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ORIGINAL PAPER

GLOBAL SCALE INTEGRATED LOGISTICS PERFORMANCE ANALYSIS AND ITS SPILLOVER EFFECT

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ABSTRACT. Background: Countries that are efficient in terms of logistics infrastructure have easy access to different markets in terms of production and foreign trade and thus achieve economic prosperity. In order to compare the performance of countries in logistics processes, there are international logistics indexes published by various organizations for different country categories. Each of these indexes is used to follow the performance of the logistics infrastructures of the countries and the logistics operations accordingly.

Methods: The aim of this study is calculation and comparison of the integrated logistics performance of 101 countries with the ROC-based WASPAS method and the presence of spatial autocorrelation between the obtained integrated logistics performance values by using four different international logistics indexes (Logistics Performance Index (LPI) (2018), Liner Shipping Connectivity Index (LSCI) (2021), Enabling Trade Index (ETI) (2016), and Availability and Quality of Transport Infrastructures (AQTI) (2016)) data.

Results: It has been determined that the top five countries with the highest integrated logistics performance are Singapore, Germany, China, Japan, England, and USA, respectively. On the other hand, Sierra Leone, Congo, Mauritania, Gabon, Liberia, and Madagascar are the weakest countries. Integrated logistics performance of a country is generally significantly affected by the logistics performance of the neighboring country, albeit limited. This is especially prevailing for USA, Canada, and Western Europe.

Conclusion: For the global integrated logistics performance analysis, countries with strong production capacity and logistics infrastructure are in first place, and there is a positive spatial autocorrelation in terms of integrated logistics performance among some countries in Western Europe and the Americas.

Keywords: Logistics Performance, Multi-Criteria Decision-Making Techniques, ROC, WASPAS, Spatial Autocorrelation

INTRODUCTION

Considering the similarity of production technologies and resources used today, it is known that the most crucial reason for preference for the customer is the price. So, while all other production conditions are almost the same, it is clear that the most challenging issue for businesses in terms of competition will be to provide price advantage. This is because customers now have the advantage of being able to supply any product they want from anywhere in the world. At this point, there is only one aspect that can provide a price advantage for businesses: logistics operations. According to “The World is Flat”, Thomas L. Friedman [2006], while presenting the profile of the world of the future, there are ten forces that flattened the world, five of which are directly and five indirectly related to logistics. In this respect, logistics operations do not create value added for customers but are an important trigger for businesses.

Recently, the difference between the goods produced in the market and offered to the final consumer has decreased considerably. In other words, the functions of the products in the market have become closer to each other, and the technology contents that provide the similarities of these products have also converged. Although the trade of products with high value added in the international market is significant in terms of

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gaining profits, the fact that the information patterns related to these products converge and substitution characteristics increase necessitates the strategies based on price competition to be at the forefront. As a matter of fact, the global value chain created in the international production process operates based on high quality and price-oriented goals for the product [Mudambi and Puck, 2016; Ravenhill, 2014]. The strategies that emphasize supply chain and logistics operations are crucial for both businesses and countries. To be able to compete in the production and trade process, logistics operations need effective management, especially in transportation and warehousing processes. In other words, the effective management of the processes related to international logistics and logistics operations has a critical role in increasing the profitability of enterprises through foreign trade and countries achieving competitiveness in foreign trade as well. In addition, in international goods trade, international supply chain structuring has also turned into increasingly global logistics operations. Therefore, it is necessary for countries to determine multifaceted logistics operations and performance-based strategies in order to gain competitiveness and increase their income in international goods trade. In the new era business model, manufacturers often establish foreign factories in order to take advantage of tariff and trade concessions in foreign markets, low-cost direct labor, capital subsidies, and low logistics costs [Ferdows, 1997]. This situation brings manufacturers closer to different geographies and it provides convenience for them to use the geographical advantage of the country close to the supplier or where the production activity is carried out. The significant geographic distances on a global scale not only increase shipping costs, but also complicate many decisions due to increased inventory cost due to increased lead time in the supply chain [Meixell and Gargeya, 2005]. Today, about 70% of international trade involves global value chains. This means that services, raw materials, and components often cross borders many times and are shipped to consumers all over the world after being incorporated into final products [Alsamawi et al., 2020]. At this point, the role of logistics operations is large.

The strong inclusion of countries in international markets and their revenue generation depend on the extent to which they are affected by the global value chain. Therefore, strong inclusion of countries in the global value chain also requires strong logistics performance. In addition, being added to the complex value chain in the global supply chain can also affect the geographical location of the countries. With the liberalization of foreign trade, the international interaction of logistics operations has also increased. The transportation of a product that is produced and traded on a global scale to a certain region can be planted from other countries' geographical locations. As a matter of fact, this situation may have an effect on the advantageous logistics position of the countries to determine the logistics performance of the neighboring country. The logistics performance of a country is affected by its geography, and this may also affect the logistics performance of neighbor countries.

In recent years, the evaluation of logistics efficiency and performance has gained importance on a global scale. There are various indicators (Logistics Performance Index (LPI), Liner Shipping Connectivity Index (LSCI), Enabling Trade Index (ETI), and Availability and Quality of Transport Infrastructures (AQTI) e.g.) used to monitor the logistics performance of countries. These indexes, which show how effectively countries use their resources in terms of logistics, are also used to determine how strong these countries are, especially in foreign trade. These indexes can reveal the current situation of countries' logistics processes and have a key role in determining their policies regarding logistics operations in the future.

In the study, an integrated logistics performance ranking was conducted for 101 countries by using four different indexes (Logistics Performance Index (LPI), Liner Shipping Connectivity Index (LSCI), Enabling Trade Index (ETI), and Availability and Quality of Transport Infrastructures (AQTI)), which are used as a measure of international logistics performance. Rank Order Centroid (ROC) and Weighted Aggregated Sum Product Assessment (WASPAS) techniques were used to calculate the integrated logistics performance. The performance indexes were weighted using the ROC technique, and the WASPAS technique was used for ranking the countries. As far as is known in the literature, previous research on the logistics performance index have revealed that there is no study that employs different indices and methodologies in a cohesive manner as in this paper. In addition, using the scores obtained from WASPAS technique, which is calculated as an integrated performance measure in the study, the spatial relationship between the logistics performances of the countries was analyzed by using the Moran's I and Local Indicators of Spatial Association (LISA) method based on the geographic information system. Thus, it has been examined whether the logistics performances of the countries are also affected by other countries that have geographical contiguity. The objective of the spatial spillover effect analysis is to consider how improvements in logistics performance in one country can affect the performance of other countries within the same region or trade partner.

In the first section of the study following the introduction, some performance indexes calculated by different international institutions and determined for different areas of logistics were introduced. In the second section of the study, the previous studies were given as a literature review. In the third section, ROC, WASPAS, Moran' I, and LISA methods used in the study were introduced. In the fourth part, the data set, analysis, and findings were presented. In the last section, the results were discussed, and some suggestions were given.

VARIOUS LOGISTICS PERFORMANCE INDICATORS

One of the most important determinants of a country's global competitive advantage is the efficiency of logistics services in that country. An effective logistics management aims to increase efficiency and reliability, as well as to minimize logistics costs [Nordas et al., 2006].

The indexes and reports published by various international organizations are effective in terms of both seeing the logistics performance status of the countries in the world economy and determining their place among the countries in the region and revealing their visions [Yapraklı and Ünalan, 2017].

The most well-known criterion showing the logistics performance of countries at the global level is the logistics performance index (LPI) published by the World Bank. The index is published by the World Bank. The index is calculated through surveys obtained from experts in global logistics companies around the world. There are six dimensions to determine the logistics performance of countries: customs, infrastructures, ease of arranging shipments, quality of logistics services, tracking and tracing, and timeliness [Arvis et al., 2018].

The Liner Shipping Connectivity Index (LSCI), another measure of logistics performance on a global scale, has been published by the United Nations Conference on Trade and Development (UNCTAD) since 2004. The index in question shows how well countries are connected to global maritime transport networks in maritime transport. In the measurement made by UNCTAD, the year 2006 is accepted as 100 based. LSCI consists of five main components: the number of shipping companies, the amount of services provided by the companies, the number of ships, the container carrying capacity of the ships, and the size of the largest ship [UNCTAD, 2022].

Enabling Trade Index (ETI) has been published since 2008 by the World Economic Forum, through many academics, partner organizations and companies, to facilitate and evaluate trade. The index evaluates the countries' policies, infrastructure, institutions, and services that enable trade from the point of origin to the point of consumption. ETI is obtained by combining various factors that mediate enabling trade. These factors consist of seven pillars under the four main dimensions. These can be sorted into market access, border administration, infrastructure, and operating environment [WEF, 2016].

Another indicator is Availability and Quality of Transport Infrastructures (AQTI), which is one of the pillars of Enabling Trade Index. This pillar measures the availability and quality of domestic infrastructure for each of the four main modes of transport: road, air, railroad, and seaport infrastructures. Air connectivity and sea line connectivity are also assessed [WEF, 2016].

LITERATURE REVIEW

While numerous studies have been conducted to determine the logistics performance of nations, most have typically utilized the Logistics Performance Index or combined various data sets related to logistics functions. A few of these studies have utilized different multi-criteria decision-making methodologies, which are presented below.

Nguyen et al. [2022] evaluated the performance of maritime transport in 24 European Union countries by data envelopment analysis. In the study, the short sea shipping, energy consumption, containers, labor force, number, and gross tonnage of vessels were used as inputs and passenger and gross weight of goods transported were used as outputs. As a result, it has been determined that the countries with the best performance in maritime transport are Estonia, Croatia, and Latvia, respectively.

Mešić et al. [2022] compared the logistics performance of Western Balkan countries, which are Bosnia and Herzegovina, North Macedonia, Albania, Serbia and Montenegro, with the CRITIC and MARCOS methods, using the six criteria in the logistics performance index in 2018. According to the results, the most important criterion is shipment delivery within scheduled times, and it was stated that Serbia is the best country and Albania is the worst.

Işık et al. [2020] analyzed the logistics performance of 11 Central and Eastern European countries by analysis of variance and MABAC. It has been determined that the most important and least important criteria in logistics performance are timing and infrastructure, respectively. It has been determined that the country with the best performance in logistics performance is the Czech Republic, Poland, and Hungary, respectively.

Yalçın and Ayvaz [2020] evaluated customs management, infrastructure, international transportation, logistics service quality and adequacy, monitoring and tracking, and timing of Türkiye and Türkiye's four border neighbors Bulgaria, Greece, Georgia, and Iran by using Fuzzy AHP and Fuzzy TOPSIS methods. As a result of the analysis, it was found that the best performing countries are Türkiye, Iran, Bulgaria, Greece, and Georgia, respectively.

Kısa and Ayçin [2019] analyzed the logistics performance of OECD countries with the SWARA and EDAS methods. According to the results, the logistics service quality was found to be the most important criterion. In the ranking results, Germany, the Netherlands, and Sweden are in the first three places, while Latvia, Mexico, and Slovakia are in the last three.

Ulutaş and Karaköy [2019] examined the logistics performances of G20 countries using standard deviation and WASPAS methods. In the study, six factors in the logistics performance index were used for 2018. Germany, Japan, the United Kingdom, the United States, and France are the best countries.

Rezaei et al. [2018] weighted the six criteria in the logistics performance index with the Best-Worst Method by consulting 107 experts from six continents in 2016. Infrastructure was found to be the most important criterion in logistics performance, while traceability was the least important criterion. In addition, it has been suggested in the study that environmental effects, innovation, and investments in information technologies can be added to the logistics performance index.

Marti et al. [2017] aimed to propose a data envelopment analysis (DEA) approach to compute a synthetic index of overall logistics performance (DEA-LPI) and benchmark the logistics performance of the countries with LPI for 141 countries. It was determined that logistics performance depends largely on income and geographical area. High income countries are in the group of best performers, which is highly dominated by the EU.

Yu and Hsiao [2015] purposed to evaluate LPI using meta-frontier data envelopment analysis with assurance regions (Meta-DEA–AR) model. For conformity with the ranking of original World Bank LPI, the assurance region of each logistics indicator is obtained by a regression model. It has been found that the LPI rankings obtained by the proposed model are very comparable to those of World Bank LPI.

Considering previous literature, the logistics performance index published by the World Bank was generally used to measure the logistics performance of countries. In contrast to previous research, the current study seeks to integrated logistics performance of countries by using three different indexes including LPI.

METHODS

Rank Order Centroid (ROC)

There are different strategies for weighting the criteria affecting the decision. One of them is the ROC (Rank Order Centroid - Ranking Center Weights) technique, which was suggested by Barron and Barrett [1996] to be used in criterion weighting. The application steps of the ROC technique, which has reached a conclusion, are as follows by ranking only the criteria in order of importance and using the sort values with that array by decision makers [Ahn, 2011];

Ranking the decision criteria in order of importance; At this stage, n predetermined decision criteria, which are evaluated to affect the decision and are ranked in order of importance.

$$K_{r_1} > K_{r_2} > \cdots > K_{r_n} \quad (1)$$

Calculation of criterion weight values; The criteria weights are determined by using Equation 2.

$$w_n = \frac{1}{N} * \sum_{k=n}^{N} \left(\frac{1}{r_k}\right) \quad (2)$$

Weighted Aggregated Sum Product Assessment (WASPAS)

WASPAS (Weighted Aggregated Sum Product Assessment) was suggested by Zavadskas et al. [2012] to rank alternatives by using their criterion values and weights. The application stages of the WASPAS technique are as follows [Jahan, 2018];

Decision matrix has been prepared to represent m as the number of alternatives and n as the number of criteria. It is based on the criteria to be used in the analysis, as in Equation 3.

$$A_{ij} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix} \quad (3)$$

Normalized decision matrix is prepared by using Equation 4 for utility-oriented criteria and Equation 5 for cost-oriented criteria.

$$x_{ij} = \frac{x_{ij}}{\underset{i}{max}\,(x_{ij})} \quad (4)$$

$$x_{ij} = \frac{\underset{i}{min}\,(x_{ij})}{x_{ij}} \quad (5)$$

In the next step, **weighted sum technique** is calculated by using Equation 6 and **weighted product technique** is calculated by using Equation 7.

$$WSM; Q_i^{(1)} = \sum_{j=1}^{n} x_{ij} * w_j \quad (6)$$

$$WPM; Q_i^{(2)} = \prod_{j=1}^{n} (x_{ij})^{\pm w_j} \quad (7)$$

In the last stage, **the compromised solution** is calculated by using Equation 8. The λ parameter in this equation can be determined freely by the decision maker.

$$WASPAS; Q_i = \lambda * Q_i^{(1)} + (1-\lambda) * Q_i^{(2)} \quad (8)$$

In the compromised solution of the method, a ranking is made such that the alternative with the highest Q_i value is in the first place.

Spatial Autocorrelation: Moran's I and Local Moran's I Index

Spatial analysis methods are frequently used, especially in regional studies. Sample space data in regional studies belong to locations that represent a point in space. The basic principle underlying spatial data analysis is that observations that are close to each other are more related than observations that are far [Anselin, 1995; LeSage, 1999]. Spatial autocorrelation analyses show whether the variables are systematically and spatially distributed. In other words, it is about the covariance or correlation between data and contiguity observations. One of the statistics frequently used to measure spatial autocorrelation is Moran's I index. Moran's I value ranges from -1 to 1. A positive Moran's I value indicates clustering of similar values, and a negative Moran's I value indicates clustering of dissimilar values. A value of 0 indicates that there is no clustering. Moran's I index is calculated as shown in Equation 10 and Equation 11 [Anselin, 1995].

$$\mathrm{I} = \frac{n}{S_0} \sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij} \tag{10}$$

$$S_0 = \sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij} \tag{11}$$

In the equations, n is the number of observations, w_{ij} is the spatial weight and thus is the sum of the spatial weights, x_i is the value of the variable belonging to the *i* location, x_j is the value of the variable to the *j* location, and $\overline{x}$ is the mean of the variable.

Moran's I statistic takes the entire data set in spatial autocorrelation and gives a single statistic for the interpretation of spatial autocorrelation. Moran's I does not include information on whether the dataset values are clustered with high or low values. On the other hand, local statistics allow for the analysis of the locations of the sample separately. For such an approach, spatial interaction is measured for each spatial unit (region) by using the Local Indicator of Spatial Association (LISA), and information about the type of this interaction can be obtained. The LISA index, which is used to determine the locations of possible clusters, is calculated as shown in equations 12 and 13 [Anselin, 1995].

$$I_i = \frac{x_i - \overline{x}}{S_i^2} \sum_{j=1}^{n} w_{ij} \tag{12}$$

$$S_i^2 = \frac{\sum_{j=1}^{n} w_{ij}}{n-1} - X^2 \tag{13}$$

The LISA index, which employed spatial autocorrelation at the local level, gives information about whether regions with high and low values are clustered or not. With this index, the existence of four separate relationships can be revealed. There are two categories of positive and negative autocorrelation. There are hot spot areas (High-High, HH) and cold spot areas (Low-Low, LL). In hot spot areas where regions with similar data cluster together, high-value regions of the relevant variable are clustered together. In cold spot areas, low-value regions of the relevant variable are clustered. For the negative correlation, there are two categories, the high-value region is surrounded by low-value neighbors, or low-value regions are surrounded by high-value regions. Spatially deviating regions can be detected with this type of autocorrelation [Fischer and Wang, 2011].

In the study, the spatial pattern was also taken into consideration when examining the country's performance in logistics processes. For this, the effect of spatial autocorrelation presented by the geographic information system was included in the analysis as well. Thus, it has been revealed whether the logistics performances of the countries are also affected by other geographical neighbors or contiguity countries. In the study, Moran's I test statistics were calculated for the integrated performance values obtained from WASPAS in examining the spatial autocorrelation. Then, the Local Moran's I index (LISA), which considers the autocorrelations of each country's logistics performance data, was calculated. Thus, the spatial significance of the clustering or outlier values of the data group in the analysis was also examined.

ANALYSIS AND FINDINGS

Integrated Logistics Performance by Various Logistic Index Values

In the study, an integrated logistics performance ranking was employed for 101 countries. Furthermore, in the analysis, the spatial autocorrelation tests were according to this performance score. The ROC-based

WASPAS method was used in the measurement of logistics integrated performance. The 101 countries included in the study and their compiled data are presented in Appendix 1, and the decision matrix was created based on this. The criteria and data year representing the indexes used for the integrated calculated performance measures are as follows:

- C1; Logistics Performance Index (LPI) (2018)
- C2; Liner Shipping Connectivity Index (LSCI) (2021)
- C3; Enabling Trade Index (ETI) (2016)
- C4; Availability and Quality of Transport Infrastructures (AQTI) (2016).

The ROC technique was used for the determination of criterion weight values. At this stage, a group of six experts, three of whom are academics and three of whom are industry professionals, was asked to rank the criteria in order of importance. In the study, the geometric mean of the ranking values made by the expert group was taken and a new and consensus ranking was obtained. These rank values are shown in Equation 1. Then, using Equation 2, the weight values of all the criteria were determined and presented in Table 1.

Table 1. Rank and Weight Values of Criteria According to Expert Group Opinions

Criteria	Academic Assessors			Sector Assessors			Geometric Average	Rank Values	Weight Values
	A1	A2	A3	IP1	IP2	IP3			
C1	1	1	2	1	2	1	1,2599	1	0,5208
C2	4	4	4	4	3	4	3,8127	4	0,0625
C3	2	2	3	3	4	2	2,5698	3	0,1458
C4	3	3	1	2	1	3	1,9442	2	0,2708

For the logistics efficiency ranking of the countries, a decision matrix has been prepared so that the criteria weight values obtained by the ROC technique will be used in WASPAS. Then, with the decision matrix presented in Appendix 1, the WASPAS process steps were followed. As a result, the efficiency scores, consisting of five different compromise solutions, and the rank values of the countries were obtained and are presented in Appendix 2 by giving different values to the compromise solution parameter (λ).

Singapore, Germany, China, Japan, England, and USA are the top five countries in logistics performance on a global scale. The common feature of these countries is that they have significant production and foreign trade volume. In addition, these countries have a strong infrastructure in logistics. These countries have an important place in the global value chain by continuing international production, trade, investments, and different stages of production processes in different countries as well.

According to the results of the analysis, the countries in the last place were Sierra Leone, Congo, Mauritania, Gabon, Liberia, and Madagascar. These countries do not have an important share in the global production and supply chain and are therefore behind in terms of foreign trade volume. In addition, the fact that the infrastructure of these countries for logistics operations is not developed can be shown as another reason for this result.

Integrated Logistics Performance and Spatial Autocorrelation

Using the WASPAS scores of the 101 countries included in the analysis, the existence of neighborhood relations between countries for integrated logistics performance was examined using Moran's I and Local Moran's I index. Thus, the spillover effect was investigated for logistics performance between geographically contiguity countries. In order to scrutinize the spatial autocorrelation, first the map of integrated logistics performance of the countries included in the analysis was drawn and presented in Figure 1. Accordingly, it is observed that countries with high logistics performance are clustered in North America and Western Europe.

In Figure 1, it is seen that the logistics performances of the countries may be related to the geographically neighboring countries. In other words, it is observed that there may be spatial autocorrelation between the logistics performances of countries. Univariate Moran's I test statistic was calculated in the examination of spatial autocorrelation using queen contiguity-based spatial weight matrix. According to Moran's I statistics, the logistics performance score of a country is affected by the logistics performance value of the neighboring country. Spatial correlation was I=0.3487, and this is statistically significant at the 5% level. As the value gets closer to 1, the importance of spatial lag increases. This finding indicates that the international logistics performance of a country is affected by the logistics performance of the neighboring country but is limited. (Fig. 2).

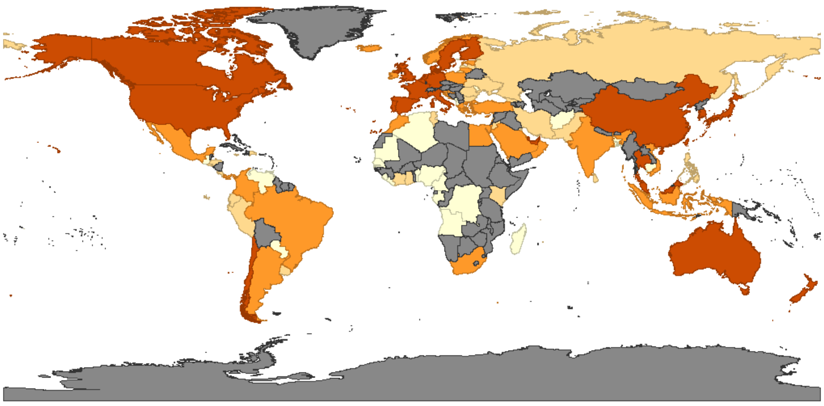
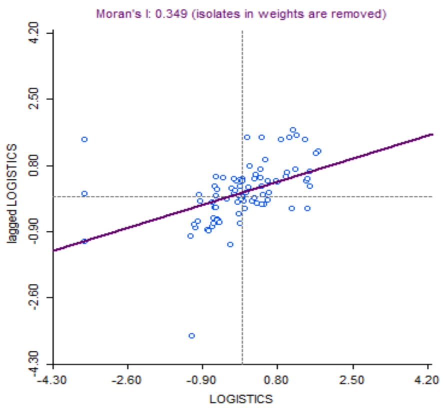


Fig. 1: Integrated Logistics Performance Clustering Map



I: 0.3487	E[I]: -0.0119	Sd.: 0.1047	z-value: 3.4119	p-value: 0.005

Fig. 2: Moran's I Scatter Plot and Index

The clustering map of the Local Indicator of Spatial Association (LISA) for the Local Moran's I calculation, which deals with the lagged spatial effect from each country level, is given in Figure 3. Accordingly, a pattern is observed in which local spatial autocorrelation has a significant effect for some regions. For LISA index (spatial autocorrelation at the local level), the areas marked in red in the cluster map are located in the I. region of the Moran's I scatter plot, and the level of correlation is “high-high” (both high logistics performance of the country and high logistics performance of its neighbors). This spatial autocorrelation is especially valid and statistically significant (p=0.05) for some of the Americas and Western European countries. In other words, the integrated logistics performance value of the countries in this region positively affects other neighboring/contiguity countries and it is also determinant of logistics process efficiency. Clearly, Canada's logistics performance is also affected by America's high logistics performance. Similarly, Portugal and

Ireland are also positively affected by the logistics performance of their neighboring countries. The spatial autocorrelation effect of integrated logistics performance is positive for Germany, Belgium, Netherlands, and Denmark as well. It can be said that there is a spatial positive externality among logistics operations in these countries.

The blue colored regions on the map are in the III. region of Moran's I scatter plot. These regions shows that the level of correlation is "low-low" (both low logistics performance of the country and high logistics performance of its neighbors). This spatial autocorrelation is statistically significant (p=0.05) and limited for Congo and Liberia in Africa and Iran in the Middle East. On the other hand, there is no statistically significant autocorrelation in the cluster of countries which are in the II. and IV. regions of the Moran's I scatter plot with low logistics performance and high logistics performance, and vice versa. These regions are colored in grey.

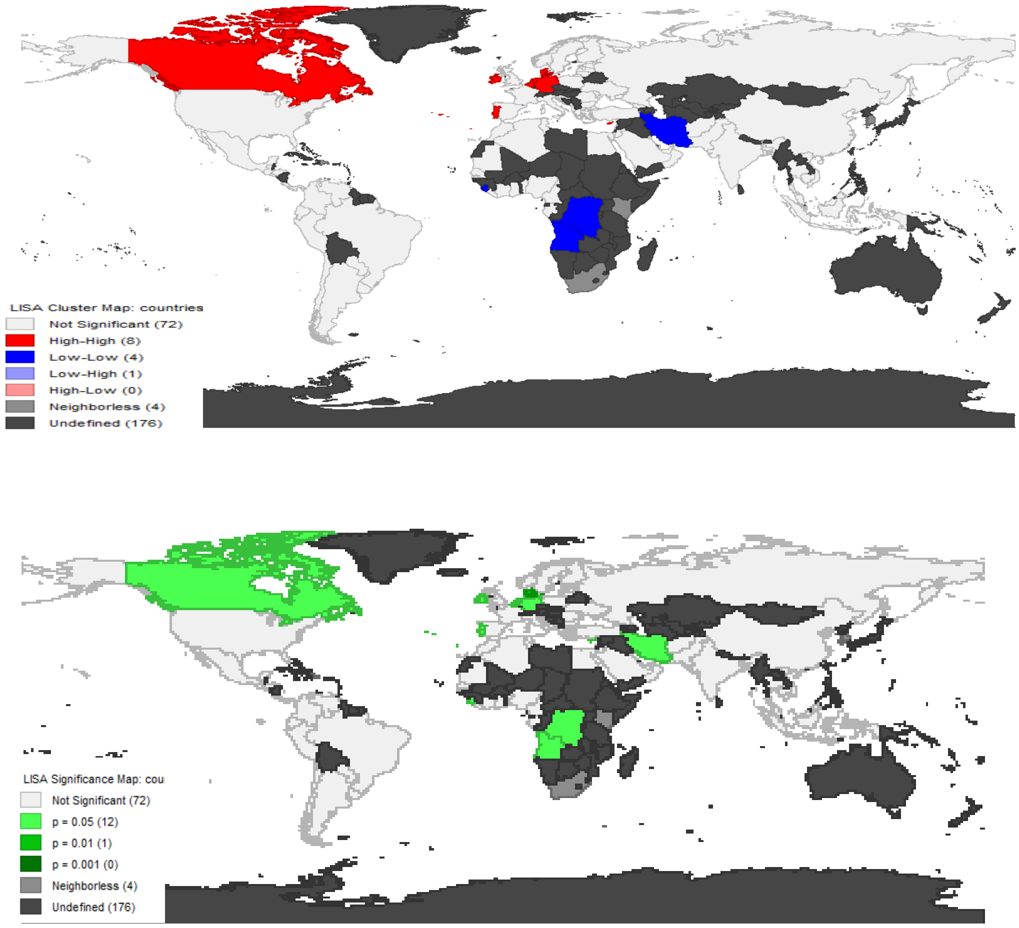


Fig. 3. LISA Clustering and Significance Map

DISCUSSION AND CONCLUSION

It is a well-established fact that logistics costs can exert a significant influence on the overall cost of products. Therefore, logistics is one of the critical issues that businesses can save on to maintain their competitiveness and to provide a sustainable production cycle [Ekici et al., 2016]. The fact that the countries have a strong infrastructure in terms of logistics also contributes positively to the competitiveness of the enterprises that produce goods subject to foreign trade and operate within the country. At the same time, this situation can contribute positively to the country's economic prosperity [Manavgat and Demirci, 2021]. Logistics performance is becoming more and more important for international trade in many countries [Martí et al., 2014]. In this respect, the creation of strategies for countries to come to the fore in terms of logistics on a global scale is one of the current issues.

In the study, integrated logistics performances were determined by using four basic index data prepared by different institutions to determine and monitor the logistics performances of countries. For this, the Logistics Performance Index, Liner Shipping Connectivity Index, Enabling Trade Index, and the Availability and Quality of Transport Infrastructures have been used as the criterion. Calculations were made for 101 countries with the ROC-based WASPAS technique. At the same time, using the WASPAS scores of the countries, spatial autocorrelation existence based on geographical information system has been analyzed by using Moran's I and Local Indicators of Spatial Association (LISA) method. Thus, it has been revealed whether the logistics performances of the countries are also affected by other geographical contiguity countries.

The outcome of the analysis shows that the top five countries with the highest integrated logistics performance are Singapore, Germany, China, Japan, England, and the USA, respectively. It can be inferred that these countries have a significant share in world trade and are sophisticatedly added to the global supply chain, so they have succeeded in managing their logistics infrastructure and processes relatively effectively. Earlier research has determined that these countries outperform others in terms of logistics performance as well and thus corroborating the outcomes of this study [Ulutaş and Karaköy, 2019; Kısa and Ayçin, 2019; Martí et al., 2017; Yu and Hsiao, 2015]. It has been found that Sierra Leone, Congo, Mauritania, Gabon, Liberia, and Madagascar are the weakest countries. These countries possess a relatively small proportion of the global production and supply chain; consequently, they lag behind in terms of foreign trade volume. Moreover, the inadequately developed logistics infrastructure in these countries reinforces this outcome.

Spatial pattern and autocorrelation were also considered in examining the performance of the countries covered in the study of logistics processes. When the effect of the neighborhood relationship of the countries on logistics performance was considered by using the scores obtained from WASPAS, it was determined that the integrated logistics performance of a country is generally significantly affected by the logistics performance of the neighboring country, albeit to a limited extent. According to the Local Indicator of Spatial Association (LISA), spatial autocorrelation is statistically significant and has a positive effect for some regions. This is especially the case for the USA, Canada, and Western Europe. The logistics performance of Canada is also affected by the USA's high logistics performance. Similarly, Portugal, Ireland, Germany, Belgium, Netherlands, and Denmark are positively affected by the logistics performance of their neighboring countries.

These results show that in Europe, it contributes to the improvement of the logistics performance of other neighboring countries, especially in the geography in which Germany is located. This is because the largest logistics market in the European Union is Germany (European Commission, 2015). Many countries, such as Slovenia, Belgium, Netherlands, and Slovakia are dependent on Germany through international trade, and the more effective functioning of these countries in the logistics market is affected by Germany's efficiency in logistics processes [Sternad et al., 2018]. Furthermore, the presence of Europe's 2nd and 3rd largest ports in Germany and Belgium also supports the ability of neighboring countries' international trade and logistics performance [World Shipping Council, 2019; Beysenbaev and Dus, 2020]. On the other hand, the fact that Germany has become the trigger of the global value chain in Central and Eastern Europe, increases Germany's role as an input supplier in the exports of Central and Eastern European countries (backward linkage rather than forward linkage) [Ambroziak, 2018]. This situation also supports the effect of the geographical neighborhood on logistics performance in the results of the study. Therefore, determining an inclusive or holistic logistics strategy between these countries would be a policy that would increase the strength of logistics network structuring.

Moreover, the negative spatial autocorrelation was also observed for very few African and Middle Eastern countries in the study. In the integrated logistics performance, the low logistics performance of Congo and Liberia in Africa and Iran's neighboring country in the Middle East has a significant effect on the low logistics performance of these countries. Another reason why these countries rank low in many logistics indicators (besides being behind in terms of economic and foreign trade volume) can also be stated as the fact that they are affected negatively by their neighbors geographically. This consequence may reveal that it would be more significative for them to turn to individual country-specific policies and even logistics strategies that would differ from geography rather than developing policies for the establishment of an integrated logistics network system based on geographical contiguity among these countries.

On the other hand, the limits of the study can be expressed for different perspectives. The analysis relies heavily on the availability and quality of data, which may be limited in some regions or countries. The measurement of integrated logistics performance has been attempted on a broad scale encompassing many countries, but incorporating data from countries missing data would strengthen global-scale analysis. Furthermore, the analysis solely depicts the current scenario, and it could be worthwhile to track the trend of logistics performance by contrasting the findings with past or future data. The analysis may not capture all aspects of logistics performance well, such as environmental sustainability and social responsibility for countries. Additionally, the spillover effects may not consider all potential impacts on different stakeholders, such as between consumers and local communities in terms of logistics performance.

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Appendix 1. Decision Matrix

No.	Countries	C1	C2	C3	C4
1	Albania	2,6596	4,3941	4,5100	2,6400
2	Algeria	2,4481	12,4657	3,5100	3,3330
3	Argentina	2,8870	34,2050	3,9800	4,0748
4	Australia	3,7514	36,6750	5,1000	4,8700
5	Bahrain	2,9348	27,9310	4,7900	4,8724
6	Bangladesh	2,5766	14,5477	3,4800	3,0720
7	Belgium	4,0391	87,9031	5,4500	5,2500
8	Benin	2,7499	20,4112	3,4800	2,6900
9	Brazil	2,9858	37,4589	3,8000	4,1408
10	Brunei Darussalam	2,7066	5,9573	4,2700	3,3900
11	Bulgaria	3,0340	7,7913	4,5400	3,1200
12	Cambodia	2,5786	8,8061	3,9600	3,1729
13	Cameroon	2,5955	19,7007	3,2000	2,4200
14	Canada	3,7267	48,0055	5,1500	5,2900
15	Chile	3,3171	36,6099	5,2600	4,5844
16	China	3,6051	168,4928	4,4900	5,0456
17	Colombia	2,9416	49,4777	4,1000	3,7550
18	Congo, Dem. Rep.	2,4284	4,7795	3,0300	2,0300
19	Costa Rica	2,7917	24,2429	4,5200	2,5700
20	Côte d'Ivoire	3,0823	20,2474	3,8700	3,6700
21	Croatia	3,1041	33,5668	4,7600	3,6600
22	Cyprus	3,1508	17,5659	4,6100	3,8400
23	Denmark	3,9919	46,0720	5,4200	4,8800
24	Dominican Rep.	2,6618	40,4564	4,2000	3,8200
25	Ecuador	2,8816	37,8637	4,1400	3,8766
26	Egypt, Arab Rep.	2,8249	66,9717	3,7200	3,9899
27	El Salvador	2,5755	8,1176	4,2500	3,1500
28	Estonia	3,3116	10,3838	5,3200	3,8400
29	Finland	3,9691	14,8988	5,6000	4,8900
30	France	3,8445	76,4629	5,3700	6,1300
31	Gabon	2,1619	12,6817	3,2400	2,4900
32	Gambia, The	2,4012	5,8825	3,9500	3,2200
33	Georgia	2,4428	6,0850	4,8000	3,3500
34	Germany	4,2014	84,4317	5,4900	6,0500
35	Ghana	2,5653	38,0037	3,9300	3,4557
36	Greece	3,2046	60,3570	4,5500	3,8600
37	Guatemala	2,4146	35,8639	4,3200	2,7000
38	Honduras	2,6039	11,9106	4,0800	3,1100
39	Hong Kong SAR	3,9201	92,9344	5,6600	6,4000
40	Iceland	3,2250	6,9932	5,2700	3,9400
41	India	3,1766	59,4728	3,9100	4,1500
42	Indonesia	3,1501	33,0762	4,3000	3,8977
43	Iran, Islamic Rep.	2,8527	31,1522	3,1600	3,5516

No.	Countries	C1	C2	C3	C4
52	Kuwait	2,8612	10,4070	4,0700	4,1739
53	Latvia	2,8099	9,6777	4,8600	3,7200
54	Lebanon	2,7169	40,7662	4,0300	3,6873
55	Liberia	2,2292	6,5652	3,5300	2,6700
56	Lithuania	3,0175	18,1860	5,0100	3,9400
57	Madagascar	2,3894	7,9261	3,8000	2,1600
58	Malaysia	3,2209	99,0150	4,9000	5,1645
59	Malta	2,8138	56,3857	4,9500	3,8600
60	Mauritania	2,3311	7,4742	3,1800	2,2200
61	Mauritius	2,7330	31,3259	4,8900	3,7400
62	Mexico	3,0514	47,6724	4,5500	4,2938
63	Moldova	2,4559	0,6354	4,2000	2,7400
64	Montenegro	2,7456	4,9197	4,4600	2,7300
65	Morocco	2,5397	69,2554	4,6000	4,3211
66	Netherlands	4,0193	91,2893	5,7000	4,3300
67	New Zealand	3,8756	29,9973	5,2700	4,0300
68	Nigeria	2,5321	21,6948	3,2500	3,0552
69	Norway	3,6966	10,5649	5,2700	3,7000
70	Oman	3,1968	59,4869	4,6700	4,6307
71	Pakistan	2,4192	37,6157	3,5100	3,2734
72	Panama	3,2760	50,7336	4,5200	4,5100
73	Paraguay	2,7823	1,8508	3,8600	3,2693
74	Peru	2,6932	40,0014	4,5400	3,6319
75	Philippines	2,9037	25,6278	4,1300	3,4534
76	Poland	3,5395	51,9434	4,9600	3,8800
77	Portugal	3,6432	56,7627	5,0100	4,7500
78	Qatar	3,4742	39,1696	4,7800	5,1484
79	Romania	3,1186	26,6299	4,6100	2,9800
80	Russian Fed.	2,7569	34,4747	3,7900	4,4006
81	Saudi Arabia	3,0110	70,0976	4,3300	4,7666
82	Senegal	2,2524	17,2524	3,9700	3,0000
83	Sierra Leone	2,0780	6,7336	3,2500	2,5500
84	Singapore	3,9961	112,2410	5,9700	6,2800
85	Slovenia	3,3148	34,4841	4,9600	3,6400
86	South Africa	3,3761	40,0156	4,5200	4,6686
87	Spain	3,8313	90,7593	5,2800	6,0900
88	Sri Lanka	2,5979	71,5236	3,9000	3,9366
89	Sweden	4,0529	48,1324	5,6100	4,8100
90	Taiwan, China	3,5997	84,9041	4,9200	5,2200
91	Thailand	3,4111	64,5727	4,4500	4,4349
92	Trini. & Toba.	2,4156	15,3668	3,8600	3,0100
93	Tunisia	2,5695	5,6920	4,0200	3,6679
94	Turkey	3,1458	61,3270	4,5200	4,4827

44	Ireland	3,5104	12,4619	5,2700	4,1100
45	Israel	3,3078	41,6096	4,9900	4,1600
46	Italy	3,7392	75,5442	4,9100	4,7900
47	Jamaica	2,5187	35,0179	4,0300	3,3800
48	Japan	4,0257	73,9028	5,2800	6,1000
49	Jordan	2,6880	33,9628	4,7300	4,0646
50	Kenya	2,8149	17,3683	4,2000	3,7613
51	Korea, Rep.	3,6122	109,2519	5,0400	5,7100
95	Ukraine	2,8302	28,4272	3,9700	3,9104
96	Uni. Arab Em.	3,9564	75,3083	5,2300	5,9913
97	Uni. Kingdom	3,9871	90,2067	5,5200	5,7300
98	United States	3,8851	99,1369	5,2400	6,0800
99	Uruguay	2,6851	32,7657	4,3700	4,1066
100	Venezuela, RB	2,2292	8,9891	2,8500	2,9892
101	Vietnam	3,2740	76,7531	4,2600	4,0826
Criteria Weighs		**0,5208**	**0,2708**	**0,1458**	**0,0625**

Appendix 2. WASPAS Scores and Ranking

Countries	λ = 0,00		λ = 0,25		λ = 0,50		λ = 0,75		λ = 1,00	
	Score	**Rank**	**Score**	**Rank**	**Score**	**Rank**	**Score**	**Rank**	**Score**	**Rank**
Albania	0,4739	92	0,4937	90	**0,5135**	**89**	0,5334	85	0,5532	83
Algeria	0,4975	86	0,5068	87	**0,5162**	**88**	0,5255	88	0,5349	87
Argentina	0,6210	52	0,6258	53	**0,6306**	**53**	0,6354	51	0,6402	51
Australia	0,7778	20	0,7857	20	**0,7936**	**20**	0,8014	20	0,8093	20
Bahrain	0,6669	40	0,6745	41	**0,6821**	**39**	0,6897	39	0,6974	40
Bangladesh	0,5040	82	0,5129	84	**0,5219**	**86**	0,5308	86	0,5398	85
Belgium	0,8797	10	0,8820	10	**0,8842**	**10**	0,8864	10	0,8886	10
Benin	0,5137	79	0,5221	79	**0,5305**	**81**	0,5389	83	0,5473	84
Brazil	0,6340	46	0,6385	46	**0,6431**	**49**	0,6476	49	0,6521	49
Brunei Darussalam	0,5174	76	0,5344	75	**0,5515**	**75**	0,5685	73	0,5855	72
Bulgaria	0,5509	73	0,5687	71	**0,5864**	**70**	0,6042	69	0,6219	64
Cambodia	0,5023	84	0,5152	82	**0,5281**	**82**	0,5410	82	0,5539	82
Cameroon	0,4774	90	0,4855	93	**0,4935**	**93**	0,5016	93	0,5096	93
Canada	0,8073	17	0,8128	17	**0,8184**	**16**	0,8239	16	0,8295	17
Chile	0,7209	27	0,7275	27	**0,7341**	**26**	0,7407	25	0,7473	26
China	0,8306	14	0,8311	14	**0,8316**	**15**	0,8321	15	0,8326	16
Colombia	0,6304	48	0,6333	50	**0,6362**	**50**	0,6391	50	0,6421	50
Congo, Democratic Republic	0,3993	101	0,4151	100	**0,4310**	**100**	0,4469	100	0,4627	99
Costa Rica	0,5370	74	0,5463	74	**0,5556**	**74**	0,5649	74	0,5742	75
Côte d'Ivoire	0,6019	60	0,6113	57	**0,6207**	**57**	0,6301	55	0,6394	52
Croatia	0,6422	44	0,6487	44	**0,6553**	**45**	0,6619	45	0,6684	47
Cyprus	0,6267	50	0,6381	47	**0,6495**	**46**	0,6609	46	0,6722	45
Denmark	0,8226	15	0,8297	15	**0,8367**	**14**	0,8438	14	0,8509	14
Dominican Republic	0,5957	64	0,5991	64	**0,6025**	**65**	0,6059	68	0,6092	69
Ecuador	0,6195	53	0,6237	54	**0,6280**	**54**	0,6322	54	0,6364	53
Egypt, Arab Republic	0,6304	47	0,6315	51	**0,6326**	**52**	0,6337	53	0,6347	56
El Salvador	0,5036	83	0,5175	81	**0,5315**	**79**	0,5455	81	0,5594	80
Estonia	0,6355	45	0,6534	43	**0,6712**	**42**	0,6890	40	0,7068	36
Finland	0,7684	22	0,7866	19	**0,8048**	**19**	0,8231	17	0,8413	15
France	0,8845	9	0,8872	9	**0,8900**	**9**	0,8928	9	0,8955	8
Gabon	0,4263	97	0,4341	97	**0,4418**	**98**	0,4495	99	0,4572	100
Gambia, The	0,4736	93	0,4884	91	**0,5031**	**91**	0,5179	91	0,5326	88
Georgia	0,4980	85	0,5145	83	**0,5311**	**80**	0,5476	78	0,5641	79
Germany	0,9318	2	0,9344	2	**0,9370**	**2**	0,9397	2	0,9423	2
Ghana	0,5611	71	0,5644	72	**0,5677**	**72**	0,5710	72	0,5743	74
Greece	0,6826	35	0,6855	37	**0,6884**	**37**	0,6913	38	0,6941	41
Guatemala	0,5137	78	0,5184	80	**0,5231**	**85**	0,5277	87	0,5324	89
Honduras	0,5139	77	0,5250	77	**0,5362**	**77**	0,5473	79	0,5585	81
Hong Kong SAR, China	0,9221	3	0,9240	3	**0,9258**	**3**	0,9277	3	0,9295	3
Iceland	0,6150	54	0,6357	49	**0,6564**	**44**	0,6771	43	0,6978	39
India	0,6772	36	0,6797	38	**0,6821**	**40**	0,6845	42	0,6870	43
Indonesia	0,6480	42	0,6542	42	**0,6604**	**43**	0,6666	44	0,6727	44
Iran, Islamic Rep.	0,5715	69	0,5768	70	**0,5821**	**71**	0,5874	71	0,5927	71

Countries	λ = 0,00		λ = 0,25		λ = 0,50		λ = 0,75		λ = 1,00	
	Score	**Rank**	**Score**	**Rank**	**Score**	**Rank**	**Score**	**Rank**	**Score**	**Rank**
Ireland	0,6740	38	0,6911	35	**0,7082**	**33**	0,7253	31	0,7425	29
Israel	0,7013	33	0,7068	31	**0,7124**	**31**	0,7179	33	0,7234	33
Italy	0,8043	18	0,8067	18	**0,8092**	**18**	0,8117	19	0,8142	19
Jamaica	0,5516	72	0,5554	73	**0,5592**	**73**	0,5629	75	0,5667	77
Japan	0,9006	4	0,9038	4	**0,9071**	**4**	0,9103	4	0,9136	4
Jordan	0,6128	56	0,6180	56	**0,6231**	**56**	0,6282	57	0,6334	58
Kenya	0,5794	68	0,5888	68	**0,5983**	**68**	0,6077	67	0,6172	65
Korea, Rep.	0,8510	11	0,8515	11	**0,8520**	**11**	0,8525	12	0,8531	13
Kuwait	0,5794	67	0,5932	67	**0,6070**	**63**	0,6208	60	0,6346	57
Latvia	0,5683	70	0,5833	69	**0,5982**	**69**	0,6131	63	0,6281	61
Lebanon	0,5931	65	0,5964	65	**0,5997**	**67**	0,6031	70	0,6064	70
Liberia	0,4290	96	0,4412	96	**0,4535**	**97**	0,4657	97	0,4780	96
Lithuania	0,6260	51	0,6369	48	**0,6479**	**48**	0,6589	47	0,6699	46
Madagascar	0,4295	95	0,4430	95	**0,4565**	**96**	0,4699	95	0,4834	95
Malaysia	0,7722	21	0,7727	22	**0,7732**	**22**	0,7737	23	0,7743	24
Malta	0,6431	43	0,6458	45	**0,6485**	**47**	0,6513	48	0,6540	48
Mauritania	0,4147	98	0,4269	99	**0,4390**	**99**	0,4512	98	0,4634	98
Mauritius	0,6043	59	0,6102	59	**0,6162**	**59**	0,6222	59	0,6281	60
Mexico	0,6749	37	0,6784	39	**0,6818**	**41**	0,6853	41	0,6888	42
Moldova	0,4027	100	0,4329	98	**0,4630**	**94**	0,4931	94	0,5232	92
Montenegro	0,4889	88	0,5083	86	**0,5278**	**83**	0,5472	80	0,5667	78
Morocco	0,6299	49	0,6314	52	**0,6328**	**51**	0,6343	52	0,6357	54
Netherlands	0,8403	12	0,8439	12	**0,8475**	**12**	0,8510	13	0,8546	12
New Zealand	0,7458	24	0,7570	24	**0,7683**	**23**	0,7796	22	0,7908	22
Nigeria	0,5062	81	0,5123	85	**0,5184**	**87**	0,5245	89	0,5306	90
Norway	0,6661	41	0,6864	36	**0,7068**	**35**	0,7271	29	0,7475	25
Oman	0,7183	29	0,7208	29	**0,7234**	**29**	0,7259	30	0,7284	31
Pakistan	0,5272	75	0,5299	76	**0,5326**	**78**	0,5354	84	0,5381	86
Panama	0,7118	30	0,7154	30	**0,7190**	**30**	0,7226	32	0,7262	32
Paraguay	0,4761	91	0,5016	89	**0,5272**	**84**	0,5527	77	0,5782	73
Peru	0,5976	62	0,6015	63	**0,6054**	**64**	0,6094	65	0,6133	67
Philippines	0,5880	66	0,5952	66	**0,6023**	**66**	0,6094	66	0,6165	66
Poland	0,7222	26	0,7275	26	**0,7328**	**27**	0,7381	27	0,7434	27
Portugal	0,7799	19	0,7840	21	**0,7880**	**21**	0,7920	21	0,7961	21
Qatar	0,7546	23	0,7609	23	**0,7672**	**24**	0,7735	24	0,7798	23
Romania	0,5973	63	0,6068	61	**0,6163**	**58**	0,6257	58	0,6352	55
Russian Federation	0,6149	55	0,6195	55	**0,6241**	**55**	0,6287	56	0,6334	59
Saudi Arabia	0,7012	34	0,7026	34	**0,7040**	**36**	0,7054	36	0,7067	37
Senegal	0,4810	89	0,4882	92	**0,4953**	**92**	0,5024	92	0,5095	94
Sierra Leone	0,4042	99	0,4150	101	**0,4258**	**101**	0,4366	101	0,4474	101
Singapore	0,9450	1	0,9459	1	**0,9468**	**1**	0,9477	1	0,9486	1
Slovenia	0,6687	39	0,6762	40	**0,6838**	**38**	0,6913	37	0,6989	38
South Africa	0,7191	28	0,7247	28	**0,7302**	**28**	0,7358	28	0,7413	30
Spain	0,8886	7	0,8903	8	**0,8920**	**8**	0,8936	8	0,8953	9
Sri Lanka	0,6080	57	0,6086	60	**0,6092**	**62**	0,6098	64	0,6104	68
Sweden	0,8324	13	0,8395	13	**0,8466**	**13**	0,8537	11	0,8609	11

Countries	λ = 0,00		λ = 0,25		λ = 0,50		λ = 0,75		λ = 1,00	
	Score	**Rank**	**Score**	**Rank**	**Score**	**Rank**	**Score**	**Rank**	**Score**	**Rank**
Taiwan, China	0,8132	16	0,8146	16	**0,8160**	**17**	0,8174	18	0,8188	18
Thailand	0,7329	25	0,7355	25	**0,7381**	**25**	0,7406	26	0,7432	28
Trinidad and Tobago	0,4937	87	0,5020	88	**0,5103**	**90**	0,5185	90	0,5268	91
Tunisia	0,5085	80	0,5249	78	**0,5413**	**76**	0,5577	76	0,5741	76
Turkey	0,7041	32	0,7063	33	**0,7084**	**32**	0,7106	34	0,7128	34
Ukraine	0,6005	61	0,6064	62	**0,6122**	**61**	0,6180	62	0,6238	63
United Arab Emirates	0,8880	8	0,8909	7	**0,8938**	**7**	0,8968	7	0,8997	7
United Kingdom	0,8979	6	0,8997	6	**0,9015**	**5**	0,9033	5	0,9050	5
United States	0,8987	5	0,8999	5	**0,9012**	**6**	0,9024	6	0,9037	6
Uruguay	0,6058	58	0,6107	58	**0,6157**	**60**	0,6206	61	0,6255	62
Venezuela, RB	0,4372	94	0,4469	94	**0,4565**	**95**	0,4662	96	0,4758	97
Vietnam	0,7047	31	0,7063	32	**0,7079**	**34**	0,7095	35	0,7112	35