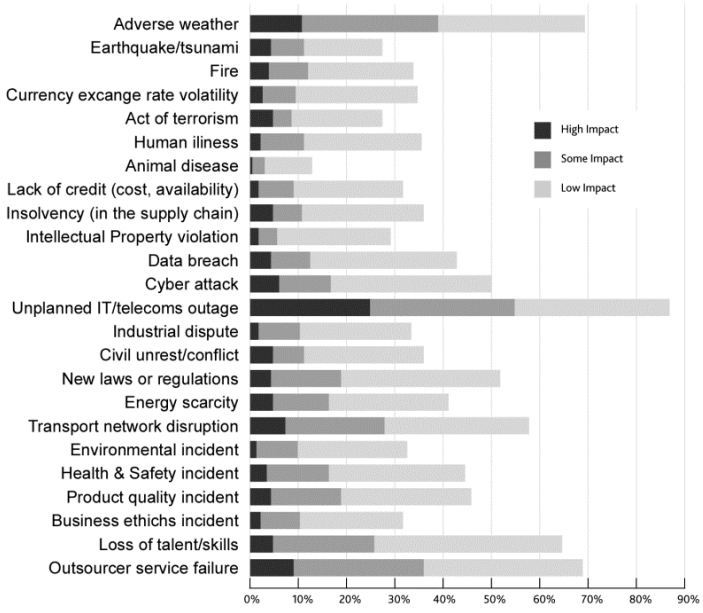

Fig. 1. Causes of Disruption[1].

2.1. The impact of risk in the supply chain

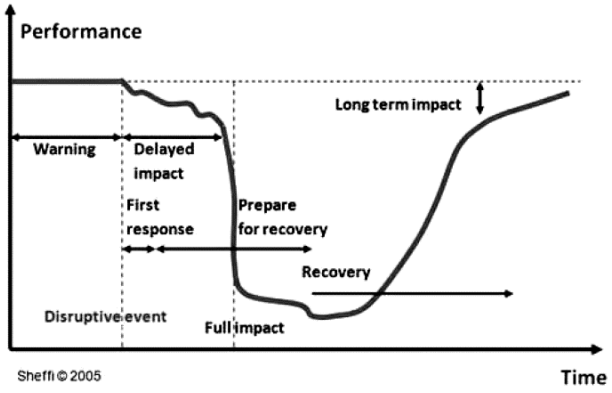

Fig. 2. Impact of Disruptions[7].

After a risk occurs, the time for an organization to bounce back and starts normal operation is a concern and it may be quite lengthy if the particular organization lacks continuity management, flexibility and agility. Figure 2, above shows the performance over time after a disruptive event in an organization with traditional practices[7]. After a disruptive event, it is obvious that there is a drop in performance, hence productivity is affected. The first response, preparing for recovery and recovering from the disruptive event is quite a lengthy process and only organizations

with strong financial and strategic background like Apple, Toyota or General Motors etc could survive at a high cost. On the other hand, many small and middle size organizations (SMEs) would hardly survive, and in fact, the number of corporate insolvencies in Western Europe increased dramatically between 2007 and 2012 from 130, 910 to 174,914 insolvencies respectively[8]. It is possible to prevent these worrying statistics of insolvencies from happening if there is proper planning in the business continuity management of the organizations involved as it is a stepping-stone for organizations to become more resilient. The resilient strategy is discussed in the next chapter.

3. Developing a resilient strategy

Before developing a resilient strategy, it is necessary to understand its meaning. Resilience could be defined as the ability of a substance to return back to its original state after deformation. The dictionary definition states that 'resilience is the ability of a substance to return to its original shape after it has been bent, stretched or pressed'[9]. From another perspective, Lengnick-Hall et al.[10] looked at resilience with respect to an organization stating that it is 'the firm's ability to effectively absorb, develop situation-specific responses to, and ultimately engage in transformative activities to capitalize on disruptive surprises that potentially threaten organization survival'. A well-developed resilient strategy needs to satisfy all the aspects of the definitions given above. The preceding statement is supported by Christopher and Peck[2] in their publication 'Building the Resilient Supply Chain', where they emphasized the following key points in developing a resilient strategy:

- 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.

For example, by reengineering the overall planning process, which includes large amount of data and data flows, Intel has been able to reduce its 'number of manual processes, data errors and associated correction efforts'[11]. This has resulted in an increase of its supply chain efficiency and responsiveness making it more resilient as it is in a better position to meet supply chain challenges. Establishing a high level of collaboration with supply chain parties enables organizations to improve business performances by setting goals and sharing information yielding to competitive advantages and profitability. This could be clearly seen in the cooperation between Wal-Mart and Procter & Gamble as Figure 3 shows below.

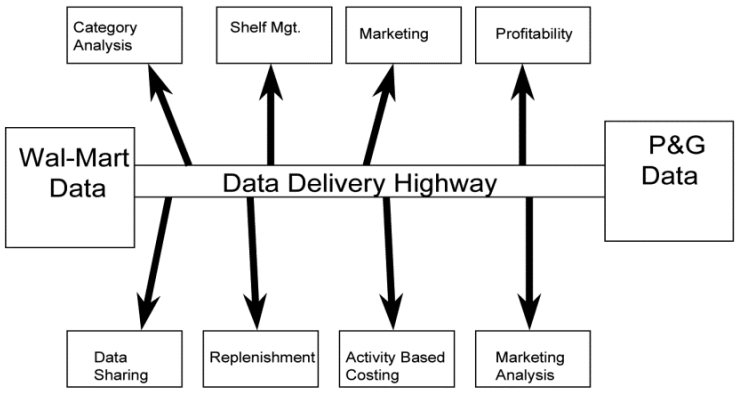

Fig. 3. The Data Highway for the Manufacturing/Retailing Integration[12].

The collaboration between Wal-Mart and Procter & Gamble has enabled both organizations to exchange sensitive information and improve transparency by exploiting the Data Delivery Highway which is an IT platform linking them. This has not only resulted in better communication yielding to lower inventory, but also competitive

advantages and higher profitability. Above all, through collaboration, which has stimulated flexibility and agility, Wal-Mart and Procter & Gamble are now more resilient especially when dealing with risks in demand and changing markets. From another perspective, Mensah and Merkuyev[4], point out that a resilient strategy can be developed by 'planning and implementing six sigma practices, establishing lean production processes, achieving a high level of flexibility and building a strong corporate culture'.

Due to the limitation of this paper, the authors will be focusing on the six sigma practices.

3.1. Six sigma practices

The Six Sigma can be divided into two methodologies namely DMAIC (Define, Measure, Analyze, Improve, Control) and DFSS (Design for Six Sigma). The DMAIC is exploited in improving existing processes and performances whilst the DFSS is used in developing new processes, products and services to meet customer needs at the Six Sigma level. The Six Sigma was developed by Motorola in 1995 in order to solve business problems like declining sales and poor performance among employees as well as to improve the quality of management by means of statistical measurements and benchmarking. 'It is also a highly potent statistics-based methodology that helps to eliminate defects, optimize processes, and produce significant financial results across the organization'[13]. In fact, Ford has been able to become successful by implementing it in its supply chain processes[14]. If applied appropriately, an organization will be able to experience 3.4 defects per million activities or opportunities, as they will be able to prevent or stop problems from happening due to their solid grasps of the problems in their organizations. On the other hand, the Six Sigma can be very expensive to implement as far as SMEs are concerned. It is therefore advisable for SMEs to adapt flexibility, develop a strong culture where effective communication is practiced and encourage transparency throughout the supply chain. This paper will be focusing on the DMAIC methodology.

4. The role of ICT

¬The strategies given in the preceding chapter can only be effectively implemented if integrated within an ICT platform. Reflecting back on these resilient strategies, the authors are focusing on the six sigma processes in conjunction with ICT. 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[15]. The six sigma consists of five phases namely DMAIC (Define-Measure-Analyse-Improve -Control) methodology as shown in Figure 4, and as Knowles highlighted, all projects should be conducted through these phases or process steps[16].

The five phases of the Six Sigma are described below.

The Define phase:

The problem is identified in this phase and customer requirements are determined by using Quality Function Deployment (QFD) interface. The QFD links the needs of the customer (end user) with design, development, engineering, manufacturing, and service functions in order to reduce the risk of misunderstanding between producers and users.

The Measure phase:

The Measure phase comes next after identifying the problem(s) and customer requirements in the Define phase. Current performances are analysed while identifying any variability and its sources. It is vital to record accurate data in this phase. Tools like process flow diagrams, histograms and control charts are used in the measure phase.

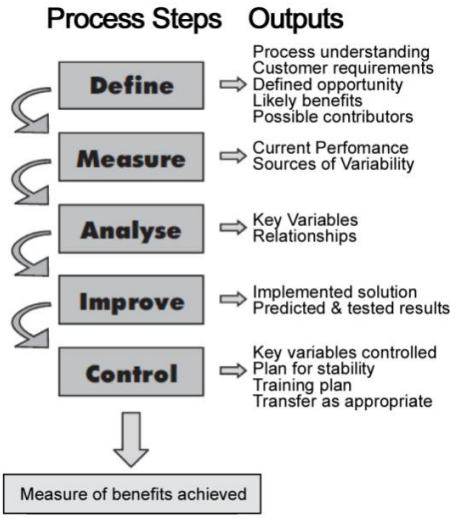

Fig. 4. The Six Sigma DMAIC Process and Key Outputs[17].

The Analyse phase:

In this phase, causes and effect analysis, also known as Ishikawa, is used to analyse the relationship between the key variables and priority for actions is taken into consideration[18]. Hence, identification and verification of the main causes of the problems are discovered.

The Improve phase:

The next process step 'Improve' is where the process is modified in order to eliminate the causes of defects. The main aim is to choose the best possible solution whilst predicting the new capabilities of the process. This involves re-engineering the process and implementing its solution. The predicted results are also tested.

The Control phase:

The best solution from the improve phase is implemented and maintained in the control phrase. The key variables are being controlled and the performance is always monitored with the help of tools like Statistical Process Control (SPC) charts that can easily track performance measures over time.

5. The role of simulation

By exploiting simulation, the behaviour of a business process of an organization can be studied for decision making purposes which includes developing a supply chain resilient strategy etc. The supply chain design, management and optimization can also be supported by modelling and simulation application technique[19], 'as any network of the supply chain can be easily represented by a stimulating process'[20]. In addition, Longo points out that stimulation can be used as decision support tools in order to improve the supply chain management, reduce risks and vulnerability[19].

Tools like SIMUL8, WITNESS, ARENA etc are very effective in simulating supply chain processes. For example, Ford has been able to adopt WITNESS simulation to support its six sigma processes. 'WITNESS provides a natural tool to support the Analyse and Improve phases of DMAIC, with also having potential to aid other phases as well'[21]. The WITNESS software also links directly with MINITAB and other modelling tools that are relevant for the Six Sigma specialist. By exploiting simulation with the help of WITNESS within the Six Sigma, Ford was able to identify two major opportunities that led to an increase of 10% in capacity resulting in higher efficiency

5.1. Simulation and Six Sigma

The phases of the DMAIC in the Six Sigma discussed in the former chapter can be integrated into a Discrete Event Simulation process model making it a strong platform with respect to business processes especially in the supply chain. By utilizing the discrete event simulation software -SIMUL8-, it is possible to observe the behaviour of the processes of the nodes and links of the supply chain of an organization prior to and after implementing the Six Sigma. Before implementing the Six Sigma, the behaviour of nodes and links of the supply chain is observed and areas vulnerable to certain risks are identified. Different scenarios are then run and the time it takes the organization to bounce back after disruption, which will most probably coincide with figure 2, is recorded. This is then compared to a model built exploiting the six sigma with SIMUL8 as a platform in which the same scenarios will be run. If the time it takes the same organization to bounce back after deformation is reasonably shorter, then a successful resilient strategy has been developed.

Figure 5 below, illustrates the application of SIMUL8 within the six sigma DMAIC processes. Each phase of the DMAIC process is integrated into the simulation platform as discussed in chapter 3.

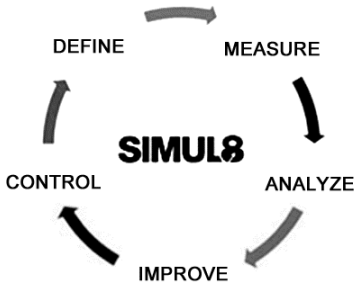

Fig. 5. SIMUL8 and the Six Sigma processes[22].

In the define phase, key variables and processes are identified yielding to better understanding of the processes and their contents. This will make it possible for problems to be identified. This leads onto the measure phase where relevant data are collected while identifying any variability and its sources.

The Analyze phase is next where 'the relationship between key variables are analysed through cause and effect analysis, called Ishikawa, and prioritise for actions'[18]. Hence, in the case of product or process design, the necessary changes could be made in this phase before moving onto the improve phase. The process undergoes re-engineering and solutions for implementation are identified in the improve phase. The control phase is the last in which continuous monitoring is ensured especially with the performance whilst controlling the variables.

6. Conclusion

The required task, whereby it is essential to develop a resilient supply chain strategy in collaboration with an ICT platform in order to make organizations resilient to disruptions, has been successfully completed through careful investigation of various relevant articles, journals and publications including the authors' academic experiences in management and simulation. Before developing the resilient strategy, it was discovered that many organizations have fallen short of taking supply chain vulnerability into consideration which could have negative impact on their performances in case of disruptions. What is more, the risk of miscommunication costs organizations billions of Euros yearly and this is evident in the French train operator SNCF that purchased 2,000 new trains at a cost of €15 billion only to find out that they were too wide for the regional platform. In order to avoid these worrying problems, a supply chain resilient strategy was developed with appropriate strategies and tools namely, six sigma practices, lean production, flexibility and a strong corporate culture. The Six Sigma strategy was discussed in more detail and it was recommended to integrate it into an ICT platform in order to enhance its efficiency.

The role of simulation was also discussed as it could be used as an application technique to support supply chain design, management and optimization[19] as any network of supply chain[20] can be easily represented by a stimulating process. Moreover, the discrete event simulation software- SIMUL8-, can also be exploited in a way where it is possible to observe the behaviour of the processes of the nodes and links of the supply chain of an organization before and after implementing the Six Sigma. Hence, organizations, implementing the recommended strategies, will not only be well prepared in dealing with risks and their impacts but will also be highly resilient as they will be able to resume normal operations in the shortest possible time after disruptions.

Finally, from the perspective of a practical approach, further research needs to be conducted in a real organization where the recommended supply chain resilient strategies in collaboration with an ICT platform and simulation may be tested by exploiting different scenarios. This will illustrate how effective the recommended strategies are, as the time for the organization to bounce back after any form of disruption along the supply chain will be observed, recorded and comparisons would be made accordingly.

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