A Novel Classification of Supply Chain Risks

A Review

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***Abstract*—Every organization is a complex supply chain system. If any fragment of this supply chain is disturbed, it will directly affect the entire structure. Numerous studies have been conducted to categorize the supply chain risk sources, but very few available cover all types of risks. This study did an extensive literature review and content analysis on the subject. A supply chain is the flow of information, material, and money starting from suppliers and ending to end-users. To cover all types of risks, risk sources must be based on three perspectives: (i) internal to the firm, (ii) external to the firm but internal to the supply chain, and (iii) external to the supply chain. Risks can be categorized into seven types under these three perspectives. Regarding internal risks, three types of risks come from the supply side, process side, and demand side, while these members of the supply chain are connected with the supply affected by logistic side risks, finance side risks, and collaboration side risks. The external environment also affects the supply chain so the seventh type of risks comes from environmental side risks. This study extends the literature of supply chain risk management by identifying new risk sources. This study will help the managers to understand what kind of risks can affect their supply chain. Future study can be conducted to empirically verify these risks sources.**

Keywords-supply chain risks; risk sources; classification of risks

I. INTRODUCTION

Supply chain (SC) is the flow of material, finance, and information [1]. Currently, the SC is involved in every business part, either directly or indirectly. Any disruption, either natural or not, disturbs not only the core organization but the whole network and ultimately the economy [2]. In a few decades, SCs gained notable attention due to globalization [3]. In a global survey, it was noted that political uncertainties, natural disasters, and economic issues would be among top risks regarding SCs. In the same survey, it is exposed that loss of income due to this risks has been increased from 28% to 42% in just two years [2]. There are many examples in the history that add the value of SC risk management (SCRM) [4]. In the current study, a thorough literature review has been conducted and a content analysis approach was followed. It was found that there is no study available, to the best of our knowledge, that categorizes the risks while following the flow of information, material, and finance from the supplier to the end user. It can be concluded that risks come from the supply side, process side, demand side, logistic side risks, collaboration side risks, finance side risks, and environment side risks.

Numerous studies have been conducted to categorize risk sources [5, 6] but no study covers all types of risks. Identification, categorization, and mitigation are essential for the success of any SC, which is only possible when risks are identified. SCRM can be categorized according to risk sources [6]. Effective risk management can only be made possible if risks are properly identified, whether they are dealing with quality or safety challenges, supply shortages, legal issues, security problems, regulatory and environmental compliance, natural disasters, or terrorism [7]. Risk sources are "any variables which cannot be predicted with certainty and from which disruptions can emerge" [8] and this research discovered by consensus, that risk sources have become more essential as SCs become more complex and modern. A systematic review of 90 articles on SC risk sources shows that 25% of the articles considered only supply side risk, very few studies applied external risks and the studies that covered all dimensions of risks were very limited [9]. Suthor in [7] reviewed 138 articles and found that less than 25% of them applied the quantitative technique in SC risk management. This study analyzed articles from 2000 to 2018 and found that most of the studies considered either operational risks, disruption risks or risks as general. The studies that use multi-dimensions of risks and

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evaluate the effects of overall SC risks on performance are very limited.

II. LITERATURE REVIEW

Supply chain risk sources [5] can be divided into two categories: internal risks/operational risks and external risks/disruption risks [10] Internal risks are divided into operational activities i.e., information risks and capacity related problems, customer demand, and quality related issues. External risks can be divided into competition, economic issues, political instability, natural disasters, and terrorist attacks [11]. There are various perspectives for developing risk sources, i.e. they can be classified in three different clusters: (i) environmental risks (those external to the supply chain), (ii) network-related risks, and (iii) organizational risks (which cannot be predicted with certainty and affect the supply-chain-outcome variables) [12]. Similarly, they can also be categorized into three groups: (i) internal to the firm, (ii) external to the firm but internal to the SC, and (iii) external to the SC. The developed five risk sources are supply issues, process issues, demand issues, environmental issues and control issues [13]. The above two perspectives and categories can be combined into four groups: (i) internal to the organization, (ii) external to the organization, (iii) internal to SC, and (iv) external to the SC [14]. Most of the relevant studies are based on this perspective and develop the risk sources either for internal risks or external risks or general. Thus, researchers divide SC risks into three perspectives: internal to organization also called organizational factors, external to organization but internal to network, also known as industry factors, and external risks also called environmental factors and the SC risks are categorized into four risk sources: supply risk, process risks, demand risks and environment risks [16, 17].

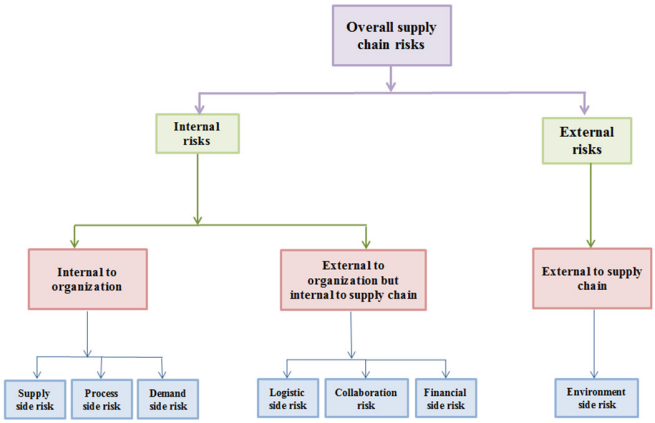

Fig. 1. Classification of supply chain risks

It is understood that if any fragment of the SC is disturbed, it will directly disturb the entire structure. Thus, to cover all the risk sources has become essential. SC not only deals with internal operations but essentially considers the external relationship with partners. Meanwhile, in another perspective, some researches define SC according to three types of flow: physical flow, information flow, and financial flow [23, 24]. SC is the relationship among SC partners and these partners are linked through flow, according to the adopted definition. Material flow creates logistic side risks [19] whereas finance flow causes financial side risks and information flow originates information side risks [26, 27]

A. Supply Side Risks

Supply risk is the chance of occurrence of an event in inbound supply that impacts the organizational capacity in satisfying the customers, either it is due to individual or market supply side. Authors in [22] describe the importance of supply side risks as most of the research in SC disruption is on supply disruptions. In supply, risks start form supplier's supply to manufactures (backward integration). Supply risk is defined as "the potential occurrence of an incident associated with inbound supply from individual supplier failures or the supply market, in which its outcomes result in the inability of the purchasing firm to meet customer demand or cause threats to customer life and safety". Toyota had to shut down plants and halt its 50% assembling for 6 weeks just because one of its suppliers had a fire incident in its plant and discontinued supply [8]. Supply risks may arise from the reliability of the supplier, moral hazards, environmental compliances, purchasing decisions, multiple sourcing and security problems or it can be, sudden price change, quality issues, supplier's bankruptcy, conflicts in goals, inventory problem, delays, product complexity, and problems in technology access [23]. This study is limited to poor logistics performance of suppliers, supplier quality problems, sudden default of a supplier (e.g. due to bankruptcy), poor logistics performance, and capacity fluctuations or shortages on the supply market [5].

B. Process Side Risks

Imperfect production is an important element that can impact significantly the performance of a company. Firms can have a massive loss, not only financial, but also in their reputation [22]. "Process side risks/infrastructure risks/operational risks are losses resulting from inadequate or failed internal processes, people and systems or from external events". An internal process risk is defined as the probability of occurrence of an event related with the principal organization that may disturb the internal ability of that organization, either producing goods or services. Disturbance may be quality or timing issues. Process side risks may be inefficiency in the manufacturing process, high level of changing in the process, material shortage or outdated technology [24]. The focus of this study is downtime or loss of production capacity due to local disruptions (e.g. labor strike, fire, explosion, industrial accidents), perturbation or breakdown of internal IT infrastructure (e.g. caused by computer viruses, software bugs), loss of production capacity due to technical reasons (e.g. machine deterioration), and perturbation or breakdown of external IT infrastructure [5].

C. Demand Side Risks

Demand side risks are derived from the downstream of the SC, or from customer side issues [8]. Demand risk is defined as "the possibility of an event associated with outbound flows that may affect the likelihood of customers placing orders with the focal firm, and/or variance in the volume and assortment desired by the customer" [25]. Demand risks may be delays,

laziness in new product development, wrong forecasting, variation in demand, inaccurate information, industrial factors further explored as input market uncertainties, product market uncertainties, and competitive uncertainties. Organizational factors also have a group of uncertainties, i.e. operating, liability, research and development, credit, and behavioral uncertainties [26]. Very limited literature is available on demand fluctuation in the SC [22]. The side risks are unanticipated, e.g. very volatile customer demand and insufficient or distorted information from customers about orders or demand quantity.

D. Logistics Side Risks

Logistics uncertainty is viewed as a factor that causes delays or interruptions originating from the firm's or partners' logistics systems or natural disasters throughout the logistic process [19]. Logistics are considered as the flow of goods from the supply side to the demand side. Little attention has been paid to the logistics side. Although, it has been noted that logistic disruption can "quickly cripple the entire supply chain" [27]. Normally, logistic side risks originate from cargo damage, supply side or warehouse problems, delays in delivery [28], improper packaging [29], labor disputes, natural disasters, terrorist activities and transportation infrastructure failures [30], wrong choice of mode of transportation [31], and transportation complexity [32].

E. Collaboration Side Risks

Collaboration can produce more effectual and considerable results, but it also carries numerous issues/risks. Collaboration risk is "the apprehensive with cooperative relationships or the probability that the partner does not comply with the spirit of cooperation" [33]. It may also be defined as "risks refer to uncertainty in coordination and information" [34]. Thus, it would be a serious issue if one member of the SC does not obligate itself to the cooperation as anticipated by the other members [27]. Information risks are associated with the systems and flows of information and include data capture and transfer, integrity, information processing, and market intelligence or system failure. This study covers the risks generated from the information flow among partners of the SC. Partners share information, but issues regarding trust, lack of coordination, lack of competency and high dependencies may occur [23]. This study enhanced the scope of information side risks and considered it as collaboration side risks. New challenges such as collaboration risks would arise when partners are involved in the SC, such as the decision making becomes complex when more partners are involved with various interests, culture, and preferences [35]. It has been learned from a validated sample of 162 responses that the complexity of partnerships has the most significant effect on SC risks and the collaboration risks are considered as the top risks that can impact SC performance to its most extent. Collaboration side risks have gained little attention in the literature [20]. Mainly, there are two types of flows: information flow and relationship flow. Some studies measured information flow risks only [31], while some cover both [9]. This study changes the name from information side risks to collaboration side risks to cover both types of risks.

F. Financial Side Risks

Financial side risks are defined as risks "that a member of the supply chain encounters, financial challenges that could impact its ability to produce and supply particular goods/services". The financial crisis was highlighted by both public (16%) and private organizations (17%) as one of the most recurrent disruptive occasions. The financial side risks have to do with cash flows, the incurrence of expenses and the use of investments for the entire network, payable accounts, settlements, and receivable accounts [33]. A financial side risk can also be defined as "the risk that a potential event will have a financial impact". [36]. It is empirically verified for garment manufacturing SC financial risks has 46.3% of probability of loss, making it one the highest risks [37].

G. Environmental Side Risks

Environmental side risks have low probability but dire consequences [38]. Natural disasters obstruct smooth operations [39]. It has been mentioned previously that nature can disrupt not only one company, but the entire SC system. In some countries, regulations are also setting big obstacles in starting a business or operate it effectively. Administrative decisions sometimes come to execution suddenly and can affect performance. Regulatory laws are defined as legal enforcement and execution and their frequency and degree of change are potentially SC risks [5]. Any change in the political environment due to new laws or modifications in existing ones may cause disruption in the SC operations. It may increase cost or even sometimes halt production [40]. It has been proved that regulation disruptions reduce the shareholder's wealth by 3.8% [40]. Environment side risks are categorized into political instability, macroeconomic uncertainties, social uncertainties, natural uncertainties, political instability, diseases or epidemics natural disasters, and international terrorist attacks [5].

III. RESEARCH METHODOLOGY

A two fold methodology was adopted for this study: systematic literature review approach to perform a first selection of the most relevant articles to be included in the analysis, and citation network analysis (CNA) in order to perform a second selection based on citations [41]. A literature review is a tool to analyze the diversity of information under inquiry and enables researchers to assess existing knowledge and further research [42]. Systematic literature review uses the relevant literature about risk sources in the SC. At first, keywords such as "topology of risk sources", "categorization of supply chain risks", "risk sources in the supply chain" and "types of supply chain risks" were identified. The retrieved articles were evaluated through manual screening and selected articles were considered for review. Meanwhile, citation analysis and content analysis were performed on the selected articles.

IV. DISCUSSION

Most of the researchers categorize SC risks into three categories: organizational factors, industry factors, and environmental factors [16]. Regarding organizational factors, most studies divide further the SC risks into three types that are broadly referred to as supply side, process side and demand

side [1]. Industrial factors describe relationships among SC partners and these partners are linked through the flow, which in has three kinds: information flow, material flow, and financial flow. Hence, material flow creates logistic side risks [19] whereas finance flow cause financial side risks and information flow causes information side risks [20]. Most of the researchers use information risks to cover information flow risks but this study argues that the information side covers information related risks and misses the relational risk coordination. To cover all these issues, the current study uses collaboration side risk and this argument is supported by [16]. To cover external factors, this study considers environmental factors like natural disasters and global issues. This view is supported by [31] which divides the overall SC risks into six factors, but it does not cover the financial side of risk. Author in [7] categorized the overall SC risks into six factors ommitting logistic side risks. To cover all supply chain risks, the organization must consider seven aspects: supply, process, demand, logistics, collaboration, financial, and environmental side risks. Additionally, from the operational definitions of this study, the SC not only deals with internal operations but essentially considers the external relationship with partners.

V. CONCLUSION

It can be concluded that SC is the flow of information, material, and finance that starts from suppliers and ends to end-users. Thus, to cover all types of risks, SC has to be categorized into: supply side risks, process side risks, demand side risks, logistic side risks, and environmental side risks. Three of these risk sources originate from supply chain members such as suppliers, internal processes, and customers. The other risks are generated from the flow that links these SC members. Moreover, the external environment cannot be neglected, so another risk category comes from environment side risks. This study adds a new categorization of SC risks. This study will help managers to understand what kind of risks they should consider while making decisions. Further study can include the empirical verification of these risks.

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