LogForum

> Scientific Journal of Logistics <

2020, 16 (2), 239-250

http://doi.org/10.17270/J.LOG.2020.432

http://www.logforum.net p-ISSN 1895-2038 e-ISSN 1734-459X

ORIGINAL PAPER

TIME PERIOD BASED COPRAS-G METHOD: APPLICATION ON THE LOGISTICS PERFORMANCE INDEX

Burcu Adiguzel Mercangoz, Bahadir Yildirim, Sultan Kuzu Yildirim

Istanbul University, Istanbul, **Turkey**

ABSTRACT. **Background:** Logistics is vital for the trades of countries. The inputs such as raw materials and energy that is needed for production and also the outputs of these processes are transported and distributed effectively as a result of an efficient logistics process. In order to measure the logistics performance of countries, The World Bank (WB) is publishing an index entitled Logistics Performance for every two years.
Methods: The main value of this study is to provide logistics performance scores of the selected countries for a selected time period. Thus, periodic evaluations can be done for a selected time period. The grey numbers are used for determining a new dataset for a time period and implement to Complex Proportional Assessment of Alternatives (COPRAS) method. 28 European Union (EU) member states plus 5 EU Candidate Countries are ranked by using the COPRAS-Grey (COPRAS-G) method according to their logistics performance scores. In order to see if the ranking calculated by COPRAS-G is representing the past index data, the bilateral comparisons of the rankings are investigated by using the Spearman Rank and Kendall's Tau Correlation methods.
Results: The results showed that the dataset obtained by using grey numbers represent the LPI scores of the countries for the selected time period. Although there are slight differences between the Spearman and Kendall correlation coefficients, the ultimate result is the same. The ranking calculated by COPRAS-G has the strongest relationship with all rankings published by WB.
Conclusions: By using the grey numbers combined with the COPRAS-G method, the LPI of Countries can be evaluated for a time period.

Key words: COPRAS-G, logistics performance, multi criteria decision making, grey numbers, correlation analysis.

INTRODUCTION

With the rise of world trade as a result of globalization, firms and countries have entered into a race to gain a competitive advantage. This process has increased the importance of each activity in the supply chain. Logistics activities, which form an important part of the supply chain, are an effective area for companies and countries to create competitive advantage [Civelek, 2015]. Logistics activities have great prospects in the company profitability and the country's economy in this sense. The development of countries in the field of logistics makes them indispensable part of the global trade. They become a master hub in the supply chain and also the preferred hub. As a result, logistics become one of the main drivers of the countries' economies. Thus, performance of the logistics needs to be calculated and improved. The logistics performance of the countries and the companies are evaluated by some different metrics. This study focused on evaluating the country's logistics performance. The World Bank (WB) publishes the Logistics Performance Index (LPI) that is used for ranking and sorting the countries according to their logistics performances. The data is obtained from professionals that are working at international logistics companies all around the world. There are six indicators used for evaluating the performance of countries. The

Citation: *Mercangoz B.A., Yildirim B., Yildirim S.K., 2020. Time Period Based COPRAS-G Method: Application on the Logistics Performance Index. LogForum 16 (2), 239-250, http://doi.org/10.17270/J.LOG.2020.432*
Received: 03.01.2020, Accepted: 02.03.2020, on-line: 30.03.2020.

definitions of these indicators are shown in Table 1.

Table 1. Definition of Logistics Performance Index Indicators

LPI Indicators	Definitions
Customs	The efficiency of customs and borders
Infrastructure	The quality of trade and transport infrastructure
International Shipping	The ease and cost-folding level of international shipping arrangements
Logistics Quality and Competence	The competence and quality of logistics services
Tracking and Tracing	Ability to monitor international shipments
Timeliness	Timely availability of shipment to arrival

Source: World Bank [2018]

The Multi-Criteria Decision making methods support the decision making process that has more than one criterion. For deciding which alternative to choose from a set of alternatives decision making process is used. Also, there is not only one criterion affecting the decision making process every time. There can be conflicting criteria that make the decision process harder. Indeed, for most cases, every alternative provides the criteria at the different level. Therefore, a concession needed to be formed. Multi-Criteria Decision Making (MCDM) methods support decisions for considering more than one criterion.

In some cases where the decision criteria cannot be expressed with an exact number, it is possible to use a certain interval for the evaluation by expressing it in fuzzy or grey numbers. This study aims to make an evaluation of 5-term index data. The dataset was formed with intervals using grey numbers. The following research questions were examined.

Research Question 1: When the LPI scores are evaluated for a certain period of time, can the results obtained by the proposed model accurately represent the period covered?

Research Question 2: Which countries are effective on the field of logistics, according to the results of the periodic evaluation with the proposed COPRAS-G method?

The study is organized in four sections. At the following part of the study, the literature is reviewed by examining the studies that are related to LPI scores and the studies related to application areas of the COPRAS-G method. At the "Methodology" part of the study, Grey Number Theory and the COPRAS-G method is explained in detail. The data, application steps and the results of the study are given in the third part. In order to see if the proposed model is an effective tool to represent the selected period, the correlation analysis is applied in the discussions section. The conclusions and the suggestions for the further studies take place in the last part of the study.

LITERATURE REVIEW

The literature review section is in twofold: (i) Studies Related with the Logistics Performance Index Scores of the Countries, and (ii) Studies Related with the Application Areas of COPRAS Method.

Studies Related with the Logistics Performance Index Scores of the Countries

Bentyn [2015] examines changes of LPI scores of Poland along with its EU membership process. He found out that there has been a significant development in all indicators of LPI over the selected period. Solakivi et al [2014] examined LPI of Finland. They compared Finland's logistics performance with its neighbor countries. Also similar studies are conducted to evaluate the logistics performance of countries separately such as Brazil [Faria et al. 2015], England [Khan, Qianli, 2017], Turkey [Iris, Tanyas, 2011; Yaprakli, Unalan, 2017], Malaysia [Bakar, Jaafar, 2016; Nur Fadiah et al. 2017]. Jumadi and Zailani [2010] examined logistics performance by using LPI and compare its performance with other countries and also its situation within the OECD countries. Dekker et al. [2016] examined the LPI score of Costa Rica to produce strategies and alternatives.

Hoekman and Nicita [2011] considered the various indices related to trade and applied them to developing countries. They search for various kinds of trade costs that have importance on logistics performance and they found the importance of logistics performance

in increasing trade. Yildirim and Adiguzel Mercangoz [2019], used Additive Ratio ASsesment [ARAS] Grey method to evaluate the Logistics performance of OECD countries.

Marti et al. [2014] studied the value of each LPI indicators on trade for emerging economies to investigate the total trade in these economies. Similar to their study, Celebi [2017] conducted a study on determining the effects of LPI on international trade. Puertas et al. [2014] analyzed the importance of logistics performance in relation to EU exports between the years 2005 and 2010. According to the results of their study, Competence and Tracking component of LPI is found as the component that needs greater importance for those years. Marti et al. [2017] investigated the potential differences to be observed with the use of different income and geographical area in their studies. They found out that the logistics performance largely depends on income and geographical area. The countries that are highly dominated by the EU, are in the group of best performers. Candemir and Celebi [2017] analyzed the role of logistics sector in economic development.

On the other hand, there are some studies conducted for identifying the relations between LPI and some other economical indexes. For instance, Cemberci et al. [2015] studied the efficacy of the Global Competitiveness Index (GCI) on the LPI by using hierarchical regression analysis on each of the components of the LPI. Similar to their study, Civelek et al. [2015] used the same model for analyzing the effect of LPI on GCI and the Gross Domestic Product [GDP]. The bilateral relations were statistically significant. Gani [2017] explored that the overall logistics performance is positively and statistically related to exports and imports in his study. Different from others, Uca et al. [2016] performed hierarchical regression analysis between LPI and Corruption Perception Index (CPI) and Foreign Trade Volume (FTV). Onsel Ekici et al. [2016] concerned with the GCI and the LPI. Differently, they do not assume that the relationship is linear and used an artificial neural network (ANN) model to investigate the relation between the GCI and the LPI. Some indicators of GCI that may effect on LPI components are selected in their study. Erkan [2014] investigate the relationship between the indicators of GCI and LPI related to the "infrastructure" indicator. 113 countries are included in a regression analysis to investigate the significant relation between overall LPI score and each of the selected components. Vaillancourt and Haavisto [2015] addressed to the importance of logistics performance for humanitarian context. They investigate the relationship between the logistics performance of the country and the disaster impact for epidemic, flood and storm.

Studies Related with the Application Area of COPRAS Method

Chatterjee and Chakraborty [2013] used COPRAS method to solve a gear material selection problem and compare the results with the results obtained by using ARAS method. Bayrakci & Aksoy [2019] evaluate the performance of individual pension companies that manage individual pension investments, which are considered as long-term investment instruments, in comparison with ARAS and COPRAS methods in their study. COPRAS method is also used in the field of Learning Management System (LMS) [Bakhouyi et al. 2016], location selection problem [Arslan et al. 2018].

COPRAS method is used with grey theory in order to cope with the uncertainty. Zavadskas et al. [2008] determined the values at intervals and used COPRAS-G for selecting effective versions of the external walls construction. Zolfani et al. [2012] used COPRAS-G method for selecting a supplier problem. Like their studies, Chatterjee and Kar, [2018] used COPRAS-G method for supplier selection problem. In order to check the reliability of the results, spearman's correlation analysis is used between the ranking results of proposed method with VIKOR-G, ARAS-G and TOPSIS-G. Liou et al. [2016] used a hybrid model that deals with the dependent relationships between various criteria and uncertain information from decision makers. They used Decision-making Trial and Evaluation Laboratory (DEMATEL), influential network relationship map (INRM), DEMATEL-based, Analytical Network Process (ANP) and COPRAS-G methods. Tavana, et al. [2013] proposed a hybrid model

and integrates the ANP with fuzzy set theory and the COPRAS-G method for the social media platform selection problem in a fuzzy environment. Aghdaie et al. [2013] proposed a hybrid model and integrate the Step-wise Weight Assessment Ratio Analysis [SWARA] and COPRAS-G method for machine tool evaluation and selection considering the company strategies, recourses and policies for the organizations. Nguyen et al. [2014] used fuzzy ANP and COPRAS-G for evaluating machine tools taking into account of the interactions between the criteria. The results are compared with the other MCDM methods. Zhang et al. [2018] proposed a method for making wisely choice about the green building investment by using AHP and COPRAS-G methods. Mousavi-Nasab and Sotoudeh Anvari, [2017] reviewed the literature for material selection problem and found out that COPRAS and TOPSIS mostly used methods for material selection problem in general. Pancholi and Bhatt [2018] used COPRAS-G for the maintenance-planning problem. Bitarafan et al. [2012] used COPRAS-G for crisis management. A study about the coal-fired thermal power plants is conducted by Adhikary et al. 2014. The grey numbers are used to deal with the uncertain data; the criteria against each alternative are expressed in grey number instead of crisp values.

COPRAS method is also used with fuzzy theory. Garg et al. [2019] used fuzzy theory in order to make the selection of websites for e-learning platforms in educational organizations. Cakir and Ozdemir [2018] used fuzzy COPRAS in order to select suitable six-sigma project from eleven alternatives.

As a result of the literature survey, to the best of our knowledge, there isn't any study calculating the Logistics Performance Index by using COPRAS-G method for a selected time period. Thus, this study constitutes a different application area of the COPRAS-G technique in the literature.

METHODOLOGY

COPRAS method was first introduced by Zavadskas et. al [1994] and Zavadskas and Kaklauskas [1996]. In COPRAS method, for conflicting weighted criteria, the alternatives are compared, and their utility degree is determined [Zavadskas et al., 2008]. The calculated utility degree is used for evaluating complex processes of both maximizing and minimizing criteria values. The method assumes direct and proportional dependence of significance and priority of investigated alternatives, finally selects the best decision considering both the ideal and the ideal-worst solutions.

Different from the COPRAS method the COPRAS-G method uses the grey numbers. Grey numbers are part of Grey System theory, which is a new method for studying problems where partial information is known. Grey system theory was initiated by Julong [1982] where "grey" means poor, incomplete, and uncertain of knowledge. Grey system theory use "black" to indicate unknown information, "white" the completely known information, and "grey" the partially known and partially unknown information [Liu and Lin, 2010]. Grey numbers are useful when dealing with a system containing limited information. In this study, we used the grey number to refer the countries as upper and lower limits of LPI scores.

Applied COPRAS-G steps below proposed by Zavadskas et. al. [2008]:

Step 1. Selecting the set of the most important criteria and types of criteria as cost or benefit, describing the alternatives.

Step 2. Constructing the grey decision-making matrix

$$\otimes X = \left[\left[\underline{x}_{ij};\overline{x}_{ij}\right]\right]_{mxn} = \begin{bmatrix} [\underline{x}_{11};\overline{x}_{11}] & [\underline{x}_{12};\overline{x}_{12}] & \cdots & [\underline{x}_{1n};\overline{x}_{1n}] \\ [\underline{x}_{21};\overline{x}_{21}] & [\underline{x}_{22};\overline{x}_{22}] & \cdots & [\underline{x}_{2n};\overline{x}_{2n}] \\ \vdots & \vdots & \ddots & \vdots \\ [\underline{x}_{m1};\overline{x}_{m1}] & [\underline{x}_{m2};\overline{x}_{m2}] & \cdots & [\underline{x}_{mn};\overline{x}_{mn}] \end{bmatrix} \quad i=1,2,...,m \quad j=1,2,...,n \tag{1}$$

Step 3. Normalizing the grey decision-making matrix

$$\tilde{\underline{x}}_{ij} = \frac{\underline{x}_{ij}}{\frac{1}{2}\left(\sum_{i=1}^{m}\underline{x}_{ij} + \sum_{i=1}^{m}\overline{x}_{ij}\right)} = \frac{2\underline{x}_{ij}}{\sum_{i=1}^{m}\underline{x}_{ij} + \sum_{i=1}^{m}\overline{x}_{ij}} \tag{2}$$

$$\tilde{\bar{x}}_{ij} = \frac{\bar{x}_{ij}}{\frac{1}{2}\left(\sum_{i=1}^{m}\underline{x}_{ij} + \sum_{i=1}^{m}\bar{x}_{ij}\right)} = \frac{2\bar{x}_{ij}}{\sum_{i=1}^{m}(\underline{x}_{ij} + \bar{x}_{ij})} \quad (3)$$

Step 4. Calculating the weighted normalized grey decision matrix. The weighted normalized values are calculated by using equation (4) and (5), respectively:

$$\hat{\underline{x}}_{ij} = \tilde{\underline{x}}_{ij} \cdot w_j \quad (4)$$

$$\hat{\bar{x}}_{ij} = \tilde{\bar{x}}_{ij} \cdot w_j \quad (5)$$

$$\otimes\hat{X} = \left[\left[\hat{\underline{x}}_{ij};\hat{\bar{x}}_{ij}\right]\right]_{mxn} = \begin{bmatrix} \left[\hat{\underline{x}}_{11};\hat{\bar{x}}_{11}\right] & \left[\hat{\underline{x}}_{12};\hat{\bar{x}}_{12}\right] & \cdots & \left[\hat{\underline{x}}_{1n};\hat{\bar{x}}_{1n}\right] \\ \left[\hat{\underline{x}}_{21};\hat{\bar{x}}_{21}\right] & \left[\hat{\underline{x}}_{22};\hat{\bar{x}}_{22}\right] & \cdots & \left[\hat{\underline{x}}_{2n};\hat{\bar{x}}_{2n}\right] \\ \vdots & \vdots & \ddots & \vdots \\ \left[\hat{\underline{x}}_{m1};\hat{\bar{x}}_{m1}\right] & \left[\hat{\underline{x}}_{m2};\hat{\bar{x}}_{m2}\right] & \cdots & \left[\hat{\underline{x}}_{mn};\hat{\bar{x}}_{mn}\right] \end{bmatrix} \quad i=1,2,...,m \;\; j=1,2,...,n$$

(6)

Step 5. Calculating the sums and of criterion values, whose , benefit criteria (larger numbers are more preferable); , cost criteria (smaller numbers are more preferable):

$$S_{+i} = \frac{1}{2}\sum_{j=1}^{k}\left(\hat{\underline{x}}_{ij} + \hat{\bar{x}}_{ij}\right) \quad i=1,2,...,m \;\; j=1,2,..,k \quad (7)$$

$$S_{-i} = \frac{1}{2}\sum_{j=k+1}^{n}\left(\hat{\underline{x}}_{ij} + \hat{\bar{x}}_{ij}\right) \quad i=1,2,...,m \;\; j=k+1,k+2,...,n \quad (8)$$

Step 6. Calculating the relative significance of each alternatively the expression:

$$Q_i = S_{+i} + \frac{S_{-\min}\cdot\sum_{i=1}^{m}S_{-i}}{S_{-i}\cdot\sum_{i=1}^{m}\left(\frac{S_{-\min}}{S_{-i}}\right)} \quad i=1,2,...,m \quad (9)$$

Step 7. Calculating the utility degree of each alternative by the formula so calculate performance index P,

$$P_i = \left[\frac{Q_i}{Q_{\max}}\right]\cdot 100\% \quad i=1,2,...,m \quad (10)$$

APPLICATION AND RESEARCH RESULTS

At the first survey that is published in 2007, there were 7 indicators used to calculate the LPI, thus the data from the year 2007 is not considered in this study. The data set of the study is consisted of five Logistic Performance Index published by the World Bank.

5-Period LPI data were used as initial data. The maximum and minimum values of the 5-year data for each country were converted into the upper and lower limits of the grey numbers to be used in the decision matrix. Thus, grey numbers belonging to 7 indicators representing each country were formed.

28 EU plus 5 EU Candidate Countries are taken as alternatives. Seven indicators (Customs, Infrastructure, International Shipping, Logistics Quality & Competence, Tracking & Tracing, Timeliness) constitute the criterion set of the study. The importance of the criteria in the decision matrix was obtained from the study conducted by Yildirim and Adiguzel Mercangoz [2019]. In their study, weights of the criteria were calculated by Fuzzy Analytic Hierarchy Process (fuzzy-AHP) method by taking expert opinions. The importance of the criteria is shown in Table 2.

Table 2. Importance Weightings of Indicators

Criteria	C#	W	%
Customs	C1	0,14	14%
Infrastructure	C2	0,39	39%
International Shipping	C3	0,08	8%
Logistics Quality & Competence	C4	0,14	14%
Tracking & Tracing	C5	0,07	7%
Timeliness	C6	0,19	19%

Source: Yildirim and Adiguzel Mercangoz [2019]

The grey performance values calculated for the countries and the criterion weights are combined in the grey decision matrix and shown in Table 3.

The performance values in the decision matrix were normalized by using Equation (5) and (6). After this process, weighted normalized decision matrix was obtained by using criterion weights with the help of Equation (7) and (8). The optimization direction is maximum in all seven indicators in

the decision matrix. For this reason, S+ values are calculated by using Equation (10). Calculated S+ values are used in Equation (12) to calculate Q values for all country alternatives. Finally, values were calculated by Equation (13) and the countries are ranked according to these values. The country rankings obtained by the Q and P scores is shown in Table 4.

Table 3. Grey Decision Matrix

Weights	0.14	0.39	0.08	0.13	0.07	0.19
	C1	C2	C3	C4	C5	C6
Australia	[3.49, 3.79]	[3.64, 4.18]	[3.26, 3.88]	[3.56, 4.18]	[3.83, 4.36]	[3.79, 4.37]
Belgium	[3.66, 3.85]	[3.98, 4.12]	[3.31, 4.05]	[3.98, 4.13]	[4.05, 4.22]	[4.20, 4.43]
Bulgaria	[2.40, 2.97]	[2.30, 4.19]	[2.93, 3.31]	[2.85, 3.10]	[2.72, 3.16]	[3.18, 4.04]
Croatia	[2.62, 3.07]	[2.36, 4.19]	[2.93, 3.12]	[2.53, 3.21]	[2.82, 3.2]	[3.22, 3.59]
Cyprus	[2.88, 3.11]	[2.89, 4.19]	[2.80, 3.21]	[2.72, 3.17]	[2.54, 3.51]	[3.31, 3.79]
Czech Republic	[2.95, 3.58]	[2.96, 4.19]	[3.01, 3.75]	[3.27, 3.72]	[3.17, 3.84]	[3.40, 4.16]
Denmark	[3.58, 3.93]	[3.75, 4.07]	[3.46, 3.70]	[3.74, 4.14]	[3.36, 4.18]	[3.92, 4.41]
Estonia	[2.51, 3.41]	[2.75, 4.19]	[2.82, 3.34]	[2.82, 3.27]	[2.95, 3.25]	[3.23, 4.08]
Finland	[3.82, 4.01]	[3.52, 4.12]	[3.41, 3.85]	[3.72, 4.14]	[3.31, 4.32]	[3.80, 4.28]
France	[3.59, 3.71]	[3.96, 4.01]	[3.30, 3.73]	[3.75, 3.87]	[3.89, 4.02]	[4.02, 4.37]
Germany	[3.87, 4.12]	[4.26, 4.44]	[3.66, 3.86]	[4.09, 4.31]	[4.05, 4.27]	[4.32, 4.48]
Greece	[2.38, 3.36]	[2.88, 4.19]	[2.69, 3.30]	[2.69, 3.23]	[2.98, 3.59]	[3.32, 3.85]
Hungary	[2.82, 3.35]	[3.08, 4.19]	[2.78, 3.44]	[2.87, 3.35]	[2.87, 3.82]	[3.41, 4.06]
Ireland	[3.36, 3.8]	[3.29, 3.84]	[3.40, 3.83]	[3.54, 3.94]	[3.62, 4.13]	[3.76, 4.47]
Italy	[3.34, 3.47]	[3.72, 3.85]	[3.21, 3.65]	[3.62, 3.77]	[3.73, 3.86]	[4.03, 4.13]
Latvia	[2.71, 3.22]	[2.52, 4.19]	[2.72, 3.38]	[2.64, 3.29]	[2.79, 3.55]	[2.88, 4.06]
Lithuania	[2.73, 3.42]	[2.58, 4.19]	[2.79, 3.49]	[2.85, 3.49]	[2.73, 3.68]	[3.60, 4.14]
Luxembourg	[3.53, 4.04]	[3.63, 4.24]	[3.37, 4.24]	[3.67, 4.01]	[3.61, 4.12]	[3.90, 4.80]
Malta	[2.65, 3.00]	[2.89, 4.19]	[2.70, 3.23]	[2.80, 3.01]	[2.56, 3.15]	[3.01, 3.79]
Netherlands	[3.85, 4.12]	[4.15, 4.29]	[3.61, 3.94]	[4.05, 4.22]	[4.02, 4.17]	[4.15, 4.41]
Poland	[3.12, 3.30]	[2.98, 4.19]	[3.22, 3.68]	[3.26, 3.58]	[3.32, 3.54]	[3.80, 4.52]
Portugal	[3.17, 3.37]	[3.17, 4.19]	[3.02, 3.83]	[3.15, 3.71]	[3.38, 3.72]	[3.84, 4.13]
Romania	[2.36, 3,00]	[2.25, 4.19]	[2.99, 3.32]	[2.68, 3.20]	[2.90, 3.39]	[3.22, 4.00]
Slovak Republic	[2.79, 3.28]	[2.99, 4.19]	[2.84, 3.41]	[3.07, 3.16]	[2.84, 3.54]	[3.14, 3.94]
Slovenia	[2.59, 3.42]	[2.65, 4.19]	[2.84, 3.34]	[2.90, 3.51]	[3.16, 3.51]	[3.10, 3.82]
Spain	[3.40, 3.63]	[3.58, 4.19]	[3.11, 3.83]	[3.62, 3.83]	[3.54, 3.96]	[4.00, 4.12]
Sweden	[3.68, 4.05]	[4.03, 4.27]	[3.39, 4.00]	[3.90, 4.25]	[3.82, 4.38]	[4.26, 4.45]
United Kingdom	[3.73, 3.98]	[3.95, 4.21]	[3.63, 3.77]	[3.92, 4.05]	[4.00, 4.13]	[4.19, 4.37]
Albania	[2.07, 2.43]	[2.14, 4.19]	[2.48, 2.84]	[2.39, 2.65]	[2.15, 2.67]	[3.01, 3.58]
Macedonia. FYR	[2.21, 2.55]	[2.47, 4.19]	[2.38, 2.84]	[2.36, 2.76]	[2.32, 2.82]	[2.79, 3.13]
Montenegro	[2.17, 2.83]	[2.30, 4.19]	[2.22, 3.15]	[2.31, 2.72]	[2.37, 2.76]	[2.65, 3.33]
Serbia	[2.19, 2.6]	[2.30, 4.19]	[2.63, 3.41]	[2.55, 3.02]	[2.67, 3.07]	[2.80, 3.55]
Turkey	[2.71, 3.23]	[3.08, 4.19]	[3.06, 3.41]	[3.05, 3.64]	[3.09, 3.77]	[3.63, 3.94]

Source: own work

Table 4. Ranking Countries According to LPI Scores Calculated by COPRAS-G

Countries	Q	P	Rank	Countries	Q	P	Rank
Germany	0.036	100%	1	Turkey*	0.03	82%	17
Netherlands	0.036	98%	2	Hungary	0.029	81%	18
Sweden	0.035	97%	3	Slovak Republic	0.029	80%	19
United Kingdom	0.035	96%	4	Lithuania	0.029	80%	20
Belgium	0.035	95%	5	Estonia	0.028	78%	21
Luxembourg	0.034	94%	6	Slovenia	0.028	78%	22
France	0.034	93%	7	Greece	0.028	78%	23
Denmark	0.034	92%	8	Cyprus	0.028	78%	24
Australia	0.033	92%	9	Latvia	0.028	76%	25
Finland	0.033	92%	10	Malta	0.028	76%	26
Spain	0.033	90%	11	Romania	0.027	75%	27
Italy	0.032	89%	12	Bulgaria	0.027	75%	28
Ireland	0.032	88%	13	Croatia	0.027	74%	29
Portugal	0.031	85%	14	Serbia*	0.026	71%	30
Poland	0.031	85%	15	Macedonia, FYR*	0.025	69%	31
Czech Republic	0.03	84%	16	Montenegro*	0.025	68%	32
				Albania*	0.025	68%	33

* Turkey, Serbia, Macedonia, FYR, Montenegro, and Albania are official Candidate Countries to become member states of the EU.
Source: own work

From Table 4. it can be seen that Germany ranked 1 for the selected period. Germany, Netherlands, Sweden, Belgium, and the United Kingdom can be seen as the main drivers of logistics of EU Countries. 12 EU countries have a ranking after Turkey. As Turkey compared within the EU candidate countries, it can be seen that EU candidate countries except Turkey are located at the end of the EU countries. Turkey ranked 17. Turkey has an important difference in candidate countries according to its ranking.

DISCUSSIONS

In order to see if the results obtained by the proposed model are effective to represent the selected period, the correlation analysis are applied. LPI rankings published by WB and ranking calculated by COPRAS-G are investigated by using by rank correlation tests. Once the ranking results are unsatisfied the parametric relation analyses conditions, Spearman Rank and Kendall's Tau Correlation Analysis are applied in order to find out the relations between the rankings. The results of the Spearman Rank and Kendall's Tau Correlation Analysis can be seen from Table 5. Although there are slight differences between the Spearman and Kendall correlation coefficients, the ultimate result is the same.

Table 5. Non-Parametric Correlations Matrix

			2018	2016	2014	2012	2010	COPRAS-G
Kendall's Tau_b	2018	Correlation Coefficient	1,000	,742**	,758**	,750**	,723**	,803**
		Sig. (2-tailed)	.	,000	,000	,000	,000	,000
	2016	Correlation Coefficient	,742**	1,000	,803**	,682**	,860**	,864**
		Sig.	,000	.	,000	,000	,000	,000
	2014	Correlation Coefficient	,758**	,803**	1,000	,705**	,830**	,864**
		Sig.	,000	,000	.	,000	,000	,000
	2012	Correlation Coefficient	,750**	,682**	,705**	1,000	,670**	,758**
		Sig.	,000	,000	,000	.	,000	,000
	2010	Correlation Coefficient	,723**	,860**	,830**	,670**	1,000	,852**
		Sig.	,000	,000	,000	,000	.	,000
	COPRAS-G	Correlation Coefficient	,803**	,864**	,864**	,758**	,852**	1,000
		Sig.	,000	,000	,000	,000	,000	.
Spearman's rho	2018	Correlation Coefficient	1,000	,890**	,907**	,905**	,883**	,936**
		Sig.	.	,000	,000	,000	,000	,000
	2016	Correlation Coefficient	,890**	1,000	,945**	,862**	,963**	,973**
		Sig.	,000	.	,000	,000	,000	,000
	2014	Correlation Coefficient	,907**	,945**	1,000	,877**	,954**	,966**
		Sig.	,000	,000	.	,000	,000	,000
	2012	Correlation Coefficient	,905**	,862**	,877**	1,000	,854**	,903**
		Sig.	,000	,000	,000	.	,000	,000
	2010	Correlation Coefficient	,883**	,963**	,954**	,854**	1,000	,967**
		Sig.	,000	,000	,000	,000	.	,000
	COPRAS-G	Correlation Coefficient	,936**	,973**	,966**	,903**	,967**	1,000
		Sig.	,000	,000	,000	,000	,000	.

** Correlation is significant at the 0.01 level (2-tailed)

Source: own work

In comparison with the relationships between the ranking calculated by COPRAS-G and the ones calculated by WB is stronger than relationships calculated within the yearly rankings calculated by WB. The ranking calculated by COPRAS-G has the strongest relationship with all rankings published by WB. According to the results, the proposed model can be used as an effective decision making method that provides evaluation opportunity for a certain period, rather than a single year data.

CONCLUSIONS AND FUTURE RESEARCHES

It is tried to eliminate the uncertainty confronted due to the nature of decision problems, the lack of complete knowledge, by using grey system theory in this study. The main value the proposed method is to give an opportunity to evaluate the Logistics Performances of the countries for a selected period. Different from other studies, grey numbers are used to represent the performances of the selected countries by intervals obtained from the past datasets. The countries are ranked according to their evaluated LPI scores for this period.

This study also provides a different application area of COPRAS-G method. COPRAS-G method is used to evaluate the logistics performance of the countries. The criteria weights can be determined by MCDM methods such as Analytic Network Process (ANP), Stepwise Weight Assessment Ratio Analysis (SWARA), Factor Relationship (FARE), The Decision Making Trial and Evaluation Laboratory (DEMATEL), Entropy Weight Method and further analysis can be performed comparatively. Grey numbers obtained from the mean and standard deviations can be used instead of max-min performances for forming the data set. The study can be repeated using analyzes with new approaches such as Evaluation Based on Distance from Average Solution (EDAS) and Weighted Aggregated Sum Product Assessment (WASPAS) which are similar to the COPRAS method.

With the proposed method, it is considered that decision makers are presented with general ranking that includes and represents all published statistics rather than a single term. Periodic comparisons can be made with performance indexes that can be formed with more data. It will be useful to compare the results by making calculations for more than one period using grey numbers in the following years.

ACKNOWLEDGMENTS AND FUNDING SOURCE DECLARATION

The author(s) received no financial support for the research, authorship, and/or publication of this article.

REFERENCES

Adhikary D.D., Bose G.K., Dipankar B., Mitra S., 2014. Multi criteria FMECA for coal-fired thermal power plants using COPRAS-G. International Journal of Quality & Reliability Management; 31(5), 601-614. http://doi.org/10.1108/IJQRM-04-2013-0068

Aghdaie M.H., Zolfani S.H., Zavadskas E.K., 2013. Decision making in machine tool selection: An integrated approach with SWARA and COPRAS-G methods. Economics of Engineering Decisions, 24(1), 5-17. http://doi.org/10.5755/j01.ee.24.1.2822

Arslan R., Bircan H., Eleroglu H., 2018. Optimally rating of biogas, compost, vermicompost facilities to be installed in Yozgat Province with ARAS and COPRAS methods. Turkish Journal of Agriculture - Food Science and Technology 6 (12),1844-1852. http://doi.org/10.24925/turjaf.v6i12.1844-1852.2319

Bakar M.A.A, Jaafar H.S., 2016. Malaysian logistics performance: A manufacturer's perspective. In Peoceedings of the 6th International Research Symposium in Service Management. Procedia . 571-578. http://doi.org/10.1016/j.sbspro.2016.05.442

Bakhouyi A., Dehbi R., Talea M., 2016. Multiple criteria comparative evaluation on the interoperability of LMS by applying COPRAS method, 2016 Future Technologies Conference (FTC), 361-366. http://doi.org/10.1109/FTC.2016.7821635

Bayrakci E., Aksoy E., 2019. Comparative Performance Assessment with Entropy Weighted ARAS and COPRAS Methods of Private Pension Companies, Business and Economics Research Journal, 10(2), 415-433.

Bentyn Z., 2015. Changes of Logistics Performance in Poland as a Result of Integration with the European Union States. We Wrocławiu Research Papers of Wrocław University of Economics, 407.

Bitarafan M., Zolfani S.H., Arefi S.L., Zavadskas E.K., 2012. Evaluating the construction methods of cold-formed steel structures in reconstructing the areas damaged in natural crises, using the methods AHP and COPRAS-G, Archives of Civil and Mechanical Engineering 12, 3, September 2012, 360-367.

Cakir E., Ozdemir M., 2018. Alti Sigma Projelerinin Bulanik Copras Yöntemiyle Degerlendirilmesi: Bir Üretim Isletmesi Ornegi (Six Sigma Projects Evaluation Using Fuzzy Copras Method: A Case Of Manufacturing Company), Verimlilik Dergisi 2018, 1 (1) 7-40.

Candemir Y., Celebi D., 2017. An Inquiry into the Analysis of the Transport & Logistics Sectors' Role in Economic Development. Transportation Research Procedia, 25, 4692-4707. http://doi.org/10.1016/j.trpro.2017.05.317

Celebi D., 2017. The Role of Logistics Performance in Promoting Trade. Maritime Economics & Logistics, 21, 3, 307-323. http://doi.org/10.1057/s41278-017-0094-4

Çemberci M., Civelek M.E., Canbolat N., 2015. The Moderator Effect of Global Competitiveness Index on Dimensions of Logistics Performance Index. Procedia-Social and Behavioral Sciences, 95(2015) 514-1524. http://doi.org/10.1016/j.sbspro.2015.06.453

Chatterjee P., Chakraborty S., 2013. Gear material selection using complex proportional assessment and additive ratio assessment-based approaches: a comparative study. International Journal of Materials Science and Engineering, 1(2), 104-111. http://doi.org/10.12720/ijmse.1.2.104-111

Chatterjee K., Kar A.S., 2018. Supplier Selection in Telecom Supply Chain Management: A Fuzzy-RASCH Based COPRAS-G Method, Technological and Economic Development of Economy, 24, 2: 765–791.

Civelek M.E., Uca N., Cemberci M., 2015. The Mediator Effect of Logistics Performance Index on the Relation between Global Competitiveness Index and Gross Domestic Product. European Scientific Journal 11 (3): 368–375. Available at SSRN: https://ssrn.com/abstract=3338312

Dekker M.J., Looff E.J., Roelofsen D.S., Roekel W.S., 2016. Improving the Logistical Situation of Costa Rica. Delf Uiversity of Technology Report.

Erkan B., 2014. The Importance and Determinants of Logistics Performance of Selected Countries. Journal of Emerging Issues in Economics, Finance and Banking, 3(6), 1237-1254.

Faria R.N.D., Souza C.S.D., Vieira J.G.V., 2015. Evaluation of Logistic Performance Indexes of Brazil in the International Trade. Revista de Administração Mackenzie 16 (1) 213–235.

Gani A., 2017. The Logistics Performance Effect in International Trade. The Asian Journal of Shipping and Logistics, 33, 4, 279-288. http://doi.org/10.1016/j.ajsl.2017.12.012

Garg R., Kumar R., Garg S., 2019. MADM-Based Parametric Selection and Ranking of E-Learning Websites Using Fuzzy COPRAS, IEEE Transactions on Education, 62, 1, February 2019.

Hoekman B., Nicita A., 2011. Trade Policy, Trade Costs, and Developing Country Trade. World Development 39(12), 2069–2079.

Iris C., Tanyas M., 2011. Analysis of Turkish Logistics Sector and Solutions Selection to Emerging Problems Regarding Criteria Listed in Logistics Performance Index (LPI). International Journal of Business and Management Studies, 3, 1, 93-102.

Julong D., 1982. Control problems of Grey Systems, System and Control Letters, 5, 288-94.

Jumadi H., Zailani S., 2010. Integrating Green Innovations in Logistics Services Towards Logistics Services Sustainability: A Conceptual Paper. Environmental Research Journal 4(4), 261-271.

Khan S., Qianli D., 2017. Does National Scale Economic and Environmental Indicators Spur Logistics Performance? Evidence from UK. Environmental Science and Pollution Research 24 (34) 26692-26705. http://doi.org/10.1007/s11356-017-0222-9

Liou J.J.H., Tamošaitienė J., Zavadskas E.K., Tzeng G.H., 2016. New hybrid COPRAS-G MADM Model for improving and selecting suppliers in green supply chain management. International Journal of Production Research, 2016, 54, 1, 114–134. http://doi.org/10.1080/00207543.2015.1010747

Liu S., Lin Y., 2010. Introduction to Grey Systems Theory. In: Grey Systems. Understanding Complex Systems, vol 68. Springer, Berlin, Heidelberg.

Martí L., Puertas R., García L., 2014. The Importance of the Logistics Performance Index in International Trade. Applied Economics 46 (24): 2982–2992. http://doi.org/10.1080/00036846.2014.916394

Martí L., Martín J.C. Puertas R., 2017. A DEA-Logistics Performance Index. Journal of Applied Economics, 20, 1, 169-192. http://doi.org/10.1016/S1514-0326(17)30008-9

Nguyen H.T., Dawal S.Z.M., Nukman Y., Aoyama, H., 2014. A hybrid approach for fuzzy multi-attribute decision making in machine tool selection with consideration of the interactions of attributes. Expert Systems with Applications, 41, 6, May 2014, 3078-3090. http://doi.org/10.1016/j.eswa.2013.10.039

Nur Fadiah M.Z., Wahab S.A., Mamun A.A., 2017. Logistics Capability, Logistics Performance, and The Moderating Effect of Firm Size: Empirical Evidence From East Coast Malaysia. Journal of Developing Areas, 51, 2, 171-182. http://doi.org/10.1353/jda.2017.0038

Onsel Ekici, S., Kabak, O., Ulengin F., 2016. Linking to Compete: Logistics and Global Competitiveness Interaction. Transport Policy 48:117-128. http://doi.org/10.1016/j.tranpol.2016.01.015

Pancholi N., Bhatt M., 2018. FMECA-Based Maintenance Planning through COPRAS-G and PSI, Journal of Quality in Maintenance Engineering, 2018, 24, 2, 224-243. http://doi.org/10.1108/JQME-03-2017-0015

Puertas R., Martí L. García L., 2014) Logistics Performance and Export Competitiveness: European Experience. Empirica, 41 (3) 467–480. http://doi.org/10.1007/s10663-013-9241-z

Mousavi-Nasab S.H., Sotoudeh Anvari A., 2017. A comprehensive MCDM-based approach using TOPSIS, COPRAS and DEA as an auxiliary tool for material selection problems. Materials & Design. May 2017, 121, 237-253, 17. http://doi.org/10.1016/j.matdes.2017.02.041

Solakivi T., Ojala L., Laari S., Lorentz H., Toyli J., Malmsten J., Viherlehto N., 2015. Finland State of Logistics 2014. Turun Kauppakorkeakoulun Julkaisuja Sarja E-1:2015.

Tavana M., Momeni E., Rezaeiniya N., Mirhedayatian S.M., Rezaeiniya H., 2013. A Novel Hybrid Social Media Platform Selection Model using fuzzy ANP and COPRAS-G. Expert System with Applications 40(14): 5694-5702. http://doi.org/10.1016/j.eswa.2013.05.015

Uca N., Ince H., Sumen H., 2016. The Mediator Effect of Logistics Performance Index on the Relation Between Corruption Perception Index and Foreign Trade Volume. European Scientific Journal 12(25) 37-45. https://hdl.handle.net/11467/1573

Vaillancourt A., Haavisto I., 2015. Country Logistics Performance and Disaster Impact. Disasters 40(2), 262-283. https://doi.org/10.1111/disa.12146

Yapraklı T.S. Unalan M., 2017. The Global Logistics Performance Index and Analysis of the Last Ten Years Logistics Performance of Turkey. Ataturk University Journal of Economics & Administrative Sciences, 31, 3, 589-606.

Yildirim B.F., Adiguzel Mercangoz B., 2019. Evaluating the Logistics Performance of OECD Countries by Using Fuzzy AHP and

ARAS-G. Eurasian Economic Review, 1-19. http://doi.org/10.1007/s40822-019-00131-3

Zavadskas E.K., Kaklauskas A., Sarka V., 1994. The new method of multicriteria complex proportional assessment of projects, Technological and Economic Development of Economy, 1(3): 131–139.

Zavadskas E.K., Kaklauskas A., 1996. Determination of an Efficient Contractor by using the new Method of Multi Criteria Assessment. In Langford, D. A.; Retik, A. (eds.) Interna. Symposium for "The Organization and Management of Construction". Shaping Theory and Practice, 2: Managing the Construction Project and Managing Risk. CIB W 65; London, Weinheim, New York, Tokyo, Melbourne, Madras. - London: E and FN SPON, 94-104.

Zavadskas E.K., Kaklauskas A., Turskis Z., Tamosaitiene J., 2008. Selection of the Effective Dwelling House Walls by Applying Attributes Values Determined at Intervals. Journal of Civil Engineering and Management, 14(2), 85-93. http://doi.org/10.3846/1392-3730.2008.14.3

Zavadskas E.K., Turskis Z., Tamošaitienė J., Marina V., 2008. Multicriteria Selection of Project Managers by Applying Grey, Technological and economic development 14(4): 462–477. http://doi.org/10.3846/1392-8619.2008.14.462-477

Zhang Y, Tan Y., Li N., Liu G., 2018. Decision-Making in Green Building Investment Based on Integrating AHP and COPRAS-Grey Approach, In Proceedings of the International Conference on Construction and Real Estate Management 2018, :65-71. http://doi.org/10.1061/9780784481738.008

Zolfani S.H., Chen I.S., Rezaeiniya N., Tamosaitiene J., 2012. A Hybrid MCDM Model Encompassing AHP and Copras-G Methods for Selecting Company Supplier in Iran. Technological and Economic Development of Economy, 18(3): 529-543. http://doi.org/10.3846/20294913.2012.709472

METODA OKRESOWA COPRAS-G: ZASTOSOWANIE WSKAŹNIKA SPRAWNOŚCI LOGISTYCZNEJ (LPI)

STRESZCZENIE. **Wstęp:** Logistyka jest istotną częścią handlu wielu krajów. Wkład w postaci surowców oraz energii jest niezbędny w procesie produkcji, wymaga on jednak najczęściej transportu, tak samo jak i wyroby finalne uzyskanie w procesie produkcji, zrealizowanego w efektywny sposób jako element całego procesu logistycznego. W celu pomiaru tego procesu w różnych krajach, Bank Światowy publikuje w okresach dwuletnich dane dotyczące aktywności logistycznych.
Metody: Podstawowym celem tej pracy jest dostarczenie oceny działalności logistycznej wybranych krajów w wybranym okresie czasu. Liczby szare są stosowane do określenia danych dla danego okresu oraz zastosowania metody Complex Proportional Assessment of Alternatives (COPRAS). Stworzono ranking sprawności logistycznej obejmujący 28 państw członkowskich UE oraz 5 państw kandydujących do EU. W celu oszacowania poprawności danych wyliczonych przy pomocy metody COPRAS, wykonano podwójne porównanie otrzymanych rankingów przy użyciu metod Spearman Rank oraz korelacji Kendalla Tau.
Wyniki: Uzyskane wyniki pokazują, że dane otrzymane poprzez użyciu liczb szarych reprezentują dane LPI badanych krajów w wybranym okresie. Występujące różnice, ujawnione w postaci współczynników korelacji Spearman i Kendall, nie są istotne. Ranking uzyskany w oparciu o metodę COPRAS-G wykazuje silną korelację ze wszystkimi rankingami publikowanymi przez Bank Światowy.

Wnioski: Wskaźnik LPI dla wybranych krajów na założony okres został wyliczony poprzez zastosowanie liczb szarych w połączeniu z metodą COPRAS-G.

Słowa kluczowe: COPRAS-G, sprawność logistyczna,wielokryterialne podejmowanie decyzji, szare liczby, analiza korelacji

Burcu Adiguzel Mercangoz ORCID ID: https://orcid.org/0000-0003-2250-1052
Faculty of Transportation and Logistics
Istanbul University
I.U.C. Avcilar Campus, 34320 Avcilar, Istanbul, **Turkey**
e-mail: burcua@istanbul.edu.tr

Bahadır F. Yildirim ORCID ID: https://orcid.org/0000-0002-0475-741X
Faculty of Transportation and Logistics
Istanbul University
I.U.C. Avcilar Campus, 34320 Avcilar, Istanbul, **Turkey**
e-mail: bahadirf.yildirim@istanbul.edu.tr

Sultan KUZU YILDIRIM ORCID ID: https://orcid.org/0000-0001-6577-1584
School of Business
Istanbul University
I.U.C. Avcilar Campus, 34320 Avcilar, Istanbul, **Turkey**
e-mail: sultan.kuzu@istanbul.edu.tr