



SUPPLY CHAIN RISK MANAGEMENT: A SURVEY STUDY ON CLASSIFICATION OF RISKS

Murat Taha BİLİŞİK *

*Dr. Öğr. Üyesi, İstanbul Kültür Üniversitesi, İşletme Bölümü, m.bilisik@iku.edu.tr

Received Date:12.11.2020, Revised Date:20.12.2020, Accepted Date:08.01.2021

Copyright © 2021 Murat Taha BİLİŞİK. This is an open access article distributed under the Eurasian Academy of Sciences License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

ABSTRACT

Supply chain risk management (SCRM) is crucial for a long-term profitable, competitive and sustainable supply chain. Since defining, classifying and prioritizing risks within the scope of SCRM is an important issue in terms of both supply chain and business performance, the study has aimed to offer a road map for the companies which includes identification of the risks that companies operating in the manufacturing sector may encounter in their supply chains, calculation of risk points consisting of probability and impact values of identified risks and prioritization of risks. Using the survey method, data were collected on the probability and impact of the risks that enterprises may encounter in their supply chains. SPSS and AMOS programs were used for the validity and reliability calculations of the measurement model and as a result, risk groups have been listed by calculating probability, impact and significance scores for each risk element.

Keywords: Supply Chain Risk Management (SCRM), Risk Identification, Prioritization Of Risks

JEL-Classification: C13,C51, M11

I. Introduction

Supply chain management, besides being one of the key processes of success for any business in today's competitive global environment, is one of the main components of the competitive strategy in increasing organizational efficiency and profitability (Gunasekaran, Patel, & McGaughey, 2004: 333).

Supply chain management, which is the structure created by businesses to support the production of goods or services (Keskin, 2015), includes all parties that have come together directly or indirectly to fulfill the demands of the customer (Chopra & Meindl, 2004). Thanks to this integrated system consisting of suppliers, manufacturers, warehouses, retailers and customers, products can be produced and distributed throughout the system in the right quantities, places and time to minimize costs and maximize services (Faizal & Palaniappan, 2014: 20). Based on the definitions of various authors in the literature, the definition of Supply Chain Management created by Tang (2006: 453) is as follows: "Supply chain management aims to produce and offer products or services for consumers and is



based on suppliers, manufacturers, logistics providers, wholesalers, distributors and retailers. It is defined as the management of material, information and financial flows through the network of organizations. It includes the coordination and cooperation of processes and activities between different functions such as marketing, sales, production, product design, procurement, logistics, finance and information technology within the relevant organizational network.”

In this structure, which is also known as the value chain or demand chain, the relationship of every business included in the chain is a strategic choice (Bowersox, Closs, & Cooper, 2002). This choice requires the integration of core business processes between the end user and the first supplier to provide products, services and information that add value to customers and other stakeholders (Lambert, Cooper, & Pagh, 1998). It is an important management process that will enable businesses to get ahead of the competition by helping them to offer their customers better products and services, at a lower cost and faster (Demirci Orel & Akkan, 2018: 84). An efficient supply chain enables to improve business performance by meeting customer needs in a timely manner (Punniyamorthy, Thamaraiselvan, & Manikandan, 2013: 79). Successfully managed supply chains are of great importance in terms of both logistics performance and business performance (Özgüner & Özgüner, 2019: 67).

In order to increase cost pressure, increase productivity, meet the demands of emerging markets and gain competitive advantages, businesses tend to use outsourcing strategies on a global scale, which causes the expansion of their supply chain networks. Thus, the number of connection points in the system is also increasing (Faizal & Palaniappan, 2014: 20; O. Tang & Nurmaya Musa, 2010: 109). The complexity of the supply chain also increases the risks it has to bear. Therefore, existing supply chains have become more vulnerable to disruptions because of increasing network complexity, more interaction between different businesses that make up the supply chain, more dependence on external suppliers, shorter product life cycles and dynamic environment (Punniyamorthy et al., 2013: 80). Increasing complexity in a supply chain prevents the transparency of the system and reduces its control over the process (Faizal & Palaniappan, 2014: 19). On the other hand, the increasing number of businesses in the supply chain and the complexity of the chain have made supply chains more cumbersome. However, the decrease in the ability to adapt to changes in the external environment is another reason why it turns into a more fragile structure against disruptions (Tang & Tomlin, 2008: 12). Political and environmental threats, which have been faced especially recently, bring along problems in both the supply of raw materials and the transportation of the produced goods and services to the markets (Özgüner & Özgüner, 2019: 68). These problems can lead to financial losses, a negative corporate image, and loss of demand as well as reduced performance of the supply chain (Jüttner, Peck, & Christopher, 2003: 197). In order to reduce and control the negative consequences of disruptions in the supply chain and reduce the vulnerability of the supply chain to risks, Supply Chain Risk Management continues to gain importance as a discipline and researches in this area are rapidly increasing (Hudnurkar, Deshpande, Rathod, & Jakhar, 2017: 183).

The aim of this study is to define the risk categories in the supply chain and evaluate the risk factors in these categories in terms of probability and impact values. The main objective of this study is to make a sector-specific risk ranking thanks to the findings obtained as a



result of the research conducted with the enterprises operating in the production sector. In the following sections of the study, the concept of risk factor in the supply chain will be explained and various risk classifications in the literature will be included, followed by the methodology, findings and results sections, respectively.

2. Risk Concept in Supply Chain

In the past years, the risk was less and easier to manage as businesses only produced in their own factories, procured from local markets and sold directly to the customer (Faizal & Palaniappan, 2014: 20). With the effect of globalization, the geographical boundaries of countries have almost disappeared in business life, which has forced businesses to face some changes. Products and production processes that become more complex in parallel with increasing customer expectations, increase in competition, uncertainties, crises and losses, decrease in ethical values and investor confidence are events that emphasize the importance of risk management for businesses.

Shareholders wish the company value to increase, customers wish product and service quality, employees wish salary, job security and job satisfaction, suppliers wish to maintain honest and long-term cooperation, lenders wish on time pay loans, government wishes rational use of resources, full and timely payment of state taxes, transparent accounts and expects regulations to be followed. However, while companies are trying to reach their goals and meet the expectations of their stakeholders, they are faced with internal and external uncertainties and risks (Özsoy, 2012: 170). Any material, financial or information flow within the supply chain brings along the risk problems (Tang & Nurmaya Musa, 2010: 109).

The concept of risk, which is often used in the same sense as the concept of uncertainty, is the probability of deviation from the situation we expect to occur due to a business transaction (Özsoy, 2012: 170). There are many risk factors that make it difficult and in some cases impossible to provide the product and additional services to the customer (Demirci Orel & Akkan, 2018: 84). All kinds of risks related to the flow of information and materials in the process from the first supplier to the end consumer are within the scope of supply chain risk (Jüttner et al., 2003: 197). According to Heckman et al. (2015: 119), possible losses in the quality of the supply chain, the occurrence of triggering events and uncertain developments in the target values of the efficiency and effectiveness of the supply chain create supply chain risks. These are the risks arising from both the supplier and the general situation of the sector, reducing the ability of the enterprises to meet the demands and expectations of the market or jeopardizing the continuity of the customer and resulting in some financial losses (Zsidisin & Wagner, 2008: 401). When the various events that businesses have experienced in the past years are examined, it is seen that it has become necessary to manage supply chain risks, which include all kinds of events that will disrupt the flow of products, information or services in the supply chain (Demirci Orel & Akkan, 2018: 87).

According to researchers, although the goal of completely eliminating supply chain risks is unrealistic, it is a feasible goal to reduce the likelihood of a harmful event. Therefore, supply chain risk management consists of purchasing efforts that reduce the likelihood of harmful supply activities occurring and / or their impact on the firm (Zsidisin & Ellram, 2003: 15). In this direction, coordination or cooperation between supply chain partners are necessary



to manage risks on the one hand and ensure profitability and continuity on the other. (Tang, 2006: 453). Before businesses can design effective tools to reduce supply chain risks, managers must understand the universe of risk categories and the events and conditions that drive them. Then, businesses equipped with clear and specific information about these important risks can continue to select and adapt the most effective mitigation strategies (Chopra & Sodhi, 2004: 54).

Nowadays, it is more difficult to manage risks in the supply chain because the risks that appear to be alone are often interdependent, and actions that reduce one risk can make the other worse (Chopra & Sodhi, 2004: 54). Therefore, any risk management strategy requires an integrated risk management approach due to this risk interaction in the supply chain (Punniyamoorthy et al., 2013: 80). In this context, as in the transition from known risk management to corporate risk management, in supply chain risk management, risks should be evaluated with an integrated perspective rather than an independent and separate approach.

Defining, evaluating and managing the risks that businesses will face in achieving the goal of sustainable growth is a very important issue. For this reason, businesses see their risks as a strategic factor and foresee to gain competitive advantage by managing them systematically (Walker, Shenkir, & Barton, 2002).

In the logistics literature, it is seen that the studies on supply chain risks have increased in recent years. Among these, the effects of risks on performance are examined (Özgüner & Özgüner, 2019; Yolaç, Tuzcuoğlu, & Şahin, 2019), supply chain related risks are defined and a risk management system is established (Blos, Quaddus, Wee, & Watanabe, 2009), supplier and supplier risk assessment methodology was developed to measure, monitor and analyze component-specific risks (Blackhurst, Scheibe, & Johnson, 2008), and the risk assessment and prioritization tool was developed and tested for sectors with common risk profiles (Punniyamoorthy et al., 2013; Wang, Jie. , & Abareshi, 2014).

Looking at the theoretical studies, studies assessing increasing importance of supply chain risks with the effect of both legal regulations and changes in environmental conditions (Ceritoğlu, 2018), analyzing the origins of supply chain risks, the relationship between supply chain risk and supply chain performance (Demirci Orel & Akkan, 2018), listing the supply chain risks and the strategies that can be applied reducing these risks (Chopra & Sodhi, 2004), identifying supply chain risk sources and listing them with content analysis (Hudnurkar et al., 2017), the development stages of the supply chain risk management field, how the risk is defined, the research methods used, the risks encountered in the sector (Singhal, Agarwal, & Mittal, 2011) are some of the publications.

2.1. Grouping Risks in Supply Chain Management

According to the Global Risk Report published by the World Economic Forum for the 14th time in 2019, the risks that are most likely to occur in the world are classified according to their importance, impact level and category. These risks are listed in Table 1 below.

**Table 1.** Top 10 risk types according to probability and impact value in the world

Top 10 risks by level of probability	Top 10 risks by impact level
1. Extreme climatic events (E)	1. Destruction by weapons of mass destruction (G)
2. Climate change mitigation and climate change failure to comply (E)	2. Climate change mitigation and climate change failure to live in compliance (E)
3. Natural disasters (E)	3. Extreme climatic events (E)
4. Data fraud / theft (T)	4. Water crises (S)
5. Cyber attacks (T)	5. Natural disasters (E)
6. Human-made environmental disasters (E)	6. The reduction of biodiversity, the collapse of the ecosystem (E)
7. Large scale unwanted migration (S)	7. Cyber attacks (T)
8. The reduction of biodiversity, the collapse of the ecosystem (E)	8. Deterioration of critical information infrastructure (T)
9. Water crises (S)	9. Human-made environmental disasters (E)
10. Asset bubbles in the general economy (Ec)	10. Spread of infectious diseases (E)
E: Environmental risk, T: Technologic risk, Ec: Economical risk, S: Social risk, G: Geopolitics risk	

Reference: The Global Risks Report 2019: 14th Edition (World Economic Forum, 2019)

Another research conducted by the World Economic Forum is on the supply chain and transportation risks. Various malfunctions occur in the supply chain and transportation networks in daily periods. However, certain environmental factors, when combined with vulnerabilities in existing networks, have the potential to cause widespread systemic disruptions. Table 2 lists the environmental risk factors that may cause significant and systemic effects on the supply chain or transportation networks (World Economic Forum, 2012).

Table 2. Environmental risk factors that trigger disruptions in the global supply chain

Risk type	Environmental Risk Factors	Rate
Environmental risk group	Natural disasters	%59
	Bad weather	%30
	Outbreaks	%11
Geopolitics risk group	Geopolitical conflict and political unrest	%46
	Export / import restrictions	%33
	Terror	%32
	Corruption	%17
	Illegal trade and organized crime	%15
	Sea piracy	%9
	Nuclear / biological / chemical weapons	%6
Economical risk group	Economic sudden demand shocks	%44
	Excessive volatility in commodity prices	%30
	Border delays	%26
	Currency fluctuations	%26
	Global energy shortage	%19
	Ownership / investment restrictions	%17
	Labor shortage	%17
Technological risk group	Technological information and communication interruptions	%30
	Transport infrastructure failures	%6

Reference: New Models for Addressing Supply Chain and Transport Risk (World Economic Forum, 2012)



Defining various risk sources related to factors inside and outside the business in a supply chain is important for understanding and managing risk (Punniyamoorthy et al., 2013: 95). Identifying risks is an important first step in the supply chain risk management process. Once risks are identified, it is important to categorize risks into different categories to enable risk managers to understand the universe of risk categories and the events and conditions that drive the risks. This understanding will then facilitate the selection and design of different risk reduction strategies that are likely to be the most effective (Chopra & Sodhi, 2004: 54). Risks encountered in the supply chain are listed under different groupings in the literature. This classification is included in the name of risk types or risk sources. It is important to have a universally accepted classification of supply chain risks in order to establish a common vocabulary for risk identification and assessment among organizations in a supply chain and to standardize risk reduction strategies for known supply chain risks (Hudnurkar et al., 2017: 185).

There are extensive studies in the supply chain management literature that define and classify risk sources. Various supply chain risk classifications in the literature are shown in Table 3 to provide a perspective.

Table 3.Supply chain risk classifications

Risk types classification	Author
Financial risk, organizational risk, supply risk, production risk, customer and market risk, logistics and transportation risk, technology risk, environmental risk, geopolitical risk, legal and bureaucratic risk, sector specific risk, risk related to supply chain structure	(Er Kara & Oktay Firat, 2017)
Product features, supply chain management processes, supply chain infrastructure, external environment and human resources	(Hudnurkar vd., 2017)
Operational, infrastructure, legal, cultural and social, economic, supplier, storage risks arising from distribution, labor, natural disasters	(Rogers, Srivastava, Pawar, & Shah, 2016)
Supplier-originated risks, manufacturer-originated risks, demand-driven risks, logistics-based risks, information-based risks and environmental risks, Internal and external risks but within the supply chain and outside the supply chain risks	(Punniyamoorthy vd., 2013)
Material flow risks (source - single supplier risk, supplier flexibility risk, supplier selection, supply quality, supply capacity, Production - product and process design risk, production capacity risk, production stop Distribution - demand fluctuation / seasonality and balance of unmet demand and excess stock Information flow risks (information accuracy, information system security, intellectual property and information outsourcing risk Financial flow risks (currency risk, price and cost risk, supply chain financial strength of its partners and financial transactions)	(Musa, 2012)
Supply-borne risks, demand-driven risks, process risks, environmental risks, logistics risks, catastrophic risks Internal, external and on-network, off-network risks	(Sharma & Bhat, 2012)
Risks arising from suppliers, risks related to the manufacturer, and customer Risks caused by environmental factors	(Büyüközkan, 2008)
Supply risks, operational risks and demand risks	(Manuj & Mentzer, 2008)



Supply risk, process risk, demand risk, intellectual property risk, behavioral risk and political / social risks	(C. Tang & Tomlin, 2008)
Delay risk, information systems related risks, forecast risk, intellectual property risk, purchasing risk, receivable risk, inventory risk and capacity risk. Supplier sourced, business sourced or customer sourced risks	(Chopra & Sodhi, 2004)
Inside the business, outside the business and within the supply chain, outside the supply chain risks	(Christopher & Peck, 2004)

The risks faced by every business are different from each other. The risks may vary according to many factors such as the field of activity of the business, the country, sector, customer profiles, supply chain, employees, business model, intensity of technology use, type of technology used, competition structure (Özsoy, 2012: 176). In addition to all these classifications, the occurrence of such a risk may be frequent or infrequent, causing short- or long-term and minor to very large scale problems for affected organizations. A simple delay along the chain may create a temporary risk, whereas the only supplier that forces the producer to a price increase represents a long-term risk. While a machine failure may have a relatively small effect on a manufacturing company with redundant capacity, a war on transport routes has a major impact on a shipping company (Chopra & Sodhi, 2004: 54). The types of risks used in this study and included in the classification of Punniyamoorthy et al. (2013: 85) are briefly described below.

2.1.1. Supplier related risks

Businesses are exposed to numerous risks in their supply chains. Risks on the supply side are found in supply products, purchasing and supplier relationships (Sharma & Bhat, 2012: 354). The risk arising from the supplier may occur between the producer business and the supplier businesses or in the general supplier market.

The risk associated with the inability of the company to deliver the materials they need to effectively meet the production requirements / demand forecasts due to incoming uncertainties and is also referred to as input risk. (Ceritoğlu, 2018: 206; Faizal & Palaniappan, 2014: 20). Examples of supplier-related risks include quality problems, complexity of critical material, incomplete supply, inelastic supplier, failure of the supplier to fulfill its responsibilities, financial problems of the supplier, holding a single supplier, frequent changes in the supplier, capacity constraints in the supply market, delays in supply, intellectual property risks, key supplier not reducing prices, sudden increase in purchase prices, emergence of unethical practices of suppliers (Punniyamoorthy et al., 2013: 82; Sharma & Bhat, 2012: 356).

2.1.2. Manufacturer risks

Incorrect planning in the production and logistics process of the manufacturing company, unexpected problems in human resources and production tools and the changes in production time and quality as a result of these are the risks that cause production to be interrupted or stopped (Ceritoğlu, 2018: 210). Machine failure during production, strikes, occupational accidents are examples of risks related to the producer's business processes (Sharma & Bhat, 2012: 356). To increase internal quality and capacity, businesses have been investing in programs such as Total Quality Management, Lean Manufacturing and Six Sigma for more than 10 years. However, internal activities are still susceptible to



problems that could cause fluctuations in effective capacity and quality. (Tang & Tomlin, 2008: 13)

2.1.3. Demand-driven risks

Unforeseen changes in the demand amount, fluctuations in production quantities and delivery times, unexpected order cancellations put manufacturers and suppliers in a difficult situation (Büyükoğkan, 2008). Therefore, demand risk includes uncertainties in both volume and product mix (Tang & Tomlin, 2008: 13). Variable demand, prediction error, insufficient or complex information from customers, key customer loss and credit risk are listed as demand-driven risks (Sharma & Bhat, 2012: 356). Demand-driven risks are risks arising from the uncertainty of random consumer behavior (Nagurney, Cruz, Dong, & Zhang, 2005: 120). In this context, an important problem affecting forecast quality and thus causing an increase in demand fluctuations in the upstream flow of the supply chain is called the bullwhip effect. The causes of the bullwhip effect are distorted information, sales incentives, mass ordering, overreactions, unnecessary interventions, second guessing and insecurity (Lee, Padmanabhan, & Wang, 1997: 546).

2.1.4. Logistics-related risks

Logistics disruptions affect the delivery to the end customer. Logistics and shipping risks include risks associated with the storage, packaging and delivery of goods. The reasons for the low logistics performance include the lack of professionalism in the logistics sector, uncertain traffic conditions, problems at ports and customs gates due to traffic congestion and poor infrastructure, blocked routes, stopping aircraft flights, and wrong practices at highway toll booths (Er Kara & Oktay Fırat, 2017: 48 ; Sharma & Bhat, 2012: 355).

2.1.5. Information based risks

Information based risks include information systems, communication systems, and technology-related developments. Lack of information for information systems, information delay, information infrastructure disruption, information sharing problems, information system security, privacy risk, cyber attacks, system implementation and system malfunctions are the main risk issues. Risks related to communication systems arise from communication problems, unstable and inefficient communication networks and infrastructure, and differences in communication standards. Risks arising from technological developments refer to changes in technology, breakthrough scientific discoveries, rapid technological developments, technology incompatibilities and technological innovations in the sector (Er Kara & Oktay Fırat, 2017: 48; Punniyamoorthy et al., 2013: 83).

2.1.6. Environmental risks

This type of risk includes uncontrollable events caused by external factors. It consists of uncertainties arising from the supply chain and environmental interactions. Natural disasters, war or terrorist activities, changes in rules and regulations are examples of environmental risks (Faizal & Palaniappan, 2014: 21). Authorities such as administrative, legal, and regulatory agencies are an important factor of uncertainty in the establishment and operation of the supply chain. Administrative barriers such as customs and trade regulation can constrain the operational performance of supply chains. Legal changes often involve sudden and difficult to predict situations. With new environmental regulations,



investment in reverse logistics systems, changing conditions of logistics increase the complexity of the supply chain (Sharma & Bhat, 2012: 355). The most recent example of environmental risks can be given as epidemics. Coronavirus (COVID-19) threat, which is effective worldwide, constituted the most important environmental risk factor in 2020. Within the scope of the measures taken to prevent the spread of the virus, the closing of borders, disruption of transportation, production stops and other quarantine measures have caused supply chains to come to a standstill.

3. RESEARCH METHODOLOGY

3.1. Purpose of The Research

The purpose of risk assessment is to show which areas and activities in the value chain are more sensitive to hazards. Risk management, on the other hand, is a broad planning and decision-making activity designed to deal with risks. Understanding the types of risks, their occurrence possibilities and effects is a starting point for businesses to develop effective risk management strategies (Faizal & Palaniappan, 2014: 22). In this direction, the main purpose of this study is to evaluate the types of risks that businesses may face in the supply chain, the probability of occurrence of these risks and their effects, calculating the importance score of each risk type and revealing the priority risks. For this purpose, the answers of the following questions are investigated.

1. What are the risk groups encountered in supply chain management and the risks included in these groups? (Description and classification)
2. When the risk groups in the supply chain are examined, what is the share of these groups on the total risk? (Evaluation)
3. When these risks are evaluated with a risk score calculated on the basis of probability and impact values, what are the primary risks? (Prioritization)
4. Is there any difference in terms of sector, operating year and size of risk groups according to their importance? (Analysis of differences)

3.2. Research Method

Many different classifications have been made in the literature regarding the risks encountered in the supply chain. This study was based on the risk classification proposed by Punniyamoorthy et al. (2013: 85). According to this classification, the basic risk types that can be encountered in a supply chain are; supplier-sourced risks, producer-sourced risks, demand-driven risks, logistics-sourced risks, information-based risks and environmental risks. In the questionnaire form used, supplier-sourced risk factors consist of 12 statements, producer-sourced risk factors consisted of 11 statements, demand-driven risk factors were composed of 6 statements, logistics-sourced risk factors were composed of 7 statements, information-based risk factors were composed of 4 statements, and environmental risks were composed of 6 statements. For the probability of occurrence in this developed risk scale, a 5-point Likert scale was used. While the scale expressions were evaluated by the survey participants in terms of probability, the expression frequency of the occurrence of the relevant risk is very small if it is a year, small if it is quarterly, medium if it is once a month, high if it is once a week and very high if it is every day. Here, very small probability of occurrence is represented by 1 and very high probability of occurrence is represented by 5. While evaluating in terms of the impact on the business, the expressions



used are very light if the effect is very low, light if limited, moderate if there is a moderate effect, serious if there is a serious / permanent effect, and very serious if there is an effect that causes the business to close / bankruptcy. Here, very light expression is represented by 1 and very serious expression is represented by 5. The questionnaire form used is included in the appendices of the study. First, reliability and validity analyzes were made for the scale used. Then, by calculating the probability, impact and importance scores for each risk element, the risks and risk groups were listed. 300 enterprises operating in various fields in the production sector within the borders of Istanbul constitute the sample of this study. The main sectors of the enterprises surveyed are listed as food, textile, metal, automotive, electronics, medicine and construction. The survey study started in October 2020 and continued until December.

3.3. Research Findings

In the first part of the questionnaire questions used for the research, descriptive information was requested on three subjects: the sector of the enterprise, its size and the activity period. In line with the data obtained; It is seen that the sectors of the participating enterprises are mainly composed of food (34%), textile (13%), metal (13%), automotive (12%) and other (27%) sectors. 45% of these enterprises are in the small business category, 20% are in the medium, again 20% are in the large and 15% are in the very large business category. Finally, 43% of the enterprises are 25 years and above, 8% 20-24 years, 7% 15-19 years, 10% 10-14 years, 17% 5-9 years and 15% has been operating in the range of 1-4 years.

Table 4. Results of validity and reliability analysis of supply chain risks measurement model

	Risk Groups	Number of items	Cronbach's alpha	CMIN/DF	GFI	CFI	RMSEA
Supply Chain Risks	Supplier-sourced risk factors	12	0,922	1,355	0,910	0,976	0,061
	Producer-sourced risk factors	11	0,932	1,529	0,900	0,966	0,074
	Demand-driven risk factors	6	0,827	1,097	0,972	0,996	0,032
	Logistics-sourced risk factors	7	0,911	1,572	0,955	0,987	0,077
	Information-based risks	4	0,918	2,838	0,974	0,987	0,038
	Environmental risks	6	0,865	1,241	0,976	0,994	0,050

CMIN/DF:1,592 GFI:0,958 CFI:0,988 RMSEA:0,079

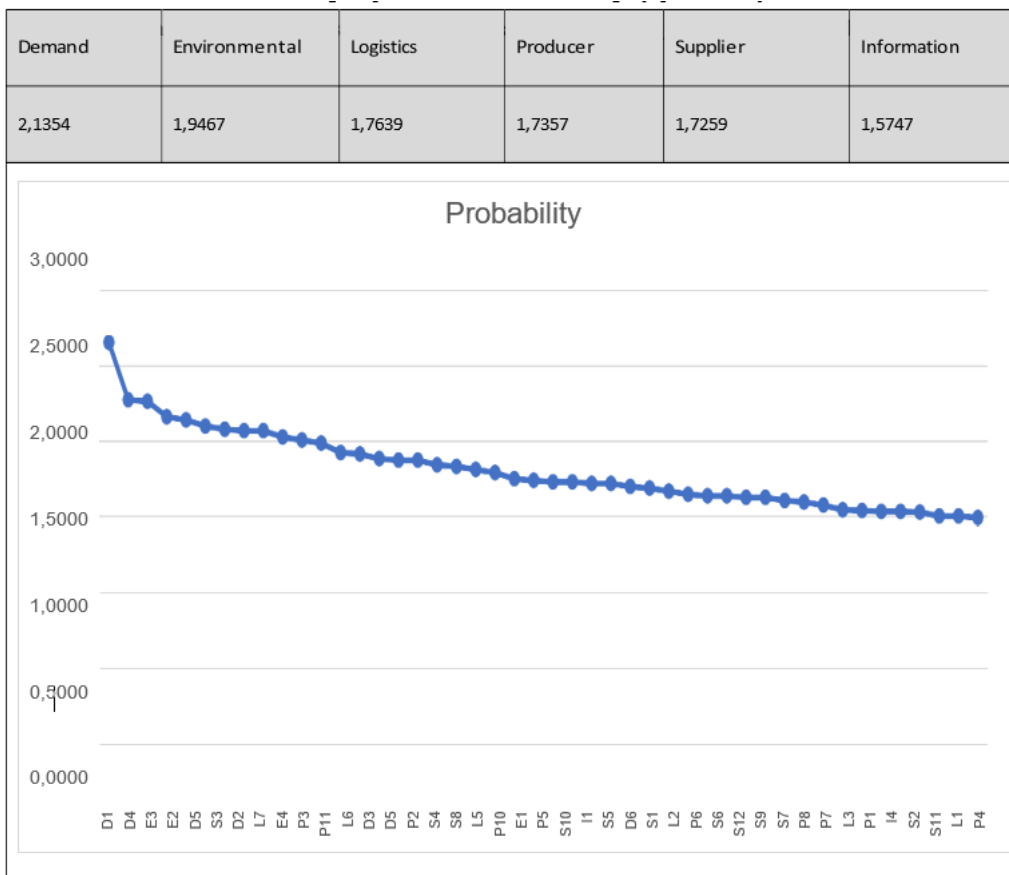


- Ranking all risk items and risk groups in terms of probability values,
- Ranking all risk items and risk groups in terms of impact values,
- Ranking of all risk items and risk groups in terms of importance scores (importance score = probability x impact) have been performed.

The measurement model used has been tested for reliability and validity. Cronbach's alpha coefficient was used for the reliability value. It has been observed that all risk groups have sufficient reliability values. ($\alpha > 0.70$) Confirmatory factor analysis was also performed for scale validity. The goodness of fit values found as a result of the confirmatory factor analysis have good or acceptable fit values. The values found and the total risk model factor loadings are shown in the table.

The graphical view in which the risk groups are listed by using probability values and all items are included according to their probability values is given in Table 5 below. In the first place, it is seen that demand-driven risk factors have the highest probability value, while information-based factors are in the last place. When all items are examined, it has been found that the top five are the items belonging to demand and environmental factors, respectively, unexpected / temporary customers (D1), credit risk (D4), uncertainty in government regulations and laws (E3), macroeconomic uncertainty (E2) and change in customer preferences (D5).

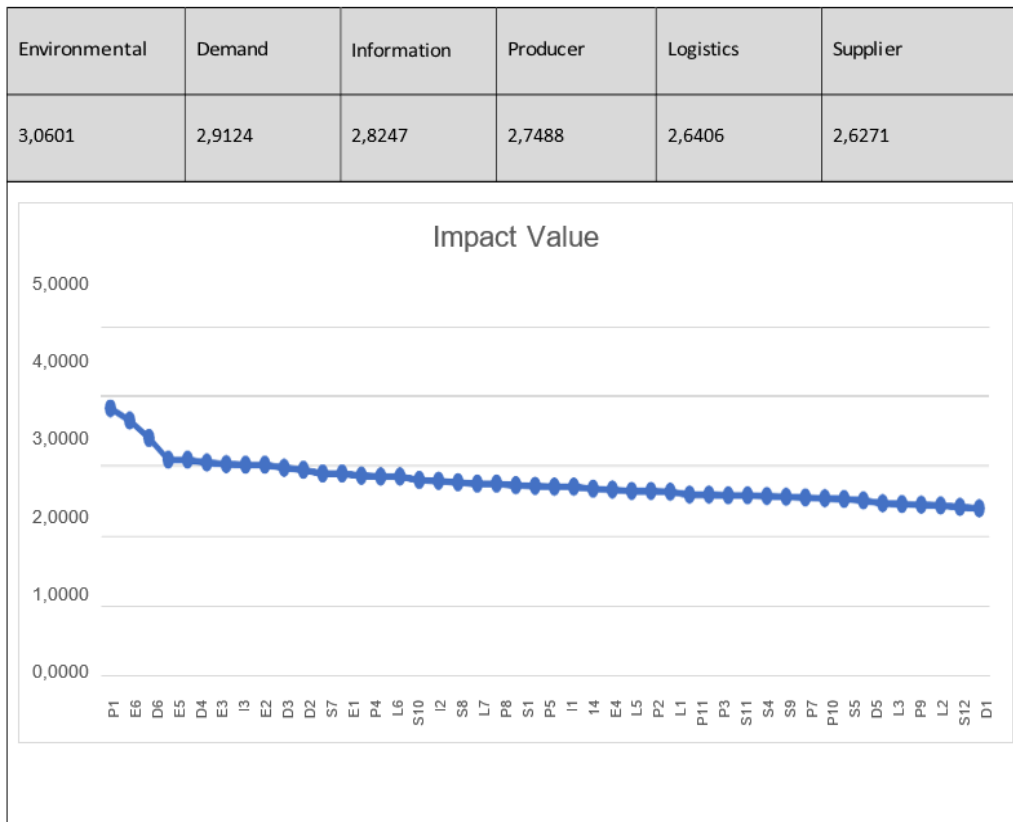
Table 5. Risk groups and risk items ranking by probability value





When the risk groups for the impact values were examined, it was found that the environmental risk factors were the first risk group. Lastly, there are risk factors originating from the supplier. When we look at risk items, factors such as cessation of production (P1), war, terrorism, natural disasters, strikes, insurrection (E6), reputational risk (D6), lack of qualification (E5) and receivable risk (D4) appear. Table 6 shows the ranking of risk groups and risk items.

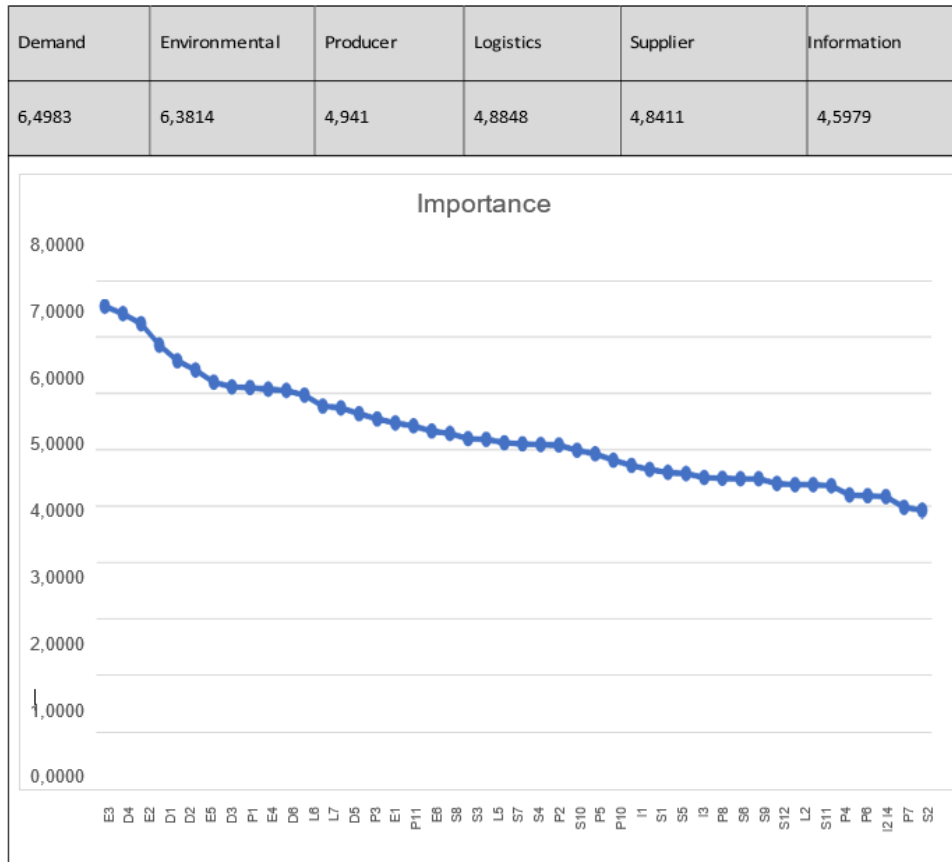
Table 6. Ranking of risk groups and risk items according to the impact value



The importance score is calculated by multiplying the probability and impact value of each item. This value is also called risk score (Yazıcı, 2018: 24). The chart in which the risk groups are ranked according to priority order and importance scores is given in the table 7 below. According to this; uncertainty in government regulations and laws (E3), risk of receivables (D4), macroeconomic uncertainty (E2), unexpected / temporary customers (D1), and significant estimation errors in demand (D2) are the top five and environmental and demand-driven risk factors. The ranking of risk groups is also similar to the order in probability values with a small difference.



Table 7. Ranking of risk groups and risk items according to importance score



It has been investigated whether risk groups differ in terms of sector, operating year and size according to their probability, impact and importance. As a result of the Anova analysis, no significant difference was found. ($p > 0.05$)

4. Conclusion

With the increasing dependency on external resources from the past to the present, businesses focus better on their core capabilities and thus achieve their competitive advantage, efficiency and productivity targets, and on the other hand, their dependence on non-business supply chain members increases and they encounter negative situations such as uncertainty and disruptions arising from this situation. From a management perspective, the responsibility of supply chain managers in managing supply chain risks is increasing day by day. For this reason, it is necessary to identify and evaluate important risks, to manage them with the right methods, to review them regularly and to carry out these studies with a holistic perspective in which all employees are included at certain points throughout the enterprise. This is also the main purpose of supply chain risk management. By grouping and prioritizing supply chain risks, it is possible for senior management to focus on priority risks and manage them by planning accordingly.

In recent years, many studies focusing on supply chain risks have been published. These studies define and classify supply chain risks (Heckmann et al., 2015; Hudnurkar et al., 2017; Musa, 2012; Punniyamorthy et al., 2013; Singhal et al., 2011). It is of great importance to prioritize these risks as there are both time and cost constraints so that managers can focus on all risks at the same time. For this



reason, in this study, the risks in the supply chain were first identified and grouped with a comprehensive literature review. Then, using the data obtained from the survey study conducted with the participation of 300 companies operating in the manufacturing sector, the importance scores were calculated using the probability and impact values of the supply chain risks, and both the risk groups and the items that make up each risk group were listed. A total of 46 risk items are classified under 6 basic risk groups. The measurement model used was found to have high validity and reliability values. There was no need for any item to be removed from the relevant risk group due to low factor load or similar reasons.

Studies usually focus on high probability and low impact risks, while ignoring low probability and high impact risks. This is because there is not enough data available to make the necessary estimates for infrequent risk situations. (Er Kara & Oktay Firat, 2017: 49). However, when considered in terms of importance value, both cases will have similar importance values. For this reason, it is recommended that businesses develop management techniques by prioritizing risks based on importance scores and calculation of importance points using realistic probability and impact values using a number of estimation methods, rather than just looking at probability or impact value unilaterally.

This study is thought to contribute to the supply chain management and risk management literature by defining and grouping supply chain risks and ranking in terms of risk factors in line with their probability, impact and importance scores. When the results obtained were evaluated, it was concluded that the risks in demand-driven and environmental-related risk groups were at the top. Receivable risk, especially in the demand-driven risk group, is among the top five risk factors in terms of probability, impact and importance scores. In addition, unexpected / temporary customers from demand-driven risks and macroeconomic uncertainty from the environmental risk group and uncertainty risks in government regulations and laws are among the top five risk factors for both probability and importance scores. When the impact values are analyzed, demand and environmental risks are also in the first place, while the risk of stopping production, one of the production-related risk factors, is the first.

In the relevant study, some findings were reached in line with the data obtained from the enterprises in the production sector. In future studies, it is thought that it will be beneficial to carry out new studies on the determination of supply chain risks for different sectors and their effects on business performance.

REFERENCES

- Blackhurst, J. V., Scheibe, K. P., & Johnson, D. J. (2008). Supplier Risk Assessment and Monitoring for the Automotive Industry. *International Journal of Physical Distribution & Logistics Management*, 38(2), 143–165. <https://doi.org/http://doi.org/10.1108/09600030810861215>
- Blos, M. F., Quaddus, M., Wee, H. M., & Watanabe, K. (2009). Supply Chain Risk Management (SCRM): A Case Study on the Automotive and Electronic Industries in Brazil. *Supply Chain Management*, 14(4), 247–252.
- Bowersox, D., Closs, D. J., & Cooper, M. B. (2002). *Supply Chain Logistics Management* (2. Baskı). Mc Grawhill. Büyüközkan, G. (2008). Tedarik Zincirinde Risk Yönetimi. *Lojistik Dergisi*, (8).
- Ceritoğlu, A. (2018). Tedarik Zinciri Kapsamında Risk Yönetimi. İçinde S. Schöning, E. H. Sümer Göğüş, & H. Pernsteiner (Ed.), *İşletmelerde Risk Yönetimi*. İstanbul: İstanbul Bilgi Üniversitesi Yayınları.
- Chopra, S., & Meindl, P. (2004). *Supply Chain Management* (2. Baskı). Pearson Education International.
- Chopra, S., & Sodhi, M. S. (2004). Managing Risk to Avoid Supply-Chain Breakdown. *MIT Sloan Management Review*, 46(1), 52–61.
- Christopher, M., & Peck, H. (2004). Building the Resilient Supply Chain. *International Journal of Logistics Management*, 15(2), 1–13.



- Demirci Orel, F., & Akkan, E. (2018). Tedarik Zincirinde Risk, Risk Yönetimi ve Performans İlişkileri: Bir Literatür Taraması. *Beykoz Akademi Dergisi*, 6(1), 84–117. <https://doi.org/10.14514/BYK.m.21478082.2018.6/1.84-117>
- Demirkol, İ., Üngan, M. C., & Ayanoğlu, M. (2015). Tedarik Zinciri Risklerinin İşletme Performansı Üzerindeki Etkisi : Otomotiv Sektöründe Bir Uygulama. *İşletme Bilimi Dergisi*, 3(1), 20–37.
- Er Kara, M., & Oktay Fırat, S. Ü. (2017). Tedarik Zinciri Riskleri: Literatür Taraması ve Yeni Bir Sınıflandırma. *Beykent Üniversitesi Fen ve Mühendislik Bilimleri Dergisi*, 10(1), 31–60.
- Faizal, K., & Palaniappan, P. K. (2014). Risk Assessment and Management in Supply Chain. *Global Journal of Researches in Engineering*, 14(2), 19–30.
- Gunasekaran, A., Patel, C., & McGaughey, R. E. (2004). A Framework for Supply Chain Performance Measurement. *International Journal of Production Economics*, 87(3), 333–347.
- Heckmann, I., Comes, T., & Nickel, S. (2015). A Critical Review on Supply Chain Risk–Definition, Measure and Modeling. *Omega*, (52), 119–132.
- Hudnurkar, M., Deshpande, S., Rathod, U., & Jakhar, S. K. (2017). Supply Chain Risk Classification Schemes : A Literature Review. *Operations and Supply Chain Management*, 10(4), 182–199. <https://doi.org/10.31387/oscm0290190>
- Jüttner, U., Peck, H., & Christopher, M. (2003). Supply Chain Risk Management: Outlining An Agenda For Future Research. *International Journal of Logistics : Research & Applications*, 6(4), 197–210.
- Keskin, H. (2015). *Tedarik Zinciri Yönetimi – Arka Planı, Gelişimi ve Güncel Uygulamaları* (1. Baskı). Ankara: Nobel Yayınevi.
- Lambert, D. M., Cooper, M. C., & Pagh, J. D. (1998). Supply Chain Management: Implementation Issues and Research Opportunities. *International Journal of Logistics Management*, 9(2).
- Lee, H. L., Padmanabhan, V., & Wang, S. (1997). Information Distortion in a Supply Chain: The Bullwhip Effect. *Management Science*, 43(4), 546–558.
- Manuj, I., & Mentzer, J. T. (2008). Global Supply Chain Risk Management Strategies. *International Journal of Physical Distribution & Logistics Management*, 38(3), 192–223.
- Musa, N. S. (2012). *Supply Chain Risk Management : Identification , Evaluation and Mitigation Techniques*. Linköping University.
- Nagurney, A., Cruz, J., Dong, J., & Zhang, D. (2005). Supply Chain Networks, Electronic Commerce, and Supply Side and Demand Side Risk. *European Journal of Operational Research*, (164), 120–142.
- Özgüner, M., & Özgüner, Z. (2019). Tedarik Zinciri Riskleri'nin Lojistik Performans Üzerindeki Etkisinin Yapısal Eşitlik Modellemesi ile Belirlenmesi. *Eskişehir Osmangazi Üniversitesi İktisadi ve İdari Bilimler Dergisi*, 14(1), 67–82. <https://doi.org/10.17153/oguiibf.437166>
- Özsoy, M. T. (2012). Yeni Türk Ticaret Kanunu ve Şirketlerde Kurumsal Risk Yönetimi. *İSMMMO Mali Çözüm Dergisi, Mart-Nisan*, 165–186.
- Punniyamoorthy, M., Thamaraiselvan, N., & Manikandan, L. (2013). Assessment of Supply Chain Risk : Scale Development and Validation. *Benchmarking: An International Journal*, 20(1), 79–105. <https://doi.org/10.1108/14635771311299506>
- Rogers, H., Srivastava, M., Pawar, K. S., & Shah, J. (2016). Supply Chain Risk Management in India – Practical Insights. *International Journal of Logistics Research and Applications*, 19(4), 278–299. <https://doi.org/10.1080/13675567.2015.1075476>
- Sharma, S. K., & Bhat, A. (2012). Identification and Assessment of Supply Chain Risk: Development of AHP Model for Supply Chain Risk Prioritisation. *International Journal of Agile Systems and Management*, 5(4), 350–369. <https://doi.org/10.13140/2.1.2648.1286>
- Singhal, P., Agarwal, G., & Mittal, M. L. (2011). Supply Chain Risk Management: Review, Classification and Future Research Directions. *International Journal of Business Science and*



Applied Management, 6(3), 15– 42.

- Tang, C. S. (2006). Perspectives in Supply Chain Risk Management. *International Journal of Production Economics*, 103, 451–488. <https://doi.org/10.1016/j.ijpe.2005.12.006>
- Tang, C., & Tomlin, B. (2008). The Power of Flexibility for Mitigating Supply Chain Risks. *International Journal of Production Economics*, 116(1), 12–27.
- Tang, O., & Nurmaya Musa, S. (2010). Identifying Risk Issues and Research Advancements in Supply Chain Risk Management. *International Journal of Production Economics*, 124(1), 109–120.
- Walker, P. L., Shenkir, W. G., & Barton, T. L. (2002). *Enterprise Risk Management: Pulling It All Together. The Institute of Internal Auditors Research Foundation Publication.*
- Wang, M., Jie, F., & Abareshi, A. (2014). The Measurement Model of Supply Chain Uncertainty and Risk in the Australian Courier Industry. *Operations and Supply Chain Management: An International Journal*, (February 2019), 89–96. <https://doi.org/10.31387/oscm0180114>
- World Economic Forum. (2012). *New Models for Addressing Supply Chain and Transport Risk*. Cenevre. World Economic Forum. (2019). *The Global Risks Report 2019: 14th Edition*. Cenevre.
- Yazıcı, M. (2018). *İşletmelerde Risk Yönetimi ve Karar Verme* (1. baskı). İstanbul: Beta Basım Yayım Dağıtım A.Ş.
- Yolaç, G., Tuzcuoğlu, A., & Şahin, M. (2019). Tedarik Zincirinde Risk Yönetimi ve Performans İlişkisi : İstanbul İlinde Bir Araştırma. *Ekoist: Journal of Econometrics and Statistics*, (31), 95–106. <https://doi.org/10.26650/ekoist.2019.31.0015>
- Zsidisin, G. A., & Ellram, L. M. (2003). An Agency Theory Investigation of Supply Risk Management. *Journal of Supply Chain Management*, 39(2), 15–27. <https://doi.org/10.1111/j.1745-493X.2003.tb00156.x>
- Zsidisin, G., & Wagner, S. (2008). Supply Risk Perceptions And Practices: An Exploratory Comparison Of German And US Supply Management Professionals. *International Journal of Technology, Policy and Management*, 8(4), 401–419.

APPENDICE: QUESTIONNAIRE APPLIED

Information About The Business:

What are the main industrial / commercial activities of your business? Which sector does it operate in?

.....

How many years has your business been operating?

1-4 years 5-9 years 10-14 years 15-19 years 20-24 years 25 years and more

Number of people working (As employee):

Small(1-50) Medium (51-250) Large (251-2000) Very Large

Evaluate the following supply chain risk factors in terms of their likelihood of occurrence and their impact on your business. Use the following scale when evaluating.

When assessing the probability of occurrence:

- 1: Very small => Once a year
- 2: Small => Quarterly
- 3: Medium => Once a month
- 4: High => Once a week

When evaluating the impact on your business:

- 1: Very Light => Very low impact
- 2: Light => With limited impact
- 3: Moderate => Medium impact
- 4: Serious => Serious impact



Logistics Based Risk Factors	Possibility of occur					Impact on Business				
	1	2	3	4	5	1	2	3	4	5
1. The operational / financial power of the logistics business to be insufficient										
2. Storage issues										
3. The distribution network is poorly designed										
4. Wrong selection of transport mode										
5. Improper packing and marking										
6. Improper stacking / accident damage										
7. Delay in shipping process										
Information Based Risk Factors	Possibility of occur					Impact on Business				
	1	2	3	4	5	1	2	3	4	5
1. Delays in the information and communication infrastructure inside or outside the enterprise										
2. Crashes in internal / external information infrastructure										
3. Inadequate security in information systems										
4. Wrong selection of communication / information sharing medium										
Environmental Risk Factors	Possibility of occur					Impact on Business				
	1	2	3	4	5	1	2	3	4	5
1. Uncertain policies										
2. Macroeconomic uncertainty										
3. Uncertainty in government regulations and laws										
4. Social uncertainty										
5. Lack of qualification power										
6. Uncontrolable issues such as war, terrorism, natural disasters, strikes										

Reference: Punniyamorthy, M., Thamaraiselvan, N., & Manikandan, L. (2013). Assessment of Supply Chain Risk : Scale Development and Validation. *Benchmarking: An International Journal*, 20(1), 79–105. <https://doi.org/10.1108/14635771311299506>