Supply Chain Risk Management Literature Review



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Supply chain management has become a competitive tool for firms to achieve competitive advantage. Any business operating in product delivery supply chain is faced with an uncertainty cycle. This has become a major problem area and has been attracting attention of many companies, regarding how to address the supply chain uncertainty issues. This paper draws insight on Supply Chain Risk Management (SCRM) literature and highlights major issues underlying SCRM. There are four major issues regarding SCRM namely identification of supply chain risk sources and drivers, risk assessment, risk mitigation and implementation of SCRM. This literature review paper puts past research finding and then proposes a SCRM framework.

Keywords: Supply Chain Management, Risk Identification, Risk Assessment, Risk Mitigation Strategies

1. Introduction

With increasing global competition, high pressures on cost reduction, vertical disintegration and demanding customer needs have somewhat diminished the individual identity of firms. Firms are operating in networked supply chains and this is positing a strategic challenge in integrating and collaborating all activities, both downstream as well as upstream. As competition is shifting from firms to supply chains, global sourcing affords many benefits in the form of lower prices and expanded market access. Senior executives have begun to recognize the increased risk attributed to the higher probability of product and service flow disruptions in global sourcing networks. A major disruption in the offshore supply chain can "shut down" a company, and have dire consequences on its profitability. This was felt most drastically in the last few years, when such catastrophic events such as war in Iraq, 9/11, natural disasters etc. happened. Even less serious events like transport and communication disruptions, fire and theft etc. can impact customer service through poor communication of customer requirements, part shortages and poor quality problems. These disruptions can be costly and have in many cases brought distribution and production to a screeching halt. Supply chain disruptions have been found to negatively impact shareholder value significantly. These disruptions are amplified in "time-sensitive" environments where early market introduction is critical to success. Supply chain risk management is hence attracting the attention of most of the companies.

2. Review Methodology

First, a general search for literature about risk and risk management, supply chain management and supply chain risk was conducted, and the theories found were structured and presented. Then a thorough review of scientific journal articles within supply chain risk was conducted, and the information structured. Together these literature reviews describe the present theoretical knowledge base within supply chain risk and related areas.

The study focused on peer reviewed journals from data bases like Emerald, Science direct, Taylor & Fransis and Wiley Interscience. Some inputs were taken from case studies and news clipping. A key word (supply chain risk) had been searched form databases, which showed more than 500 research papers. All the research papers screened on the basis of relatedness to topic. All papers were classifies in four types (1) Papers gave the conceptual framework for SCRM, (2) Papers focused on constructs of SCRM like risk sources identification, risk assessment, risk divers and risk mitigation strategies. Some papers from management science and operation research covering complex mathematical models, which do not serve purpose for beginners.

3. Literature Review

Supply chain management paradigm is becoming very popular across the world and it has stimulated many domains from material management to integrated logistics. The various approaches and initiatives related to SCM are: strategic purchasing, supply management, logistics integration and supply network coordination (Chen & Pulraj, 2004) Around 1990 academics first describes SCM from a theoretical standpoint and explained how SCM is different than flow of materials and information flow (Ellram & Cooper, 1990). There are many variables controllable and uncontrollable which can affect the normal flow in supply chain. The events like 9/11, SARS and foot and mouth outbreak in UK profoundly affected many aspects of society and business Increasing uncertainty in supply networks by changing customer demands, rapid technology advancement, threats created by global firms, terrorist attacks, have forced firms to realize the importance of supply chain integration. There exist dependencies between firms in any market place (lambert, 1998). Dependencies demonstrate that any disruption affecting an entity in the supply chain network has a direct effect on corporations' ability to meet the customer requirements. In recent years the dependencies and drive to become a more efficient supply chain (e.g. through outsourcing) has resulted in more vulnerability. Supply chain risks are now getting the attention of firms. Many companies have recognized the need to carry out formal risk audit as well as manage the risks across the supply chain (Cristopher, 2004).

a) Risk Definition

At an academic level there is a growing body of research on risks from different perspectives e.g. finance, economics, strategy and international business. Following table gives the definitions of risk from different discipline perspective.

S. No.	Risk Definition	Author Name
1	Variance of returns	Markowitz, 1952
2	Probability of Expected Loss	Mitchell, 1999
3	Risk is essentially a manifestation of uncontrollability rather than merely a downside possibility	Arrow, 1970
4	Risk is essentially the process of choosing between prospects that have different outcomes, each with differing probability	Kahneman and Tversky, 1979
5	Risk is a measure of the probability and severity of adverse effects	Lowrance, 1980
6	Risk is the likelihood of the occurrence of an uncertain event or set of circumstances that would have an adverse effect on the achievement of a project's activities.	Simon et al., 1997
7	Risk associated with failure to satisfactorily implement a business process re-engineering project	Crowe et al., 2002
8	Within the SCM context, it is purely the downside that accurately reflects the business reality	Wagner and Bode, 2008

These and several other definitions provided by supply chain managers are consistent with the literature that suggests two components of risk:

1. Potential losses (if the risk is realized, what losses will result and what is the significance of the consequences of the losses (Harland et al., 2003; Manuj and Mentzer, 2008; Mitchell, 1995)); and
2. Likelihood of those losses (the probability of the occurrence of an event that leads to realization of the risk).

From examples such as the above, we can conclude that the definition of risk is context specific. It can also be defined as objective or perceptual/subjective. Some risks are purely objectively determinable and some risk assessment is only subjective based. It is the biggest challenge to separate out the objective and subjective portion of the risk.

b) Risk and SCM

The term "supply chain" can be interpreted in many ways, but is defined here in its broadest sense, as "the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer" (Christopher, 1998).

SCM integrates the business processes from the end user to original source of material. It provides the products/services and information that adds value to customer and shareholder (Lambert et. al. 1998). Driving force behind SCM is that sub optimization occurs if any entity tries to optimize its own performance rather that optimization of the whole supply chain (cooper, 1997).

Nowadays the competition is not among single firms, but on the contrary, among supply chains (Caputo et al., 2005; Sadler and Gough, 2005).

Firms are going global and firms are focusing on their core competencies, in that way they are losing control. Globalization and outsourcing trend is increasing the complexity of supply networks.

Complexity is due to several sources: product/service complexity, e-business, outsourcing and globalization (Harland et al., 2003). There are some factors concerning product/service that increase the supply chain complexity i.e. scale, technological development, quantity of sub-systems components, degree of customization of components in the final product/service, quantity of alternative design and delivery paths, number of feed back loops in the production and delivery systems, variety of distinct knowledge bases, skills and competencies incorporated in the product/service package, intensity and extent of the end-user involvement, uncertainty and change of end-user involvement and requirements, extend of supplier involvement in the innovation and transformation process, regulatory involvement, number of actors in the network, web of financial arrangements supporting the product/service, and extent of political and stakeholder intervention. Owing to the increasing supply chain network complexity each node which is called decision making unit has potential to create negative disturbances in the network.

Over the last three decades, the economic emphasis on speed and efficiency has caused members of supply chains to adopt concepts like "just in time," "build to order," and "vendor managed inventories." As a result, supply chains today have become leaner and more profitable since the capital previously locked in inventory is instead available for other profitable activities **(**Martha and Subbakrishna, 2002**).**In this there are many reasons for risk events creations in supply chain, which affects the supply chain profitability of all members in the supply chain.

Risk in a supply chain context has been defined as the potential occurrence of an incidence associated with inbound supply in which the result is the inability of the purchasing organization to meet customer demand (Zsidisin, 2003).

c) Why Supply Chain Risk Management is Important

Tang (2006) argues that with the kind of business disruptions that have taken place in recent times (e.g. terrorist attacks, hurricanes, earthquakes, and SARS); business continuity and supply chain risk will become as important a criterion as cost reduction in SCM.

Supply chain risks affect the business profitability. Different risks create different negative impacts. In a study by Hendricks and Singhal, (2005) found that supply chain risks have a huge impact on its stockholder wealth. In recent years, there have been several instances of disruptions in the supply chains. Some of them were due to natural disasters, such as the earthquake in Taiwan that affected PC manufactures like Dell and Apple in 1999; hurricane Mitch that destroyed banana plantations, thus affecting supply chains like Dole in 1998; and hurricane Floyd that flooded the Daimler-Chrysler plant in Greenville in 1999. Other disruptions were caused by epidemics, like the outbreak of mad-cow disease that caused a shortage of leather goods in Europe in 2001 and the outbreak of SARS that impacted the IT supply chains in 2003. And some resulted from man-made disasters, like the fire accident at the electronics plant in Albuquerque, New Mexico, which caused $400 million in lost sales at Ericsson; longshoreman strikes at US ports in 2002, which caused an

estimated $11 to 22 billion in lost sales; and terrorist actions like 9/11 that crippled transportation networks across the USA. For instance, in 1997 Boeing experienced a supplier delivery failure of two critical parts with an estimated loss to the company of $2.6 billion **(**Radjou, 2002). In 2002, less than 100 workers in a longshoreman union strike disrupted west coast port operations. It took six months for some containers to be delivered and schedules to return to normal (Cavinato, 2004). In July 2007, Toyota Motor Corporation halted production in all Japanese factories due to an earthquake that severely damaged Riken Corporation, their major parts supplier for piston and seal rings. Moreover, the damage to Riken affected other automotive manufacturers, prompting suspended production at facilities for Mitsubishi Motor Corporation, Suzuki Motor Corporation and Honda Motor Corporation, all of whom depend on Riken for engine parts **(**Hayashi et al., 2007). Moreover, much more research has been published in recent years following such disasters as the 2001 terrorist attack on the World Trade Center and the 2004 tsunami in the Indian Ocean.

As a more specific example, let us analyze the fire accident at the Ericsson's supplier (Phillips) plant in New Mexico. Though the fire accident was caused by lightening, an external factor, the source of crisis can also be classified as an internal factor. The reason for internal classification is Ericsson's lack of crisis preparation and inability to respond to crisis rapidly. For instance, Nokia was using the same facility for its products; however, immediately after the accident, Nokia tied up spare capacities at the other Phillips' facilities and also renewed some of its products so that chips from other manufacturers could be used (Norrman, 2004). Therefore, the source of crisis is classified as both internal (poor supply chain management) and external (lightening) for this case. All proceeding examples show why risk management is important in supply chain.

4. Framework on SCRM

Supply chain risk management is "the identification and management of risks for the supply chain, through a co-ordination approach amongst supply chain members, to reduce vulnerability as a whole" (Juttner et. al., 2003) suggest that there are four interrelated constructs to supply chain risk management:

1. Risk sources;
2. Risk drivers of supply chain strategy;
3. Supply chain risk management strategies; and
4. Outcomes of supply chain risk.

Christopher (2002) suggests that SCRM is the management of external risks through a coordinated approach among the supply chain members to reduce supply chain vulnerability as a whole. Tang (2006, p. 453) define SCRM as "the management of supply chain risks through coordination or collaboration among the supply chain partners so as to ensure profitability and continuity".

(Global) SCRM is the identification and evaluation of risks and consequent losses in the global supply chain and implementation of appropriate strategies through a coordinated approach among supply chain members with the objective of reducing one or more of the following – losses, probability, speed of event, speed of losses, the time for detection of the events, frequency, or exposure – for supply chain outcomes that, in turn, lead to close matching of actual cost savings and profitability with those desired.

Supply chain disruptions are "unplanned events that may occur in the supply chain which might affect the normal or expected flow of materials and components" (Svensson, 2000). The management of supply chain risk has garnered an increased focus from supply chain managers due to the detrimental impact that supply chain glitches or disruptions can have on supply chain performance. Supply chain disruptions can result in a variety of problems such as long lead-times, stock-outs, inability to meet customer demand, and increases in costs (Levy, 1995; Svensson, 2000; Riddalls and Bennett, 2002; Chopra and Sodhi, 2004). Ultimately, these problems have an adverse effect on the financial performance of the firm (Hendricks and Singhal, 2003, 2005).

Risks from a supply chain are difficult to management for three primary reasons (Shi, 2004). Risks are difficult to identify because of the mutual interactions. They can arise in every echelon of the supply chain; and. There are fewer well-defined tools and techniques for SCRM, so that they are generally managed in an ad hoc fashion.

SCRM should be aware of both events that may cause disturbances and every significant link along the supply chain (Finch 2004).

The focus of the SCRM is to understand and try to avoid the devastating ripple effects that disasters, for even minor business disruptions, can have in supply chain (Norrman Jansson 2004).

Shi D. 2004 suggested a system approach to management risk in supply chain that consists of the following steps:

1. Risk Identification
2. Risk categorization based on their nature and collective impact.
3. Risk Management Programme

A risk management system is basically an action plan that specifies which risks can be addressed, and how to address them.

4.1 Risk Sources and their Identification

The literature review suggests four categories of risks: supply, demand, operational, and security risks (Christopher and Peck, 2004; Manuj and Mentzer, 2008).

In another widely used classification, Ghoshal (1987) classifies risks as:

- Macroeconomic risks associated with significant economic shifts in wage-rates, interest rates, exchange rates, and prices;
- Policy risks associated with unexpected actions of national governments;
- Competitive risks associated with uncertainty about competitor activities in foreign markets; and
- Resource risks associated with unanticipated differences in resource requirements in foreign markets.

It is possible to identify three clusters of uncertainty sources inside a supply chain: order forecast horizon, input data and decision processes (Van der Vorst et al., 1998).

The increasing complexity that characterizes the actual supply chains determines an always-increasing number of sources of uncertainty inside a network.

Risk and uncertainty have always been an important issue in supply chain management. Earlier literature consider risks in relation to supply lead time reliability, price uncertainty, and demand volatility which lead to the need for safety stock, inventory pooling strategy, order split to suppliers, and various contract and

hedging strategies (Tang (2006a). Supply chain risks could be in the form of delays of materials from suppliers, large forecast errors, system breakdowns, capacity issues, inventory problems, and disruptions. Another classification is provided by Tang (2006a) who categorized supply chain risks into operations and disruptions risks. The operations risks are associated with uncertainties inherent in a supply chain, which include demand, supply, and cost uncertainties while disruption risks are those caused by major natural and man-made disasters such as flood, earthquake, tsunami, and major economic crisis.

Finch (2004) classified risks into three broad categories which include the three levels of coverage: application level, organizational level, and inter-organizational level. At the application level, the risks include natural disasters, accidents, deliberate acts, data/information security risks, and management issues. At the organizational level, such risks as legal and strategic changes in decisions could happen, while at the inter-organizational level, there are possible uncertainty from the outside of the organization which could pose risks.

Norrman and Lindroth (2004) categorize the type of risks addressed in the SCRM papers into operational accidents, operational catastrophes, and strategic uncertainty. The operational accidents are those affecting the operational process or resources related to logistics / supply chain, such as fires, truck accidents, machine failures, labour strikes, etc). Most companies are facing day-to-day operational accidents, but the frequency of those risks happening depends on how good they manage supply chain risks. Operational catastrophes are risks associated with rare and difficult to predict events, but once occurred; they have severe impacts on the company. Such risks as natural disaster, socio-political instability, economic disruptions, and terrorist attacks are examples of operational catastrophes. Finally, the strategic uncertainties are the type risks that are generally difficult to address and affect the company not at the operational level, but strategically. The strategic uncertainty could be in the form volatile demand, supplier default/bankruptcy, increasing competition, market constraint, and technology change.

Mason-Jones and Towill (1998) suggested five overlapping categories of supply chain risk sources viz. environmental risk sources, supply risk sources demand risk sources , process risk sources and control risk sources. *Environmental risk* sources are related to external environment for example fuel crisis and natural disasters etc. *Supply risk* is associated with inbound logistics for example supplies delays, quality problems. *Demand risk* is associated with outbound logistics for example seasonality, new product developments, and shorter product life cycles. Environmental risks can also cause supply and demand risks. *Process risks* can either amplify or absorb the effects of risks in supply chain. Similarly *supply chain control* mechanisms like decision rules and policies regarding batch size and safety stock can amplify or absorb the risk effect in supply chain.

It is worth considering that risk exists at various levels, both inside the company as well as at the network level. A recent categorization Shashank Rao (2009) of various sources of risk in supply chain is given below:-

1. Environmental risk (Political risk, Policy risk, Macroeconomic risk, Social risk)
2. Industry risk (Input market risk, Product market risk, Competitive Market risk)
3. Organizational risk (Agency risk, Credit risk, Liability risk, operating risk)

4. Problem specific risk (Risk interrelationship, Objectives and constraints risk, Task complexity risk)
5. Decision maker risk **(**Knowledge / Skill / Biases risk, Information seeking risk, Rules and procedures risk, Bounded rationality risk.

According to Miller (1991), general environmental risk variables could include political instability, shifts in government policy, macroeconomic uncertainties, social uncertainties, and natural uncertainties. Short descriptions of each follow.

However, as Miller (1991) argues, the basis for differentiating between the two lies with the understanding that changes in government may not necessarily result in changes in government policy affecting business involvement. Some of the most relevant types of government policy uncertainties could then include fiscal and monetary reforms, price controls, minimum-wage agreements, or nationalization/privatization. Moreover, Miller (1991) argues that even when policies do not actually change, firms may be apprehensive about the government's commitment to keep existing trade policies in place for long time periods. Societies may thus bypass existing government policy and appeal directly to business for reforms. Researchers have argued that social uncertainty is indeed very important to understand as it can be a precursor to political uncertainty (Miller, 1991).

An example of how product market uncertainty can affect firms can be seen in the accelerated demise of pager service companies with the rapid adoption of cellular telephones. In a widely publicized case, Cisco was forced to write off inventory worth $2.5 billion in 2001 ostensibly because of the slowdown in the information technology and networking market following 9/11 (Ritchie and Brindley, 2004). This example also illustrates how one form of uncertainty (social uncertainty) can influence another (product market uncertainty). Product liability uncertainty relates to the prospect of legal or market actions against the producer. A much cited case of 2007 finds toy manufacturer Mattel facing prospective legal action and clear market resistance following the recall of almost 1.5 million toys found to pose potential hazards to children (Bogoslaw, 2007).

Hazardous material regulation, product recall requirements, and product liability issues have increased the cost and complexity of logistics operations throughout the economy. In one example, the 3M company demonstrated proactive management of liability by voluntarily removing one of its most popular products (ScotchGard) from store shelves in May 2000 until it could be reformulated into a more environmentally friendly product (Goldsby and Garcia-Dastugue, 2003).

Supply risk sources: three main sets of supply risk sources have been identified, and each of them is broken down into sub-sources: product-related (complexity, customization, impact on costs, impact on time, impact on quality), market-related (low number of qualified suppliers, high degree of market saturation, general increase in price, high geographical concentration of the suppliers, low cost countries suppliers, low level of supplier certification), supplier-related (problems in the product innovation, delivery mistakes, delivery delays, conflict relationships, supplier contractually linked to other customers, qualitative problems, cost increases, difficulties in satisfying the demand, technological backwardness, discontinuity of supply, under-capacity, poor environmental performance, financial stability, information technology backwardness, information technology incompatibility, inadequate transport, inadequate inventory management, inability to quickly

implement technological changes, inability to quickly implement product changes, poor mix/volume flexibility.

Literature review on supply chain risks indicates there is no unanimity on risks identification. Different authors used different bases frameworks for risk sources identification. What are supply chain characteristics which cause different supply chain risks that need be investigated?

4.2 Supply Chain Risk Drivers

Supply chain risk drivers are the competitive factors, which forces the firm to adapt them to be competitive in market. These drivers simultaneously increase the risk exposure of the firm.

For the second construct, Juttner et al. (2003) suggest five primary reasons that risk within supply chains have increased in recent years:

1. A stronger focus on efficiency rather than on effectiveness;
2. Supply chain globalization;
3. Focused factories and centralized distribution;
4. Increased outsourcing; and
5. Supply base reduction

Companies' obsession with speed and costs also causes supply chains to break down particularly during the launch of new products (Lee, 2004). Also coordinating actions across firms is tough because organizations have different cultures and companies cannot count on shared beliefs or loyalty to motivate their partners (Narayanan and Raman, 2004).

4.3 Supply Chain Risk Assessment

Sheffi Y. 2005 disruption can also be classified as random events i.e. natural disasters, accidents intentional disruption. The method of estimation each class differs. The probability of intentional disruption known as adaptive threats because they are designed by their perpetrators to inflict maximum damage is more difficult to estimate.

Potential disruption can be categorized as a function of their probability and consequence. Individual companies can create an enterprise vulnerability map, which can direct management attention. These maps continuously updated.

Assessing supply risk, including appraising its likelihood of occurrence, stage in the product life cycle, exposure, likely triggers, and likely loss, is a critical step in managing the risk inherent in a firm's overall supply network (Harland et al., 2003).

Risk is analyzed objectively through measures such as financial data, subjectively with measures such as the strength of the relationship between the firms, or through a combination of objective and subjective measures.

A risk rating is assigned by an operations team or functional specialist based on data such as product audits, system evaluations, and performance. Each system or key process is classified as a high, moderate, or low risk.

Supply risk assessments involve a proactive approach by purchasing organizations for understanding the impact and likelihood that detrimental events can have on inbound supply. Benefit of the implementation of proactive supply management tools, particularly those that focus on addressing supplier quality issues, improving supplier performance, and preventing supply interruptions.

Two commonly used techniques for researching factors and causes contributing to accidental events are the "fault tree analysis" (FTA) and the "event tree analysis" (ETA). Both are logic diagrams that represent the sequences of failures that may propagate through a complex system. FTA examines all potential events leading up to the critical event and is a graphical diagram that shows how a system can fail. The analysis starts with top events, then the necessary and sufficiently hazardous events, the causes and contributing factors of which are identified together with their logical relationships by way of a "backward logic". The ETA is also a graphical logic diagram, but goes the other way. It focuses on events that could occur after a critical event and identifies and quantifies possible outcomes following initiating events by looking at potential consequences (e.g. Mullai and Paulsson, 2002). For both techniques, quantitative data, such as probabilities for events, could be used to get an idea of the final probability. Deloach (2000) proposes a similar tool called risk driver map, where potential threats are mapped.



Source: Based on Zsidisin and Ellram (1999)

Ericsson focuses on the financial impact when assessing which risks prioritizing and for which supplier or components to take actions. To get a financial value of the impact on Ericsson's own business, the company calculates the business interruption value (BIV). Currently this value is defined by gross margin multiplied by the "business recovery time" (BRT) plus extra costs such as idle capacity labour and equipment, inventory carrying etc. Its aim is to also consider values such as lost goodwill (Andreas Norrman Ulf Jansson, 2004).

According to Ericsson, an important success factor, to make SCRM work, is having an open discussion with the suppliers, both during risk analysis and assessment, but particularly when handling incidents. Many ideas and tools have been taken from normal risk management practice, but have been applied with a supply chain perspective, focusing not only on Ericsson's own activities relating risk consequences to time (business recovery time) and money (business interruption value).

Zsidisin et al. (2004) examined tools and techniques used by purchasing departments within organizations to assess supply risk. Sinha et al. (2004) investigated supplier risk in the aerospace industry and developed an integrated definition for function modelling (IDEF0) based risk management method. IDEF0 is a structured modelling method for developing functional or activity models of systems or enterprises (Mayer et al., 1994). Once the model was developed, they employed failure modes and effect analysis (FMEA) to analyze and prioritize potential failures. Pai et al. (2003) developed a Bayesian network to assess and

analyze supply chain risk. Wu et al. (2006) developed an analytic hierarchy process (AHP) based supplier risk assessment tool to determine the relative weights of individual risk factors. Using these weights and the probability of each risk factor occurring for a supplier, an overall risk index was computed. Methods for assessing risk are also contained in the growing literature bases on supplier assessment and selection (Talluri and Narasimhan, 2004).

APS are identified as potential support tools for managing complex SCP problems and as means for supply chain integration software use of a so-called SCP module, but the module is used on different planning levels addressing different problems. One of the cases uses the SCP as a SND tool.

Study demonstrates tangibly that the exchange of high-quality information as part of an improvement initiative does lead to significant improvements in the overall performance of the supply chain. The approach presented appears deceptively simple however, the development of a robust set of templates to assist in the identification of the gaps in current practice to act as the focus for the project team are key to the effective use of resources. Also the leveraging of an internet-based platform to facilitate the exchange of information between supply chain partners has shown itself to be a powerful approach to avoid the complexities of trying to integrate IT systems across the partner organizations.

4.4 Risk Mitigation Strategies

Different companies adopt different strategies to mitigate supply chain risks. Firms can adopt risk management strategies, which they use in single organization in supply chain context. Some of these are:

- Avoidance (dropping some of the product/ markets),
- Control (vertical integration, maintain excess capacity, imposing & contractual obligation),
- Co-operation (joint efforts to improve the supply chain visibility, joint efforts to shared risk related information, & preparing supply continuity plan),
- Flexibility (postponement, multiple sourcing, and localized sourcing) (Uta, 2005).

However, the general theme was that a supply chain that adopts and invests in strategies for managing the types of risks it faces should do better than supply chains that mismatch the type of risks faced and the risk management strategy selected. Risk mitigation strategy selection base on supply and demand environment which may be low and high uncertainty suggested six strategies postponement, speculation, hedging, share/ transfer control, security and avoidance.

Postponement entails delaying the actual commitment of resources to maintain flexibility and delay incurring costs (Bucklin, 1965).

Yang et al. (2004) also argue that with increasing attention to mass customization, agile operations, and e-business strategies, there should be more interest in postponement.

Speculation (also called selective risk taking) is a demand-side risk management strategy that is the opposite of postponement (Bucklin, 1965). Bucklin (1965, 27), mentions that “the principle of speculation holds that changes in form, and the movement of goods to forward inventories, should be made at the earliest possible

time in the marketing flow in order to reduce the costs of the marketing system." It includes such actions as forward placement of inventory in country markets, forward buying of finished goods or raw material inventory, and early commitment to the form of a product, all in anticipation of future demand.

Hedging is an expensive strategy because it involves creating multiple options for decision variables. For example, dual sourcing can be used as a hedge against risks of quality, quantity, disruption, price, variability in performance, and opportunism (Berger et al., 2004), but dual sourcing requires more investment than single sourcing.

Control, share, or transfer of risks takes the form of vertical integration, contracts, and agreements. Vertical integration increases the ability of a member of a supply chain to control processes, systems, methods, and decisions. Vertical integration may take the form of forward (downstream) or backward (upstream) integration, and is therefore, both a supply side and demand side risk management strategy. The literature suggests that integration may also be used to create entry or mobility barriers (Bucklin, 1965). Desirability of control and hence the level of integration also depend on the commitment of the focal firm to the target market. Vertical integration may increase control and reduce risks in a supply chain, but it changes variable costs into fixed costs.

Vertical integration ties up capital and reduces the flexibility of the supply chain to react to environmental changes. There is a growing trend toward supply and demand side disintegration, with firms focusing more on core competencies, and outsourcing non-critical activities.

Security strategy is aimed at increasing a supply chain's ability to sort out what is moving, and identify unusual or suspicious elements. Security strategy also encompasses working closely with government and port officials to proactively comply with regulations and avoid unnecessary delays at border-crossing points. Some strategies, such as vertical integration and avoidance, may reduce security strategy costs while others, such as transferring risks, may increase the cost of implementing security strategies.

Miller (1992) suggests that avoidance takes the form of exiting through divestment of specialized assets, delay of entry into a market or market segment, or participating only in low uncertainty markets.

Once the risks are assessed, a number of strategies can be used to manage the risk. These include: transferring risk, taking risk, eliminating risk, reducing risk and subdividing risk into individual levels for further analysis (Hallikas et al., 2004). Rice and Caniato (2003) classified mitigation techniques by failure mode in a supply chain.

Zsidisin et al. (2005) examined how and why firms created business continuity plans to manage risk in the supply chain. Zsidisin and Smith (2005) performed case study research focused on managing supply risk through early supplier involvement.

Johnson (2001) presented strategies for dealing with risks related to toys. Faisal et al. (2006, 2007) used graph theory and matrix methods to mitigate supply chain risk. Finally, Nagurney et al. (2005) used multi-criteria decision-making to manage risk of manufacturers and distributors.

The introduction of the real options inside a supply chain allows the introduction of a greater level of flexibility in the network useful to cover the damages of market volatility. For instance, the damages from the uncertainty related to the level of

product demand and the price/exchange rate can be limited through the use of the real options.

The application of a real option approach inside a supply chain operating in an uncertain environment. By the use of real option firm management can deal with a different situation, indeed greater is the uncertainty, and greater is the option value turbulent business environment in which the actual supply chains operate. Owing to this even increasing turbulence, the supply chain can gain better performance through an intense collaboration among the several actors, that is, several kinds of joints that coordinated effort between two parties in a supply chain for achieves a common goal are even more necessary. Effective collaboration within each entity and between entities in the supply chain is essential to achieve good performances. However, only a little number of collaboration initiatives has successful and the collaboration appears more and more difficult to achieve. A way for reduce the damages of collaboration failure is increase the supply chain flexibility and, with this regard, real option instrument can be used. In so doing the management have the opportunity to adjust their decisions to the new situation that no one can foresee.

Based on the relative degree of probability and their negative consequences four generic strategies are reduce, avoid, retain and transfer. Different authors gave different framework. Two most interesting are Sunil Chopra (2004).



Source: Chopra & Sodhi, 2004

Authors classified risk mitigation strategies in different ways using different basis of risk definition. Classification by Chopra & Sodhi, 2004 showed the impact of

various mitigation strategies on various risks, which clearly shows that each risk mitigation strategy has limitation and there is need to identify specific strategy to specific risks.

5. SCRM Issues

Business with a supply chain strategy requires integration, cooperation, coordination, open communication and sharing information risks and rewards. Collaboration is based on mutual trust and openness, which yield competitive advantage. More and more companies are collaborating to manage supply chain risks. Ten firms were surveyed and managers expressed that Collaboration results in incremental innovation, more efficient operations, better quality and lower cost (Claudine et. al. 2008).

It would seem that as long as firms decide to work collaboratively, share information, and link their futures to a common destiny, there will exist risk by virtue of the interdependence. Notion of opportunistic risk that can exist only when firms rely on each other and have begun a trading relationship based on notions of trust. Being trustworthy opens one partner to the possibility that the other partner will take advantage of this trust and behave in its own self-interest, thereby violating this trust to gain an upper hand. High levels of mutual trust exist among supply chain members; the likelihood of such behaviour is very low (Robert et. al., 2004).

For SCRM Information sharing, agility in supply chain, trust among supply chain partners, collaborative relationships, aligning incentives and revenue in a supply chain and strategic risk planning are key variables. No variable is disconnected from the whole system and management has pay attention to all variables (Faisal et. al. 2006).

Literature review suggests that risk mitigating strategies have to be investigated in conjunction with risk drivers. Risk drivers are factors which compel firms to take risk and impact directly the network related risk sources e.g. focused factories, focus on efficiency, globalization, and reduction of supplier base. Together these factors build several trade-offs decisions for example trading the benefits of repeatable process against cost of lack of flexibility; lowest bidder versus unknown supplier; centralization against decentralization in decision making in production and procurement; and finally collaboration against secrecy. Trade-off decision is between managing risk and cost. Trade-off decisions are of a high concern to managers (Sheffi, 2002).

Information systems and technologies have the potential to coordinate and integrate the activities across the supply chain. Internet enables companies to get real time data, which improves the performance of the whole supply chain. It has been demonstrated that the internet can have an important impact on the management of the supply chain risks and it can improve the competitiveness of firms. With the development of web-technologies, SCRM will focus on helping decision makers better manage customer relationships, efficiently integrate internal processes and collaborate in real time with trading partners Information technology infrastructure implementation has become the major concern for supply chain managers. For IT-enabled SCM, three pillars are required viz: e-commerce, e-procurement and e-collaboration (Riccka, 2006). SCRM system implementation is more than technology adoption; it should take consideration of company's strategies as well as supply chain strategies.

Supply chain risk management (SCRM) system entails the specific ordering of activities, techniques and tools across time and place, with a beginning, an end, clearly identified inputs and outputs and structure for action. All the tools and techniques must be consistent with supply chain strategies (John, 2008).

Companies that can identify and develop contingency plans for the various risks that exist internally and externally to the organization will be successful. At the strategic level, supply chain risk management is relatively new and rapidly expanding discipline that is transforming the way that manufacturing and non-manufacturing operations meet the needs of their customers (Gunasekaran, 2004). Formulation of appropriate and effective organizational strategy to a certain extent mitigates supply chain risks. The optimization of the complete supply chain is accomplished through efficient planning decisions. Research shows that managers must do two things when they begin to construct a supply-chain risk management strategy. First, they must create a shared, organization-wide understanding of supply-chain risk and secondly, they must determine how to adapt general risk-mitigation approaches to the circumstances of their particular company (Chopra & Sodhi, 2004).

Develop the concept of trust and to utilize its operational form in how suppliers are evaluated and developed, as part of a supply chain-wide performance improvement activity, requires a major change in culture, norms and values for many companies. Moreover, it demands that senior management embrace its tenets and demonstrate its Ideals.

Kim et al. (2006) study indicates that the exchange of high-quality information between partners improves the channel coordination and improves the overall responsiveness of the partnership and ultimately market performance. Furthermore, the sharing of information across the chain will also lead to closer integration, which has been linked to improvements in productivity, customer service and overall marketplace performance **(**Frohlich and Westbrook, 2002).

Christopher and Lee (2001) acknowledge the inherent complexity of inter-organizational supply chain networks, promoting the virtues of visibility, velocity and control as key elements of risk management. They argue that greater visibility and control improves quality and allows managers to make their supply chains more responsive and manageable, thus preventing an undesirable accumulation of slack – in the form of inventory buffers or additional safety time built into logistics lead-times. More specifically, Christopher and Lee advocated careful monitoring of the supply chain for deviations from schedules or business plans to allow appropriate parties to be alerted and corrective actions to be taken. In this sense "risk management" has parallels to statistical process control and contemporary lean Six Sigma methodologies **(**George, 2002).

Braithwaite and Hall (1999) pointed out that inter-organizational networks are so complex that monitoring them is beyond the capabilities of any single organization and control is far from complete.

The project orientation in supply management, which allows a company to have a deeper risk management culture and then to apply project management techniques in supply management leads to a greater focus on the SRM. The use of partnerships with suppliers implies a higher relevance of SRM rather than SS, basically because the relationship has to be managed along the partnership time-window (which is much longer than a simple supply time-window), and this leads to a greater focus on

the SRM. Another finding is that a high level of corporate standardization leads to a greater focus on the SRM because there is a need of knowledge about what happens in a supply, in order to allocate the contingencies for deviations or disruptions. In addition, there is a need of standardization in terms of internal reporting, which leads to a formal and extensive use of the SRM.

In summary, with respect to the contextual factors identified in the literature (mainly product- and supplier-related) for the SRM, some cultural (project orientation in supply management), strategic (use of partnerships with suppliers), and organizational (corporate standardization) contextual factors are identified. The need of co-design pushes a company to make a great effort in order to select the most proper supplier, because of the difficulty in overcoming the risk related to supplier incapability in co-design. This need for co-design seems to lead to a greater use of local suppliers, due to the current unavailability of economic and easy-to-use specific e-tools.

Security issues are likely to continue to influence supply chains, relationships, and the efficient movement of goods. But even with the security measures that are taken, attacks on supply chains will occur and supply chains will suffer (Sheffi, 2002). As a result, planning for disruptions to the supply chain is a necessity (Hale and Moberg, 2005). Firms should integrate preventive security measures (Zsidisin et al., 2005) and be ready to respond to the disruption when it occurs (Sheffi, 2002; Hale and Moberg, 2005; Zsidisin et al., 2005).

Sub-optimization across business functions remains an immense challenge for firms seeking to fulfill cross-functional supply chain processes (Lambert, 2005). To this end, researchers and firms seek to develop measures that support activity and functional performance that contribute optimally to firm and supply chain objectives (Lambert and Pohlen, 2001).

This tendency towards personally beneficial behaviour decreasing the overall value of the firm and consequently impairing the supply chain is not limited to the top management echelons of the firm. An example of this could be the much publicized Enron scandal and its impact on the supply chain could be gauged by the firms that took the fall along with Enron, such as the accounting firm Arthur Anderson. Research suggests that while the notions of what behaviour is “acceptable” and what is “unacceptable” become clear between supply chain members over time, these notions are relatively murky during the formative period (Carter, 2000). It thus logically emerges that “pressure to conform” to specifications may induce supply chain members to behave in unethical, self-fulfilling means, thus increasing overall supply chain risk.

Some of the variables that influence the “contract” or relationship between the buyer and supplier include information systems, outcome uncertainty, goal conflict, relationship length, adverse selection and moral hazard (Eisenhardt, 1989a; Logan, 2000).

6. Discussion and Analysis

Uncertainty issues in supply chain management are attracting attention of practitioners and researchers. It got major attention after 9/11, which was the major reason for whole US economy’s stagnation. This paper presents the extensive literature review on supply chain risk management, high lighting the major issues in supply chain management. Major research papers are of conceptual nature and

exploratory nature. As literature suggested a generic classification of risks in supply chain:

Risks within the network

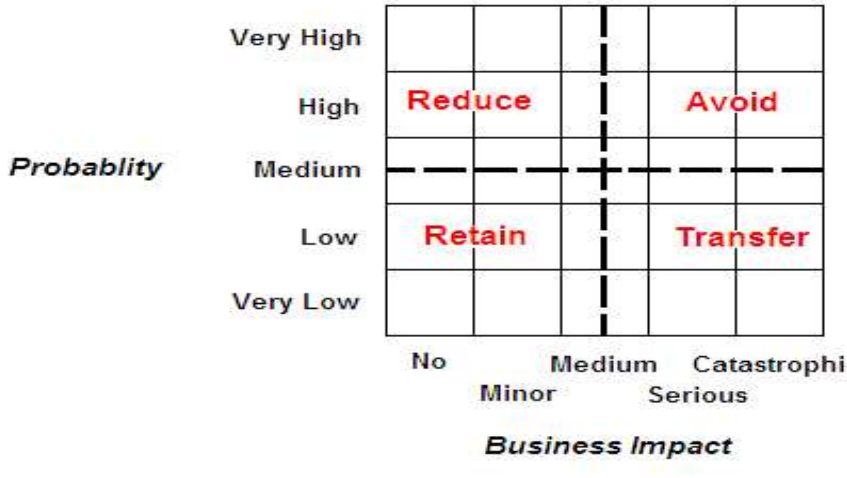
Risks within the network and outside the organization

Risks outside the network.

Authors emphasized on risk sources identification, one source may create more risk events. Just find risks are not enough, identifying risk events originating source is more important. Managers should also focus on factors which are responsible for creation of risks in supply chain. These factors are competitive forces, which need to be adopted to remain competitive in marketplace. For example cost reduction effort "outsourcing", created dependence on other firms. Focused factories which are adopted for efficiency gain, also may creates disruption.

Bridley considered classified risks in systemic risk and non systemic risks. Author included two more risks i.e. decision specific and problem specific risks.

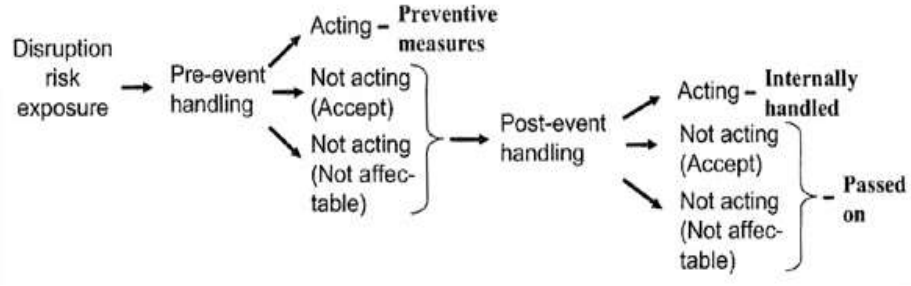
Risks assessment is an important construct of SCRM. Prioritizing risk help the managers to understand which risk are important and which risks need to be handled quickly and what level of efforts is required. Two parameters used to assess risks are probability and their relative business impact.



S. Chopra has suggested specific mitigation for specific risks, but still risks which not covered by author. There two approaches towards risk management; one is contingency approach and another mitigative approach. Here research gap exists, establishing suitability of approach for different risks.

A model is suggested bases on exiting literature to meet the above mentioned research gap, where both approaches contingency and mitigative approaches a firm should have for effective risk management.

Risk is a perception and that matters a lot. At different stages of supply chain, supply chain professionals have differing perception towards supply chain risk and differing attitudes towards methods of managing risk. This differing perception and attitudes can be tested in future.



Finally SCRM implementation is like supply chain management project, whose objective should be strategic. SCRM implementation is strategic challenge; it needs efforts from all supply chain members. The enablers and benefits from SCRM need to be investigated in more detail.

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