



Detection of Sustainable Logistics Sub-Components and Determination of Impact Levels of Sustainable Logistics Components with Dematel Method

Sürdürülebilir Lojistik Alt Bileşenlerinin Tespiti ve Sürdürülebilir Lojistik Bileşenlerinin Etki Düzeylerinin Dematel Yöntemi ile Belirlenmesi

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Abstract

Sustainable logistics can be defined as all logistics activities carried out by preserving and maintaining the present and the future for generations in environmental, economic, and social dimensions. In the study, the impact levels and sub-components of the main components in environmental, economic, and social dimensions, which are important for sustainable logistics, are examined. When the environmental dimension is examined, it is seen that its sub-components are use of resource (energy, water, material, etc.), water/soil pollution, greenhouse gas emissions, noise pollution, and waste management. When the sub-components of the economic dimension are examined, it includes the components of product and service quality, cost minimization, recycling, market share/growth, and goods transport intensity. When the sub-components of the social dimension are examined, it is seen that the components of occupational health and safety, education and training, working conditions, and public health are covered. The impact levels of the main components of sustainable logistics are evaluated with the DEMATEL method, which is one of the MCDM methods. According to the DEMATEL method, while economic and environmental dimensions are in the affecting group, social dimension is in the affected group.

Keywords: Sustainable Logistics, MCDM, DEMATEL Method.

Öz

Sürdürülebilir lojistik, çevresel, ekonomik ve sosyal boyutlarda bugünü ve geleceği nesiller boyu koruyarak ve yaşatarak gerçekleştirilen tüm lojistik faaliyetler olarak tanımlanabilir. Çalışmada sürdürülebilir lojistik için önemli olan çevresel, ekonomik ve sosyal boyutlardaki ana bileşenlerin etki düzeyleri ve alt bileşenleri incelenmiştir. Çevre boyutu incelendiğinde, alt bileşenlerinin kaynak kullanımı (enerji, su, malzeme vb.), su/toprak kirliliği, sera gazı emisyonları, gürültü kirliliği ve atık yönetimi olduğu görülmektedir. Ekonomik boyutun alt bileşenleri incelendiğinde ürün ve hizmet kalitesi, maliyet minimizasyonu, geri dönüşüm, pazar payı/büyüme ve mal taşıma yoğunluğu bileşenlerini içermektedir. Sosyal boyutun alt bileşenleri incelendiğinde iş sağlığı ve güvenliği, eğitim ve öğretim, çalışma koşulları ve halk sağlığı bileşenlerinin kapsandığı görülmektedir. Sürdürülebilir lojistiğin ana bileşenlerinin etki düzeyleri, ÇKKV yöntemlerinden biri olan DEMATEL yöntemi ile değerlendirilmektedir. DEMATEL yöntemine göre ekonomik ve çevresel boyutlar etkilenen grupta yer alırken, sosyal boyut etkilenen grupta yer almaktadır.

Anahtar Kelimeler: Sürdürülebilir Lojistik, ÇKKV, DEMATEL Yöntemi.

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1. INTRODUCTION

Sustainability is all of the efforts applied to protect and maintain the existence of natural and human resources. Although sustainability is encountered in many areas of our lives, technological changes, globalization, increasing population, use of fossil fuels, and social and environmental pressures have integrated sustainability into the field of logistics. For this reason, it is seen that the logistics industry gains more importance than ever in terms of sustainability. The field of logistics is significantly impacted by Industry 4.0 in an accelerated manner and there is a constant need to use these new technologies to support sustainability by increasing efficiency, reliability, and flexibility along with saving energy and time by protecting the environment (Akkad et al., 2020).

There are different definitions of sustainable logistics. According to Chang and Qin (2008), sustainable logistics "planning, control, management and implementation of the logistics system through advanced logistics technology and environmental management aimed at reducing pollutant emission". Zhao et al. (2009), it is defined as "improving resource use, reducing resource consumption and waste, and minimizing environmental pollution through rational planning while implementing logistics activities, optimizing resource allocation and using environmental technology". Sbihi and Eglese (2010) state that "green logistics is concerned with the sustainable production and distribution of products, taking into account environmental and social factors". In general terms, sustainable logistics can be defined as all the logistics activities from the starting point to the end point of the products, which are carried out by preserving and continuing for the present and future generations in environmental, economic, and social dimensions.

A sustainable logistics system framework combines sustainable development with elements typically found in a traditional logistics system. Focusing on sustainable development and implementing a sustainable logistics system, can positively impact long-term performance goals. A sustainable logistics system will enable long-term performance goals to take steps to maximize profitability, minimize its environmental impact, and ensure that it has a positive impact on improving society's quality of life (Croom et al., 2009).

Sustainability is an essential issue in economic, social, and environmental fields. Two aims are considered in this study. As a first aim, the impact levels of the main components in environmental, economic, and social dimensions, which are essential for sustainable logistics, are taken into account. This purpose is used to help reveal which main component is affected by which conditions, which main components are affected, and which main components should be given weight. There is no study in the literature examining the effect levels of the main components. As a second aim of the study, sub-components for sustainable logistics were examined. It is thought that this aim will contribute to the development of sustainability.

In the Introduction section, which is the first part of the study, the introduction to sustainable logistics and the aim of the study is included. The literature review is handled in the second section. In the third part of the study, in the Methodology section, the definition of the problem and the details of the DEMATEL method are given. The fourth section of the study includes Results and Discussions. In the last section, the Conclusion section, the results of the study and suggestions for future studies are included.

2. LITERATURE REVIEW

Within the scope of Sustainable Logistics, there are current studies (Neto et al., 2008; Grant et al., 2017; Grzybowska and Awasthi, 2020; Lan et al., 2020; D'Amico et al., 2021; Hussein et al., 2022; Jayarathna

et al., 2022) in the literature. Elkington (1997) proposes considering three closely related economic, ecological (environmental), and social aspects of sustainability. Wichaisri and Sopadang (2013) stated in their study that a sustainable logistics system takes into account three aspects and that economic, environmental, and social areas are necessary for a logistics system. This article provides a framework for a sustainable logistics system that will address these three criteria. In the study, social criteria include the sub-criteria of health and safety and quality of life. Environmental criteria include the sub-criteria of resource usage, pollution, emission, waste, and eco-efficiency. Economic criteria include the sub-criteria of quality, responsiveness, cost, profit, and mobility. Morana and Gonzalez-Feliu, J. (2015) state in their study that the evaluation of urban logistics projects should be viewed from the perspective of sustainable development, and three dimensions (economic, environmental, and social/social) should be taken into account. Alshubiri (2017) states in his study that green logistics includes three components, the independent variables of which are economic, social, and environmental, and that these components can be applied to clarify the effect of expansionary monetary policy indicators as an important signal in determining a country's economy. Qaiser et al. (2017) state to explore the current state of research in the field of Decision Support Systems for logistics, taking into account the sustainability aspects. As a result of the study, it is seen that social impact is given less importance compared to economic and environmental aspects. Zhu and Hu (2017) examine the sustainability optimization of corporate logistics networks from a strategic perspective and propose a multi-purpose sustainable logistics optimization model that takes into account three dimensions of sustainability: economy, environment, and society. In their work, Çetin and Sain (2018) aim to reveal the level of sustainability practices in the logistics sector, and the concepts of environmental, economic, and social sustainability are discussed in terms of the logistics sector investigated. Solomon et al. (2019) state that there are very few studies showing a clear relationship between economic, operational, and environmental performance. In this context, he considers the role of social performance (both in terms of society and employees) in his work. Ren et al. (2020) stated in their study that about a quarter of the literature they reviewed (71 out of 306 articles) focused on evaluating and measuring social, environmental, and economic criteria. Yontar (2021), discussed 15 articles that were studied with sustainable logistics criteria between 2008-2020 and determined the sustainable logistics criteria and ranked the criteria according to their importance with Pareto analysis. In the study of Mücevher (2021), priority strategies that can be used for sustainability in the logistics sector are examined. In the study, three priority strategies that can be used for sustainable logistics are emphasized. These strategies are reverse logistics, green logistics, and lean logistics approaches. Yontar (2022) deals with the logistics activities carried out by companies on the basis of sustainability and the aim of the article is to present a framework that will contribute to the sustainability initiative of companies that carry out logistics activities.

In order to ensure that the decision-making process operates smoothly with minimum error, Multi-Criteria Decision Making methods abbreviated as "MCDM" are used to obtain the solution (Singh and Pant, 2021). There are also studies using MCDM methods within the scope of sustainable logistics. Senir and Büyükkeklik (2017) aim to rank some logistics companies in terms of environmental performance within the scope of their sustainability reports. Environmental Performances of logistics companies are evaluated by the TOPSIS method, one of the MCDM Techniques. In the study of Broniewicz and Ogrodnik (2021), the application potential of Multi-Criteria Decision Making (MCDM) methods is used in decision-making problems in transportation in the light of sustainable development. Within the scope of literature studies, a review has been made of the latest applications of MCDM/MCDM methods for decision-making problems in the field of transportation. For this purpose, a mixed approach consisting of three selected MCDM methods was used: DEMATEL, REMBRANDT, and VIKOR. It is stated that multi-criteria analyses are performed to allow the final multidimensional evaluation of the most popular

MCDM methods currently applied in the field of transportation. Pamucar et al. (2021) present a long-term strategic perspective to reach a zero-carbon city by 2050. According to the results of the MCDM method proposed in the study, "introducing zero-emission zones" emerges as the first attempt to be applied. As a result of the study, it is revealed that the proposed method will be transferred to other cities aiming to provide zero-carbon transportation.

3. METHODOLOGY

3.1. Problem Definition

It is an approach that enables sustainable logistics products to be carried out from the starting point to the end point in an innovative and environmentally conscious manner. Sustainable logistics basically includes three main components: environmental, economic and social. In this study, the effect levels of the main components (environmental, economic, and social) are examined with the DEMATEL method, which is one of the Multi-Criteria Decision Making methods. It is aimed to generate effecting - effecting cause and effect diagrams of the main components. In addition, the sub-components of the main components are investigated in the study. It is planned to find out which sub-components each main component has. In this context, there are two main research questions in the study:

- What are the impact levels of the main components of sustainable logistics?
- What are the sub-components of sustainable logistics?

3.2. DEMATEL Method

MCDM methods are applied in a different way from statistical analysis techniques, that is, it is one of the methods in which objective and non-objective factors are evaluated together. Analyzes are carried out within the framework of and at the same time, a single expert opinion or The study can also be shaped according to the opinion of a group of experts (Korucuk, 2021).

Multi-Criteria Decision Making methods are methods used to rank, select, evaluate or determine the effect levels of different alternatives in accordance with the determined criteria. There are many Multi-Criteria Decision Making methods available. One of these methods is the DEMATEL method. The DEMATEL method is an effective method that examines the structure and relationships between system components or a valid number of alternatives. DEMATEL can arrange the criteria in order of priority in terms of the type of relations and the importance of their effects on each other.

The DEMATEL method has become popular mainly because it is a pragmatic approach to visualizing the structure of complex causal relationships. Specifically, the DEMATEL method is based on digraphs that can separate the relevant factors into cause group and effect group. Directed graphs, known as digraphs, are more useful than undirected graphs because digraphs can show directed relationships of subsystems (Wu and Lee, 2007).

The DEMATEL methodology consists of the following five steps (Gabus and Fontela, 1972; Fontela and Gabus, 1976):

1. Establishment of the direct relationship matrix. Five scales are used to measure the relationship between criteria: 0 (no impact), 1 (very low impact), 2 (low impact), 3 (high impact), and 4 (very high impact).
2. Normalization of the direct relationship matrix.
3. Calculation of the total relationship matrix.

4. Generating a cause and effect diagram.
5. Obtaining the internal dependency matrix.
- 6.

4. RESULTS AND DISCUSSIONS

4.1. Results

There are two main research questions in the study:

- What are the impact levels of the main components of sustainable logistics?
- What are the sub-components of sustainable logistics?

The main components of Sustainable Logistics are economic, social, and environmental. In this context, the effect levels of the main components of sustainable logistics in the research question in the first item are evaluated by The Decision Making Trial and Evaluation Laboratory (DEMATEL) method, which is one of the Multi-Criteria Decision Making methods. The direct relationship matrix, which is the first step of the applied DEMATEL method, is shown in Table 1. Table 2 shows the normalized direct relationship matrix.

Table 1. Direct Relation Matrix

	Social	Environmental	Economic
Social	0	1	1
Environmental	3	0	1
Economic	3	2	0

Table 2. Normalization of The Direct Relationship Matrix

	Social	Environmental	Economic
Social	0.00	0.17	0.17
Environmental	0.50	0.00	0.17
Economic	0.50	0.33	0.00

Prominence levels (D+R) and relation levels (D-R) are determined in Table 3.

Table 3. The Prominence and Relation Axis for Cause and Effect Group

	D (Sum)	R (Sum)	D+R	D-R
Social	0.872	2	2.872	-1.128
Environmental	1.4	1.127	2.527	0.273
Economic	1.727	0.872	2.599	0.855

Figure 1 shows the cause and effect graph. The figure is arranged according to Table 3. According to the figure, economic and environmental criteria are in the group that affects them. Social criteria are included in the affected group. In addition, when the prominence levels are examined, it is seen that each main component takes approximate values.

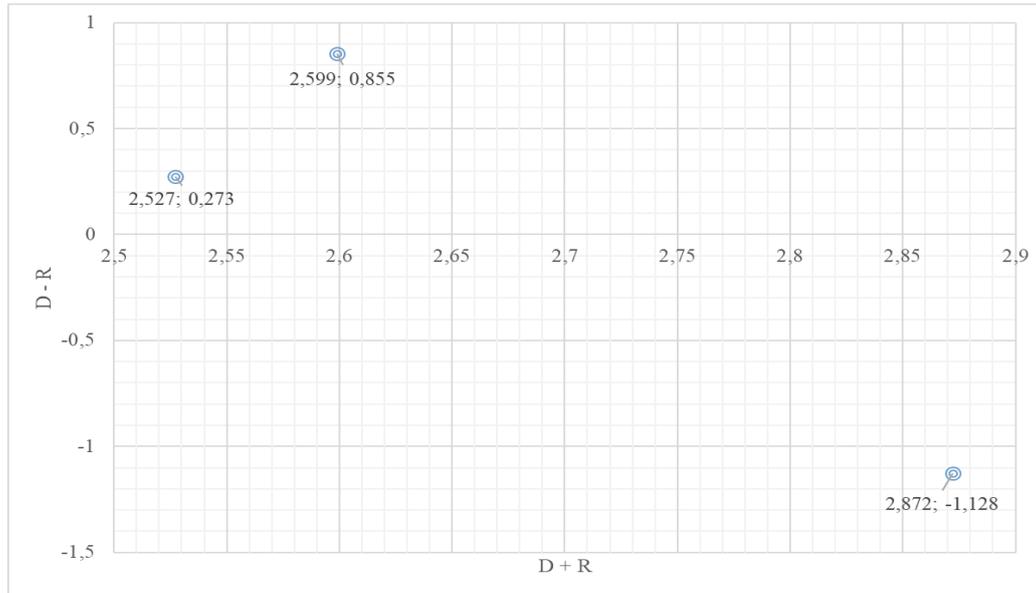


Figure 1. Cause and Effect Graph

Economic, social, and environmental main components are taken into consideration as the main components of Sustainable Logistics. When the sub-components of these main components are examined, they emerge as follows.

Sub-components of the environmental main component;

- ✓ Use of resources (energy, water, materials, etc.) (Chaabane et al., 2012; Large et al., 2013)
- ✓ Water/Soil pollution (Large et al., 2013)
- ✓ Greenhouse gas emission (Large et al., 2013)
- ✓ Noise pollution (Björklund and Forslund, 2019)
- ✓ Waste management (Large et al., 2013; Björklund and Forslund, 2019)

Sub-components of the main economic component;

- ✓ Product and service quality (Chaabane et al., 2012; Large et al., 2013)
- ✓ Cost minimization (Björklund and Forslund, 2019; Sidiropoulos et al., 2021)
- ✓ Recycling
- ✓ Market share/growth (Chaabane et al., 2012; Rota et al., 2012)
- ✓ Goods transport density (Large et al., 2013)

Sub-components of the social main component;

- ✓ Occupational health and safety (Gallego, 2006; Gimenez et al., 2012)
- ✓ Education and learning
- ✓ Working conditions
- ✓ Public health (Gallego, 2006)

4.2. Discussions

Sustainable logistics can be defined as all logistics activities carried out by preserving and sustaining the present and the future for generations in environmental, economic, and social dimensions. In the study, sustainable logistics are discussed within the scope of the main components. The main components of sustainable logistics: environmental, economic, and social aspects are discussed. These main components have been taken into account in many studies. Elkington (1997), Sopadang (2013), Morana and Gonzalez-Feliu, J. (2015), Cetin and Sain (2018), and Ren et al. (2020) discussed the environmental, economic, and social aspects of sustainable logistics in their work. There are two main aims of the study. The first purpose is to measure the impact levels of the main components of

sustainable logistics (environmental, economic, and social components). As a result of the study, it is seen that the economic and environmental component is in the affecting group and the social component is in the affected group within the scope of sustainable logistics. In addition, when the degree of importance of the main components is examined, it is seen that they take approximately close values. In the study of Wichaisri and Sopadang (2013), the importance degrees of the main components were evaluated and it was seen that the main component with the highest importance was the economic component. Social and environmental components have taken close value.

The second aim addressed in the study is to determine the sub-components of the main components. When the sub-components of the main environmental component are examined, it is seen that the sub-components are use of resource (energy, water, material, etc.), water/soil pollution, greenhouse gas emissions, noise pollution, and waste management. When the sub-components of the economic main component are examined, they include the components of product and service quality, cost minimization, recycling, market share/growth, and goods transport intensity. When the sub-components of the social main component are examined, it is seen that the components of occupational health and safety, education, and training, working conditions, and public health are covered. These components are obtained by reviewing the literature.

5 CONCLUSION

Sustainability can be defined as all practices carried out to protect and maintain resources. Sustainability has begun to be taken into account in many different sectors with increasing environmental awareness. One of the leading ones in these fields is the logistics sector. Sustainable logistics can be defined as all logistics activities carried out by preserving and sustaining the present and the future for generations.

Two main problems are investigated in the study. First of all, environmental, economic, and social components, which are the main components of sustainable logistics, are taken into account, and the effect levels of the main components of sustainable logistics are evaluated with the DEMATEL method, one of the MCDM methods. According to the DEMATEL method, the economic and environmental components are in the affecting group. Social component is included in the affected group. When the importance degrees of the main components are examined in the study, it is seen that each main component takes approximate values. These components are listed from most to least as social, economic, and environmental. Secondly, the sub-components of the main components are determined by examining the literature. When the sub-components of the main environmental component are examined, it is seen that the sub-components are use of resource (energy, water, material, etc.), water/soil pollution, greenhouse gas emissions, noise pollution, and waste management. When the sub-components of the economic main component are examined, they include the components of product and service quality, cost minimization, recycling, market share/growth, and goods transport intensity. When the sub-components of the social main component are examined, it is seen that the components of occupational health and safety, education and training, working conditions, and public health are covered.

In future studies, the importance levels of the sub-components can be examined and comparisons can be made by applying different Multi-Criteria Decision Making Methods.

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