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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.

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