EFFICIENCY OF SCALE OF LOGISTICS IN THE PRODUCTION OF THE WORLD'S COUNTRIES (2007-2018)

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ABSTRACT

Logistics is an important factor in global production. However, this does not mean that we know the impact of logistics on production and its efficiency in the short and long term.

The content of the paper reflects the results of research conducted on the contribution of logistics to the scale efficiency of the world's countries.

This research uses a production function of the type proposed by Mankiw et al. (1992) to study the effect of logistics on scale efficiency through data envelopment analysis (DEA) for one hundred and thirty-three countries in the world during the period 2007-2018. This research establishes that logistics is an important channel for improving scale efficiency for the countries of the world in view of the estimation results.

This research contributes to the literature by estimating the contribution of each of the components of the Logistics

Performance Index (LPI), developed by the World Bank, to scale efficiency.

The results highlight the significant impact of logistics on global efficiency. Available World Bank data show that a 1% increase in the logistics performance index increases the current global level of the efficiency scale by 0.42%.

1. INTRODUCTION: EFFICIENCY AND ECONOMIC GROWTH

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 production and its efficiency in the short and long term 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 very few studies that analyze the contribution of logistics, there are only two works, Coto-Millán et al. (2013) and Coto-Millán et al. (2016), both of which provide an approximation of the contribution of logistics to economic growth and global technical efficiency. 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 Data Envelopment Analysis (hereafter DEA) we can detect additional determinants of output growth (beyond the input factors) that affect the efficiency of real inputs, physical capital, human capital and employment, and thus directly affect the productivity factor.

First, by estimating the overall scale efficiency through DEA techniques, taking as a starting point the growth model proposed by Mankiw et al. (1992).

Secondly, by assessing the impact of global logistics and its components as explanatory variables of the global scale efficiency of the different countries. The objective is to analyse the impact, at least in part, of logistics on the overall scale efficiency 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 extent that it has created what some call a new revolution in production, storage, distribution and transport.

For this purpose, and given data limitations, a panel of data from the years 2007-2010-2012-2014-2016-2018 for 133 countries has been studied.

According to Farrel's (1957) classical definition, an economy is considered technically efficient if it obtains the maximum achievable output (outputs) with the resources (inputs) used and the technology available. Graphically, this can be understood by viewing output growth from the perspective of a production possibilities frontier where countries may be operating within and, where the distance to the frontier reflects technical inefficiency (Ghosh and Mastromarco 2013).

The frontier literature is quite extensive and can be roughly divided into two groups according to the method chosen to estimate the production function frontier, namely deterministic versus stochastic frontiers (SFA) .

It is well known that the first work applying SFA and data envelopment analysis (DEA) to economic growth was by Rao and Coelli (1998). The authors conducted an updated analysis of productivity convergence and inequality around the world. Their finding showed that transition to thrift achieves inefficiency reduction in planned economies.

Following the analysis of Technical Efficiency (hereafter TE), Delgado and Álvarez (2003) conducted a study for the EU-15. The authors used the SFA to explore the determinants of TE in European economies.

The results of this research, estimating a translog function, show that larger endowments of public capital and education can facilitate access to productive activity at efficient levels for their members.

Deliktas and Balcilar (2005), using DEA, conducted a production frontier for one hundred and thirty countries over the period 1991 to 2000; however, they eventually focused on estimating TE for twenty-five transition countries. Their results revealed that public capital had a positive impact on private sector efficiency.

Lam (2010) used SFA methods to conduct a cross-sectional analysis of the role of institutions in TE in countries around the world. This research concluded that institutions play a positive role.

Alonso and Aubyn (2010) estimated a panel-based TE frontier for the output of the nineteen EU countries for the years 1970, 1980, 1990 and 2000. The authors used stochastic frontiers and semi-parametric approaches with the calculation of Malmquist productivity indices. The main conclusion was that inefficiency could be explained by government efficiency in investing in net capital stock with a positive coefficient.

Oliveira-Pires and Garcia (2012) estimated a world production function as well as its frontier for the period 1965 -2000, concluding that there was a set of explanatory variables that determined that of each country. Using a similar methodological approach, Ghosh and Mastromarco (2013) showed that the impact of human capital was important in increasing efficiency through trade flows and foreign direct investment flows, while immigration to countries richer in human capital improved their efficiency relatively more than immigration to countries with lower human capital.

2. INFORMATION AND COMMUNICATION TECHNOLOGIES, EFFICIENCY AND ECONOMIC GROWTH

Stiglitz (2014) stresses that the current situation is analogous to the developments that took place in the 1980s with the use of personal computers. Solow (1987) wrote: "What this means is that I, like everyone else, am a little embarrassed by the fact that what everyone feels has been a technological revolution, a dramatic change in our productive lives, has been accompanied for everyone, including Japan, by a slowdown in productivity growth, not a step forward. You can see the computer age everywhere, but not in productivity statistics.

The study of the effects of ICT on output and productivity growth was initiated by Bauer (1990), who decomposed the contribution to total factor and productivity growth of the world's countries in the presence of cost inefficiency, technological progress and no constant returns to scale. A few years later, Fereetal (1994) has analyzed the contribution of productivity, technological progress and efficiency to industrial growth across countries.

Most studies analyzing the relationship between ICT productivity and economic growth find positive correlations between the variables, although there are also some studies in which this relationship is not found or is negative.

In the context of findings of negative effects or spillovers, Berndt et al. (1992) examined the contribution of ICT capital to US industries, productivity growth and found a positive relationship. Another approach in the US, Olinery Sichel (1994) studied whether the positive impact of innovation in terms of ICT can leave a macroeconomic trace. He concluded that the macroeconomic impact on the productivity factor was minimal. Olinery Sichel (2000) incorporated ICT as a productive input in the overall production function and, as in his earlier work, found no positive macroeconomic impact for any variable proxy with ICTs.

Some of the studies have found a positive and significant relationship between ICT and economic growth. Brynjolfsson and Hitt (1996, 2002) find signs of a positive impact of ICTs on the microeconomic level of productivity. For a sample of US firms during the period 1987-1991, the authors found a positive correlation between ICT investments and changes in productive organization, process decentralization and the incorporation of skilled people. Schreyer (2000) has studied the contribution of ICTs to economic growth in the most developed OECD countries in 1996. His main result was that ICTs had a significant impact on economic growth in the United States, leading the ranking.

Meanwhile, Pilat and Lee (2001) studied OECD countries and concluded that the contribution of ICTs to labour productivity growth was high, with countries such as Finland, Ireland and the United States standing out.

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

There is a relationship between the level of development of an economy and logistics costs. While logistics costs can be as high as 25% of shipping costs in some developing economies, they reach 8% to 9% in advanced economies (Roberts 2003).

Consequently, logistics costs in international trade directly affect international trade. If logistics costs are so high, they may outweigh 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 needs to be considered.

There is a large literature assessing the spillover effect of transport and its external impact generated by transport 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 the growth of the global economy, and there are no studies considering the impact of logistics on the Scale Efficiency of global production.

Yang (2007) studied the relationship between logistics and economic development. Based on data from North America, Japan and Europe, he found 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 leads to an annual per capita growth of 0.9-1.5 %.

While some have argued that ICTs have 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 transport innovation (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.

Moreover, Coto-Millán et al. (2013) have 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 %. Coto-Millán et al. (2016) estimate synthetic LPI efficiency for a sample of 34 developed countries. Finally, Tang and Abosedra (2019) estimate the influence of LPI for a model of export-led economic growth in Asia for the period 2010 to 2016 for 23 countries.

3. DEA METHODOLOGY

Statistical and econometric approaches can be used to assess efficiency. The measurement of efficiency in empirical research has myriad applications. The most commonly used methodological approaches are the parametric stochastic frontier analysis (SFA) method (Aigner et al., 1977) and the non-parametric approach of Data Envelopment Analysis (DEA) (Charnes et al., 1978). The latter methodology can be applied to obtain technical and scale efficiency. In addition, DEA measures the relative performance of organizational units presented by multiple inputs and outputs. In the method, if the output appears within the production set, the unit is considered technically inefficient. The Decision Making Unit (DMU) measure assesses inefficiency by the distance from its observed input and output values to the production frontier (Coelli et al., 2005).

The DEA model can be either input-oriented or output-oriented. In the study of global production efficiency, the choice is an output-oriented specification rather than an input-oriented model. The reason for this is that countries' economic policy is generally directed towards the growth of the country's output or income. Thus, for the j-n countries, the output-oriented technical efficiency with constant returns to scale (CRS) is obtained by solving the following linear programming problem.

$$\underset{\theta_j^{CRS},\lambda}{Máx} \quad \theta_j^{CRS}$$
$$sujeto\ a\!: \begin{cases} \theta Y_j \le Y\lambda \\ X_j \ge X\lambda \\ \lambda \ge 0 \end{cases} \qquad (1)$$

Where X is the vector of inputs and Y is the vector of outputs, and where $\varphi_j^{CRS} = 1/\theta_j^{CRS}$ is the technical efficiency (TE) of countries in the world under CRS and λ is an n x 1 vector of weights.

The efficiency contribution of the countries of the world as measured by non-negative weights λ is selected as a determinant of a benchmark for the world's countries. Generally, if the countries of the world are on the production frontier and within $0 \le \varphi_j^{CRS} \le 1$where

$\varphi_J^{CRS} = 1$is the maximum technical efficiency. Where $\varphi_J^{CRS} < 1$indicates that the country is technically inefficient.

In the case of variable returns to scale (VRS), the technical efficiency φ_J^{VRS} has the convexity constraint $\sum_{j=1}^{n} \lambda_j = 1$ for the linear program expressed in (1). All this can be seen in detail in Banker et al. (1984).

The estimation of the effect of the synthetic LPI and its six efficiency components will be carried out through the second stage method of a truncated regression with the application of Simar and Wilson (2007). It is performed by a process of data generation under a method consisting of two stages. An advantage that drives the method of Simar and Wilson (2007) is that it allows for obtaining unbiased coefficients in valid confidence intervals. The discriminatory power of the first stage is not affected as the explanatory variables are not included in the first stage (Liebert and Niemeier, 2013).

The second stage regression to explain efficiency levels is presented as follows:

$$\varphi_j = a + \delta\, z_j + \varepsilon_j \tag{2}$$

Where a is a constant term, ε_j is the error term, z_j is a vector (row) of possible variables that are expected to explain the efficiency levels of each decision unit, φ. We will apply the homogeneous approach with 2000 iterations to overcome the potential problem of biased results in our second stage regressions, for further discussion see Simar and Wilson (2000) and Simar Wilson (2008).

The impact of the LPI and its six components on each country's production efficiency can now be measured from the estimation results of equation (2).

4. DATA

The Logistics Performance Index or LPI is an indicator defined by the World Bank, with the aim of assessing trends in logistics in the countries of the world. Data is available for the years 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.

Figure 1 shows a representation of the components of the LPI. The components of the Logistics Performance Index (LPI) are:

1.- Customs: efficiency in customs processes and formalities.
2.- Infrastructure: related to trade and transport.
3.- Quality and logistics competences: in logistics services.
4.- Punctuality (Timeliness): shipments within the scheduled delivery times.
5.- International shipments: international trade transactions.
6.- Traceability and tracking: real-time location of shipments and their traceability throughout the logistics chain.

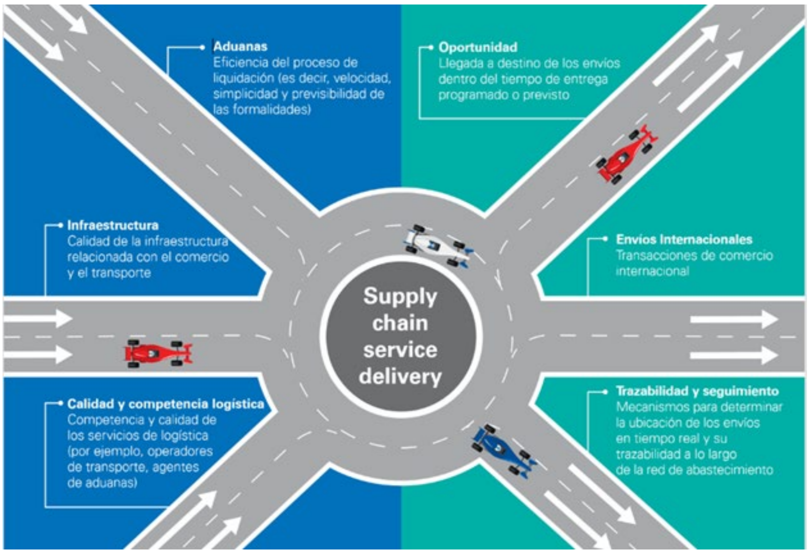

Figure 1 - Representation of the components of the Logistics Performance Index
Source: KPMG

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

The World Bank publication (2018) includes the LPIs in its sixth edition, which facilitates this research work from a scientific approach, and which, as will be seen, allows us to verify the theses that I am maintaining in this chair competition with coherence in the teaching and research aspects; adapting to the emerging reality as a result of digital transformation, sustainability and inclusion.

The LPIs for 2018 are shown at the world map level in Figure 2.

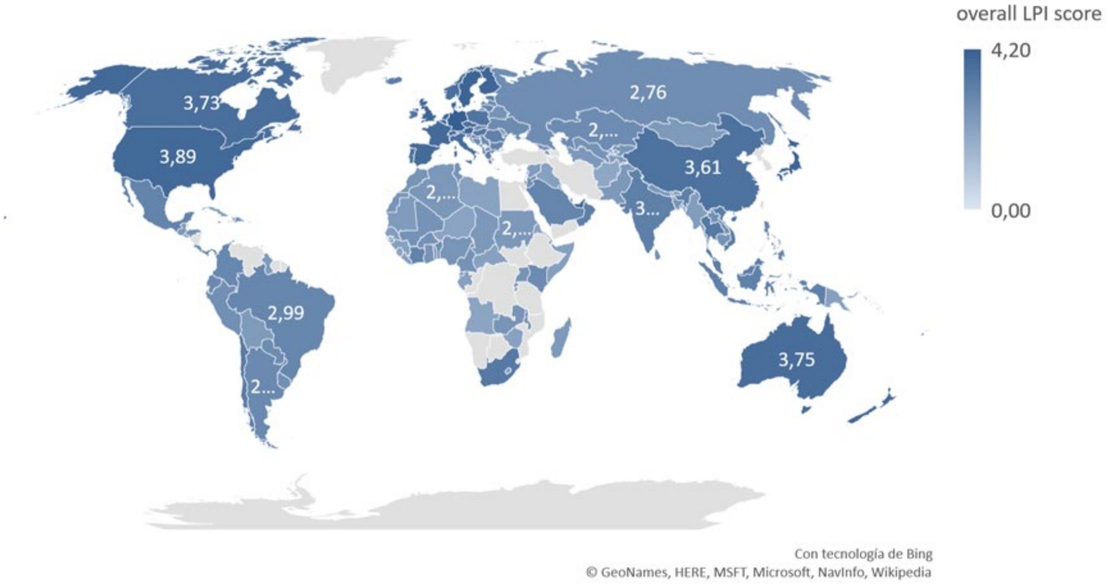

Figure 2. Logistics Performance Index (LPI) rankings by country in 2018

Figure 3 shows the top ten countries in the world with the highest LPI, as of 2018.

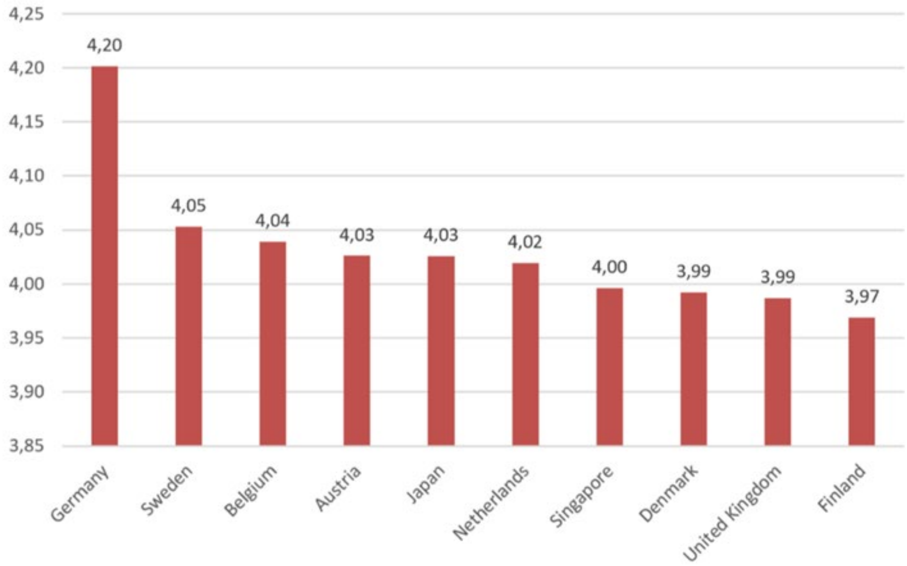

Figure 3 - Top ten countries in the world with the highest LPI in 2018

Figure 4 shows the ten countries in the world with the lowest LPI, for the year 2018.

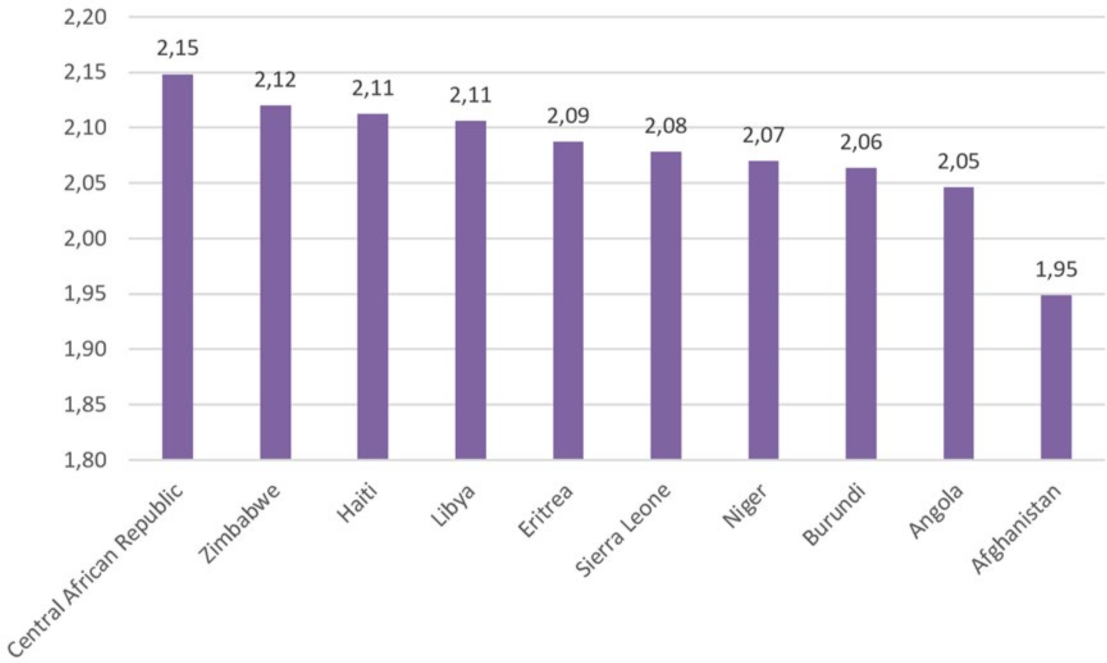

Figure 4 - Top ten countries in the world with the lowest LPI in 2018

An empirical test of the proposed model has been carried out 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. Since its creation in 1944, it has devoted an increasing share of its resources to the collection of statistics and indicators, which are organized in databases.

For the empirical analysis, a sample of 133 countries has been used, for which complete logistics data is available for the years 2007, 2010, 2012, 2014, 2016 and 2018 .

Table 1 provides a detailed description of the variables included in the estimation of the production function and those as determinants in the Technical Inefficiency Effects Frontier model (hereafter TIE model).

Variable definition data		
Production function		
GDP	(in $)	WDI
EDU	% secondary school working age population.	WDI
EMP	% employed population	WDI
GBF	% of GDP of fixed capital in dollars.	WDI
For the efficiency explanatory stage of the production function, the following are used:		
LPI	logistics performance index	WDI
LPI1	infrastructures	WDI
LPI2	Customs	WDI
LPI3	Quality and Logistics Competence	WDI
LPI4	Tracking and Tracing	WDI
LPI5	Punctuality	WDI
LPI6	International Shipments	WDI

Source: Own elaboration based on World Bank WDI data.

Table 1 - Structure of the variables used

Table 2 shows the main statistics for the variables used.

Variable	Media	Medium	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

Table 2 - Principal statistics
Source: Own elaboration based on World Bank data.

The dependent variable is real GDP per capita and the independent variables are capital stock per capita for each country and human capital (which measures the percentage of the working-age population in secondary school).

To assess the efficiency of Logistics and Innovation in TE of global production we include the LPI variables. The Logistics Performance Index, as defined by the World Bank, is an interactive benchmarking tool.

To obtain the LPIs the World Bank conducted a worldwide survey of land operators (global freight forwarders and express carriers), providing feedback on the logistics co-modality of the countries in which they operate and those with which they trade. They combine in-depth knowledge of the countries in which they operate with qualitative assessments of other countries where they trade and operate in global logistics environments.

Operators' comments are complemented by quantitative data on the performance of key components of the logistics chain in the country. It is expected that an increase in LPI will decrease technical inefficiency. Similarly, we expect that each of the disaggregated indices, if functioning properly, will promote technical efficiency.

5. RESULTS

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).

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

Variable	Coefficient	Standard deviation	Statistic t	p-value	Sig.
const	-0.0251427	0.400771	-0.06274	0.9500	
l_EDU	1.40084	0.0915710	15.30	<0.0001	***
l_GFB	0.0461570	0.0235357	1.961	0.0512	*
LPI1	0.0406124	0.194689	0.2086	0.8350	
LPI2	0.617081	0.182377	3.384	0.0009	***
LPI3	-0.0334662	0.146374	-0.2286	0.8194	
LPI4	-0.0450878	0.230131	-0.1959	0.8449	
LPI5	-0.219594	0.167897	-1.308	0.1923	
LPI6	0.470041	0.141023	3.333	0.0010	***

Mean of variable. dep.	9.411849	D.T. of the vble. dep.	1.091432
Sum of waste squares	44.95717	T.D. of the regression	0.460502
R-squared	0.885288	Unbiased' R-squared	0.846043
F(117, 212)	13.98378	p-value (of F)	1.47e-58
Log-likelihood	-139.3416	Akaike criterion	514.6832
Schwarz Criterion	962.9762	Hannan-Quinn Crit.	693.5008
rho		Durbin-Watson	2.195793

statistically significant at 99% ** statistically significant at 95% *** statistically significant at 99% ** statistically significant at 95% *** statistically significant at 99% ** statistically significant at 95% ** statistically significant at 95% statistically significant at 90%. Joint contrast of regressors (except for the constant) -
Contrast statistic: F (8, 212) = 145.626 with p-value = P (F (8, 212) > 145.626) = 9.34981e-082. Contrast of different intercepts by groups Null hypothesis: The groups have a common intercept. Contrast statistic: F (109, 212) = 0.715557 with p-value = P(F(109, 212) > 0.715557) = 0.974277.
Source: Own elaboration. Estimated with GRETL software.

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

As can be seen, the only indices that are significant are those corresponding to Infrastructure and Punctuality. The other four are not significant. The following question arises: Why these results? To answer this question we will carry out an analysis of efficiency in world production using the DEA methodology.

In the production function, from which the efficiency scores are obtained, the specification of the Cobb-Douglas function is used and therefore constant and unit elasticity of substitution between inputs is required.

The question now is to analyse why some countries have high levels of efficiency while others have low levels.

That is, what is the cause of scale efficiency in the countries of the world?

To answer this question we will use the information on logistics and its components provided by the World Bank. As explained above, the model of Simar and Wilson (2007) will be used to study how LPI and its components influence the efficiency of global production.

Table 4 shows the estimated efficiency explained by the LPI synthetic index for 133 countries in the period for which LPI is available, i.e. 2007, 2009 and 2012, 2014, 2016 and 2018.

Variable	Coefficient	Standard deviation	Statistic t	p-value	Sig.
const	-0.9918894	0.062191	-15.95	0.000	***
LPI	0.3693917	0.0176201	20.96	0.000	***

Table 4 - Efficiency Estimation with CRS, Simar and Wilson (2007).
Source: Own elaboration based on World Bank data, with STATA.

As can be seen in Table 2 the variable LPI (overallLPI-e) is significant and positive with a value of 0.369. This is when we assume that there are Constant Returns to Scale (CRS).

Table 5 presents an estimate in which the LPI is broken down into its components.

In the following table, the component indices of the LPI are very significant and positive: Infrastructure (LPI1) and Opportunity (LPI4). It can be observed that some component indices of the LPI are not significant such as Customs (LPI2), International Shipping (LPI6) and Tracking (LPI4). In addition the logistics quality index contributes to inefficiency (LPI3).

Variable	Coefficient	Standard deviation	Statistic t	p-value	Sig.
const	-0.851728	0.400771	-0.06274	0.9500	
LPI1	0.310270	0.041805	7.42	0.000	***
LPI2	0.000745	0.037201	0.02	0.984	
LPI3	-0.169600	0.048583	-3.49	0.000	***
LPI4	0.027368	0.039388	0.69	0.487	
LPI5	0.137383	0.030776	4.46	0.000	***
LPI6	0.011185	0.031561	0.35	0.723	

Table 5 - Efficiency Estimation with CRS, Simar and Wilson (2007): Components
Source: Own elaboration based on World Bank data, with STATA.

Variable	Coefficient	Standard deviation	Statistic t	p-value	Sig.
const	0.76879	0.019816	38.80	0.000	***
LPI	-0.00468	0.006652	- 0.70	0.481	

Table 6- VRS Efficiency Estimation, Simar and Wilson (2007): LPI.
Source: Own elaboration based on World Bank data, with STATA.

Table 6 presents an estimate in which we assume Variable Returns to Scale for the synthetic LPI.

As can be seen in Table 6 when we assume variable returns to scale, the contribution of synthetic LPI is not significant.

Variable	Coefficient	Standard deviation	Statistic t	p-value	Sig.
const	0.812954	0.025753	31.57	0.000	***
LPI1	0.052526	0.021072	2.49	0.013	***
LPI2	-0.383546	0.020884	-1.84	0.066	
LPI3	0.043975	0.026048	1.69	0.091	
LPI4	-0.040080	0.0200177	-2.00	0.045	***
LPI5	-0.022385	0.0150446	-1.49	0.137	
LPI6	-0.011638	0.0169149	-0.69	0.491	

Table 7- Efficiency Estimation with VRS, Simar and Wilson (2007): Components
Source: Own elaboration based on World Bank data, with STATA.

Table 7 shows that only the infrastructure index (LPI1) has a significant and positive contribution. On the other hand, Tracking(LPI4) has a significant and negative contribution to efficiency. Finally, the remaining indices are not significant at the required levels.

Table 8 shows that the results for Scale Efficiency are very similar to those obtained in Table 5. The explanation is similar.

Variable	Coefficient	Standard deviation	Statistic t	p-value	Sig.
const	-1.084573	0.061704	-17.70	0.000	***
LPI	0.427494	0.017901	23.88	0.000	***

Table 8 - Estimation of Scale Efficiency, Simar and Wilson (2007): LPI.

Variable	Coefficient	Standard deviation	Statistic t	p-value	Sig.
const	-0.913269	0.068212	-13.39	0.000	***
LPI1	0.328735	0.043929	7.48	0.000	***
LPI2	0.034905	0.038692	0.90	0.367	
LPI3	-0.165906	0.051516	-3.22	0.001	***
LPI4	0.029209	0.039352	0.74	0.458	
LPI5	0.133755	0.031214	4.29	0.000	***
LPI6	0.007969	0.033503	0.24	0.811	

Table 9 - Estimation of Scale Efficiency, Simar and Wilson (2007): Components
Source: Own elaboration based on World Bank data, with STATA.

Table 9 shows that the results for Scale Efficiency are very similar to those obtained in Table 5. The explanation is similar.

Figure 5 presents the Efficiency of Scale results for countries around the world.

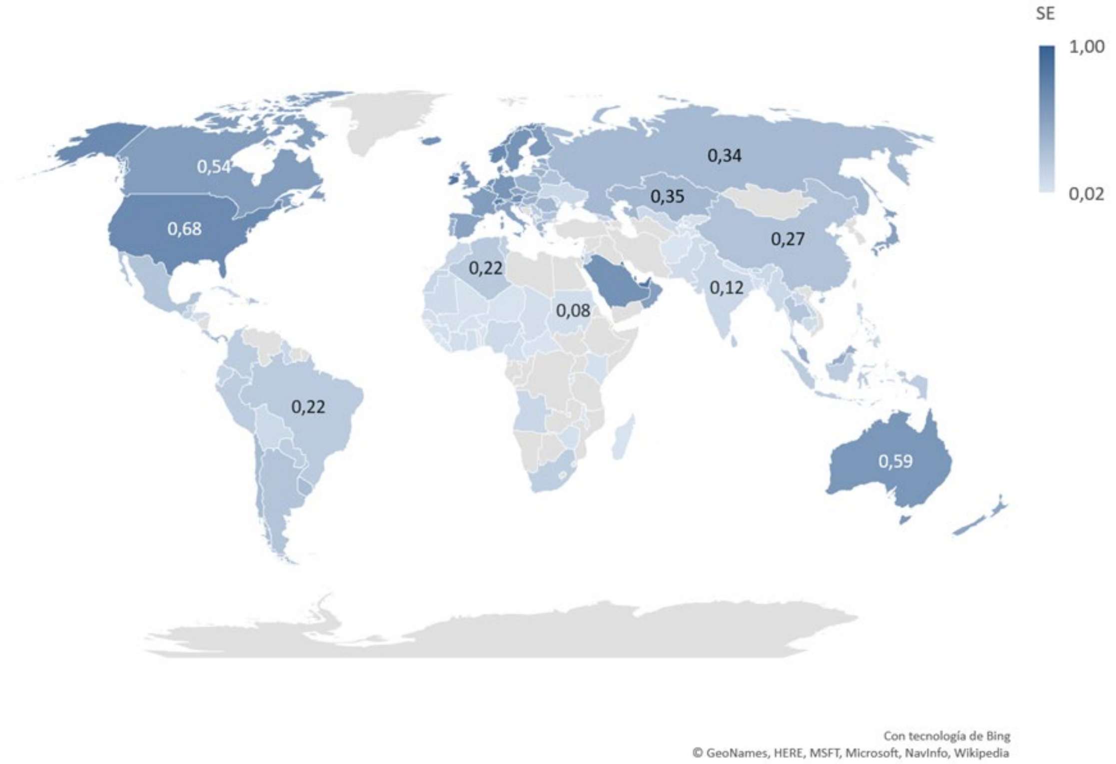

Figure 5 - Efficiency of scale ranking for the world's countries for the year 2018
Source: Own elaboration based on the estimation of a production function of world GDP by country explained by physical capital, human capital and employment.

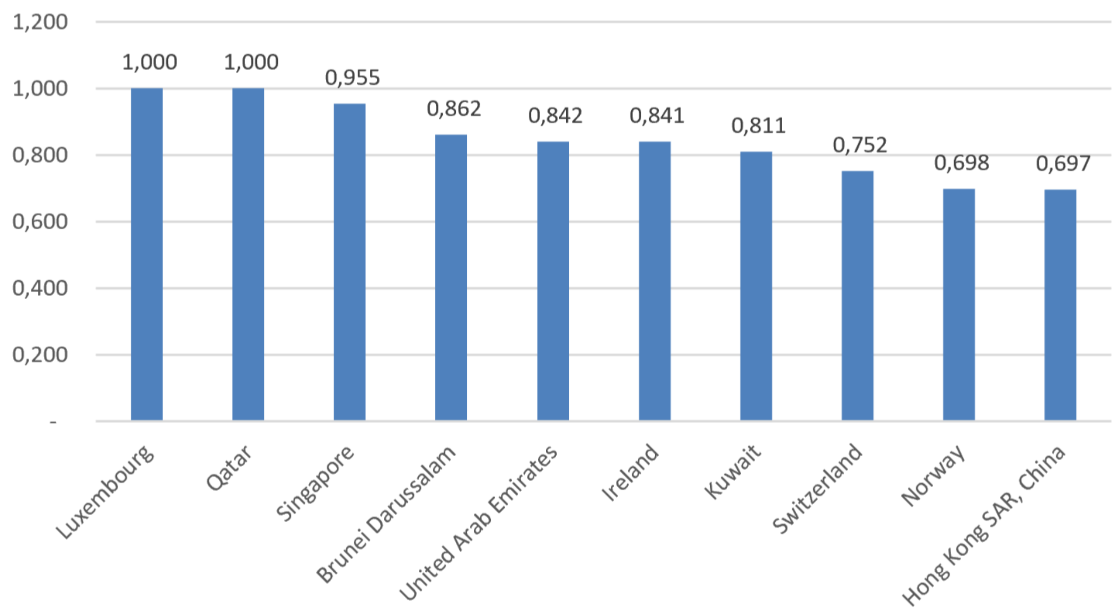

Figure 6 - Top ten countries in the world with the highest Efficiency of Scale in 2018
Source: Own elaboration based on the estimation of a production function of world GDP by country explained by physical capital, human capital and employment.

It can be seen that Qatar, Luxembourg and Singapore are the countries with the highest production scale efficiency (Figure 6), while Congo, Liberia and Gambia have the lowest production scale efficiency levels (Figure 7).

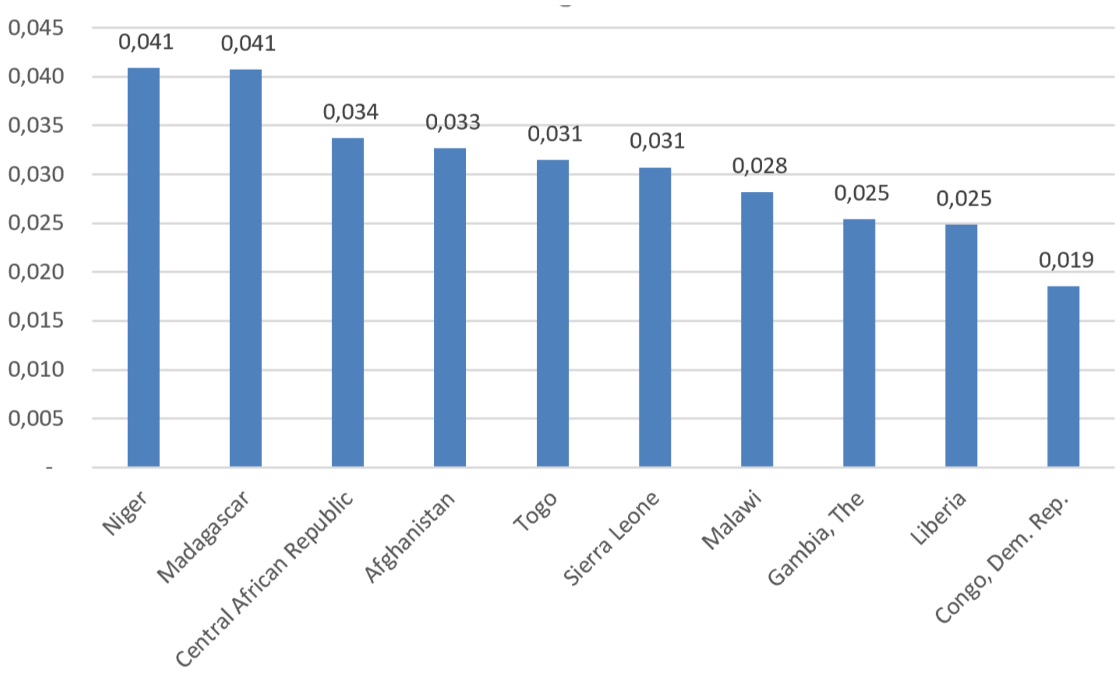

Figure 7 - Top ten countries in the world with the lowest Efficiency of Scale by 2018
Source: Own elaboration based on the estimation of a production function of world GDP by country explained by physical capital, human capital and employment.

Note that Scale Efficiency is defined as the quotient between Efficiency with Constant Returns to Scale and Efficiency with Variable Returns to Scale. As can be seen the results for Scale Efficiency are consistent with those for Efficiency at Constant Returns to Scale.

Logistics (LPI) has a positive sign and is statistically significant at the 1 % level, indicating that its impact on efficiency is positive and helps individual countries to approach their production frontier. Therefore, we find that countries with a high degree of logistical development perform well because of the benefits they gain in terms of scale efficiency.

As for the impact of LPI performance on Global Efficiency of Scale, the estimated LPI coefficient suggests that a 1 % increase in LPI performance increases the efficiency of scale of the world's countries by 0.42 %.

The results confirm that it is the right combination of non-isolated LPI components that causes the growing importance of networks in the evolution of the global economy.

These results also have important policy implications.

Policy makers can use preferential policies to encourage innovation and logistics activities and thus improve their productivity. In addition, governments should facilitate networking activities and develop the necessary infrastructure to encourage the establishment of logistics activities.

As noted by Rollery Waverman (2001), an adequate and reliable supply of infrastructure (e.g. infrastructure associated with communication and transport) facilitates mobility and efficient allocation of inputs as well as final products, reduces transaction costs and improves productivity.

6. CONCLUSIONS

Logistics has allowed the reduction of transport costs, facilitating the growth of the world economy through the use of logistics networks and platforms. Using a production function of the type proposed by Mankiw et al. (1992) the scale efficiency of 133 countries for the period 2007-2018 has been estimated through the DEA method and the application of the Simar and Wilson (2007) model.

This paper contributes to the literature by estimating the contribution of logistics to the scale efficiency 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 (as the sole explanatory variable of efficiency) increases productivity through improved scale efficiency. It also includes as a novelty the breakdown of each of the components of LPI as explanatory factors of scale efficiency.

The results highlight the significant impact of logistics on global scale efficiency. Available data from the World Bank show that a 1 % increase in the logistics performance index increases the current global level of scale efficiency by 0.42 %.

There are substantial variations in the level of efficiency among the countries in the sample. Qatar, Luxembourg and Singapore achieve the highest technical efficiency. Congo, Liberia and The Gambia, on the other hand, have the lowest levels of scale efficiency in production.

In the empirical study, an estimation of the world production function has been carried out first. Here a panel data estimating a Cobb-Douglas type production function has been used.

In this first estimation, only the infrastructure quality index and the punctuality index are significant. The rest of the logistic components are not significant. I then carried out a more detailed non-parametric analysis using linear programming techniques with a DEA.

The results obtained with this second method verify the previous ones and also indicate that the logistic quality index goes from not being significant to being significant and having a negative sign. This means that logistics quality is currently a barrier to global production.

The results are meaningful and useful for policy makers. The different components of the synthetic LPI index show different results, allowing governments to improve the productivity of countries by acting on these components of the LPI.

The results obtained with the DEA methodology in the LPI components reveal glaring inefficiencies in customs processes and formalities, and in the quality and competencies of logistics services, which clearly identify the lack of global logistics. Inefficiencies in international transactions, and in the tracking and tracing of logistics chains could be corrected with blockchain technology, especially in multimodal and intermodal chains.

The results contrasted with DEA analysis indicate that logistics efficiency is positive and significant in its infrastructure and punctuality, significant but negative in logistics quality and not significant in customs, international shipment transactions, and tracking and tracing.

NOTES

1 In this study we use the LPI variable to approximate the level of logistical performance of each country. The World Bank has only published the International LPI for the periods mentioned.
2 See Coelli et al. (2005) for a more comprehensive review of the literature related to efficiency and productivity.
3 Connecting to Compete 2018 Trade Logistics in the Global Economy. The Logistics Performance Index and Its Indicators. World Bank 2018
4 In order to avoid problems of heterogeneity in the sample, only countries considered by the World Bank have been taken into account in the upper middle-income and high-income groups.
5 The capital stock of each country was calculated cumulatively from gross capital formation (in constant 2005 dollars). The methodology of Dhareshwar and Nehru(1994) has been followed.

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