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Proposals for improving the Logistics Performance Index

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ABSTRACT

The purpose of this study is to propose ways for improving the current Logistics Performance Index published by the World Bank. The Logistics Performance Index is based on a global survey of logistics experts, which can be biased towards a subjective view on different countries' logistics systems, which leads to a potentially skewed rating. The authors propose a modified index that qualitatively and quantitatively represents an objective view of 159 countries' logistics systems and subsystems, based on international statistical data, which can be used as a benchmarking tool for governments.

1. Introduction

Modern logistics is greatly influenced by the processes of globalization and internationalization. In the rapidly developing process of economy globalization, transportation management issues are of great importance. The development of global economic integration and the globalization of business both contribute to the creation of international logistics systems and global supply chains on the international market.

At the current stage of global development, the international market is a system of goods and services exchange between countries through export and import operations. Like in any market system, on a global scale, there exists competitiveness between market participants, or, in this case, countries. The need for global economic competitiveness and competitive market positions through global integration for countries has been recognized by the global community through the creation of such benchmarking tools as the annual Global Competitiveness Report of the World Economic Forum and the World Competitiveness Yearbook produced by the Institute for Management Development.

Policy-makers understand that countries that are capable of producing higher-quality products at a lower price or are capable of being a convenient and cheap transport corridor for goods will have an undoubted competitive advantage on the international market (Aigigner, 1998). Countries with high logistics costs severely lack international competitiveness (Devlin & Yee, 2005). In order to develop a logistic competitive advantage, governments have to assess the current country-level logistics system and identify which subsystems need to be optimized, developed, created or removed completely through policies and initiatives (Jhawar, Garg, & Khera, 2017). The analysis can be carried out in the form of an in-country assessment of the logistics system, or (if the in-country assessment is not possible or in addition to it), a cross-country assessment of the logistics system. In this case, an international country-level logistics rating could be used by the government as a benchmarking tool that allows the comparison of individual indicators, so as to be able to concentrate on specific individual areas within the logistics system.

The lack of many serious tools for evaluating country-level logistics efficiency is partly due to research generally being done more commonly at a micro-logistics level rather than at the level of global logistics. While effective micro-logistics tend to result in a more efficient country-level logistics system, it is important for governments to see and compare their countries' logistical and transport systems against other countries in order to understand existing bottlenecks.

The current leading ratings used to measure country-level logistics systems' effectiveness are the Logistics Performance Index (LPI), produced by the World Bank, the Agility Emerging Markets Logistics Index (AEMLI) Transport Intelligence (2018), produced by the Agility Logistics Company, and the Global Competitiveness Index "Basic requirements" subindex "Infrastructure" pillar (GCII) issued by the World Economic Forum Schwab and Sala-i-Martin (2017).

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Table 1
GCII/LPI-SUMEXPIMP correlation.

			SUMEXPIMP	GCII	LPI
Kendall's tau-b	SUMEXPIMP	Correlation coefficient	1.000	0.368	0.490
		Sig. (2-tailed)		.001	.000
		N	41	41	41
	GCII	Correlation coefficient	0.368	1.000	0.488
		Sig. (2-tailed)	.001		.000
		N	41	41	41
	LPI	Correlation coefficient	0.490	0.488	1.000
		Sig. (2-tailed)	.000	.000	
		N	41	41	41

Source: Own construction.

2. Literature review

Logistics and transport have been increasingly playing a pivotal role in international trade relations. Several studies have shown logistics to be positively correlated to international trade through different analytical approaches. Some studies link logistical performance fluctuation with international trade volume changes (Beysenbaev, 2018; Gani, 2017), showing correlation between key logistical indicators and world trade. Other works have included analysis of product costs and logistics performance, showing that transport costs and distance between countries majorly contribute towards trade friction (Yip, 2012) and increase total landed costs (Hausman, Lee, & Subramanian, 2012). Transportation and logistics processes are also constantly adapting and changing, which means that, due to their interdependence with international trade, changes in the former necessarily might affect the latter in the future and vice versa (Duško & Božica, 2016).

Considering the links between country logistics and global trade, it is important to take a look at the effect of public policies and government participation in the development of trade logistics. One potential side of government control is trade facilitation. The WTO defines trade facilitation as the simplification and harmonization of international trade procedures. While international trade can be directly influenced through simple tariff measures, research has shown trade facilitation to be more beneficial to bilateral trade (Márquez-Ramos, Martínez-Zarzoso, & Suárez-Burguet, 2012). As for its structure – an analysis of three main areas of trade facilitation measures by Moïsé (2013) has shown equipment and infrastructure to be the most expensive aspects of state-level trade facilitation with special note given to border agency training.

Furthermore, it is widely acknowledged that insufficient government agency coordination, general lack of cohesion and complex compliance requirements can lead to time delays and, thus, increased costs for logistics services providers (Djankov, Freund, & Pham, 2010; Hummels & Schaur, 2013) while overall incoherent regulation of logistics services as an integrated sector causes major trade bottlenecks (Czapnik & Saeed, 2016).

In this way, we understand that country-level logistics and international trade are interdependent and that government policy can and should consider analysis and management of the logistics infrastructure of the country as an aspect of its participation in international trade.

3. Review of existing logistics performance measures

Currently, there exist several approaches to assessing the logistics efficiency of countries, with scholars noting the LPI, AEMLI and GCII. To choose the most relevant and accurate existing logistics-measuring tool a two-step analysis was conducted.

First, we compared the scope of each tool, with the LPI encompassing 160 countries, AEMLI – 50 countries and the GCII – 140 countries. Thus, the AEMLI was excluded due to a narrower focus and also because of several index factors (e.g., "Market accessibility" and "Domestic stability") being more directed at socioeconomic rather than logistical aspects.

Next, the accuracy of the GCII and the LPI was determined through a statistical correlation check. In order to analyze how accurate these international ratings are in assessing the level of logistics development in different countries, we considered the logistics of countries as a factor of international trade as the latter is wholly dependent on actual physical movement of goods from producers/sellers to consumers/buyers. So, as a result, in this study we will characterize the trade efficiency of countries as the sum of export and import of their goods (SUMEXPIMP), which is the value of all goods provided to the rest of the world.

To determine the closeness of the relationship between the general trade of the country and the various efficiency ratings of logistics systems, Kendall's tau-b correlation was used, as a number of studies have shown it to be preferable to Spearman's correlation when applying to ordinal data and rankings (Croux & Dehon, 2010; Weichao, Yunhe, Hung, & Yuexian, 2013). In order to test the null hypothesis equally for all ratings and due to the different number of included countries, those countries that are not considered simultaneously in all three ratings were excluded from the database. Thus, only data for 41 countries was considered. All countries were ranked from lowest value to highest value by their rank in the LPI and the GCII, and by the sum of the export and import of goods from and to the country. All 3 groups were sorted alphabetically, retaining their ranks and this rank dataset was tested using Kendall's tau-b correlation (Table 1).

As both relationships have p-value ≤ 0.001, it can be said that both tests have statistical significance. We can see that the LPI has ~12% more correlation with the volume of goods export and import per country than GCII, which means that the LPI is the most accurate and broad logistics efficiency assessment tool to date. Thus, in this paper, we will be concentrating on it, its methodology and ways to improve it.

4. The LPI

The LPI is calculated on the basis of a global survey of global freight forwarding companies and logistics carriers. It is an online benchmarking tool developed by the World Bank that measures productivity across the entire supply chain of logistics within a country (Arvis et al., 2018). The index can help countries identify logistic systems' problems and find opportunities to improve logistics efficiency.

The World Bank conducts a survey every 2 years. The latest current rating was compiled by the World Bank in 2018 and was calculated for 160 countries. The higher the LPI value, the more developed the logistics system in the country. Each survey respondent evaluates eight overseas markets based on six key logistics performance indicators. The eight countries are selected on the basis of the most important export and import markets of

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the country in which the respondent is located. If the respondent's country is landlocked, then the selection is done on the basis of neighboring countries in the logistics chain that connect them with international markets.

The international LPI is an overall measure of the efficiency of the logistics sector, combining data on six key performance indicators into a single aggregated measure. Some respondents do not or cannot provide information on all six indicators, so statistical interpolation is used to determine missing values. Missing values are replaced by the country's average answer for each question, adjusted by the average deviation of the respondent from the average level of the country in the answers to the questions. The six key indicators are: (C) the efficiency of customs and border management clearance ("Customs"), (I) the quality of trade and transport infrastructure ("Infrastructure"), (E) the ease of arranging competitively priced shipments ("Ease of arranging shipments"), (Q) the competence and quality of logistics services—trucking, forwarding, and customs brokerage ("Quality of logistics services"), (T) the ability to track and trace consignments ("Tracking and tracing"), and (TM) the frequency with which shipments reach consignees within scheduled or expected delivery times ("Timeliness").

The LPI is based on these six indicators and calculated using Principal Component Analysis (PCA), a standard statistical method used to reduce the dimension of a data set. In the LPI, the input data for the PCA are the scores for countries averaged over all respondents providing data on a foreign market. Estimates are normalized by subtracting the mean of the sample and dividing by the standard deviation before performing the PCA. The output from PCA is the LPI, which is the weighted average of these indicators. To then build the international LPI, the normalized scores for each of the six original indicators are multiplied by their component weights and then summarized. Since the weights are the same for all six components, the international LPI is close to the arithmetic mean of the indicators.

The LPI is widely used in global logistics research as a tool for country benchmarking and comparison (Dang & Yeo, 2018), as a basis for developing new processes and tools (Su & Ke, 2017), and as a way for analyzing intracountry logistics performance (Edirisinghe, 2013).

Despite the fact that it is one of the most complete sources of data for analyzing country-level logistics and for finding ways to simplify international trade, the LPI has several significant drawbacks.

Firstly, the experience of international freight companies may not represent a wider logistical situation in poor countries, which often depend on domestic operators (Arvis et al., 2018). Both international and domestic operators may differ in their interaction with government agencies and in the level of services offered.

Furthermore, the LPI may reflect problems in freight transit for landlocked countries and small island states (Arvis et al., 2018). A low score for a landlocked country may not adequately reflect its efforts to facilitate trade, which depend on the operation of complex international transit systems and, thus, landlocked countries are not able to solve transit problems through internal reforms and policies.

Several studies have also noted that the LPI survey results raise certain doubts as to their reliability, with sharp indicator jumps for Kazakhstan, Kyrgyzstan (Raimbekov, Syzdykbaeva, Mussina, Moldashbaeva, & Zhumataeva, 2017), Ukraine (Kurochkin, 2013) (over 50 places in the space of 2 years) and the lack of rank movement for Russia despite logistical improvements being done in the country (Kurochkin, 2013; Raimbekov et al., 2017). These factors are surmised to be due to the fact of the LPI being very subjective and more influenced by social, rather than economic factors as shown by Güner and Coskun (2012). Their research proves that data from LPI respondents shows countries' logistics performances as independent from gross transportation infrastructure investment spending and other economic indicators like growth rate, which cannot be the case, as evidenced by several studies. Investment into infrastructure is highly correlated with logistics performance (measured as the volume of bilateral trade in goods) (Beysenbaev, 2018), while sustainable economic growth has been proven to be dependent on efficient logistics systems (Sezer & Abasiz, 2017; Vilko, Karandassov, & Myller, 2011).

In order to negate the observed subjectivity of the LPI, it is the authors' opinion that an index containing both objective statistical information, as well as several aspects that can only be subjectively measured (e.g., the competence and quality of logistics services – to fully encompass all aspects of country-level logistics) would be a more accurate estimation of a country-level logistics system's efficiency.

5. Methodology and framework for the ILPI

To improve the LPI methodology, it is proposed to compile an index and a subsequent rating based on statistical data. The index should be a method of qualitative and quantitative assessment of the logistics efficiency of a country that meets two important criteria:

1. The possibility of an understandable visual representation of the country's logistics efficiency in several areas in the form of a ranked rating;
2. Convenience as a benchmarking tool that allows countries to develop their logistics infrastructure in a concentrated and systematic way.

The Integrated Logistics Performance Index (ILPI) can be created similarly to the LPI. It could consist of six subindexes, each of which may comprise several indicators, which necessitates the inclusion of subindex levels (see Fig. 1). Each subindex reflects an aspect of international logistics, so, in order for all of them to be comparable and eligible for aggregation (due to each subindex being a different measure), each subindex has a value in the range from 0 to 1. If a subindex has several indicators, they are also given a value from 0 to 1 and all indicator values are summed up into the subindex.

The subindex values of each nth country is calculated as the ratio of the measure value for the country to the maximum value of the measure in the measure sample, which is a constant for all countries (Eq. (1)), or, in the case of a subindex comprising several indicators, each subindex indicator receives a value through the same ratio and the subindex value will be the sum of weighted indicator values (Eq. (2)).

$$Sub_n = \frac{M_n}{M_{\max}} \tag{1}$$

where Sub_n is the Lone subindex (without indicators) for country n at the 2nd level, M_n the country n measure value and M_{max} is the maximum measure value in measure sample.

$$Sub_{n,x} = \frac{1}{N_x}\sum_{i=1}^{N}\frac{M_{n,i}}{M_{imax}} \tag{2}$$

where $Sub_{n,x}$ is the multifactor subindex (with indicators) for country n at the x level, N_x the number of subindex indicators at the x level, $M_{n,i}$ the subindex indicator i measure value for country n and M_{imax} is the maximum subindex indicator i measure value in the measure sample.

In accordance with the 160 countries in the 2018 LPI (see Table A1 in Appendix A) 159 countries were chosen, as Taiwan was excluded from the ILPI due to insufficient statistical data. All further

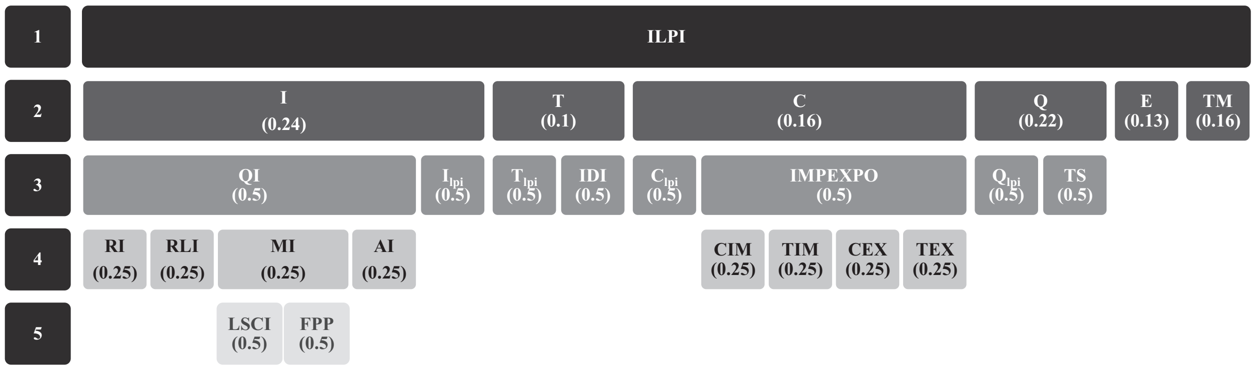

Fig. 1. ILPI structure.

Source: Own construction.

calculations and data (including the LPI) should be understood as excluding Taiwan.

The ILPI is projected to be a quantitative and qualitative tool for benchmarking logistics performance and, thus, the survey results of the LPI are included in it. They are to comprise the qualitative side of the ILPI, with statistical data introducing objective quantitative corrections. The survey results are processed through Eq. (1) to be comparable to other data and are introduced into the ILPI at the 3rd subindex level with a weight of 0.5 (in the case of multifactor subindexes) and 1 (in the case of lone subindexes).

The current LPI weights assume that all subindexes have equal importance to logistics performance when in reality this cannot be the case due to the complex nature of logistics systems and there is little information in logistics literature, which may allow the assigning of objective weights for the subindexes.

Several independent studies of the LPI weights have been rejected as usable in this research. Dang and Yeo (2018) used consistent fuzzy preference relations method to distribute the LPI weights in their research of Vietnamese logistics systems. Their research was based on logistics experts exclusively connected with Vietnam and several LPI aspects were changed. Yildirim and Mercangoz (2019) used fuzzy analytical hierarchy method in their research but only for OECD countries within a specific time frame. Some research into this problem has also been done using a pairwise comparison in the context of the Best-Worst method (BWM).

BWM is a multi-criteria decision-making method that is used to evaluate a set of alternatives relative to a set of decision criteria. BWM is based on a systematic pairwise comparison of decision criteria. After the decision maker (DM) determines the decision criteria, the DM selects two criteria: the best criterion and the worst criterion. The best criterion is the one that is the most important in the decision-making, while the worst criterion is the least important. The DM then individually compares the best criterion with all other criteria, and also compares all the criteria with the worst criterion, using a number from a predefined scale (for example, from 1 to 9). These two sets of pairwise comparisons are used as input to an optimization problem, the optimal results of which are the weights of the criteria. A characteristic feature of BWM is that it uses a structured method to generate consistent pairwise comparisons, which lead to very reliable results (Rezaei, 2016).

In order to assign appropriate weights to the six components of the LPI, Rezaei, Van Roekel, and Tavasszy (2018) conducted an international survey of 107 academics and logistics professionals, analyzed the results through BWM, and calculated the importance and weights of each subindex in the LPI. This research has been chosen because of the nature of BWM, wherein the method gives accurate results, all while constantly checking for respondent bias and attention, since the comparison of two criterions is always conducted at least 2 times. The ILPI subindex weights will be thus based on the empirical data of the Rezaei research (Table 2).

Table 2
ILPI subindex weights.

Subindex	C	I	TM	T	E	Q
Weight	0.159	0.235	0.160	0.102	0.126	0.217

Source: Rezaei et al. (2018).

Several subindexes consist of a number of subindex indicators, which should also be weighted. It is the authors' opinion that these subindex indicators can be weighted equally since they are all aggregated into a complex subindex, which has further weight correction, and because of the difficulty that is due to previously stated lack of research being done into logistics factor comparison.

5.1. *ILPI subindexes*

5.1.1. *(I) Infrastructure subindex*

In determining the quality of infrastructure related to transport, it was decided to review the effectiveness of individual modes of transport and then aggregate them into one determining factor.

The infrastructure score will have a weight of 0.24 in the ILPI. At the 3rd level, the subindex indicators will be the LPI score for this subindex (ILPI) and the qualitative infrastructure subindex (QI), both with a weight of 0.5. The following modes of freight transport were highlighted for inclusion in QI with a weight of 0.25 for each:

(RI) Road

When talking about road efficiency, there are several models for assessment, primarily nodal/network models (Terelius & Johansson, 2015) and aggregate Key Performance Indicator (KPI) based models (Litman, 2018). To determine road effectiveness in the ILPI, road network density was chosen, which is determined by the length of the country's road network divided by the country's area. This measure was chosen due to the availability of international public data, as well as due to the absence of another generalizing factor that does not assess road infrastructure efficiency too narrowly (e.g., car throughput, cost efficiency) or too broadly (e.g., country road network length) (Kaare, Kuhi, and Koppel, 2012; Santosa & Joewono, 2005).

(RLI) Rail

Similar to road infrastructure, the density of countries' rail networks was chosen. A significant factor in determining the effectiveness of railway networks in Europe is the European Railway Performance Index (RPI), published annually by the Boston Consulting Group (BCG). This index cannot be used, as it comprehensively measures both freight and passenger traffic with a clear methodological bias toward passenger traffic (Duranton, Audier,

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Langhorn, & Gauche, 2017), which is not applicable in this study. A modification of this index also turned out to be ineligible for inclusion due to the limited international statistical information required for most of the countries studied (e.g., the number of accidents, punctuality of freight trains, etc.).

Public data concerning volume of freight transported by rail is not suitable for use, despite there being several databases (World Bank, Eurostat, UIC, UNECE), since the data is either incomplete for all countries or inconsistent. In the future, this data may be added into the ILPI, since, after the adoption of Regulation (EU) 2018/643 on rail transport statistics, which repealed Regulation (EC) No 91/2003, it is expected that it will facilitate the production of harmonized data and official statistics at least at the European level.

(MI) Maritime

To assess the effectiveness of countries' maritime infrastructure, a multifactor weight assessment was selected, consisting of two factors with a weight of 0.5 for each:

1. (LSCI) LSCI is the Liner Shipping Connectivity Index, published by UNCTAD United Nations (2018), which measures the level of a country's integration into the global network of liner shipping based on the number of ships in a country's merchant fleet, the total annual container-carrying capacity of those ships, maximum vessel size, etc.
2. (FPP) The annual average volume of freight transported by maritime transport divided by the number of a countries' commercial ports, wherein a port is considered a commercial port when it allows the unloading and loading of cargo ships, storage, and handling of goods and containers.

(AI) Air

The multitude of factors affecting air connectivity is the main reason why airline ratings can be very complex (Burghouwt & Redondi, 2013). Researchers often face a dilemma in analyzing air connectivity and choosing which metrics to use. Two major ratings are the Air Connectivity Index (ACI) of the World Bank Arvis and Shepherd (2011) and the OAG Megahubs International Index. The ACI index was not chosen since it was last released in 2011 and measured connectivity according to 2007, while the 2018 OAG Megahubs International Index was not chosen because the index includes passenger air transport, which does not reflect the efficiency of freight transported by air.

AI will be comprised of the average annual volume of cargo transported by air divided by the number of international airports in the country. Public data concerning cargo airports is scarce, which is why the assumption is being made that an international airport has facilities to conduct freight handling, storage, and processing.

5.1.2. (T) Tracking and tracing subindex

The ability to track and trace cargo will be assessed through the Information and Communication Technology Development Index (IDI) – an indicator that characterizes the achievements of countries in the world in terms of information and communication technology (ICT) development (ITU, 2018). This combined indicator is calculated and published by the International Telecommunication Union. The score for this indicator will have a weight of 0.1 in the ILPI.

5.1.3. (C) Customs subindex

The effectiveness of the customs clearance process will be measured according to two subindex indicators with a 0.5 weight: the LPI score for this subindex (C_{lpi}) and the multifactor import/export operations (IMPEXPO) subindex indicator, which measures the time and costs associated with importing and exporting goods. Each subindex indicator in IMPEXPO will have a weight of 0.25 and the overall C will, in turn, have a weight of 0.16 in the ILPI. Thus, IMPEXPO will consist of: (CIM) Cost to import (US$), (CEX) Cost to export (US$), (TIM) Time to import (hours), and (TEX) Time to export (hours).

According to the World Bank, these factors measure the cost and time that are related to compliance with a country's customs regulations and with other government body regulations that are necessary for goods to cross the country's border, as well as the time and cost for handling that takes place at its port or border.

5.1.4. (Q) Quality of logistics services

The quality of logistics services will be assessed by the LPI score for this subindex (Q_{lpi}) and the share of transport service in overall service exports (TS), both of which will have a weight of 0.5 in Q.

Transport services as a share of service exports are, according to the World Bank, all transport services performed by residents of one economy for those of another and involving the movement of freight, related support, and auxiliary services, and excluding freight insurance, goods procured in ports by nonresident carriers, maintenance and repairs on transport equipment and repairs of railway facilities, harbors, and airfield facilities.

In the framework of this study, we must assume that the higher the quality of exported services, the more demand there is for it and, consequently, the higher the volume of exported transport services. The only consistent survey of logistics service quality is the LPI subindex, so there is no opportunity to calculate the interdependence of exported transport service and logistics service quality, since it is biannual and has only 6 points for analysis, which is an insufficient sample size for any significant Pearson's correlation (significant at $n \geq 25$) (Bonett & Wright, 2000).

5.1.5. Ease of arranging shipments subindex (E) and timeliness subindexes (TM)

The assessment of the frequency with which deliveries reach the consignee during the planned or expected time or the ease of arranging shipments cannot be determined by quantitative methods or statistical analysis. These factors, according to the authors, cannot be calculated from statistical or other data, since, in the first case, this is a qualitative characterization, which can only be determined by interviewing active logistics participants, and in the second case – a lack of statistical data, as well as the complexity of creating and introducing a unified system for assessing these aspects predetermine the use of the results of a survey of active logistics participants. Thus, the LPI scores for these subindexes (processed through Eq. (1)) will be used, with a weight of 0.16 for the former and 0.13 for the latter in the ILPI.

The overall composition of the ILPI methodology is presented in Fig. 1.

After determining the ILPI for each country from the sample, the resulting indexes were ranged and a final rating was made, according to which it would be possible to perform benchmarking and evaluate the logistics efficiency of each individual country (Table A1 in Appendix A).

6. Results

6.1. ILPI top scorers

According to the results of the ILPI, the top five countries in terms of logistics efficiency are Denmark, Belgium, the Netherlands, Germany, and Austria as opposed to Germany, Sweden, Belgium, Austria, and Japan in the 2018 LPI.

Both rankings included Germany and Belgium – European countries that are members of the EU and are the economic and political centers of this union. These countries have the 2nd and 3rd largest ports in Europe, respectively (World Shipping Council, 2019), with Austria's rank dropping by 1 place, replaced by Germany.

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Table 3
ILPI/LPI-SUMEXPIMP correlation.

			SUMEXPIMP	ILPI	LPI
Kendall's tau-b	SUMEXPIMP	Correlation coefficient	1.000	0.571	0.544
		Sig. (2-tailed)		.000	.000
		N	159	159	159
	ILPI	Correlation coefficient	0.571	1.000	0.815
		Sig. (2-tailed)	.000		.000
		N	159	159	159
	LPI	Correlation coefficient	0.544	0.815	1.000
		Sig. (2-tailed)	.000	.000	
		N	159	159	159

Source: Own construction.

Furthermore, both rankings include Scandinavian countries – Denmark and Sweden. As a result of adjusting the data in accordance with actual objective statistics, the factors according to which Denmark lost to Sweden in LPI 2018 (specifically: logistics infrastructure, customs clearance and ease of arranging shipments) were adjusted towards Denmark in the ILPI (except ease of arranging shipments), which allowed it to get a higher score, given the slight difference in territorial location. Moreover, Denmark's merchant navy fleet is approximately 1.77 times larger than Sweden's (CIA, 2017).

Finally, the Netherlands scored higher than Japan on every subindex except the infrastructure subindex, with the customs subindex being approximately 2 times greater than Japan's, which shows that the objective statistical data clashes slightly with the subjective view of experts.

6.2. ILPI reliability

In the framework of this study, we will characterize countries' trade efficiency as the sum of their goods export/import (SUMEXPIMP), which represents the value of all goods provided to the rest of the world. On this basis, we will compare the validity of the proposed improvements (in the context of the ILPI) to the LPI.

For this reliability check, Kendall's tau-b correlation was used. To test the null hypothesis, data was corrected and entered into the sample. First, all countries were ranked from smallest to largest in three groups by the value of their LPI, ILPI scores and their sum of goods exports/imports. Second, all three groups were sorted alphabetically, retaining their ranks. This ranks dataset was tested through Kendall's tau-b correlation with the results shown in Table 3.

For all variables, p-value ≤ 0.001, which can be said to show statistical significance of tests, although it must be noted that such low p-values (1.18×10^{-26}, 2.29×10^{-24}) can also be attributed to large sample size ($n = 159$).

In any case, it can be concluded that the ILPI has 3% more correlation than the LPI, which may be a basis as to suggesting that the former improves the latter and allows a more accurate assessment of country-level logistics systems. It should be understood that although a 3% increase in correlation with goods export/import might seem negligible, a comparison of the ILPI and LPI shows a lot of rank changes among countries, with some, such as Moldova climbing 42 positions and Sao Tome and Príncipe dropping by 30 points, which are drastic rearrangements, showing a different snapshot of where countries stand in terms of logistics systems.

More accurate assessment is also crucial when considering the main users of the LPI, and, consequently, the ILPI:

1. Researchers – there is significant interest in country- and region-level logistics systems in the scientific community, and the ILPI can be used as a tool for comparing countries in terms of the effectiveness of their logistics systems, as well as the six aspects highlighted in it.
2. Multinational organizations and companies engaged in foreign economic activity – the ILPI may be an instrument for choosing a foreign market (among other factors). For example, if a company is physically equidistant from Kazakhstan and Belarus and in both markets there is a demand for the company's goods, provided that pricing policies and potential sales markets allow transport and related costs to be included in the price of the goods, it can use the ILPI when deciding which market to choose.
3. Government bodies – the ILPI allows the pinpointing of weaknesses and bottlenecks in countries' logistics systems. This, in turn, can lead to setting priorities for their improvement and correctly allocating resources to large development projects. Few countries have the ability and resources to fund all needed logistics development programs and so a sort of "triage" is crucial to understand which aspects of a country-level logistics system need the most attention, in what order and when.

The ILPI would be able to help identify barriers to greater integration of a country into the global value chain and would allow each country to individually improve its logistics system, which improves the global logistics system.

6.3. ILPI biases and caveats

First, the weights for several subindexes at the 3rd, 4th and 5th levels in the ILPI have been chosen as a share of 100 divided by the number of subindex indicators, which may be a simplified methodology that understands each subindex indicator as equal, which may not be the case in reality. Further research may need to be done in order to assess the subindex priorities.

Some statistical information has to be collected individually by country, since several databases do not include information on all 159 countries, which means more work needed to be done to construct the ILPI, which, in turn, may lead to human error and potential inaccuracies as well as the risk of unharmonized data skewing the results.

Neither the LPI nor the ILPI consider internal canal/river type waterways, which may be used to transport freight inside country borders since such information is scarce and not compiled in an easily accessible statistical database, which precludes its inclusion into an international logistics efficiency assessment tool.

Finally, both tools do not include any distance parameters. While many countries benefit from and/or depend on major hubs and ports for their trade, it is logical that, barring the appearance of new hubs, the distance between the existing ones and countries will remain the same and will be a constant, thus necessitating distance consideration. We believe that air, rail road and maritime transport connectivity may need more research in the future.

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7. Conclusions

Due to the multivariate nature of logistics, measurement and presentation of its efficiency in different countries is difficult. Considering time and costs associated with the logistics processes (customs clearance, transportation, etc.) facilitates the study and, in most cases, information is already available, but, notwithstanding its availability, the information is difficult to aggregate into a single multi-country dataset, due to structural differences in country supply chains. More importantly, many critical elements of a good logistics system, such as transparency of transactions and the level of service, reliability, and predictability cannot be investigated using statistical information, which necessitates the inclusion of surveys. The ILPI is a proposed assessment tool which builds upon the existing LPI with the intention of grounding it in objective statistical data, in order to serve as a KPI in national transport or logistics strategies, a benchmarking tool for detailed analysis of logistics subsystems as well as a snapshot of where a country stands, in terms of its logistics systems.

Conflict of interest

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Appendix A.

Table A1

Table A1
ILPI/LPI comparison.

ILPI			LPI 2018	*Rank comparison*	
Country	*Score*	*Rank*	*Rank*		
Afghanistan	0.34	**151**	**159**	*8*	↑
Albania	0.48	**86**	**87**	*1*	↑
Algeria	0.44	**105**	**116**	*11*	↑
Angola	0.34	**153**	**158**	*5*	↑
Argentina	0.51	**68**	**60**	*-8*	↓
Armenia	0.49	**78**	**91**	*13*	↑
Australia	0.64	**34**	**18**	*-16*	↓
Austria	0.80	**5**	**4**	*-1*	↓
Bahamas	0.43	**113**	**111**	*-2*	↓
Bahrain	0.52	**63**	**58**	*-5*	↓
Bangladesh	0.44	**109**	**99**	*-10*	↓
Belarus	0.56	**51**	**102**	*51*	↑
Belgium	0.82	**2**	**3**	*1*	↑
Benin	0.44	**106**	**75**	*-31*	↓
Bhutan	0.41	**126**	**148**	*22*	↑
Bolivia	0.44	**107**	**130**	*23*	↑
Bosnia and Herzegovina	0.52	**67**	**71**	*4*	↑
Brazil	0.53	**61**	**55**	*-6*	↓
Brunei	0.55	**54**	**79**	*25*	↑
Bulgaria	0.60	**43**	**51**	*8*	↑
Burkina Faso	0.43	**119**	**90**	*-29*	↓
Burundi	0.34	**155**	**157**	*2*	↑
C.A.R.	0.34	**156**	**150**	*-6*	↓
Cambodia	0.45	**103**	**97**	*-6*	↓
Cameroon	0.46	**93**	**94**	*1*	↑
Canada	0.67	**29**	**20**	*-9*	↓
Chad	0.38	**136**	**122**	*-14*	↓
Chile	0.60	**41**	**33**	*-8*	↓
China	0.65	**32**	**26**	*-6*	↓
Colombia	0.52	**66**	**57**	*-9*	↓
Comoros	0.40	**130**	**106**	*-24*	↓
Congo, Dem. Rep.	0.43	**115**	**119**	*4*	↑
Congo, Rep.	0.39	**132**	**114**	*-18*	↓
Costa Rica	0.48	**85**	**72**	*-13*	↓
Cote d'Ivoire	0.50	**76**	**49**	*-27*	↓
Croatia	0.63	**36**	**48**	*12*	↑
Cuba	0.38	**139**	**145**	*6*	↑
Cyprus	0.58	**48**	**44**	*-4*	↓
Czech Republic	0.76	**10**	**22**	*12*	↑
Denmark	0.85	**1**	**8**	*7*	↑
Djibouti	0.47	**92**	**89**	*-3*	↓
Dominican Republic	0.45	**100**	**86**	*-14*	↓
Ecuador	0.50	**75**	**61**	*-14*	↓
Egypt, Arab Rep.	0.54	**58**	**66**	*8*	↑
El Salvador	0.46	**96**	**100**	*4*	↑
Equatorial Guinea	0.38	**140**	**135**	*-5*	↓
Eritrea	0.32	**157**	**154**	*-3*	↓
Estonia	0.68	**25**	**35**	*10*	↑
Fiji	0.44	**108**	**132**	*24*	↑
Finland	0.71	**20**	**10**	*-10*	↓
France	0.76	**7**	**16**	*9*	↑
Gabon	0.36	**145**	**149**	*4*	↑
Gambia	0.42	**125**	**126**	*1*	↑
Georgia	0.46	**94**	**118**	*24*	↑
Germany	0.80	**4**	**1**	*-3*	↓
Ghana	0.43	**110**	**105**	*-5*	↓
Greece	0.64	**35**	**41**	*6*	↑
Guatemala	0.42	**123**	**124**	*1*	↑
Guinea	0.36	**144**	**144**	*0*	=
Guinea-Bissau	0.38	**141**	**128**	*-13*	↓
Guyana	0.38	**135**	**131**	*-4*	↓
Haiti	0.34	**154**	**152**	*-2*	↓
Honduras	0.43	**114**	**92**	*-22*	↓
Hong Kong, China	0.79	**6**	**12**	*6*	↑
Hungary	0.70	**22**	**30**	*8*	↑
Iceland	0.60	**42**	**39**	*-3*	↓
India	0.54	**60**	**43**	*-17*	↓
Indonesia	0.54	**56**	**45**	*-11*	↓
Iran, Islamic Rep.	0.48	**84**	**63**	*-21*	↓
Iraq	0.35	**150**	**146**	*-4*	↓
Ireland	0.61	**39**	**28**	*-11*	↓
Israel	0.59	**44**	**36**	*-8*	↓
Italy	0.74	**13**	**19**	*6*	↑
Jamaica	0.43	**112**	**112**	*0*	=
Japan	0.72	**18**	**5**	*-13*	↓
Jordan	0.49	**79**	**83**	*4*	↑
Kazakhstan	0.59	**45**	**70**	*25*	↑
Kenya	0.51	**71**	**67**	*-4*	↓

Table A1 (*Continued*)

Korea, Rep.	0.68	**26**	**25**	*-1*	↓
Kuwait	0.52	**65**	**62**	*-3*	↓
Kyrgyz Republic	0.48	**89**	**107**	*18*	↑
Lao PDR	0.45	**102**	**81**	*-21*	↓
Latvia	0.59	**46**	**69**	*23*	↑
Lebanon	0.49	**82**	**78**	*-4*	↓
Lesotho	0.39	**134**	**138**	*4*	↑
Liberia	0.36	**147**	**142**	*-5*	↓
Libya	0.36	**146**	**153**	*7*	↑
Lithuania	0.65	**31**	**53**	*22*	↑
Luxembourg	0.74	**12**	**24**	*12*	↑
Macedonia, FYR	0.51	**70**	**80**	*10*	↑
Madagascar	0.42	**122**	**127**	*5*	↑
Malawi	0.44	**104**	**96**	*-8*	↓
Malaysia	0.57	**50**	**40**	*-10*	↓
Maldives	0.46	**95**	**85**	*-10*	↓
Mali	0.41	**127**	**95**	*-32*	↓
Malta	0.54	**59**	**68**	*9*	↑
Mauritania	0.42	**121**	**134**	*13*	↑
Mauritius	0.48	**88**	**77**	*-11*	↓
Mexico	0.52	**64**	**50**	*-14*	↓
Moldova	0.51	**73**	**115**	*42*	↑
Mongolia	0.46	**98**	**129**	*31*	↑
Montenegro	0.51	**74**	**76**	*2*	↑
Morocco	0.48	**90**	**108**	*18*	↑
Myanmar	0.39	**133**	**136**	*3*	↑
Nepal	0.42	**124**	**113**	*-11*	↓
Netherlands	0.81	**3**	**6**	*3*	↑
New Zealand	0.67	**27**	**15**	*-12*	↓
Niger	0.32	**158**	**156**	*-2*	↓
Nigeria	0.45	**101**	**109**	*8*	↑
Norway	0.71	**19**	**21**	*2*	↑
Oman	0.61	**38**	**42**	*4*	↑
Pakistan	0.42	**120**	**121**	*1*	↑
Panama	0.61	**37**	**37**	*0*	=
Papua New Guinea	0.36	**148**	**147**	*-1*	↓
Paraguay	0.51	**72**	**73**	*1*	↑
Peru	0.49	**81**	**82**	*1*	↑
Philippines	0.49	**77**	**59**	*-18*	↓
Poland	0.73	**17**	**27**	*10*	↑
Portugal	0.73	**16**	**23**	*7*	↑
Qatar	0.70	**23**	**29**	*6*	↑
Romania	0.66	**30**	**47**	*17*	↑
Russian Federation	0.53	**62**	**74**	*12*	↑
Rwanda	0.51	**69**	**56**	*-13*	↓
São Tomé and Príncipe	0.43	**118**	**88**	*-30*	↓
Saudi Arabia	0.55	**55**	**54**	*-1*	↓
Senegal	0.37	**143**	**140**	*-3*	↓
Serbia	0.56	**53**	**64**	*11*	↑
Sierra Leone	0.32	**159**	**155**	*-4*	↓
Singapore	0.76	**8**	**7**	*-1*	↓
Slovak Republic	0.65	**33**	**52**	*19*	↑
Slovenia	0.70	**24**	**34**	*10*	↑
Solomon Islands	0.45	**99**	**103**	*4*	↑
Somalia	0.34	**152**	**143**	*-9*	↓
South Africa	0.58	**49**	**32**	*-17*	↓
Spain	0.75	**11**	**17**	*6*	↑
Sri Lanka	0.49	**80**	**93**	*13*	↑
Sudan	0.40	**129**	**120**	*-9*	↓
Sweden	0.76	**9**	**2**	*-7*	↓
Switzerland	0.74	**14**	**13**	*-1*	↓
Syrian Arab Republic	0.38	**137**	**137**	*0*	=
Tajikistan	0.48	**83**	**133**	*50*	↑
Thailand	0.58	**47**	**31**	*-16*	↓
Togo	0.40	**131**	**117**	*-14*	↓
Trinidad and Tobago	0.46	**97**	**123**	*26*	↑
Tunisia	0.47	**91**	**104**	*13*	↑
Turkey	0.61	**40**	**46**	*6*	↑
Turkmenistan	0.37	**142**	**125**	*-17*	↓
Uganda	0.43	**117**	**101**	*-16*	↓
Ukraine	0.56	**52**	**65**	*13*	↑
United Arab Emirates	0.67	**28**	**11**	*-17*	↓
United Kingdom	0.73	**15**	**9**	*-6*	↓
United States	0.71	**21**	**14**	*-7*	↓
Uruguay	0.48	**87**	**84**	*-3*	↓
Uzbekistan	0.43	**111**	**98**	*-13*	↓
Venezuela, RB	0.38	**138**	**141**	*3*	↑
Vietnam	0.54	**57**	**38**	*-19*	↓
Yemen, Rep.	0.35	**149**	**139**	*-10*	↓
Zambia	0.43	**116**	**110**	*-6*	↓
Zimbabwe	0.41	**128**	**151**	*23*	↑

Source: World Bank, UNCTAD, Eurostat, OECD, UNECE, and CIA.

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