SUPPLY CHAINS RISKS: A SYSTEMS THINKING PERSPECTIVE

Abhijeet Ghadge, Samir Dani

School of Business & Economics, Loughborough University, Loughborough, LE11 3TU

ABSTRACT
This paper considers a systems perspective towards managing these risks. It presents variables that may affect next generation supply chains and applies a causal loop model towards depicting the causal linkages of these variables with future supply disruptions. The causal linkages between the variables are then highlighted with regards to the supply chain process and the nodes, and the causes of future risks are identified. From the causal loop diagram the risk propagation is derived in a form of risk framework.

SUPPLY CHAIN RISKS
Risk management has become an integral part of a holistic SCM ideology (Christopher and Lee, 2004). Supply chains are increasingly challenged in today's global world due to uncertainties in supply and demand, shorter product and technology life cycles, the globalised market and changing environmental conditions. Tang (2006) argues that with so many (e.g. terrorist attacks, hurricanes, earthquakes) disruptions that have happened in recent times, supply chain risk will become an important criterion for cost reduction in SCM. Chopra and Sodhi (2004) classify the supply chain risks in the form of delays of materials from suppliers, large forecast errors, system breakdowns, capacity issues, inventory problems, and disruptions. Whereas, Tang (2006) classifies risks as supply chain risks into operations and disruptions risks. According to Ritchie and Marshall (1993) risks emerge from one of the following sources: (1) Environmental factors (2) Industry factors (3) Organizational factors (4) problem-specific factors and (5) Decision-maker related factors. Tang and Tomlin (2008) recently classified supply chain risks as strategic (long term) or tactical (medium term). Zsidisin (2008) have attempted to identify risks for the aerospace industry. There are several other classifications of supply chain risks (Sinha et al., 2004; Finch, 2004; Norrman and Lindroth, 2004; Kleindorfer and Saad, 2004; Manuj and Mentzer, 2008; Wu et al., 2006) available in literature.

RESEARCH METHODOLOGY
The research was conducted to understand the factors that would affect next generation supply chains. It was also necessary to understand how these factors would lead to risk propagation through the supply chain. The basic assumption considered was that all the identified factors will lead to some risk in the supply chain. To understand the interdependencies within these factors and the risk propagation on account of these factors it was decided to adopt a systems perspective. This perspective is based upon application of a causal loop diagram which considers the interdependencies between the factors affecting next-generation supply chains. The causal linkages between the variables are then highlighted with regards to the supply chain process and the nodes and causes of future risks are identified. Using the causal loop diagram, a risk framework is developed for next generation supply chains showing the impact of the risk. This is checked with some instances of risk propagation within the aerospace sector.

SYSTEMS THINKING
Systems of Systems (SOS) are large scale concurrent and distributed systems that are comprised of complex systems (Kotov, 1997). The Systems of systems concept originally evolved in the defence sector, but now it being widely spread globalised in all sectors. In today's world early identification and management of the supply chain risks that could affect product and/or service quality becomes increasingly necessary. Oehmen et al. (2009) has developed supply chain risk models to identify possible dynamics of the risk development. The systems thinking perspective adopted in this research focuses on understanding how the physical processes, information flows and managerial policies interact so as to create the dynamics of the variables of interest. Supply chain is similarly

such a complex system consisting of a complex network of stakeholders and their dynamic interrelationships. Supply chain risk management ensures the continuous success of customers supply base by delivering products and/or services in accordance with set quality standards. Figure 1 represents the system of systems approach to a typical supply chain network showing the hub and spoke structure of supply chain system and interrelating network links within supply chain entities. The figure presents supply chains as a complex network of entities from the perspective of inter-related risks which can cause the flow to disrupt.

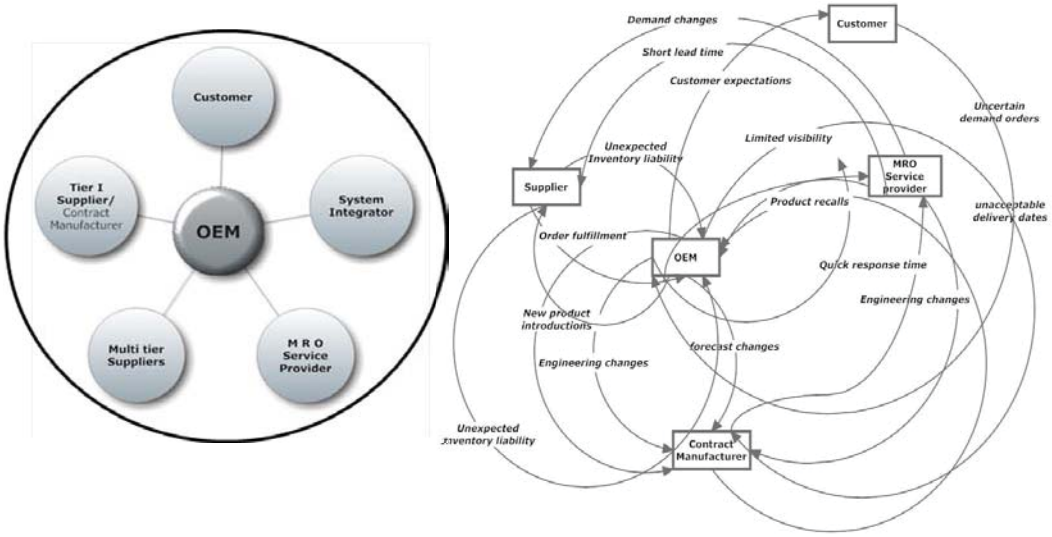

Figure 1 Typical supply chain behaviour from a systems perspective

In next section, Using systems thinking, interactions of its variables through feedback loops are captured, where a change in one variable affects other variables over time, which in turn affects the original variable. We identify and define the problem in terms of risks arising due to internal and external factors within supply chain observed from sustainability perspective.

NEXT GENERATION SUPPLY CHAIN RISK VARIABLES: CAUSAL RELATIONSHIP

Causal loop diagrams are the basis on which the SD model is built. They depict, graphically, the interactions and cause-and-effect relationships among the different system parameters (Lertpattarapong, 2002). During the model development, Causal loop diagrams serve as preliminary sketches of causal hypotheses and they can simplify the representation of a model. The structure of a dynamic system model contains stock (state) and flow (rate) variables. Stock variables are the accumulations (i.e. inventories), within the system, while flow variables represent the flows in the system (i.e. order rate). The model structure and the interrelationships among the variables are represented by causal loop diagrams. The Next generation supply chain issues were identified from various workshops conducted as a part of NEXGEM workshops and an extensive literature review. Following are the identified issues for next generation supply chain:

1. Environmental regulations
2. Information and communication technology
3. 3PL/4PL Logistics service
4. Global market
5. Customer expectations
6. Skills shortage

Figure 2 shows the causal relationship of identified next generation supply chain issues with risk assessment parameters.

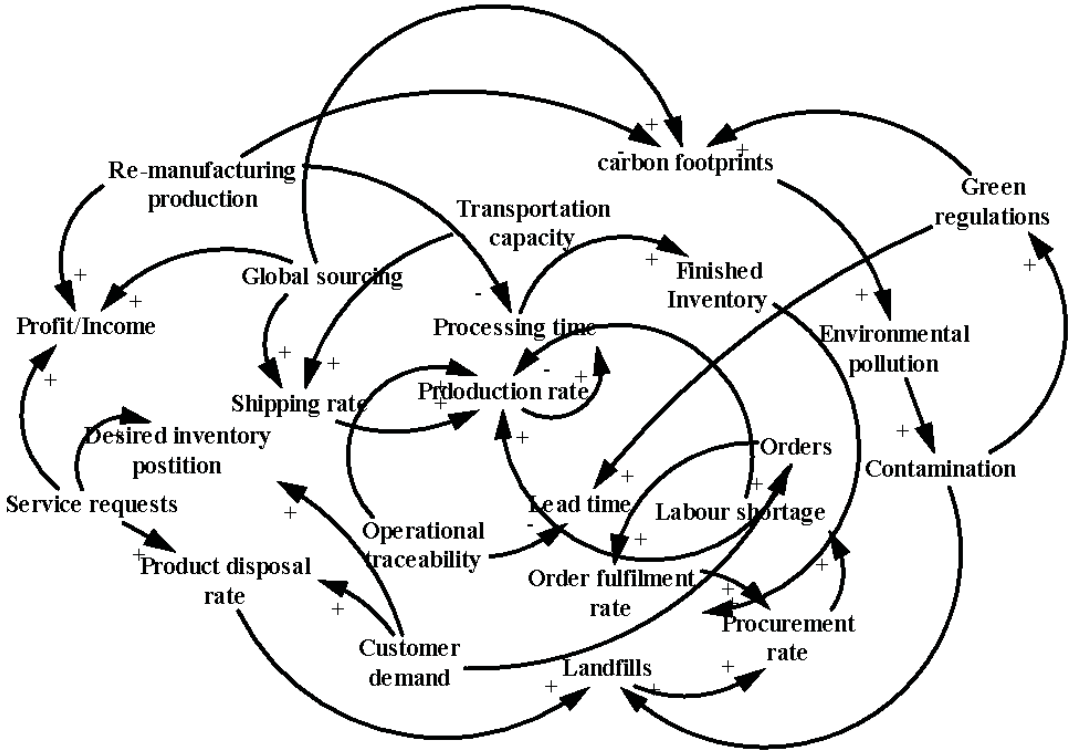

Figure 2: Causal loop diagram for supply chain system (Ghadge, Dani and kalawsky, 2010)

With reference to the causal model, it can be inferred that this is not complete. Supply Chains are dynamic and as factors change, the risk parameters will modify and propagate. It is important to get a perspective to initially understand the system and then create the capability to dynamically modify it. From the causal loop diagram above, the risk propagation is derived in a form of risk framework as shown in figure 3.

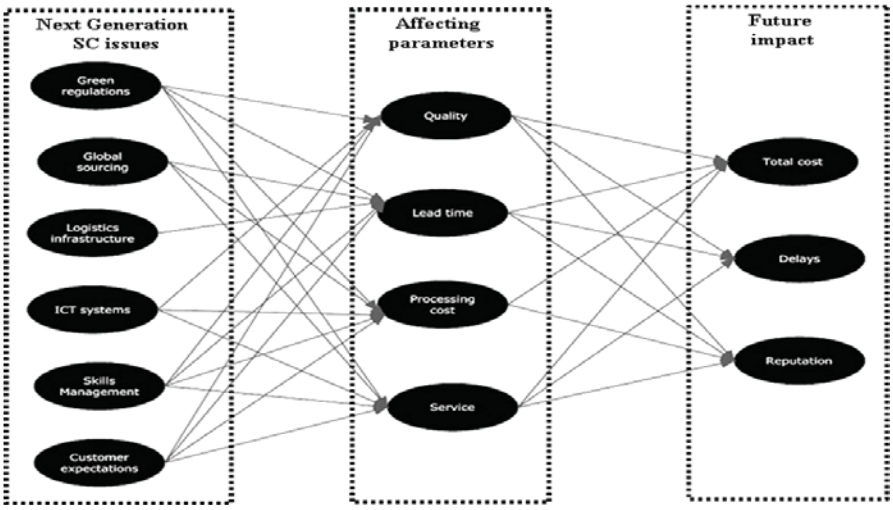

Figure 3: Next generation supply chain risk framework (Ghadge, Dani and Kalawsky, 2010)

Research impact

The research has focussed on literature and case examples derived from literature sources. The causal linkages between the next generation supply chain variables is highlighted with regards to the supply chain process and the nodes and causes of future

risks. Using, the causal loop diagram a risk framework is developed for next generation supply chains showing the impact of the risk.

Practical impact
The outcomes of this study will help researchers and managers to identify next generation supply chain risks (which is based on variables, such as: green sc, lack of skills, role if technology, etc.). This research presents a new method for managers to consider their supply systems and map out the future risks. This will then help to implement a proactive approach towards managing risks within the Supply chain network.

CONCLUSION
The research approach for the paper is based upon application of systems engineering thinking to understand supply chain systems and identify various risks associated with in the closed loop supply chain network. Outcomes of research will help academicians and practitioners to gain insights into risks seen from systemic perspective and will guide them in developing simulation models for future supply chain management. The Risk framework is in its infancy and needs further testing and would be developed further as a future work.

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