The role of ICT in the supply chain resilience

Peter Mensah, Yuri Merkuryev

Department of Modeling and Simulation, Riga Technical University, 1 Kalku Street, LV-1658 Riga, Latvia
E-mail: p_mensah@hotmail.com, merkur@itl.rtu.lv

Abstract: The supply chain, with so many definitions consisting of overlapping terminology and meanings, has evolved greatly over the past 50 years from the traditional form where big and powerful companies used to be wholly and solely responsible for supplies, manufacturing and distribution to the modern innovative companies that are actually outsourcing almost all the processes in the supply chain. As many research programs have also shown that modern supply chains are at greater risks than their supply chain managers recognise, supply chain vulnerability has become a very significant issue for many companies. These risks including natural disasters, terrorism, cyber attacks, credit crunch and many more could yield to a drastic loss in productivity, revenue, competitive advantage, profitability etc., if not managed appropriately. Should in case one of the risks occurs and therefore deforming the supply chain, the possibility of the supply chain returning back to its original state is a concern and this is where developing a resilient supply chain is of great importance. Hence, resilience is now vital in the supply chain management since the numbers of threats that can undermine a supply chain are now greater. With cutting-edge technology on the increase, ICT would play a vital role in reducing risk, increasing management efficiency resulting in a more resilient supply chain. The aim of this paper is therefore to analyze the definition of the supply chain, investigate the sources of the supply chain risk and elaborate on the role of ICT in developing a more resilient supply chain.

Keywords: supply chain management, supply chain risks, resilient supply chain, Information and Communication Technology.

Introduction

This paper discusses a theoretical approach in developing a supply chain resilient strategy with Information and Communication Technologies (ICT) playing an important role that would help organizations to bounce back after deformation in any area along the supply chain. According to the research findings of the 3rd Annual Survey of the Business Continuity Institute in Supply Chain Resilience in 2011, where more than 550 organizations from over 60 countries were surveyed, ‘Supply chain incidents led to a loss of productivity for almost half of businesses along with increased cost of working (38%) and loss of revenue (32%)’ (The Business Continuity Institute, 2011). These incidents were due to natural disasters, terrorism, cyber-attacks, credit crunch and many more, and as they are unpredictable it is now important for organizations to develop a more resilient supply chain. The above has motivated the authors to conduct a research and recommend certain strategies in the area of the supply chain resilience.

The research methods are mainly qualitative where various relevant literatures, journals and other scientific publications as well as the authors’ professional lecturing experiences in the field of management and modelling and simulation were exploited. On the other hand, quantitative secondary resources were also used to portray the degree of the loss of productivity due to supply chain incidents. The objectives of the research is to develop a supply chain resilient strategy with ICT playing an important role along the upstream and lower stream that will help organizations to bounce back after deformation on any area along the supply chain.

The paper is divided into four chapters namely, the supply chain, the supply chain management, the supply chain resilience and the role of ICT in the supply chain resilience.

Various definitions of the Supply Chain and the Supply Chain Management are analysed. The authors introduce a new and more realistic definition for the supply chain as the supply chain management consists of many definitions with overlapping terminology and meanings (Croom et al., 2000). In addition, various strategies and tools are also recommended in order to implement an effective supply chain management.

The next chapter which is the Supply Chain Resilience investigates the issues facing today’s organizations and how they affect the supply chain, and in case of any deformation along the upper stream and or lower stream, it portrays the possibilities of organizations bouncing back to normal through certain recommended strategies given by the authors.

The last chapter deals with the role of ICT in the Supply Chain Resilience as it speeds up information and financial flows between the upstream and downstream of the supply chain resulting in improved services, reduced logistics costs and faster communication between customers and their suppliers.
Defining the Supply Chain

It is evident that over the past 50 years the Supply Chain has been defined differently where they consist of overlapping terminologies and meanings by different authors. Although these definitions general cover most of the sectors of the supply chain, a more appropriate definition is yet to be determined. In order to come up with a new definition, the authors of this paper have randomly selected and analyzed ten out of many definitions between 1999 and 2011 given in Table 1 below.

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Year</th>
<th>Definition of Supply Chain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lu, D.</td>
<td>2011</td>
<td>...a group of inter-connected participating companies that add value to a stream of transformed inputs from their source of origin to the end products or services that are demanded by the designated end-customers...</td>
</tr>
<tr>
<td>Pienaar, W.</td>
<td>2009</td>
<td>...a general description of the process integration involving organizations to transform raw materials into finished goods and to transport them to the end-user...</td>
</tr>
<tr>
<td>Bridgefield Group</td>
<td>2006</td>
<td>...a connected set of resources and processes that starts with the raw materials sourcing and expands through the delivery of finished goods to the end consumer...</td>
</tr>
<tr>
<td>S, Cholette</td>
<td>2011</td>
<td>...a sequenced network of facilities and activities that support the production and delivery of a good or service...</td>
</tr>
<tr>
<td>Sunil, C., Meindl, P.</td>
<td>2004</td>
<td>...consists of all parties involved, directly or indirectly, in fulfilling a customer request. The supply chain not only includes the manufacturer and suppliers, but also transporters, warehouses, retailers, and customers themselves. Within each organization, such as manufacturer, the supply chain includes all functions involved in receiving and filling a customer request...</td>
</tr>
<tr>
<td>Croker, J.</td>
<td>2003</td>
<td>...a total flow of materials, information and cash through a business network, all the way from the suppliers’ suppliers to the customers’ customers...</td>
</tr>
<tr>
<td>Tecc.com.au</td>
<td>2002</td>
<td>...a chain starting with raw materials and finishing with the sale of the finished good...</td>
</tr>
<tr>
<td>Ayers, J. B.</td>
<td>2001</td>
<td>...life cycle processes involving physical goods, information, and financial flows whose objective is to satisfy end consumer requisites with goods and services from diverse, connected suppliers...</td>
</tr>
<tr>
<td>Little, A.</td>
<td>1999</td>
<td>...the combined and coordinated flows of goods from origin to final destination, also the information flows that are linked with it...</td>
</tr>
<tr>
<td>Beamon B.</td>
<td>1998</td>
<td>...a structured manufacturing process wherein raw materials are transformed into finished goods, then delivered to end customers...</td>
</tr>
</tbody>
</table>

From Table 1 above, most of the definitions are similar and too general and basically deals with processes that start with raw materials and transformed into finished goods that will eventually reach the customers. However, three of the definitions (Sunil, 2004; Croker, 2003; Ayers, 2001) included materials, information and financial flows in their definition that plays a crucial role in the supply chain. After careful analysis, the authors of this paper have developed a new supply chain definition which is given below:

'Supply chain is a sequenced network of business partners involved in production processes that convert raw materials into finished goods or services in order to satisfy the consumers’ demand.'

The Supply Chain Management

Just like the Supply Chain, the Supply Chain Management (SCM) has numerous definitions. One of the most recent definitions of the SCM according to CSCMP (Council of Supply Chain Management Professionals) states that ‘Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers (CSCMP, 2013). In essence, supply chain management integrates supply and demand management within and across companies’. Furthermore, Supply Chain Management is aimed at examining and managing Supply Chain networks (Janvier, 2012).
To simplify the above, the authors would describe the SCM as the Business Management of the activities of the Supply Chain aimed at satisfying the demand of the end consumer. In order for an effective SCM to be implemented, three levels of decision making namely planning, strategy and operations have to be considered.

**Planning:**
What is to be done and how it should be done are questions if answered to correctly; then the organization is on the right path. As a matter of fact, planning consists of defining the organization’s goals, establishing a strategy to achieve the necessary goals, and on the other hand integrating and coordinating activities through proper arrangements. All of these lead to the development of an appropriate strategy for the supply chain.

**The strategic decision making:**
After planning, the supply chain has to be designed, crafted and developed for the production of particular goods or services. As top managers are responsible for decision making about the mission and direction of the organization, and establishing policies that affect all organizational members, they will have to take the responsibilities of crafting the appropriate cost effective supply chain that is responsive to customers’ demand, whilst facilitating product development, manufacturing and logistics.

**Operations:**
The application of the transformation process where organizations add value by converting inputs into outputs along the supply chain is known as operations. From a general perspective point of view, it is organized by determining what tasks to be done and by whom; how the tasks are to be grouped; who reports to whom and where decisions are to be made.

**Supply Chain Resilience**

Many research programs have also shown that modern supply chains are at greater risks than their supply chain managers recognise. ‘In today’s uncertain and turbulent markets, supply chain vulnerability has become an issue of significance for many companies’ and appropriate research on resilient supply chain are yet to be conducted (Christopher, 2004; Peck, 2004).

The risks including natural disasters, terrorism, cyber attacks, credit crunch shrinking product lifecycles, volatile and unpredictable markets and many more, could yield to a drastic loss in productivity, revenue, competitive advantage, profitability etc, if not managed appropriately.

Should in case one of the risks occurs and therefore deforming the supply chain, the possibility of the supply chain returning back to its original state is a concern and this is where developing a resilient supply chain is of great importance.

As the numbers of threats that can undermine a supply chain are now greater, organizations are facing greater challenges in managing risks (Sheffi, 2005). Hence, resilience is now vital in the supply chain management.

According to the research findings of the Business Continuity Institute in Supply Chain Resilience in 2011, where more than 550 organizations from over 60 countries were surveyed, ‘Supply chain incidents led to a loss of productivity for almost half of businesses along with increased cost of working (38%) and loss of revenue (32%)’

Although ‘resilience’ could be defined as the ability of a substance to go back to its original state or form after deformation, the Supply Chain Resilience is still a new area of management to be explored as the possibility of it returning back to its original form after deformation is still ‘theoretical’, and 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.

**Developing a Resilient Supply Chain:**

Historically, immediate solutions to disrupted supply chains like the outbreak of the SARS or the Hurricane Sandy that affected 24 states in the USA in October last year that brought many businesses and production into a halt due to flooding streets, subway lines and tunnels, and power failure in some cities especially New York, was not possible and might not be possible in the future if organizations lack proper planning.

However, organizations with better planning, strategy and operations tend to have a way out and competitive advantages over their rivals after disruptions in the short run.

According to the authors of this article, organizations would be able to develop a more resilient supply chain by planning and implementing six sigma practices, lean production, flexibility and a strong corporate culture. Consequently, these organizations would have the capabilities to speed up the process of bouncing back after deformation on any part along the supply chain. The authors have tabularised these strategies in table 2 below in order to portray their effectiveness and shortcomings.

All of the strategies in Table 2 are significant and could be adopted and practiced in organizations depending on their capabilities.

Due to the limitation of this paper, the authors will be focusing on the theoretical analysis of the six sigma strategy only.
### Resilient Strategies (The authors)

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Six sigma supply chain</td>
<td>3.4 defects per million activities or opportunities. Stops and prevents problems from happening. Management will be able to solve problems effectively as they have a solid grasp on the problems of their organization. Pay off in the long run.</td>
<td>High cost in investing both time and money into training employees in order to utilize the sigma tools effectively. A long-term method.</td>
<td>Ford, General Electric, Motorola, Allied Signal</td>
</tr>
<tr>
<td>Lean production with JIT delivery and low inventory</td>
<td>Minimise waste and inefficiency. Continuous improvement in quality, productivity and responsiveness. Tight control over production process. Shortening product development cycles.</td>
<td>Necessitates rapid and frequent flow of goods and information Entails close relationship with suppliers</td>
<td>Kellogg’s</td>
</tr>
<tr>
<td>Increasing SC flexibility</td>
<td>Better respond to a change in demand Capabilities in reallocating resources when needed Developing good relationship with suppliers</td>
<td>Basically no disadvantages except for the fact that employees have to be trained which is an increase in costs</td>
<td>Intel</td>
</tr>
<tr>
<td>Developing a strong corporate culture</td>
<td>Employees well informed about the organization activities through continuous communication. Empowering employees to make quick decisions. Quick recovery after disruptions.</td>
<td>Might create dysfunctional conflict among employees if they are not well informed.</td>
<td>Toyota, Apple</td>
</tr>
</tbody>
</table>

**Six Sigma:**
The Six Sigma, which is currently used by a number of successful companies, was originally started by the Motorola Corporation during the 1980s. It was designed to solve business problems like declining sales and poor performance among employees.

The Six Sigma is also a highly potent statistics-based methodology that helps to eliminate defects, optimize processes, and produce significant financial results across the organization. This is evident in Ford as it has gained tremendous success by applying Six Sigma to its supply chain processes (Moore, 2002).

Sigma tools like the Fishbone Diagram and the FMEA (Failure Modes and Effects Analysis) are the most common ones used today as companies will be able to make amendments in their production processes (Aveta Business Institute, 2013). Furthermore, according to Graeme Knowles, all projects should be conducted through the DMAIC (Define-Measure-Analyse-Improve-Control) methodology as shown in Fig. 1 below.

With reference to Fig. 1, in the Define process step, the organization needs to know what it is seeking to improve and should therefore define its opportunity correctly as failing to do so will lead to a catastrophic output. After defining the process, the next step is ‘Measure’ where current performances should be analysed and any variability and its sources identified before moving onto the ‘Analyse’ step where the relationship among the key variables are analysed through cause and effect analysis, called Ishikawa, and prioritise for actions (Christopher, 2004; Rutherford, 2004).

The next process step ‘Improve’, involves re-engineering the process and implementing its solution, where predicted results are also tested.

‘Control’ comes next with its key variables being controlled and the performance monitored. Finally, the benefits achieved should be measured and if the benefits coincide with the advantages of the six sigma strategy in Table 2, then the organization is on the brink of achieving a supply chain resilient.
Implementing the six sigma also needs a good leadership which is provided by a team of champions namely, senior champion at the corporate level; deployment champion at the unit level and project champion at the department level all maintained by a team of experts.

The experts are referred to as Black Belts and Master Black Belts. The Master Black Belts provide mentoring, training and expert support to the Black Belts whilst the Black Belts usually work full time on projects at process level to solve critical problems and achieve bottom-line results (Canales et al., 2005).

ICT and the Supply Chain Resilience

The role of ICT in the supply chain is not only significant because it speeds up information and financial flow between the upstream and downstream of the supply chain resulting in improved services, reduced logistics costs and faster communication between customers and their suppliers, but it also helps the organization to make accurate and quick decisions after deformation of its supply chain that will eventually bounce it back to normal activities.

How does the ICT help to make the activities of an organization bounce back after a supply chain disruption?

The recommended strategies and tools in the chapter of the supply chain resilience namely, six sigma practices, lean production, flexibility and a strong corporate culture could be linked to a shared ICT infrastructure consisting of six sigma software, Enterprise Resource Planning (ERP) in order to facilitate lean production, and Social Intranet Software to develop a strong corporate culture that would engage management and employees on the activities of the organization through online communication and collaboration.

According to the Times of India’s article, how tech is powering Spencer's supply chain, the company Spencer Retail Ltd, has been able to manage the dynamic markets of the retail industry by investing in a robust ERP solution from SAP in 2008 (The Times of India, 2013). Transactions are managed in the company’s warehouse through SAP’s Warehouse Management System (WMS) whereas the ERP systems have been linked with the suppliers and visibility to all key metrics are provided. As a result, it has helped the company to manage its perishable supply chain especially from the upstream where they have to deal with local farmers.

Another example is that Intel has identical layouts for machinery and production process in its semiconductor fabrication factories that enables it to switch production among facilities in case of supply chain disruptions and when necessary (Sheffi, 2005).

From another perspective, Modeling and Simulation could be used as an application technique to support supply chain design, management and optimization (Longo, 2012) as any network of supply chain (Kilmov et al., 2010) can be easily represented by a stimulating process.

Furthermore, stimulation can be used as decision support tools in order to improve the supply chain management, reduce risks and vulnerability (Longo, 2012).

Hence, the role of ICT in the supply chain is now vital in structuring and implementing the supply chain, speeding up information flow resulting in better communication, and giving the organization the capabilities and competencies to bounce back through accurate and quick decisions after deformation of its supply chain.
Therefore, the entire above if put into practice would yield to a more resilient supply chain in an organization.

Conclusions

In order to fulfil this task, various resources including journals and other scientific publications were discussed in the paper, and by analyzing the Supply Chain and the Supply Chain Management concepts, it was discovered that there are too many definitions overlapping with authors having various definitions from different perspective. In this case, after thorough analysis, a more appropriate definition of the supply chain was introduced which states that ‘Supply chain is a sequenced network of business partners involved in production processes that convert raw materials into finished goods or services in order to satisfy the consumers’ demand’. Three levels of decision making namely planning, strategy and operations were also recommended in order to implement an effective SCM. Deformation in any part of the supply chain due to the risks facing the modern supply chains today than the supply chain managers would actually recognise was discussed in the chapter of the supply chain resilience, and appropriate strategies and tools namely, six sigma practices, lean production, flexibility and a strong corporate culture were recommended. Only the Six sigma strategy was discussed in more detail due to the limitation of this paper. However, it is necessary to conduct a research in the other strategies and tools as they are of equal importance.

The role of ICT in the supply chain resilience was discovered to be very important as it speeds up information and financial flow between the upstream and downstream of the supply chain and helps organizations to make accurate and quick decisions after deformation of its supply chain that will eventually bounce it back to normal activities. In addition, Modelling and Simulation was also recommended as it could be used as an application technique to support supply chain design, management and optimization (Longo, 2012) as any network of supply chain (Kilmov et al., 2010) can be easily represented by a stimulating process.

Finally, although the authors have investigated the topic and given recommendations using a theoretical approach, a practical approach of the role of ICT in the supply chain resilience is yet to be investigated and applied in an industry, most probably the auto industry, where simulation based analysis would be developed portraying deformation and its impact on any part of the supply chain as this would make supply chain managers to be well prepared to deal with any occurrence of hazardous phenomena and its impact along the supply chain.

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