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Research Article

Assessment of Cargo Distribution Efficiency in Türkiye with Data Envelopment Analysis (DEA)

Türkiye'de Kargo Dağıtım Etkinliğinin Veri Zarflama Analizi (VZA) ile Değerlendirilmesi

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Öz

Bu çalışma, Türkiye'deki kargo dağıtım sektöründe faaliyet gösteren firmaların göreli etkinliklerini Veri Zarflama Analizi (VZA) yöntemi kullanarak değerlendirmeyi amaçlamaktadır. Veri zarflama analizi etkinlik ölçümünde kullanılan, popüler, akademik çevrelerce de kabul gören ve çok çeşitli alanlarda kullanılan bir analiz türüdür. Çalışmada sektördeki önde gelen 6 adet firması ve bir adet sektörde yer alan nispeten daha küçük firmaları temsil etmek üzere diğer firmalar adında bir değişken oluşturularak toplam 7 adet değişken ele alınmıştır. Çalışma kapsamında bütün değişkenler yüzdesel olarak dönüşümü yapılmıştır. Girdi değişkeni olarak çalışan sayısı, şube sayısı, 1/şikâyet sayısı verileri temsil ediyorken, çıktıları ise taşınan kargo miktarı ve gelir miktarı temsil etmektedir. Ölçeğe göre değişken getiri varsayımı kullanılarak etkinlik analizi ve çıktı odaklı ve çoklu yıllar kullanılarak Malmquist VZA modeli kullanılmıştır. Sonuçlar incelendiğinde her dönemde iki, üç firmanın etkin olduğu, diğer firmanın çeşitli sebepler ile etkin olmadığı ve firmaların arasında müşteri geçişlerinin olduğu bulunmuştur. Etkin olmayan firmaların operasyonel, personel ve teknik verimlilik konularında problem yaşadığı, bu problemleri çözen firmaların daha etkin olduğu bulunmuştur. Çalışma, Türkiye kargo sektöründe etkinlik ve verimlilik artışına yönelik politika önerileri sunarak literatüre ve sektöre katkı sağlamaktadır.

Anahtar Kelimeler: *Kargo, Dağıtım, Vza, Etkinlik, Toplam Faktör Verimliliği*

Abstract

This study aims to assess the relative efficiency of firms in Türkiye's cargo distribution sector using the Data Envelopment Analysis (DEA) method. DEA is a widely recognized approach for measuring efficiency, supported by academic communities and applicable in various fields. In the analysis, seven variables were considered, encompassing six leading firms in the sector and one additional firm representing relatively minor companies. Within the scope of the study, all variables were transformed into percentages. While the number of employees, branches, and customer complaints were considered, the output variables focused on the amount of cargo transported and revenue generated. The efficiency analysis was conducted under the assumption of variable returns to scale, employing the Malmquist DEA model with an output-oriented approach over multiple years. Upon reviewing the results, it was determined that two or three firms demonstrated efficiency in each of the

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periods. In contrast, the remaining firms exhibited inefficiencies due to various issues, including customer shifts between companies. Inefficient firms faced challenges in operational, personnel, and technical efficiencies; firms that solve these problems are more efficient. The study contributes to the literature and the sector by providing policy recommendations for increasing efficiency and productivity in the Turkish cargo sector.

Keywords: *Cargo, Distribution, DEA, Efficiency, Total Factor Productivity*

1. Introduction

In the globalizing world economy, the logistics sector is viewed as a strategic element that determines the competitive power of countries. Especially during the COVID-19 pandemic, the rapid spread of e-commerce and changes in consumer behavior have further increased the importance of cargo distribution services (Guo et al., 2021). This situation necessitates companies operating in the sector to continuously review and improve their operational efficiency (Ivanov, 2020). Türkiye's geographical location, serving as a connecting point between Europe, Asia, and Africa, makes it a strategic hub for international logistics. In addition to this advantageous location, the developing technological infrastructure and increasing population potential offer growth opportunities for the Turkish cargo sector at both the national and international levels (Aydin, 2022). However, to capitalize on these opportunities, it is necessary to evaluate the current performance of companies operating in the sector using objective criteria and identify areas for improvement.

The primary objective of logistics is to deliver the right product to the right place at the right time and at the ideal cost (Türkoğlu, 2022). Logistics involves the effective planning, implementation, and control of the flow of materials, information, and finances from the point of production to the point of final consumption, which significantly impacts a company's performance (Pinar & Diken, 2020). One of the sub-branches of logistics is cargo transportation. Cargo transportation refers to the transportation of goods and commodities within the same city, between cities, or between countries at a specified time according to established standards. This activity covers both individual and corporate customers. Cargo transportation provides a comprehensive range of services, from small-scale personal shipments to large-scale corporate logistics. In recent years, the increasing number of people using computers, phones, and tablets has rapidly expanded e-commerce, which has no spatial or temporal boundaries (Karabulut, 2019). The rapid growth in the sector has increased the importance of the logistics and cargo distribution sector. The timely and secure delivery of ordered products is a crucial factor in ensuring customer satisfaction. Karadeniz and Işık (2014) emphasized the significance of timely delivery in enhancing customer satisfaction in their study on logistics services in e-commerce (Karadeniz & Işık, 2014).

The efficiency of cargo companies is a critical factor in ensuring customer satisfaction and gaining a competitive advantage. Due to the growth of e-commerce and increasingly competitive conditions, logistics activities are becoming increasingly complex and costly (Karabulut et al., 2023). An efficient cargo distribution system offers advantages such as efficient use of resources, timely delivery, and low costs. Air cargo transportation, which is both expensive and faster than traditional transportation, has undergone significant development over the last 20 years. In particular, air cargo transportation has developed various strategies to increase its efficiency, as it is required to transport products of different sizes to a specific area within certain rules (İnan, 2018). From a physical perspective, various models are employed to increase efficiency, such as the use of loading pallets and containers of different sizes. From a software perspective, the arrangement of pallets or containers is optimized according to weight to enhance the aerodynamics of the aircraft.

2. Literature review

Cargo transportation activities in Türkiye have started to be redefined as the transportation of individual and e-commerce packages rather than traditional commercial cargo services. Changes in social needs and technological advances have increased the social importance of cargo transportation services and brought a new dimension to the sector. The widespread use of the Internet and the increase in the number of devices connected to the Internet have laid the groundwork for the significant growth of e-commerce in developing countries. The development shaped by the impact of e-commerce has radically transformed people's social life (Bolis & Maggi, 2003). This transformation process, combined with the continuous increase in e-commerce volume and the rise in customer expectations, leads cargo companies

to develop innovative methods to increase their operational efficiency. Strategic collaborations with international firms play a critical role in the development of these methods. While local firms have been dominant in the Turkish cargo services sector for many years, international delivery companies carry out their market activities in cooperation with local firms. While the number of authorized companies in the sector is 62, 37 of these are local companies (BTK, 2024).

When the academic studies on the cargo sector are examined, it is seen that the weight is in large cargo sizes measured in thousands of tons, and small package transportation is a little more in the background. The fact that studies on the transportation of small cargo packages are handled in different dimensions is due to the dynamics of the sector. Academic studies on the transportation of small cargo packages are handled in 4 ways: firm performance and efficiency measurement, service quality and customer satisfaction, cargo company selection with the help of multi-criteria decision-making methods, and sustainable distribution methods.

2.1 Efficiency and Performance Evaluation Studies in the Cargo Sector

Measuring the operational efficiency of cargo firms is important for the survival of the firms, given the competitive structure of the sector. In this context, Data Envelopment Analysis (DEA), which is frequently used to measure efficiency and productivity, stands out.

In 2016, Ma and Ahn tested the efficiency of firms using Data Envelopment Analysis in Korea, Japan, and a global cargo distribution efficiency study. In the study, cargoes were divided according to firms and sizes and tested with data from three years between 2011-2014. As a result of the test, it was observed that the efficiency values of Korean firms were higher than those of global firms. The transportation efficiency of medium-sized packages was found to be more efficient than that of large packages, despite the higher unit cost (Ma & Ahn, 2016). This study is an important methodological guide on how DEA can be applied to efficiency measurement in the cargo sector.

In the performance evaluation of cargo companies, Tüysüz and Şimsek conducted a study in 2017, which examined the factors affecting the performance of a Turkish cargo company in Türkiye. The study analyzed seven main factor groups (operational, human resources, financial, customer relations, sales and marketing, safety and security, cooperation with other units) using the fuzzy AHP method and found that safety and security factors have the highest importance (Tüysüz & Şimşek, 2017). The study revealed that firm performance should be evaluated not only by operational efficiency but also by taking into account multidimensional factors.

2.2. Customer Satisfaction and Service Quality Research

In the cargo industry, customer expectations and service quality play a decisive role for companies to gain a sustainable competitive advantage. Adopting a customer-oriented approach ensures that changing consumer demands are analyzed correctly and service standards are shaped in line with these expectations.

In the study conducted by Özydın et al. with 469 students from Süleyman Demirel University in 2019, the importance of cargo services, their contribution to the economy, and the degree of meeting consumer expectations were evaluated by conducting a survey. As a result of the study, it was determined that reliability and on-time delivery are the most important criteria, and the most complaints are about not being delivered on time, price differences, difficulties in product return, and staff attitudes (Özaydın et al., 2019).

Similarly, Berivan Kızılırmak systematically analyzed 300 complaints written by users to Şikayetvar.com.tr, a 3-party complaint site of Yurtiçi Kargo, Aras Kargo, and MNG Kargo, which are important companies in the cargo distribution sector in Türkiye, in 2023. When the complaints were ranked in terms of the frequency of repetition, it was determined that the most complaints were related to non-delivery to the address, not being at the address, and the attitude of the personnel (Kızılırmak, 2023). Both studies showed that delivery reliability and staff quality are critical factors in customer satisfaction.

2.3. Cargo Carrier Selection Studies

When the studies on the cargo sector in Türkiye are examined, there are generally studies on the selection

of cargo with a multi-criteria decision-making method and customer satisfaction (Alp et al., 2019; Atmaca & Turgut, 2015; Deste & Savaşkan, 2021; Duran, 2017; Özgül et al., 2022; Ulutaş, 2020). These studies in the literature carry valuable information about the criteria on which customers or businesses make choices and contribute to understanding the competitive dynamics in the sector.

2.4. Sustainable Cargo Distribution Methods

In recent years, increasing environmental awareness and the challenges faced by urban logistics have encouraged the search for alternative and sustainable methods of cargo delivery. Studies, especially in Europe, have highlighted the effectiveness of electric bicycles and hybrid delivery models.

Ritzer et al. investigated the impact on traffic in Hamburg, Germany, as a result of the hybrid use of cargo bicycles in cargo distribution. In 2023, it was observed that the combined use of bicycles and panel vans contributed to sustainability and reduced traffic congestion (Ritzer et al., 2023). From a similar perspective, Robichet and other researchers measured the social cost of different vehicles used for cargo delivery in Paris, France. This 2023 study revealed that bicycles and electric bicycles are useful up to a certain distance, but for longer distances, the use of panel vans is more efficient. For this reason, at the end of the article, they recommended the use of a mixed system in the city of Paris (Robichet et al., 2023).

Galkin et al. conducted a study in the Czech Republic on cargo delivery with electric bicycles for sustainability in a medium-sized city. In this study, they aimed to reduce carbon emissions and improve cargo operations with an innovative approach by using different types of electric bicycles. At the end of the study, it was revealed that carbon emissions, traffic congestion, and operating costs can be significantly reduced as a result of distributing electric bicycles and thus contribute to companies in the name of sustainability (Galkin et al., 2025).

As seen in the literature, the use of electric bicycles has a positive impact on the environment. However, the use of electric bicycles in cargo delivery is not common in Türkiye; some delivery companies prefer to use motorcycles. The main reason for this is the geographical conditions in Türkiye.

2.5. Gaps in the Literature and Contribution of the Study

As a result of the literature review, it is seen that the studies on the cargo sector in Türkiye are mainly focused on issues such as company selection, customer satisfaction, and service quality. Although the concepts of efficiency and effectiveness in the sector directly affect firms, they have been indirectly addressed in the literature. Based on this gap in the literature, the current study seeks answers to the following questions:

- What is the operational efficiency performance of firms operating in the Turkish cargo sector?
- In which direction do the efficiency trends of firms operating in the Turkish cargo sector move over time?
- How can the impact of customer satisfaction levels on firm efficiency and market performance be evaluated?

In line with these research questions, the study aims to evaluate the efficiency of cargo distribution firms in Türkiye using the DEA method, to identify the best-performing firms in the sector, and to make recommendations accordingly. In the study, relative efficiency scores will be calculated by analyzing the relationship between the inputs and outputs of the firms, the improvement potential of the firms will be revealed, and policy recommendations for the sector will be developed. In this respect, the study will fill the gap in the literature on efficiency measurement in the Turkish cargo sector and provide important managerial implications for the sector managers with the research questions mentioned above.

3. Method

This study aims to evaluate the current situation by systematically examining the data of cargo distribution companies and to offer suggestions for improvement. The process begins with identifying the current status of cargo companies, followed by researching data belonging to these companies and preparing an appropriate data set in a suitable software environment. After completing these preparatory stages, Data Envelopment Analysis (DEA) is performed using DEAP software, and the results are

interpreted. In this study, Grammarly Pro was used for English grammar checking.

3.1. Detailed explanation of the data envelopment analysis method

Data Envelopment Analysis (DEA) is a method used to measure organizational efficiency using multiple input and output variables. DEA is based on linear programming techniques and determines the relative efficiency of firms (Thanassoulis, 2001). This method is widely used in the cargo sector for performance evaluation and identification of areas for improvement (Güdelek et al., 2024).

DEA began with the work first presented by Farrell in 1957 and published by Charnes et al. (1978) as the CCR model. DEA is a method that examines the relationship between multiple inputs and multiple outputs and performs linear-based efficiency calculations (Charnes et al., 1978). The BBC model, developed by Banker et al. (1984), measures technical efficiency by comparing units of similar scale under the VRS (variable returns to scale) assumption (Yıldırım & Ayvaz, 2019). DEA analyses are utilized in a wide range of fields, including health, education, banking, agriculture, livestock, aviation, logistics, manufacturing, urban planning, and regional development. The BCC model is an extended version of the CCR model. Like the CCR model, this model has two approaches: input-oriented and output-oriented. In the input-oriented BCC model, inputs are minimized based on the assumption of variable returns to scale. In the output-oriented BCC model, the main objective is to maximize output. In our study, the output-oriented model was used. The mathematical calculation of the model is explained below. (1) represents the objective function, while (2) and (3) represent the constraints.

$$\max e_0 = \sum_{r=1}^{s} u_r \, y_{ro} \tag{1}$$

The model's limits are given in equations (2) and (3).

$$\sum_{r=1}^{s} u_r \, y_{rj} - \sum_{i=1}^{m} v_i \, x_{ij} \tag{2}$$

$$\sum_{i=1}^{m} v_i \, x_{io} = 1 \tag{3}$$

Equivalents and meanings of symbols

r= 1,2,…….,s

i= 1,2,……..,m

m= number of inputs

s= number of outputs

u_r= weight value for outputs from 0 to r

v_i = weight value for inputs from 0 to i

x_{io} = amount of input from 0 to i

y_{ro}= amount of output from 0 to r

x_{ij} = amount of input from i to j

y_{rj} = amount of output from r to j

Scale efficiency is calculated by dividing the total efficiency value obtained from the CCR model by the technical efficiency values obtained from the BBC model (Cooper et al., 2000). If the scale efficiency equals 1, the system is operating at optimal efficiency; if it is less than 1, improvements are needed to increase efficiency.

$$Scale\ Efficiency = \frac{Total\ Activity_{CCR}}{Technical\ Activity_{BBC}}$$

The main reasons why the DEA method is so widely preferred are its objectivity, ability to combine different data, efficiency, and applicability in both academic and practical settings (Ayrıçay & Özçalıcı, 2015).

DEA is frequently preferred in scientific research. Its free availability, ability to compare multiple years, versatility, and capability to perform input or output-based calculations make it a preferred choice for efficiency calculations.

3.2. Introduction of data set and variables

For consumers in Türkiye, there are generally no major differences between cargo companies. Most of the consumers make decisions in the light of reasons such as habit or price difference. There are closely competing brands in the cargo sector in Türkiye (Ilicali et al., 2016). The most important feature that distinguishes these companies from each other is that the service provided from region to region and from branch to branch does not meet the same standard.

3.2.1. Determination of Input and Output Variables

The input and output variables used in the study were determined on the basis of the methods used in similar studies in the literature. The inputs of the study include the percentage of the number of personnel working in the cargo sector according to the companies, the percentage of branch branches of the companies, the percentage of the total amount of complaints published about the company according to the companies. In the outputs section, the percentage distribution of the total number of cargo transported according to the companies and the percentage share of the companies in terms of income from the sector are included. Details are presented in Table 1.

Table 1: Data Set Variables and Sources

Items	Input/Output	Source
Number of Employees	Input	BTK
Number of Branches	Input	Company Websites
Number of Complaints	Input	www.sikayetvar.com.tr
Amount of Cargo Transported	Output	BTK
Amount of Revenue	Output	BTK

Deste and Savaşkan (2021) used data on the number of branches, number of personnel, and number of complaints in a similar study. However, this study differs from the literature.

3.2.2. Data Normalization and Methodological Differentiation

The most important methodological innovation that distinguishes it from other studies is the way the number of complaints is treated. While the studies in the literature include the number of complaints directly as an output variable, in this study, the inverse of the number of complaints (1/number of complaints) is used as an input variable. The main reason for adopting this approach is the emergence of a situation that is incompatible with the principle of minimizing inputs and maximizing outputs due to the nature of DEA. Since it is desirable to reduce the number of complaints, inverting this variable provides a more analytically consistent approach. In addition, there are large-scale differences between the variables in the data set. While the number of complaints is expressed in hundreds of thousands, other variables are in 3-4 digits. These differences between the numbers cause the analysis results to be inaccurate. All variables were recalculated and processed in percentage units in order to proceed more accurately. If this normalization process is not performed, the analysis results are meaningless and uninterpretable.

3.2.3. Data Sources and Use of Complaint Data

As a data set, data from the third-party online service provider şikayetvar website and the sectoral data

of the Turkish Information and Communication Technologies Authority (BTK) on the cargo sector were used, as used in previous similar studies. BTK publishes sectoral data in 6-month periods. Complaints about cargo transportation are made individually by citizens to the Presidential Communication Center (CIMER). Although the number of these complaints is included in the BTK reports, the data of the 3rd party communication method, the şikayetvar website, was preferred due to the low number of complaints and the idea that it does not fully reflect the current situation.

A complaint is an evaluation process in which expectations are compared with actual performance (Clark, 2013). Companies should carefully analyze complaints and use them to improve themselves in this highly competitive sector. In this regard, the percentage distribution of the number of complaints received by BTK by subject matter provides a valuable perspective to understand the main problem areas in the sector. Details are presented in Figure 1.

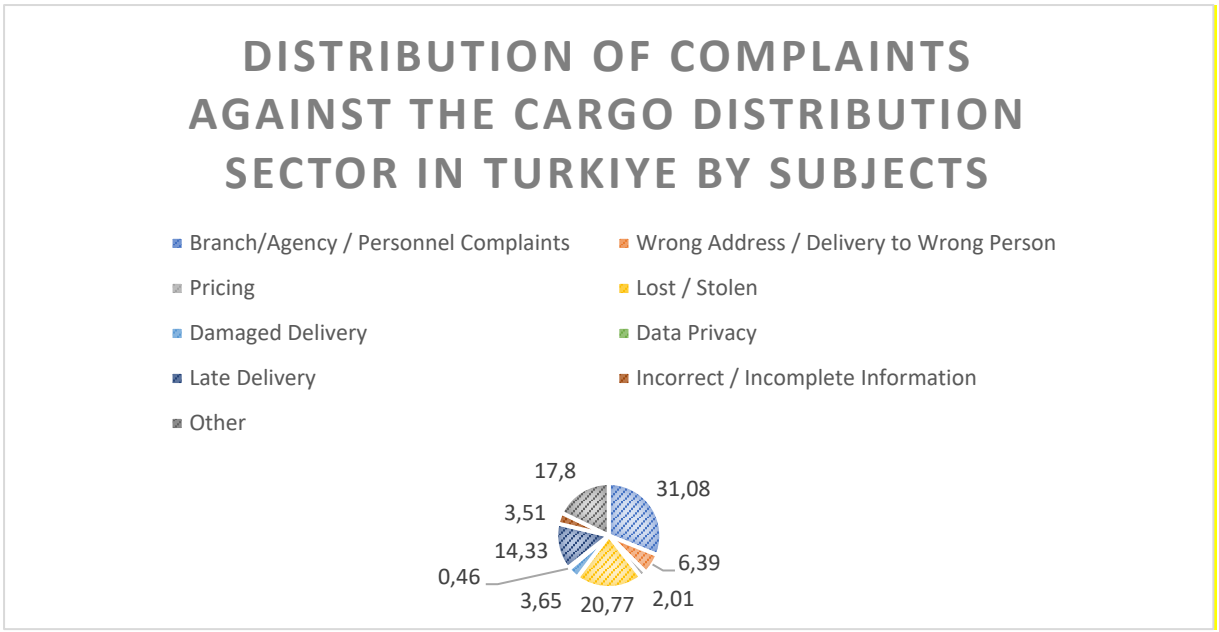


Figure 1: Distribution of Complaints Regarding the Turkish Cargo Distribution Sector by Subject (Source: BTK 2024/2 Türkiye Postal Sector Market Data Report)

An analysis of the distribution of the complaints received by BTK in the 2024/2 period according to their subject matter clearly reveals the main problem areas in the cargo sector. The "Branch/Agency/Personnel Complaints" section, which constitutes 31.08% of the complaints, represents the biggest problem area in the sector. This situation shows that cargo companies have serious deficiencies in human resources management and customer service.

The second largest complaint section, "Lost / Stolen", with 20.77%, indicates inadequacies in cargo security and tracking systems. This rate constitutes a critical problem that undermines customer confidence. Damaged delivery and pricing complaints also reflect the lack of quality in operational processes.

In a study conducted in Erzurum province in 2011, Deniz and Gödekmerdan examined the attitude of customers towards the services provided by cargo companies. While the most common complaint of customers was found to be the problems experienced in cargo delivery, the least common complaint was found to be the delivery of the cargo to someone else (Deniz & Gödekmerdan, 2012). The findings of this study support the data in the BTK report above.

In online shopping, the seller informs the buyer of an estimated arrival time. In the event that this time is exceeded, buyers apply to the complaint platform due to the fact that they are unsuccessful when they try to reach the headquarters or branch to report their grievances. This situation not only victimizes the buyer but also negatively affects the image of the company. Consumers may prefer not to shop even from sellers that have an agreement with the cargo company with which they have a problem

(Kızılırmak, 2023). The distribution of complaints in the report helps to make sense of the negative impact of the number of complaints used as an input variable in the DEA analysis on firm efficiency.

3.2.4. DEA Model Setup and Determination of Firm Sample

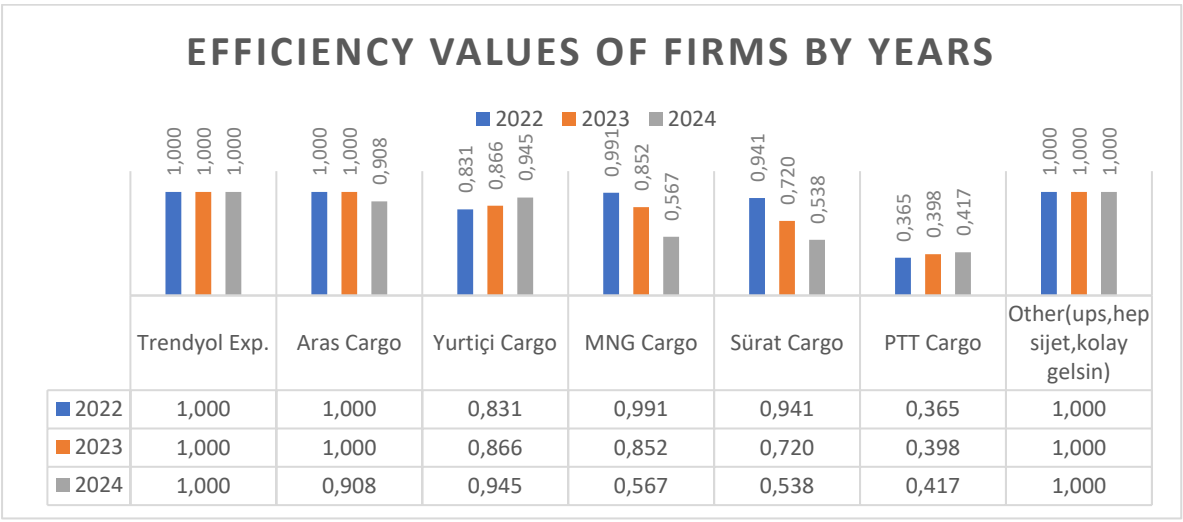
In the creation of the DEA working model, the maximum amount of data, three inputs and two outputs, was prepared by combining the data of the last three years published by BTK and the data obtained from other sources by the authors. According to the generally accepted methodological conditions of DEA analysis, the number of decision-making units (DMUs) to be used should comply with the assumption of (number of inputs + number of outputs) X 2 or (number of inputs X number of outputs) + 1. Since three inputs and two outputs were used in this study, the minimum number of firms was determined and provided as 7.

The data set was organized in the Excel program in a suitable format to be processed in version 2.1 of the DEAP software. The main reason for choosing DEAP software in this study is that it is user-friendly and allows for quick analysis of transactions (Kim & Yoo, 2019). It is also possible to perform this process through add-ins to applications such as Excel and RStudio.

In the sector reports published by BTK, the data of large companies and total figures are included in detail. However, due to the fact that the details of small market share companies are not shared separately, the distribution networks of small companies in the sector are limited, and the customers are limited or consist of certain individuals or institutions, small companies are combined and included in the analysis under the name of other companies in order to include them in the process. This approach can be considered a limitation of the study, but it was deemed appropriate by the authors to ensure a sufficient number of decision-making units for the analysis and to ensure the validity of the analysis.

4. Findings

As a result of processing the data in the study using the program, efficiency data for the companies were obtained. These values range from 0 to 1. A result of 1 indicates that the company is efficient, while a result less than 1 indicates that the company is not efficient.



	Trendyol Exp.	Aras Cargo	Yurtiçi Cargo	MNG Cargo	Sürat Cargo	PTT Cargo	Other(ups,hepsijet,kolay gelsin)
2022	1,000	1,000	0,831	0,991	0,941	0,365	1,000
2023	1,000	1,000	0,866	0,852	0,720	0,398	1,000
2024	1,000	0,908	0,945	0,567	0,538	0,417	1,000

Figure 2: Companies' Efficiency Values by Year

Figure 2 shows significant changes in the efficiency levels of companies during the analysis period. This situation may be due to high competition or structural issues within the sector related to sustainability.

According to the study's results, Trendyol Express, Aras Kargo, and the group representing other companies were efficient in 2022. In 2023, Trendyol Express, Aras Cargo, and the group representing other cargo companies were efficient. In 2024, Trendyol Express and the group representing other cargo companies were efficient. Trendyol Express, Aras Cargo, and the group representing other cargo companies are the most efficient companies.

Although PTT Cargo has a good revenue/package ratio compared to its competitors, the high number of

employees and branches reduces its efficiency ratio. Trendyol Express, on the other hand, is efficient despite its low revenue-to-package ratio, thanks to its small number of employees and branches.

The results of the DEA reference group analysis identify specific areas for improvement among companies in the sector. PTT Cargo has excess branches and personnel based on the operations performed. To become more efficient, PTT Cargo should adopt the efficiency model of Trendyol Express and the agility of the group, which represents other companies. For MNG Cargo, reducing the number of complaints is the top priority. Customer service should be restructured for more efficiency. Radical operational transformations are necessary for domestic cargo.

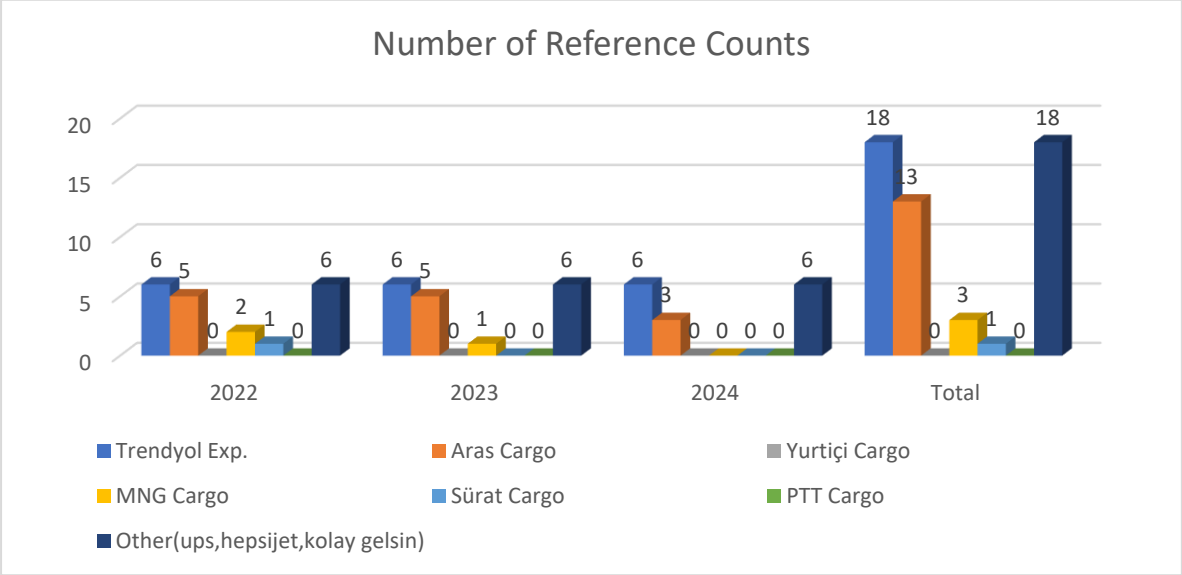


Figure 3: Number of References

The reference graph in Figure 3 is a representative example showing which efficient companies and inefficient companies should be taken as examples. According to the results obtained from this study, Trendyol Express and other companies representing other cargo companies that were active during the three periods were referenced 18 times each and served as examples for the sector.

Aras Cargo was active for two periods and was referenced a total of 13 times. On the other hand, the fact that other companies were not referenced at all or only very rarely indicates that they need to make fundamental changes in line with their current input and output combinations and that there are important practices they can learn from efficiency companies in the sector. The frequency of references can also be used to objectively assess companies' operational excellence levels.

The Malmquist Index is a key indicator used to measure productivity. According to this technique, when the results exceed 1, companies have demonstrated improvement compared to the previous year. When the results are less than 1, there is a decline. Table 2 presents the Malmquist Index and productivity results for companies from 2022 to 2024.

Table 2: Malmquist Index results for cargo companies

firm	effch	techch	pech	sech	tfpch
Trendyol Exp.	1,000	0,947	1,000	1,000	0,947
Aras Cargo	0,953	0,855	1,000	0,953	0,815
Yurtiçi Cargo	0,956	1,048	0,897	1,066	1,002
MNG Cargo	1,044	1,017	1,381	0,756	1,062
Sürat Cargo	0,899	0,842	1,189	1,069	1,039
PTT Cargo	1,090	0,953	1,069	1,000	1,040
Others (UPS,hepsijet,kolay gelsin)	1,000	0,961	1,000	1,000	0,961
Mean	0,990	0,943	1,060	0,934	0,934

During the analysis period, companies generally observed an increase in productivity. Although MNG Cargo performed well throughout the analysis period, its effectiveness was hindered by the negative impact of other factors. The high number of complaints against the company, the fact that the number of branches did not increase in line with the sector's growth, and the decrease in the number of employees compared to the total number of employees in the sector caused the company to fall behind other institutions.

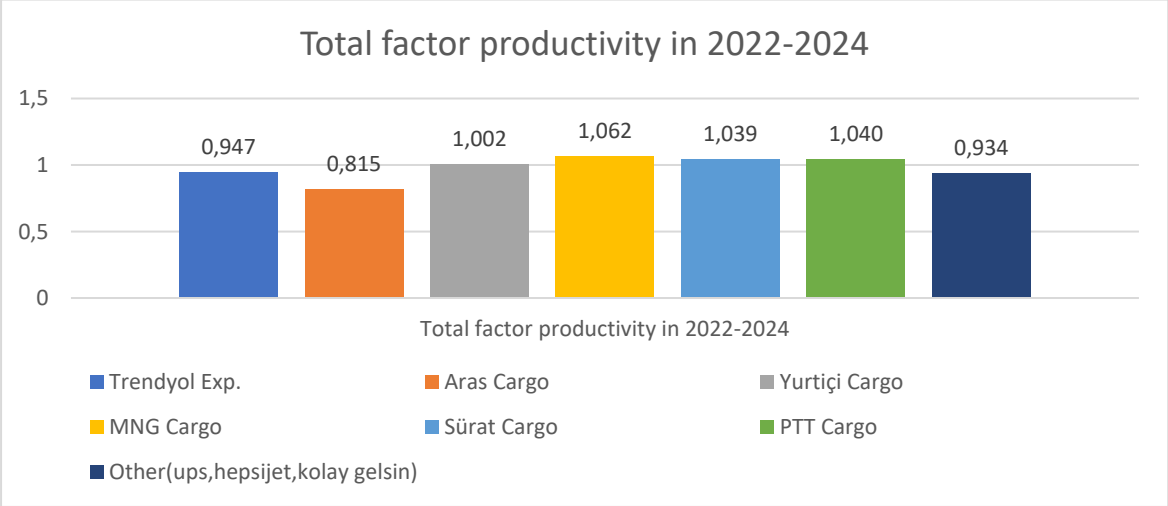


Figure 4: Malmquist Total Factor Productivity

The cargo distribution sector in Türkiye is experiencing rapid growth. However, excessive losses in efficiency are reducing the sector's profitability. While logistics costs account for 14% of GDP worldwide, this figure is around 22% in Türkiye. This situation suggests that there is a significant efficiency issue in the sector. Newly established companies are struggling to achieve efficiency, while established companies are experiencing a decline in efficiency due to the entry of new competitors into the market. The rapid growth of e-commerce in Türkiye has led to an increase in revenue for cargo companies. Some companies in the sector, unable to meet the demand of e-commerce, have established their cargo distribution networks. In today's highly competitive business world, customer satisfaction has become a crucial factor for companies to thrive and expand. A study conducted by Aşır Özbek in 2024 revealed that criteria such as timely delivery, problem resolution, and accessibility are important for customer satisfaction. At the end of the study, a ranking was made based on customer preferences using the MOORA method, resulting in the following preference order: Trendyol Express > Yurtiçi Cargo > MNG Cargo > Aras Cargo > Sürat Cargo > Others > PTT Cargo (Özbek, 2025). Assuming that results vary by region and preferences are made on a personal basis, the study can be considered consistent with the literature.

5. Discussion and Conclusion

When examining the efficiency table resulting from the study, it is evident that the companies' activities underwent significant changes and that competition was intense. Trendyol Express and the group representing other cargo companies were effective for three periods, thanks to their growing market share and revenue share. The situation is different for other companies. Customer satisfaction and preference influence companies periodically. Companies are either effective or ineffective depending on customer preferences. This situation indicates a customer transfer between companies. In this regard, the fact that the number of annual customer complaints remained at similar levels throughout the periods indicates that companies need to pay more attention to this issue.

The strengths of this study lie in the fact that it is the first efficiency analysis conducted using multi-year data on cargo distribution companies in Türkiye, thereby filling a gap in the literature. Researchers conducting similar studies have generally focused on efficiency analysis for a single year and then proceeded to ranking or selection using multi-criteria decision-making methods. In this study, however, it is possible to observe the difference in efficiency between companies over time. Companies will be able to track whether the strategies they have followed over the years have been effective or not. At the

same time, by the end of this study, readers will be able to assess the efficiency of companies, as well as the progress and challenges faced by the sector. The study's weaknesses include that the efficiency results are relatively limited due to the limited data processed. Furthermore, the number of complaints is crucial for analyzing customer satisfaction in the industry. Although we cannot assume that everyone who is dissatisfied with the service or product they received has filed a complaint, the high number of complaints in the table indicates that the industry is not at the desired level.

In this study, the efficiency performance of companies operating in the Turkish cargo distribution sector was analyzed using the Malmquist Total Factor Productivity Index. The results of the output-oriented Data Envelopment Analysis conducted using DEAP 2.1 software have revealed the efficiency dynamics in the sector. The Malmquist index results presented in Table 3 reveal the efficiency performance of cargo companies in the 2022-2024 period. The Malmquist efficiency index analysis measures the performance of shipping companies based on five key components. The eefch value indicates how well companies utilize their own sources, the techch value indicates technological developments and innovations within the sector, the pech value indicates management competence of companies, the sech value indicates whether companies are operating at an optimal size, the tfpch shows the combined effect off all factors, revealing companies' overall productivity performance. The value greater than 1 indicates progress, while the value less than 1 indicates regression. The sector average decreased by 9.9% in total factor productivity to 0.901. The main reasons for this decline are technological decline and a decrease in scale efficiency. The constant increase in population, the expansion of residential areas in cities, the rise in the number of online shoppers, and customers' desire for access to products are forcing companies to technologically renew themselves. To increase the sector's sustainable growth and competitiveness, it must first make comprehensive investments in technological renewal and digital transformation. The integration of automation, artificial intelligence, big data analytics, and IoT technologies will be critical steps in reversing technological decline. In addition, redesigning the network structure for scale optimization, improving capacity planning, and enabling operational processes are necessary. Malmquist's results guide us in this regard. The successful performance of PTT Kargo and MNG Kargo sets an example for other companies in the sector. Analyzing and sharing the best practices of these companies across the sector can contribute to raising the overall level of efficiency. The positive development in pure technical efficiency demonstrates that companies have the capacity for operational improvement and is considered a promising indicator. In the coming periods, enhancing the technological infrastructure of the sector, making more effective use of economies of scale, and developing sustainable growth strategies will be critical for maintaining and increasing competition.

When examined in terms of efficiency, three companies achieved full efficiency in 2022, three companies in 2023, and two companies in 2024. Trendyol Express, PTT Cargo, and the group representing other cargo companies were efficient in 2022, 2023, and 2024. Multiple factors drive the low efficiency observed in the cargo distribution sector. At the operational level, route optimization is one of the most critical issues in the sector. Outdated tracking systems and the fact that cargo companies, other than PTT Cargo, are private sector entities with high employee turnover rates, inadequate training programs, and low motivation are among the challenges hindering the efficiency of these companies.

Logistic management is of vital importance for businesses seeking to achieve their strategic objectives in terms of competitiveness, time management, and service quality, particularly in today's economic environment, where trade is globalizing, and industrial cycles are becoming more rapid. Advances in technological infrastructure, the increasing complexity of trade flows, intensifying global competition, and economic trends focused on sustainable development directly influence and shape developments in this field. In this regard, the design and planning of logistics networks have become increasingly important for both business managers and academic researchers. Digital route optimization and vehicle planning systems reduce fuel and labor costs by making more deliveries with fewer miles, ensuring operational efficiency and environmental sustainability. Blockchain technology increases trust in high-value cargo by keeping track of all stages of the supply chain with unchangeable records and protecting personal information.

Limitations of the study include the relative nature of the results due to limited data and the collection of complaint data from the single platform (sikayetvar.com). Although it is assumed that not all customers report their complaints, the current number of complaints indicates that the sector needs

improvement in service quality. The absence of a centralized system for complaint management in Türkiye, uncertainties between consumer rights and company comments, and a lack of adequate follow-up on complaints enforcement complicate the data collection process. Although the sikayetvar.com platform was preferred due to its online accessibility, user-friendliness, and widespread use, the fact that other platforms are excluded constitutes a limitation. For future research, this method can be revisited or modified to include additional variables such as environmental factors (CO2 emissions, cargo bikes, number of electric vehicles, reduction in paper usage due to digitalization), on-time delivery rates, customer satisfaction levels, and shipping costs.

The Turkish cargo distribution sector is undergoing a significant transformation in tandem with the growth of e-commerce. Companies that make progress in technological investments, operational optimization, and human resources development are expected to achieve sustainable success. Maintaining the sector's long-term competitive strength is not only dependent on the efforts of companies but also on sectoral cooperation, public policy support, and the development of a technological ecosystem. Türkiye has significant potential in this area due to its geographical location. Evaluating this potential by both the sector and the public is essential for the growth and sustainability of the country and companies.

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Araştırma Makalesi

Türkiye'de Kargo Dağıtım Etkinliğinin Veri Zarflama Analizi (VZA) ile Değerlendirilmesi

Assessment of Cargo Distribution Efficiency in Türkiye with Data Envelopment Analysis (DEA)

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Genişletilmiş Özet

Küreselleşen dünya ekonomisinde lojistik sektörü, ülkelerin rekabet gücünü belirleyen stratejik unsurlardan biri olarak görülmektedir. Özellikle COVID-19 pandemisi sürecinde, e-ticaretin hızla yaygınlaşması ve tüketici davranışlarındaki değişim, kargo dağıtım hizmetlerinin önemini daha da artmaktadır. Bu durum sektörde faaliyet gösteren firmaların operasyonel etkinliklerini sürekli olarak gözden geçirmeleri ve iyileştirmelerini gerekli kılmaktadır. Türkiye'nin coğrafi konumu itibariyle Avrupa, Asya ve Afrika kıtalarını birbirine bağlayan bağlantı noktası işlevi, ülkeyi uluslararası lojistik açısından stratejik bir merkez haline getirmektedir. Bu avantajlı konumunun yanı sıra, gelişen teknolojik altyapı ve artan nüfus potansiyeli, Türk kargo sektörünün hem ulusal hem de uluslararası düzeyde büyüme fırsatları sunmaktadır. Ancak bu fırsatların değerlendirilebilmesi için sektörde faaliyet gösteren firmaların mevcut performanslarının objektif kriterlerle değerlendirilmesi ve iyileştirme alanlarının belirlenmesi gerekmektedir.

Kargo firmalarının etkinliği hem müşteri memnuniyetini sağlamak hem de rekabet avantajı elde etmek için kritik bir faktördür. E-ticaretteki büyüme, artan rekabet koşulları nedeniyle lojistik faaliyetleri gittikçe karmaşıklaşmakta ve maliyetleri artmaktadır. Türkiye'de kargo taşımacılığı faaliyetleri, geleneksel ticari kargo hizmetinden ziyade bireysel ve e-ticaret paketlerinin taşınması şeklinde yeniden tanımlanmaktadır. Toplumsal ihtiyaçlardaki değişimler, teknolojik ilerlemeler, kargo taşıma hizmetinin toplumsal önemini arttırmakta ve sektöre yeni bir boyut kazandırmaktadır. İnternetin yaygınlaşması ve internete bağlanan cihaz sayısındaki artış, gelişmekte olan ülkelerde e-ticaret ciddi oranlarda büyümesine altyapı hazırlamaktadır. E-ticaretin etkisiyle şekillenen gelişim, insanların toplumsal yaşamını köklü bir şekilde dönüştürmektedir. Dönüşüm süreci, e-ticaret hacmindeki sürekli artış ve müşteri beklentilerindeki yükselme ile birleşerek, kargo firmalarını operasyonel etkinliklerini arttıracak yenilikçi yöntemler geliştirmeye yöneltmektedir. Bu yöntemlerin geliştirilmesi sürecinde uluslararası firmalarla kurulan stratejik iş birlikleri kritik bir rol oynamaktadır. Türkiye kargo hizmetleri sektöründe uzun yıllardır yerel firmalar dominant konumda bulunurken, uluslararası dağıtım yapan firmalar yerel firmalar ile iş birliği yaparak pazar faaliyetlerini gerçekleştirmektedir. Sektörde yer alan yetki almış firma sayısı 62 iken bunun 37 si yerel firmalardan oluşmaktadır.

Bu çalışma, Türkiye'deki kargo dağıtım sektöründe faaliyet gösteren firmaların göreli etkinliklerini Veri Zarflama Analizi (VZA) yöntemi kullanarak değerlendirmeyi amaçlamaktadır. Veri zarflama analizi etkinlik ölçümünde kullanılan, popüler, akademik çevrelerce de kabul gören ve çok çeşitli alanlarda kullanılan bir analiz türüdür. VZA konu ile ilgili uluslararası kargo sektöründe, sağlık, imalat sektöründe, hava taşımacılığı ve lojistik gibi birçok akademik çalışmada kullanmış, bilimsel açıdan

kabul görmektedir. Literatür incelendiğinde kargo dağıtım etkinliği ile ilgili doğrudan bir çalışma olmamakla beraber benzer amaçlarla ve farklı girdi-çıktı değişkenleri kullanılarak gerçekleştirilmiş çalışmalar bulunmaktadır. Çalışmada sektördeki önde gelen 6 adet kargo firması ve sektörde yer alan nispeten daha küçük firmaları temsil etmek üzere diğer firmalar adında bir değişken oluşturularak toplam 7 adet değişken ele alınmaktadır. Çalışma kapsamında ki değişkenler arasında farklılıkların büyük olması, sonuçları etkilemese dahi yanlış anlaşılmalara sebebiyet verebilmektedir. Buradan hareket ile bütün değişkenlerin yüzdesel olarak dönüşüm işlemi yapılmış ve analize tabii tutulmuştur. Girdi değişkeni olarak çalışan sayısı, şube sayısı, 1/şikâyet sayısı verileri temsil ediyorken, çıktıları ise taşınan kargo miktarı ve gelir miktarı temsil etmektedir. Şikâyet sayısının normalde sonuç kısmında kullanılırken bu çalışma sektörlerin kar ve payı odaklı olarak yapılması sebebi ile ters orantılı olarak giriş kısmında yer almaktadır. Ölçeğe göre değişken getiri varsayımından hareket ile etkinlik analizi, çıktı odaklı ve çoklu yıllar kullanılarak Malmquist VZA modeli çalışmada kullanılmaktadır.

DEAP 2.1 yazılımı ile gerçekleştirilen çıktı yönelimli VZA sonuçları, sektördeki verimlilik dinamiklerini ortaya koymaktadır. Sektör ortalaması 0,901 ile toplam faktör verimliliğinde %9,9'luk düşüş yaşanmaktadır. Bu düşüşün temel nedeni teknolojik gerileme ve ölçek etkinliğindeki azalmadan kaynaklanmaktadır. Firma bazında incelendiğinde PTT Kargo ve MNG Kargo en yüksek performansı göstermektedir. MNG Kargonun etkinlik performansına rağmen teknolojik gerilemedeki etki firmanın etkinliğini etkilemektedir. Malmquist bileşenlerinde saf etkinlik değişimi pozitif gelişim gösterirken, ölçek etkinliği ve teknolojik değişim olumsuz seyretmektedir. Bu sonuçlar, sektörün teknolojik yenilenme ve ölçek optimizasyonu konularında iyileştirmelere ihtiyaç duyduğunu göstermektedir.

Araştırma bulguları etkinlik açısından incelendiğinde 2022 yılında 3 firma, 2023 yılında 3 firma ve 2024 yılında 2 firma tam etkinlik seviyesine ulaşmıştır. Trendyol Express, PTT Kargo ve diğer kargo şirketlerini temsil eden grup 2022, 2023, 2024 yıllarında etkin olmuştur. Kargo dağıtım sektöründe gözlenen etkinlik düşüklüğünün arkasında çok boyutlu faktörler bulunmaktadır. Operasyonel düzeyde rota optimizasyonu sektörün en kritik sorunlarındandır. Eski tip takip sistemleri ve PTT Kargo dışında kalan kargo firmalarının özel sektör kuruluşu olup yüksek personel devir hızlarına sahip olmaları, yetersiz eğitim programları, düşük motivasyon firmaların etkin olması önündeki zorluklardandır.

Gelecekteki araştırmalar için çevre faktörleri (CO_2 emisyonu, kargo bisikletleri, elektrikli araç sayısı, dijitalleşme ile kullanılan kâğıt sayısındaki azalma gibi), teslimatın zamanında yapılma oranları, müşteri memnuniyet dereceleri ve kargo ücreti gibi değişkenlerinden çalışmaya eklenerek geliştirilmesi önerilmektedir. Türkiye kargo dağıtım sektörü, e-ticaretin büyümesi ile birlikte kritik bir dönüşüm içerisindedir. Teknolojik yatırımlar, operasyonel optimizasyon ve insan kaynakları gelişimi konusunda ilerleme kaydeden firmalar sürdürülebilir başarı elde etmesi beklenmektedir. Sektörün uzun vadeli rekabet gücünün korunması, sadece firmaların çabalarıyla değil, sektörel iş birliği, kamu politikası desteği ve teknolojik ekosistemin geliştirilmesi ile mümkündür. Türkiye coğrafi konumu sebebiyle bu alanda ciddi potansiyel taşımaktadır. Bu potansiyelin sektör tarafları ve kamu tarafından değerlendirilmesi, ülke ve firmaların büyümesi ve sürdürülebilirlik açısından bir gerekliliktir.