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Assessing the problems encountered by companies using e-logistics via a Polytopic fuzzy methodology: A case of Giresun province

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ABSTRACT

Manufacturing companies are always competing because of globalization, both in terms of sectoral level and meeting customer demands. Companies that want to gain competitive advantages want to offer the best quality products and services at the most affordable cost and aim to deliver them to the end consumer by creating added value. This requirement and flexibility level can only be achieved through logistics applications. Businesses that provide efficiency and speed in logistics applications take a few steps forward in market conditions and respond to customer needs on time. It has become a necessity to use electronic-based systems in logistics applications, especially to meet customer requirements. Information communication-based electronic business has also changed the methods and models of doing business for its users. Internet technology has caused businesses to change their business models and practices, along with their production and service structures. Developments in e-commerce and technology have brought e-logistics applications to the forefront and made it necessary to emphasize them. Because e-logistics applications are important for facilitating business operations and increasing performance and customer satisfaction, they also eliminate distances in world trade and offer access to markets that are difficult to access. There are various problems in e-logistics applications and it is important to identify them. In this context, the problems faced by businesses using e-logistics become critical and one of the components that need to be meticulously emphasized. According to the results of the study, it is understood that the most important e-logistics barriers in enterprises are "lack of skill to manage digital technologies to support the system" and "need for qualified personnel". It is obvious that the results will guide business managers.

1. Introduction

Today, the main focus of companies is on concepts such as cost optimization, efficiency, performance, profit, and customer satisfaction, which are of vital importance for companies and are

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indispensable for their continuity. On the other hand, one of the most important elements for companies is electronic logistics applications [1]. In competitive conditions, it is seen that traditional logistics support activities are no longer seen as one of the main activities that do not have strategic importance, and many businesses in the world have started to develop various methods to increase their competitiveness, to continue their activities, to minimize their costs, and to turn to these developing methods. Especially this situation has led to the emergence of the concept of e-logistics with the application of the Internet and information technologies in the activities of logistics enterprises [2].

As a concept, e-logistics refers to the use of electronic and digital technologies to streamline and optimize various logistics processes, from procurement and order fulfillment to transportation and distribution. E-logistics plays a crucial role in improving the efficiency, transparency, and competitiveness of supply chains in today's digital age [3]. In another definition, this concept is the delivery of goods sold over the Internet to customers. E-logistics has been described as a system that has the effect of eliminating intermediaries (e.g. wholesalers or retailers) and encouraging the emergence of new logisticians whose role is to adapt [4].

E-logistics offers profound societal benefits by optimizing supply chains, reducing traffic congestion, and minimizing emissions through efficient route planning, thus enhancing environmental sustainability and urban livability. It facilitates timely disaster response, aids the development of remote areas, and stimulates economic growth by streamlining trade and creating employment opportunities. In addition, e-logistics leverages data insights for informed decision-making, supports healthcare delivery, fosters technological innovation, and ensures social inclusion by providing access to goods and services for diverse populations, collectively contributing to a more efficient, connected, and resilient environment [5].

The services and processes provided by e-logistics applications lead to the emergence of new business models and make production more convenient with fewer cost and time constraints. Therefore, it can be said that companies allocating e-logistics services or establishing cooperative relationships that allocate e-logistics services provide an advantage in the competitive environment [6]. On the other hand, thanks to e-logistics, customers have access to real information, and electronic systems also help businesses anticipate potential problems and minimize them by taking appropriate measures. In connection with this, providing customers with accurate and real-time information about their stocks and freight movements is considered to be one of the other strategic points in the development of e-logistics [7]. The importance of e-logistics is increasing day by day, especially due to globalization and digitalization. Although electronic logistics has many disadvantages, the importance of e-logistics cannot be ignored. Based on all these developments, it is clear that the importance of e-logistics will increase in the coming years and will be used by many people and organizations in the future [8]. E-logistics is all the logistics processes of the transactions carried out in e-commerce to provide online customers with a satisfying shopping experience. Apart from these processes, e-logistics makes processes such as inventory management, storage, transportation, and distribution more compatible with the new demands of the digital age [9].

At the same time, e-logistics, customer service, and automatic identification/data collection (AIDC) technologies are crucial elements for business success. Providing efficient and effective customer service is essential for building customer loyalty and satisfaction. Customer service and AIDC technology can help businesses build strong relationships with customers and streamline operations to help them succeed. With efficient customer service methods and reliable AIDC technology, businesses can increase customer satisfaction, reduce costs, and improve efficiency, increasing profitability and competitiveness [10]. In this context, the theoretical and practical contributions of e-logistics in logistics management are enormous. Adopting e-logistics principles will

enable logistics managers to make data-driven decisions, optimize processes, and improve supply chain visibility, ultimately leading to improved customer satisfaction and overall operational efficiency.

Based on the relevant issues, the obstacles faced by businesses in the use of e-logistics are important and concern critical issues such as addressing business costs and strategies. Therefore, the concept is one of the issues that needs to be meticulously emphasized.

In the study, the obstacles faced by enterprises in Giresun province at the point of e-logistics applications were investigated. It is aimed at identifying the barriers to e-logistics implementation and prioritizing the relevant factors with the subjective weighting approach defined under the Polytopic fuzzy sets (PTFSs). In the following sections of the study, the literature review on the concept of e-logistics is emphasized, explanations about the PTF subjective weighting approach, which constitutes the method of the study, and the application of the method for Giresun province are examined. In the last part of the study, conclusions and information about future studies are presented.

2. Literature

Various domestic and foreign studies on e-logistics and e-logistics applications are given below.

- Oliveira and Martins [11] discussed the contributions of e-logistics functions to businesses and expressed an opinion on the spread of e-logistics.
- Rao et al. [12] examined the impact of electronic logistics service quality on customer purchase satisfaction and retention [12].
- Karagöz [13] investigated the extent to which firms use e-logistics in e-commerce and their attitudes towards software development and implementation.
- Liu [14] investigated the e-logistics system based on the Tibetan logistics industry and made several suggestions [14].
- Moroz et al. [15] investigated the transformation process of logistics to e-logistics with the example of electronic freight exchange.
- Chung et al. [16] examined the implementation of e-logistics systems for e-commerce development as a conceptual model in small and medium-sized enterprises.
- Thongniam et al. [17], investigated the competencies of SME entrepreneurs for e-logistics strategy and proposed solutions.
- Dębkowska [18] examined e-logistics practices as an element of business model maturity in enterprises in the transportation, freight forwarding, and logistics sectors.
- Iskandar and Ramantoko [19] investigated the factors affecting the adoption of e-logistics in the Indonesian e-commerce sector.
- Karayün and Uca [20] revealed the impact of online customer portals, which are becoming increasingly widespread within the scope of e-logistics, on cargo operations in a company providing international maritime transportation services.
- Kanagavalli and Azeez [21] aimed to understand the main benefits and new tasks between logistics and e-logistics and proposed various solutions.
- Çakılcı and Öztürkoğlu [22] identified the success factors that are critical for sustaining e-logistics activities with increasing Internet shopping.
- Rahman et al. [23] identified the driving factors of e-logistics using a systematic literature review and proposed a conceptual model.
- Chen et al. [24], reviewed e-logistics and transportation and retrospectively examined 25 years.

- Uvet et al. [25] examined two hybrid logistics service quality models in the context of business-to-consumer e-commerce and their impact on satisfaction, loyalty, and future purchase intention.

In the detailed literature review, many studies on e-logistics were found and it is thought that the related study will contribute to the literature in terms of the methodology used.

3. Methodology

In recent years, e-logistics applications have become increasingly important to business competitiveness. E-logistics applications can help businesses gain a substantial competitive advantage. Similarly, e-logistics enables the formation of new competitive sectors on a regional, national, and global scale, hence fostering economic development. However, e-logistics applications encounter a range of obstacles in the business sector, and the desired level of performance is not achieved. As a result, this study focuses on the challenges of e-logistics applications and enhancing business success. The results aim to improve competitiveness and efficiency by identifying components that will help e-logistics applications. The study aims to identify problems faced by organizations and users of e-logistics systems and provide solutions for developing new strategies. This allows for innovative modeling by incorporating business executives' e-logistics infrastructures and perspectives into this domain. Furthermore, because there is little research on e-logistics applications in Turkey, businesses are unable to assure the accuracy of customer and service quality evaluations. This research is expected to identify e-logistics application-level problems and provide businesses with concrete data, as well as function as a guiding source for the associated literature gap.

The studied problem includes expert judgments and components that have never been defined in a systematic way before. In this case, accurate modeling of the problem's uncertainty is critical. Fuzzy set extensions to multi-criteria decision analysis methods produce extremely helpful results when solving problems involving uncertainty. However, numerous fuzzy sets and methods can be employed. Undoubtedly, the fundamental reason for this expansion is the lack of a single method capable of accurately modeling all possible scenarios. PTFS, a novel approach, was chosen in this study to efficiently model the problem's uncertainties.

Bet et al. [26] presented the PTFSs as a generalization of the spherical fuzzy sets (SFSs), the picture fuzzy sets (PFSs), and the q-rung orthopair fuzzy sets (q-ROFSs). It was stated that the PTFS theory provides appropriate approaches for dealing with imprecisions and uncertainties in input data needed for decision-making problems where the SFS, PFS, and q-ROFS theories are inapplicable. In this context, we employed PTFS to solve the decision-making problem in our study.

Let X be a universe of discourse, then a PTFS G of X can be expressed as $G = \{\langle x, \alpha_G(x), \eta_G(x), \beta_G(x)\rangle : x \epsilon X\}$. $\alpha_G : X \to [0,1]$ is the positive membership degree, $\eta_G : X \to [0,1]$ is the neutral membership degree, and $\beta_G : X \to [0,1]$ is the negative membership degree of $x \epsilon X$ to PTFS G, where $0 \leq \alpha_G(x)^q + \eta_G(x)^q + \beta_G(x)^q \leq 1$ [26]. For the simplicity, the triplet $\langle \alpha, \eta, \beta \rangle$ is called PTF number (PTFN). The basic operators, the score function ($\mathcal{S}(g)$), and the accuracy function ($\mathcal{A}(g)$) are given below, where $g = \langle \alpha, \eta, \beta \rangle$, $g_1 = \langle \alpha_1, \eta_1, \beta_1 \rangle$, $g_2 = \langle \alpha_2, \eta_2, \beta_2 \rangle$ are three PTFNs [26].

$$\boldsymbol{g_1 \oplus g_2 = \langle \left(\alpha_1^q + \alpha_2^q - \alpha_1^q \alpha_2^q\right)^{1/q}, \eta_1 \eta_2, \beta_1 \beta_2 \rangle} \quad \textbf{(1)}$$

$$\boldsymbol{g_1 \otimes g_2 = \langle \alpha_1 \alpha_2, \eta_1 \eta_2, \left(\beta_1^q + \beta_2^q - \beta_1^q \beta_2^q\right)^{1/q} \rangle} \quad \textbf{(2)}$$

$$\boldsymbol{g^{\lambda}} = \langle \boldsymbol{\alpha^{\lambda}}, \boldsymbol{\eta^{\lambda}}, \left(\mathbf{1} - (\mathbf{1} - \boldsymbol{\beta^{q}})^{\lambda}\right)^{\mathbf{1}/\boldsymbol{q}} \rangle \quad \textbf{(3)}$$

$$\boldsymbol{g\lambda} = \langle \left(\mathbf{1} - (\mathbf{1} - \boldsymbol{\alpha^{q}})^{\lambda}\right)^{\mathbf{1}/\boldsymbol{q}}, \boldsymbol{\eta^{\lambda}}, \boldsymbol{\beta^{\lambda}} \rangle \quad \textbf{(4)}$$

$$\boldsymbol{g^{c}} = \langle \boldsymbol{\beta}, \boldsymbol{\eta}, \boldsymbol{\alpha} \rangle \quad \textbf{(5)}$$

$$\boldsymbol{\mathcal{S}(g)} = \frac{\mathbf{1}+\boldsymbol{\alpha^{q}}+\boldsymbol{\eta^{q}}-\boldsymbol{\beta^{q}}}{\mathbf{3}} \quad \textbf{(6)}$$

$$\boldsymbol{\mathcal{A}(g)} = \frac{\mathbf{1}+\mathbf{max}(\boldsymbol{\alpha^{q}},\boldsymbol{\eta^{q}})-\boldsymbol{\beta^{q}}}{\mathbf{2}} \quad \textbf{(7)}$$

The PTF weighted aggregation operator (PTFWAO) is given in Eq. (8), where g_i for $i = 1, \dots, m$ are PTFNs. Besides, λ is the weight vector [26].

$$\boldsymbol{PTFWAO(g_1, \dots, g_m)} = \langle \left(\left(\mathbf{1} - \prod_{\boldsymbol{i=1}}^{\boldsymbol{m}} \left(\mathbf{1} - \boldsymbol{\alpha_i^{q}}\right)^{\boldsymbol{\lambda_i}} \right)^{\mathbf{1}/\boldsymbol{q}} \right), \prod_{\boldsymbol{i=1}}^{\boldsymbol{m}} \boldsymbol{\eta_i^{\lambda_i}}, \prod_{\boldsymbol{i=1}}^{\boldsymbol{m}} \boldsymbol{\beta_i^{\lambda_i}} \rangle \quad \textbf{(8)}$$

Expert evaluations are frequently employed to solve decision-making problems. On the other hand, these evaluators are often unfamiliar with multi-criteria decision-making procedures. This complicates the application process of many methodologies for them, limiting the usefulness and accuracy of their assessments. In such a setting, simple, understandable, and adaptive methods are desired. For these reasons, the subjective weighting approach employing PTFWAO was preferred for evaluating the criteria in this study. The PTF subjective weighting approach includes the implementation steps detailed below.

Step 1. The decision-making problem is defined. In this context, $N_1, \dots, N_n$ denotes the criteria, and $U_1, \dots, U_r$ shows the experts.

Step 2. The experts assess the importance level of criteria based on the linguistic terms given in Table 1 [27]. Accordingly, $\iota_{jk} = \langle \alpha_{jk}, \eta_{jk}, \beta_{jk} \rangle$ shows the importance of criterion j by defining the expert k, where $k = 1, \dots, r$ and $j = 1, \dots, n$.

Table 1
Linguistic terms for evaluation of criteria

		Corresponding PTFNs		
Linguistic Terms	**Notations**	$\boldsymbol{\alpha}$	$\boldsymbol{\eta}$	$\boldsymbol{\beta}$
Extremely	**EI**	**0.9**	**0.1**	**0.1**
Very high	**VHI**	**0.8**	**0.2**	**0.2**
High	**HI**	**0.7**	**0.3**	**0.3**
Slightly more	**SMI**	**0.6**	**0.4**	**0.4**
Medium	**MI**	**0.5**	**0.5**	**0.5**
Slight low	**SLI**	**0.4**	**0.4**	**0.6**
Low	**LI**	**0.3**	**0.3**	**0.7**
Very low	**VLI**	**0.2**	**0.2**	**0.8**
Not at all	**NA**	**0.1**	**0.1**	**0.9**

Step 3. The importance level of experts' evaluations (ι_k) are determined using the linguistic terms listed in Table 1. Accordingly, the PTF number $\iota_k = \langle \alpha_k, \eta_k, \beta_k \rangle$ denotes the PTF importance of k.th expert's evaluations. Then, the weights of experts are computed using Eq. (9), where $\mathcal{S}(\iota_k)$ denotes the score function of ι_k.

$$\boldsymbol{\lambda_k = \frac{\mathcal{S}(\iota_k)}{\sum_{k=1}^{r} \mathcal{S}(\iota_k)}} \quad \textbf{(9)}$$

Step 4. The aggregated PTF importance values are obtained by applying Eq. (10).

$$\boldsymbol{\iota_j = \left\langle \left(\left(1 - \prod_{k=1}^{r} \left(1 - \alpha_{jk}^{q} \right)^{\lambda_k} \right)^{1/q} \right), \prod_{k=1}^{r} \eta_{jk}^{\lambda_k}, \prod_{k=1}^{r} \beta_{jk}^{\lambda_k} \right\rangle} \quad \textbf{(10)}$$

Step 5. The weights of criteria are computed using Eq. (11), where $\mathcal{S}(\iota_j)$ depicts the score function of ι_j.

$$\boldsymbol{w_j = \frac{\mathcal{S}(\iota_j)}{\sum_{j=1}^{n} \mathcal{S}(\iota_j)}} \quad \textbf{(11)}$$

Accordingly, the weight coefficients of criteria are determined, where $\sum_{j=1}^{n} w_j = 1$, and $0 \leq w_j \leq 1$.

4. Findings

Three experts were consulted to determine the relative importance of the problem's criteria. Experts have careers in the fields of customs, manufacturing, and academics. In terms of the problem under investigation, all three experts have extensive experience and knowledge. The selected experts are field managers who specialize in e-logistics and e-logistics applications and have over 15 years of industry experience. Experts have been chosen from among those with at least a bachelor's degree and extensive knowledge of e-logistics applications. Their information and experiences, together with e-logistics applications, provide a thorough understanding of e-logistics. In this study, we gave equal weights to experts. Three experts (U1, U2, and U3) assessed the importance levels of the criteria as seen in Table 2.

Table 2
Experts' linguistic assessments for the criteria

Criteria	Source	Notations	U1	U2	U3
Lack of skill to manage digital technologies to support the system	**[7], [20], [28]**	**N1**	**VHI**	**HI**	**EI**
Infrastructure-related additional costs	**[1], [8]**	**N2**	**HI**	**HI**	**VHI**
Need for qualified personnel	**[9], [17]**	**N3**	**VHI**	**HI**	**VHI**
Need for training and seminars	**[9], [29], [33]**	**N4**	**HI**	**HI**	**HI**
Uncertain legal arrangements for e-logistics applications	**[7], [8], [30]**	**N5**	**MI**	**MI**	**MI**
High cost of software updates and maintenance	**[11], [17]**	**N6**	**HI**	**HI**	**VHI**
Uncertainty in selecting the proper system to be used	**[9], [31]**	**N7**	**MI**	**SLI**	**HI**
Organizational resistance to e-logistics applications and channel conflicts	**[8], [32], [33]**	**N8**	**MI**	**SLI**	**SLI**
Security, safety, and privacy issues	**[7], [29]**	**N9**	**MI**	**HI**	**HI**

The implementation steps of the PTF subjective weighting approach were followed. As a result, the weight coefficients of the criteria are obtained as seen in Table 3.

Table 3
The PTF subjective weighting approach results

Criterion	**N1**	**N2**	**N3**	**N4**	**N5**
$\mathbf{W_j}$	0.133	120	0,125	0.115	0.096
Ranking Order	**1**	**3**	**2**	**5**	**8**
Criterion	**N6**	**N7**	**N8**	**N9**	
$\mathbf{W_j}$	0.120	0.099	0.084	0.109	
Ranking Order	**3**	**7**	**9**	**6**	

According to the findings given in Table 3, the most important criterion is “Lack of skill to manage digital technologies to support the system” (N1). Moreover, the importance ranking order of criteria is determined as N1≻N3≻N2∼N6≻N4≻N9≻N7≻N5≻N8.

5. Conclusion

Today, although cost is seen as the strongest competitive factor for businesses, the impact of customer satisfaction is undeniable. In particular, businesses have to offer value-added services in addition to cost advantages to increase their competitive advantage and sustainability in the local and international markets. One of these value-added services is e-logistics applications. E-logistics optimizes all operations, including operations, efficiency, customer satisfaction, transportation, storage, and inventory management for businesses. In addition to being so important, e-logistics provides new opportunities for growth and expansion, as well as the development of new business models such as drop shipping and multi-channel retailing. E-logistics applications provide several advantages to businesses. We can express them as follows [34]:

- Due to their ease of access, the flow of information with customers is more efficient and extensive.
- The ability to track transaction processes online provides more flexibility in setting controls.
- The percentage of orders delivered on time and in full is increasing.
- The frequency of lost or damaged orders is decreasing.
- It allows you to compare quality and price among supply chains around the world.
- The transportation and preparation of orders within the specified time restrict are well defined.
- It enables the decrease of stock levels to a bare minimum through effective resource allocation.
- It helps businesses grow into worldwide markets.
- Simplifying route and vehicle selections in transportation systems saves money while also improving safety.
- It enables more systematic storage activities and space usage, as well as a reduction in human requirements.
- To facilitate more systematic and convenient product sales and returns.

- Businesses benefit from it since it allows them to digitize documents, invoices, receipts, and other items that require physical presence while also decreasing stationery costs.
- It enables easier adaptation to changing market conditions and product types.

Despite all these advantages, e-logistics applications have serious challenges. These can be expressed as follows: e-logistics operation and maintenance costs are very high, e-logistics activities are not used to full capacity due to a lack of infrastructure, e-logistics activities are very expensive to implement, e-logistics costs are very high, and the number of qualified personnel in information technologies is insufficient [35].

In this context, the problems faced by enterprises using e-logistics become one of the critical components that need to be meticulously emphasized. At this point, the levels of problems faced by enterprises using e-logistics were investigated in the study. The most important problem was found to be a "lack of skill to manage digital technologies to support the system". Other important problems are the "need for qualified personnel" and "infrastructure-related additional costs".

Within the framework of these results, it is important to pay more attention to technology issues and to have effective infrastructure facilities. One of the most significant challenges in e-logistics application procedures is technological infrastructure and equipment issues. These obstacles may prevent users from successfully using e-logistics. Businesses that lack the necessary technological infrastructure or those who struggle to access a good Internet connection have a detrimental impact on e-logistics procedures. This harms corporate performance. At the same time, the presence of qualified personnel to use technology is also important and affects the cost. The lack of qualified workers is an important concern in e-logistics applications. Staff who will use the appropriate technologies must be provided with extensive training. Frequent training, system updates, and integration of e-logistics applications are very important. System efficiency should be ensured by highlighting the value of training for working personnel. Moreover, any additional expenditures incurred by the infrastructure problem should be corrected following business plans. If necessary, external resources should be provided by completing a project, and the business's costs should be lowered.

In other words, it has been revealed in the study that e-logistics is a critical factor in increasing profitability in enterprises, providing competitive advantage, and creating a sustainable business model. As a result, the theoretical and practical contributions of using e-logistics in logistics management are many. The adoption of e-logistics principles is expected to enable logistics managers to make data-driven decisions, optimize processes, and improve supply chain visibility, ultimately leading to improved customer satisfaction and overall operational efficiency. It is therefore clear that adopting e-logistics will enable businesses to gain a competitive advantage, optimize their logistics operations, and achieve overall success in today's digital age.

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