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Transportation Research Procedia 78 (2024) 394–401

Transportation Research Procedia

www.elsevier.com/locate/procedia

25th Euro Working Group on Transportation Meeting (EWGT 2023)

Automation in logistics port and freight transport with blockchain technology

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Abstract

According to World Economic Forum the COVID-19 crisis exposed the vulnerabilities in global supply chains. One notable impact was in shipping rates, as transport ground to a halt and a worldwide backlog of containers built up in ports around the world. Another was a dramatic increase in the number of people shopping online as measures to safeguard public health meant that many were confined to their homes. Logistics service providers were forced to get creative and identify means of mitigating costs while maintaining the speed and quality of service.

Within the commodity supply chain, there are many stakeholders, each with their own set of platforms and methods. Multiple versions of the same document can inundate end-users, especially if they need to enter one set of data in multiple places. These circumstances open up loopholes for fraudulent or malicious activity in the supply chain. Logistics suppliers are fragmenting their operations in response to this shift, spreading out their processes to minimize concentration risk and the disruption caused by events like geopolitical tension or a pandemic.

Using a world production growth function the contribution of the Logistics Performance Index(LPI) components of 133 countries has been estimated for the period 2007-2018 through the econometric method of panel data with fixed effects.

Blockchain Technology can guarantee transparency and quality, and automation where Smart Contracts can be written and often reused between different entities and a set of agreements that can automatically take effect after a period or condition is met.
The content of the paper reflects the results of research conducted on the contribution of logistics port and freight transport with which we can solve inefficiencies in the ease of arranging international shipments at competitive prices with Blockchain to get Automation of whole supply chain with ports nodes.

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10.1016/j.trpro.2024.02.050

1.- Introduction

Today there is no doubt that logistics is an important factor in global production. However, this fact does not mean that the impact of logistics on global production and economic growth is known. There is even some controversy about the extent to which logistics affects production and efficiency. Ultimately, this is what Stiglitz (2014) calls a puzzle about the nature of the comparative advantage of technologies and logistics.

There are only three papers, Coto-Millán et al. (2013), Coto-Millán et al. (2016), and Pesquera (2021), in which the contribution of logistics to economic growth and global technical efficiency is examined. Even more striking is the lack of studies and research on the impact of logistics since the crisis of recent years.

An important question is how to accurately describe the aggregate production function. Output growth is typically explained as the accumulation of factor inputs and growth in total factor productivity. Apart from the basic factors of production, growth accounting looks for additional determinants that can explain growth and efficiency. This leads to a regression that treats all determinants of output growth as inputs, which is conceptually incorrect, as many determinants that can be included can only indirectly affect output production (Miller and Upadhyay (2000)). However, using the Mankiw, Romer and Weill (1992) model extended with the logistics factor, we will be able to detect additional determinants of output growth (beyond the input factors) that affect it from different combinations of the actual inputs, physical capital, human capital, employment, and the various components of logistics, and thus directly affect the productivity factor.

Due to their relevance and importance, as well as their expectations, in the current context of digital transformation and compliance with the Sustainable Development Goals (SDGs) of the United Nations, two technologies stand out in transportation and logistics: the "Physical Internet", which is based on the diagnosis of the inefficiency of current logistics from the technical, economic and social perspectives; and Blockchain, as a distributed data accounting technology, to achieve, with its application, the ultimate goal of intelligent automation, to improve efficiency and sustainability.

"Physical Internet" diagnoses notable deficiencies in the field of logistics, therefore this paper aims to contribute to the economic literature in two different aspects:

First, by estimating global economic growth using econometric techniques, taking the growth model proposed by Mankiw et al. (1992) as a starting point.

Secondly, by evaluating the impact of logistics through its components as explanatory variables of the economic growth dynamics of the different countries of the world. My aim is to analyze the impact, at least in part, of logistics on the economic growth of world production. This question is considered of great interest, given that progress in logistics is one of the most significant social and economic issues in recent decades, to the point that it has created what some call a new revolution in production, storage, distribution and transportation.

With this objective, and data limitations, a panel of data from the years 2007-2010-2012-2014-2016-2016-2018 corresponding to 133 countries has been studied.

I will organize the rest of this research as follows. In the second section I will review the existing literature on the impact of logistics in the literature closest to this analysis, which is the one related to economic growth. The third section proposes the methodology that will be subsequently estimated, and, the statistical information used in this paper is reviewed. The main results are then presented in fourth the section. Finally, the fifth section presents the main conclusions of this research.

Finally, I make an interpretation of the results in relation to the proposals that can be carried out with public policies and regulations, and with changes in transport and logistics companies or organizations; with the incorporation of knowledge and current technological implementation.

2.- Literature Review: Logistics, Blockchain, Efficiency and Economic Growth.

Blockchain technology as a key to logistics and trade, we can see it in many references, especially in the last two years.

As an area of exploration, and a topic of great debate, it has been included in the 2018 and 2019 Annual Meetings of the World Economic Forum in Davos. Fruit of these is the research "Inclusive Deployment of Blockchain for Supply Chains" by Warren and Wolff (2019), convinced of the lasting potential for global logistics chains and improved efficiency.

Along the lines of efficiency with Blockchain platforms in logistics chains, the DHL study (2018), highlights the potential that Blockchain has in logistics. However, moving from concepts and pilot applications, to the implementation of viable solutions will require the technology to be further developed, as well as organizational transformation and a willingness to collaborate among all stakeholders. Success depends on all parties involved working to transform current processes and jointly adopting new ways of creating logistics value.

The complexity of international logistics systems in many sectors has grown as a result of product variation and differentiation. Whereby recent economic developments are linked to the creation of complex production networks (Ducruet and Beauguitte, 2013).

There is a relationship between the level of economic growth and logistics costs. While logistics costs can reach 25% of shipping costs in some developing economies, they reach 8% to 9% in advanced economies (Roberts 2003). Consequently, logistics costs directly affect international trade. If logistics costs are so high, they may exceed the benefit derived from the price differential, so that international trade would not gain a positive economic benefit. However, as Lin et al. (2014) have pointed out, there is also an environmental cost of traffic networks that must be considered.

There is a large literature evaluating the spillover effect of transportation and its external impact generated by transportation infrastructure on economic development. Evidence from different countries (e.g., Munnell 1990; Aguas2004; Xiushan et al. 2015) as well as theoretical evidence (Illenberger et al.2013; Batabyal and Nijkamp2014) supports the existence and importance of spillover effects. Other studies have focused on the relationships between the spatial structure of networks and their vulnerability and resilience in critical situations (e.g., Reggiani et al.2002; Griffith and Chun 2014; Caschiliet al.2015). However, despite the importance of logistics, there are few papers assessing its impact on global economic growth, which is the purpose of this research.

Yang (2007) studied the relationship between logistics and economic growth. Based on data from North America, Japan and Europe, the author determined that logistics and economic growth are cause and effect of each other by cointegration techniques.

Using an instrumental variable model, Czernich et al.(2011) estimates the effect of broadband infrastructure on economic growth. The author concludes that a 10 % increase in broadband penetration poses an annual per capita growth of 0.9-1.5 %.

While some have argued that ICT has been the main technological enabler of economic globalization, bringing about a 'death at a distance' (Cairncross 1997) in a 'flat world' (Friedman 2005), this perspective does not fully appreciate the role of innovation in transportation (Levinson, 2006). It is precisely the combination of logistics and ICT that led to the reduction of transport costs and the growing importance of networks in the evolution of the global economy.

On the other hand, Coto-Millán et al.(2013) has studied the impact of logistics on economic growth, focusing on the long-run equilibrium solution of a growth model and estimated that a 1 % increase in synthetic LPI could generate economic growth in a range of 0.011 and 0.034 %. In this paper we extend the sample to the most current data available and disaggregate the synthetic LPI into its respective components,

Coto-Millán et al. (2016) estimates synthetic LPI efficiency for a sample of 34 developed countries.

Finally, Tang and Abosedra (2019) estimate the influence of LPI for an export-oriented economic growth model in Asia for the period 2010 to 2016 for 23 countries.

Finally Pesquera (2021) the impact of logistics on the efficiency of scale for all countries in the world.

3.- Methodology and Data

We will use the model of Mankiw, Romer and Weill (1992) to estimate the world production function. In essence it is to explain the world output measured by GDP, by the following world inputs: Human Capital (EDUC), Physical Capital (GFB) and Employment (EMP). Continuing with the economic growth model, we start from the variable to be explained, which will be the output measured by the world GDP and the explanatory variables, which in addition to the inputs mentioned above will be the different components of the LPI. In this way, the estimation of the six components of the LPI will be carried out through the specification of the dynamics of economic growth.

The impact of the six LPI components on economic growth in each country's output can now be measured from the estimation results of the Mankiw, Romer and Weill (1992) model extended "ah hoc" with the LPI components.

The Logistics Performance Index or LPI is an indicator defined by the World Bank, with the objective of evaluating trends in Logistics in the countries of the world. Data is available for 2007, 2010, 2012, 2014, 2016, and 2018.

The LPI was designed to measure the components of the supply chain, such as transportation, customs, timeliness of shipments, tracking, etc. It measures the efficiency of each country's supply chain and how it performs in international trade with other countries around the world.

Inefficient logistics poses problems in global integration affecting developing and emerging countries to be more competitive.

The LPI attempts to capture how a country is logistically accessible, and connected to the physical internet, globally.

The components of the Logistics Performance Index (LPI) are:

1.- Infrastructure: the quality of the infrastructure related to trade and transportation.

2.- Customs: the efficiency of clearance and management at customs borders.

3.- The competence and quality of logistics services.

4.- Tracking and Traceability, real-time location of shipments in the logistics chain.

5.- Punctuality (Timeliness): shipments within the scheduled delivery times.

6.- The ease of arranging international shipments at competitive prices.

The first three correspond to areas of regulatory policy and the last three to time, cost, and reliability.

The World Bank (2018) publication includes the LPIs in its sixth edition, which facilitates the conduct of the present research from a scientific approach.

This paper performs an empirical test of the proposed model with the indicators included in the World Economic Indicators (WDI) database created by the World Bank. The World Bank is an international organization with several objectives, most of which are closely related to poverty and economic development in all countries. To this end, since its creation in 1944, it has devoted an increasing part of its resources to the collection of statistics and indicators, which are organized in databases.

To carry out our empirical analysis, a sample of 133 countries will be considered, for which complete logistics data is available for the years 2007, 2010, 2012, 2012, 2014, 2016 and 2018.

A detailed description of the variables included in the estimation of the production function is provided in Table 1.

Table 1. Structure of the variables used

Variable definition data		
Production function		
GDP	(in $)	WDI
EDU	% working age population in secondary school	WDI
EMP	% population employed	WDI
GBF	% of GDP of fixed capital in dollars.	WDI
LPI	Logistics Performance Index	WDI
LPI1	Infrastructures	WDI
LPI2	Customs Efficiency	WDI
LPI3	Quality and Logistics Competence	WDI
LPI4	Tracking and Traceability	WDI
LPI5	Punctuality	WDI
LPI6	Competitive Pricing on International Shipments	WDI

Source: Own elaboration based on World Bank WDI data.

Table 2 shows the main statistics corresponding to the variables used.

Table 2.- Principal statistics

Variable	Media	Median	D. T.	Minimum	Maximum
GDP	8.67e+005	1.76e+005	2.46e+006	1.83e+003	2.05e+007
EDU	86.8	93.7	26.7	10.7	100
EMP	57.4	57.7	10.1	35.4	87.8
GBF	24.89	23.22	7.74	11.91	67.91
LPI	2.98	2.86	0.53	1.61	4.18
LPI1	2.82	2.66	0.66	1.40	4.34
LPI2	2.76	2.63	0.57	1.63	4.21
LPI3	2.93	2.83	0.58	1.43	4.32
LPI4	3.00	2.93	0.59	1.67	4.27
LPI5	3.41	3.38	0.54	1.67	4.71
LPI6	2.94	2.89	0.46	1.57	4.05

Source: Own elaboration based on World Bank data.

The dependent variable is the annual economic growth rate of real GDP per capita and the independent variables are: fixed capital per capita for each country, human capital which measures the percentage of the working age population in secondary school, employment, and logistics performance disaggregated into each of its components.

4. Results

Using the Mankiw, Romer and Weill (1992) model extended to estimate the world production function, we explain world output measured by GDP (GDP), and by the following world inputs: Human Capital (EDUC), Physical Capital (GFB) and Employment (EMP).

Once the variables have been defined and their main statistics have been provided, we proceed to estimate the world production function incorporating the indices related to the different components of the LPI. This estimation is shown in Table 3.

Where using 665 observations, 133 cross-section units have been included, corresponding to the 133 countries of the world considered. Length of the time series = 5. Dependent variable: CREC.

Table 3.- Estimation of the World Production Function of a panel 2007-2018 by the Fixed Effects Method. Dependent variable: l_GDP_pc

Variable	Coefficient	Standard deviation	Statistic t	p-value	Sig.
const	-2.24848	0.777537	-2.892	0.0040	***
l_GDPpc_1	-0.846875	0.0237156	-35.71	<0.0001	***
l_EDU	1.59140	0.0773397	20.58	<0.0001	***
l_EMPL	0.371043	0.156554	2.370	0.0181	**
l_GFB	0.0611983	0.0164350	3.724	0.0002	***
LPI1	0.904000	0.235519	3.838	0.0001	***
LPI2	0.437740	0.222990	1.963	0.0502	*
LPI5	0.176346	0.254501	0.6929	0.4887	
LPI6	-0.392193	0.198760	-1.973	0.0490	**

Variable mean. dep.	-0.001181	D.T. of the vble. dep.	0.720780
Sum of quadr. Waste	69.71870	T.D. of regression	0.364762
R-squareMCVF(LSDV)	0.797896	R-squared 'unbiased'.	0.754482
F(140, 524) MCVF)	14.77657	p-value (of F)	4.4e-117
Log-likelihood	-193.7008	Akaike Criteria	669.4015
Schwarz Criteria	1303.871	Hannan-Quinn Crit.	915.2405
Rho	0.059541	Durbin-Watson	1.303388

*** statistically significant at 99%
** statistically significant at 95%
* statistically significant at 90%
Joint contrast of regressors (except for the constant)
Contrast statistic: F(132, 524) = 4.41831
with p-value = P(F(132, 524) > 4.41831) = 2.83677e-34
Contrast of different intercepts by groups
Null hypothesis: The groups have a common intercept.
Contrast statistic: F(132, 524) = 4.41831
with p-value = P(F(109, 212) > 0.715557) = 0.974277
Source: Own elaboration. Estimated with GRETL software.

As can be seen, the only indices that are significant are those corresponding to Customs, Infrastructure, and competitive prices of international shipments. The other three are not significant.

5. Conclusions

Logistics has allowed the reduction of transportation costs, facilitating with the use of logistics networks and platforms, the growth of the world economy. Using a world production growth function of the type proposed by Mankiw et al. (1992) the contribution of the LPI components of 133 countries has been estimated for the period 2007-2018 through the econometric method of panel data with fixed effects.

My work contributes to the literature by estimating the contribution of logistics to the economic growth of countries around the world. Therefore, to improving the state of knowledge on the impact of logistics in the world. This research is the first to document that logistics performance as measured by LPI components increases productivity through improved global output.

The results highlight the significant impact of logistics on global economic growth. Available data from the World Bank show that a 1 % increase in the index of efficiency in customs management increases the current global level of growth by 0.43 % and the index of quality of infrastructure in international trade and transport by 0.90 %.

On the other hand, the index of ease of arranging international shipments at competitive prices is significant and negative. Thus, in view of this result, it can be interpreted that a 1% increase in the index of ease of arranging shipments at competitive prices decreases the current world level of economic growth by 0.39%.

The results, contrasted with econometric analysis, indicate that logistics contributes positively and significantly to its infrastructure and customs management efficiency, being significant but negative in ease of organizing international shipments at competitive prices, and not significant in timeliness, tracking and traceability, and the competence and quality of logistics services.

I propose actions in the components of LPI policy decisions, such as: the facility to organize international shipments at competitive prices, scaling with interoperable platforms, and standardized with blockchain, with which we will overcome the current system of siloed databases, which need verifications, intermediations, and show their inefficiencies; by shared and immutable records that allow us to create intelligent autonomous systems, with "smart contracts".

The proposal is completed at the global trade level, applying blockchain technologies, with which we can solve inefficiencies in the ease of arranging international shipments at competitive prices.

With the construction of blockchain platforms in different logistics spaces, such as international trade, port logistics, urban mobility, etc., more efficient systems will be generated and adapted to open and complex worlds thanks to digital automation. will generate more efficient systems adapted to open and complex worlds thanks to **digital automation**, with changes that generate value with efficiently connected logistics.

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