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A STUDY ON CRITICAL FACTORS OF DIGITALIZATION IN REVERSE LOGISTICS

TERSİNE LOJİSTİKTE DİJİTALLEŞMENİN KRİTİK FAKTÖRLERİ ÜZERİNE BİR ÇALIŞMA

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Yeşim Deniz Özkan-Özen[1] , Volkan Yavaş[2,*]

Abstract

Reverse logistics or closed loop supply chains play a critical role in today's business environment in order to achieve sustainable operations management practices that include environmental, social, and economic considerations. Reverse logistics covers the collection of end-of-life phased products from end users and continues with recovery processes, i.e., reuse, remanufacturing, recycling, refurbishment, and disposal. These activities have significant impacts on environmental and social issues as well as economic conditions of the company. Therefore, closed loop structures become essential for organizations, and reverse logistics becomes an indisputable element of the supply chains. Rapid digitalization in industry, so called Industry 4.0 or digital era, can be seen as a great opportunity to support and improve reverse logistics operations to contribute to sustainability. Although the relationship between sustainable practices and digital operations received the attention of both practitioners and academicians, the current literature lacks in providing factors that directly cover digitalization implementations in reverse logistics activities. From this point of view, this study, firstly, aims to propose critical factors for digitalization in reverse logistics, and secondly to evaluate them to make a prioritization for practical implementations. To achieve these aims, initially a literature review will be conducted to propose critical factors that are supported by the literature. Secondly, Fuzzy-Entropy Weighting Method is going to be used to prioritize these factors and to reveal the most important concepts. At the end of the study, it is expected to contribute to the literature by providing new concepts and suggesting future research ideas based on the results.

Keywords: Digitalization, Fuzzy-Entropy Weighting Method, Reverse Logistics, Sustainability, Sustainable Operations Management

Özet

Tersine lojistik veya kapalı döngü tedarik zincirleri, çevresel, sosyal ve ekonomik hususları içeren sürdürülebilir operasyon yönetimi uygulamalarına ulaşmak için günümüzün iş ortamında kritik bir rol oynamaktadır. Tersine lojistik, ömrünü tamamlamış ürünlerin son kullanıcılardan toplanmasını kapsar ve yeniden kullanım, yeniden üretim, geri dönüşüm, yenileme ve bertaraf gibi geri kazanım süreçleriyle devam eder. Bu faaliyetlerin çevresel ve sosyal konularda olduğu kadar şirketin ekonomik durumu üzerinde de önemli etkileri bulunmaktadır. Bu nedenle, kapalı döngü yapılar organizasyonlar için vazgeçilmez hale gelmekte ve tersine lojistik, tedarik zincirlerinin tartışılmaz bir unsuru haline gelmektedir. Endüstri 4.0 veya dijital çağ olarak adlandırılan endüstrideki hızlı dijitalleşme, sürdürülebilirliğe katkıda bulunmak için tersine lojistik operasyonlarını desteklemek ve geliştirmek için büyük bir fırsat olarak görülebilir. Sürdürülebilir uygulamalar ile dijital operasyonlar arasındaki ilişki hem uygulayıcıların hem de akademisyenlerin dikkatini çekmiş olsa da mevcut literatür, tersine lojistik faaliyetlerinde doğrudan dijitalleşme uygulamalarını kapsayan faktörleri sağlama konusunda yetersizdir. Buradan hareketle bu çalışma, öncelikle tersine lojistikte dijitalleşme için kritik faktörleri ortaya koymayı ve ikinci olarak bunları değerlendirerek pratik uygulamalar için bir önceliklendirme yapmayı amaçlamaktadır. Bu amaçlara ulaşmak için, öncelikle literatür tarafından desteklenen kritik faktörleri önermek için bir literatür taraması yapılacaktır. İkinci olarak, bu faktörleri önceliklendirmek ve en önemli kavramları ortaya çıkarmak için Bulanık Entropi Ağırlıklandırma Yöntemi kullanılacaktır. Çalışmanın sonunda yeni kavramlar sunarak ve sonuçlara dayalı olarak gelecek araştırma fikirleri önererek literatüre katkı sağlaması beklenmektedir.

Anahtar Kelimeler: Dijitalleşme, Bulanık Entropi Ağırlıklandırma Yöntemi, Tersine Lojistik, Sürdürülebilirlik, Sürdürülebilir Operasyon Yönetimi

[1] Yasar University, Faculty of Business, Department of Logistics Management, yesim.ozen@yasar.edu.tr, orcid.org/0000-0003-4520-6590

[2,*] Corresponding Author: Ege University, Aviation Higher Vocational School, volkan.yavas@ege.edu.tr, orcid.org/0000-0002-4237-6386

1. INTRODUCTION

The concept of logistics has moved away from the traditional approach in a positive sense today. There has been a transformation with various specializations and sub-fields that require special attention. One of these sub-fields is reverse logistics activities. The first connotation that comes to mind with logistics is a forward movement or flow and communication between the provider and the consumer. However, in the modern world, with the changing and transforming consumption dynamics, it is clear that more is needed. At this point, the concept of reverse logistics comes to the fore. Reverse logistics refers to the processes of collecting a used product from consumers for purposes such as reuse, repair, reproduction, recycling, or disposal (Agrawal et al., 2015). There may be various technical and legal scopes for reverse logistics; these scopes can be discussed, but in their most concise form, reverse logistics can be expressed as a part of sustainable development (Sun, 2017).

Reverse logistics is undoubtedly a process that has been known and practiced for many years. However, it is possible to say that its importance has increased in recent years with the concept of sustainability. Reverse logistics can be seen as an important element of sustainable operations management in terms of managing end of life activities and contributing sustainability practices.

On the other hand, there are paradigms brought by the changing and transforming world. The most recent of these is the concept of Industry 4.0 and digitalization. This new paradigm in the industry has also emerged as a new challenge for many sectors. And in many sectors, the process of learning or adapting to digital transformation has begun. The logistics sector has also been one of the leading sectors of this process. However, of course, critical elements come to the fore in the transformation process, both for the sector in general and for sub-operations.

In this study, critical factors of digital transformation in reverse logistics will be investigated. The importance order of the factors will be presented, and the implementation practices will be revealed. The study will continue with a literature review. Then, research will be done in the methodology section, and the results will be interpreted in the applications and discussion section. The study will end with a discussion and conclusion part.

2. PROPOSED CRITICAL FACTORS OF DIGITALIZATION AND REVERSE LOGISTICS

Digitalization, industry 4.0, circular economy, and sustainability are the topics that have been discussed extensively in the current literature, and the integration of these concepts receives great attention by the authors. Current digital trends directly affect the circular and sustainable practices, where new technologies can be beneficial to improve the systems (Dev et al., 2020). As a directly related topic, reverse logistics is also an area that may gain benefit from the new industrial revolution. Sun et al. (2022) defined the relationship between reverse logistics and Industry 4.0 by using the term reverse logistics 4.0 and stated that: *"Reverse logistics 4.0 is the sustainable management of all relevant flows and activities for value recovery and/or propper disposal of EoL products by using data driven and smart technologies enables individualization and innovative services."*

Shah et al. (2019) summarized the potential advantages of digitalization on reverse logistics as follows: increase in efficient tracking, better responsiveness, better planning and forecasting, cost savings, improved recycling with innovative technologies, and better inventory management. These advantages can be extended by considering reverse logistics activities separately and matching them with the appropriate digital technologies.

Furthermore, technologies such as Blockchain, RFID, and IoT enable the advanced traceability in reverse logistics activities, which results in waste minimization and decreased environmental impacts (Panghal et al., 2022). In addition to these, reliability and data accuracy in reverse logistics activities can be supported by embedded systems and machine learning applications (Kazancoglu et al., 2022).

Based on the previous studies related to digitalization and reverse logistics, in this study seven critical factors (CF) are proposed and presented below:

CF1: Value added recovery (Sangwan, 2017; Sun et al., 2022)

CF2: Real time monitored reverse activities (Krstić et al., 2022; Shah et al., 2019)

CF3: Smart operations and resource sharing (Sun et al., 2022; Yan et al., 2022)

CF4: IoT embedded smart bins (Haque et al., 2020; Sun et al., 2022)

CF5: Robotic EoL product collection and sorting (Fofou et al., 2021; Sun et al., 2022)

CF6: Data Driven redesign and remanufacturing (Goodall et al., 2019; Sun et al., 2022)

CF7: Availability of skilled labor on circular and digital approaches (Sangwan, 2017)

These critical factors cover the most important elements of digitalization and reverse logistics activities. However, for more practical implications, it is important to determine the importance levels of these factors. From this point of view, in the following section, the methodology that is used to evaluate these critical factors is explained briefly.

3. METHODOLOGY

FEW method is applied in this study to evaluate critical factors that are related to digitalization and reverse logistics activities. FEW is a simplified method, which is derived from entropy weighting. The entropy weighting method is used for deriving weights for the objective criteria; on the other hand, FEW enables the integration of subjective judgements and expert knowledge to the system by using fuzzy linguistic terms (Ighravwe and Oke, 2017).

FEW method has three main steps, which are:

Stage 1: Designing the decision matrix

Stage 2: Calculating the entropy values

Stage 3: Calculating the factor weights

In this study, a trapezoidal linguistic scale that have 8 different linguistic terms is used. These terms are: extremely important (EI): (0.7, 0.8, 0.9, 1), highly important (HI): (0,6, 0.7, 0.8, 0.9), slightly important (SI): (0.5, 0.6, 0.7, 0.8), important (I): (0.4, 0.5, 0.6, 0.7), no comment (NC): (0.3, 0.4, 0.5, 0.6), unimportant (U): (0.2, 0.3, 0.4, 0.5), slightly unimportant (SI): (0.1, 0.2, 0.3, 0.4), highly unimportant (HU): (0.0, 0.1, 0.2, 0.3). The graded mean integration method is used to make defuzzification, in other words converting them into crisp values.

4. IMPLEMENTATION OF THE STUDY

Implementation of the study is conducted by the participation of five decision makers (DM). These DMs are working in the fields related to reverse logistics, 3 of them work in electronic waste sector, and two of them are academicians, whose expertise are on sustainability, circular economy, and reverse logistics. All these DMs are also familiar with the digital transformation and the potential applications.

The implementation of the study is started by the linguistic evaluation of the critical factors. DMs were asked to evaluate the importance level of each critical factor by using the linguistic scale presented in the previous section. Table 1 shows the evaluation of critical factors.

Table 1: Linguistic evaluation of critical factors.

	CF1	CF2	CF3	CF4	CF5	CF6	CF7
DM1	I	U	HI	NC	HI	I	U
DM2	I	I	EI	HI	SI	NC	I
DM3	SI	SI	HI	I	SI	SI	U
DM4	I	SI	HI	SI	HI	I	I
DM5	SI	HI	I	I	HI	SI	I

After applying the steps of FEW method, Table 2 is derived as the result table. In this table Ej values represent the entropy values of each critical factor, and weights show the importance order.

Table 2: Summary of the results.

		Ej	Weights
Value added recovery	CF1	-1.914	0.178
Real time monitored reverse activities	CF2	-1.825	0.172
Smart operations and resource sharing	CF3	-0.821	0.111
IoT embedded smart bins	CF4	-0.623	0.099
Robotic EoL product collection and sorting	CF5	-2.000	0.183
Data Driven redesign and remanufacturing	CF6	-1.756	0.168
Availability of skilled labor on circular and digital approaches	CF7	-0.473	0.090

According to the results, Robotic EoL product collection and sorting (CF5) is revealed as the most important criteria and followed by value added recovery (CF1) and real time monitored reverse activities (CF2). On the other hand, availability of skilled labor on circular and digital approaches (CF7) is found as the least important critical factor. These results are discussed in the following section, and implications are presented.

5. IMPLICATIONS AND DISCUSSIONS

There are various studies that reveal the effects or applications of digitalization in reverse logistics activities. It will be possible to give the following examples in terms of the prominent criteria in the study. First of all, reverse logistics activities may include more difficult and critical tasks apart from the normal logistics flow. At this point, there may be some critical tasks that people may want to avoid or are risky. In this sense, robots can be used in many application points with systems that can do risky, monotonous, dirty, and boring jobs instead of humans, and this can provide a high-efficiency increase (Fofou et al., 2021). In addition, with the data that can be obtained and processed more easily with digitalization, value-adding activities such as savings in production costs, increase in service quality, and efficient energy use will be offered with real-time and accurate data (Krstić et al., 2022). While logistics service providers state that returns have negative effects on their margins and that one of the biggest difficulties in tracking this is the need for software, it is stated that with digitalization, all stakeholders in the process have a chance to combat these negativities with transparent access and control (Gautam, 2020). Industry 4.0 and digitalization are perceived as a threat to people in terms of employment, which is the issue that causes the most concern. While this may be considered relatively correct for some areas, the process will be a helpful element in the framework of human adaptation to digitalization in the future. As in all sectors regarding this process, the decisions to be taken according to time and learned operations will be decisive in the logistics sector.

6. CONCLUSION

Logistics has always existed in various forms as one of the oldest applied fields of humanity. And with each industrial revolution, it has also provided adaptation and continued its operations in line with the needs of industrial and individual users. Industry 4.0 and digitalization, one of the most showcased features, seems to be the most important challenge for the logistics industry today. It is known that the logistics sector and its stakeholders increase their successful practices in this transformation in many operations every day. However, in logistics operations, reverse logistics is perhaps one of the most persistent sub-activities in this transformation. As an important aspect of sustainable operations management, it is important to investigate potential applications of reverse logistics through digitalization. From this point of view, the aim of this study is to reveal the most important factors in the digitalization process in reverse logistics activities. In this way, suggestions that can facilitate the transformation and contribute to the process are presented. It is thought that the bottlenecks in the sector and those who resist the transformation can be identified with comprehensive studies of these clues.

REFERENCES

Agrawal, S., Singh, R. K., & Murtaza, Q. (2015). A literature review and perspectives in reverse logistics. *Resources, Conservation and Recycling*, *97*, 76-92. https://doi.org/10.1016/j.resconrec.2015.02.009

Dev, N. K., Shankar, R., & Swami, S. (2020). Diffusion of green products in industry 4.0: Reverse logistics issues during design of inventory and production planning system. *International Journal of Production Economics*, *223*, 107519. https://doi.org/10.1016/j.ijpe.2019.10751

Fofou, R. F., Jiang, Z., & Wang, Y. (2021). A review on the lifecycle strategies enhancing remanufacturing. *Applied Sciences*, *11*(13), 5937. https://doi.org/10.3390/app11135937

Gautam A. (2020), *Transforming reverse logistics through the digital route*. https://innoverdigital.com/transforming-reverse-logistics-through-the-digital-route/. Access: 09.10.2022

Goodall, P., Sharpe, R., & West, A. (2019). A data-driven simulation to support remanufacturing operations. *Computers in Industry*, *105*, 48-60. https://doi.org/10.1016/j.compind.2018.11.001

Haque, K. F., Zabin, R., Yelamarthi, K., Yanambaka, P., & Abdelgawad, A. (2020, June 1). An IoT based efficient waste collection system with smart bins. *IEEE World Forum on Internet of Things, WF-IoT 2020 - Symposium Proceedings*. https://doi.org/10.1109/WF-IoT48130.2020.9221251

Ighravwe, D. E., & Oke, S. A. (2017). A multi-hierarchical framework for ranking maintenance sustainability strategies using PROMETHEE and fuzzy entropy methods. *Journal of Building Pathology and Rehabilitation*, *2*(1), 1-18. https://doi.org/10.1007/s41024-017-0028-7

Kazancoglu, Y., Ozbiltekin-Pala, M., Sezer, M. D., Kumar, A., & Luthra, S. (2022). Circular dairy supply chain management through Internet of Things-enabled technologies. *Environmental Science and Pollution Research*, *1*, 1-13. https://doi.org/10.1007/s11356-021-17697-8

Krstić, M., Agnusdei, G. P., Miglietta, P. P., Tadić, S., & Roso, V. (2022). Applicability of Industry 4.0 technologies in the reverse logistics: A circular economy approach based on comprehensive distance based ranking (COBRA) method. *Sustainability*, *14*(9), 5632. https://doi.org/10.3390/su14095632

Panghal, A., Manoram, S., Mor, R. S., & Vern, P. (2022). Adoption challenges of blockchain technology for reverse logistics in the food processing industry. *Supply Chain Forum*, *24*(1), 7–16. https://doi.org/10.1080/16258312.2022.2090852

Sangwan, K. S. (2017). Key activities, decision variables and performance indicators of reverse logistics. *Procedia Cirp*, *61*, 257-262. https://doi.org/10.1016/j.procir.2016.11.185

Shah, S., Dikgang, G., & Menon, S. (2019). The global perception of industry 4.0 for reverse logistics. *International Journal of Economics and Management Systems*, *4*, 103-107.

Sun, Q. (2017). Research on the influencing factors of reverse logistics carbon footprint under sustainable development. *Environmental Science and Pollution Research*, 24, 22790-22798. https://doi.org/10.1007/s11356-016-8140-9

Sun, X., Yu, H., & Solvang, W. D. (2022). Towards the smart and sustainable transformation of Reverse Logistics 4.0: A conceptualization and research agenda. *Environmental Science and Pollution Research*, *29*(46), 69275–69293. https://doi.org/10.1007/s11356-022-22473-3

Yan, X., Liu, W., Lim, M. K., Lin, Y., & Wei, W. (2022). Exploring the factors to promote circular supply chain implementation in the smart logistics ecological chain. *Industrial Marketing Management*, *101*, 57-70. https://doi.org/10.1016/j.indmarman.2021.11.015

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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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Emel Yontar[1], Şölen Zengin[2,*]

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

[1] Tarsus University, Faculty of Engineering, Department of Industrial Engineering, eyontar@tarsus.edu.tr, orcid.org/0000-0001-7800-2960

[2,*] Corresponding Author: Tarsus University, Faculty of Engineering, Department of Industrial Engineering, solenzengin@tarsus.edu.tr, orcid.org/0000-0003-2309-4954

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)
		Wrong supplier selection (Song et al., 2017)
Supply	Environmental	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*
Reverse Logistics	Environmental	Inadequate recycling policies * Hazardous air emission (Song et al., 2017) Risks of dumping waste (Rostamzadeh et al., 2018)

* Created by authors.

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.

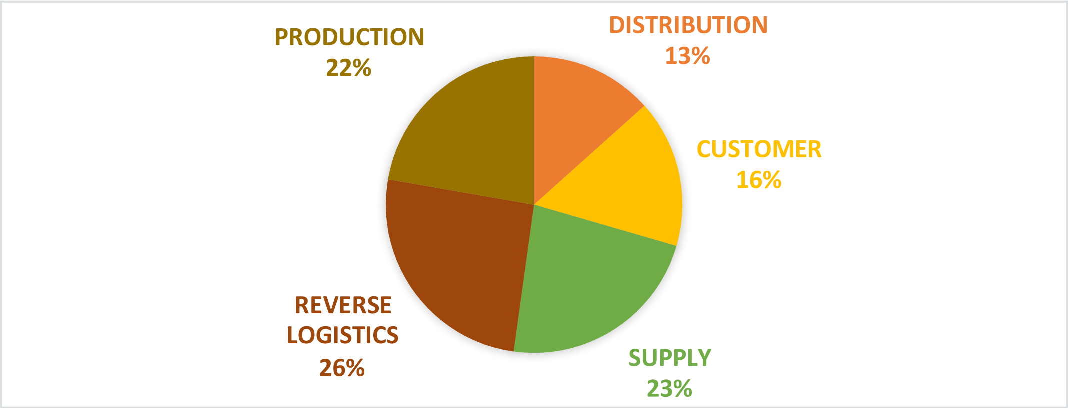

Figure 1: Risk distribution by main dimensions.

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.

7. REFERENCES

Abdel-Basset, M., & Mohamed, R. (2020). A novel plithogenic TOPSIS-CRITIC model for sustainable supply chain risk management. *Journal of Cleaner Production*, *247*, 119586. https://doi.org/10.1016/j.jclepro.2019.119586

Ali, S. M., Moktadir, M. A., Kabir, G., Chakma, J., Rumi, M. J. U., & Islam, M. T., (2019). Framework for evaluating risks in food supply chain: Implications in food wastage reduction. *Journal of Cleaner Production*, *228*, 786–800. https://doi.org/10.1016/ j.jclepro.2019.04.322

Beske, P., Land, A., & Seuring, S. (2014). Sustainable supply chain management practices and dynamic capabilities in the food industry: A critical analysis of the literature. *International Journal of Production Economics*, *152*, 131–143. https://doi.org/10.1016/j.ijpe.2013.12.026

Beyene, T. D., Gebeyehu, S. G., & Mengistu, A. T. (2018). Application of failure mode effect analysis (fmea) to reduce downtime in a textile share company. *Journal of Engineering, Project, and Production Management*, *8*(1), 40–46.

Bilici, S., & Kosanoğlu, F. (2021). Değer akış haritalama ve fmea yöntemleri kullanılarak tekstil sektöründe yalın üretim uygulaması. *International Journal of Advances in Engineering and Pure Sciences*, *33*(1), 131–142. https://doi.org/10.7240/jeps.784530

Breen, L. (2008). A preliminary examination of risk in the pharmaceutical supply chain (PSC) in the national health service (NHS). *Journal of Service Science and Management*, *1*(2), 193–199. https://doi.org/10.4236/jssm.2008.12020

Dai, M., & Liu, L. (2020). Risk assessment of agricultural supermarket supply chain in big data environment. *Sustainable Computing: Informatics and Systems*, *28*, 100420. https://doi.org/10.1016/j.suscom.2020.100420

Das, D. (2018). The impact of sustainable supply chain management practices on firm performance: Lessons from Indian organizations. *Journal of Cleaner Production, 203*, 179–196. https://doi.org/10.1016/j.jclepro.2018.08.250

Dewanti, N. A. Y., Setyaningsih, Y., & Jayanti, S. (2018). Working environmental hazard at home-based workers in the charcoal ındustrial sector in Semarang. *KnE Life Sciences*, *4*(5), 484–495. https://doi.org/10.18502/kls.v4i5.2578

Erdil, A., & Taçgın, E. (2018). Potential risks and their analysis of the apparel & textile industry in Turkey: A quality-oriented sustainability approach. *Fibres & Textiles in Eastern Europe*, *6*(132), 30–42. https://doi.org/10.5604/01.3001.0012.2526

Esfahbodi, A., Zhang, Y., & Watson, G. (2016). Sustainable supply chain management in emerging economies: Trade-offs between environmental and cost performance. *International Journal of Production Economics*, *181*, 350–366. https://doi.org/10.1016/j.ijpe.2016.02.013

Esmaeilian G., Ahmad M., Ismail N., Sulaiman S., & Hamedi M. (2008). Particular model for improving failure mode effect analysis (FMEA) by and using of overall equipment efficiency (OEE). In *2008 International Symposium on Information Technology*, Kuala Lumpur, Malaysia (pp. 1–9). IEEE. https://doi.org/10.1109/ITSIM.2008.4631974

Fithri P, Andra D. J., & Wirdianto E. (2020). The use of FMEA for the quality control analysis of greige fabrics (case study in the weaving department of pt. unitex, tbk). In *IOP Conference Series: Materials Science and Engineering* (Vol. 847). IOP Publishing. https://doi.org/10.1088/1757-899X/847/1/012002

Giannakis, M., & Papadopoulos, T. (2016). Supply chain sustainability: a risk management approach. *International Journal of Production Economics*, *171*, 455–470. https://doi.org/10.1016/j.ijpe.2015.06.032

Guan, G. F., Dong, Q. L., & Li, C. H. (2011). Risk identification and evaluation research on F-AHP evaluation based supply chain. In *IEEE 18th International Conference on Industrial Engineering and Engineering Management* (pp. 1513–1517). IEEE. https://doi.org/10.1109/ICIEEM.2011.6035447

Gurnani, H., Ray, S., & Wang, Y. (2011). Special issue of production and operations management:"Global supply chain risk management." *Production and Operations Management*, *5*(20), 786–786. https://doi.org/10.1111/j.1937-5956.2011.01283.x

Hamdy, O., Elsayed, K. & Elahmady, B. (2018). Impact of sustainable supply chain management practices on Egyptian companies' performance. *European Journal of Sustainable Development*, *7*(4), 119–130.

Jing, X., Dongjie, Z., & Zhongsu, M., (2009). The research on the BP neural network application in food supply chain risk management. In *2009 International Conference on Information Management. Innovation Management and Industrial Engineering* (pp. 545–548). IEEE. https://doi.org/10.1109/ICIII.2009.137

Karasan, A., & Erdogan, M. (2021). Creating proactive behavior for the risk assessment by considering expert evaluation: A case of textile manufacturing plant. *Complex & Intelligent Systems*, *7*, 941–959. https://doi.org/10.1007/s40747-020-00246-0

Küçük, M., İşler, M., & Güner, M. (2016). An application of the FMEA method to the cutting department of a clothing company. *Textile and Apparel*, *26*(2), 205–212.

Liu, M., & Fan, H. (2011, August). Food supply chain risk assessment based on the theory of system dynamics. In *2011 2nd International Conference on Artificial Intelligence, Management Science and Electronic Commerce (AIMSEC)* (pp. 5035–5037). IEEE.

McCormack, B., McCance, T., & Maben, J. (2013). Outcome evaluation in the development of person-centred practice. In B. McCormack, K. Manley, & A. Titchen (Eds.), *Practice development in nursing and healthcare* (pp. 190-211). John Wiley & Sons.

Mcdermott, R. E., Mikulak, R. J., & Beauregard, M. R. (2009). *FMEA* (2nd ed.). CRC Press Taylor & Francis Group.

Mutlu, N. G., & Altuntas, S. (2019). Hazard and risk analysis for ring spinning yarn production process by integrated FTA-FMEA approach. *Textile and Apparel, 29*(3), 208–218. https://doi.org/10.32710/tekstilvekonfeksiyon.482167

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*(1), 120–142. https://doi.org/10.1016/J.Ejor.2003.11.007

Narasimhan, R., & Talluri, S. (2009). Perspectives on risk management in supply chains. *Journal of Operations Management*, *27*(2), 114–118. https://doi.org/10.1016/j.jom.2009.02.001

Natarajarathinam, M., Capar, I., & Narayanan, A. (2009). Managing supply chains in times of crisis: A review of literature and insights. *International Journal of Physical Distribution & Logistics Management*, *39*(7), 535-573. https://doi.org/10.1108/09600030910996251

Nguyen, T. L., Shu, M. H., & Hsu, B. M. (2016). Extended FMEA for sustainable manufacturing: An empirical study in the non-woven fabrics industry, *Sustainability*, *8*(9), 939. https://doi.org/10.3390/su8090939

Nogueira, F. G. E., Castro, I. A., Bastos, A. R. R., Souza, G. A., de Carvalho, J. G., & Oliveira, L. C. A., (2011). Recycling of solid waste rich in organic nitrogen from leather ıindustry: Mineral nutrition of rice plants. *Journal of Hazardous Materials*, *186*(2–3), 1064–1069. https://doi.org/10.1016/j.jhazmat.2010.11.111

Ortolano, L., Sanchez-Triana, E., Afzal, J., Ali, C. L., & Rebellón, S. A. (2014). Cleaner production in Pakistan's leather and textile sectors. *Journal of Cleaner Production*, *68*, 121–129. https://doi.org/10.1016/j.jclepro.2014.01.015

Özyazgan, V. (2014). FMEA analysis and implementation in a textile factory producing woven fabric. *Textile and Apparel*, *24*(3), 303–308.

Rostamzadeh, R., Ghorabaee, M. K., Govindan, K., Esmaeili, A., & Nobar, H. B. K. (2018). Evaluation of sustainable supply chain risk management using an integrated fuzzy TOPSIS-CRITIC approach. *Journal of Cleaner Production*, *175*, 651–669. https://doi.org/10.1016/j.jclepro.2017.12.071

Song, W., Ming, X., & Liu, H. C. (2017). Identifying critical risk factors of sustainable supply chain management: A rough strength-relation analysis method. *Journal of Cleaner Production*, *143*, 100–115. https://doi.org/10.1016/j.jclepro.2016.12.145

Stamatis, D.H. (1995). *Failure mode and effect analysis: FMEA from theory to execution* (1st ed.). Quality Press.

Thawkar, A., Tambe, P., & Deshpande, V. (2018). A reliability centred maintenance approach for assessing the impact of maintenance for availability improvement of carding machine. *International Journal of Process Management and Benchmarking, 8*(3), 318–339. https://doi.org/10.1504/IJPMB.2018.092891

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A MCDM MODEL PROPOSAL AND SOLUTION FOR EVALUATING AGILE METHODS USED IN SUPPLY CHAIN MANAGEMENT

TEDARİK ZİNCİRİ YÖNETİMİNDE KULLANILAN ÇEVİK YÖNTEMLERİN DEĞERLENDİRİLMESİNE YÖNELİK ÇKKV MODEL ÖNERİSİ VE ÇÖZÜMÜ

https://doi.org/10.20854/bujse.1215618 G.Nilay Yücenur[1,*], Sena Çalışkan[2], Özge İrten[3], İlker Şahin[4]

Abstract

In the developing and changing world, the field of technology hosts many innovations. Supply chain management has also evolved in the light of technological developments and incorporated the concept of agility. Agile supply chain is the ability to respond quickly to the unexpected changes in demand and supply. As supply chains compete in a rapidly changing and growing market, the agility of the supply chain provides a significant competitive advantage to firms. An agile supply chain has the ability to respond flexibly and quickly to demands and problems. It benefits companies by adopting the right product, the right customer, the right transportation, and the right supply system. In this study, it was aimed to evaluate the agile methods used in the supply chain management processes, and for this purpose, a multi-criteria model consisting of 12 criteria and 9 alternatives was proposed. This proposed model was solved with two-stage multi-criteria solution techniques, and in the first stage of the solution, criterion weights were calculated with the SWARA method, while the evaluation and ranking of alternative agile methods were carried out with the WASPAS method. Thus, the most appropriate agile method methodology to be used in supply chain management was determined.

Keywords: Agile Management, Agile Supply Chain, Supply Chain Management, SWARA, WASPAS

Özet

Gelişen ve değişen dünyada teknoloji alanı birçok yeniliğe ev sahipliği yapmaktadır. Tedarik zinciri yönetimi de teknolojik gelişmeler ışığında evrim geçirmiş ve çeviklik kavramını bünyesine katmıştır. Çevik tedarik zinciri, talep ve arzdaki beklenmedik değişikliklere hızla yanıt verme yeteneğidir. Tedarik zincirleri hızla değişen ve büyüyen bir pazarda rekabet ederken, tedarik zincirinin çevikliği firmalara önemli bir rekabet avantajı sağlamaktadır. Çevik bir tedarik zinciri, taleplere ve sorunlara esnek ve hızlı bir şekilde yanıt verme yeteneğine sahiptir. Doğru ürünü, doğru müşteriyi, doğru nakliyeyi ve doğru tedarik sistemini benimseyerek firmalara fayda sağlar. Bu çalışmada tedarik zinciri yönetimi süreçlerinde kullanılan çevik yöntemlerin değerlendirilmesi amaçlanmış ve bu amaçla 12 kriter ve 9 alternatiften oluşan çok kriterli bir model önerilmiştir. Önerilen bu model iki aşamalı çok kriterli çözüm teknikleri ile çözülmüş ve çözümün ilk aşamasında SWARA yöntemi ile kriter ağırlıkları hesaplanırken alternatif çevik yöntemlerin değerlendirilmesi ve sıralaması WASPAS yöntemi ile gerçekleştirilmiştir. Çalışmada uygulama sonuçları sunulmuş, böylece tedarik zinciri yönetiminde kullanılacak en uygun çevik yöntem metodolojisi belirlenmiştir.

Anahtar Kelimeler: Çevik Yönetim, Çevik Tedarik Zinciri, Tedarik Zinciri Yönetimi, SWARA, WASPAS

[1,*] Corresponding Author: Istanbul Istanbul Beykent University, Faculty of Engineering and Architecture, Department of Industrial Engineering, nilaynil@hotmail.com, orcid.org/0000-0002-2670-6277
[2] COLIN' S ERK Marketing and Clothing Industry and Trade Inc. Sarıyer, Istanbul, clsknsena@gmail.com, orcid.org/0000-0001-6671-2199
[3] COLIN' S ERK Marketing and Clothing Industry and Trade Inc. Sarıyer, Istanbul, ozgeirtenn@gmail.com, orcid.org/0000-0002-7711-9734
[4] ilkeersahin@gmail.com, orcid.org/0000-0002-4986-1966

1. INTRODUCTION

It is very important for companies to be able to respond to the expectations of customers as a result of constantly changing conditions and increasing competition with the developing technology, and companies that cannot keep up with today's technological innovations disappear because they cannot adapt to the age. In order for companies to ensure their continuity, they need to adapt to technology, meet customer needs, and determine their production and logistics strategies in the light of this information.

In recent years, while customers are looking for quality and easy availability features in the product and/or service they buy, they also want manufacturers to establish a structure that can produce quick solutions to their problems, and minimize waiting times. For this reason, the profitability and continuity of companies depends on looking at the results and taking quick action according to these results, taking into account the other companies with which they are in competition, being sensitive to the needs and feedback of the customers. It will become more important in time for companies to focus on customer needs and to adapt to unforeseen events in the sector over time, and it will be possible for companies to respond quickly to these requirements by being agile in all processes. Today, it has become important for companies to have an agile understanding in order to ensure continuos success, and this understanding has begun to influence all sectors.

In this study, it is aimed to determine the necessary criteria for a company's supply chain management (SCM) to be agile, and to reach the optimal one among the agile methods with a multi-criteria decision-making approach. For this purpose, a multi-criteria decision-making (MCDM) model consisting of 12 criteria and 9 alternatives has been proposed, and this proposed model has been solved by sequentially used SWARA and WASPAS MCDM techniques. In this direction, general information about the study is given in the introduction part of the study. In the second part, information about SCM is given; its purpose and advantages are explained. In the third chapter, the concept of agile management and agile practices in SCM are mentioned. In the fourth chapter, a multi-criteria model is proposed for the evaluation of agile techniques used in SCM and the solution of this proposed model is realized. In the fifth and last chapter, an evaluation is made in the light of the solutions obtained, and the results and suggestions are given.

2. SUPPLY CHAIN MANAGEMENT

The supply chain can be defined as a network of physical and technological tools, processes, and methods, including the functions of procuring the raw material, transforming this supplied raw material into intermediate products or end-products, distributing these value-added products to customers, manufacturers, and distributors. SCM, on the other hand, is the planning and optimization of all processes from the producer to the consumer, down to the last detail. The main purpose is to bring together more than one activity in the SCM and to ensure that it works as a single system and increases customer satisfaction through customer feedback. Thus, the final product is delivered to the consumer at the right time, at the right place, and at the optimum cost.

SCM, which has a great importance for ensuring/maintaining the efficiency of companies and ensuring customer satisfaction, can direct the information and material flow that emerges because it has a command of all processes (Soltanmohammadi et al., 2021).

The main objectives of SCM are to standardize production, to ensure material and information flow, to keep stock costs and losses at the lowest level, to protect the quality of the product and to reduce product faults, to find reliable suppliers and to manage processes with the lowest management expense. In order to achieve these goals, companies need to improve and increase the flow of information between suppliers and customers. High-quality information flow ensures that the performance of companies will become high-quality.

By adopting SCM, competitive advantage is achieved; quality control requirement and supply related problems are minimized, and faster and more flexible operation is achieved (Moktadir et al., 2021). In addition, with the help of the technologies used in SCM, all the processes become easier; the uncertainties that may arise for the customer are minimized and eliminated, and human errors are largely eliminated with automation systems. As a result of a successful collaboration with SCM, each company gains advantages in terms of cost, quality, speed, and reliability.

3. AGILE MANAGEMENT

The concept of agile management is a different perspective on projects and products and includes cyclical processes (Marnada et al., 2022). These processes trigger each other and interact with each other. This interaction requires flexibility and continuity.

While classical project management focuses on the whole, the agile approach focuses on the parts. The risks that will arise when focusing on the whole are reduced by focusing on the parts. Self-managed teams do all these processes, and these teams produce high-quality solutions that meet the ever-changing needs, with minimum cost and in a timely manner, with sufficient formality, in a highly collaborative manner. While producing solutions, the teams pay attention to include the customer in the process.

This principle, which first emerged in the software world, has been started to use over time in other sectors with the development of technology. The principles of agile management are customer satisfaction, adapting to change, fast results, working together with business partners and the team, trust and freedom in the team, face-to-face communication, result-oriented, fast transactions, attention, simplicity, self-organizing team, and regular self-control (Loiro et al., 2019).

3.1 Agile Supply Chain

Agile supply chain is the ability to respond quickly to the unexpected changes in demand and supply. The agility of the supply chain, which grows and becomes more complex with each passing day, provides an important competitive advantage in the rapidly changing market (Ciccullo et al., 2018; Shashi et al., 2020).

Agile supply chain consists of four main criteria such as market sensitivity (uses technology based on predicting customer’s future orders), process integration (requires all stakeholders in the chain to act as a whole), network integration (requires strong communication and complete information flow among stakeholders), virtual network (with the developing technology, the data flow in the chain is facilitated and constantly observed).

The differences between the agile supply chain and the classical supply chain are shown in Table 1.

Table 1: Comparison of agile and classical supply chain (Taş, 2022).

Feature	Agile Supply Chain	Classical Supply Chain
Market demand	Variable	Predictable
Product lifecycle	Short	Long
Costs	Marketing costs	Physical costs
Collaborations	Short-term and variable	Stationary and long-term
Profit rate	High	Low
Product types	Trending products	Raw Materials
Product variety	High	Low
Guidance of customers in the market	Accessibility	Price
Logistics planning	Quick answers	Fixed period
Key assessment criterion	Customer satisfaction	Cost and efficiency
Estimation mechanism	Based on consultation	Algorithmic
Structure of processes	Increased automation	Standardization
Information	Necessary	Expected

4. MULTI-CRITERIA MODEL PROPOSAL AND SOLUTION FOR EVALUATING AGILE METHODS USED IN SUPPLY CHAIN MANAGEMENT

In today's developing and changing world, the field of technology hosts many innovations. Companies investing in technology gain competitive advantages by being positively affected by these technological developments.

SCM has evolved in the light of technological developments and incorporated the concept of agility. An agile supply chain has the ability to respond flexibly and quickly to demands and problems. Agile supply chain benefits companies by adopting the right product, the right customer, the right transportation, and the right supply system.

In this study, the agile methodologies used in SCM were evaluated according to the proposed MCDM model, and SWARA and WASPAS methods were used in this evaluation. With these evaluations, it is aimed to determine the most appropriate agile methodology to be used in SCM in the light of the proposed model.

4.1 Proposed Research Model with Its Criteria and Alternatives

The ability of companies to respond quickly to customer needs depends on the agility of the processes they contain. Today, companies have come a long way in agility. Companies that apply agility in their processes have added the value to themselves by gaining effectiveness in business life.

In this study, agile methods that can be used for a company's supply chain to be agile were evaluated with the MCDM approach. The MCDM model established within the scope of the study consists of 12 criteria and 9 alternative agile methods. The criteria and alternatives that make up the model are explained as follows, respectively:

Research criteria:

- *C_1 Reliability*: The data to be obtained with the agile method to be used should be precise and reliable, and the method should produce similar results under certain conditions.
- *C_2 Cost*: The agile method to be used should have cost advantage.
- *C_3 Time*: The agile method to be used should be effective in supplying all kinds of goods or services on time and ensuring the continuity of production, which is very important for SCM.
- *C_4 Flexibility*: The agile method to be used should be flexible enough to adapt to the changes that may occur in the process.
- *C_5 Usability*: It is preferred that the agile method to be used is user-friendly and has reusability feature.
- *C_6 Quality*: It is expected that the agile method to be used will be able to meet the demands and expectations accurately and in the best way.
- *C_7 Testability*: It is expected that the agile method to be used will be testable, that the written codes, established network models and more can be tested.
- *C_8 Technical competence*: The agile method to be used should have the necessary technical skills to perform supply chain processes.
- *C_9 Risk Oriented*: With the agile method to be used, it is aimed to examine the existing or potential risks and to reduce these risks to the minimum level by.
- *C_{10} Cooperation*: A collaborative approach is important for the interaction of individuals in agile teams to be productive.
- *C_{11} Continuous improvement*: The agile method to be used should be in accordance with the continuous improvement strategy and practices.
- *C_{12} Open communication*: Open communication with all stakeholders is very important for any problems or improvement suggestions that may occur.

Research alternatives:

- *A_1 SCRUM*: The SCRUM method, which is used in the management of complex processes, breaks the whole project into process pieces and relies on repetition while managing the processes. It also helps to achieve the goal with regular feedback and plans. Communication between the team members is very important in the method that uses a flexible structure for needs.

- *A_2 XP Programming*: The focus of the method in which communication is very important is on the customer and customer requirements. In this method, the customer's requirements are learned in detail before the project to be carried out and to be acted accordingly. Because the project progresses will increase the cost when the changes to be needed according to customer expectations.

- *A_3* Kanban: With the Kanban methodology, which is a visual methodology applied to manage the work in a process while it is in progress, the ongoing workflow is visualized, constraints are made clear for the whole team, and continuous improvement is encouraged.

- *A_4 Lean Software*: The method, whose basic principle is to eliminate all kinds of wasted resources, aims to remove all processes or all efforts that are meaningless for the customer from the workflow.

- *A_5 Feature Driven Development (FDD)*: The method focuses on development with short iterations to help the development team become more adaptive and responsive to customer needs. The method performs the new update step by step, rather than making an all-encompassing update in the system.

- *A_6 Dynamic System Development Method (DSDM)*: The method that helps determine the process model and team roles consists of agile management philosophies such as iterative delivery, effective communication, collaboration, and focusing on continuous improvement.
- *A_7 Adaptive Software Development (ASD)*: Since the method used to build complex software and systems has a complex structure, it is based on self-organized human association in its infrastructure.
- *A_8 Microsoft Solution Framework (MSF)*: The method is an adaptive approach that provides high-quality results while successfully delivering technology solutions faster, with fewer people and with less risk.
- *A_9 Rational Unified Process (RUP)*: The method is based on a step-by-step iterative development model.

The proposed research model is seen in Figure 1.

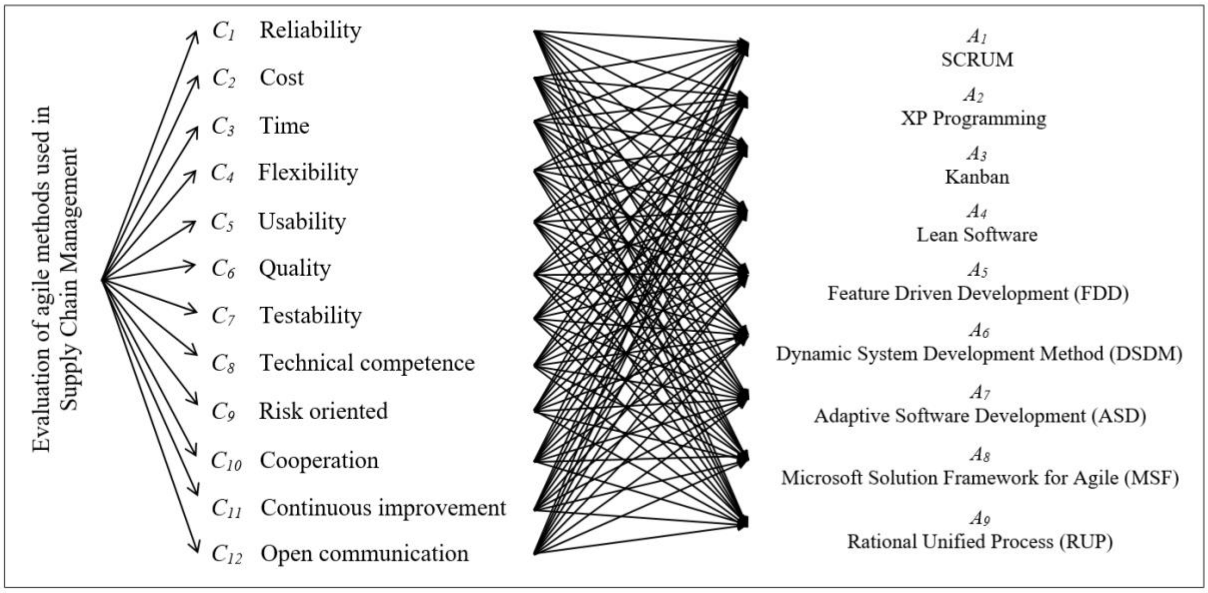

Figure 1: Proposed research model in MCDM structure.

4.2 Solution of the Problem

In the solution of the proposed MCDM model, SWARA and WASPAS, which are among the MCDM solution methods, were used. In the first stage of the solution, the criteria weights were found by the SWARA method, while in the second stage of the solution, alternative agile methods were evaluated with the WASPAS method. Opinions were taken from three experts with high sectoral experience in order to make evaluations during the solution phase.

4.2.1 SWARA method

SWARA method was developed by Keršulienė, Zavadskas, and Turskis in 2010 and has been used to determine the criterion weights of many problems until today. The process steps of the method, which is simple, suitable for working with experts, and very easy to use, are as follows (Prajapati et al., 2019):

Step 1: The criteria are simply ranked by the decision makers in descending order of importance. Then, each decision maker assigns the p_j^k value between 0 and 1 to each criterion in accordance with the first sorting (*j = 1, …,n; k = 1, …l*).

Step 2: If more than one decision maker evaluates the criteria, the geometric mean of the p_j^k values created by each decision maker is taken with the help of Equation 1, and the $\bar{p}_j$ value is formed.

$$\bar{p}_j = \frac{\sum_{k=1}^{l} p_j^k}{l} \tag{1}$$

Sorting of criteria according to decision makers and calculated $\bar{p}_j$ values are seen in Table 2.

Table 2: Sorting of the criteria and calculated $\bar{p}_j$ values of criteria.

Criteria		*Decision Makers*						$\bar{p}_j$
		DM_1	*DM_2*	*DM_3*	*DM_1*	*DM_2*	*DM_3*	
C_1	Reliability	6	7	7	0.75	0.60	0.60	0.650
C_2	Cost	1	2	1	1.00	0.95	1.00	0.983
C_3	Time	2	1	3	0.95	1.00	0.90	0.950
C_4	Flexibility	3	4	4	0.90	0.80	0.85	0.850
C_5	Usability	5	8	6	0.80	0.50	0.70	0.667
C_6	Quality	4	3	2	0.85	0.90	0.95	0.900
C_7	Testability	7	9	8	0.70	0.45	0.50	0.550
C_8	Technical competence	8	5	5	0.65	0.75	0.80	0.733
C_9	Risk oriented	9	6	9	0.60	0.65	0.45	0.567
C_{10}	Cooperation	12	11	12	0.20	0.20	0.10	0.167
C_{11}	Continuous improvement	10	10	11	0.40	0.40	0.30	0.367
C_{12}	Open communication	11	12	10	0.30	0.05	0.35	0.233

Step 3: The criteria are ordered from the largest to the smallest according to their $\bar{p}_j$ values, and the relative importance (s_j) of each criterion is obtained by subtracting in each other the $\bar{p}_j$ values of successive criteria.

Step 4: The coefficient value (c_j) is calculated with the help of Equation 2. For the criterion with the largest s_j value, $c_j = 1$.

$$c_j = s_j + 1 \tag{2}$$

Step 5: Adjusted weights (s_j') are calculated with the help of Equation 3. For the criterion in the first row $s_j' = 1$.

$$s_j' = \frac{s_{j-1}'}{c_j} \tag{3}$$

Step 6: Importance weights (w_j) are calculated with the help of Equation 4.

$$w_j = \frac{s_j'}{\sum_{j=1}^{n} s_j'} \tag{4}$$

Calculated $\bar{p}_j$, s_j, c_j, s_j', and w_j values of criteria are seen in Table 3.

Table 3: $\bar{p}_j$, s_j, c_j, s'_j and w_j values of criteria.

	$\bar{p}_j$	s_j	c_j	s'_j	w_j		$\bar{p}_j$	s_j	c_j	s'_j	w_j
C_2	0.983	-	1.000	1.000	0.1130	C_1	0.650	0.017	1.017	0.725	0.0819
C_3	0.950	0.033	1.033	0.968	0.1094	C_9	0.567	0.083	1.083	0.670	0.0756
C_6	0.900	0.050	1.050	0.922	0.1042	C_7	0.550	0.017	1.017	0.658	0.0744
C_4	0.850	0.050	1.050	0.878	0.0992	C_{11}	0.367	0.183	1.183	0.556	0.0629
C_8	0.733	0.117	1.117	0.786	0.0888	C_{12}	0.233	0.134	1.134	0.491	0.0554
C_5	0.667	0.066	1.066	0.737	0.0833	C_{10}	0.167	0.066	1.066	0.460	0.0520

As seen in Table 3, cost is the most important criterion with a weight of 11.3% in determining the appropriate agile method for the supply chain according to the proposed model. While this criterion was followed by time and quality criteria, respectively, cooperation was determined as the least important criterion with a weight of 5.2%.

4.2.2 WASPAS method

In the WASPAS method, which combines the results of two different models, the Weighted Sum and the Weighted Product Model, the alternatives are ranked according to the value of the combined optimality criterion. The method proposed by Chakraborty and Zavadskas in 2014 does not require extra sensitivity analysis due to its nature. The steps of the method are as follows (Prajapati et al., 2019):

Step 1: The MCDM model is established by determining the alternatives ($A_{i(i=1,\ldots m)}$) and criteria ($C_{j(j=1,\ldots n)}$).

Step 2: With one of MCDM methods, the importance weights of the criteria are calculated. In this study, SWARA method was used for this step.

Step 3: Using the (1-5) scale, the initial decision matrix is created according to the evaluations of the decision makers. Table 4 shows the initial decision matrix for this study.

Table 4: Initial decision matrix.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
	max	*min*	*min*	*max*	*max*	*max*	*max*	*max*	*max*	*max*	*max*	*max*
w_j	0.082	0.113	0.109	0.099	0.083	0.104	0.074	0.089	0.076	0.052	0.063	0.055
A_1	4	1	4	4	4	4	5	3	5	5	5	5
A_2	4	2	3	5	3	5	5	5	2	4	5	5
A_3	5	3	5	5	5	4	5	4	3	4	5	4
A_4	3	2	5	4	3	5	3	4	5	5	4	5
A_5	3	3	3	3	3	4	2	2	2	4	3	4
A_6	4	3	1	4	4	4	3	3	3	5	4	5
A_7	4	3	4	4	3	3	3	3	5	5	5	4
A_8	5	2	5	5	4	5	3	4	5	3	5	5
A_9	4	2	2	5	4	2	5	5	3	2	4	4

Step 4: The initial decision matrix is normalized according to the characteristics of the criteria. Equation 5 is used for benefit-based criteria that should be maximized, and Equation 6 is used for cost-based criteria that should be minimized.

$$\overline{x_{ij}} = \frac{x_{ij}}{max_i x_{ij}} \quad (5)$$

$$\overline{x_{ij}} = \frac{min_i x_{ij}}{x_{ij}} \quad (6)$$

The created normalized decision matrix is shown in Table 5.

Table 5: Normalized decision matrix.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
w_j	0.082	0.113	0.109	0.099	0.083	0.104	0.074	0.089	0.076	0.052	0.063	0.055
A_1	0.80	1.00	0.25	0.80	0.80	0.80	1.00	0.60	1.00	1.00	1.00	1.00
A_2	0.80	0.50	0.33	1.00	0.60	1.00	1.00	1.00	0.40	0.80	1.00	1.00
A_3	1.00	0.33	0.20	1.00	1.00	0.80	1.00	0.80	0.60	0.80	1.00	0.80
A_4	0.60	0.50	0.20	0.80	0.60	1.00	0.60	0.80	1.00	1.00	0.80	1.00
A_5	0.60	0.33	0.33	0.60	0.60	0.80	0.40	0.40	0.40	0.80	0.60	0.80
A_6	0.80	0.33	1.00	0.80	0.80	0.80	0.60	0.60	0.60	1.00	0.80	1.00
A_7	0.80	0.33	0.25	0.80	0.60	0.60	0.60	0.60	1.00	1.00	1.00	0.80
A_8	1.00	0.50	0.20	1.00	0.80	1.00	0.60	0.80	1.00	0.60	1.00	1.00
A_9	0.80	0.50	0.50	1.00	0.80	0.40	1.00	1.00	0.60	0.40	0.80	0.80

Step 5: For all alternatives as the total relative importance value, while ${Q_i}^{(1)}$ is calculated with the help of Equation 7 according to the Weighted Sum Model, ${Q_i}^{(2)}$ is calculated with the help of Equation 8 according to the Weighted Product Model.

$${Q_i}^{(1)} = \sum_{j=1}^{n} \overline{x_{ij}}\, w_j \quad (7)$$

$${Q_i}^{(2)} = \prod_{j=1}^{n} \left(\overline{x_{ij}}\right)^{w_j} \quad (8)$$

Step 6: The Combined Optimality Value (Q_i) for the alternatives is calculated with the help of Equation 9. $\lambda \epsilon [0,1]$ which is the combined optimality coefficient was accepted as 0.5 for this study.

$$Q_i = \lambda {Q_i}^{(1)} + (1-\lambda){Q_i}^{(2)} \quad (9)$$

Step 7: Alternatives are ranked according to their Q_i values; the alternative with the largest Q_i value is the best solution.

In Table 6, calculated $Q_i^{(1)}, Q_i^{(2)}$, Q_i values and the ranking of alternatives are shown.

Table 6: $Q_i^{(1)}, Q_i^{(2)}$, Q_i values and the ranking of alternatives.

Alternatives	$Q_i^{(1)}$	$Q_i^{(2)}$	Q_i	*Ranking*
A_1 SCRUM	0.8081	0.7568	0.7824	1
A_2 XP Programming	0.7642	0.7118	0.7380	2
A_3 Kanban	0.7461	0.6668	0.7064	5
A_4 Lean Software	0.7095	0.6493	0.6794	7
A_5 Feature Driven Development (FDD)	0.5346	0.5081	0.5214	9
A_6 Dynamic System Development Method (DSDM)	0.7419	0.7101	0.7260	4
A_7 Adaptive Software Development (ASD)	0.6547	0.6025	0.6286	8
A_8 Microsoft Solution Framework for Agile (MSF)	0.7705	0.7001	0.7353	3
A_9 Rational Unified Process (RUP)	0.7074	0.6711	0.6893	6

According to the values in Table 6, the alternatives are listed as $A_1 > A_2 > A_8 > A_6 > A_3 > A_9 > A_4 > A_7 > A_5$. Accordingly, with a Q_i value of 0.7824, SCRUM is the most appropriate agile method to be used in SCM for the MCDM model proposed in this study. XP Programming follows this method with a Q_i value of 0.7380.

5. CONCLUSION AND RECOMMENDATIONS

Supply chain consists of suppliers, manufacturers, wholesalers, retailers, customers, consumers, distributor elements, and warehouses. The uninterrupted communication among these elements is very important for the supplier, the company, and the customer. In addition, in agile methodologies where communication is very important, agility includes elements such as responsiveness, flexibility, open communication between the team, and examining the existing problem at the piece level.

In this study, agile methodologies that can be used rather than traditional methods in SCM are evaluated. In this evaluation, the proposed MCDM model was analyzed by using the SWARA and WASPAS methods, considering the dimensions such as the reliability, cost, time, flexibility, usability, testability, technical competence, risk-oriented, continuous improvement, and open communication.

After all evaluations, SCRUM was found the most suitable agile methodology for SCM according to proposed model. In future researches, the proposed model can be expanded with new criteria, or the solution techniques can be changed.

REFERENCES

Ciccullo, F., Pero, M., Caridi, M., Gosling, J., & Purvis, L. (2018). Integrating the environmental and social sustainability pillars into the lean and agile supply chain management paradigms: A literature review and future research directions. *Journal of Cleaner Production*, *172*, 2336–2350. http://doi.org/10.1016/j.jclepro.2017.11.176

Loiro, C., Castro, H., Avila, P., Cruz-Cunha, M. M., Putnik, G. D., & Ferreira, L. (2019). Agile project management: A communicational workflow proposal. *Procedia Computer Science*, *164*, 485–490. https://doi.org/10.1016/j.procs.2019.12.210

Marnada, P., Raharjo, T., Hardian, B., & Prasetyo, A. (2022). Agile project management challenge in handling scope and change: A systematic literature review. *Procedia Computer Science*, *197*, 290–300. https://doi.org/10.1016/j.procs.2021.12.143

Moktadir, M. A., Dwivedi, A., Khan, N. S., Paul, S. K., Khan, S. A., Ahmed, S., & Sultana, R. (2021). Analysis of risk factors in sustainable supply chain management in an emerging economy of leather industry. *Journal of Cleaner Production*, *283*, 124641. https://doi.org/10.1016/j.jclepro.2020.124641

Prajapati, H., Kant, R., & Shankar, R. (2019). Prioritizing the solutions of reverse logistics implementation to mitigate its barriers: A hybrid modified SWARA and WASPAS approach. *Journal of Cleaner Production*, *240*, 118219. https://doi.org/10.1016/j.jclepro.2019.118219

Shashi, Centobelli, P., Cerchione, R., & Ertz, M. (2020). Agile supply chain management: where did it come from and where will it go in the era of digital transformation?

Industrial Marketing Management, *90*, 324–345. https://doi.org/10.1016/j.indmarman.2020.07.011

Soltanmohammadi, A., Ardakani, D. A., Dion, P. A., & Hettiarachchi, B. D. (2021). Employing total quality practices in sustainable supply chain management. *Sustainable Production and Consumption*, *28*, 953–968. https://doi.org/10.1016/j.spc.2021.07.013

Taş, M. A. (2020). Selecting a green, agile and industry 4.0 supplier with the fuzzy-SWARA-BWM integrated method. *Süleyman Demirel University*, Institute of Natural and Applied Sciences, Master Thesis.

İstanbul Beykent Üniversitesi Fen ve Mühendislik Bilimleri Dergisi 2023, 16(1), 33-42
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AN EXACT SOLUTION FOR REAL-LIFE TRANSSHIPMENT PATH PROBLEM

GERÇEK HAYAT AKTARMA PROBLEMİNE TAM ÇÖZÜM

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Zehra Hafızoğlu Gökdağ[1,*], Salih Cebeci[2]

Abstract

In industrial engineering, transportation planning, vehicle routing problem, warehousing, inventory management, and customer service are logistics problems. Graph theory algorithms provide solutions to logistics problems such as the shortest path, minimum spanning tree, and vehicle routing problems. In a logistics company system with branches and transfer centers to which the branches are affiliated, if the sorting process is carried out in the transfer centers, the deliveries collected from the branches must be transported to a transfer center. Thus, there are situations where delivery is transferred in the sending branch, the sending transfer center, the receiving transfer center, and the receiving branch, respectively. In this flow, transferring with a single transfer center without visiting two transfer centers reduces the total cost. While moving from the sender transfer center to the receiver transfer center, stopping by some branches on the way allows us to complete the transfer process with a single transfer center and eliminates the necessity of leaving the vehicle from the receiver transfer center to these branches again. Thus, the number of vehicles that need to go from the receiver transfer center to the branches is reduced. The mentioned logistics structure is defined as a graph that is considered a network design problem. Given the sender transfer center S, the receiver transfer center T, the set of branches A connected to S, and the set of branches C that are not connected to S or T, a counting algorithm that gives the minimum value route among all combinations are designed in order to find the optimal route from the source node $s \in A \cup \{S\}$, to the target node $t = T$. The algorithm has been implemented in Python and Gams and tested by the different number of elements of the set A and the set C.

Keywords: Combinatory Problem, Graph Theory, Logistics, Network Design Problem

Özet

Şubelerin ve şubelerin bağlı olduğu aktarma merkezlerinin bulunduğu bir lojistik firma sisteminde, eğer ayrıştırma işlemi aktarma merkezlerinde yapılıyorsa, şubelerden toplanan gönderilerinbir aktarma merkezine taşınması gerekir. Böylece gönderiler sırasıyla gönderen şubede, gönderen transfer merkezinde, alıcı transfer merkezinde ve alıcı şubede transfer edildiği durumlar ortaya çıkmaktadır. Bu akışta iki aktarma merkezine uğramadan tek bir aktarma merkezi ile aktarma yapılması toplam maliyeti düşürmektedir. Gönderici aktarma merkezinden alıcı aktarma merkezine hareket ederken yol üzerindeki bazı şubelere uğramak aktarma işlemini tek bir aktarma merkezi ile tamamlamamızı sağlar ve alıcı aktarma merkezinden bu şubelere tekrar araç yönlendirme zorunluluğunu ortadan kaldırır. Böylece alıcı aktarma merkezinden şubelere gitmesi gereken araç sayısı azaltılmış oluyor. Söz konusu lojistik yapı, bir ağ tasarım problemi olarak ele alınan bir çizge olarak tanımlanmaktadır. Gönderici transfer merkezi S, alıcı transfer merkezi T, S'ye bağlı A şubeleri kümesi ve S veya T'ye bağlı olmayan C şubeleri kümesi verildiğinde, $s \in A \cup \{S\}$ kaynak düğümünden $t = T$ hedef düğümüne giden en uygun rotayı bulmak için tüm kombinasyonlar arasından minimum değerli rotayı veren bir sayma algoritması tasarlanmıştır. Algoritma Python ve Gams'da uygulanmış ve A ve C kümelerinin farklı eleman sayıları ile test edilmiştir.

Anahtar Kelimeler: Kombinasyon Problemi, Grafik Teorisi, Lojistik, Ağ Tasarımı Problemi

[1,*] Corresponding Author: Hepsijet & Kadir Has University, Faculty of Engineering and Natural Sciences, Department of Industrial Engineering, zehra.gokdag@hepsijet.com, orcid.org/0000-0002-5804-3105
[2] Hepsijet & Kadir Has University, Faculty of Engineering and Natural Sciences, Department of Industrial Engineering, salih.cebeci@hepsijet.com, orcid.org/0000-0003-2200-6318

1. INTRODUCTION

Logistics network topology analysis studies have been carried out in the literature with the definitions of graph theory. A method to analyze the attributes of nodes and edges in the graph structure of the Urban Logistics system, with some graph theory and complex network definitions, was proposed (Li & Zhang, 2009). In transportation planning, factors such as reducing transportation cost, route length, and the number of machines (or drivers) are of great importance in order to maximize profit (Malandraki et al., 2001).

In the logistics system, some problems such as Shortest Path Problem, Vehicle Routing Problem, Traveling Salesman Problem, and Minimum Spanning Tree are well-known Network Design Problems (Feremans et al., 2003). The Network Design problem is the problem of finding the S_G subgraph of a G graph that satisfies the balance of the flow and side constraints.

Exact algorithms such as Set Partitioning Algorithm (Balinski & Quandt, 1964), Branch-and-Bound Algorithm (Christofides & Eilon, 1969), Dynamic Programming (Eilon et al., 1971), and heuristics such as Clarke and Wright Algorithm (Clarke & Wright, 1964), Nearest Neighbor Algorithm (Bellmore & Nemhauser, 1968), A* Search Algorithm (Hart et al., 1968), Set Partitioning Heuristics (Gillett & Miller, 1974), 2-Opt & 3- Opt (Croes, 1958), Lin Kernighan Heuristic (Lin & Kernighan, 1973), Tabu Search (Glover, 1986), Simulated Annealing (Kirkpatrick et al., 1983), Genetic Algorithm (Holland, 1962) have been developed since the early 20th century for the solution of VRP and TSP.

Kruskal’s Algorithm (Kruskal, 1956), Prim’s Algorithm (Prim, 1957), Boruvka’s Algorithm (Boruvka, 1926) are known as solution algorithms for the minimum spanning tree problem.

The Shortest Path Algorithm is a simple network design algorithm. Various methods such as Dijkstra’s Shortest Path algorithm (Dijkstra, 1959), Bellman-Ford Algorithm (Bellman, 1958; Ford, 1956), Floyd- Warshall’s Algorithm (Floyd, 1962), and Path Labeling Algorithm (Pandian & Rajendran, 2010) have been developed since the past to solve this problem.

2. NETWORK DESIGN PROBLEM

The Network Design Problem's (NDP) goal is to identify the optimal subgraph $S_G = (V', E')$ in a graph $G = (V, E)$ under the constraints of forcing, flow balance, and side constraints (Magnanti, 1984). In order to explain NDP, sets, parameters, and decision variables notations are defined as

Sets:

- $V = \{v_1, v_2, \ldots, v_n\}$ is the set of nodes and $v_i \in V$ is the node in the set of nodes
- E contains each edge e_{ij} from v_i to v_j
- k is the commodity in the commodities set K
- M is the constraints set

Parameters:

- c_{ij}^{k} is the cost of one unit $k \in K$ along $e_{ij} \in E$
- f_{ij} is the fixed cost of containing $e_{ij} \in E$
- q_k is the total quantity of commodity $k \in K$
- l_{ij} is the capacity of $e_{ij} \in E$

Decision Variables:

- $x_{ij} = \begin{cases} 1, & if\ e_{ij} \in E\ is\ containing\ in\ the\ S_G \\ 0, & otherwise \end{cases}$
- y_{ij}^{k} is the fraction of commodity $k \in K$ on $e_{ij} \in V$

Mathematical Formulation:

$$\min \sum_{k \in K} \sum_{e_{ij} \in E} c_{ij}^{k}\, q_k y_{ij}^{k} + \sum_{e_{ij} \in E} f_{ij} x_{ij} \qquad (1)$$

$$\sum_{\in K} q_k y_{ij}^{k} \le l_{ij} x_{ij} \qquad \forall e_{ij} \in E \qquad (2)$$

$$\sum_{j:e_{ij} \in E} y_{ij}^{k} - \sum_{j:e_{ji} \in E} y_{ji}^{k} = \begin{cases} 1, & if\ i = O(k) \\ -1, & if\ i = D(k), \\ 0, & otherwise. \end{cases} \qquad \forall v_i \in V, \qquad k \in K \qquad (3)$$

$$\left(y_{ji}^{k}, x_{ij}\right) \in M \qquad (4)$$

$$x_{ij} \in \{0,1\} \qquad (5)$$

$$0 \le y_{ji}^{k} \le 1 \qquad \forall v_i \in V, \qquad k \in K \qquad (6)$$

The aim of Equation (1) is to minimize the network's total cost, which is made up of the cost of each commodity and the fixed cost of each included arc. The "forcing" limits shown in Equation (2) ensure that the flow on any arc does not go over the capacity designated for that arc. The flow balancing constraint, also known as the flow conservation constraint, is found in Equation (3) and assures that commodities only enter or exit the network at their respective origin $O(k)$ or destination $D(k)$ nodes. To add additional restrictions to the NDP to adapt it to particular applications, see the side constraints, Equation (4). The range restrictions for the flow and decision variables are Equation (5) and Equation (6). The problem examined in this study is a simple network design problem.

3. PROBLEM DEFINITION

The logistics company has branches and transfer centers to which these branches are affiliated. Packages are collected from branches in the region of Transfer Center 1 (S) and brought to S. The vehicle is taken out from S and transferred to Transfer Center 2 (T), then the vehicles are directed to the branches in the region of T.

In this study, in the scenario given in Figure 1, the optimal route solution that goes to the node T is obtained by visiting all the points in $A = \{A_1, A_2, \ldots, A_n\}$, $C = \{C_1, C_2, \ldots, C_m\}$, and S. A is the set of branches that are connected to the transfer center S, while C is the set of branches that are connected to different transfer centers that are not connected to the transfer center S or T. This combinatory problem is solved by considering all possibilities with some external factors (weather conditions, traffic, road works, closed roads, etc.).

Figure 1: Problem scenario.

Let $G = (V, E)$ be a graph, the node set be $V = \{S, T\} \cup A \cup C$ (Figure 2) where the source node $\theta \in A \cup \{S\}$, a target node $t = T$. The set of edges E is a distance associated with each edge $(i, j) \in E$, in this study, distances between nodes are taken from the open routing service. At the same time, a random value is added to this value.

In the problem examined in this study, the starting point must be S or a point from the set A. There is no priority between point S and a point of set A, so the arc between A and S is bidirectional in Figure 2. It is not possible to go to any point in set C without visiting point S. After the point S is visited, there is no priority between the elements of set C and set A, and the route ends at the point T.

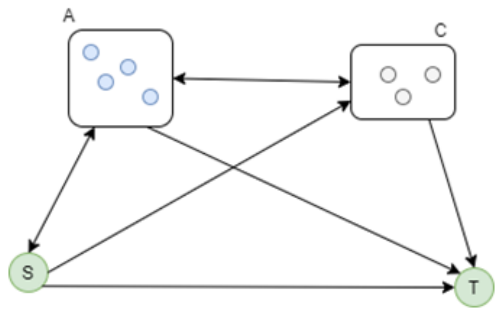

Figure 2: The graph structure of the problem.

Each node in $V\setminus\{T\}$ must be visited once by a vehicle and all vehicle routes will start at the point in $\{S\}\cup A$ and end at point T. The integer programming formulation to determine the route with minimum cost vehicle routes according to the constraints is as follows:

Sets:

- A: the set of branches that are connected to the point S, and $A = \{A_1, A_2, \dots, A_n\}$
- C: the set of branches that are not connected to the point S or the point T, and $C = \{C_1, C_2, \dots, C_m\}$.
- V: the set of all nodes, $V = \{S, T\} \cup A \cup C$.

Parameters:

- d_{ij}: the edge cost, $d_{ij} \in R$
- M: a big number.

Decision variables:

- x_{ij}: the binary variable that take value 1 if the arc of (i, j) belongs to the path.
- δ_i: the order at which location i is visited, $\delta_i > 0$.
- θ: the starting point.

Objective Function:

$$min \sum_{i\in V}\sum_{j\in V} d_{ij}.x_{ij} \qquad (7)$$

Constraints:

$$\sum_{i \in V} x_{ij} = 1, \quad \forall j \in V \setminus \{\theta\} \tag{8}$$

$$\sum_{j \in V} x_{ij} = 1, \quad \forall i \in V \setminus \{t\} \tag{9}$$

$$\sum_{i \in V} x_{i\theta} = 0 \tag{10}$$

$$\sum_{j \in V} x_{tj} = 0 \tag{11}$$

$$x_{ii} = 0, \quad \forall i \in V \tag{12}$$

$$\delta_j > \delta_i - M(1 - x_{ij}), \quad \forall\, i, j \in V,\ i \neq j \tag{13}$$

$$\delta_c > \delta_S, \quad \forall c \in C \tag{14}$$

Constraints (8) and (9) specify that only one arc enters each vertex, and only one arc leaves from each vertex, respectively. Constraints (10) and (11) specify that there is no arc entering θ, and there is no arc leaving from t, respectively. Constraint (12) means that no node comes back to itself; there is no loop. Constraint (13) is for subtour elimination. (If $x_{ij} = 1$, $\delta_j > \delta_i$.) Constraint (14) means that any point of the set C cannot be visited without visiting point S.

4. METHODOLOGY AND NUMERICAL EXPERIMENTS

The formula $f(n, m)$ for the number of all feasible solutions where $n = |A|$ and $m = |C|$ is as follows:

$$f(n,m) = \sum_{i=0}^{n} \binom{n}{i} . i!\,(m + n - i)!$$

The algorithm is implemented in Python 3.9. All experiments are implemented on a Laptop with a Core 5 CPU, 64-bit operating system, and 16 GB ram. The algorithm generates all feasible solutions and calculates the total path distance for every solution. Then we choose the solution with the minimum total path distance. The number of all feasible solutions for different m and n values, and algorithm run-time are given in Table 1 and Table 2, respectively.

Table 1: The number of feasible solutions.

f(x)	m=0	m=1	m=2	m=3	m=4	m=5	m=6
n=0	1	1	2	6	24	120	720
n=1	2	3	8	30	144	840	5760
n=2	6	12	40	180	1008	6720	51840
n=3	24	60	260	1260	8064	60480	518400
n=4	120	360	1680	10080	72576	604800	5702400
n=5	720	2520	13440	90720	725760	6652800	68428800
n=6	5040	20160	120960	907200	7983360	79833600	889574400

Table 2: Algorithm run-time (miliseconds).

t	m=0	m=1	m=2	m=3	m=4	m=5
n=0	0	0	0	0	0	0
n=1	0	0	0	0	0	0
n=2	0	0	0	0	0	15
n=3	0	0	0	0	16	113
n=4	0	0	0	17	188	1443
n=5	0	0	16	171	1585	14794

The mathematical model is also modeled by Gams 36. The real-life problem given above is also solved by this Gams model, and it was seen that the same optimal solution was obtained.

A real-life problem instance where $S = \{İzmir\ TM\}$, $T = \{Antalya\ TM\}$, 6 branches connected to S (n=6) and 3 branches not connected to S and T (m=3) is examined. For these specific m and n values, the number of feasible solutions is 907200, and the run-time of the algorithms is measured as 1569 milliseconds. The optimal solution is shown in Figure 3.

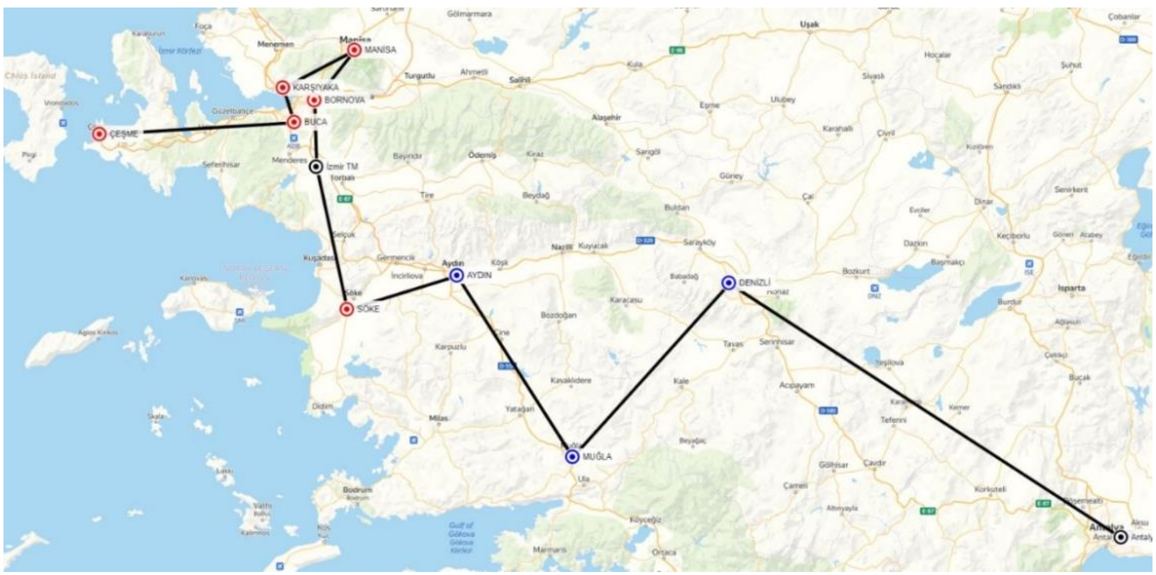

Figure 3: The optimal solution of the real-life example with n=6 branches (red), m=3 branches (blue), and transfer centers (black).

5. CONCLUSION

In this study, the problem of transshipment between transfer centers in logistics structure is discussed. While transferring between two transfer centers, the brute force optimal result was determined by adding the branches to the route and examining all combinations with the counting algorithm for the optimal route result. It is concluded that it is a suitable algorithm for real-life small-sized problems. However, the heuristic algorithm can be proposed to solve large-sized problems in the future.

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REFERENCES

Balinski, M. L., & Quandt, R. E. (1964). On an integer program for a delivery problem. *Operations Researc*h, *12*(2), 300–304. https://doi.org/10.1287/opre.12.2.300

Bellmore, M., & Nemhauser, G. L. (1968). The traveling salesman problem: A survey. *Operations Research*, *16*(3), 538–558. https://doi.org/10.4018/978-1-7998-3970-5.ch006

Boruvka, O. (1926). Borůvka, Otakar: Scholarly works. *The Czech Digital Matematics Library*. 37-58.

Christofides, N., & Eilon, S. (1969). An algorithm for the vehicle-dispatching problem. *Journal of the Operational Research Society*, *20*(3), 309–318.

Clarke, G., & Wright, J. W. (1964). Scheduling of vehicles from a central depot to a number of delivery points. *Operations Research*, *12*(4), 568–581. https://doi.org/10.1287/opre.12.4.568

Croes, G. A. (1958). A method for solving traveling-salesman problems. *Operations Research*, *6*(6), 791-812.

Eilon, S., Watson-Gandy, C. D. T., & Heilbron, A. (1971). A vehicle fleet costs more. *International Journal of Physical Distribution*, *1*(3), 126–132. https://doi.org/10.1108/eb038836

Feremans, C., Labbé, M., & Laporte, G. (2003). Generalized network design problems. *European Journal of Operational Research*, *148*(1), 1–13. https://doi.org/10.1016/S0377-2217(02)00404-6

Gillett, B. E., & Miller, L. R. (1974). A heuristic algorithm for the vehicle-dispatch problem. *Operations Research*, *22*(2), 340–349.

Glover, F. (1986). Future paths for integer programming and links to artificial intelligence. *Computers and Operations Research*, *13*(5), 533–549. https://doi.org/10.1016/0305-0548(86)90048-1

Hart, P. E., Nilsson, N. J., & Raphael, B. (1968). Formal basis for the heuristic determination Eijj. *Systems Science and Cybernetics*, *4*(2), 100–107.

Holland, J. H. (1962). Outline for a logical theory of adaptive systems. *Journal of the ACM (JACM)*, *9*(3), 297–314. https://doi.org/10.1145/321127.321128

Kirkpatrick, S., Gelatt, C. D., & Vecchi, M. P. (1983). Optimization by simulated annealing. *Science*, *220*(4598), 671–680. https://doi.org/10.1007/978-3-642-24974-7_7

Kruskal, J. B., Jr. (1956). On the shortest spanning subtree of a graph and the traveling salesman problem. *American Mathematical Society*, *7*(1), 48–50.

Lin, S., & Kernighan, B. W. (1973). An effective heuristic algorithm for the traveling-salesman problem. *Operations Research*, *21*(2), 498–516. https://doi.org/10.1007/s10489-006-8514-7

Open Routing Service. (n.d.). https://openrouteservice.org/

Prim, R. C. (1957). Shortest connection networks and some generalizations. *Bell System Technical Journal, 36*(6), 1389–1401. https://doi.org/10.1002/j.1538-7305.1957.tb01515.x

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PARCEL LOCKER APPLICATIONS IN TURKEY

TÜRKİYEDE'Kİ KARGO DOLABI UYGULAMALARI

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Kutay Akdoğan[1,*], Eren Özceylan[2]

Abstract

Alternative delivery applications are gaining popularity today, and parcel lockers are differentiated from others as they offer different delivery location options to customers. One of the biggest problems faced by courier companies today is that customers are not always available at the place of delivery during delivery. This leads to an increase in failed deliveries that place an extra burden on last mile operations, not only in terms of cost, but also in terms of environmental concerns. One of the effective methods to deal with this problem is parcel lockers. Parcel lockers and related concepts are currently used in various countries worldwide, and in some countries, their installation and use are supported by the government. Parcel lockers not only help logistics companies navigate their operations and costs, but also give the customer the power of choice. Therefore, it is considered necessary to investigate the parcel locker applications in Turkey. This paper intends to present the current state of parcel lockers in Turkey, the companies providing the service, their profiles, and their plans to provide beneficial knowledge to academia and industry.

Keywords: Automated Parcel Machines, Delivery Locker, Parcel Locker, Smart Locker

Özet

Alternatif teslimat uygulamaları günümüzde popülerlik kazanmakta ve koli dolapları, müşterilere farklı teslimat yeri seçenekleri sunması nedeniyle diğerlerinden ayrılmaktadır. Günümüzde kargo şirketlerinin karşılaştığı en büyük sorunlardan biri, teslimat saatlerinde müşterilerin teslimat yerinde bulunmamasıdır. Bu durum, yalnızca maliyet açısından değil, aynı zamanda çevresel kaygılar açısından da son mil operasyonlarına ekstra bir yük getiren başarısız teslimatlarda artışa yol açmaktadır. Bu sorunla baş etmenin etkili yöntemlerinden biri de koli dolaplarıdır. Koli dolapları ve ilgili konseptler şu anda dünyanın çeşitli ülkelerinde kullanılmaktadır ve bazı ülkelerde bunların kurulumu ve kullanımı hükümet tarafından desteklenmektedir. Koli dolabı kullanımı, lojistik şirketlerinin operasyonlarını ve maliyetlerini yönlendirmesine yardımcı olmakla kalmaz, aynı zamanda müşteriye seçme gücü de verir. Bu nedenle Türkiye'deki koli dolabı uygulamalarının araştırılması gerekli görülmektedir. Bu makale, Türkiye'deki koli dolaplarının mevcut durumunu, hizmet veren firmaları, profillerini ve planlarını sunarak akademi ve endüstriye faydalı bilgiler sağlamayı amaçlamaktadır.

Anahtar Kelimeler: Otomatik Parsel Dolapları, Teslimat Dolabı, Kargo Dolabı, Akıllı Dolap

[1,*] Corresponding Author: Iskenderun Technical University, Maritime Vocational School of Higher Education, Program of Logistics, kutay.akdogan@iste.edu.tr, orcid.org/0000-0002-1517-3559

[2] Gaziantep University, Faculty of Engineering, Department of Industrial Engineering, erenozceylan@gmail.com, orcid.org/0000-0002-5213-6335

1. INTRODUCTION

1.1. E-commerce and Parcel Lockers

Changing world conditions caused e-commerce, which was expected to grow, to grow even faster with the momentum triggered by Covid 19. In 2020, e-commerce retail sales exceeded $4.2 trillion worldwide, and over two billion people made purchases online (Coppola, 2021). When the e-commerce volumes in Turkey are analyzed, it is seen that the e-commerce volume in the first six months of 2021 increased by 75.6% compared to the first half of 2020, reaching 161 billion TL. In the first 6 months of 2021, the number of orders increased by 94.4% from 850.7 million to 1 billion 654 million. While the ratio of e-commerce to traditional commerce was 17.6% on average in the first half of 2021, the highest rate was observed in May (20.2%) see Figure 1 (T.R. Ministry of Commerce, 2021). An e-commerce report prepared for Turkey and published in November 2021 presented the top 5 online stores holding 55% of the market share in total, and these are given as Trendyol, Hepsiburada, LCW, Çiçek Sepeti, Modanisa, respectively. According to the same report, 41 million people shopped online in 2021, and this number is expected to reach 58 million by 2025 (Eden et al., 2021). This shift from traditional commerce to e-commerce brings its own challenges, such as increased individual orders and delivery numbers.

In light of the statistics, it can be indicated that rising online shopping, parcels, and delivery numbers will further complicate last-mile logistic operations. Customers demand fast, reliable, and low-cost delivery; however, last-mile delivery operations remain the most expensive and incompetent part of the logistics journey for goods (Gevaers et al., 2009). Therefore, it can be said that managing vast number of parcels with minimum cost while ensuring quick delivery and service satisfaction is one of the biggest hurdles of last mile distribution caused by expanding e-commerce volumes (Buzzega & Novellani, 2022).

In addition to cost and speed concerns, another aspect to consider is failed deliveries. Repetitive deliveries due to the customer not being at home during delivery hours place an extra strain on operational efficiency. Given the traffic congestion in urban areas, second or third visits to customer addresses will further delay the delivery time and cause dissatisfaction, in addition to causing extra costs and environmental damage. The parcel locker concept which is seen to be recognized by many logistic firms can be an effective solution to last mile delivery problem.

Parcel lockers can be classified under collection points that are located in public areas that are accessible 24/7, keep the parcels for a certain time, and provide flexibility to the customer to collect delivery in a more suitable time with a given order code (Lagorio & Pinto, 2020). These lockers are generally used for parcels nonetheless can also be used for food and drug dispatches with the right equipment such as climate control devices. Lockers, through its nature of being accessible 24/7, diminish the need of synchronizing delivery time between customer and dispatcher and lessen failed delivery rates (Buzzega & Novellani, 2022).

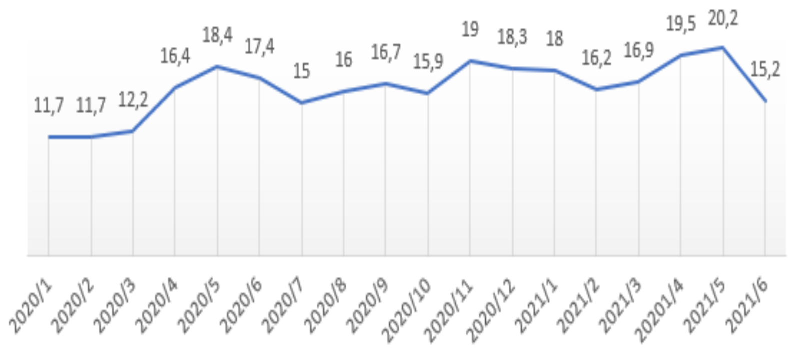

Figure 1: E-commerce to traditional commerce ratios.

1.2. Parcel Lockers Around the World

Currently it is reported that there are 322 parcel shop and locker networks in 69 countries with numbers reaching 1,8 million worldwide (Proud & Chapman, 2021). First parcel locker application (DHL Packstation) was launched in Germany in 2001 by DHL (Behnke, 2019); it is one of the largest locker networks in Europe and has over 8500 locations. DHL plans to expand its network to 12000 in Germany alone by 2023.

Hive Box is China's biggest parcel locker company, founded in 2015, managing up to 170000 parcel locker stations in more than 100 cities and delivering around 9 million parcels everyday (Liu et al., 2021; Morgan, 2021). Hive Box lockers are also supported and promoted by the government and are seen as an active social dinstancing measure against Covid 19 (Morgan, 2021).

Singapore is another country where the use of the parcel locker is supported by the government (Lyu & Teo, 2019). In fact, a nationwide locker delivery network called the Locker Alliance was launced in 2018 with a pilot trial that ended the same year with astonishing results. Since then 4 different locker operators, Blu, Parcel Santa, Pick, and Singapore Post, are providing service around the island under the Locker Alliance with nearly 1400 lockers (Locker Alliance, 2022).

Even though the United States currently have multiple parcel locker operators, parcel lockers were not deployed until 2011. Amazon implemented Amazon Hub Locker service in 2011 and can be seen as a pioneer firm in parcel locker installation, followed by the United States Postal Service (USPS) and UPS (Keeling et al., 2021). Amazon Hub Lockers currently operate in more than 900 cities in strategic locations such as shopping malls, grocery stores, and the like (Fries Holsenbeck, 2018).

Inpost is a Polish company founded in 2006 that manufactures and operates parcel cabinets. It is the first Polish company to establish a locker network in the country (Iwan et al., 2016). Inpost has around 16,000 lockers in Poland alone and provides service, lockers, and even refregirated lockers to 20 different countries around the world including the UK, France, United Arab Emirates to name a few (Iwan et al., 2016; Pruchnicka, 2021).

Australia Post, a government-owned postal service, launched its parcel locker program, 24/7 Parcel Locker in 2012. Initial installation sites were owned by Australia Post, but since then Australia Post has also made some strategic partnerships with chain stores and petrol stations for the locker stations to be installed. There are currently over 1,000 locations in the country, and the network is expanding every year (Lachapelle et al., 2018).

1.3. Methodology

The implementation of the parcel lockers is not a new phenomenon for some countries in the world such as Germany, Poland, and UK. However, it is still in the introduction phase of its life cycle in Turkey. To the best of our knowledge, there is not any paper that investigated the parcel locker applications in Turkey. Therefore, with this study it is aimed to answer two questions:

- What are the benefits, acceptance rates, and location related aspects of the parcel lockers?
- What kind of parcel locker implementations are made in Turkey? Which companies are these, and in which cities is this service being provided?

Secondary data is used to answer these research questions. Secondary data is collected through academic data bases, internet searches, scientific papers, reports and also, logistics provider websites are extensively searched.

2. LITERATURE REVIEW

2.1. Benefits

Parcel lockers offer so many benefits as a solution to last mile delivery problems. It has its advantages to the cities, carriers, and consumers such as regulating traffic jams, reducing flow and failed deliveries, and increasing consolidation and savings (Deutsch & Golany, 2018). Other positive aspects are to reduce the total distance traveled for the customer and the carrier (Song et al., 2009; Song et al., 2012), thus reducing both energy consumption and carbon emissions in line with sustainability needs. Parcel locker practice will be unavoidable in the future and needs to be integrated to the logistics network and can be used to increase profit. Parcel lockers are being addressed as a solution to decrease the energy consumption and utilizing different sized lockers can have an impact on decreasing cost and energy consumption even more (Ji et al., 2019). Compared to stationery locker units, movable locker units require smaller fleet size to cope with the volume (Schwerdfeger & Boysen, 2020). Avoiding traffic jams will be a logical option, as it increases carbon emissions in addition to the costs it generates (Wen & Li, 2016), and carbon emissions caused by last mile operations could be decreased up to 51,2% by using parcel lockers (Jiang et al., 2019).

2.2. Acceptance and Preference

Optimizing the locker network is evidently a strategical task, and it should not be considered separately from customer satisfaction. It should be kept in mind that while reducing cost is important, it depends on customer satisfaction which is influenced from maximum distance that customer is willing to take (Huang & Chen, 2016). It is seen that if customers have fixed delivery method preferences, operational costs and total distance traveled increase; therefore, it would be a clever maneuver to reward customers who are compatible with various delivery methods (Enthoven et al., 2020). One of the pressing factors that leads customers to prefer a locker can be named as convenient location (Guerrero-Lorente et al., 2020).

2.3. Locations

When choosing locker installation sites, high demand points should be considered in order to obtain high efficiency (Guerrero-Lorente et al., 2020). Also, high density urban areas and crowded residential complexes are other good locations to further secure the use of the lockers while bringing a solution to real estate problem for the locker installment (Iyer & Zhang, 2019). Safety and easy accessibility to lockers need to be taken into account for customers who do not use private transportation vehicles to reach the service stations (Lachapelle et al., 2018). According to Wang et al. (2020) movable locker units with few lockers are more suitable for scattered low demand area; and if the locker units have more lockers, fewer units will be necessary for covering demand.

3. PARCEL LOCKER APPLICATIONS IN TURKEY

3.1. Trendyol 7/24 Delivery Lockers

Trendyol, one of the biggest online shopping platforms in Turkey, announced its cargo vending machines in November 2020. The company, which aims to provide both an environmentally friendly solution and a contactless delivery experience for customers, also offered a 20 TL coupon to cabinet users to encourage the use of cabinets (Marketing Türkiye, 2020). Trendyol also uses the delivery locker networks of PTT, Yurtiçi Cargo, and Aras Cargo to serve its customers apart from its own lockers (Trendyol, 2022). In 2021, 500 cargo lockers were offered to customers in 7 provinces, and it is aimed to increase this number to 4 times by the end of 2022 and to provide services in 24 provinces in total (Garip, 2021).

Trendyol's cooperation on this issue was not limited to the listed cargo companies. BP started to serve as a delivery point in the field of e-commerce with its smart cargo cabinet service at various gas stations with heavy pedestrian traffic in cooperation with Trendyol in 2021. The service points have been determined as 40 points in 5 provinces as of August 2021, and this figure is planned to be over 100 in 20 provinces by the end of the year (Lojiport, 2021). Moreover, Apsiyon, a site management software company that currently serves 18,442 sites, (Apsiyon, 2022) announced at the beginning of 2022 that they are collaborating with Trendyol and that lockers will be placed on sites to make life easier for site residents. It is aimed to increase the number of cabinets, which was 5 as of the announcement, to 200 by the end of the year (Para, 2022).

3.2. Easy Point Express

Established by Mall Logistics in 2017, Easy Point aims to support users with delivery points and cargo lockers located at the busiest points of cities. Trendyol, Amazon, Hepsiburada, Morhipo, N11, DHL, Aras are listed as the companies they cooperate with (Easypoint, 2022a). Hepsiburada, which is another of Turkey's largest online shopping platforms, announced its Hepsimat delivery lockers (Easy Point Express) in December 2020 (Marketing Türkiye, 2020). While aiming to spread this service all over Turkey, it first started to serve in 5 locations in İstanbul, namely Beşiktaş, Moda, Kadıköy, Taksim, and Şişhane. Hepsiburada customers can choose one of the Easy Point Express delivery locker locations by using the "Send to Delivery Point" option (Horuz, 2020). In addition to working with many online shopping platforms, easy point express draws attention by offering users the ability to return products using the cabinets, and at the same time, the packages are covered by insurance for possible damage and loss. As of now, Easy Point Express provides service at more than 100 points in Istanbul, Ankara, and Izmir (Easypoint, 2022b).

3.3. PTT Kargomat

The oldest locker application in our country was started by PTT in 2010, and a total of five cabinets, three in Ankara and two in Istanbul, were put into service for customers (PTT, 2010). However, this attempt was not successful, and the cabinets could not be operated efficiently. In 2017, the initiative was successful with the use of cabinets produced in cooperation with Turkish engineers and manufacturers, and the total number of cabinets reached 217 with the introduction of cabinets in İzmir, Bursa, and Antalya. Mass housing, metro stops, universities, student dormitories, shopping malls and squares stand out as the locations chosen for the placement of these lockers (Gökçe, 2021; Milliyet, 2019). In 2021, these numbers increased to 335 in 7 provinces with the cabinets installed in Eskişehir and Kocaeli provinces (Yıldız Ünal, 2021). As of 2022, PTT Kargomat provides service in a total of 9 provinces with one locker installed in Yalova and Hatay provinces and cooperates with companies such as Trendyol and Hepsiburada. An example of PTT Kargomat can be seen in Figure 2.

Figure 2: PTT kargomat (Yeşil, 2018, https://teknoseyir.com/durum/1096105).

3.4. Rovenma RovLocker

Rovenma is a company established in Ankara in 2016 with 100% domestic capital to produce delivery cabinets. It produces lockers used for services offered by companies such as PTT Kargomat, Trendyol 7/24, and Pudo. It is one of the few manufacturers in Turkey and in the world. The company also won two design awards from Turkey and Italy. While the company offers a modular design that can adapt to different places and conditions, it also produces in different sizes and dimensions in line with the demands of the customers. Design, development, hardware and software productions are carried out by the company's own teams. The research and design team carries out its work in Hacettepe Teknokent. With its software that provides ease of use to customers and logistics companies, it can be used with both mobile applications and smart watches. The ability to give commands via Bluetooth and mobile app without a touch screen and to be used offline can be presented as advantageous features of the smart lockers produced. In addition, the company promises a high level of security with its own lock system (Rovenma, 2022). Finally, it should be noted that in 2021, the company stated that they received orders for 5,000 units for the next three years, and they predicted Turkey's need as 10,000 units for the next five years (Gökçe, 2021).

3.5. Pudo PudoBOX

Pudo, established in 2020, is an Istanbul based service company that provides innovative, sustainable, smart package delivery solutions and services supported by technology in order to create added value for the e-commerce business. Pudo is a location-independent, time-flexible smart delivery network model that works with the 'pick-up/ drop off' system. Users can track shipments instantly, list the closest pudoPOINTs, and manage shipment transactions through both Android and iOS compatible mobile applications (pudoAPP). PudoPOINTs are pick-and-drop points located in large residences and key locations in the cities. PudoPOINTs are divided into five categories according to the places where they are installed as pudoPOINT-H (housing complex), pudoPOINT-B (business centers – offices), pudoPOINT-S (shopping centers), pudoPOINT-R (retail), and pudoPOINT-C (University Campuses). Smart lockers are called PudoBOX, and the company continues its operations in 6 provinces, namely Istanbul, Ankara, Izmir, Bursa, Kocaeli, and Antalya, and plans to increase these figures. According to the company, the use of PudoBOX will reduce carbon dioxide emissions by 25%, city traffic by 15%, and logistics costs by 53% and provide significant fuel savings (Pudo, 2022).

3.6. Kargopark

Another smart locker manufacturer in Turkey is Kargopark, and the products have been developed with domestic software and technology. The company is located in Istanbul, Yıldız Technical University Davutpaşa Campus Technology Development Zone. Their first production started with the smart cargo cabinet produced for Borusan in 2015. While the company focused on site needs in 2016, they switched to a business model for the cargo sector in 2019. The company started cooperation with e-commerce companies and cargo companies in 2020 with the effect of the pandemic. Opet can be named as one of these significant cooperations which is announced in 2020 (Erkul Kaya, 2020).

As of 2022, the business’s products provide services at more than 150 points in 9 provinces. The firm offers 4 different product types focusing on different needs: Maxi, Eco, Mini, and Dropbox. While Maxi lockers are modular units produced according to the needs of customers, Eco models are low-energy lockers that operate without being connected to the electricity grid and the internet, using long-life batteries. Mini lockers are also products that work with low energy and have the feature of working with grid or solar energy. Dropboxes, on the other hand, are lockers that allow small businesses to drop off products or customers to return cargo (Kargopark, 2022).

3.7. Yurtiçi Kargo YK Plus 7/24 / Aras Kargo Aras Pratik 7/24

Yurtiçi Kargo launched the smart locker application in 2020. In May 2021, the company reported that there were YK plus 7/24 lockers at 50 different points throughout Turkey. In December 2021, it was announced that the number was close to 200 and that returns could be made with smart cargo lockers (Yurtiçi Kargo, 2021a; Yurtiçi Kargo, 2021b). It is known that

Aras cargo also has smart cargo lockers that can be used 24/7 at various locations (Topçu, 2022).

3.8. SWOT Analysis of Parcel Lockers in Turkey in General

A general SWOT analysis including parcel locker service providers and manufacturers in Turkey was made in the light of the information given in the previous sections and researches. The findings can be examined in Table 1 below.

Table 1: SWOT analysis of parcel lockers in Turkey in general.

Strengths	Weaknesses
The presence of two national companies producing lockers The fact that these companies do their own research and development for both hardware and software Modular production according to customer requirements Reduction in emissions, city traffic, fuel use, and logistics costs The ability of using the delivery lockers for returns	Not having a locker network spread across the country Insufficient promotion of delivery lockers
Opportunities	**Threats**
Increasing trend of e-commerce volume in Turkey Existing collaborations of e-commerce platforms with cargo locker service providers and manufacturers	The fact that this application is at the entry stage in Turkey The possibility that increasing e-commerce volume may generate more demand than the current locker network can handle

4. CONCLUSION

The increasing need for logistics services over the years and environmental and cost-oriented problems make the industry's need for alternative solutions undeniable. Parcel locker applications can meet some of these needs in harmony with the digitalizing world. As a result of this study, although the history of these practices in our country is not very old, it has been seen that both service providers and manufacturers are engaged in important activities. The number of locker networks and points in our country is not as high as in other countries mentioned in this study, but the fact that this practice is relatively new for our country justifies this situation, and it is thought that the numbers will increase in the coming years. The fact that service providers have plans to increase these numbers and their collaborations with different sectors coincide with this idea.

REFERENCES

Apsiyon. (2022). *Apartman, site yönetimi yazılımı*. https://www.apsiyon.com/

Behnke, M. (2019). Recent trends in last mile delivery: Impacts of fast fulfillment, parcel lockers, electric or autonomous vehicles, and more. In C. Bierwirth, T. Kirschstein, and

D. Sackmann (Eds.), *Logistics management. Lecture notes in logistics.* (pp. 141–156). Springer. https://doi.org/10.1007/978-3-030-29821-0_10

Buzzega, G., & Novellani, S. (2022). Last mile deliveries with lockers: Formulations and algorithms. *Soft Computing*, 1–19. https://doi.org/doi.org/10.21203/rs.3.rs-410932/v1

Coppola, D. (2021, October 27). *E-commerce worldwide - statistics and facts*. Statista. https://www.statista.com/topics/871/online-shopping/#dossier-chapter3

Deutsch, Y., & Golany, B. (2018). A parcel locker network as a solution to the logistics last mile problem. *International Journal of Production Research*, *56*(2), 251–261. https://doi.org/10.1080/00207543.2017.1395490

Easypoint. (2022a). *Easypoint*. https://www.easypoint.com.tr/#easyPoint

Easypoint. (2022b). *EasyPoint Express*. https://www.easypoint.com.tr/easy-point-express/

Eden, S., Hoyer, A. L., Niemeier, D., & Peters, L. (2021). *eCommerce in Turkey 2021*. https://www.statista.com/study/70416/ecommerce-in-turkey/

Enthoven, D. L. J. U., Jargalsaikhan, B., Roodbergen, K. J., uit het Broek, M. A. J., & Schrotenboer, A. H. (2020). The two-echelon vehicle routing problem with covering options: City logistics with cargo bikes and parcel lockers. *Computers and Operations Research*, *118*, 104919. https://doi.org/10.1016/j.cor.2020.104919

Erkul Kaya, N. (2020). Opet müşterileri kargolarını istasyonlardan teslim alabilecek. *Anadolu Ajansı*. https://www.aa.com.tr/tr/sirkethaberleri/enerji/opet-musterileri-kargolarini-istasyonlardan-teslim-alabilecek/661577

Fries Holsenbeck, K. (2018, June). *Everything you need to know about Amazon Hub Locker*. Amazon. https://www.amazon.com/primeinsider/tips/amazon-locker-qa.html

Garip, E. (2021). Trendyol Gel-Al nokta sayısı 11 bine ulaştı. *Anadolu Ajansı*. https://www.aa.com.tr/tr/sirkethaberleri/e-ticaret/trendyol-gel-al-nokta-sayisi-11-bine-ulasti/667525

Gevaers, R., Van De Voorde, E., & Vanelslander, T. (2009). Characteristics of innovations in last mile logistics-Using best practices, case studies and making the link with green and sustainable logistics. *European Transport Conference*, 1–21.

Gökçe, H. (2021, June 2). Rovenma Türkiye'nin ilk akıllı kargo otomatını üretti. *Ekonomim*. https://www.dunya.com/sirketler/rovenma-turkiyenin-ilk-akilli-kargo-otomatini-uretti-haberi-623280

Guerrero-Lorente, J., Gabor, A. F., & Ponce-Cueto, E. (2020). Omnichannel logistics network design with integrated customer preference for deliveries and returns. *Computers and Industrial Engineering*, *144*, 106433. https://doi.org/10.1016/j.cie.2020.106433

Horuz, M. E. (2020, December 1). Hepsiburada kargo teslimat dolapları 7 gün 24 saat hizmette. *Anadolu Ajansı*. https://www.aa.com.tr/tr/sirkethaberleri/guncel/hepsiburada-kargo-teslimat-dolaplari-7-gun-24-saat-hizmette/661182

Huang, A., & Chen, T. (2016). Research on express smart locker location considering customer satisfaction under e-commerce environment. *2016 International Seminar on Education Innovation and Economic Management (SEIEM 2016)*.

Iwan, S., Kijewska, K., & Lemke, J. (2016). Analysis of parcel lockers' efficiency as the last mile delivery solution – The results of the research in Poland. *Transportation Research Procedia*, *12*, 644–655. https://doi.org/10.1016/J.TRPRO.2016.02.018

Iyer, P., & Zhang, Y. (2019). Universal locker systems for urban areas. *53rd ORSNZ Annual Conference*. http://orcid.org/0000-0001-5009-455X

Ji, S. F., Luo, R. J., & Peng, X.-S. (2019). A probability guided evolutionary algorithm for multi-objective green express cabinet assignment in urban last-mile logistics. *International Journal of Production Research*, *57*(11), 3382–3404. https://doi.org/10.1080/00207543.2018.1533653

Jiang, L., Chang, H., Zhao, S., Dong, J., & Lu, W. (2019). A travelling salesman problem with carbon emission reduction in the last mile delivery. *IEEE Access*, *7*, 61620–61627. https://doi.org/10.1109/ACCESS.2019.2915634

Kargopark. (2022). *Hakkımızda*. https://kargopark.com/hakkimizda/

Keeling, K., Schaefer, J. S., & Figliozzi, M. (2021). Accessibility and equity analysis of transit facility sites for common carrier parcel lockers. *Transportation Research Record*, *2675*(12), 1075–1087. https://doi.org/https://doi.org/10.1177/03611981211032214

Lachapelle, U., Burke, M., Brotherton, A., & Leung, A. (2018). Parcel locker systems in a car dominant city: Location, characterisation and potential impacts on city planning and consumer travel access. *Journal of Transport Geography*, *71*, 1–14. https://doi.org/10.1016/j.jtrangeo.2018.06.022

Lagorio, A., & Pinto, R. (2020, April 22). The parcel locker location issues: an overview of factors affecting their location. *8 Th International Conference on Information Systems, Logistics and Supply Chain ILS Conference, April 22-24, Austin, USA*. https://www.researchgate.net/publication/350726102

Liu, S., Liu, Y., Zhang, R., Cao, Y., Li, M., Zikirya, B., & Zhou, C. (2021). Heterogeneity of spatial distribution and factors influencing unattended locker points in Guangzhou, China: The case of hive box. *ISPRS International Journal of Geo-Information*, *10*(6). https://doi.org/10.3390/IJGI10060409

Locker Alliance. (2022). *Locker Alliance brings together parcel locker operators to improve the efficiency of last mile parcel delivery operations*. https://www.lockeralliance.net/

Lojiport. (2021). *BP ve Trendyol Express'ten akıllı kargo otomatı ağı*. https://www.lojiport.com/bp-ve-trendyol-expressten-akilli-kargo-otomati-agi-111166h.htm

Lyu, G., & Teo, C.-P. (2019). Last mile innovation: The case of the locker alliance network. *SSRN Electronic Journal*, *3471166*. https://doi.org/10.2139/ssrn.3471166

Marketing Türkiye. (2020, December 1). *Kargoyu artık otomatlardan teslim alacağız!* https://www.marketingturkiye.com.tr/haberler/kargoyu-artik-otomatlardan-teslim-alacagiz/

Milliyet. (2019). *PTT'den 217 noktada akıllı cihazla kargo teslimi*. https://www.milliyet.com.tr/ekonomi/pttden-217-noktada-akilli-cihazla-kargo-teslimi-6018578

Morgan, E. (2021, March). *Hivebox case study: How lockers became essential to Chinese ecommerce*. https://www.doddle.com/us/blog/hivebox-case-study-how-lockers-became-essential-to-chinese-ecommerce/

Para. (2022). *Apsiyon ve Trendyol'dan kargo otomatı çözümü*. https://www.paradergi.com.tr/is-dunyasi-kulis/2022/01/27/apsiyon-ve-trendyoldan-kargo-otomati-cozumu

Proud, F., & Chapman, P. (2021). *Global parcel shops and locker networks: Market insight report 2021. Apex Insight Ltd.* https://apex-insight.com/product/global-parcel-shops-and-locker-networks-market-insight-report/

Pruchnicka, A. (2021, December). *InPost increases number of automated parcel machines in Poland by 50% in 2021*. Reuters. https://www.reuters.com/markets/europe/inpost-increases-number-automated-parcel-machines-poland-by-50-2021-2021-12-21/

PTT. (2010). *Kargomatik*. https://web.archive.org/web/20120111205312/http://www1.ptt.gov.tr/tr/genel/kargomatik2010.php

Pudo. (2022). *Pudo Point*. https://pudo.com.tr/pudopoint/

Rovenma. (2022). *Rovlocker Brochure*. https://www.rovenma.com/content/uploads/Rovlocker-Brochure-1-1.pdf

Schwerdfeger, S., & Boysen, N. (2020). Optimizing the changing locations of mobile parcel lockers in last-mile distribution. *European Journal of Operational Research*, *285*(3), 1077–1094. https://doi.org/10.1016/j.ejor.2020.02.033

Song, L., Cherrett, T., Guan, W., & Zhang, W. (2012). Alternative solution for addressing failed home deliveries. *Transportation Research Record*, *2269*, 83–91. https://doi.org/10.3141/2269-10

Song, L., Cherrett, T., McLeod, F., & Guan, W. (2009). Addressing the last mile problem: Transport impacts of collection and delivery points. *Transportation Research Record*, *2097*, 9–18. https://doi.org/10.3141/2097-02

Topçu, F. E. (2022). Aras Burası ile esnek hizmet ve 7/24 teslimat kolaylığı. *Anadolu Ajansı*. https://www.aa.com.tr/tr/sirkethaberleri/ulastirma/aras-burasi-ile-esnek-hizmet-ve-7-24-teslimat-kolayligi-/673551

T.R. Ministry of Commerce. (2021). *Electronic commerce department data for the first 6 months of 2021*. https://www.eticaret.gov.tr/dnnqthgzvawtdxraybsaacxtymawm/content/FileManager/Dosyalar/E-TI%CC%87CARET%20B%C3%9CLTEN%C4%B0%202021%20%C4%B0lk%206%20ay.pdf

Trendyol. (2022). *Gel al noktası*. https://www.trendyol.com/s/gel-al-noktasi

Wang, Y., Bi, M., Lai, J., & Chen, Y. (2020). Locating movable parcel lockers under stochastic demands. *Symmetry*, *12*(12), 2033. https://doi.org/10.3390/sym12122033

Wen, J., & Li, Y. (2016). Vehicle routing optimization of urban distribution with self-pick-up lockers. *In 2016 International Conference on Logistics, Informatics and Service Sciences (LISS)*, 1–6. https://doi.org/10.1109/liss.2016.7854384

Yıldız Ünal, A. (2021). PTT'nin akıllı cihazla kargo teslimi uygulaması yurt geneline yaygınlaştırılıyor. *Anadolu Ajansı*. https://www.aa.com.tr/tr/sirkethaberleri/hizmet/pttnin-akilli-cihazla-kargo-teslimi-uygulamasi-yurt-geneline-yayginlastiriliyor/662776

Yurtiçi Kargo. (2021a). *Kargo dolaplarına kullanıcıdan tam not*. https://www.yurticikargo.com/kargo-dolaplarina-kullanicidan-tam-not

Yurtiçi Kargo. (2021b). *Yurtiçi Kargo 7/24 iade dönemini başlattı*. https://www.yurticikargo.com/yurtici-kargo-7-24-iade-donemini-baslatti

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POSSIBILITIES AND LIMITS OF DIGITALIZATION TO INCREASE SUPPLY CHAIN RESILIENCE

TEDARİK ZİNCİRİ DİRENCİLİĞİNİ ARTIRMAK İÇİN DİJİTALLEŞME OLASILIKLARI VE SINIRLARI

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Marc-André Weber[1,*], Ulrike Aumüller[2], Peter Franke[3]

Abstract

In case any unexpected circumstances occur, a supply chain may be heavily influenced with a wide range of negative con-sequences such as inability to deliver or large delays in delivery. Therefore, it is important for every supply chain and the companies that are involved in them to reduce these negative outcomes. In this context, the term Supply Chain Resilience (SCR) stands for the level of adaptability of a supply chain to respond to and recover from disruptions. A high SCR is given if re-maintaining operational continuity is quickly possible. As an example of unexpected disruptions, the COVID-19-crisis showed major impacts on the functionality of global supply chains. The upcoming technologies of industrial Digitalization, mainly known as Industry 4.0, provide opportunities to increase SCR. In this paper, first a brief overview of different surveys is given to show the COVID-19-impact on global supply chains and therefore prove the need to generally increase SCR. Sec-ond, an insight of how especially Digitalization may help to increase SCR is provided. Especially improving the database for all supply chain partners, faster and more precise decision-making processes, including the use of Artificial Intelligence, are described. Finally, positive chances and major challenges of using Digitalization to increase SCR are addressed.

Keywords: COVID-19, Digitalization, Industry 4.0, Resilience, Supply Chain Management

Özet

Beklenmeyen herhangi bir durumun meydana gelmesi durumunda, bir tedarik zinciri, teslim edilememe veya teslimatta büyük gecikmeler gibi çok çeşitli olumsuz sonuçlarla büyük ölçüde etkilenebilir. Bu nedenle, her tedarik zinciri ve bunlara dahil olan şirketler için bu olumsuz sonuçların azaltılması önemlidir. Bu bağlamda, Tedarik Zinciri Esnekliği (SCR) terimi, bir tedarik zincirinin kesintilere yanıt verme ve kesintilerden kurtulma konusundaki uyarlanabilirlik düzeyini ifade eder. Operasyonel sürekliliğin sürdürülmesi hızlı bir şekilde mümkünse, yüksek bir SCR verilir. Beklenmedik kesintilere bir örnek olarak, COVID-19 krizi, küresel tedarik zincirlerinin işlevselliği üzerinde büyük etkiler gösterdi. Temelde Endüstri 4.0 olarak bilinen endüstriyel Dijitalleşmenin yaklaşan teknolojileri, SCR'yi artırmak için fırsatlar sunuyor. Bu yazıda, öncelikle küresel tedarik zincirleri üzerindeki COVID-19 etkisini göstermek ve bu nedenle genel olarak SCR'yi artırma ihtiyacını kanıtlamak için farklı anketlere kısa bir genel bakış verilmektedir. İkinci olarak, özellikle Dijitalleşmenin SCR'yi artırmaya nasıl yardımcı olabileceğine dair bir fikir verilmektedir. Özellikle tüm tedarik zinciri ortakları için veri tabanının iyileştirilmesi, Yapay Zeka kullanımı da dahil olmak üzere daha hızlı ve daha kesin karar verme süreçleri anlatılmaktadır. Son olarak, SCR'yi artırmak için Dijitalleşmeyi kullanmanın olumlu şansları ve başlıca zorlukları ele alınmaktadır.

Anahtar Kelimeler: COVID-19, Dijitalleşme, Endüstri 4.0, Dayanıklılık, Tedarik Zinciri Yönetimi

[1,*] Corresponding Author: Kiel University of Applied Sciences, marc-andre.weber@fh-kiel.de, orcid-org/0000-0001-8385-5685
[2] Kiel University of Applied Sciences, ulrike.aumueller@fh-kiel.de, orcid-org/0000-0003-1209-2187
[3] Kiel University of Applied Sciences, peter.franke@fh-kiel.de, orcid-org/0000-0002-6206-9754

1. INTRODUCTION

The recent COVID-19-crisis proved that unexpected events may cause heavy negative influences on global supply chains. As the beginning of the crisis was only less than three years ago and it is still continuing, a full scientific exploration is not given. However, several surveys prove that the effects on supply chains were globally recognized among all industries, and the "classic" risk management systems have not been able to overcome the obstacles. For example, several surveys from EulerHermes, Capgemini, McKinsey, and others show that more than 50% of the companies examined have been negatively affected by COVID-19 (Capgemini, 2021; McKinsey, 2020; Semmann, 2020; Sherman, 2020; VDMA, 2020).

Therefore, an improvement of the resilience of supply chains is inevitable. This paper addresses this problem and provides selected solutions to the problem based on the use of digitalization.

2. RESILIENCE IN SUPPLY CHAIN MANAGEMENT

The term 'resilience' generally stands for the ability of a system to recover from any disruption (Figure 1). Especially, if it is related to supply chains, the term 'supply chain resilience' (SCR) stands firstly for the ability of a supply chain to prepare for an unexpected event in advance (ideally avert the disruption), secondly for responding to it quickly once it occurs, and thirdly for a fast recovery from the disruption, back to the desired level of service (Belhadi et al., 2021; Black, 2020).

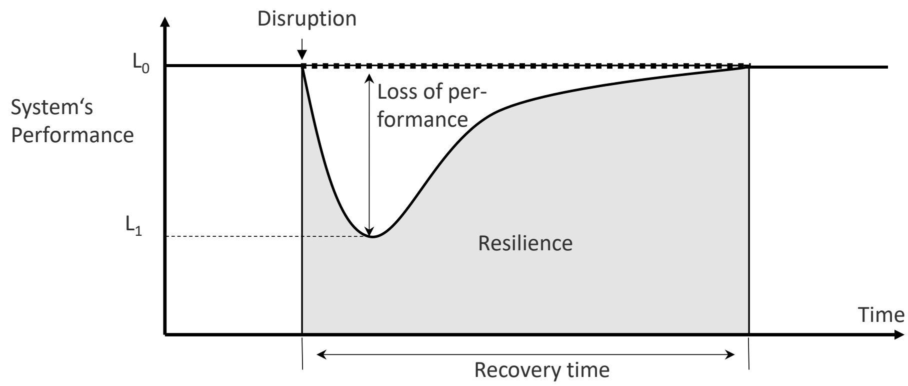

Figure 1: Resilience as a function of recovery time for a system's performance (Belhadi et al. 2021).

Dealing with SCR is generally a part of a company's risk management. Recent research on risk management for supply chains has heavily focused on operational risks (such as currency fluctuations etc.) with mostly short-term impacts. However, dealing with unexpected, disruptive changes that may cause long-term implications on a company's business, especially on a global basis concerning all industries, has not been in scope of the research so far (Black and Glaser-Segura, 2020; Shen and Sun, 2021). Therefore, it is necessary to provide scientifically-based assistance for practitioners in preparing for future disruptions comparable to the COVID-19-crises.

3. DIGITALIZATION'S CONTRIBUTION TO SUPPLY CHAIN RESILIENCE

Several options are given to improve SCR. Generally speaking, first of all the top-management of a company should fulfill its leadership and management role in a proactive, risk-anticipating form. If this is given, a best-as-possible planning for any critical case may take place in form of an identification of potential operational and non-operational risks and the development of basic solutions that establish robust processes (Figure 2). Digital process support within a single company and within a supply chain by using suitable technologies is one of the key aspects, also referred to as Digitalization (or Industry 4.0) (Black and Glaser-Segura, 2020).

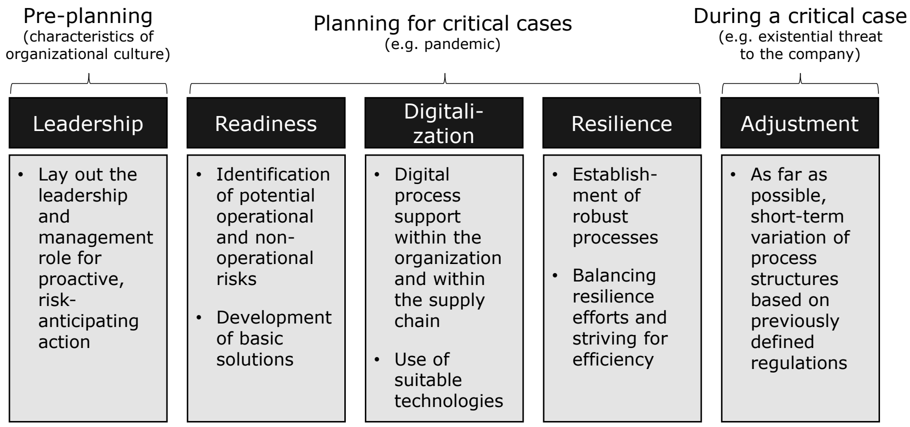

Figure 2: Stages of overcoming disruptive, negative effects (Black and Glaser-Segura, 2020).

The use of Digitalization includes in a first step measurement technologies for binary status descriptions of processes. Afterwards, in most cases, any technology such as networking transmitters and receivers is used for transferring the data from the point-of-recording to the point-of-processing. The latter is done by automated data processing and information gathering, such as Big Data Analytics. Additionally, the data can optionally be displayed to human workers involved in the processes via digital media. Finally, the processed data is deployed for previously defined tasks and objectives, mostly within a framework of control loops (Weber, 2021). As Digitalization includes a wide range of technologies and approaches, we refer to those that promise to increase SCR in a best-suitable way, based on our literature review.

3.1. Improvement of Supply Chain Overview

If data is available from all partners in a supply chain, and if it is processed simultaneously and shared, the overview of the status-quo within the supply chain is improved. Real-time data transmission of physical activities of all partners in the supply chain allows for calculating different key performance indicators, showing for example current inventory levels, production rates or transports. This mainly allows for establishing alarm-systems if the measured as-is data is compared to pre-defined goals (Das et al., 2021; Deloitte, 2020; Karger and Seewald, n.d.). Having a clearly defined description of the current status of the supply chain is the basis for the second step as described in the next chapter.

3.2. Ease of Scenario Calculation and Decision Making

Any decisions made in supply chains should be based on accurate calculations. Digitalization helps in those calculations by using Big Data Analytics and simulation models based on statistical foundations. First of all, the current status-quo needs to be adequately described based on historical and actual data as described in the previous section. This offers the possibility for ratings based on indicators in the second step. Afterwards, scenarios can be calculated based on assumptions about future development possibilities and their probabilities. Finally, all calculated scenarios are the basis for finding an "optimal" solution, based on the most likely scenario. This serves as the basis for actual decisions (Figure 3) (Belhadi et al., 2021; Ivanov and Das, 2020; Miceli et al., 2021).

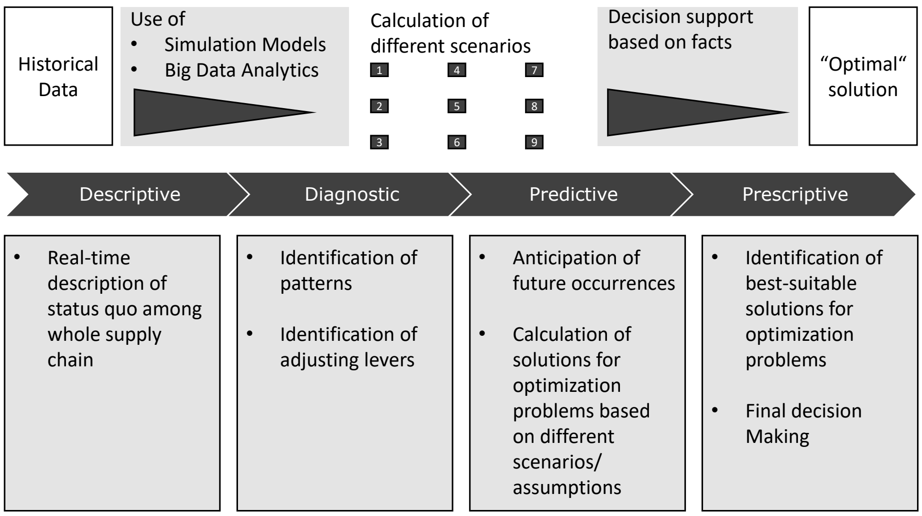

Figure 3: From the status-quo to an "optimal" decision finding.

As all of those calculations need a good database, it might be necessary to improve the given database as described in the next chapter.

3.3. Improvement of Database and Support for Strategic Decision Making

There are two promising technologies within the broad field of Digitalization that can improve the database for decision finding processed. First to mention is the use of Blockchain, which is a technology for decentralized and highly secured data storage with accessibility to all partners within a supply chain. It also allows for data quality verification. Secondly, Artificial Intelligence allows for data completion in case of missing information, and also for a certain simplification of complex decision findings. It can help in anticipating future happenings, in compensating given information asymmetries as well as establishing early warning systems. (Black and Glaser-Segura, 2020; Das et al., 2021; Deloitte, 2020; Hobbs, 2021; Miceli et al., 2021; Shen and Sun, 2021; Tasnim, 2020).

By using these two technologies jointly, fast, transparent, and straight decision finding processes can be established. Furthermore, this allows for supporting strategic decision-making processes, as changes within the supply chain or on markets can be anticipated in a much better way. Especially AI allows for a "view into a distant future" in a much better sense than common technologies.

4. CHANCES AND RISKS

There are several chances as well as risks if Digitalization is used to improve SCR. Regarding the chances and positive effects, a gain of transparency by the use of real-time data as well as faster and more accurate communication along supply chain stages are given. More detailed forecasts can be made, which leads to a reduction of bullwhip and ripple effects. Additionally, a reduction of operational transaction costs based on more efficient use of resources can be a positive outcome. Generally speaking, faster and more precise actions in alignment with supply chain partners are possible.

Regarding the risks and challenges, a harmonization of IT-systems (e.g., the integration of different IT-systems in use) is not easy. Especially, it may result in a challenge to integrate non-long-term partners and/or smaller partners without sufficient digitalized processes. Additionally, the availability of powerful IT resources, especially in remote areas, during transportation etc., is often not given. And, obviously, more cyber-attacks are likely to occur in case more Digitalization is used.

Generally speaking, all Digitalization approaches are not applicable in a short time-span. In some cases, legal frameworks need to be fully adapted to allow the use of Digitalization. Furthermore, Artificial Intelligence and Blockchain themselves are evolving technologies and therefore are currently not usable in a way they ideally should be. Finally, it can be stated that Digitalization may itself cause effects which negatively influence SCR, e.g., if data connections are interrupted, power failures occur, or data exchanges fail (Black and Glaser-Segura, 2020; Deloitte, 2020; Heß and Kleinlein, 2021; Miceli et al., 2021; Nandi et al., 2020; Nandi et al., 2021; Riecke, 2020).

5. CONCLUSION

As stated in this paper, COVID-19 caused major problems in global supply chains, showing that there is a general need for improving supply chain resilience (SCR). Digitalization can be used as one tool to improve it. Real-time data about the current status-quo within a supply chain that is shared among the supply chain partners serves as a basis for all digitalization applications. This can be the basis for decision finding calculations, which are mostly based on scenario calculations. Furthermore, Artificial Intelligence and Blockchain are promising technologies to increase SCR. However, future research is required on SCR strategies for long-term, disruptive, and global changes as well as on digitalization technologies in general.

REFERENCES

Belhadi, A., Kamble, S., Jabbour, C.J.C., Gunasekaran, A., Ndubisi, N.O., & Venkatesh, M. (2021). Manufacturing and service supply chain resilience to the COVID-19 outbreak: Lessons learned from the automobile and airline industries. *Technological Forecasting and Social Change*, *163*, 120447. https://doi.org/10.1016/j.techfore.2020.120447

Black, S., & Glaser-Segura, D. (2020). Supply chain resilience in a pandemic: The need for revised contingency planning. *Management Dynamics in the Knowledge Economy, 8*(4), 325-343. https://doi.org/10.2478/mdke-2020-0021

Capgemini. (2021). *The wake-up call: Building supply chain resilience in consumer products and retail for a post-COVID world*. https://www.capgemini.com/de-de/wp-content/uploads/sites/5/2021/03/Supply-Chain-in-CPR_2021-03-10_Web.pdf

Das, D., Datta, A., Kumar, P., Kazancoglu, Y., & Ram, M. (2021). Building supply chain resilience in the era of COVID-19: An AHP-DEMATEL approach. *Operations Management Research*, 1–19. https://doi.org/10.1007/s12063-021-00200-4

Das, D., Datta, A., Kumar, P., Kazancoglu, Y., & Ram, M. (2022). Building supply chain resilience in the era of COVID-19: An AHP-DEMATEL approach. *Operations Management Research*, *15*(1–2), 249–267. https://doi.org/10.1007/s12063-021-00200-4

Deloitte. (2020). *Building Supply Chain Resilience beyond COVID-19*. file:///C:/Users/marc-/Desktop/deloitte-ch-study-building-supply-chain-resilience-covid-19-2020.pdf

Heß, G., & Kleinlein, A.C. (2021). *Resilienz im Einkauf - Konzept und Praxisleitfaden zum Management unerwarteter Risiken in der Lieferkette*. SpringerGabler.

Hobbs, J.E. (2021). Food supply chain resilience and the COVID-19 pandemic: What have we learned?. *Canadian Journal of Agricultural Economics*, *69*, 189-196. https://doi.org/10.1111/cjag.12279

Ivanov, D., & Das, A. (2020). Coronavirus (COVID-19/SARS-CoV-2) and supply chain resilience: a research note, *International Journal on Integrated Supply Management, 13*(1), 90-102. https://dx.doi.org/10.1504/IJISM.2020.107780

Karger, T., & Seewald, D. (n.d.). *Aufbau einer Supply Chain nach COVID-19*. https://www.efficioconsulting.com/de/publikationen/insights/aufbau-einer-supply-chain-nach-covid-19/

McKinsey. (2020). *Resetting supply chains for the next normal*. https://www.mckinsey.com/business-functions/operations/our-insights/resetting-supply-chains-for-the-next-normal

Miceli, A., Hagen, B., Riccardi, M.P., Sotti, F., & Settembre-Blundo, D. (2021). Thriving, not just surviving in changing times: How sustainability, agility and digitalization intertwine with organizational resilience. *Sustainability*, *13*, 2052. https://doi.org/10.3390/su13042052

Nandi, S., Sarkis, J., Hervani, A., & Helms, M. (2020). Do blockchain and circular economy practices improve post COVID-19 supply chains? A resource-based and resource dependence perspective. *Industrial Management and Data Systems, 121*(2), 333-363. https://doi.org/10.1108/IMDS-09-2020-0560

Nandi, S., Sarkis, J., Hervani, A., & Helms, M. (2021). Redesigning supply chains using blockchain-enabled circular economy and COVID-19 experiences. *Sustainable Production and Consumption*, *27*, 10-22. https://doi.org/10.1016/j.spc.2020.10.019

Riecke, T. (2021, August 16). Trotz dramatischer Engpässe: Deutsche Firmen halten an Ihren Lieferketten fest. *Handelsblatt*. https://www.handelsblatt.com/meinung/kolumnen/globale-trends/globale-trends-trotz-dramatischer-engpaesse-deutsche-firmen-halten-an-ihren-lieferketten-fest/27519328.html?ticket=ST-4715831-9kCEhYf0r6oekygYrYne-cas01.example.org

Semmann, C. (2020, December 16). Lieferketten nach Corona: Was Unternehmen planen. *Deutsche Verkehrszeitung*. https://www.dvz.de/dossiers/zukunft-der-lieferketten/detail/news/lieferketten-auf-dem-pruefstand-1.html

Shen, Z.M., & Sun, Y. (2021). Strengthening supply chain resilience during COVID-19: A case study of JD.com. *Journal of Operations Management*. https://doi.org/10.1002/joom.1161

Sherman, E. (2020). *94% of the Fortune 1000 are seeing coronavirus supply chain disruptions: Report.* https://fortune.com/2020/02/21/fortune-1000-coronavirus-china-supply-chain-impact/

Tasnim, Z. (2020). Disruption in global food supply chain (FSCs) due to Covid-19 pandemic and impact of digitalization through block chain technology in FSCs management. *European Journal of Business and Management, 12*(17), 73-84. https://doi.org/10.7176/EJBM/12-17-08

VDMA, IfW. (2020). *Lieferketten in der Zeit nach Corona. Kurzgutachten im Auftrag der IMPULS Stiftung für den Maschinenbau, den Anlagenbau und die Informationstechnik*. https://www.ifw-kiel.de/fileadmin/Dateiverwaltung/IfW-Publications/-ifw/Policy_Papers/2021/Lieferketten_in_der_Zeit_nach_Corona_Endbericht.pdf.

Weber, M.A. (2021). *Nutzung der Digitalisierung zur Produktivitätsverbesserung in industriellen Prozessen unter Berücksichtigung arbeitswissenschaftlicher Anforderungen*. Springer.

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THE EFFECT OF USING NEARSHORING STRATEGY ON CO_2 EMISSIONS FOR SUSTAINABILITY IN GLOBAL TEXTILE SUPPLY LOGISTICS

KÜRESEL TEKSTİL TEDARİK LOJİSTİĞİNDE SÜRDÜRÜLEBİLİRLİK İÇİN YAKIN TEDARİKÇİ (NEARSHORING) STRATEJİSİNİN KULLANIMININ CO_2 EMİSYON ÜZERİNE ETKİSİ

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D. Özgün Sarıoğlu[1,*]

Abstract

The new world order, in which company interests do not conflict with social interests, and social and environmental issues become the responsibility of companies, has revealed the concept of sustainability. In this context, according to the statements of the European Parliament, sustainability is also important for the textile sector, which is one of the most environmentally harmful sectors according to the amount of production and waste. On the other hand, the textile industry has a complex supply chain in which many distant chain members try to act together under globalization and cost constraints. This situation makes the sustainability studies of the textile sector difficult. However, businesses that create a sustainable supply chain structure and continuously improve this structure are expected to create a competitive advantage. In this study, the nearshore supplier strategy is adopted to improve environmental sustainability. Therefore, old inbound transpostation has been calculated to understand the reduction of CO_2 emissions. The calculation methods used are placed in EN 16258. With nearshoring, the textile company selected suppliers from nearby region. These suppliers, called FM, have reached 30% of total fabric suppliers in the last two years. The reduction of CO_2 emissons rate for inbound transportation became 669 t CO_2e at the end of 2022. The total emission reduction during the next 10-year period is 20,122 tons CO_2e for transportation. It is obvious that this research will be a sustainability study that will create value in terms of the inbound supply process.

Keywords: Calculation of CO_2 Emissions, CO_2 Emissions Based on Transport, Nearshoring, Sustainabile Textile Supply Chain

Özet

Şirket çıkarlarının toplumsal çıkarlarla çatışmadığı, toplumsal ve çevresel konuların şirketlerin sorumluluğu haline geldiği yeni dünya düzeni sürdürülebilirlik kavramını ortaya çıkarmıştır. Bu bağlamda Avrupa Parlamentosu'nun açıklamalarına göre üretim ve atık miktarı göz önünde bulundurulduğunda çevreye en zararlı sektörlerden biri olan tekstil sektörü için de bu kavram oldukça önemlidir. Öte yandan tekstil sektörü, küreselleşme ve maliyet kısıtlamaları altında birbirinden uzak konumdaki birçok zincir üyesinin birlikte hareket etmeye çalıştığı karmaşık bir tedarik zincirine sahiptir. Bu durum tekstil sektörünün sürdürülebilirlik çalışmalarını zorlaştırmaktadır. Ancak sürdürülebilir bir tedarik zinciri yapısı oluşturan ve bu yapıyı sürekli iyileştiren işletmelerin rekabet avantajı yaratması beklenmektedir. Bu çalışmada, çevresel sürdürülebilirliği iyileştirmek için yakın tedarikçi (Near Shore) stratejisi benimsenmiştir. Bu nedenle, nearshoring ile CO_2 emisyonlarının taşıma alanındaki azalma miktarını anlamak için, geçmiş ve planlanan tedarik taşımalarının emisyonları hesaplanmıştır. Tekstil şirketi tedarikçilerinin %30'unu FM (Full Merchandised) adı verdikleri yakın bölge tedarikçilerinden seçerek, taşımadan kaynaklı CO_2 emisyonlarındaki azalış ile, iki yılda 669 t CO_2e azalma sağladığı ortaya konulmuştur. Önümüzdeki 10 yıllık dönemde toplam emisyon azaltımı, nakliye için 20,122 ton CO_2e'dir. Bu araştırmanın tedarik taşımaları süreci açısından değer yaratacak bir sürdürülebilirlik çalışması olacağı açıktır.

Anahtar Kelimeler: CO_2 Emisyonu Hesaplama, Ulaştırma Kaynaklı CO_2 Emisyonu, Nearshoring, Sürdürülebilir Tekstil Tedarik Zinciri

[1,*] Corresponding Author: Adnan Menderes University, Köşk Vocational School, ozgun.sarioglu@adu.edu.tr, orcid.org/0000-0002-6575-6277

1. INTRODUCTION

The fashion industry continues to brutally destroy natural resources. For this reason, calls for sustainability are heard in the European Union and in the world. Various non-governmental organizations apply sustainability measurements and standards that will force textile businesses in this regard. Especially corporate textile companies strive to comply with these standards in order to lead the sector. These textile companies publish their sustainability reports every year, reflecting their transparency to the public. However, studies on this subject in the world are somewhat scattered. Due to the different standards used by businesses, it is difficult to measure sustainability by comparing them. Based on this, businesses have been creating their sustainability reports according to GRI standards since 2016 (Saygılı et al., 2019). Thus, they not only make their own analyses more accurately, but also allow the public and non-governmental organizations to make an understandable assessment.

GRI helps businesses all around the world to understand and communicate their impact on critical sustainability issues such as climate change, human rights, governance, and social welfare. The GRI Sustainability Reporting Standards are developed with multi-stakeholder contributions and are based on the public interest.

In addition, industry-specific performance indicators are also included in the GRI standards. These standards are also guiding for textile companies engaged in sustainability studies. Sustainability has a wide scope from valuing people to production that is harmless to nature. There are different headings in the GRI report covering all areas. This study is under the title of environmental sustainability. Textile enterprises give importance to water consumption, CO_2 emission, use of toxic chemicals, pesticides, and fertilizer control in the environmental sustainability topic. In this study, the nearshoring application of an international textile company, which pioneered the textile industry and adopted GRI standards, was evaluated. The enterprise is located in the "İzmir Free Zone." With the Nearshoring application, the aim is to reduce the CO_2 emissions in the raw material supply process. So, this study includes calculating CO_2 emissions from supply transportation. When the literature is considered, there can be found several studies. In 2012, Klein and his friends calculated the carbon dioxide emissions of Cargill. Based on the results, several carbon dioxide reduction possibilities and European Union regulation scenarios have been evaluated by them. Mock (2016) studied to reduce road-sourced CO_2 emissions in Turkey. Binh and Tuan (2016) presented that nearly 100 tons of CO_2 were emitted from freight movement in the rice industry in 2011, approximately 0.8% of total CO_2 emission borne by freight transport sector of Vietnam with their study. Mubarak and Zainal (2018) developed a CO_2 emissions framework by considering the actual conditions of the region and by calculating the level of emissions with a case study of Indonesia. Xinguang et al. (2022) determined according to the transportation mode and energy type, and the carbon emission factor of each energy source is also determined according to the local energy structure.

As it can be understood from the studies, freight shipments causes high CO_2 emissions. And ıt is also known that heavy truck transportation is increasing throughout the world as a result of globalization and shifting patterns of production and consumption. It is estimated that the global heavy-duty truck that generates a disproportionate share of GHGs fleet will increase by a factor of 2.6 to 64 million by 2050 (Mulholland et al., 2018). 23% of the transport sector is carried out by the trucks (USEPA, 2018). Therefore, a major target is designing nearshoring transportation for the heavy trucks (Giuliano et al., 2021).

In this study, the textile company, which makes nearshoring application by reducing the fabric goods supplied from the Far East, is the subject. A CO_2e emission calculation has been made for the company that wants to estimate the decrease in CO_2 emission level and add it to the 2023 sustainability report prepared in accordance with GRI standards. CO_2 equivalent calculation was made by adhering to the formulas specified in EN 16258 standards.

2. METHODS AND STUDY

The aim of this study is to make a measurable and standards-compliant CO_2e calculation by applying nearshore under the title of Environmental Sustainability study. For this purpose, four steps have been offered, and each step has been defined in Figure 1.

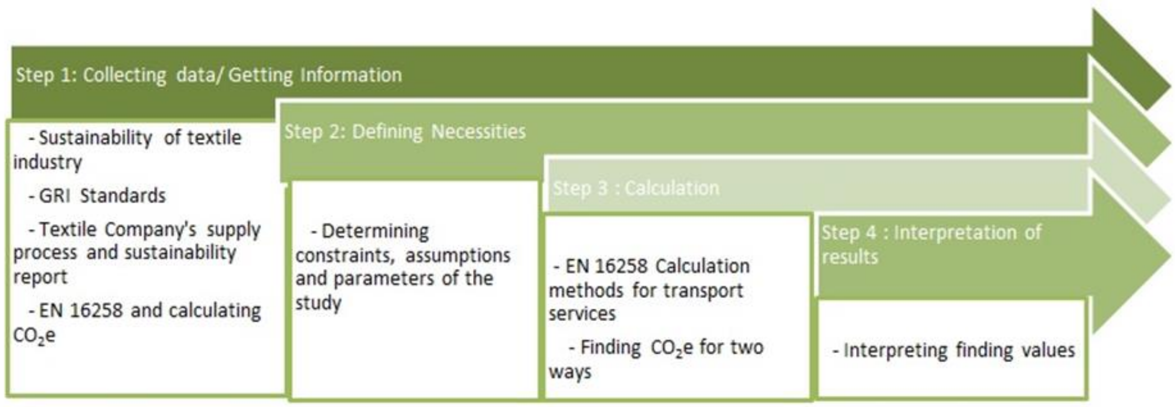

Figure 1: Study steps.

2.1. Collecting Data/Getting Information

A green supply chain is defined as the operational management method and optimization approach to reduce the environmental impact along the life cycle of the green product, from the raw material to the end product.

Fig. 2 illustrates the green supply chain procedure. The green supply chain stimulates chain members to use less harmful and sustainable materials. In producing process, green studies can be applied for decreasing the energy usage or reusing the energy. The logistics has an impressive impact in green supply chain, as it emits significant CO_2 emissions. So, logistics management should be detailed systematically to prevent redundant processes of materials. Also, if the supply chain includes more than one stakeholder, emissions can be reduced (Manavalan et al., 2021). The reverse logistics will help to recover the used products. But it is clear with the Paris climate conferences that the green supply chain cannot be applied sufficiently today. Various factors have been listed as the reason for this in academic studies. Complexity of green process and system design was found to be the most elementary barrier, having the maximum driving power. Lack of consumer support and encouragement, lack of guidance and support from regulatory authorities, and high implementation and maintenance cost are the other elementary barriers of green textile supply chain.

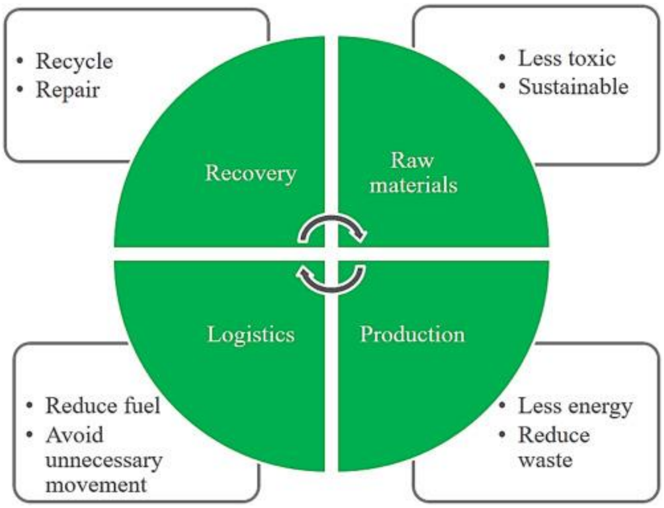

Figure 2: Green supply chain procedures (Manavalan et al., 2021).

As can be seen, there are problems in the wide scope and application of the green supply chain. The subject of this study is to reduce CO_2 emissions by reducing fuel consumption in the product supply process. So, "nearshoring," which can be defined as a geographical relocation of business functions and processes in surrounding or nearby countries, is an optimistic way to solve CO_2 emissions problem caused by transportation (Müller, 2016). Nearshoring strategy is chosen on the basis of the total costs as well as production and personnel costs. In addition, the delivery time and, nowadays, the importance of reducing CO_2 emissions play a basic role for the choice of this strategy.

The Global Reporting Initiative (GRI) is also known as a non-profit organisation that designs well known standards nowadays for sustainability reporting. These standards are schemed to be used for creating a standard sustainability report for all sectors. The standards guide companies to figure out their impacts economically, environmentally and socially. Protecting nature and human rights are the main topics in that standards. GRI report, which is formed by these standards, raises responsibility and increases clearness on the sustainable development. The textile company has been preparing sustainability report based on GRI standards since 2016. In its sustainability report "environment" is the main topic that has a sub-topic which is called "transportation emissions." Also, the company has three steps for sustainability level (Fig. 3).

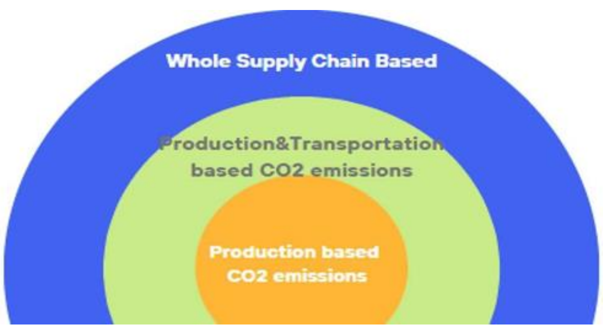

Figure 3: Sustainability levels of the textile company.

Production based CO_2 emissions are first level and have been calculated so far. As it can be seen in Figure 3, the second level also includes transportations which are supply and product movements. The company's first aim is to reduce transportation caused CO_2 emissions level.

When the company completes the second sustainability level, as a last step, the whole supply chain based CO_2 emissions level will reduced.

The company recently declared that "Increasing supply bottlenecks have taught us that we need to become more independent and sustainable. For this reason, we are planning to shorten routes. This "nearshoring" will enable us to respond more quickly and with greater flexibility, and also translates into fewer transport-related CO_2 emissions and lower consumption of resources." So, the aim of shortening routes means nearshoring applications. One of the projects that the company has started is "Reducing Far East Supply." The company supplies all fabric materials from China. 10 times in a month, the company supplies this raw material via 40'container. Sea and roadways are used.

The company uses sub-contractors for transportation. So, EN 16258 (2012) standards offer a formula that needs information about energy consumption, actual cargo weight, and actual transportation distance.

2.2. Defining Necessities

The company management has estimated uncertain road shipments. For this reason, it is assumed that the supply is carried out by sea 9 times and by road once a month. Only 40' container is used for transportation.

Assumptions are listed below:

- "Average goods" category is suitable for fabric materials that EN 16258 has defined.
- Uncertain national road transports are assumed to be equal in both countries (Turkey and China)
- Port of Shangai and Xian is start point of tranportations (Fig. 4)

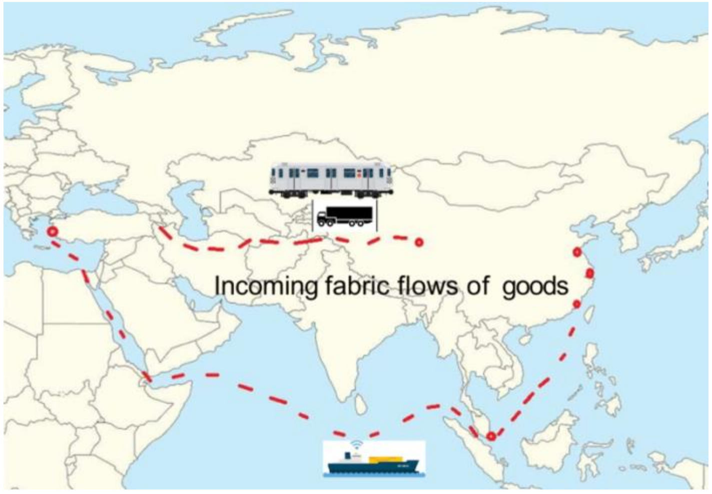

Figure 4: Supply flows of fabric goods.

Parameters are listed below:

- İzmir to China with vessel -->16,500 km
- İzmir to China with truck-->10,000 km
- 9 times with vessel, 1 time with road in a month
- 40' container is 2 TEU (EN 16258)
- A 40-t articulated lorry transport

- Diesel consumption coefficient: 0.19 --> for road
- Diesel consumption coefficient: 0.1 --> for container ship
- Container ship is articulated tub barge 240 TEU
- 24-40 t load weight
- Greenhouse gas emissions calculating CO_2 equivalent coefficient for diesel: 2.67 (EN 16258, 2012)
- The textile company causes 4,000 t CO_2e emission based on production in a year
- The textile company has reduced 30% Far East Supply until now

2.3. Calculation

$$GT = F * gT \tag{1}$$

Equation 1 variables:

GT = Tank-to-wheels GHG emissions in kg CO_2 equivalents (CO_2e)
F = Measured energy consumption (e.g., l, kg or kWh)
gT = Tank-to-wheels GHG emission factors from measured values in kg CO_2e

F is a variable that can be found in Equation 2.

$$F = W * D * E \tag{2}$$

Equation 2 variables:

F = energy consumption in l, kg, or kWh
W = actual cargo weight in t or TEU
D = actual transportation distance in km
E = specific energy consumption (in l, kg, or kWh) per tkm or TEU-km

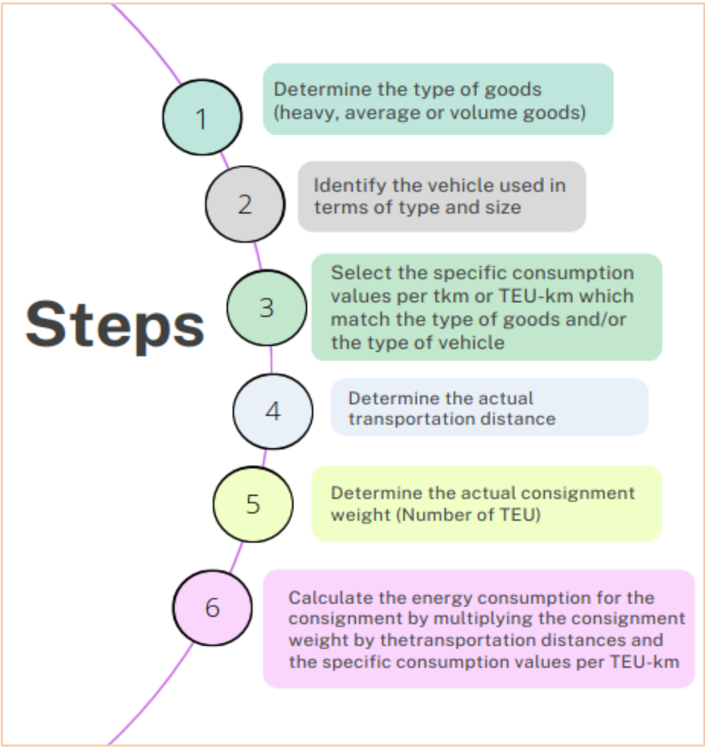

Figure 5: Steps for CO_2e calculation for outsource transportation (CLECAT, 2012).

2.4. Energy Consumption by A Container Transport Service

The company has started nearshoring strategy since the beginning of 2021. It means that the company stepped in after covid times. The calculation of the emission for Far East transports in 2021 is as follows:

A 40-t articulated lorry transports 2 TEU of insulation from China to Turkey.
Determining the parameters for the calculation:
Lorry class: container (articulated lorry) 24 – 40 t
Type of goods: average goods
Transport weight: 25 t (12.4*2)
Transport distance: 10,000 km
Road category: motorway

Energy consumption:
F [liter] = W [t] x D [km] x E [l/tkm]
F = 2 t x 10,000 km x 0.19 l/tkm = 39,800 liter energy consumption of one-way shipment with truck

In general, the same physical rules apply to ships as to road mode of transport in terms of energy consumption: the larger the ship and loading capacity, the smaller the specific energy consumption per unit load (EN 16258, 2012).

Determining the parameters for the calculation:
Type of ship: container ship
Type of goods: average goods
Transported weight: 2 TEU
Distance transported: 16,500 km (determined using EcoTransIT)

Calculating energy consumption:
F [l] = W [TEU] x D [km] x E [l/TEU]
= $2 \text{ x } 16{,}500 \text{ km x } 0.1 \text{ l/Tkm}$
= 3,300 liter energy consumption of one-way shipment with container ship

Total consumption calculation:
Sea way consumption: 3,300 liter (*9 times for a month)
Roadway consumption: 39,800 liter (*1 time for a month)
Supply transportation consumption: $\mathrm{F} = 3{,}300 \ * 9 \ + 39{,}800 \ * 1$
$\mathrm{F} = 29{,}700 + 39{,}800 \ \ \mathrm{F} = 69{,}500$ liter consumption per month

Formula 1 is calculated for CO_2e value:
GT = 69,500 x 2.67
GT= 185,565 CO_2e per month
185,565*12=2,227 tonne CO_2e in a year (2021 value)

The business expects its suppliers to fulfill certain commitments through the Supplier Code of Conduct it has published. With the three modules of the Supplier Code of Conduct - 'Social Compliance Management', 'Environmental Management', and 'Governance' - it combines environmental and social topics. This currently covers all fabric and trimming suppliers that are Far East.
In this way, the company wants to establish a binding framework for fair working conditions and human rights in its supply chain for sustainability. For example, the company denies the

suppliers that have child and forced labor, and it has a Child Labor Policy for this. The company focuses on measures to create constraints for climate change, save water and soil, and avoid air pollution thanks to the Environmental Management module. Also, the objective of the Governance module is to ensure suppliers with responsibility tools. These tools make possible suppliers to get on growing responsibility for their own supply chain accordingly the "Supplier Code of Conduct". They also reduce their own environmental and social risks in supply chain. In short, all these constraints are incorporated by the company into its global textile supply chain management for sustainability works.

The company works with many suppliers for the supply of raw materials. It needs a close supply policy without compromising on raw material quality, cost, technological production, and expectations specified in Code of Conduct. Evaluation of the suppliers in the regions close to the business, whose current location is in Izmir, is an ongoing process. This process includes requesting a new product from the supplier, converting the supplier's product to the quality requested by the company, and fulfilling the supplier code of conduct requirements. Besides, the company has business relationships with its strategic partners that go back eleven years and more. Suppliers are also the one of the most important partners of them. The company's supply chain management strategy includes long-term partnerships that are essential to finding answers to social and environmental challenges together. As the manager said, nearshoring needs time for this transformation. And the company’s estimation for nearshoring rates and supply rates year by year is shown Table 1.

Table 1: Estimated nearshoring rates and increase of supply rates.

Year	Estimation in Supply Plan (nearshoring rate)	Estimated rate of increase in supply (raw material)	Units of Truck year by year
2021	10%	8%	10
2022	30%	7%	11
2023	55%	7%	12
2024	65%	6%	12
2025	75%	6%	13
2026	80%	5%	14
2027	88%	4%	14
2028	94%	4%	15
2029	97%	3%	15
2030	99-100%	3%	16

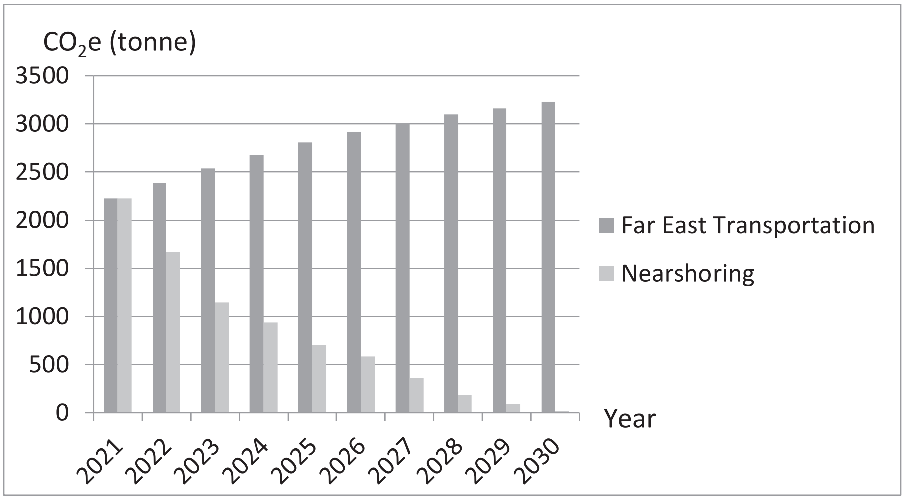

Figure 6: Comparision of CO_2e values between Far East and Nearshore Regions for the next ten years.

3. RESULTS

The company has declared in its sustainability reports that it releases 4,000 tons of CO_2 per year as a result of only its production at its İzmir facility. With this study, it is found that the company emitted 2,227 tons of CO_2 during transportation for fabric products in a year. When the data is analyzed, it is seen that the transportation process corresponds to 55% of the CO_2e emission emitted in production. In the past 2 years, the business has brought 30% of its fabric product supply closer to the business with its nearshoring strategy. This means that as of this year, the CO_2e value of the transportation made from the Far East has been decreased and become approximately 1,558 tons. This means that two years reduction of emissons rate for inbound transportation has become 669 t CO_2e.

Considering the supply increase and nearshore rates between 2021 and 2030, the sustainability gain of 2030 is 3229 tons CO_2e (Figure 6). The total emission reduction during this 10-year period is 20122 tons CO_2e. It is obvious that this research will be a sustainability study that will create value in terms of the inbound supply process.

It can be said that this analysis is a start for the company's second part of the sustainability efforts that include distribution transportations between the company and customers. Also, the textile company will be able to use this calculation at the end of this year in its sustainability report which is to be prepared in accordance with GRI standards. This research will be a shiny guide for other calculations of the company's logistics functions (handling, warehousing, etc.) which cause CO_2 emissions.

REFERENCES

Binh, N., & Tuan, V. (2016). Greenhouse gas emission from freight transport-accounting for the rice supply chain in Vietnam. *Procedia CIRP*, *40*, 46–49. https://doi.org/10.1016/j.procir.2016.01.051

CLECAT (European Association for Forwarding, Transport, Logistics and Customs Services). (2023, March 20). *Calculating GHG emissions for freight forwarding and logistics services*.

https://www.clecat.org/media/CLECAT_Guide_on_Calculating_GHG_emissions_for_freight_forwarding_and_logistics_services.pdf

Jovanović, B., Ghodsi, M., van Zijverden, O., Kluge, S., Gaber, M., Mima, R., & Mandić, M. (2021). *Getting stronger after COVID-19: Nearshoring potential in the Western Balkans (No. 453).* WIIW Research Report. https://wiiw.ac.at/getting-stronger-after-covid-19-nearshoring-potential-in-the-western-balkans-dlp-5814.pdf

Klein, J., Geilenkirchen, G., & Hulskotte, J. (2012). *Methods for calculating the emissions of transport in the Netherlands.* Statistics Netherlands Report.

Li, X., Lv, T., Zhan, J., Wang, S., & Pan, F. (2022). Carbon Emission Measurement of Urban Green Passenger Transport: A Case Study of Qingdao. *Sustainability*, *14*(15), 9588. https://doi.org/10.3390/su14159588

Majumdar, A., & Sinha, S. (2018). Analyzing the barriers of green textile supply chain management in South-east Asia using interpretive structural modeling. *Sustainable Production and Consumption*, *17*, 176-187. https://doi.org/10.1016/j.spc.2018.10.005

Manavalan, E., Thanigai M.A., & Kandasamy, J. (2021). Chapter 14 - Sustainable supply chain management in manufacturing industries, In K. Gupta & K. Salonitis (Eds.), *In Handbooks in Advanced Manufacturing, Sustainable Manufacturing,* (pp. 367-389). Elsevier.

Mock, P. (2016). *Policy options to reduce emissions from the road transport sector in Turkey*. IPM-Mercator Policy Brief, 1-13. https://ipc.sabanciuniv.edu/Content/Images/Document/policy-options-to-reduce-emissions-from-the-road-transport-sector-in-turkey-31c3c2/policy-options-to-reduce-emissions-from-the-road-transport-sector-in-turkey-31c3c2.pdf

Mubarak, A., & Zainal, F., (2018). Development of a framework for the calculation of co2 emissions in transport and logistics in southeast asia. *International Journal of Technology*, *9*(4), 787–796. https://doi.org/10.14716/ijtech.v9i4.1432

Müller-Dauppert, B. (2016). Production nearshoring in Europe and their consequences to the supply chain. *Gazdaság és Társadalom*, *8*(2), 5-25. https://doi.org/10.21637/GT.2016.2.01.

Saygılı, E., Saygılı, A. T., & Gören Yargı, S. (2019). An analysis of sustainability disclosures of textile and apparel companies in Turkey. *Textile and Apparel*, *29*(3), 189-196. https://doi.org/10.32710/tekstilvekonfeksiyon.471049

Standard EN 16258. (2012). *Methodology for calculation and declaration of energy consumption and greenhouse gas emissions of transport services*. German from Beuth Verlag. https://www.beuth.de/de

USEPA. (2018). *Fast facts on transportation greenhouse gas emissions.* https://www.epa.gov/greenvehicles/fast-facts-transportation-greenhouse-gas-emissions

YAYIN KURALLARI

(https://dergipark.org.tr/tr/pub/bujse/writing-rules)

Yazarlara Not: TÜBİTAK-ULAKBİM Fen Bilimler Veri Tabanı Komitesi, bu yayın kurallarına %100 uyulmasını istemektedir. Lütfen makaleleri bu kurallara uygun olarak hazırlayıp gönderiniz.

Beykent Üniversitesi Fen ve Mühendislik Bilimleri Dergisi, yılda İKİ kez (altı ayda bir) yayınlanır.

Hakemli ve özgün çalışmaları amaçlayan bir dergidir. Makalelerin, hakem değerlendirilmesine girmek üzere, yayın kurulu sekreterliğine yazar adı, e-postası, cep /telefonu ile gönderilmesi gerekmektedir. Yazarlar makalelerinde hakemlerin de değerlendirmelerinde dikkate alacağı aşağıdaki kriterleri de gözden uzak tutmamalıdırlar:
a. Makalelerindeki ekseni, dayandığı temel fikri, ikincil kaynak incelemesi ve bunlara göre yeniliği, Fen ve Mühendislik Bilimleri ve uygulama alanına katkısını,
b. Araştırmalarının makalenin ana eksenine katkısını, hipotez ve metodolojisi, istatistiksel analiz tekniğinin yeterliliğini,
c. Makalenin mantıksal bütünlüğü ve kendilerini tatmin edip etmediğini,
d. Makalenin başlığa uygunluğu ve anahtar kelimelerin makaleyi yansıtabilmesini,
e. İyi kalitede bir model, şekil, tablo vb. ile öğretime katkı seviyesini değerlendirmelidirler.

Tüm makale türleri için MS Office Word şablonu mevcuttur ve yazarların makaleleri gönderilmek üzere hazırlarken MS Office Word şablonunu kullanmaları önerilir. Makalenin toplam uzunluğu 25 sayfayı geçmemelidir. Makale, MS Office Word dosyası (MS DOC, MS DOCX) olarak yüklenmelidir. Farklı formatlarda yüklenmiş dosyalar değerlendirmeye alınmayacaktır.
Genel olarak, makaledeki bölümlerin sırası aşağıda belirtilen şekilde olmalıdır.
Başlık – Yazar(lar) – Yazar Bilgileri – Anahtar Sözcükler – Özet –– Ana Metin [Şekiller ve Tablolar dahil] – Teşekkür – Kaynakça
Başlık: Calibri (14 punto, Kalın/Bold yazı tipi) kullanılmalı ve bütün harfler büyük yazılmalıdır (Mikroorganizma, bitki ve hayvan türleri için Latince adları gibi küçük olması gereken kelimeler hariç). Satır aralığı 1 punto ve paragraf aralığı öncesi ve sonrası 6 nk olmalıdır. Başlık toplamda 25 kelimeyi geçmemelidir.
Yazar(lar): Yazar bilgileri başlık sayfasında, makale metninden ayrı bir şekilde yazılmalıdır. Calibri (14 punto, Normal yazı tipi) kullanılmalıdır. Satır aralığı 1 punto olmalıdır. Paragraf aralığı öncesi ve sonrası 0 nk olmalıdır.
Yazar Bilgileri: Bütün yazarların bağlı bulundukları güncel kurum bilgileri başlık sayfasında verilmelidir. Yazar bilgileri "Kurum Adı, Fakülte/Yüksekokul/MYO Adı, Bölüm Adı, E-mail, ORCID" bilgilerini içerecek şekilde olmalıdır. Calibri (9 punto, Normal yazı tipi) kullanılmalıdır. Satır aralığı 1 punto, paragraf aralığı öncesi ve sonrası 0 nk olmalıdır. Sorumlu yazar için bir e-posta adresi verilmelidir.
Anahtar Sözcükler: Anahtar kelime sayısı en az 3, en fazla 5 olmalıdır. Calibri (9 punto, Normal yazı tipi) kullanılmalıdır. Satır aralığı 1 punto olmalıdır. Paragraf aralığı öncesi ve sonrası 0 nk olmalıdır.
Öz/Abstract: Öz ve Abstract metinleri en fazla 300 kelime olmak üzere hazırlanmalıdır. Calibri (9 punto, Normal yazı tipi) kullanılmalıdır. Öz ve Abstract başlıkları kalın (bold) olmalıdır. Öz ve Abstract metinlerinde, paragraf aralığı öncesi ve sonrası 0 nk, satır aralığı 1 punto olmalıdır. Paragraf başında girinti kullanılmamalı ve metinler tek paragraf olarak yazılmalıdır. Öz/Abstract, araştırmanın amacı, yöntemi, bulguları, sınırlılıkları ve özgün değerini ifade edecek şekilde yazılmalıdır.
Ana Metin: Ana metin yazıları Calibri (12 punto, Normal yazı tipi) kullanılarak ve iki yana yaslı şekilde yazılmalıdır. Satır aralığı 1 punto ve paragraf aralığı öncesi ve sonrası 6 nk olmalıdır. Yunanca harfler ve matematiksel karakterler simge olarak metne eklenmelidir. Denklemler ardışık sayılarla etiketlenmeli ve metin içinde atıf yapılmalıdır (Örn: Denklem (1)). Denklemler düzenlenebilir formatta verilmeli, resim olarak eklenmemelidir.

Üst, alt ve sol ve sağ kenar boşlukları 2,5 cm olarak ayarlanmalıdır. Kaynaklar dahil tüm sayfalar ardışık olarak numaralandırılmalıdır.

Ana metin Giriş, Materyal & Metot (gerekli ise) ve Sonuç bölümlerinden oluşmalıdır. Tüm birincil başlıklar Calibri (12 punto, Kalın/Bold yazı tipi) kullanılarak bütün harfleri büyük olacak şekilde yazılmalıdır. Satır aralığı 1 punto, paragraf aralığı öncesi 18 nk ve sonrası 12 nk olmalıdır. İkincil başlıklar, (12 punto, Kalın/Bold yazı tipi) kullanılarak her kelimenin ilk harfi büyük olacak şekilde yazılmalıdır. Satır aralığı 1 punto, paragraf aralığı öncesi 12 nk ve sonrası 6 nk olmalıdır. Üçüncül başlıklar, Calibri (12 punto, Kalın/Bold yazı tipi) kullanılarak sadece ilk harf büyük olacak şekilde yazılmalıdır. Satır aralığı 1 punto, paragraf aralığı öncesi ve sonrası 6 nk olmalıdır.

Ana metin içerisinde gerektiği yerlerde tablo ve şekiller kullanılmalıdır.

Tablolar ile birlikte tablonun üst kısmında başlık ve kısa bir açıklama metni verilmelidir. Yalnızca bir veya iki sütunlu tablolardan ve yalnızca bir veya iki girişli sütunlardan kaçınılmalıdır. Tablo açıklaması Calibri (11 punto, Normal yazı tipi) kullanılarak ve ortalanmış şekilde yazılmalıdır. Satır aralığı 1 punto, paragraf aralığı öncesi 12 nk ve sonrası 6 nk olmalıdır. Tablolardaki dipnotların numaralandırılmasında üst indis Latin harfleri kullanılmalıdır. Dipnotlar Calibri (8 punto, Normal yazı tipi) ile yazılmalıdır. Satır aralığı 1 punto, paragraf aralığı öncesi ve sonrası 0 nk olmalıdır. Tüm tablolar metinde atıfta bulunulan sıraya göre Arap rakamları ile numaralandırılmalıdır (Örn: Tablo 1, Tablo 2, vb.). Metin içinde tablolara atıfta bulunulurken kısaltma yapılmadan "Tablo" sözcüğü kullanılmalıdır.

Makalede kullanılan şekil ve şemanın açıklayıcı bir başlığı olmalı ve şekil ve şema başlıklarına şeklin alt kısmında yer verilmelidir. Tüm şekiller ve şemalar metin içinde numara sırasına göre belirtilmelidir ve Arap rakamları kullanılmalıdır (Örn: Şekil 1, Şekil 2, vb.). Şekil ve şema açıklaması Calibri (11 punto, Normal yazı tipi) kullanılarak ve ortalanmış şekilde yazılmalıdır. Satır aralığı 1 punto, paragraf aralığı öncesi 6 nk ve sonrası 12 nk olmalıdır. Şekillere atıfta bulunulurken, makalenin tüm bölümlerinde "Şekil" kelimesinin tamamı kullanılmalıdır.

Teşekkür: Raporlanan çalışma ile ilgili tüm finansman kaynakları, hibe numaraları ve finansman kuruluşlarının adları da dahil olmak üzere Teşekkür başlığı altında belirtilmelidir. Yazarlık kriterlerini karşılamayan herkesin katkıları, katkıda bulunanın izniyle Teşekkür bölümünde listelenmelidir. "Teşekkür" başlığı Calibri (12 punto, Kalın/Bold yazı tipi) kullanılarak yazılmalıdır. Satır aralığı 1 punto, paragraf aralığı öncesi 18 nk, sonrası 12 nk olmalıdır.

Kaynakça: Makalede kullanılan kaynaklar, kaynakça başlığı altında listelenmelidir. Ana metin içinde atıf yapılmayan kaynaklar Kaynakça listesinde yer almamalıdır. Yararlanılan kaynaklar nitelik (tez, kitap, makale, rapor vb.) ayrımı yapılmaksızın alfabetik olarak sıralanmalıdır. Kaynaklar APA 7 stiline göre yazılmalıdır. Kaynakça düzenlenirken Mendeley, EndNote veya Zotero benzeri yazılımların kullanılması önerilir. Kaynakça başlığı Calibri (12 punto, Kalın/Bold yazı tipi) kullanılarak yazılmalıdır. Satır aralığı 1 punto, paragraf aralığı öncesi 18 nk, sonrası 12 nk olmalıdır.

İLETİŞİM

İstanbul Beykent Üniversitesi Fen ve Mühendislik Bilimleri Dergisi, Sıraselviler Cd, 34437 Beyoğlu-İstanbul

Tel: 0212 444 1997
Faks: 0212 867 51 72

bujse@beykent.edu.tr