

Supply Chain Risk Management: A Review

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Abstract - Many different entities are responsible for or reliant upon the functioning of the global supply chain, including regulators, law enforcement, public-sector buyers, private-sector businesses, and other foreign and domestic partners; mainly because the global supply chain provides the food, medicine, energy, and products that support our way of life. To do this, the global system relies upon an interconnected web of transportation infrastructure and pathways, information technology, and cyber and energy networks. While these interdependencies promote economic activity, they also serve to propagate risk across a wide geographic area or industry that arises from a local or regional disruption. This paper aims to introduce the concept and framework of supply chain risk management (SCRM) by reviewing the literature. The review emphasises on the definition of each component within SCRM followed by the integration of the components into one of the current models applied by the global supply chain industry.

Keywords- Supply Chain Management, Supply Chain Risk Management (SCRM), Enterprise Risk Management (ERM), Supply Chain Operations Reference (SCOR) Model, Risk Analysis, Risk Self-Assessment and Risk Scorecards.

1. Introduction

Global and multinational industries have slowly starting to emphasize on supply chain risk management (SCRM) concept in their day-to-day operations. The industries realize that the chain that provides people for the food, medicine, energy, and products, an organization can easily face multiple risks across its entire supply chain such as supplier, process, regulator and regulations, intellectual property, political and economic risks. With the global system relying on an interconnected web of transportation infrastructure and pathways, information technology, and cyber and energy networks, the organizations are beginning to realize that to succeed and mitigate the risks they face,

they need to adopt a risk framework for their supply chain processes. This way, they will be able to identify key risks, the management and control, mitigation factors and the actions to minimize the impact on business performance (these can be summarised as Enterprise Risk Management (ERM) best practice) that are now included in many corporate agendas of global SCRM top managements.

The SCRM is said to be made up of at least two key components that are critical for organization's marketplace survivability and company performance within a global supply chain, i.e. supply chain and risk management. The importance of supply chain component is acknowledged as most organizations increased their dependency on their fellow supply chain members and networks that in today's scenario, more and more supply chains are observed to be competing against one other in the industry instead of the organizations. The increased awareness of risk management component on the other hand is unavoidable since the business environment today is characterized by globalization and amplified efficiency requirements. The problem is, while many organizations have beginning to accept the concept, there are however many more of them who are still contemplating on whether they want to implement it, or other organizations who have not realized until today of its importance resulting in the SCRM to be still considered as an often overlooked risk within an organisation. It is thus important to make these organizations aware of what SCRM can offer and do to them. The main benefit being that SCRM may be the one concept that can help organization in minimizing or zeroing on the probability of an occurrence of undesirable event that causes extensive supply chain disruption. The gist of it all is for an organization to identify what are the key SCRM issues, the need for it to make a risk self assessment as well as carrying out risk analysis within and outside the organization. These will be discussed in the review of SCRM in this paper.

2. Literature Review

The literature has identified at least two key components of SCRM, i.e. supply chain and risk

management. Each component has their definition issues that need to be explained before one reaches a definition for SCRM.

2.1 Supply Chain Definition

The first component of SCRM is supply chain. In general, it refers to a system of organizations, people, activities, information, and resources involved in moving a product or service from supplier to customer. It includes purchasing, manufacturing, warehousing, transportation, customer service, demand planning, supply planning and supply chain management. In short, supply chain is made up of people, activities, information and resources that are responsible in moving a product from its supplier to customer. In other words, the supply chain encompasses the steps it takes to get a good or service from the supplier to the customer [28]. Another definition of supply chain is “a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer” [19]. While this definition seems to be similar to the one presented earlier, it is still criticized for the interpretation of the term chain which is argued to be simplistic and misleading. For example, Chapman et al. (2002), Christopher (2005) and Lambert et al. (1998) argue that a supply chain should be considered as something more complex than merely a chain which is too simplistic considering the increased number of geographic distribution of companies today. With organizations operating from many geographic locations, there is no way that the supply chain can remain simple but is now increasing in complexity. In addition, the interactions amongst the chain members should now be complex as well rather than simple as previously experienced that they are now extending themselves into networks rather than chain [4, 6, and 16]. In short, according to the critiques, the term supply chain should be implying or referring to a supply network instead of a supply chain.

The suitability of the term supply in the supply chain variable has also been questioned with many researchers suggesting new word to replace it. For instance, Christopher (2005) suggests and use the term demand chains/networks to replace supply chain [6], while Kempainen and Vepsalainen (2003) added the word demand in front of the term supply and change the word chain to network; resulting in the formation of a new term i.e. demand supply networks instead [15]. Since supply chains are not driven solely by supply factor, but also by other factors like demand and interaction made amongst chain members, it is important to note that arguments on which these researchers

have brought up are valid ones, and should not be ignored when one is investigating related factors in the supply chain. However, the original term i.e. supply chain remains the more commonly used term in the literature compared to the new terms discussed, probably due to its simplicity and clarity for lay-mans understanding. Because of this, the term supply chain will be used in the remaining parts of this paper.

Interestingly, management is also acknowledged in the literature as one integral part of supply chain hence the term supply chain management (SCM) as used by some researchers. SCM for example is said to include the state of being aware of the other supply chain members, which processes are to be linked between the supply chain members, and which management techniques should be used to integrate the processes of these members [16]. Another definition by The Global Supply Chain Forum is found to be quite similar, i.e. “Supply chain management is the integration of key business processes from end user through original suppliers that provides products, services and information that add value for customers and other stakeholders (p.1)” [16]. From these definitions, one can generally describe that SCM is about how supply chain members, stakeholders and customers manage the chain.

2.2 Risk Management Definition

Risk management is another key component of SCRM. In the literature, most discussions on this issue are confined to financial reporting and internal controls risks; apparently because they are closely associated with Sarbanes-Oxley Act (2002) which is named after its sponsors, i.e. U.S. Senator Paul Sarbanes and U.S. Representative Michael G. Oxley [36]. The Act was enacted as a reaction to a number of major corporate and accounting scandals including those affecting Enron, Tyco International, Adelphia, Peregrine Systems and WorldCom which not only cost investors billions of dollars when the share prices of affected companies collapsed, but shook public confidence in the nation's securities markets too. The implementation of SOX has led to several outcomes in the industry. Examples include, one, top management must now individually certify the accuracy of financial information; two, penalties for fraudulent financial activity are much more severe; and three, SOX increased the independence of the outside auditors who review the accuracy of corporate financial statements, and increased the oversight role of boards of directors. Today, SOX-type laws have been subsequently enacted in Japan, Germany, France, Italy, Australia, Israel, India, South Africa, and Turkey etc.

The literature on risk management has been found to mainly focus on the uncertainty factor that plays an intricate role in most business situations. According to March and Shapira (1987: p. 1404), risk is “the variation in the distribution of possible outcomes, their likelihood, and their subjective values” [17]. Risk is often used in conjunction with the terms uncertainty and vulnerability as organizations face the possibility of being vulnerable to other supply chain members that put them into a disadvantage state. Here, vulnerability is defined as the exposure to serious disturbance arising from risks [4], whereas uncertainty arises when something “reduces the predictability of corporate performance, that is, increases risk (p. 312)” [21]. Another definition of risk management is - a coordinated set of activities and methods that is used to direct an organization and to control the many risks that can affect its ability to achieve objectives (<http://www.praxiom.com/iso-31000-terms.htm>). In the Introduction to ISO 31000 2009, the term risk management is defined as the architecture that is used to manage risk. This architecture includes risk management principles, a risk management framework, and a risk management process [24]. Hutchins and Gould’s (2004: p. 75) explanation of risk management as the essential process of responding to the existence of uncertainties (and, hence, risks) through “controlling variability from an objective, target specification or standard” [13] similarly shows the influence of the supply chain perspective in the definition that is laden with company-specific techniques of risk management. In reviewing the risk management definitions, it is observed that they emphasize mainly on various risks, management and technique aspects in order to address both uncertainty and vulnerability issues for organizations.

2.3 Supply Chain Risk Management (SCRM) Definition

From the many definitions on the SCRM key components earlier, we can safely assume that the definitions of each component like supply chain, supply chain management, risk, and risk management can all be integrated into one single definition of SCRM. With a single integrative SCRM definition, it indicates not only the importance of each SCRM components, i.e. supply chain and risk management to be woven into one SCRM definition, but it also pinpoints to the kind of strategies needed by organizations to ensure their survivability in the supply chain and marketplace. Quite a few integrative definitions of SCRM have been observed in the literature. One example is the definition of SCRM as an organisation's ability to identify strategic vulnerabilities and improve supply chain resiliency;

and these require direct discussions with those outside the company, such as suppliers, contractors, customers, as well as necessity at times for a cross-sector and intra-sector exchange of information and collaboration among competing companies [9]. SCRM is also defined as the process of risk mitigation that is achieved through the collaboration, coordination, and application of risk management tools among the partners to ensure continuity coupled with long-term profitability of the supply chain [10]. This is interesting because according to Juttner (2005), the concepts of supply chain vulnerability and its managerial counterpart supply chain risk management (SCRM) are still in their infancy [14]. In addition, organizations must be able to realize that potential supply chain risks include delays, disruptions, forecast inaccuracies, system breakdowns, intellectual property breaches, procurement failures, inventory problems, and capacity issues [5]. Thus, in modelling SCRM, researchers need to take into consideration of risks in supply chains, discusses the determinants of risk susceptibility in a supply chain, and presents the alternative strategies that are commonly employed to mitigate risk in supply chains.

Although discussions found in the literature on the topic of financial and strategic risks often include SOX and the concept of Enterprise Risk Management (ERM), in reality, the total risks an organization actually face in Supply Chain Risk Management (SCRM) is much broader especially as it includes Hazard Risks (e.g. weather disasters, equipment shutdown, or product liability) and Operational Risks (e.g. major disruptions such as theft, later supplier deliveries, IT systems shutdowns, etc.). In general, the supply chain encompasses all organizations and activities associated with the flow and transformation of goods from the raw materials stage, through to the end user, as well as the associated information flows.

From previous discussions, one can summarize SCRM as the integration and management of supply chain organizations and activities through cooperative organizational relationships, effective business processes, risk management and high levels of information sharing to create high-performing value systems that provide member organizations with a sustainable competitive advantage. One thing to note from the definition is on the role of risk management in SCRM's success.

2.3.1 Risk Management role in SCRM

While risk management has been acknowledged as a component of SCRM, it is equally important to note its increased formal role in the existing supply chains, materials, and operational management; a

trend that stems from the rising visibility of supply chain risk. Amongst the driving factors for this trend have been the uncontrolled events like natural disasters faced in many countries over the last several years (e.g. Hurricane Katrina in USA to the earthquake and tsunami in Japan), apart from increased information technology capability, and top management's support. Organization's top business management have recognised that with improved risk management in SCRM, they have observed that the organization can endure and even benefit from (any type of) risk in challenging economic times, compared to competitors that are not properly equipped or those that have not started to implement SCRM. Although the visibility of risk management tends to rise and fall with reported disasters, it is important to note that formal ongoing roles and responsibilities can only help counter the cyclical rising and falling attention given to risk management only as risks occur. The formal roles of risk management in SCRM include [9, 10]: i) to stimulate the many supply chain best practices like being the stakeholder in eliminating waste (e.g. using avoidable resources/assets can create unnecessary risk burden to an organization as each deployed asset, fully utilized or not, requires its own risk protection overhead such as insurance; that they may additionally increase complexity and the inherent risk of unintended consequences); ii) to improve supply chain partner relationships from the practice of joint risk sharing and risk information, and increased trust from partner's commitment); iii) to minimize the reality of soft risk (risk that is difficult to measure) which is often goes unattended in an organization (note: risk management role is to provide constant awareness and vigilance toward decisions, processes, practices, and goals that may unintentionally increase or decrease risk in the supply chain); and iv) to balance between strategic risk and reward from its people, assets, capabilities, and resources.

As local disruptions to supply chain management networks occur on a daily basis, certain external events, when combined with existing network vulnerabilities, have the potential to cause widespread, systemic disruptions. Thus, risk management roles as listed above are crucial for organizations to understand and implement. In a study, survey respondents have ranked the exogenous disruptions most likely to provoke significant and systemic effects on supply chain or transport networks [41].

2.3.2 Risk Categories in SCRM

Environmental, geopolitical, economic and technological risks are four risk categories identified in the literature with the first three ranked the highest [32].

Environmental risk is environmental in nature as they arise in, or are transmitted through, the air, water, soil or biological food chains to man. Their causes and characteristics are very diverse as some are created by man through the introduction of a new technology, product or chemical, while others, such as natural hazards, result from natural processes which happen to interact with human activities and settlements [35]. The 2011 earthquake and tsunami in Japan are examples of this risk. A survey identified natural disasters as the mostly likely cause of systemic supply chain or transport disruptions followed by weather [32]. The 2011 Global Risks Perception survey found meteorological and hydrological catastrophes as two of the most likely environmental risks to occur [34]. It was reported that in 2010 alone, worldwide economic losses from natural disasters is said to total US\$ 194 billion [42]. Such disasters can damage infrastructure, interrupt production and significantly impact private sector financial performance. Operating profits of fifteen public listed multinational companies are reported to fell by up to 33% in the financial quarter following the 2011 earthquake and tsunami in Japan as a result of supply chain disruptions [43]. The public sector can also face significant costs, with the Japanese government allocating a ¥ 12.1 trillion (US\$ 239.3 billion) budget for the reconstruction of areas devastated by the 2011 earthquake and tsunami [44]. In implementing risk management in SCRM, it is important to note that natural disasters are hard to predict or prevent, thus, organization's top management must focus on making the right investments before the event to reduce supply chain and transport network system vulnerability and improve recovery capability.

Geopolitical disruptions encompass a range of potential disruptions including conflict and unrest, terrorism, organized crime and corruption. As an example, the on-going concern about the effects of terrorism on global supply chains is illustrated by the cumulative increase in expenditure of over US\$ 1 trillion in US domestic homeland security since 9/11, as well as a range of new industry regulations and requirements across supply chain and transport networks [45]. While businesses are concerned that a security disruption may affect a critical production or distribution hub, they also worry that fear of such events can trigger legislation that could have an equally disruptive effect. The expert group pointed out that new security requirements following 9/11 to build enhanced protection, while well-meaning, have failed to strike the right balance between protecting against terrorist threats and facilitating the smooth flow of goods and people [46]. Conflict and political unrest were identified as a key concern by 46% of respondents.

Persistent military conflict can cause disruption to major transport routes or production hubs. According to the International Energy Agency, escalating violence in Libya in March 2011 meant that up to two-thirds of Libya's oil production would not make it to market [47]. Maritime piracy is another increasing concern for supply chain professionals and transport providers, and is estimated to be costing the international economy between US\$ 7 billion and US\$ 12 billion per year [48]. Areas where terrorism or limited law enforcement is prevalent – whether in trade routes such as the Malacca Straits, or countries such as Indonesia – pose risks to employees and goods within the supply chain. In addition is the illicit trade which is now thought to represent between 7% and 10% of the global economy, and rough estimations by the Forum's Global Agenda Council in 2009 put the market size at US\$ 1.3 trillion [46]. The shadow supply chains, counterfeit products and IP infringement can have an extensive impact across supply chain networks; for instance, they undermine economic development by raising the cost of doing legitimate business. From these evidences, geopolitical disruptions can be said as ones that are hard to manage in the short term, with limited opportunities for industries to influence outcomes; which imply that a dual approach on risk reduction and increased network resiliency need to be implemented in SCRM.

Economic disruptions cover a range of issues, including currency fluctuations, commodity price volatility, sudden demand shocks, border delays and ownership/investment restrictions – many of which have been highlighted by the global financial crisis in 2008 and the current Euro zone crisis. Following the 2008 financial crisis, annual filings for supplier bankruptcy within the automotive sector roughly doubled from 2007 to 2008 [49]. Currency exchange rate fluctuations in 2010 dealt a financial blow to many businesses. The trend towards globalized supply chains to lower costs and improve profitability has resulted in organizations with a substantial proportion of operations overseas. Systemic disruptions driven by currency fluctuations are more likely when sourcing or access is concentrated. The economic viability of certain supply and transport chains is dependent on a critical mass of traffic. When major flows dry up, this has a cascading effect on other flows, sometimes not obviously connected for example, through passenger and belly-cargo interdependence. Export/import restrictions and border-crossing delays are another example for economic disruptions as cross-border movements remain vulnerable to customs regimes, tariff and non-tariff barriers, quota systems, security concerns and infrastructure bottlenecks. A study by the World Bank in 2004 concluded that enhanced

capacity in global trade facilitation would increase world trade of manufacturing goods by approximately US\$ 377 billion, an increase of about 9.7% in global trade [50]. The Global Risks 2012 report identifies major systemic financial failure, chronic fiscal imbalances and extreme volatility in energy and agricultural prices as three of the top five global risks having greatest impact if they were to occur [31]. This further supports the general conclusion that economic disruptions are top of mind for risk experts across many domains.

Technological risk category addresses risks that are of greatest concern in the area of current and emerging technology. Within the technology category, volatility and the inability to “know the unknowns” are revealed by the large spread of impacts and likelihood of the risks. Technological risks range from cyber attacks, highlighted as having the highest likelihood and a high impact, to critical systems failure having the highest impact and lower likelihood, and to the unintended consequences of nanotechnology, which has a lower impact and lower likelihood. [31]

As technology permeates the operations of an entire institution i.e. to develop, deliver, and manage its products, services, and support operations, this risk cannot be compartmentalised as a process that focuses on a particular area. One needs to understand the role technology plays in enabling core business operations to establish the framework for where this technology risks stands. Only then that company management will be in a better position to determine the relative importance of the functions and prioritize the systems, applications, and data involved. In short, technology risks are present throughout the company and must be addressed as a whole by developing and implementing an appropriate technology risk management strategy. [51]

3. SCRM Conceptual Framework

SCRM is based on the notion that organizations are experiencing rapid supply chain expansion with decentralized supplier base. While the expanded supplier based in supply chain is meant for organizations to gain major cost advantage and market share, it also can lead to the supply chain to be more unstable due to various types of disruptions or risks (e.g. environmental risk, economic risk, etc.) the chain faces that increase the risks in organization's business operations and survivability. Thus, SCRM should be framed as the best practice or governance that can minimize any impact on organization or chain's financial strategy and profitability. Lean management, Just-in-time and outsourced supplier network are examples of such best practices or methodologies employed by

many organizations that have provided major benefit in the in SCRM value chain. In developing a framework for SCRM then, any best practice must take into account the process that an organization go through in a chain. In this process, businesses act as partners or enablers in a supply chain (e.g. supplier, logistics provider, manufacturer, wholesalers, retailers) and are responsible for multiple functions (like managing materials, production process, information management, design process, financial management and demand planning and forecasting). Businesses need to prepare for multiple risks (e.g. supplier risk, process risk, regulatory risk, intellectual property risk, downstream partner behavior risk, political risk and economic risk) that may strike them at any moment which can then affect the businesses profitability and survivability. Thus, businesses need to adopt a risk framework for its supply chain processes to identify key risks, manage, mitigate and minimize the impact on business performance.

3.1 Types of Risk

To assess and evaluate a nation's resilience to global risks requires defining such risks in their most appropriate organizational context. [39] Harvard Business School Professors Robert Kaplan and Annette Mikes distinguish three types of risks:

1. *Preventable Risks*, such as breakdowns in processes and human error
2. *Strategic Risks*, which are undertaken voluntarily after weighing them against the potential rewards
3. *External Risks*, which are beyond one's capacity to influence or control

In the case of business, Kaplan and Mikes suggest that the first two types can be approached through traditional risk management methods, focusing mostly on organizational culture and strict compliance with regulatory, industry or institutional directives. Given the exogenous nature of external risks, cultivating resilience is the preferred approach for this last type of risk. [40] Another way of categorizing risk is to ask two questions: How predictable is its likelihood and potential impact, and how much do we know about how to deal with it? If we can predict it and we know a lot about it, we can come up with specific strategies to anticipate the risk, mitigate its effects and minimize losses.

The first step in this exercise is Risk Analysis and Risk Self-Assessment whereby an organization use related documents to evaluate each risk framework for its entire supply chain processes that include a) the key processes like procurement, manufacturing, order fulfilment, customer complaints and returns;

b) risks (e.g. Supplier, Legal, Intellectual Property, Demand Chain, Regulatory); c) events (e.g. automated or manual assessment of events such supplier non-compliance with SLA); and d) KRIs (Key Risk Indicators). The second step is Control Design and Assessments whereby the organization must define a set of controls to mitigate supply chain risks. The third step is Loss Tracking and Key Risk Indicators (KRIs) – this step involves tracking on loss incidents and near misses, record amounts, and determine root causes and ownership while the fourth step is Issue Management and Remediation on which it is expected of an organization to manage issues arising out of supplier assessment, audits and loss events and enable systematic investigation plan for issue remediation and risk treatment. The last step is Risk Scorecards and Dashboard Reports on which the organization must ensure that it gets visibility into the risk analysis, key risk metrics and risk heat map to proactively identify areas in supply chain which needs attention. The steps are shown in Figure1.

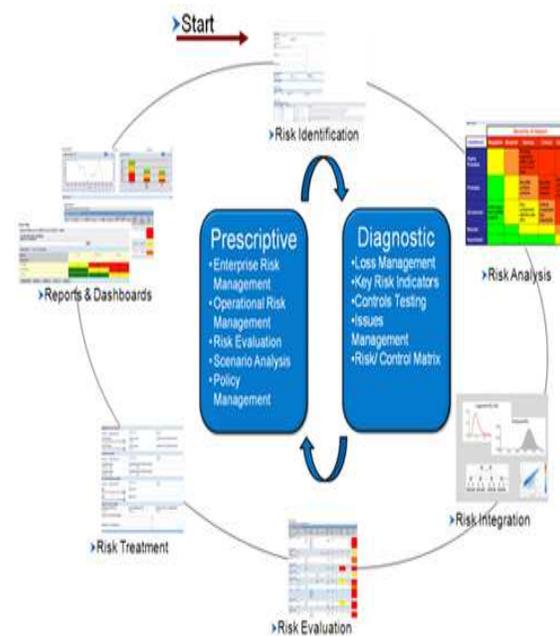


Figure 1. Supply Chain Risk Management Process [52]

A SCOR approach has been suggested by Faisal, Banwet and Shankar (2007), which allows companies to communicate using common terminology and standard descriptions of the process elements that help understand the overall supply chain management process and the best practices that yield the optimal overall performance (Huang et al., 2005). The proposed model will aid supply chain managers to consider simultaneously

different types of risks, their interdependence, and the feedback used to select the best alternative to manage risk in supply chains. The model itself contains several sections and is organized around the five primary management processes of plan, source, make, deliver, and return. SCOR is designed to enable companies to communicate, compare, and develop new or improved supply chain practices from companies within and outside of their industry segment. These five constructs are said to impact on the susceptibility of the organization and on the business approach (can be agility focused approach, supplier focused approach, or inventory focused approach) that the organization will implement. The proposed model is shown below:

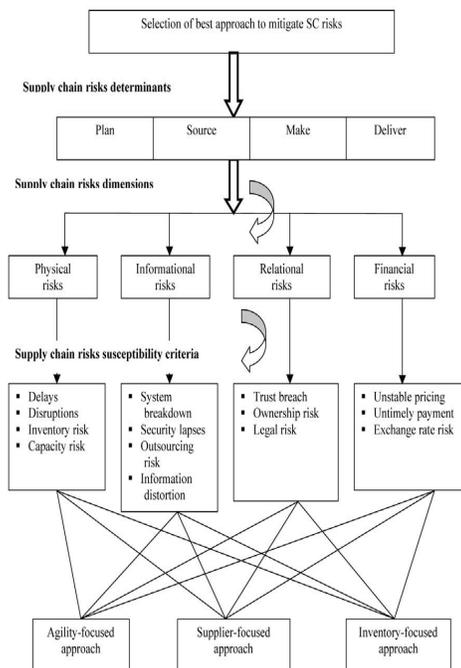


Figure 2. SCOR - Based Framework for Modelling Supply Chain Risk Susceptibility. [53]

The model seems suitable in identifying, assessing, managing and monitoring the organization's business opportunities and risks and is in line with Enterprise Risk Management (ERM) since ERM is about establishing the oversight, control and discipline to drive continuous improvement of an entity's risk management capabilities in a changing operating environment. It advances the maturity of the enterprise's capabilities around managing its priority risks. It can be expected that successfully run companies are applying many aspects of ERM infrastructure in their everyday practice. This is because it is difficult to succeed without identifying, formally assessing, responding to, controlling and monitoring risk. Risk management

practices, techniques and tools have thus been used extensively in the financial community for years. Risks with respect to a company's supply chain have begun to receive attention only more recently, as the push to increase supply chain efficiencies has illuminated the delicate balance between financial considerations and those of the customer. Trade-offs between achieving optimal supply chain efficiencies and management of supply chain risk have created a conundrum of sorts. Businesses have witnessed many supply chain malfunctions (with substantial consequences) due to supply and demand disruptions: the affected companies reported, on average, 14% increase in inventories, 11% increase in cost, and 7% decrease in sales in the year following the disruption [37, 38].

4. Conclusions

Business organizations that implement SCRM can gain many benefits, in particular as it offers organisations with an improved focus on risk and more effective risk mitigation. Other benefits of Supply Chain Risk Management include the elimination of potential and unexpected costs, reduced disruption, and decreased recovery time. Monitoring and managing supply chain events, with an eye on potential, predictable, and even uncertain risk elements, generally evidences an improvement in overall supply chain performance. As supply chain and transport networks evolve in a dynamic environment, there is an urgent need to review risk management practices to support both long- and short-term strategic decision-making. The risk exposure of organizations must be carefully analysed against objective and transparent criteria, and costs must be weighed against the benefits of potential risk mitigation methods.

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