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IDENTIFYING AND ANALYZING THE RISK FACTORS OF SUSTAINABLE SUPPLY CHAIN MANAGEMENT IN TEXTILE SECTOR

TEKSTİL SEKTÖRÜNDE SÜRDÜRÜLEBİLİR TEDARİK ZİNCİR YÖNETİMİNİN RİSK FAKTÖRLERİNİN BELİRLENMESİ VE ANALİZİ

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Abstract

Sustainable supply chain management is a management process that combines economic, social, and environmental contribution and foresees making certain decisions and planning at every stage of the supply chain line. With the understanding of sustainable management style, companies keep environmental traceability in the foreground, provide necessary regulations, take important steps in social environment cooperation, and achieve economic efficiency while doing all these. In addition to the economic investments required to make their supply chains more effective with a developing sustainability understanding, companies should also consider the risks that environmental and social factors may bring, taking into account the level of uncertainty in the future and their decisions. While the risk factor is accepted as the uncertainty associated with the occurrence of any event; on the other hand, risk management is strategically important in the planning of contingencies. Risk management in the supply chain is effective in identifying and analyzing risk factors in the economic and production cycle and in producing proactive solutions against risks. With the effect of the rapidly increasing population of the world, there is a significant increase in textile consumption. The risks were evaluated under the main headings of supply, production, distribution, customer, reverse logistics. The main headings were examined with economic, social and environmental subtitles. Potential risks are determined by reviewing the literature and taking opinions from textile sector employees. As a result of the study, it is aimed to develop a comprehensive framework for Sustainable Supply Chain Risk Management (SSCRM). Important strategies such as the ability to transform textile wastes into the raw materials of value-added products with appropriate technologies, which are included in the sustainability of textiles, are presented.

Keywords: FMEA, Risk Factors, Risk Management, Sustainable Supply Chain, Sustainable Supply Chain Management

Özet

Sürdürülebilir tedarik zinciri yönetimi ekonomik, sosyal ve çevresel katkıyı birleştiren, tedarik zinciri hattının her aşamasında belirli kararlar verilmesini ve planlamalar yapılmasını ön gören bir yönetim sürecidir. Sürdürülebilir yönetim tarzı anlayışıyla firmalar çevresel izlenebilirliği ön planda tutarak gerekli düzenlemeleri sağlar, sosyal çevre işbirliğinde önemli adımlar atar ve tüm bunları yaparken ekonomik anlamda verimlilik elde eder. Firmalar, gelişen sürdürülebilirlik anlayışı ile tedarik zincirlerini daha efektif kılmak için gereken ekonomik yatırımlara ek olarak, gelecekteki belirsizlik düzeyini ve kararlarını dikkate alarak çevresel ve sosyal etmenlerin getirebileceği riskleri de ele almalıdır. Risk faktörü, herhangi bir olayın meydana gelmesiyle ilişkili belirsizlik olarak kabul edilirken; risk yönetimi ise beklenmedik durumların planlamasında stratejik açıdan önem arz eder. Tedarik zincirinde risk yönetimi, ekonomik ve üretim döngüsündeki riskleri belirlemek, analiz etmek ve risklere karşı proaktif çözümler üretmede etkilidir. Dünyanın hızla artan nüfusunun etkisiyle tekstil tüketiminde önemli bir artış söz konusudur. Riskler tedarik, üretim, dağıtım, müşteri, tersine lojistik ana başlıkları altında değerlendirildi. Ana başlıklar ekonomik, sosyal ve çevresel alt başlıklarıla incelenmiştir. Çalışmada potansiyel riskler, literatür gözden geçirilerek ve tekstil sektörü çalışanlarından görüşler alınarak belirlenmiştir. Çalışma sonucunda sürdürülebilir tedarik zinciri risk yönetimi (SSCRM) için kapsamlı bir çerçeve geliştirilmesi amaçlanmıştır. Çalışmada, tekstilde sürdürülebilirliğin sağlanmasının içinde yer alan tekstil atıklarının uygun teknolojilerle katma değerli ürünlerin hammaddelerine dönüşebiliyor olması gibi önemli stratejiler sunulmuştur.

Anahtar Kelimeler: FMEA, , Risk Faktörleri, Risk Yönetimi, Sürdürülebilir Tedarik Zinciri, Sürdürülebilir Tedarik Zinciri Yönetimi

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1. INTRODUCTION

Risk management in the supply chain has emerged as one of the main research topics in recent years (Narasimhan & Talluri, 2009; Gurnani et al., 2011). The world economy, increasing outsourcing, developments in information technologies, and increasing market share have caused the complexity of the global supply chain to continue. This has created a risk environment arising from the uncertainties in the supply chain in a rapidly changing world.

Since businesses must be able to respond to increasing risks and uncertainties (Nagurney et al., 2005), they should identify and resolve risks in their supply chain lines in their own industries. Risks in the supply chain have been classified by different groups in the literature, and a wide variety of risks have been identified. Esfahbodi (2016), divided sustainable supply chain management into four groups: sustainable procurement, sustainable distribution, and reverse logistics. Beske et al. (2014) evaluated sustainablesupply chain management practices in five groups: strategic orientation, continuity, cooperation, risk management, and pro-activity for sustainability. Das (2018) discussed sustainable supply chain managementpractices by dividing them into five classes: environmental management practices, socially inclusive practicesfor employees, socially inclusive practices for society, operational practices, and supply chain integration. Hamdy et al. (2018) divided sustainable supply chain management practices into seven groups: internal environmental management, green purchasing, customer collaboration, eco-design, return on investment, social supply chain practices, and flexible supply chain. In the current study, sustainable supply chain management risk groups for the textile industry are determined as supply, production, distribution, customer, and reverse logistics. All risk groups are classified within themselves as economic, social, and environmental.

The main purpose of this study is to identify, analyze, and solve the risks for the textile industry, which is oneof the most important sectors within the scope of sustainable supply chain management. Failure Mode Effect Analysis (FMEA) method is applied by choosing a company from the textile industry. All stages of the supply chain have been taken into account, from the purchase of the raw material to the delivery to the customer as a result of the production process.

2. LITERATURE REVIEW

When the literature is examined, there are many studies on sustainability in the supply chain. FMEA analysis is one of the techniques frequently used in studies where risks related to errors are analyzed. Risk analysis is an important approach to improve quality and take action before failures occur, especially in labor-intensive industries. The textile industry is one of the industries where FMEA is preferred as a labor-intensive industry. Among the studies in the literature, the studies including FMEA approach are given in Table 1.

3. MATERIAL AND METHOD

3.1. Material

In the textile industry, product quality is very important. Many methods are used for quality assurance estimation, but there is not yet a preferred method for the most part. In this study, FMEA (Failure Modes and Effects Analysis) analysis, which is an important technical method, is applied to identify potential risks and prevent potential problems and quality problems. The area with the highest risk is determined, and priority is given to making the necessary improvements in this area. Before proceeding to the FMEA study, the existing literature studies are extensively researched, and the risk factors to be used in this study are determined in Table 2.

Table 2: The main dimensions and sub-risk factors that are the subject of the study.

Main Dimensions	Sustainability Dimensions	Sub Risk Factors
Supply	Economic	Demand fluctuations/demand uncertainty risk (Guan et al., 2011)
		Price and cost volatility (Abdel-Basset & Mohamed, 2020)
Supply	Social	Lack of healthy partnership among supply chain partners (Mithun et al., 2019)
		Supplier failure (Song et al., 2017)
Supply	Environmental	Wrong supplier selection (Song et al., 2017)
		Lack of commitment to green in the supply chain (Rostamzadeh et al., 2018)
		Lack of green suppliers (Rostamzadeh et al., 2018)
		Raw material scarcity (Breen, 2008)
		FMEA
Production	Economic	Frequent machine failures (Mutlu & Altuntas, 2019)
		Inefficient use of resources (Abdel-Basset & Mohamed, 2020)
		Currency and exchange rate fluctuations (Abdel-Basset & Mohamed, 2020)
		Planning and scheduling errors in production (Rostamzadeh et al., 2018)
		Wrong blend selection *
		Abrage and risk related to quality (Mutlu & Altuntas, 2019; Rostamzadeh et al., 2018)
		Wrong yarn count (Mutlu & Altuntas, 2019)
Production	Social	Management policy errors (Rostamzadeh et al., 2018)
		Operator errors/accident damage (Abdel-Basset & Mohamed, 2020)
		Lack of sustainable information technology (Abdel-Basset & Mohamed, 2020)
		Information flow errors *

Table 1: FMEA applications in the textile industry.

Author(s)	Theme of the Study	Methods
Bilici & Kosanoğlu, 2021	Improvement of bottlenecks identified using value stream mapping method in a textile factory with lean manufacturing practices	Value Stream Mapping and FMEA
Karasan & Erdogan, 2021	Risk assessment and proactive approach in a textile manufacturing business	FMEA, fuzzy AHP, and modified fuzzy TOPSIS
Fithri et al., 2020	A proposal for a hybrid approach to reduce defects in a textile company	FMEA, Pareto analysis, and fishbone
Mutlu & Altuntas, 2019	Hazard and risk analysis for the ring yarn production process with the integrated FTA-FMEA approach	FTA-FMEA
Beyene et al., 2018	Reducing Downtime in a Textile Sharing Company	FMEA
Erdil & Taçgın, 2018	Potential risks and analysis of the apparel and textile industry in Turkey	FMEA
Thawkar et al., 2018	Analysis to reduce malfunctions of carding machines in the textile industry	FMEA
Küçük et al., 2016	An application of FMEA method to the cutting department of a clothing company	FMEA
Nguyen et al., 2016	An empirical study in the non-woven fabrics industry	FMEA
Sabır & Bebekli, 2015	The use of error types and effects analysis in FMEA, textile dyeing- finishing businesses	FMEA
Özyazgan, 2014	FMEA analysis and application in a textile factory producing woven fabric	FMEA

The differences of this study from previous studies are the lack of studies on sustainability in textiles, the inclusion of possible sustainability risks in textiles within the scope of sustainable supply chain management, the fact that it is a comprehensive application since many faults are examined, a multidisciplinary approach which is presented by establishing an FMEA team, and providing proactive solutions with brainstorming and experience of the textile team in order to prevent mistakes.

Production	Environmental	Lack of qualified personnel (Jing et al., 2009) Inadequate personal protective equipment (Ortolano et al., 2014) Insufficient ventilation (Dewanti et al., 2018) Inefficient use of energy (Giannakis a & Papadopoulos, 2016) Water scarcity (Abdel-Basset & Mohamed, 2020; Giannakis & Papadopoulos, 2016) Excessive amount of hazardous waste (Abdel-Basset & Mohamed, 2020) Soil, water, air, noise pollution (Abdel-Basset & Mohamed, 2020)
Distribution	Economic	Fuel prices (Abdel-Basset & Mohamed, 2020) Damage to products during handling and shipping (Natarajarathinam et al., 2009) Inventory risk (Liu & Fan, 2011)
Distribution	Social	Information flow management risk in distribution (Dai & Liu, 2020) Deployment planning errors *
Distribution	Environmental	Excessive or unnecessary packaging (Giannakis & Papadopoulos, 2016)
Customer	Economic	The risk of changing customers purchasing desires (Dai & Liu, 2020; Mithun et al., 2019)
Customer	Social	Risk of wrong order request * The disconnection in the customer-company relationship* Expressing customer dissatisfaction *
Customer	Environmental	Risk of harming the quality of products purchased customers (Dai & Liu, 2020)
Reverse Logistics	Economic	High cost for disposal of hazardous waste (Nogueira et al., 2011)
Reverse Logistics	Social	Difficulties in recycling waste* Inadequate recycling policies *
Reverse Logistics	Environmental	Hazardous air emission (Song et al., 2017) Risks of dumping waste (Rostamzadeh et al., 2018)

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3.2. Methods

3.2.1. Failure Mode and Effect Analysis (FMEA)

Failure Mode and Effect Analysis is a systematic method used to identify and prevent product and process problems before they occur. FMEA focuses on preventing defects, improving safety, and increasing customer satisfaction. FMEA also standardizes the process approach and creates a common language that canbe used both within and between companies. FMEA is always used by engineers to analyze processes and products for potential failures. It can also be used by non-technical and technical workers at all levels (McDermott et al., 2009).

FMEA method gives more effective results when applied by a team. Detection of errors, determination of risk priority, implementation of corrective and preventive actions and

prevention of errors were carried out by the FMEA team. Elements of FMEA method are functions and error types, consequences (effects), severity, causes, occurrence, control, detectability, risk priority number. The risk priority number (RPN) is determined according to Equ (1). This coefficient shows the degree of risk, and the values are ordered from largest to smallest. The greater the value,the greater the danger of the risk.

RPN= Probability (P) x Severity (S) x Detectability (D) (1)

4. RESULTS AND DISCUSSION

The application of the study is carried out in a textile company, and it is aimed to determine the risk factors ofsustainable supply chain management in the company and to reduce the risk values by taking the necessary precautions. By examining the literature and taking the opinions of the experts working in this company, 43 risky errors are identified in the company. These errors were evaluated in terms of supply, production, distribution, customer and reverse logistics. In the FMEA method, it is one of the most common methods for experts from different departments to come together and brainstorm. In this study, a FMEA team was formed and the ROS values in Table 3 were determined with their opinions. The determined RPN values are ordered from largest to smallest. Considering the highest RPN values, possible errors in the main groups of production, supply, and reverse logistics are seen. Distribution and customer main dimensions are atthe bottom of the risk list and should be given less priority. The risk with a high RPN value is more likely to encounter a potential error and the damage it will cause is higher. Necessary corrective actions are determined for errors with a risk priority score of 100 or higher than 100, and preventive actions are developed to prevent their recurrence (Table 3). For Table 3, according to the graphic in Figure 1, the stages of supply, production, distribution, customer, andreverse logistics in the supply chain management line contain risks at different levels of importance. When the risk factors considered in the current study are compared with the relevant main dimension, the reverse logistics stage shows the risks that should be reduced in the first place with a value of 26%. It is followed by the main dimension of supply (23%) and the main dimension of production (22%). This shows that we should pay importance to sustainable risks in our sustainability-based study.

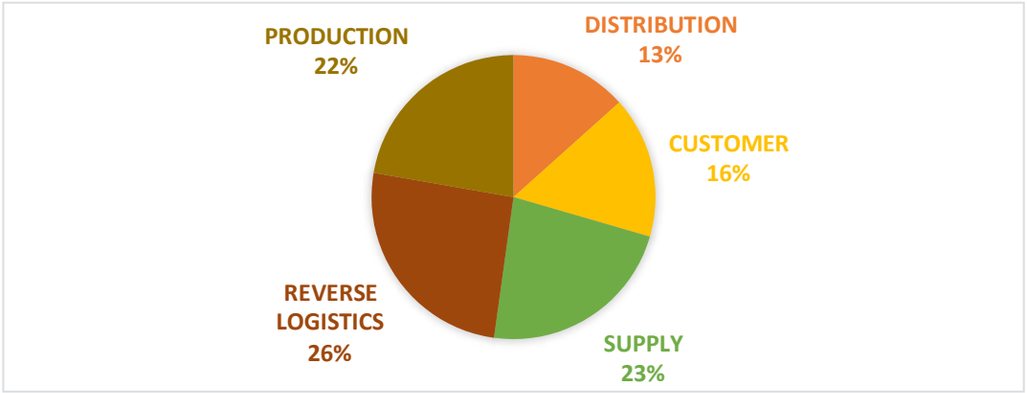

Figure 1: Risk distribution by main dimensions.

Table 3: New RPN values determined as a result of the measures taken.

Sub Risk Factors	Precaution	P	S	D	RPN	P	S	D	New RPN
Planning and scheduling errors in production	Active and efficient use of the ERP program, Integration of ERP with other programs	6	8	6	288	2	7	6	84
Lack of green suppliers	Providing sustainability training to suppliers, conveying its purpose	7	8	5	280	3	8	4	96
Frequent machine failures (blow room, card, draw frame, comber, ring, bobbin)	Planning regular maintenance, taking into account and recording the warnings given by the machine	7	7	5	245	2	7	5	70
Lack of commitment to green in the supply chain	Updating contracts and training of suppliers	6	7	5	210	3	7	4	84
Inefficient use of energy	Switching to the use of renewable energy sources, planning related investments	5	8	5	200	3	6	5	90
Operator errors/accident damage	Ensuring the use of protective equipment, checking it frequently, keeping a record ofoccupational accidents, and taking specific precautions	6	8	4	192	2	8	4	64
Hazardous air emission	Choosing clean and high quality energy sources, using technologies that will eliminatepollution at its source	6	8	4	192	3	7	4	84
Difficulties in recycling waste	Proper classification of waste at source	5	9	4	180	4	6	4	96
Abrage and risk related to quality	Keeping a record of the problems and increasing the frequency of control by the quality control unit, investigating the defective part according to quality errors, and taking precautions, maintenance	3	8	7	168	2	6	7	84
Information flow errors	Supporting compliance with information from the ERP program	3	7	8	168	3	6	4	72
Inefficient use of resources	Putting a quota on the resources used, imposing limitations, initiating necessary studies in cases of excess, testing alternative resources	5	8	4	160	4	5	4	80
Risk of wrong order request	Confirmation of the order by the customer	4	8	5	160	1	8	5	40
High cost for disposal of hazardous waste	Under the regulation, the relevant institutions undertake the costs	4	8	5	160	2	6	5	60
Risks of dumping waste	Evaluating the separation of wastes from intermediate stations for recycling, being close enough for vehicles to easily approach the warehouses during unloading; wastewarehouses should have adequate ventilation and lighting	4	8	5	160	3	5	5	75
Wrong supplier selection	Examining the performance of suppliers in certain periods and making	6	5	5	150	2	5	5	50

Sub Risk Factors	Precaution	P	S	D	RPN	P	S	D	New RPN
	adjustments according to the results								
Fire danger	Providing the fire alarm system in the company with full equipment, training the employees	3	9	5	135	2	9	4	72
Soil, water, air, noise pollution	Ensuring the use of necessary protective equipment	4	8	4	128	4	4	4	64
Currency and exchange rate fluctuations	Annual planning of necessary investments, not making instant decisions	7	6	3	126	5	4	3	60
Lack of sustainable information technology	Updating the ERP program	5	5	5	125	3	5	5	75
Demand risk associated with demand fluctuations/demand uncertainty	Ensuring demand forecasts are sales and customer-oriented	6	4	5	120	3	4	5	60
Supplier failure	Providing periodic supplier performance, increasing the frequency of communication with the supplier	4	6	5	120	4	5	3	60
Deployment planning errors	Making use of Industry 4.0 technologies, keeping track of stock management, keeping MRP up to date in the ERP program	4	4	7	112	3	4	2	24
Water scarcity	Making production according to the order by reducing the stocked work, preventing the use of extra water	3	9	4	108	3	4	4	48
Excessive or unnecessary packaging	Evaluation of green packaging options	3	7	5	105	3	7	3	63
Expressing customer dissatisfaction	Ensuring that the relations with the customer are always positive, seeking positive solutions to the incoming negativities, increasing the capacity of the after-sales serviceunit	3	7	5	105	3	5	2	30
Wrong blend selection	-	3	6	5	90				-
Inadequate personal protective equipment	-	3	6	5	90				-
Damage to products during handling and shipping	-	3	6	5	90				-
Raw material scarcity	-	4	7	3	84				-
Wrong yarn number	-	2	7	6	84				-
The risk of changing customers	-	3	4	7	84				-

Sub Risk Factors	Precaution	P	S	D	RPN	P	S	D	New RPN
purchasing desires									
Management policy errors	-	3	5	5	75				-
Insufficient ventilation	-	3	5	5	75				-
Information flow management risk in distribution	-	3	4	6	72				-
Risk of harming the quality of products purchased by custom	-	2	6	6	72				-
Inadequate recycling policies	-	2	7	5	70				-
Price and cost volatility	-	5	3	4	60				-
Lack of healthy partnership amongsupply chain partners	-	5	2	6	60				-
Fuel prices	-	2	5	6	60				-
The disconnection in the customer-company relationship	-	2	6	5	60				-
Inventory risk	-	2	4	5	40				-
Excessive amount of hazardous waste	-	1	7	5	35				-
Lack of qualified personnel	-	1	8	4	32				-

5. CONCLUSION

In this study, possible risks were determined by conducting a risk analysis within the scope of sustainable supply chain management in a company manufacturing in the textile sector, and situations with high risk weredetermined with the help of FMEA method. While determining the risks, the literature was examined; and experts working in different departments of the company came together and brainstormed. With the expert opinions, new risks such as wrong blend selection, information flow errors, distribution planning errors, risk of wrong order request, disconnection in customer-company relationship, expressing customer dissatisfaction,difficulties in recycling waste, inadequacy of recycling policies were added to the study. The probability, severity, and detectability scoring of the identified risks were determined by the team with a consensus. In the study, 43 risks were determined by the team, and 25 of them had an RPN above 100. Precautionary recommendations were made for these 25 possible risks. In the measures taken, priority was given to reducing the probability of the risk. In cases where probability could not be reduced, work was carried out to reducethe severity or increase the awareness. For all risks, recommendations that offer proactive approaches in preventing risks were presented, and RPN values were reduced below 100. The success of the results of the study enabled it to be accepted in the company. Compliance with planned control activities is an important factor in reducing risks. For this reason, it is thought that the number of dangerous behaviors will decrease ifthe recommendations are followed. In this study, radical and important change proposals such as program integration, tightening of controls, training, moving towards green and sustainable practices, and updating the contract are presented. If the company complies with these recommendations, it will take the more sustainablesupply chain management to a higher level. Risk analysis is not a one-time application; therefore, it is recommended to repeat it. Since the conditions will change over time, repeating the risk analysis at certain intervals will guide the company more accurately. In this context, the company is recommended to keep the risk analysis study up-to-date.

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