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Evaluation of logistics performance of G20 countries using SD-based COPRAS and SAW methods

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Abstract

One of the important issues in the economic development of countries is their effectiveness in logistics activities. Countries gain competitive advantage by maintaining effective and efficient logistics processes. Therefore, determining logistics performance is important for both businesses and countries. The main aim of this study is to examine the logistics performance of countries in the context of G20 countries and to determine how it changes over time. Within the framework of this aim, the Logistics Performance Index (LPI) published by the World Bank has been used to determine the logistics performance of countries [LPI (2018) and LPI (2023)]. Standard Deviation (SD) method has been used in weighting the criteria *"customs, infrastructure, international shipments, logistics competence and quality, timeliness, tracing and tracking"* included in the LPI and in determining the performance of G20 countries. Data for 2018 and 2023 have been examined using the methods COPRAS (Complex Proportional Assessment) and SAW (Simple Additive Weight). The results obtained from the methods have been compared with LPI (2018) and LPI (2023). As a result of the analysis, according to the COPRAS method, Germany, Japan, and the United Kingdom rank first in 2018, while the Russian Federation, Argentina and Brazil rank last, respectively. According to 2023 data, Germany ranks first according to both methods, while Canada and Japan follow Germany in line with the COPRAS method. According to the SAW method, Japan and Canada follow Germany. In addition, according to the results of the analysis, Russia and Argentina are in the last places in both methods, similar to the current index.

1. Introduction

Logistics activities include the management of information, products, and money flows from the point of production to the point of consumption (Pelit, 2023). The logistics sector, which has shown great development on a global scale in recent years, is the center for economies. Logistics activities are a very important issue for the production and trade sectors. Raw materials are provided by the manufacturing businesses and processed in production operations and the products are delivered to end users. Generally speaking, logistics refers to "*the processes of ensuring the flow of information from the source of the raw material to the final point where the product is consumed, and the planning and controlling this process both efficiently and at low cost through storage and stock facilities*" (Sezer and Abasiz, 2017). In other words, logistics is "*the process of managing supply, goods movement, and inventory (and related information flow) through organization and marketing channels to maximize profitability*" (Christopher, 2016; Liu et al., 2018).

Logistics is significantly affected by globalization and internationalization processes. Transportation management issues are of great importance in the rapidly developing globalization of the economy. The development of global

economic integration and the globalization of business contribute to the creation of international logistics systems and global supply chains in the international market (Beysenbaev and Dus, 2020). In addition, with globalization and increasing competitiveness, logistics has become one of the basic elements in international trade. Effective logistics services facilitate the mobility of products, increase the security and speed of the process, and reduce costs in international trade (Martí et al., 2014). Effective logistics not only provides a competitive advantage to businesses by allowing them to reduce transaction costs, create more customer value and increase their profits, but also contributes to economic development at the macro level (Tongzon, 2011).

The quality of a logistics network depends on the services, investments and policies developed by the government. It also directly affects a country's success in global trade. At the macro level, the government provides transportation infrastructure and implements standard regulations to improve logistics activities. These and similar activities lead to increasing the economic growth and competitiveness of their countries. Therefore, a country's logistics performance and competitiveness can be evaluated as interrelated concepts (Kabak et al., 2020). Logistics performances are one of the prominent criteria for attracting international capital to the country (Karaköy and Ölmez, 2019). Performance measurement in logistics can be expressed as an important competence in achieving world-class performance (Mešić et al., 2022). Therefore, it is important to determine the logistics performance of countries.

G20 "*is an international platform established to ensure that the developed countries and developing economies, whose importance and weight are increasing in the international system day by day, are more represented in global economic decision-making processes and to help create a more stable structure of the international financial system. The G20 represents approximately 85% of the World's economy, 75% of its trade and two-thirds of its population*" (https://disiliskiler.ktb.gov.tr/). Considering both its position in the world economy and its impact on trade, it can be considered an important issue for G20 countries to maintain their logistics processes effectively and successfully. In this context, the results obtained by using MCDM methods have been evaluated in determining the logistics performance of the G20[1] countries included in the LPI (2018) and LPI (2023).

MCDM methods are mathematical methods used in decision making when there are different criteria or objectives to consider (Alma, 2023). MCDM refers to making preference decisions in terms of multiple attributes over alternatives. Typically, each alternative is evaluated on a specified set/system of attributes (Zavadskas et al., 2008). Therefore, MCDM methods support the decision-making process where there is more than one criterion. The decision-making process is used to decide which alternative to choose from a set of alternatives. Moreover, there is no single criterion that always affects the decision-making process. There may be conflicting criteria that make the decision process difficult. In fact, each alternative meets the criteria at different levels in most cases. MCDM methods support decisions to consider more than one criterion (Adıgüzel Mercangöz et al., 2020).

The advantage of COPRAS, one of the MCDM methods, over other MCDM methods is that it shows the degree of benefit of the alternatives. This method compares the alternatives with each other and determines as a percentage how much better or worse they are than other alternatives (Aksoy et al., 2015). Moreover, the advantage of the SAW method is that it is a proportional linear transformation of the raw data. This means that the relative order of magnitude of standardized scores remains equal (Afshari et al., 2010). Based on this, in the scope of the study, the SD method has been applied here to weight the criteria within the parameters of the study, and the COPRAS and SAW methods have been used to rank the logistics performance of the countries. Findings have been assessed through comparison with LPI 2023 and LPI 2018. When the relevant literature is reviewed, it can be seen that the logistics performance of countries has been evaluated with MCDM methods using LPI in various studies (Ulutaş and Karaköy, 2019a; 2019b; Isik et al., 2020; Mešić et al., 2022; Miškić et al., 2023; Oğuz, 2023; Pehlivan et al., 2024). In this context, the contributions of this study to the literature can be expressed as follows:

- It is expected that the comparison of the current index from the years 2018 and 2023 with the COPRAS and SAW methods will contribute to the literature in the context of G20 countries.
- The areas in which the G20 countries ranked first are successful can be considered as a guide for the countries ranked in last place.
- It can be considered as a helpful resource in analyzing the current situation of G20 countries.

Based on the above explanations, the second part of the study includes a broad literature review. Information about LPI is presented in the third section, and the methodology of the research is included in the fourth section. The fifth section includes the findings of the research. Lastly, the obtained results are evaluated.

2. Literature Review

When the literature is reviewed, it can be seen that there are various studies carried out using the MCDM methods in determining the logistics performance of countries. In this context, to determine the methods used in the study,

[1] Obtained from https://www.mfa.gov.tr/g-20-tr.tr.mfa, Date of access: 03/14/2024

a literature review is included in two parts: "*Current Studies on Logistics Performance"* and *"Current Studies Using MCDM Methods in Determining the Logistics Performance of G20 Countries".* The literature review is included in Table 1.

Table 1. Literature review

Current Studies on Logistics Performance		
Author (s)	**Implementation Area/Method**	**Results**
Gök Kısa and Ayçin (2019)	Within the scope of the study, LPI (2018) is used to determine the logistics performance of OECD countries. SWARA (Step-wise Weight Assessment Ratio Analysis) method is used in weighting the criteria, and EDAS (Evaluation based on Distance from Average Solution) method is used in the ranking of countries.	According to the results of the analysis, the first three countries are Germany, the Netherlands and Sweden, while the last three countries are Latvia, Mexico, and Slovakia, respectively.
Ulutaş and Karaköy (2019a)	In this research, in the context of the European Union (EU) countries included in the LPI (2018), the criteria specified in the index are integrated to balance two weighting methods: SWARA (Step-Wise Weight Assessment Ratio Analysis) and CRITIC (Criteria Importance Through Intercriteria Correlation). Subsequently, the countries are ranked using the PIV (Proximity Indexed Value) method.	Results indicate that Germany ranks first; Germany is followed by Sweden and the Netherlands, respectively.
Bozkurt and Mermertaş (2019)	Türkiye and G8 countries are compared in terms of logistics performance in this work. In order to make comparisons, the LPI (2007-2018) prepared by the World Bank is used.	Firstly, within the scope of the analysis, Türkiye's score and ranking according to the LPI criteria of 2007-2018 are evaluated. Secondly, the score and ranking of Türkiye are examined according to the LPI criteria of G8 countries between 2007-2018. Lastly, G8 countries and Türkiye are evaluated comparingly in terms of score and ranking according to the LPI criteria, taking into account LPI (2018).
Arıkan Kargı (2020)	LPI (2018) is used to determine the logistics performance of OECD countries. Analyzes are carried out using MCDM methods. The Entropy method is used to determine the criterion weights, and the WASPAS (Weighted Aggregates Sum Product Assessment) method is used to rank the countries.	The rankings obtained from the analyzes are compared with LPI (2018). As a result of the analysis, Germany ranks first; Sweden and Japan follow Germany, respectively. Costa Rica, Latvia and Colombia are in last, respectively.
Isik et al. (2020)	LPI (2018) is used to determine the logistics performance of 11 selected Central and Eastern European Countries (CEECs). SV (Statistical Variance) method is used to weight the criteria, and MABAC (Multi-Attributive Border Approximation Area Comparison) methods is used to rank the countries. The results obtained are compared with LPI (2018).	Analysis reveals that the top three countries are the Czech Republic, Poland, and Hungary, respectively. The countries ranked last are Latvia, Lithuania, and the Slovak Republic, respectively.
Adiguzel Mercangoz et al. (2020)	In the study, using the LPI, 28 EU member countries and 5 EU Candidate Countries are ranked according to their logistics performance scores applying the COPRAS-Grey (COPRAS-G) method. Within the scope of the research, Spearman's Pairwise comparisons of the rankings are made to examine whether the ranking calculated by	The best countries in terms of logistics performance are Germany, the Netherlands and Sweden, respectively; Albania, Macedonia and Montenegro are ranked as the worst countries according to the analysis.

	COPRAS-G represents past index data. Rank and Kendall's Tau Correlation methods are used.	
Senir (2021)	The domestic logistics performance of Türkiye and the EU countries are compared using the domestic LPI data published by the World Bank in 2018. CRITIC method is used in weighting the criteria, and COPRAS method is used to rank the countries.	Based on the results the Netherlands, Slovenia, and Germany rank in the top three respectively. Latvia, Romania and the Czech Republic rank last, respectively.
Altıntaş (2021)	In the scope of the study the logistic performance of EU member countries are evaluated based on the LPI (2018) report. Firstly, the criteria was weighted by utilizing the CRITIC method. Secondly, the countries were ranked using WASPAS and COPRAS methods. Additionally, the results derived from the analysis were compared with the 2018 report.	The findings of both methods are the same, while Germany, Sweden and Belgium rank in the top three respectively, Malta, Latvia, and Lithuania rank last, respectively.
Mešić et al. (2022)	Based on the data in LPI (2018), the logistics performance of the countries in the Western Balkans (Bosnia and Herzegovina, North Macedonia, Albania, Serbia, and Montenegro) is determined by MCDM methods. In weighting the criteria, CRITIC method is used, and in the ranking of the countries, MARCOS (Measurement Alternatives and Ranking according to Compromise Solution) method is used.	As a result of the analysis, Serbia ranks first and Albania ranks last.
Oguz (2023)	The countries in the top 10 in LPI (2023) are ranked using TOPSIS and EDAS methods and compared with LPI (2023).	According to the results, Singapore ranks first in LPI (2023). It ranks second according to the TOPSIS method and first according to the EDAS method. Finland, which ranks second in the report, ranks first according to the TOPSIS method and second according to the EDAS method. Germany, which ranks third in the report, ranks fourth according to the TOPSIS method and seventh according to the EDAS method.
Miškić et al. (2023)	Using LPI (2018), the logistics performance of 27 EU member countries was examined as a part of the study. The countries were ranked using the MARCOS method, and their weights were determined using the MEREC (Method based on the Removal Effects of Criteria) method.	The results shows that Germany performed the best, with Sweden and Belgium following closely behind. On the other hand, Latvia, Malta, and the Slovak Republic were found to have the worst performance.
Current Studies Using MCDM Methods in Determining the Logistics Performance of G20 Countries		
Author (s)	**Implementation Area/Method**	**Results**
Ulutaş and Karaköy (2019b)	In this study, the logistics performance of G20 countries is determined using the LPI (2018) report. SD method is used in weighting the criteria within the scope of the study. The WASPAS method is used to rank the countries and the results are compared with LPI (2018).	Based on the outcomes of the analysis, the countries with the best logistics performance are Germany, Japan and the United Kingdom, respectively; The countries with the worst logistics performance are Russia, Argentina and Brazil, respectively.
Koç Ustalı and Tosun (2020)	Efficiency analysis is conducted in terms of logistics performance of G20 countries in the 2007-2018 period. Expert opinion is used to determine the criteria within the scope of the study. In this framework, *one* output and *six*	As a result of the analysis, it is determined that country efficiency values and reference groups differ from year to year. In addition, it is concluded that the most productive

	input elements are determined. Data is obtained from the World Bank. In the study, analyzes are made according to CCR and BCC input-based models.	period is 2007-2010, while the least productive period is 2010-2012.
İnce et al. (2023)	In the context of the research, the logistics performance of G20 countries before and during the COVID-19 period is examined. With this aim, LPI (2018) and LPI (2023) reports are used. MEREC method is used in weighting the criteria, CODAS (Combinative Distance-based Assessment) method is used in ranking the countries. The results are evaluated comparingly within the context of 2018 and 2023. Additionally, sensitivity and comparison analyzes are conducted to test the reliability and robustness of the model used in the study.	Considering the logistics performance ranking of G20 countries according to the CODAS method in 2018, the first three countries are Germany, Japan and the United Kingdom, while the first three countries for 2023 are Germany, Canada and Japan, respectively.
Türkoğlu and Duran (2023)	The study utilized the LPI (2018) report to determine the logistics performance of G20 countries. The CRITIC method is used to weight the criteria, and the GIA and WASPAS methods are used to rank the countries. Additionally, the data is compared with the 2018 LPI.	Analysis shows that, Germany, Japan, the United Kingdom, the USA and France are among the top five countries, according to two methods. These results are similar to the report.
Pehlivan et al. (2024)	The LPI (2023) report is used to determine the logistics performance of G20 countries. Within the scope of the study, the TOPSIS method is used to rank the countries and compare them with the 2023 report.	Findings of the research indicate that Germany, Canada, and Japan rank in the top three, respectively. Russia, Argentina and Mexico rank last, respectively. Then, countries are divided into clusters by performing cluster analysis. As a result of cluster analysis, three clusters are formed. While Germany, the USA, Australia, China, France, South Africa, Japan, Canada, the United Kingdom, and Italy are in the first cluster; Argentina, Indonesia, Mexico and the Russian Federation are in the second cluster. The countries in the third cluster are Brazil, India, Saudi Arabia, and Türkiye.

Source: Created by the authors in line with the relevant literature review.

When Table 1 is examined, it can be seen that various studies on logistics performance have been carried out in the literature. When evaluated especially in terms of G20 countries, it is seen that the number of studies is limited and various MCDM methods such as WASPAS, TOPSIS, CODAS, Data Envelopment Analysis (DEA) are used (Ulutaş and Karaköy, 2019b; Koç Ustalı and Tosun, 2020; İnce et al., 2023; Türkoğlu and Duran, 2023; Pehlivan et al., 2024). This study has been planned by using of LPI (2018) and LPI (2023) reports. It is expected that it will contribute to the literature in terms of ranking and comparisons of the logistics performance of G20 countries by using the SD weighting method and two MCDM criteria, namely SAW and COPRAS.

3. Logistics Performance Index-LPI

LPI has been published by the World Bank every two years since 2007 in order to identify the opportunities and logistical obstacles that countries face when doing international trade (Yu and Rakshit, 2025). This index is the most important study revealing the comparative situation of the world logistics industry between the countries. LPI is a comprehensive survey of international shippers and express carriers globally that aims to measure the logistics performance of countries. With these measurements, questions are asked to the employees and managers of various logistics businesses in each country, and the answers are determined and ranked according to the scores received (Çemberci et al., 2015).

There are six criteria in LPI: *"customs, infrastructure, international shipments, logistics competence and quality, tracing and tracking, timeliness"* (LPI, 2023). LPI criteria and explanations of these criteria are as follows (Gök Kısa and Ayçin, 2019):

- *Customs:* It is the effective execution of border and customs management procedures.
- *Infrastructure:* It means that the infrastructure is qualified in terms of trade and transportation.
- *International Shipments:* It is the ease of shipping at competitive prices.
- *Logistics Competence and Quality:* It is the adequacy and quality of logistics services.
- *Tracing and Tracking:* It is the ability to track shipments.
- *Timeliness:* Shipments reach the recipient within the planned delivery time.

4. Methodology of the Research

In this part of the study, information was first given about the methods to be applied in making the analyses. Based on the explanations, the results of SD, COPRAS and SAW methods are included.

4.1. SD (Standard Deviation) Method

SD method is an objective weighting method that does not benefit from expert opinions when determining the importance weights of evaluation criteria in the solution process of a problem and offers the opportunity to calculate them entirely through objective data. This method was introduced to the literature by Diakoulaki et al. (1995). The method is used to determine how much the series deviate from their mean (Akbulut and Şenol, 2021). The method consists of three stages and the steps are as follows (Diakoulaki et al., 1995).

Step 1. The decision matrix $X=[x_{ij}]_{m*n}$ is created as shown in the Equation (1) below.

$$X=[x_{ij}]_{m*n}=\begin{bmatrix} x_{11} & \cdots & x_{12} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{21} & \cdots & x_{22} & \cdots & x_{2n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

x_{ij}, represents the value of alternative *i.* in criterion *j.*

Step 2. The elements of the decision matrix are normalized by considering the benefit and cost situations. In the normalization process (transformation into common values) of the elements, Equation (2) is used if the relevant criterion is useful for the decision maker. If the relevant criterion has a cost feature for the decision maker, Equation (3) is used.

x_j^{max} = *j.* maximum value of the criterion among the alternatives

x_j^{min} = *j.* minimum value of the criterion among the alternatives

i = 1,2, …, m (alternatives)

j= 1,2, …, n (criteria);

$$x_{ij}^{*}=\frac{x_{ij}-x_j^{min}}{x_j^{max}-x_j^{min}} \quad (2)$$

$$x_{ij}^{*}=\frac{x_j^{max}-x_{ij}}{x_j^{max}-x_j^{min}} \quad (3)$$

x_{ij}^{*}, represents the normalized value of alternative *i.* in criterion *j.*

Step 3. At this stage of the method, the importance weight of each criterion is calculated with the help of Equation (4).

$$w_j=\frac{\sigma_j}{\sum_{j=1}^{n}\sigma_j} \quad j=1,2,\ldots m \quad (4)$$

The σ_j value in Equation 4 is the standard deviation value of the criterion *j*.

4.2. COPRAS (Complex Proportional Assessment) Method

The CORPAS method developed by Zavadskas and Kaklauskas (1996) make it possible to compare alternatives by evaluating the superiority of one alternative over the other (Zavadskas et al., 2009). The process steps of this method are as follows (Chatterjee et al., 2011; Hezer et al., 2021):

Step 1. The decision matrix ($F = [f_{ij}]_{n\times m}$) is normalized using Equation (5).

The normalized decision matrix is denoted by $G = [g_{ij}]_{n\times m}$.The purpose of normalization is to obtain dimensionless values of different values so that all criteria can be compared.

$$g_{ij} = \frac{f_{ij}}{\sum_{j=1}^{m} f_{ij}} \quad i = 1,2,\dots..,n; j = 1,2,\dots..,m \tag{5}$$

Step 2. The weighted normalized decision matrix $Y = [y_{ij}]_{n\times m}$ is determined according to Equation (6).

$$y_{ij} = w_i f_{ij} \quad i = 1,2,\dots..,n\ ;\ j = 1,2,\dots..,m \tag{6}$$

g_{ij}, refers to the normalized value of the j_{th} alternative according to the i_{th} criterion.

Step 3. The sums of weighted normalized values are calculated for both useful criteria and useless criteria. These totals are calculated with Equation (7) and Equation (8).

$$K_{+j} = \sum_{i=1}^{n} y_{+ij} \tag{7}$$

$$K_{-j} = \sum_{i=1}^{n} y_{-ij} \tag{8}$$

y_{+ij} and y_{-ij} represent the weighted normalized values of useful and useless criteria, respectively.

The larger the K_{+j} value and the lower the K_{-j} value, the better the alternative is considered.

K_{+j} and K_{-j} values represent the degree of target reached by each alternative.

Step 4. The meaningfulness of the alternatives is determined based on defining the characteristics of positive alternatives K_{+j} and negative alternatives K_{-j}.

Step 5. The relative importance or priority of the alternatives is determined. The priorities of candidate alternatives are calculated based on C_j. The higher C_j value, the higher the priority of the alternative. The relative meaningfulness of an alternative shows the degree to which that alternative fulfills the demand it provides.

The alternative with the highest relative importance value (C_{max}) is the best option among the candidate alternatives. C_j, the relative importance value of the j_{th} alternative, is calculated with Equation (9).

$$C_j = K_{+j} + \frac{K_{-min}\sum_{j=1}^{m} K_{-j}}{K_{-j}\sum_{j=1}^{m}(K_{-min}/K_{-j})} \ (j = 1,2,\dots\dots,m) \tag{9}$$

K_{-min}, refers to the minimum value of K_{-j}.

Step 6. Quantitative benefit (U_j) is calculated for the j_{th} alternative. The degree of utility of an alternative is directly related to its relative importance value (C_j). The degree of utility of an alternative, which provides a complete ranking of candidate alternatives, is found by comparing the priorities of all alternatives with the most effective one and is calculated with Equation (10).

$$U_j = \left[\frac{C_j}{C_{max}}\right] \times 100 \quad (10)$$

4.3. SAW (Simple Additive Weighting) Method

SAW method was first introduced into the literature by Churchman and Ackoff (1954) by applying it to the portfolio selection problem and is also known as the Weighted Sum Model (Çakır and Perçin, 2013). The method is based on weighted mean. An evaluation score for each alternative is calculated by multiplying the scaled value given to the alternative by the relative importance weights assigned directly by the decision maker and then summing the results of all criteria (Afshari et al., 2010). The detailed stages of the SAW method are shown below (Stojanov and Ugrinov, 2013; Altın et al., 2020):

Step 1. A normalized decision matrix $R = [r_{ij}]$ is created. r_{ij} values are calculated with Equation (11) and Equation (12) in the method.

For benefit criteria: $r_{ij} = \frac{x_{ij}}{max x_{ij}}$, i $= 1, \ldots\ldots,$ m, $\quad j = 1, 2, \ldots\ldots,$ n (11)

For cost criteria: $r_{ij} = \frac{min x_{ij}}{x_{ij}}$, i $= 1, \ldots\ldots,$ m $\quad j = 1, 2, \ldots\ldots,$ n (12)

x_{ij}= i means the performance value of alternative in criterion j; m=means number of alternatives; n=means the number of criteria.

Step 2. The weighted normalized decision matrix $V = [\, v_{ij}]\ mxn$ is created. The weighted normalized value v_{ij} is calculated by Equation (13).

$v_{ij} = w_j r_{ij}$, i=1,…,m, j=1,…,n (13)

w_j, represents the weight of criterion j and $\sum_{j=1}^{n} w_j = 1$.

Step 3. The total performance value of each alternative is determined. The total performance value is calculated with S_i Equation (14).

$S_i = \sum_{j=1}^{n} v_{ij}$, i=1,…,m (14)

Step 4. Following the above, the best alternative is selected or the alternatives are ranked. Alternatives are listed in descending order as they are ranked from largest to smallest, and the best alternative is calculated by A^* Equation (15).

$A^* \in \{A_i^* | = max S_i\}$ (15)

5. Findings of the Study

In this section of the study, firstly the criterion weights have been calculated and then the G20 countries have been ranked in terms of logistics performance according to the COPRAS and SAW method. At the same time, the results obtained according to these criteria have been compared with LPI 2018 and 2023. The Appendix's Table A1 contains the decision matrix that was used to assess the G20 nations' logistics performance. The six criteria and their codes used in making the rankings before the analysis are presented in Table 2.

Table 2. Criteria and Codes Used in Evaluation

Criteria	Code	Criteria: Benefit (+)/ Cost (-)
Customs	C1	+
Infrastructure	C2	+
International Shipments	C3	+
Logistics Competence and Quality	C4	+
Timeliness	C5	+
Tracing and Tracking	C6	+

5.1. Weighting of Criteria Using the SD Method

The criterion weights derived from the SD method are listed in Table 3 following the completion of the application stages.

Table 3. Calculation of criterion weights

		C1	C2	C3	C4	C5	C6
2018	σ_j	0.33841	0.32897	0.18487	0.28821	0.20661	0.27074
	w_j	0.20918	0.20334	0.11427	0.17815	0.12771	0.16735
Rank		**1**	**2**	**6**	**3**	**5**	**4**
2023	σ_j	0.31559	0.33333	0.27131	0.30194	0.27082	0.29153
	w_j	0.17685	0.18679	0.15203	0.16920	0.15176	0.16336
Rank		**2**	**1**	**5**	**3**	**6**	**4**

When Table 3 is examined, it can be seen that according to the results of the SD method, the criterion with the highest degree of importance is "*customs*" in 2018 and "*infrastructure*" in 2023. However, it is seen that the *"infrastructure"* criterion follows the "*customs"* criterion in 2023. These criterion weights obtained through the SD method were used in the ranking of countries and were used in the COPRAS and SAW methods.

5.2. Ranking of Logistics Performance of G20 Countries Using COPRAS and SAW Method

The rankings were made using the COPRAS and SAW methods, based on the criterion weights obtained from the SD method. The results obtained are presented comparatively in Table 4.

Table 4. Ranking of logistics performance of countries using COPRAS and SAW method

LPI Report		**Countries/Method**	**COPRAS**				**SAW**			
2018	**2023**		**2018**		**2023**		**2018**		**2023**	
Rank	**Rank**		U_j	**Rank**	U_j	**Rank**	S_i	**Rank**	S_i	**Rank**
18	18	Argentina	0.669743	18	0.690480	18	0.043212	18	0.042349	18
6	7	Australia	0.898403	6	0.923936	7	0.057728	6	0.056540	7
17	15	Brazil	0.694767	17	0.775912	15	0.044811	17	0.047584	15
8	2	Canada	0.882662	8	0.996751	2	0.056922	8	0.058723	3
10	7	China	0.850380	10	0.908842	8	0.054739	10	0.055711	8
5	3	France	0.910693	5	0.944369	4	0.058604	5	0.057907	4
1	1	Germany	1	1	1	1	0.064294	1	0.061258	1
12	12	India	0.742041	12	0.823976	14	0.047815	12	0.050575	14
13	16	Indonesia	0.735738	13	0.730708	16	0.047055	13	0.044837	16
7	7	Italy	0.885098	7	0.907529	9	0.056822	7	0.055638	9
2	3	Japan	0.960744	2	0.964164	3	0.061754	2	0.059025	2
15	17	Mexico	0.710031	15	0.719463	17	0.045767	15	0.044191	17
9	5	Republic of Korea	0.855388	9	0.936590	6	0.055046	9	0.057332	6
19	19	Russian Federation	0.643937	19	0.629483	19	0.041497	19	0.038593	19
16	12	Saudi Arabia	0.706672	16	0.829554	13	0.045531	16	0.050882	13
11	7	South Africa	0.787955	11	0.894541	11	0.050773	11	0.054869	11
14	12	Türkiye	0.729277	14	0.832782	12	0.047422	14	0.051096	12
3	7	United Kingdom	0.943666	3	0.904350	10	0.060723	3	0.055431	10
4	5	USA	0.924955	4	0.937987	5	0.059485	4	0.057459	5

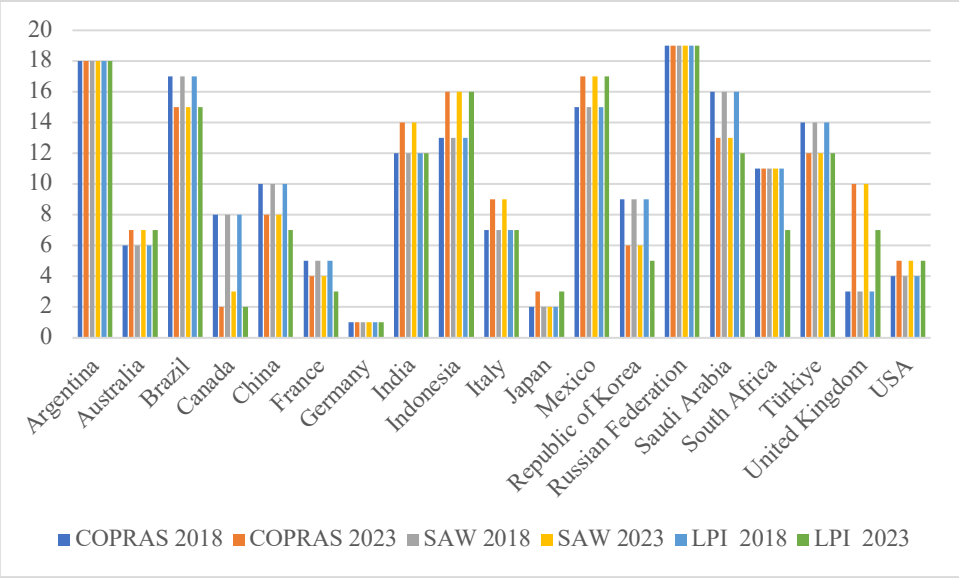

Figure 1. Ranking of logistics performance of countries using COPRAS and SAW methods

When Table 4 and Figure 1 are examined, it is seen that the COPRAS and SAW methods of the countries give similar results in terms of logistics performance when compared with the LPI (2018/2023) report. Moreover, when evaluated in terms of both methods, it is seen that similar results are obtained, except for the rankings of Japan and Canada.

When the logistics performance of the countries is examined according to the results of the COPRAS and SAW methods in 2018, the countries with the highest performance are Germany, Japan, the United Kingdom, the USA, and France, respectively. The countries with the lowest performance according to the COPRAS method are the Russian Federation, Argentina, Brazil, Saudi Arabia and Mexico, respectively.

When the logistics performance is examined in terms of methods according to 2023, the countries with the highest performance according to the COPRAS method are Germany, Canada, Japan, France, and the USA, respectively. According to the SAW method, the countries with the highest performance are Germany, Japan, Canada, France, and the USA, respectively. When the countries with the lowest logistics performance in 2023 are examined, they are the Russian Federation, Argentina, Mexico, Indonesia, and Brazil, respectively, according both to the COPRAS and SAW methods.

When countries are compared with the current index, Germany ranks first in both years. It is seen that the logistics performance of the United Kingdom, which ranks third in the LIP (2018) report, ranks tenth in 2023 according to COPRAS and SAW methods. The decrease in the logistics performance of the United Kingdom can be considered as one of the important issues that need to be examined. While Japan ranks second in 2018, it ranks third according to the COPRAS method, and it ranks second according to the SAW method. While the USA ranks fourth in 2018 according to both methods, it is seen that it ranks fifth in 2023. One of the countries with an improvement in logistics performance is France, as can be seen in the COPRAS and SAW methods. Additionally, the increase in China's logistics performance is also noteworthy. It is observed that China rose from 10th place to 8th place in both methods in 2018 and 2013. Besides, Canada can be stated as one of the countries that achieved a significant improvement in logistics performance. It is seen that the Republic of Korea has also achieved a similar improvement according to the report. However, it is seen that there is a decline in India's ranking according to two methods. The logistics performance of the Russian Federation and Argentina is in parallel with the LPI report, and they are among the countries ranked last in the analysis. When evaluated from the perspective of Türkiye, it is seen that while it ranked fourteenth in 2018 in the current report, it ranks twelfth in 2023. This increase is similar to both COPRAS (14) and SAW (12) methods. Therefore, it appears that there is an improvement in Türkiye's logistics performance.

6. Conclusion and Evaluation

Considering its impact on economic activities, sustainable development and competitiveness of countries, logistics activities can be considered a very important issue. Therefore, it is necessary to determine the logistics performance of the countries, to make improvements or regulations if necessary, and to continue activities to further improve their performance if they are good already. In this context, the aim of this study is to determine the logistics

performance of G20 countries using the LPI (2018) and LPI (2023) reports published by the World Bank and compare the results. The results obtained from the analyses were assessed as follows.

- In order to determine the logistics performance of the countries in the study, the criteria have been calculated with the SD method. According to the results of the analysis, it has been determined that the importance of the *customs* criterion had the highest value in 2018, and this criterion was followed by the *infrastructure* and *logistics competence and quality,* respectively. In 2023, it has been concluded that the *infrastructure* criterion has the highest degree of importance. It is seen that the *infrastructure* criterion is followed by *customs* and *logistics competence and quality,* respectively.
- According to the analysis made with COPRAS and SAW methods, although some rankings differ, it has been determined that the ranking results are generally similar. In addition, countries have been compared with the LPI (2018) and LPI (2023) reports in terms of logistics performance using COPRAS and SAW methods. For 2018 and 2023, Germany ranks first both in the LIP reports and according to the SAW and COPRAS methods. As stated by Yaşar Dinçer (2021), Germany has advanced transportation systems and logistics infrastructure. He also attaches importance to the use of information technologies at a high level. Germany also ranks first in Europe in terms of logistics villages and centers where intermodal transportation type is widely used. Considering the professionalization of logistics as a profession, great importance is given to university level education and vocational training programs in the field of logistics in the country. Germany aims for sustainable progress. There are many new investment projects to achieve this goal (Yaşar Dinçer, 2021). In this context, it is recommended that Germany's success in the logistics sector be examined by other countries and the success Germany has should be followed. This result obtained from the study is similar to the literature (İnci et al., 2023; Ulutaş and Karaköy, 2019b; Pehlivan et al., 2024). However, when *all country rankings* in the LPI (2023) index are examined, it is noteworthy that Germany leaves the first place to Singapore and shares the third place with Denmark, the Netherlands and Switzerland. Therefore, it is also important to determine the possible reasons that caused the decrease in Germany's recent total logistics performance.
- Considering the country rankings, it is noteworthy that Canada, which ranked eighth in 2018 in the current report, ranks second in 2023. Canada, which ranked eighth in 2018 according to the COPRAS and SAW methods, ranks second according to the COPRAS method and ranks third according to the SAW method. This rise of Canada can be associated with the level of implementation of *customs, infrastructure, international shipments, logistics competence and quality, timeliness, tracing and tracking.*
- It is noticeable that there is a serious decline in the performance of the United Kingdom in 2023 compared to 2018. It is seen that the United Kingdom has not been as successful during the Covid-19 process as Canada in terms of logistics performance. Therefore, it can be stated that while Canada managed to turn the Covid-19 pandemic into an opportunity, the United Kingdom was exposed to the negative effects of the pandemic in this field (İnce et al., 2024). In addition, when evaluated from the perspective of British companies, it is thought that the new rules implemented after Brexit, in addition to the impact of the Covid-19 pandemic, may have made the transportation of goods problematic (bigpara.com). When the United Kingdom is evaluated in the context of the criteria, it is seen that it receives lower scores in 2023. Especially the decrease in the *timeliness* criterion attracts attention. Therefore, it is necessary to take the necessary measures and improvements to improve all the criteria included in the report.
- Similar to Canada, Japan is in the category of successful countries in terms of logistics performance. It ranks second in LPI (2018) and third in LPI (2023). While the same results are obtained with the current index according to the COPRAS method, it is seen that it ranked second according to the SAW method in 2018 and still ranks the same 2023. In this context, it is seen that Japan's implementation levels of all criteria have reached similar values in both years. However, at least partially, the decline in the *timeliness* criterion emphasizes the need to focus on these issues.
- Türkiye's location in the transit corridor of Asia, Europe and the Middle East and the advantage of its geopolitical location have brought the logistics sector to an important position. This special geographical location of Türkiye has a significant positive impact on the country's logistics in terms of being a bridge. With the increase in global trade, the logistics sector has become more important. It is seen that the logistics sector has developed significantly especially in recent years (Pelit, 2023). In this context, when Türkiye's logistics performance is evaluated, it has risen from fourteenth to twelfth place according to COPRAS and SAW methods, similar to LIP (2018) and LIP (2023) reports. In addition, when Türkiye's LPI 2018 and 2023 reports are examined, it is seen that there is an increase *in the rankings of all countries*. In order to sustain the advantage that Türkiye has due to its geographical location and to further increase its logistics performance, it is of great importance to plan and implement the regulations that need to be made at both macro and micro levels in the context of criteria that increase logistics performance.
- With the effectiveness of logistics activities in national and international trade, competition between countries is shaped and positively reflects on economic development. In this context, countries that are at the bottom of the logistics performance ranking need to evaluate all criteria, ensure improvement in their logistics

performance, and take the necessary precautions. In addition, it is thought that process efficiency can be achieved by following the logistics policies of successful countries such as Germany, Canada, and Japan.

As can be the case in every scientific study, there are some limitations in this study, that could also be evaluated as points taken to be account in future research. Within the objectives of the research, comparisons have been made with LPI 2018 and 2023 reports by using SD, COPRAS and SAW methods in order to determine the logistics performance of G20 countries. In possible future studies, the logistics performance of different country groups can be analyzed with different MCDM methods. It is also suggested that making analysis by applying fuzzy MCDM methods would provide valuable insights on the subject.

Contribution of Authors

In this research, Emel GELMEZ, defining the problem, literature research, determining and applying the method, analysis of the results, writing the article; Hasan Kürşat GÜLEŞ and Muammer ZERENLER contributed to the definition of the problem, literature research, determination of the method, and writing of the article.

Conflicts of Interest

The authors declared that there is no conflict of interest.

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Appendix

Table A1. Decision matrix

Countries	LPI (2018)						LPI (2023)					
	C1	C2	C3	C4	C5	C6	C1	C2	C3	C4	C5	C6
Argentina	2.42	2.77	2.92	2.78	3.37	3.05	2.70	2.80	2.70	2.70	3.10	2.90
Australia	3.87	3.97	3.25	3.71	3.98	3.82	3.70	4.10	3.10	3.90	3.60	4.10
Brazil	2.41	2.93	2.88	3.09	3.51	3.11	2.90	3.20	2.90	3.30	3.50	3.20
Canada	3.60	3.75	3.38	3.90	3.96	3.81	4.00	4.30	3.60	4.20	4.10	4.10
China	3.29	3.75	3.54	3.59	3.84	3.65	3.30	4.00	3.60	3.80	3.70	3.80
France	3.59	4.00	3.55	3.84	4.15	4.00	3.70	3.80	3.70	3.80	4.10	4.00
Germany	4.09	4.37	3.86	4.31	4.39	4.24	3.90	4.30	3.70	4.20	4.10	4.20
India	2.96	2.91	3.21	3.13	3.50	3.32	3.00	3.20	3.50	3.50	3.60	3.40
Indonesia	2.67	2.90	3.23	3.10	3.67	3.30	2.80	2.90	3.00	2.90	3.30	3.00
Italy	3.47	3.85	3.51	3.66	4.13	3.85	3.40	3.80	3.40	3.80	3.90	3.90
Japan	3.99	4.25	3.59	4.09	4.25	4.05	3.90	4.20	3.30	4.10	4.00	4.00
Mexico	2.77	2.85	3.10	3.02	3.53	3.00	2.50	2.80	2.80	3.00	3.50	3.10
Republic of Korea	3.40	3.73	3.33	3.59	3.92	3.75	3.90	4.10	3.40	3.80	3.80	3.80
Russian Federation	2.42	2.78	2.64	2.75	3.31	2.65	2.40	2.70	2.30	2.60	2.90	2.50
Saudi Arabia	2.66	3.11	2.99	2.86	3.30	3.17	3.00	3.60	3.30	3.30	3.60	3.50
South Africa	3.17	3.19	3.51	3.19	3.74	3.41	3.30	3.60	3.60	3.80	3.80	3.80
Türkiye	2.71	3.21	3.06	3.05	3.63	3.23	3.00	3.40	3.40	3.50	3.60	3.50
United Kingdom	3.77	4.03	3.67	4.05	4.33	4.11	3.50	3.70	3.50	3.70	3.70	4.00
USA	3.78	4.05	3.51	3.87	4.08	4.09	3.70	3.90	3.40	3.90	3.80	4.20