The Impact of Logistics Performance on Countries' Export Growth: A Global Gravity Approach

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Abstract: This study deals with defining the link between logistics performance scores (LPI index) and export growth. The main aim of the paper is to evaluate the influence of logistics performance on the expansion of countries' exports, utilising the LPI index and its components, such as infrastructure quality, ability to track and trace consignments, ease of arranging competitively priced shipments, or efficiency of the customs clearance process. Poisson pseudo-maximum likelihood estimators with fixed effects were used to estimate gravity models as the core method of application. The results of the research suggest that higher logistics performance impacts export growth, while increasing the similarity of the overall LPI between countries supports more intensive bilateral trade flows. The study thus emphasises the importance of improving logistics efficiency as a tool to strengthen countries' export performance and support their global competitiveness.

Keywords: LPI Index, Logistics, Gravity Model, PPML

JEL Classification codes: C55, F14, L91

INTRODUCTION

Trade is related to logistics performance because it connects exporting and importing countries, i.e., improving logistics indicators also improve trade performance. (Suroso, 2022) Logistics is considered a crucial factor in sustainable development, as it is related to various industries and is affected by changes in the industrial structure. It is therefore important to understand performing logistics at the national level in order to plan future policies to promote trade and transport. (Song & Lee, 2022) Logistics performance refers to the efficiency of the processes involved in transporting goods from origin to destination, which includes aspects such as transportation infrastructure, customs procedures, quality of service, or overall ease of transportation. (Hoang, 2024) Understanding the relationship between logistics performance and export competitiveness is important in developing countries' bilateral trade. Initially focused on supply chain optimization, logistics now encompasses broader spatial and temporal roles due to globalization and modernization. (Ding et al., 2023) Since 2007, with introducing the Logistics Performance Index (LPI), the focus of several research studies has become to monitor the relationship between logistics and trade efficiency, with many studies focusing on total trade, selected indicators such as the competitiveness index or exports of selected commodities, e.g., palm oil exports. (Takele & Buvik, 2019; Zaninović & Bugarčić, 2023; Sergi et al., 2021; Suroso, 2022)

The aim of the paper is to evaluate the influence of logistics performance on the expansion of countries' exports, utilizing the LPI index and its components, through gravity modelling analysis. The paper will deal with defining the relationship between the logistics performance score (LPI index) and export growth. The main significance of the study lies in its analysis of the impact of individual components of the LPI index on export growth, representing an empirical contribution to scientific research. It is examining the quantity of bilateral trade flows on a large sample of countries, a sufficiently long time series, product groups and using a modern analytical apparatus, depending on the quality of logistics as a whole and then according to individual sub-indices of the LPI. However, the analysis of gravitational modelling is not limited to examining developing logistics quality in the exporting and importing countries but also focuses on the mutual interaction between the two countries. This aspect was achieved by applying and changing Linder's original hypothesis of more intensive bilateral trade between similar countries. Analyzing the links between logistics performance and exports can help identify areas where logistics processes can be improved to support export growth, contributing to overall economic growth.

The primary contribution of this article stems from empirically confirming the relationship between the LPI index and export growth. Furthermore, the research demonstrates that greater similarity in the overall LPI index and its sub-indices is associated with increased bilateral trade flows. The paper is structured as follows. First, it summarizes empirical literature dealing with the relationship between the LPI index and selected indicators, as well as with the advantages and disadvantages of the LPI index from a methodological point of view (data reliability). Next, the methodology is explained, followed by the results of this study and their discussion with the existing studies. Our core method is gravity modelling according to sound literature. Finally, conclusions and limitations are presented.

1 LITERATURE REVIEW

The LPI is an important indicator when comparing individual countries and the efficiency of the logistics sector, or the quality of transport and logistics services. It has been used since 2007, when it established itself as a global indicator of trade and transport facilitation for logistics professionals, academics, and policymakers. It is a tool to identify the challenges and opportunities faced by many companies and countries in terms of transport and logistics focused on six indicators: customs, infrastructure, international shipments, logistics competence, tracking & tracing, timeliness. (Arvis et al., 2023; Arvis et al., 2024)

The LPI index has been dealt with by several authors in their studies, looking for connections related to the impact of logistics performance on selected indicators. Sergi et al. (2021) point to the relationship between the LPI and the Global Competitiveness Index (GCI), with a focus on infrastructure, human factor, and institutions. The identified variables are essential for the proper development of the sector, with the human factor dominating the European logistics sector, infrastructure being the driving force behind logistics for Asia and Oceania. Kalansuriya et al. (2023) also examined the relationship between the LPI index and the competitiveness index in their study, examining the impact of the Corruption Perception Index (CPI), foreign direct investment (FDI), and gross domestic product per capita (PGDP) on the Global Competitiveness Index (GCI). Pehlivan et al. (2024) focused in their study on assessing the logistics performance of G20 countries in 2023 using LPI scores published by the World Bank and using the TOPSIS method and cluster analysis. Based on the analysis, they found the LPI scores were similar, and countries could be grouped into homogeneous clusters. Saini and Hrušecká (2021) investigated the causal relationship between economic development and logistics competitiveness indicators (LPI index) and logistics costs. Suroso (2022) focused on the impact of all logistical performance index indicators on exports of palm oil and palm-based products using a panel data regression approach using an extended gravity model aimed at

examining Indonesia and Malaysia as leading exporters of palm oil and palm-based products. Jayathilaka et al. (2022) investigated the impact of gross domestic product (GDP) and LPI on the international trade of countries on each continent and globally using panel regression and a random effect (RE) model. Takele and Buvik (2019) examined the impact of logistics performance and exports on African countries. Puertas et al. (2013) analysed the importance of each component of the LPI index in trade flows also using a gravitational model. Zaninović and Bugarčić (2023) empirically identified the potential contribution of logistics performance to increasing the share of domestic value added in exports. The empirical specification of the study was based on a structural gravitational model of international trade.

An important theoretical starting point for achieving the goal of the paper is defining the advantages and disadvantages of using the LPI index. This issue is dealt with in their studies by several authors who agree on its importance and use, despite some of its limitations from a methodological point of view. According to Starostka-Patyk et al. (2024), the LPI index is a tool that helps evaluate logistics services in a country, but also to see if countries are making any progress. It not only provides data on the overall score but also makes it easier to compare the different components over the course of the year and see whether policy changes have produced the expected results. According to Ju et al. (2024), it facilitates identifying the state of logistics in all countries of the world, helps to build the logistics profile of the country, allows countries to be compared with each other, but also within one country, which makes it a comprehensive international tool for comparison, measuring logistics performance and achieving facilitation of international cooperation in transport. Arvis et al. (2023) point out not only the limitations of the LPI score but also its importance, especially in the current changing environment caused by the pandemic, war, terrorist attacks, when it is important to understand, measure and monitor logistics performance. Saini and Hrušecká (2021) point to the fact that logistics costs, which are a critical component, are not included in the LPI index and in their study propose to extend the indicators used to calculate the LPI to include logistics costs.

According to study prepared by the World Bank we can also consider the limits of LPI. It is often a subjective opinion of representatives of freight forwarding and logistics companies, and also, if respondents did not provide information for all six components of the LPI index than interpolation was used to fill in the missing values replaced by the average country's answer to the question. Another limit of the LPI score may be the limited experience of survey respondents with the countries they evaluate. (Arvis et al., 2023; Arvis et al., 2024)

2 METHODOLOGY

The LPI survey does not take place in every calendar year. In addition, there is a data gap during the Covid-19 pandemic period. Therefore, for our purposes, we changed the database so that the last value of the examined country was used. In order to achieve the declared aim, the method of gravitational modelling in the RStudio software was used with the glm package (family - quasipoisson; R Core Team, 2024) and by calculating robust standard errors using a sandwich package (Zeileis et al., 2020; Zeileis & Hothorn, 2002; Zeileis, 2004, 2021). The tools of the dplyr package (Wickham et al., 2023) were used, as well as Microsoft Office tools. It is currently permissible to estimate gravitational models using a Poisson Pseudo-Maximum (PPML) estimator with specified fixed effects (Silva & Tenreyro, 2006). This approach will not only cover statistically frequent zero or low values of bilateral flows in the database, uncovered variables with a significant impact on the dependent variable, some statistical errors, but also so-called multilateral resistance terms (Adam & Cobham, 2007; Cheong et al., 2014; Hsiao, 2014; Yotov et al., 2016; König, 2021). The latest literature recommends exporter-time, importer-time and exporter-importer fixed effects (Breinlich et al., 2021), but to simplify the calculation, we apply exporter-, importer-, time-fixed effects and, in addition, a fixed effect for

the SITC product groups (0 to 9). The regression equation followed form, where β represents an estimate of the parameters of the variables, αi are the fixed effects of exporters, αj are the fixed effects of importers, αs represents the fixed effects of the SITC product groups, γt represents the time effects, and finally the error term εijt (own processing according to Silva & Tenreyro, 2006; Breinlich et al., 2021; Grübler & Reiter, 2021):

$$EX_{ijts} = \exp\left(ln_{X_1}\beta_1 + ln_{X_2}\beta_2 + ln_{X_n}\beta_n + \alpha_i + \alpha_j + \alpha_s + \gamma_t + \epsilon_{ijt}\right) \quad (1)$$

Since our effort was to create the simplest and most transparent models, only one control variable was specified for the individual components of the LPI, namely the similarity term from GDP per person employed as labour productivity and final consumption expenditures. In our case, labour productivity is a proxy variable of national competitiveness (Porter, 1990; Krugman, 1994) and final consumption was included in the specification to quantify the domestic trade flows represented by this variable (Yotov, 2022). This calculation is based on the so-called Linder's hypothesis (Linder, 1961) about the bilateral similarity of more intensely trading countries. The similarity term was expressed as the absolute value of the difference in the natural logarithms of the variables under study (Kitenge, 2021). A negative and statistically significant value of the estimated parameter of similarity terms always shows an increase in similarity between the examined countries, a positive value indicates the opposite. The variables used can be found in Table 1.

Tab. 1 Variables

Variable	Description
EX_{ijst}	Goods flow from exporting countries (i) to importing countries (j) for the period 2011 to 2022 (t) and for groups from 0 to 9 of the SITC nomenclature (s) in thousands of current USD (UNCTADStat, 2023).
GDP_ppe	Gross domestic product per person employed (output per worker) in constant and PPP USD as labour productivity (ILOStat, 2023).
F_Cons	Final consumption expenditure in current USD (WBG, 2024b)
LPI	LPI from 1 low to 5 high (WBG, 2024b).
LPI_INFR	Quality of trade and transport-related infrastructur (WBG, 2024b).
LPI_TRACK	Ability to track and trace consignments (WBG, 2024b).
LPI_QUALITY	Competence and quality of logistics services (WBG, 2024b).
LPI_PRICE	Ease of arranging competitively priced shipments (WBG, 2024b).
LPI_CUSTOMS	Efficiency of customs clearance process (WBG, 2024b).
LPI_TIME	Frequency with which shipments reach consignee within scheduled or expected time (WBG, 2024b).

Source: own processing

Obtaining data from the processed databases had a natural impact on the number of observations. Thus, the analysis contains the bilateral trade flows of 156 countries of export (i) and import (j) for the period 2011 to 2022 (t) and for 10 SITC product groups (s), which together represent 2,570,344 observations.

3 RESULTS AND DISCUSSION

The chapter focuses on specifying the results of the gravity model analysis and the LPI index and then comparing empirical results with the literature search in order to define recommendations and conclusions.

3.1 LPI index and gravity modelling analysis

We estimated the parameters of the specified variables using Pseudo Maximum-Likelihood estimators as part of our paper's methodology, which incorporates gravitational modelling with fixed and time effects. The results of the 14 alternative specifications can be found in Table 2.

Estimated parameters of control variables are the first general conclusion applicable to all model specifications. As the similarity in labor productivity between exporting and importing countries grows, so does the volume of their bilateral trade. We have not demonstrated the impact of final consumption similarity, which is a proxy variable for domestic trade flows. This indicates that we did not reject the zero statistical hypothesis of non-significance in estimating the similarity parameter of the term of final consumption, even at the maximum 10% significance threshold. The significant estimated parameter of labor productivity is logical and aligns with Linder's hypothesis. However, insignificant estimates of final consumption are contradictory. These results are statistically robust, as the effects of other uncovered variables in our specifications quantify our diverse fixed effects.

Tab. 2 Gravity models parameters estimations

Dep. Var. = EXijst	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**
Const.	11.50***	10.33***	11.48***	10.99***	11.48***	10.90***	11.51***
Sim_GDP_ppe	-0.20***	−0.27***	−0.24***	−0.27***	−0.22***	−0.27***	−0.20***
Sim_F_Cons	0.01	-0.01	0.00	-0.01	0.00	-0.01	0.01
Sim_LPI	−0.84***						
ln_LPI_it		0.50**					
ln_LPI_jt		0.32*					
Sim_LPI_INFR			−0.37***				
ln_LPI_INFR_it				0.19			
ln_LPI_INFR_jt				0.14			
Sim_LPI_TRACK					−0.55***		
ln_LPI_TRACK_it						0.18	
ln_LPI_TRACK_jt						0.23*	
Sim_LPI_QUALITY							−0.87***
Dep. Var. = EXijst	**Model 8**	**Model 9**	**Model 10**	**Model 11**	**Model 12**	**Model 13**	**Model 14**
Const.	10.46***	11.58***	11.02***	11.51***	10.96***	11.50***	11.38***
Sim_GDP_ppe	−0.27***	−0.24***	−0.27***	−0.21***	−0.27***	−0.21***	−0.27***
Sim_F_Cons	-0.01	0.01	-0.01	0.00	-0.01	0.00	-0.01
ln_LPI_QUALITY_it	0.39**						
ln_LPI_QUALITY_jt	0.34**						
Sim_LPI_PRICE		−1.29***					
ln_LPI_PRICE_it			0.18				

ln_LPI_PRICE_jt			0.16				
Dep. Var. = EXijst	**Model 8**	**Model 9**	**Model 10**	**Model 11**	**Model 12**	**Model 13**	**Model 14**
Sim_LPI_CUSTOMS				−0.53***			
ln_LPI_CUSTOMS_it					0.25		
ln_LPI_CUSTOMS_jt					0.13		
Sim_LPI_TIME						−1.03***	
ln_LPI_TIME_it							0.16
ln_LPI_TIME_jt							-0.10
n (t=2011–2022)	2,570,344						
PPML	Yes						
Robust st. errors	Yes						
Exporter fixed effects	Yes						
Importer fixed effects	Yes						
SITC 1 fixed effects	Yes						
Time fixed effects	Yes						

Source: own processing

Another important conclusion based on our results is the fact that as the similarity of the overall LPI index and all its sub-indices increases, the quantity of bilateral trade flows increases. Furthermore, we statistically significantly estimate all parameters of the variable. We observe heterogeneity within the estimated parameters of similarity terms, with absolute values ranging from 0.37 (Sim_LPI_INFR) to 1.29 (Sim_LPI_PRICE). Thus, bilateral trade flows respond least to an increase in the similarity of countries in infrastructure quality development, and most to an increase in the availability of international transport services at competitive prices, i.e., the ease of arranging competitively priced shipments. Placing these two thresholds is logical because price adjustments can be made more quickly than infrastructural ones. In addition, cost factors at the microeconomic level are still the dominant component of national competitiveness. In the past, countries influenced the value of exchange rates; today they resort to tax or cost competition, for example in wages (Albu et al., 2022; Baranová, 2013; Turner & Van't Dack, 1993; Dustmann et al., 2014; Teplická & Daubner, 2013). Therefore, this does not imply that infrastructure development should be undervalued. Our results indicate that the stimulation of trade flows will reflect the change in infrastructure quality, albeit with a time delay. That is why it is necessary to invest in infrastructure in a timely manner and with a sufficiently large amount of funds so that they have an economically positive development impact as soon as possible.

To find out how the overall LPI index or its sub-indices change bilateral trade flows, we saw that a rise in the total value of LPI had a positive effect on both exporting and importing countries. The quality of both partners got better, and the ability to track and trace shipments got better, but only in the importing country. This may be primarily since the buyer in the importing country prioritizes shipment tracking when implementing foreign trade operations.

Finally, it is possible to identify LPI sub-indices with a statistically less significant impact than other factors. These indices include the quality of the infrastructure of exporters and importers, the ability to track and trace consignments of exporters, but also the ease of arranging competitively priced shipments, the efficiency of the customs clearance process, and the frequency with which deliveries reach consignees within the scheduled time of both exporters and importers.

3.2 Applications of gravity modelling and contribution of our analysis

Gravity modelling has a wide range of applications. Khan et al. (2024) used this methodology to prove the positive potential of the so-called India Middle-East Europe Economic Corridor, which should bring benefits in terms of transport and logistics itself. Thus, our research confirms the positive impact of the overall LPI and many of its sub-indices on the current credit rating literature. Sy et al. (2020) focused on the ASEAN region and confirmed the positive impact of logistics performance on economies as such, but also on important sectors within the economic structure of the countries under study. For this, they used a rich methodological apparatus, including Poisson pseudo-maximum likelihood estimation. Unlike the presented article, our approach incorporates the latest index results, formulated during the dramatic period of the global COVID-19 pandemic. Additionally, our gravity model includes the widest possible global sample of countries available. A study by the authors Taguchi and Thet (2021) also comes from the ASEAN region, which used gravity modelling to investigate the impact of logistics performance on the integration of emerging markets within vertical global value chains (GVC). Their conclusions not only confirmed the positive impact of logistics and its quality on the deeper integration of economies in the GVC, but the authors also deduced room for positive government policy, as the quality and performance of logistics are, according to them, manageable. Kumari and Bharti (2021) worked with the theoretical assumption in the literature that smaller states achieve higher LPI score values due to their better efficiency than larger ones. Therefore, they considered the size of economies based on population. Indeed, the authors demonstrated that large states had the smallest impact of LPI on trade flows. Finally, we can mention Host et al. (2019), who, using a different specification of the gravity model, demonstrated the positive impact of trade facilitation on international trade. In this case, we used the LPI index as a trade facilitation proxy variable.

3.3 Recommendations

Based on literature review, multiple studies (Puertas et al., 2013; Suroso, 2022; Pehlivan et al., 2024), and the empirical results of our research, we can summarize a few recommendations for policymakers and practices:

- Trade takes place between countries that increase similarity in LPI scores, and countries with an increase in the value of this index export more. Therefore, it is important to improve the quality of infrastructure, take part in TEN-T networks or pan-European corridors, which contribute to increasing trade flows between countries, geographically close. Increasing investment in transport infrastructure increases logistics performance and stimulates exports and thus economic growth. Investments develop logistics infrastructures will also have a positive impact on the economic growth of countries.
- Bilateral trade flows react least to the increase differ countries in the development of infrastructure quality and the most to the determinant of ease of arranging competitively priced shipments, because of fluctuations and prompt adjustments of prices in line with the development of demand and supply in the markets, as opposed to changes in infrastructure, which are clearer in the long term. Improving performing logistics contributes to the growth of exports and the quality of infrastructure has a positive impact on it, as well as modernizing customs procedures, administration, or adapting transport policies to the real situation. Therefore, it is important for policymakers to remove barriers to trade, reducing transit times and increasing the efficiency of logistics processes.
- Because of the multidimensional nature of logistics, measuring and presenting its effectiveness in different countries is challenging, most times, information is available, but collecting it into a single dataset for multiple countries because of structural

differences in supply chains is complex. Building on the LPI, intending to base it on aim statistical data, it is appropriate to implement them as key KPIs in national transport or logistics strategies, thus serving as a reference tool for a detailed analysis of logistics subsystems, as well as an overview of where a country is in terms of its logistics systems.

CONLUSION

The main aim of the paper is to evaluate the influence of logistics performance on the expansion of countries' exports, utilizing the LPI index and its components, through gravity modelling analysis. Verification of the relationship between the LPI index and exports is especially important when making policy decisions aimed at more efficient and faster business processes, improving the business environment in terms of international transport and logistics, which contributes to increasing the country's competitiveness in the global market.

Our empirical research confirmed the relationship between the LPI index and export growth. We can also conclude that as the similarity of the overall LPI index and all its sub-indices increases, so does the quantity of bilateral trade flows. These findings highlight the importance of investing in improving logistics systems to support international trade and underline the importance of cooperation within trade partnerships. It is also important to focus on affording transport services, as cost factors at the microeconomic level are still the dominant component of national competitiveness.

We can also conclude that countries with a high LPI are more attractive to foreign investors who are looking for efficient logistics chains to support their production and business operations. Thus, the overall effect of logistics performance on a country's export capabilities is significant, which is why it is important to research and develop strategies to improve the LPI index in order to support the country's growth and economic development.

Our research limitations include the need to modify the LPI index database when using the most recent values. However, the World Bank Group's periodic compilation and publication of index values mandated this procedure. Another constraint stems from our failure to incorporate exporter-time, importer-time, and exporter-importer fixed effects, as suggested by Breinlich et al. (2021), to address the issue of multilateral resistance. We have selected a feasible approach for estimating fixed effects, which we can interpret based on temporal changes. However, there is a significant risk that incorporating the mentioned fixed effects could prevent us from estimating the variability of the variables we study, as only fixed effects can mathematically account for them.

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