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International Trade and Logistics: An Empirical Panel Investigation of the Dynamic Linkages between the Logistics and Trade and their Contribution to Economic Growth*

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Abstract:

Purpose: *The ultimate objective of this paper is to investigate the causal relationships between countries' logistics performance, international trade and economic growth.*
Design/Methodology/Approach: *We analyze the dynamic linkages among the Logistics Performance Index (LPI), trade openness as a percentage of the Gross Domestic Product (GDP), as well as the GDP growth based on a sample of 39 countries worldwide over the period 2007-2018. More particularly, we assess the significance and the direction of the detected causal effects among the three variables both in the long and the short run, using panel econometrics methodologies, namely, panel unit root tests, pooled mean group (PMG) models, and the Toda-Yamamoto approach to Granger-causality analysis.*
Findings: *The findings support that both international trade and logistics performance constitute driving forces of economic growth. Moreover, it is demonstrated that the effects of the logistics' sector on international trade are not direct but only through economic growth.*
Practical Implications: *The direction of causality is deemed quite important due to its strategic policy implications. A causal relationship running from the logistics and transport sector to trade investments in logistics and transport would cater for economic growth through increased trade. Policy makers should then adopt various policies aiming to promote or facilitate exports.*
Originality/Value: *Causal effects and more specifically the direction of causality between the transport infrastructure and economic growth have not been sufficiently studied in existing literature. Furthermore, only few studies provide some general evidence of a positive correlation between better logistics and increased trade. In our paper, we aim to further investigate the dynamic relationships between international trade and the logistics and transport sector.*

Keywords: *Logistics Performance Index (LPI), international trade, trade logistics, causality, Pooled Mean Group (PMG) models.*
JEL Codes: *C32, C33, C54,* *L91.* ***Article Type:*** *Research study.*

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1. Introduction

It is well established that the development of the logistics and transport sector has a positive impact on economic growth by facilitating the geographical decentralization of production, promoting the globalization of consumption, and hence boosting international trade (Gani, 2017). In particular, final product costs as well as expenses for importing and exporting activities are substantially reduced by various types of investments in logistical infrastructure or services, such as enhancements in transportation network infrastructure, new vehicle and cargo handling equipment, adoption of advanced information and communication technologies, collaborative and shared logistics practices, import/export facilitation etc. In a broader sense, logistics and transport advancements and investments also enable trade development (Dee and Findlay, 2006; OECD/WTO, 2013). The availability and quality of physical transportation infrastructure and logistics services, cargo handling costs, regulations, and procedures have a paramount impact on country's trade performance and competitiveness by directly influencing the cost of doing business (Hoekman and Nicita, 2011; Arvis *et al.*, 2012; Hausman *et al.*, 2012; Portugal-Perez and Wilson, 2012). In addition to the direct effects in trade, consumption and production, investments in logistics and transport create many indirect effects, as expenditure enhances growth through multiplier effects.

The logistical infrastructure and services and the performance of the broader logistics sector vary substantially with countries. The World Bank Logistics Performance Index (LPI) provides a benchmarking tool in the form of a weighted measure of the logistics performance per country. The International LPI 2018 essentially ranks 160 countries worldwide with respect to their performance and "friendliness" of trade logistics by taking into account performance dimensions such as customs efficiency, quality of trade and transport infrastructure, competitive pricing of shipments, competence and quality of logistics services (e.g., trucking, forwarding, customs brokerage), ability to track and trace consignments, as well as the timeliness of shipments. As a matter of fact, there is a huge logistics performance gap between top performer and low performer countries (Arvis *et al.*, 2014). For instance, according to International LPI 2018, Germany, Sweden, Belgium, Austria, and Japan are the top performers with an overall LPI score ranging between 4.03 and 4.20, whereas Afghanistan, Angola, Burundi, Niger, and Sierra Leone exhibit the lowest LPI scores in the order of 1.95 - 2.08.

Examining the issue from a different angle, there seems to be a direct causal relationship between international trade and logistics (Nguyen and Tongzon, 2010). In that respect, the development of international trade creates higher demand for logistics and transport services, which, in turn, triggers further business and investment growth (Lee and Rodrigue, 2006; Vasiliauskas and Barysiene, 2008). At the outset, there is some empirical evidence about a bidirectional causal relationship between the logistics and transport sector performance and international trade (Hoekman and Nicita, 2010). Despite the empirical evidence and intuition about this bidirectional causal relationship, direct effect, dynamic linkages and the direction of causality merit further investigation. To the best of the authors' knowledge, few research efforts have measured the direct effect of logistics performance on trade and vice versa. Similarly, the dynamic relationship of international trade with the transport sector has not been sufficiently addressed. More particularly, there is a need to study in more depth the response of the transport sector to growth in international trade.

Moreover, the direction of causality is deemed quite important due to its strategic policy implications. As far as the latter are concerned, a causal relationship running from the logistics and transport sector to trade investments in logistics and transport would cater for economic growth through increased trade. Policy makers should then adopt various policies aiming to promote or facilitate exports. On the other hand, in the event that the direction of causality runs from trade to the logistics and transport sector, there would be no clear incentive to invest in logistics and transport in order to promote international trade. It may be also that causality is bidirectional between transport and logistics expansion and international trade. In such a case, policies should pursue simultaneous improvements, interventions or development incentives.

In our paper, we aim to study the relationships between countries' logistics performance, international trade and economic growth and identify possible causal linkages among them based on a sample of 39 countries worldwide over the period 2007-2018. In addition, we explore the significance and the direction of the detected causal effects both in the long and the short run. The score of the International LPI provides a measure of the logistics performance of the countries under consideration. International transactions as a percentage of the Gross Domestic Product (GDP) and the GDP growth constitute the relevant metrics used to express trade openness and economic growth, respectively.

The remainder of this paper is structured into three sections. Section 2 discusses the relevant research efforts addressing the relationship between transportation infrastructure and economic growth, as well as causal linkages between logistics performance and international trade. Section 3 presents the underlying data and the associated empirical results. Finally, Section 4 summarizes the main concluding remarks, policy implications and directions for future research.

2. Literature Review

The discussion of relevant literature is structured into two main research streams. The first research stream (Section 2.1) deals with research efforts addressing the relationship between transport infrastructure and economic growth and the direction of their causal effects. The second stream (Section 2.2) summarizes research efforts on the dynamic linkages between the logistics sector performance and international trade.

2.1 Transportation Infrastructure and Economic Growth

The relationship between the transport sector and economic growth has been extensively examined in literature. Since the early 1990s, the topic has attracted the interest of both economists/researchers and policy makers.

Rietveld (1989) reviews operational multiregional economic models from the viewpoint of infrastructure and suggests three ways to describe the relationship between infrastructure and regional development. More specifically, infrastructure can be employed either as a production factor, in a production function or as a location factor affecting the location of private investment or employment or through its impact on inter-regional trade flows. Aschauer (1990) examines the relationship between infrastructure and quality of life, as well as the broader contribution of public infrastructure to the aggregate economy. In his empirical analysis, he estimates a production relationship and employed cross-sectional state-level data on gross state product and public infrastructure expenditure, averaged over the period 1965 to 1983 for the United States. The use of cross-sectional, time-averaged data reflects a deliberate attempt to focus on long-run as opposed to short-run relationships between output and infrastructure spending. Berndt and Hansson (1992) employ the theoretical and empirical models developed by Aschauer (1990) in order to assess the contribution of public infrastructure capital on private sector output and productivity growth, based on annual data sets for Sweden (1960-1988).

Gramlich (1994) provides an overview and critique of the literature on investment in public infrastructure. He concludes that past and existing policies have to be thoroughly revisited with view to their contribution to infrastructure system improvements and economic productivity benefits. In a similar context, Kessides (1996) summarizes the economic benefits of various types of infrastructure (e.g., public utilities, public works, transportation network and terminals) in the context of developing countries and considers the necessary conditions for these benefits to be realized. Most importantly, he notes that one of the main shortcomings of research on the economic impact of transportation infrastructure is that it has so far not adequately accounted for simultaneity effects on which economic growth can lead to development of the transport system as well as result from it.

Lau and Sin (1997) examine whether economic growth is generated endogenously or exogenously and estimate the externality effects due to private and public capital, respectively. Using the multivariate stochastic cointegration method of Johansen (1995) with U.S. data over the period 1925-1989, they conclude that there is one long run equilibrium relationship among the involved series, while the cointegrating coefficients further suggest that the hypothesis of endogenous growth is rejected. The above literature approximates the transportation infrastructure variable using the public infrastructure capital stock implying that it is the public funds only that contribute to the development of the transport sector and ignoring the issue of efficiency.

2.2 Logistics and Transport and International Trade

The economic impacts of international trade represent a well examined issue in existing literature. Interestingly, both directions of causation running from logistics performance to trade growth and vice versa have stimulated the interest of the research community. In what follows, we structure the discussion of relevant research on the basis of the direction of causation, thus presenting separately research efforts providing evidence in favor of causation running from logistics performance towards international trade growth (Section 2.2.1) and studies demonstrating causality effects running to the opposite direction, that is, from international trade growth towards logistics performance (Section 2.2.2).

2.2.1 Logistics Performance Causally Affects Trade Growth

The relationship between the logistics and transport services and trade has been addressed in existing literature mostly with view to the exploration of effects of logistics on trade facilitation in a wider frame of reference, without specific consideration or analysis of the direction of causality.

Wilson *et al.* (2003) analyze the relationship between trade facilitation, trade flows, and GDP per capita in the Asia-Pacific region for the period 1989-2000. As part of their research, they employ an augmented gravity model to determine the main trade facilitators. Improvements in logistics performance were found to result in sub substantial growth in trade. Arvis *et al.* (2007; 2010) apply descriptive statistics exhibiting a positive association between logistics performance and important outcome indicators such as trade openness. Hoekman and Nicita (2011) use a gravity model including indices of trade restrictiveness and trade facilitation developed by World Bank, such as the Logistic Performance Index and Doing Business. Their results suggest a significant positive association between logistics performance and trade intensity. Interestingly, it is shown that the increase of the LPI score of a low-income country to the middle-income average would increase trade by around 15 percent.

Hausman *et al.* (2012) argue that logistics performance represents a significant determinant of total cost and explore the impact of logistics performance (in terms of cost, time, and complexity in performing import and export activities) on global bilateral trade. In a similar front, OECD/WTO (2013), as well as Portugal-Perez and Wilson (2012) claimed that trade facilitation measures increase imports, while simultaneously boosting exports as a result of better access to production sources and greater participation in global and regional value chains. Furthermore, Portugal-Perez and Wilson (2012) estimate the impact of aggregate indicators of “soft” and “hard” infrastructure on the export performance of developing countries based on a data set of more than 100 countries for the years 2004 to 2007. Their results suggest that physical infrastructure, as well as Information and Communication Technology (ICT) have a notable impact particularly on exports. Gani (2017) uses a large sample of countries to analyze their overall logistics performance along with disaggregated measures of logistics performance. By incorporating variables of logistics performance in some standard export and import equations, he claims a significant positive correlation of logistics performance with imports and mostly exports.

Using disaggregate trade panel data for various subsectors in Spain, Martínez-Zarzoso and Márquez-Ramos (2008) investigate the impact of transport costs on trade and estimate the elasticity of trade with respect to transport costs for various subsectors. Their results suggest that the quality of door-to-door services, transport infrastructure, port efficiency and availability of different transport modes are among the key determinants of transport costs and international trade especially in high value-added sectors. Finally, Arvis *et al.* (2012) underline the issue of efficiency in transport and logistics as a crucial factor behind trade cost and underline the adverse impacts of inefficiencies in transportation infrastructure on trade.

2.2.2 Trade Growth Causally Affects Logistics Performance

Little focus has been placed on the exploration of the relationship between international trade and development of the logistics and transport sector. Adopting the perspective of the role of trade as a driver or trigger mechanism of the demand for logistics and transport services, many researchers (Frankel, 1998; Lee and Rodrigue, 2006; Vasiliauskas and Barysiene, 2008) argue that trade facilitating factors such as the elimination of trade barriers and market deregulation policies, and the use of containers have drastically increased containerized trade, which, in turn, stimulates container terminal development and growth of the associated logistics services. Furthermore, it is shown that steady economic and trade growth also indirectly affects logistics and transport by promoting inter-sectoral competition, thus positively affecting logistics and transportation services (Yap *et al.*, 2006). Other researchers focus particularly on Asian ports (e.g., Korea, China) showing that international trade can be considered as a key explanatory condition for the development of regional port and shipping systems (Frankel, 1998; Lee and Rodrigue, 2006)

Nguyen and Tongzon (2010) study the causal relationship between transport sector growth and trade in Australia. They use a vector autocorrelation (VAR) framework, and they find that Australia's trade with large economies (e.g., China, Japan, U.S.) largely affect transport development, by bringing enlargements and improvements in the transport sector of Australia. On the other hand, the transport sector of Australia is not able to stimulate trade growth and this was attributed to the country's relatively low population density, inefficient utilization of existing transport infrastructure, as well as the lack of targeted investment policies with a clear export facilitation orientation.

Based on the detailed review of relevant research dealing with the relationships between transport infrastructure, logistics and transport performance, and trade growth, a number of interesting conclusions with respect to gaps or limitations of the existing research can be drawn:

- The causal effects and more specifically the direction of causality between the transport infrastructure and economic growth have not been studied.
- Few studies provide some general evidence of a positive correlation between better logistics and increased trade. Hence, there is a need for a more detailed investigation and deeper understanding of the dynamic relationships between international trade and the logistics and transport sector.
- A general limitation in existing literature has to do with the lack of published long-term time series data needed for econometric analysis, hence exclusively resorting to cross-sectional data analysis. Very few efforts have used time series or combinations of time series and cross-sectional data.

3. Data and Empirical Results

3.1 Data

In modern economies, international trade is an increasingly important part of economic activity. The gains from trade are well explained and established in theory (Krugman and Obstfeld, 2003). When a country gains from trade, it is not happening at the expense of other countries. On the contrary, since the gains from trade result from specialization, which is based on a particular competitive advantage, all countries participating in trading activities may gain.

More specifically, we could identify two main reasons for countries to trade: when a country cannot produce a product or produces it in quantities which cannot satisfy local demand, then it imports the product from other countries. Another reason is that a country would import products which can be produced domestically, however at a higher price or inferior quality and, for that reason, the products are imported (Sherlock and Reuvid, 2008).

Especially after the fall of the communist regimes in Eastern Europe and the opening of China to the world markets, trade has boosted by far (WTO, 2015) and international organizations such as the World Trade Organization (WTO) have also played an important role in promoting a free trade global market. These have led to a more integrated global market and so today we are speaking of globalization of production and markets (Hill, 2008). Transportation costs and logistics services are the most important factors affecting international trade and imports and exports volume (Nordås *et al.*, 2006). The development of information and communication technologies further enforced the integration of world markets and globalization (Schwab, 2013).

The World Bank measures countries trade logistics performance since 2007 by using an index known as the Logistics Performance Index (LPI). Clearly, there are important differences in trade logistics performance. According to 2018 data, among the counties that comprise the data sample studied in our analysis, Germany performs the highest (4.2) while Belarus the lowest (2.57) LPI. Obviously, as countries improve in their logistics performance trade will improve. However, inefficiencies in logistics result in high costs and thus the potential for maximizing international trade is dampened (Arvis *et al.*, 2014).

In the context of the empirical analysis, this study employs annual data from 39 countries over the period 2007-2018. More particularly, the collected time series data sourced from the World Development Indicators Statistical Database of the World Bank and concerns the Logistics Performance Index, the Openness to Trade and the Gross Domestic Product per Capita. It should be mentioned that the above-mentioned database provides data for the Logistics Performance Index for 68 counties. However, we limited the employed number of countries to 39 focusing on the countries with complete availability of data for all the variables involved in our empirical analysis. The studied group of countries is reported in Table 1 below.

Table 1. *Group of Countries*

Australia	Finland	Netherlands
Austria	France	Russian Federation
Argentina	Germany	Poland
Belarus	Greece	Romania
Belgium	Hong Kong SAR, China	Slovak Republic
Brazil	Hungary	Serbia
Bulgaria	India	Slovenia
Canada	Ireland	Spain
China	Israel	Sweden
Cyprus	Italy	Turkey
Denmark	Japan	Ukraine
Czech Republic	Korea, Rep	United States
Croatia	Norway	United Kingdom

The overall Logistics Performance Index reflects perceptions of a country's logistics based on efficiency of customs clearance process, quality of trade- and transport-related infrastructure, ease of arranging competitively priced shipments, quality of logistics services, ability to track and trace consignments, and frequency with which shipments reach the consignee within the scheduled time. The index ranges from 1 to 5, with a higher score representing better performance.

The aggregate index is calculated by analyzing six main components using the following indicators: customs, infrastructure, international shipments, logistics quality and competence, tracking and tracing, and timeliness. Regarding the Trade Openness variable, it is the sum of exports and imports of goods and services measured as a share of gross domestic product. Finally, Gross Domestic Product (GDP) per capita represents the gross domestic product divided by mid-year population. More specifically, we use GDP per capita where gross domestic product has been converted to international dollars using purchasing power parity rates (PPP). Data are in constant 2011 international dollars. An international dollar has the same purchasing power over GDP as the U.S. dollar has in the United States.

In Figures 1-3 presented below, we provide a brief representation of the performance of the examined variables over the period under study. Actually, in all three figures below, the corresponding to each country columns 1, 2 and 3, represent respectively, the values of the presented variable in 2007, 2018 and its average value over the whole examined period. In Figure 2, we observe that the higher Logistics Performance Index score corresponds to Germany closely followed by Netherlands, Sweden, Austria and Great Britain with Belarus, Bosnia Herzegovina, Serbia and Ukraine at the lowest ranks of the classification. In Figure 2, we observe that, the higher Trade Openness corresponds to Hong Kong followed by Ireland and Slovakia with Brazil, Japan and USA at the lowest places of the classification. Finally, in Figure 3, we observe that the higher real GDP per capita corresponds to Norway, Ireland, Hong Kong and USA with India and Ukraine being placed at the lowest parts of the classification.

Figure 1. *Logistics Performance Index (LPI)*

BLUE: 2007 Data RED: 2018 Data Green: Period Average

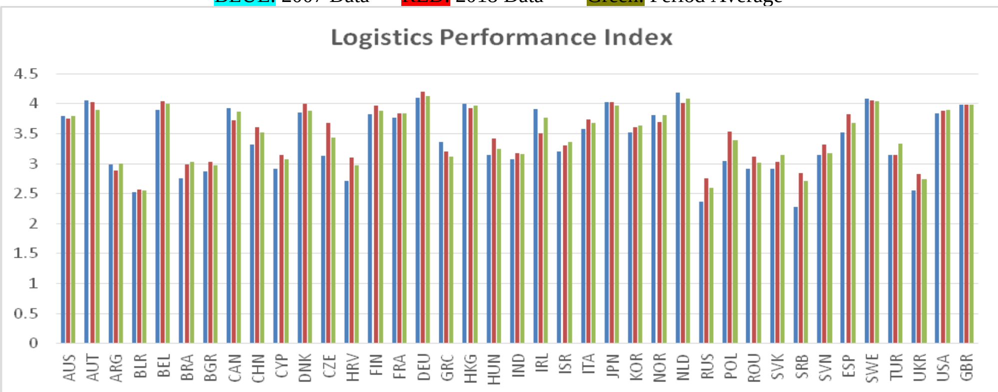
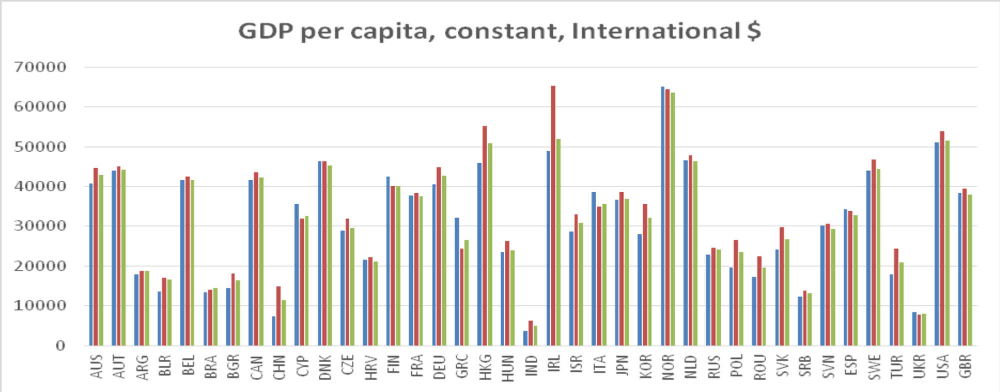


Figure 2. *Trade Openness*

BLUE: 2007 Data RED: 2018 Data Green: Period Average

Figure 3. GDP per Capita, Constant Prices, International Dollars

BLUE: 2007 Data RED: 2018 Data Green: Period Average



For the purposes of our empirical analysis, Logistics Performance Index and GDP per capita are used in logarithmic form, denoted by LLPI and LY respectively, while TRP stands for the Trade Openness.

3.2 Empirical Results

It is common practice, in the first step of an empirical analysis to determine the integration properties of the involved series. This first step is essential to avoid the so-called problem of spurious regression and help the researcher to decide in favor of the appropriate methodology to be used. In this direction, we apply complementary five 1st generation panel unit-root tests, the Levin, Lee & Chu test (LLC) (Levin *et al.*, 2002), the Breitung test (BR) (Breitung, 2000), the Im, Pesaran & Shin test (IPS) (Im *et al.*, 2003), the Fisher-ADF test (ADF) (Maddala and Wu, 1999) and the Fisher-PP test (FPP) (Choi, 2001). LLC and BR tests assume that there is a common unit root process. The IPS, FADF and FPP tests allow for individual unit root processes and are characterized by the combining of individual unit root tests to derive a panel-specific result. The results are shown in Tables 2 and 3, respectively.

Table 2. *Panel Unit-root Tests (with constant and trend)*

	Levels			First Differences		
	Individual effects, individual linear trends			Individual effects, individual linear trends		
	LLPI	TRP	LY	LLPI	TRP	LY
LLC	−7.82334 (0.0000)	−17.8525 (0.0000)	−9.82874 (0.0000)	−13.1138 (0.0000)	−35.4951 (0.0000)	−19.1032 (0.0000)
BR	1.91253 (0.9721)	−5.66491 (0.0000)	1.93614 (0.9736)	−3.47944 (0.0003)	−7.19919 (0.0000)	−0.11952 (0.4524)

IPS	-3.60216 (0.0002)	−8.13019 (0.0000)	−2.53566 (0.0056)	−3.21373 (0.0007)	−11.9849 (0.0000)	−6.03289 (0.0000)
FISHER ADF	134.670 (0.0001)	196.313 (0.0000)	115.649 (0.0036)	150.479 (0.0000)	333.492 (0.0000)	200.810 (0.0000)
FISHER FPP	57.9752 (0.9565)	181.907 (0.0000)	113.555 (0.0053)	29.3220 (1.0000)	303.363 (0.0000)	254.683 (0.0000)

Note: *Panel unit-root test include intercept and time trend; the optimal number of time lags is chosen by SBC up to a maximum of two lags.*

Table 2 above presents the results from the applied unit root tests accounting for individual effects and time trend, that is, including a constant and a time trend variable in the testing statistics. The findings support that LLPI in 2 out of 5 tests do not reject the null hypothesis of a unit root (non-stationarity), while TRP and LY reject the null in 4 and 5 out of 5 tests, respectively. In brief, based on the above, in terms of majority, we may consider that LLPI is a non-stationary series, while TRP and LY are stationary. When testing the series in first difference form, they all clearly turn to stationary. Next, we continue by repeating the above performed tests, but at this time accounting only for individual effects. The revised results are now reported in Table 3.

Table 3. *Panel Unit-root Tests (only constant)*

	Levels			First Differences		
	Individual effects			Individual effects		
	LLPI	TRP	LY	LLPI	TRP	LY
LLC	−8.15728 (0.0000)	−6.59484 (0.0000)	−5.66503 (0.0000)	−9.68826 (0.0000)	−30.0998 (0.0000)	−18.3048 (0.0000)
BR	— (−)	— (−)	— (−)	— (−)	— (−)	— (−)
IPS	−5.60549 (0.0000)	−2.01001 (0.0222)	1.01160 (0.8441)	−5.81442 (0.0000)	−18.2982 (0.0000)	−11.1654 (0.0000)
FISHER ADF	159.035 (0.0000)	98.8773 (0.0554)	69.6963 (0.7376)	166.996 (0.0000)	398.484 (0.0000)	258.846 (0.0000)
FISHER FPP	119.949 (0.0016)	104.002 (0.0262)	74.5835 (0.5886)	72.3481 (0.6592)	385.977 (0.0000)	231.418 (0.0000)

Note: *Panel unit-root test include only intercept: the optimal number of time lags is chosen by SBC up to a maximum of two lags.*

More particularly, Table 3 provides evidence against the presence of a unit root (rejection of the null hypothesis) for LLPI and TRP in 5 out of 5 statistics in level form and almost similar indications in first differences. However, LY is found non-stationary (acceptance of the null hypothesis of a unit root) in level form, in 3 out of 5 statistics but stationary in first difference form. So, we may accept that the order of integration of the examined variables could be characterized slightly inconclusive (either I(1) or I(0)), especially for LLPI and LY, while TRP is stationary, I(0).

Given that there exists some ambiguity regarding the accurate order of integration, we proceed by applying the Toda-Yamamoto Granger type causality test which does not require the variables to be integrated of order one, I(1), as it is required in most conventional cointegration methodologies. Actually, the variables are used in level form and irrespective of their stationary properties. At a preliminary stage, the optimal lag length of the included variables is determined based on a number of well-known criteria, reported in Table 4.

Table 4. *Lag Order Selection Criteria*

Endogenous variables: TRP LY LLPI
Exogenous variables: C

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-403.8638	NA	0.002724	2.608101	2.644092	2.622486
1	1839.074	4428.365	1.64e-09	-11.71202	-11.56805	-11.65448
2	1904.019	126.9747	1.15e-09	-12.07063	-12.81870*	-12.96994*
3	1979.192	145.5270	7.52e-10	-12.69482*	-12.13492	-12.35098
4	1994.646	29.62140*	7.22e-10*	-12.53620	-12.06832	-12.34920

* indicates lag order selected by the criterion.

LR: sequential modified LR test statistic (each test at 5% level). FPE: Final prediction error. AIC: Akaike information criterion. SC: Schwarz information criterion. HQ: Hannan-Quinn information criterion.

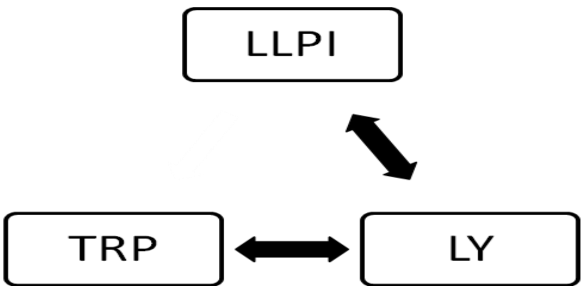
The selected lag length according to the SC and HQ criteria equals 2. Having in mind that the max order of integration of the three variables is 1, we proceed with the estimation of a VAR extended by one lag, that is a 3rd order VAR. Next, we apply Wald tests on the first two lags of each independent variables. Actually, the empirical results of Granger Causality test based on Toda and Yamamoto (1995) methodology is estimated through MWALD test. The estimates of MWALD test show that the test result follows the chi-square distribution with 2 degrees of freedom in accordance with the appropriate lag length along with their associated probability and are reported in Table 5.

Based on the above results, we can conclude in favor of a two-way causal relationship between TRP and LY, as well as of another two-way causal relationship between LLPI and LY. It seems that LLPI and TRP are not directly causally connected, but there is an indirect bi-directional causal effect between them through LY. Figure 4 below presents the detected linkages among the three variables.

Table 5. *Toda – Yamamoto Causality (Modified WALD) Test Result*

Null Hypothesis	**Chi-sq**	**Prob.**	**Granger Causality**
LY does not Granger cause TRP	18.213	0.0001	Unidirectional Causality LY-> TRP
LLPI does not Granger cause TRP	1.380	0.501	No Causality
LY and LLPI does not Granger cause TRP	18.252	0.001	Unidirectional Causality LY, LLPI -> TRP
TRP does not Granger cause LY	7.543	0.023	Unidirectional causality TRP -> LY
LLPI does not Granger cause LY	12.612	0.001	Unidirectional causality LLPI -> LY
TRP and LLPI does not Granger cause LY	21.101	0.000	Unidirectional causality TRP, LLPI -> LY
TRP does not Granger cause LLPI	0.112	0.945	No causality
LY does not Granger cause LLPI	4.711	0.094	Weak unidirectional causality LY -> LLPI
TRP and LY does not Granger cause LLPI	5.450	0.244	No causality

Figure 4. *Dynamic linkages among the three variables*



However, Toda-Yamamoto's causality test is not able to distinguish between short and long-run causality and to determine the long-run coefficients of the equilibrium long-run equations in cases of cointegration. To deal with this issue, we proceeded to the analysis by applying PMG estimation (Pesaran *et al.*, 1999). The long-run coefficients as well as the error correction terms of the examined models are presented in Table 6.

The estimation results in Table 6 suggest that there is a long-run causal effect running from the independent variables to the dependents ones, since the error correction terms are found negative and statistically significant. More specifically, there is a positive long-run causal effect running from TRP and LY to LLPI since both long-run coefficients were found positive and statistically significant (*p-value* < 0.05) at 5% level of significance. From the same table, we further observe that there is a positive long-run effect running from TRP and LLPI to LY, as well as from LY to TRP. It has to be mentioned that there is no long-run causal effect running from LLPI to TRP since the long-run coefficient was found statistically insignificant *(p* = 0.472 > 0.05). Therefore, there is a bi-directional long-run causal effect among all the involved variables.

Table 6. *Long-run Coefficients and Error Correction Term from PMG*

Dependent Variable	Independent Variables	ARDL model	Long-run coefficients (p-value)		Error Correction Term (p-value)	Result
LLPI	TRP, LY	(2,1,1)	0.016 (0.000)	0.104 (0.000)	−0.720 (0.000)	Long-run Causality
LY	TRP, LLPI	(1,1,1)	0.847 (0.000)	9.029 (0.000)	−0.032 (0.002)	Long-run Causality
TRP	LLPI, LY	(1,1,1)	0.157 (0.472)	0.073 (0.007)	−0.044 (0.036)	Long-run Causality

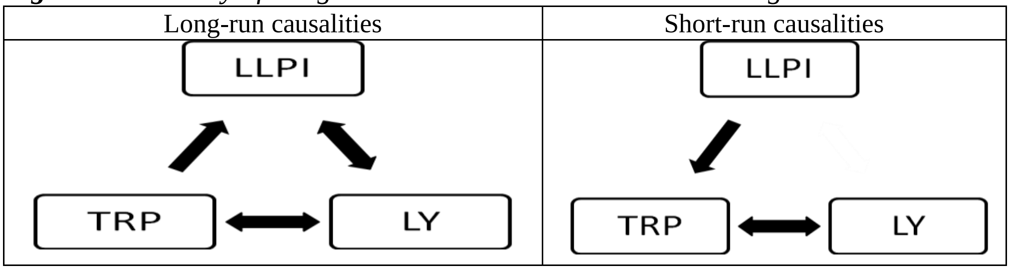
The next step of our empirical analysis concerns the detections of possible short run effects among the variables. The findings are presented in Table 7.

Table 7. *Short-run Causalities*

Dependent Variable	**Independent Variables**	**Short-run Effects (p-value)**		**Result**
LLPI	TRP, LY	(0.954)	(0.536)	No short-run Causality
LY	TRP, LLPI	(0.000)	(0.874)	Short-run Causality from TRP->LY
TRP	LLPI, LY	(0.041)	(0.000)	Short-run Causality LLPI-> TRP LY->TRP

In Table 7, it is observed that there is no significant short-run effect running from TRP and LY to LLPI neither from LLPI to LY. On the other hand, there are short-run causal effects running from TRP to LY and from LLPI and LY to TRP. Even though there is no direct short-run causal effect running from LLPI to LY, there is an indirect causality from LLPI to LY through TRP. In order to compare and understand the long-run and the short-run dynamic linkages among the involved variables of our analysis and for the whole panel data set, we present the next graph (Figure 5). Furthermore, we provide a brief presentation of the results for the long-run and short-run dynamic interactions for each one individual country in our data sample. The findings have been presented in a tabular form in the three tables that follow, where each table refers to one of the three endogenous variables under investigation.

Figure 5. *Summary of Long-run and Short-run Causalities among the Variables*



The following three tables (Tables 8-10) summarize the long and short-run causality results for every individual country involved in the empirical analysis. For every country and examined relationship, we report three columns. The first column (LR) refers to the existence of long-run causality directed to the dependent variable of the model. The next two columns report existence of short-run causality from each one of the independent variables. The YES reveals evidence of causality, the NO reveals lack of causality and the WEAK reveals weak evidence of causality.

Table 8. *Long-run and Short-run Causality Results (Dependent: Logistics Performance)*

DEPENDENT VARIABLE:LOGISTICS PERFORMANCE INDEPENDENT VARIABLES: ECONOMIC GROWTH and INTERNATIONAL TRADE											
COUNTRY	LR	SR (LY)	SR (TRP)	COUNTRY	LR	SR (LY)	SR (TRP)	COUNTRY	LR	SR (LY)	SR (TRP)
1.Australia	YES	WEAK	YES	14.Finland	YES	YES	YES	27.Netherlands	YES	NO	YES
2.Austria	YES	NO	WEAK	15.France	YES	YES	YES	28.Russia	YES	YES	YES
3.Argentina	YES	YES	YES	16.Germany	-	-	-	29.Poland	YES	YES	YES
4.Belarus	YES	YES	YES	17.Greece	YES	YES	YES	30.Romania	YES	YES	YES
5.Belgium	YES	NO	YES	18.Hong Kong	YES	YES	YES	31.Slovak Rep.	YES	YES	YES
6.Brazil	YES	NO	YES	19.Hungary	YES	YES	YES	32.Serbia	YES	YES	YES
7.Bulgaria	YES	NO	YES	20.India	YES	NO	YES	33.Slovenia	YES	YES	YES
8.Canada	NO	NO	WEAK	21.Ireland	YES	WEAK	YES	34.Spain	YES	NO	YES
9.China	YES	YES	YES	22.Israel	YES	NO	YES	35.Sweden	YES	YES	YES
10.Cyprus	NO	YES	YES	23.Italy	YES	YES	YES	36.Turkey	YES	NO	NO
11.Denmark	YES	YES	YES	24.Japan	YES	YES	YES	37.Ukraine	YES	YES	YES
12.Czech	YES	WEAK	YES	25.Korea, Rep	YES	YES	YES	38.USA	YES	YES	YES
13.Croatia	YES	YES	NO	6.Norway	YES	NO	NO	39.United Kingdom	YES	NO	YES

As far as Table 8 is concerned, the results reveal lack of long-run causality from trade and economic growth towards the logistics sector (which is our primary interest) only for Canada and Cyprus.

Table 9. *Long-run and Short-run Causality Results (Endogenous: International Trade)*

DEPENDENT VARIABLE: INTERNATIONAL TRADE INDEPENDENT VARIABLES: LOGISTICS PERFORMANCE and ECONOMIC GROWTH											
COUNTRY	LR	SR (LP)	SR (LY)	COUNTRY	LR	SR (LP)	SR (LY)	COUNTRY	LR	SR (LP)	SR (LY)
1.Australia	NO	NO	NO	14.Finland	YES	NO	YES	27.Netherlands	NO	NO	YES
2.Austria	YES	YES	YES	15.France	YES	NO	YES	28.Russia	NO	WEAK	YES
3.Argentina	YES	NO	YES	16.Germany				29.Poland	YES	YES	YES
4.Belarus	YES	NO	NO	17.Greece	YES	NO	NO	30.Romania	YES	NO	NO
5.Belgium	NO	NO	YES	18.Hong Kong	YES	NO	NO	31.Slovak Rep.	YES	YES	YES
6.Brazil	NO	YES	YES	19.Hungary	YES	NO	YES	32.Serbia	NO	NO	YES
7.Bulgaria	YES	YES	YES	20.India	YES	NO	NO	33.Slovenia	YES	YES	YES
8.Canada	NO	NO	YES	21.Ireland	NO	NO	NO	34.Spain	YES	NO	YES
9.China	NO	NO	NO	22.Israel	NO	YES	NO	35.Sweden	NO	YES	YES
10.Cyprus	NO	YES	YES	23.Italy	YES	NO	YES	36.Turkey	NO	NO	YES
11.Denmark	YES	NO	YES	24.Japan	NO	NO	YES	37.Ukraine	NO	NO	YES
12.Czech	NO	NO	NO	25.Korea, Rep	YES	NO	NO	38.USA	NO	NO	YES
13.Croatia	YES	NO	YES	26.Norway	NO	YES	YES	39.United Kingdom	YES	NO	YES

According to the findings presented in Table 9, lack of long-run causality from economic growth and the performance of the logistics sector towards international trade is reported only for Australia, Belgium, Brazil, Canada, China, Czech Republic, Ireland, Israel, Japan, Norway, Netherlands, Russia, Serbia, Sweden, Turkey, Ukraine and USA.

Table 10. *Long-run and Short-run Causality Results (Endogenous: Economic Growth)*

DEPENDENT VARIABLE: ECONOMIC GROWTH INDEPENDENT: LOGISTICS, TRADE											
COUNTRY	LR	SR (TRP)	SR (LPI)	COUNTRY	LR	SR (TRP)	SR (LPI)	COUNTRY	LR	SR (TRP)	SR (LPI)
1.Australia	NO	NO	WEAK	14.Finland	NO	YES	YES	27.Netherlands	NO	YES	YES
2.Austria	YES	YES	YES	15.France	YES	YES	NO	28.Russia	YES	YES	NO
3.Argentina	YES	YES	NO	16.Germany				29.Poland	NO	YES	NO
4.Belarus	YES	YES	NO	17.Greece	YES	YES	YES	30.Romania	NO	YES	NO
5.Belgium	YES	YES	WEAK	18.Hong Kong	YES	YES	NO	31.Slovak Rep.	YES	NO	NO
6.Brazil	YES	YES	WEAK	19.Hungary	YES	YES	NO	32.Serbia	YES	YES	YES
7.Bulgaria	NO	YES	YES	20.India	YES	YES	WEAK	33.Slovenia	NO	YES	YES
8.Canada	YES	YES	WEAK	21.Ireland	YES	YES	NO	34.Spain	YES	YES	YES
9.China	YES	YES	NO	22.Israel	YES	YES	NO	35.Sweden	YES	YES	NO
10.Cyprus	NO	YES	YES	23.Italy	YES	YES	YES	36.Turkey	NO	YES	NO
11.Denmark	NO	YES	NO	24.Japan	YES	YES	NO	37.Ukraine	NO	YES	NO
12.Czech	YES	YES	NO	25.Korea, Rep	NO	YES	WEAK	38.USA	YES	YES	YES
13.Croatia	YES	YES	NO	26.Norway	YES	YES	NO	39.United Kingdom	YES	YES	YES

As it concerns this final Table (Table 10), lack of long-run causality from trade and the performance of the logistics sector towards economic growth is reported only for Australia, Bulgaria, Cyprus, Denmark, Finland, Korea, Netherlands, Poland, Romania, Slovenia and Ukraine.

4. Conclusions

In this article, we analyzed the dynamic linkages among Logistics Performance Index, Trade Openess and Economic Growth for a sample of 39 countries over the period 2007-2018. Particularly, we investigated possible causal links between the involved variables as well as the direction of the causal effects using panel econometrics methodologies, namely panel unit root test, pooled mean group (PMG) models, and the Toda-Yamamoto approach to Granger-causality analysis.

All applied causality tests have revealed long-run bidirectional causal relations between GDP and LPI as well as between GDP and trade (TRP). The PMG approach additionally revealed a univariate causal effect running from TRP to LPI. Regarding the short-run period, PMG has detected unidirectional causal effects running from LPI to TRP as well as two-way causality between TRP and GDP.

The inability of the logistics sector to cause trade growth implies that this sector is lagging behind trade. For some countries such as Australia and Canada with demand peculiarities or constraints due to relatively low population density, it seems that investment in transport infrastructure may not be the best way to promote international transactions and economic growth. A better alternative may be to focus on improving the efficiency of the transport sector. For example, this could be pursued by improving the utilization rate of the existing transport infrastructure system. In addition, national transport policies should be more oriented to exports, and there is a need to ensure that investment is directed to areas or regions that need it most.

References:

Aschauer, D.A. 1990. Why is infrastructure important? Conference Proceedings, Conference series no. 34, Federal Reserve Bank of Boston.

Arvis, J.F., Mustra, M., Panzer, J., Ojala. L., Naula, T. 2007. Connecting to Compete 2007: Trade Logistics in the Global Economy. Washington, D.C., The World Bank.

Arvis, J.F., Mustra, M., Ojala, J., Shepherd, B., Saslavsky, D. 2010. Connecting to Compete 2010: Trade Logistics in the Global Economy. Washington, D.C., The World Bank.

Berndt, E.R. and Hansson, B. 1992. Measuring the contribution of public infrastructure capital in Sweden. Scandinavian Journal of Economics, 94, 151-168.

Breitung, J. 2000. The Local Power of Some Unit Root Tests for Panel Data. Advances in Econometrics 15, Nonstationary Panels, Panel Cointegration and Dynamic Panels, Amsterdam: JAI Press, 161-178.

Choi, I. 2001. Unit Root Tests for Panel Data. Journal of International Money and Finance, 20, 249-272.

Dee, P. and Findlay, C. 2006. Trade Facilitation: What, Why, How, Where and When? 3rd LAEBA Annual Meeting Seoul, South Korea, November 16.
Frankel, E.G. 1998. China' maritime developments. Maritime Policy and Management, 25(3), 235-249.
Gani, A. 2017. The Logistics Performance Effect in International Trade. The Asian Journal of Shipping and Logistics, 33(4), 279-288.
Gramlich, M.E. 1994. Infrastructure Investment: a review essay. Journal of Economic Literature, 32, 1176-1196.
Hausman, W.H., Lee, H.L, Subramaniam, U. 2013. The impact of logistics performance on trade. Production and Operations Management, 22(2), 236-252.
Hill, C. 2008. International Business: Competing in the Global Market Place. Strategic Direction, 24(9).
Hoekman, B. and Nicita, A. 2011. Trade policy, trade costs, and developing country trade. World Development, 39, 2069-2079.
Im, K.S., Pesaran, M., Shin, Y. 2003. Testing for unit roots in heterogeneous panels. Journal of Econometrics, 115(1), 53-74.
Johansen, S. 1995. Likelihood-Based Inference in Cointegrated Vector Autoregressive Models. Oxford University Press.
Kessides, C. 1996. A review of infrastructure's impact on economic development. In Batten,D., Karlsson, C. (Eds.), Infrastructure and the Complexity of Economic Development, Chapter 12, 213-230.
Krugman, P. and Obstfeld, M. 2003. International Economics: Theory and Policy, 6th Edition, New York, Addison-Wesley.
Lau, S.H.P., Sin, C.Y. 1997. Public infrastructure and economic growth: time-series properties and evidence. Economic Record, 73(221), 125-135.
Lee, J.Y. and Rodrigue, J.P. 2006. Trade reorientation and its effects on regional port systems: the Korea–China link along the Yellow Sea Rim. Growth and Change, 37(4), 597-619.
Levin, A., Lin, C.F., Chu, C.S.J. 2002. Unit root tests in panel data: Asymptotic and finite-sample properties. Journal of Econometrics, 108(1), 1-24.
Maddala, G.S. and Wu, S. 1999. A Comparative Study of Unit Root Tests with Panel Data and A New Simple Test. Oxford Bulletin of Economics and Statistics, 61, 631-652.
Martínez-Zarzoso, I. and Márquez-Ramos, L. 2008. The Effect of Trade Facilitation on Sectoral Trade. The B.E. Journal of Economic Analysis & Policy, 8(1), 1-46.
Nguyen, H.O., and Tongzon, J. 2010. Causal nexus between the transport and logistics sector and trade: The case of Australia. Transport Policy, 17, 135-146.
OECD/WTO. 2013. Aid for trade and value chains in transport and logistics. World Trade Organisation, Geneva.
Pesaran, M.H., Shin, Y., Smith, R.P. 1999. Pooled mean group estimation of dynamic heterogeneous panels. Journal of the American Statistical Association, 94, 621-634.
Portugal-Perez, A. and Wilson, J.S. 2012. Export performance and trade facilitation reform: hard and soft infrastructure. World Development, 40, 1295-1307.
Rietveld, P. 1989. Infrastructure and regional development: A survey of multiregional economic models. The Annals of Regional Science, 23, 255-274.
Schwab, K. 2013. The Global Competitiveness Report 2013-2014: Full Data Edition. World Economic Forum.
Sherlock, J. and Reuvid, J. 2008. The handbook of international trade: A guide to the principles and practice of export. Consultant Editors, Jim Sherlock and Jonathan Reuvid (2nd Edition), Global market briefings. London, GMB.

Toda, H.Y. and Yamamoto T. 1995. Statistical inference in vector autoregressions with possibly integrated processes. Journal of Econometrics, 66(1-2), 225-250.

Vasiliauskas, A.V. and Barysiene, J. 2008. An economic evaluation model of the logistics system based on container transportation. Transport, 23(4), 311-315.

Wilson, J., Mann, C., Otsuki, T. 2003. Trade facilitation and economic development. World Bank Policy Research Working Paper 2988, Washington.

World Bank. 2007. World Development Indicator. Washington D.C.

WTO. 2015. Speeding up trade: benefits and challenges of implementing the WTO Trade Facilitation Agreement. World Trade Report.

Yap, W.Y., Lam, J.S.L., Notteboom, T. 2006. Developments in container port competition in East Asia. Transport Reviews, 26(2), 167-188.