INNOVATION AND LOGISTICS PERFORMANCE: CAUSE AND EFFECTS

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Abstract

The aim of the paper is to highlight mainly the connection between innovation performance and logistics performance, based on Eurostat data regarding the Summary Innovation Index for 2012 (SII 2012), logistic performance index (LPI). We analyzed data from 24 European countries (22 EU members) for which SII 2012 and LPI data were available. We expected to find a relevant influence of innovation on the logistic performance and quantify the effects of that influence (volume of goods transported by each transport mode, transport prices and motorization rate).

Keywords*: LPI, innovation, logistics*

JEL classification: *O00 (Economic Development, Innovation, Technological Change, and Growth), L91 (Transportation: General)*

1. Introduction

The business environment is continuously changing. Some changes are hardly noticeable while others are very innovative with impacts on one or more industries. Nowadays, companies supply with raw materials, materials or components from different parts of the world and, at the same time, they sell their goods in countries, almost impossible to reach until not so many years ago. Facility's locations represent subject of interest for both companies and academia. The American Mathematical Society, for instance, having in mind the different location problems, created a specific code for each of those

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problems. In the context of continuously changing business environments, business practices are changing as well, so as to keep up with all the challenges. In order to survive in markets characterized by changes, companies have to innovate, and the innovations from certain domains could have impacts on other domains or industries. The introducing of containerized transportation by Malcolm McLean in 1956 is an innovation example, which revolutionized the maritime transportation and moreover, determined the consideration of new markets for sourcing or / and distributing goods. Transportation represents an important part of the economy due to its economic importance - the number of generated commercial connections and to its impact on the labour market (Franconetti, P., Ortiz, A., 2013).

In our paper, we analysed the manner in which innovation, in general, influences logistic performance. We focused also on the attractiveness a country presents to forwarders or transporters. Thus, if a country is very attractive for forwarders or transporters due to a better logistic performance, it is possible that the result is visible in the volume of the freight transported on the territory of that country. We also analysed the connection between logistic performance and transportation price or motorization rate.

2. Theoretical approaches of innovation in logistics

According to Schumpeter, economic change has a critical dimension, namely innovation (Pol and Carroll, 2006). Thus, innovation represents a key element of development. Acting in a competitive environment, characterized by rapid and continuous changes in technologies, global competition or costumers demand, companies have to innovate while striving to survive. Innovation means to produce something new or in a different manner (Schumpeter, 1947). Inspired by Schumpeter's theory, Nonaka and Takeuchi (1995) consider innovation as the main component of entrepreneurship and a key element meant to ensure the prosperity of a business. In order to differentiate itself in such an environment, it is imperative for any company to consider product, processes and organization innovation (Brafman and Folmer, 1998).

While researching the literature on innovation, we found that there is not a unique definition of this concept, which describes the manner in which innovation occurs or its consequences. In our opinion, it is important to highlight the meaning of the logistic innovation, in fact to understand, the relevance of innovation in the context of logistics. The authors who

concentrated on innovation provide interesting frameworks, from which we selected a few to present:

Innovation is seen as playing a key role in *resource-advantage theory* (Hunt and Morgan, 1996). Moreover, knowledge is considered to be the most important resource of a company that allows them to gain a sustainable competitive advantage (Grant, 1996; Turner and Makhija, 2006).

The resource-based framework was the starting point of another framework, which emerged, one based upon *dynamic capabilities*. In the context of rapid technological changes, it is very important to analyze the sources of wealth creation (Teece et al., 1997). Eisenhardt and Martin (2000) see innovation as a dynamic capability.

The exploration-exploitation framework provides another innovation approach, which distinguishes between two types of innovation:

- *exploratory innovation*, which is a radical innovation targeting the fulfillment of the needs of new markets (Benner and Tushman, 2003; Jansen et al., 2006), and
- *exploitative innovation*, which is an incremental innovation, targeting the existing needs or markets (Benner and Tushman, 2003).

The *S-curves theory* explains the origins and evolution of radical innovations (Chandy and Tellis, 2000). This theory takes the technology into account. The development of technology determines benefits for consumers, up to a certain point, when technology reaches the maturity phase.

The *network theory* represents another framework of innovation, focused on the long-term relationships between organizations (Thorelli, 1986). This approach assumes each company situated within a network has associated roles and it is focused on the resulting impact on innovation (Dhanaraj and Parkhe, 2006).

Scott J. Grawe (2009) developed o model of logistics innovation based on various other studies on innovation and logistics. His model supposes that environmental factors (the organization of labour, competition, capital scarcity) and organizational factors (knowledge, technology, relationship network factors, financial resources, and the management resources) determine logistics innovation. Logistics innovation represents an important source of competitive advantage. There is a strong correlation between a company's competitive advantage and the diffusion of logistics innovation.

In our opinion, it is very important to be able to quantify the impact of innovation on the performance of companies or specific sectors (like logistics if we consider also logistics innovation). Only a few studies analyzed the innovation's effects on company's performance, although the number of conceptual studies in the area is quite high (G. Gunday et al., 2011). A small number of empirical studies investigated the relationship between the dimensions of innovation and the performance of a company (a single performance aspect) (Jin et al., 2004). Kenneth W. Green et al. (2008) analyzed, at supply chain level, the impact of logistics performance on organizational performance. Other authors (Popescu and Sipos, 2014), investigated how the performance from a sector, in this case, the logistic one, can be a trigger for economic development.

3. The impact of innovative performance and of logistics performance

The objective of our research is to prove the causality relationship between a country's innovative performance and its logistics performance and to highlight the main effects induced by the logistics performance level. We considered the volume of freight transport, the transport prices, and the motorization rate to be the main effects of a country's logistic performance.

In our study, we used the Summary Innovation Index for 2012 (further referred to as SII 2012) in order to synthetically express the innovative performance of a country. The European Commission, through the Innovation Union Scoreboard 2013 (European Commission, 2013) presented a comparative analysis of the innovative performance of EU countries and provided information on SII 2012 values. Considering Innovation Union Scoreboard 2013, SII 2012 is a composite indicator based on data for 24 indicators and it shows the average innovation performance of each European country. Due to a lag in data availability, SII 2012 expresses the innovative performance of European countries in 2010/2011 (European Commission, 2013). According to their ranking in SII 2012, based on their average innovative performance, the European countries fit into four groups of performance (European Commission, 2013):

- innovation leaders – are the countries whose innovation performance is well above that of the EU average (Denmark, Finland, Germany, and Sweden);

- innovation followers – are the countries whose innovation performance is above or close to that of the EU average (Austria, Belgium, Cyprus, Estonia, France, Ireland, Luxembourg, Netherlands, Slovenia, and the UK);
- moderate innovators – are the countries whose innovation performance is below that of the EU average (Czech Republic, Greece, Hungary, Italy, Lithuania, Malta, Portugal, Slovakia and Spain);
- modest innovators – are the countries whose innovation performance is well below that of the EU average (Bulgaria, Latvia, Poland and Romania).

The LPI (Logistics Performance Index) expresses the logistics performance of a country, as an overall score. According to the World Bank, the LPI represents a very useful tool for countries meaning to determine the opportunities and challenges specific to the trade logistics and, to those countries aiming to improve their trade logistics performance.

In 2014, the LPI was calculated for a number of 160 countries, on the basis of a general view of the activity of forwarders and express carriers of freight, which were operating on the ground. They offered a feedback regarding the quality of the countries' logistics, in which they are operating or trading in. That feedback is not the only considered element when calculating the LPI. Besides the feedback, the LPI embodies qualitative data regarding important components of the logistics chain from the countries involved in the survey. In that context, the LPI represents both a qualitative and a quantitative measure, very useful in comparing the different countries' logistic friendliness (in terms of logistics environment, logistics process, cost data or performance time).

In order to emphasize the cause and effects of logistics performance in different situations, we formulated the following research hypotheses:

H1. High innovative performance of a country leads to superior logistics performance

H2. A higher level of a country logistics performance potentially increases both the total volume of freight transport, and the volume of goods transported by different modes (rail, air, sea, and road)

H3. The logistics performance of a country has a high impact on the transport prices

H4. The logistics performance of a country affects the motorization rate

We tested the four hypotheses based on the correlations between the variables using simple linear regression across countries. The summary statistics indicators used in the econometric analysis by simple linear regression are the Correlation Coefficient, R Square, F statistic, t-stat, and β. We used the Least Square Method (Berenson, Levine et al., 2012) to estimate the regression coefficients.

Thus, in order to highlight the causal relationship between the innovative performance of a country and the logistics performance level (H1), we tested the correlation between the Summary Innovation Index 2012 and the Logistics Performance Index for 2012. We included in our analysis all the European countries with available data for the two indicators, namely 24 countries: 22 EU member countries (Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Finland, France, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Poland, Portugal, Romania, Slovakia, Slovenia, Spain and Sweden) and two non-member countries (Norway and Serbia). We present the results of the linear regression between SII and LPI in Table 1.

Table 1. The main results of linear regression between SII and LPI

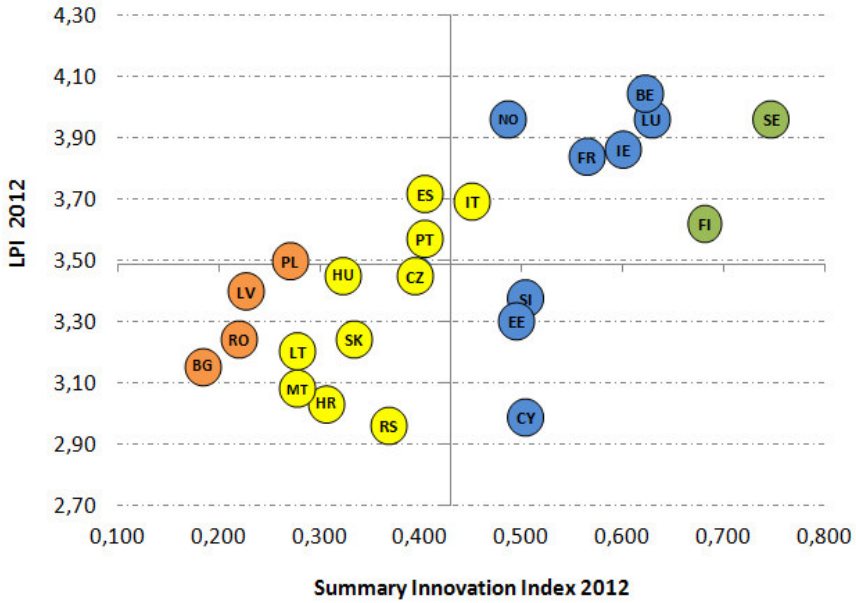
Variables	**Summary Statistics**	**LPI**
SII	Correlation Coeff.	0.685764
	R Square	0.470272
	F statistic	19.53079
	t-stat	4.419365
	β	1.461607

Source: Own calculations based on Eurostat data

We expressed this correlation also graphically in Figure 1. For a more illustrative highlighting, we marked with green the countries, considered to be *innovation leaders*, with blue the *innovation followers* countries, with yellow

the *moderate innovators* countries and with orange the *modest innovators* countries.

Figure 1: Correlation between Summary Innovation Index (SII) and Logistics Performance Index (LPI)



Source: Own calculation based on Eurostat data

In Figure 1, we see that the highest logistics performance was achieved by countries with high innovative performance. Thus, among the countries with the highest logistics performance there are the best performing innovation follower countries (Belgium, Luxembourg, Ireland, France, and Norway) and, an innovation leading country (Sweden). At the same time, countries with low innovative performance have achieved among the weakest logistics performance. Thus, the lowest logistics performance was achieved in moderate or modest innovators countries (Serbia, Croatia, Malta, Slovakia, Lithuania, Romania, and Bulgaria).

Moreover, we observe that innovation leaders countries and almost all innovation followers countries (with a few exceptions: Cyprus, Estonia and Slovenia) have recorded higher values of logistics performance than the

average value calculated considering the logistics performance of all analyzed European countries. Also, all modest innovators countries and most of moderate innovators countries (with a few exceptions: Italy, Portugal, Spain) recorded lower values of logistics performance than the average value calculated considering the logistics performance of all studied European countries.

These aspects prove the fact that the higher is the innovative performance of a country, the higher is also the logistics performance of that country. Thus, it was revealed that there is a good positive correlation between the Summary Innovation Index and the Logistics Performance Index, with a correlation coefficient of 0.685 and t-stat of 4.419. This validates the first research hypothesis of our study (H1).

When we analysed the impact of the level of logistics performance on the volume of freight transport, we highlighted the correlations between LPI for 2012 and the volume of goods transported by categories for the same year, 2012. We considered goods transported by rail, by air, by sea, by road and also the total volume of transported freight, when referring to the volume of freight transport. We used data provided by the Eurostat, in order to test the correlation between LPI and the volume of goods by transport categories. We did not find available data for all variables and for all European countries.

In order to test the impact of a country's logistics performance on the volume of transported freight, we divided the second research hypothesis into the following four assumptions:

H2a. A higher level of a country's logistics performance leads to a higher volume of goods, transported by rail;

H2b. The higher is the logistics performance of a country, the more increased is the volume of air transported goods;

H2c. The logistics performance of a country has an impact on the volume of sea transported goods;

H2d. The logistics performance of a country will affect the volume of goods transported by road.

When testing the correlation between the LPI and the goods transported by rail, we found available data for 27 European countries (25 EU countries and also for Norway and Turkey).

We tested the effect of a country's logistics performance on the volume of goods transported by rail, but we did not find a significant-statistically correlation between the two variables. The values of the statistical

indicators presented in Table 2, regarding the variables support the assumption that there is a lack of statistical correlation between LPI and the volume of goods transported by rail. Therefore, these values invalidate the H2a assumption.

Table 2. The main results of linear regression between LPI and the volume of goods by transport categories

Variables	Summary Statistics	Goods transported by rail	Air transported of goods	Sea transported of goods	Goods transported by road	TOTAL VOLUME OF TRANSPORTED FREIGHT
LPI	Correlation Coeff.	0.290892	0.546646	0.589358	0.4453	0.524838043
	R Square	0.084618	0.298822	0.347343	0.198292	0.275454971
	F statistic	2.311013	12.35897	12.77274	6.678108	9.124235
	t-stat	1.520202	3.515533	3.57389713	2.584203	3.020635
	β	53663.33	1214352	247656.9	732715.1	1104306.625

Source: Own calculations based on Eurostat data

A country's logistics performance has a positive effect on the volume of goods transported by air. We tested the correlation between LPI and air transported goods, based on data available for 31 European countries (EU28 countries and also Iceland, Norway and Switzerland). Between the LPI and the air transported goods, there is a moderate positive correlation. The correlation coefficient value of 0.546 and the t-stat value of 3.515, together with the other statistical indicators presented in Table 2 regarding these two variables prove the moderate positive impact logistics performance has on the air transported goods. This validates the H2b assumption.

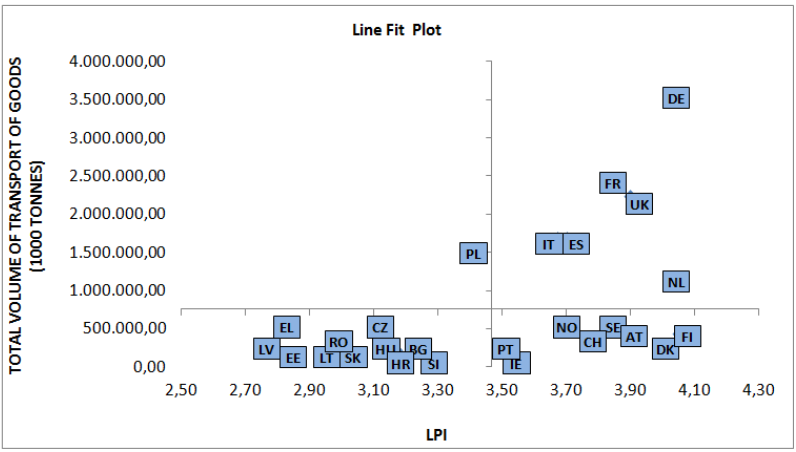
Among all studied transport categories, the logistics performance exerts the greatest influence on the sea transported goods. We tested the effect of the LPI level on sea transported goods, based on data available for 26 European countries (23 EU countries and also Iceland, Norway, and Turkey). The correlation coefficient of 0.589 and the other indicators presented in Table 2 reveal that the logistics performance of a country has a moderate positive impact on the sea transported goods. The intensity of the correlation between LPI and the sea transported goods is slightly higher than in the case of the

correlation between the LPI and the air transported goods. Thus, the H2c assumption is validated.

Indeed, the logistics performance of a country affects the volume of goods transported by road, only to a relatively small extent, however. For the correlation between the LPI and the goods transported by road, we used data available for 29 European countries (27 EU countries and also Norway and Switzerland). We tested the effect of a country's logistics performance upon the volume of goods transported by road. The analysis reveals a positive acceptable correlation between these two variables. The value of the correlation coefficient of 0.445 and the statistical indicators presented in Table 2 express the other characteristics of this correlation. They all demonstrate that the intensity of logistics performance impact on the volume of goods transported by road is mild. The H2d assumption may be considered as being validated.

Lastly, we highlighted that there is a positive impact of a country's logistics performance on the total volume of transported freight. We tested the impact of logistics performance level on total volume of transported freight using data available for 26 European countries (24 EU countries and also Norway and Switzerland).

Figure 2. Correlation between Logistics Performance Index (LPI) and Total volume of transported goods



Source: Own calculation based on Eurostat data

In Figure 2, we notice that countries with high logistics performance (Germany, France, UK) record also the highest volumes of transported goods.

We mention that a group of eleven European countries with the lowest logistics performance (Slovenia, Bulgaria, Croatia, Hungary, Czech Republic, Slovakia, Romania, Lithuania, Estonia, Greece and Latvia) record among the lowest volumes of transported goods.

But there are also exceptions. Six countries with high logistics performance (Finland, Denmark, Austria, Sweden, Switzerland and Norway) and two countries with logistics performance above the average value calculated considering the logistics performance of all studied European countries (Portugal and Ireland) record low volumes of transported goods. The situation of these countries shows that a country's level of logistics performance influences the total volume of transported goods. However, a country's territorial dimension and its geographical location influence as well the total volume of transported goods.

Thus, these findings highlight that there is a positive effect of a country's logistics performance on the total volume of transported freight. The correlation between the LPI and the total volume of transported freight is of a moderate intensity, evidenced by the value of the correlation coefficient of 0.524 and all the other statistical indicators presented in Table 2. So, the second hypothesis was only partially validated (H2). This hypothesis regarding the effect of a country's logistics performance on the volume of goods transported by rail (the H2a assumption was not confirmed) was not validated. All the other assumptions were confirmed; proving that between the logistics performance of a country and the other tested variables there is a significant positive correlation, of different intensity, however.

We tested the impact of a country's logistics performance on the transport prices (H3) based on the correlation between LPI for 2012 and HICP - annual average indices for transport prices for 2012. In this case, we found available data for 32 European countries (EU 28 countries and also Iceland, Norway, Switzerland and Turkey). The main results of linear regression between LPI and HICP - annual average indices for transport prices presented in Table 3 show that between these two variables there is a weak correlation, as the value of correlation coefficient is 0.333. This means that hypothesis 3 was not validated (H3).

Table 3. The main results of linear regression between LPI and HICP - annual average indices for transport prices

Variables	Summary Statistics	HICP - annual average indices for transport prices
LPI	Correlation Coeff.	0.333025
	R Square	0.110906
	F statistic	3.742204
	t-stat	1.934478
	β	17.6058

Source: Own calculations based on Eurostat data

Finally, we tested the effect of a country's logistics performance on the motorization rate (H4), and found that the correlation between the LPI and the motorization rates reveal a positive effect of the logistics performance on the motorization rates. In this case, we used the simple linear regression across countries for 22 European countries (EU 19 countries and also Norway, Switzerland and Turkey).

Table 4. The main results of linear regression between LPI and the motorisation rate

Variables	Summary Statistics	Motorisation rate
LPI	Correlation Coeff.	0.453047
	R Square	0.205251
	F statistic	5.165191
	t-stat	2.272706
	β	156.2882

Source: Own calculations based on Eurostat data

The summary statistics of this correlation (Table 4) highlighted that between the logistics performance of a country and the motorization rates there is a positive correlation of moderate intensity, since the correlation coefficient value is 0.453. This validates hypothesis 4 (H4).

4. Conclusions

This research revealed that logistics performance can act both as cause and as an effect. Firstly, we studied to what extent innovative performance determines logistics performance. Secondly, we highlighted the extent to which, logistics performance may induce effects on the volume of freight transport, on the transport prices or on the motorization rate.

In this paper, we analyzed logistics performance as a cause. Our research revealed that the logistics performance has a positive moderate impact especially on increasing the total volume of freight transport, the volume of air transported goods, sea transported goods and also road transported goods. This was our second hypothesis, which we validated only partially. We started from 4 assumptions correlated with the main modes of transport. In the end, we validated three of the four assumptions (H2b, H2c, H2d), which lead us to conclude that logistics performance acts as a determining cause mainly in case of air, sea and road transported goods.

We also analyzed if logistics performance can act as an effect, the extent to which innovative performance of a country leads to superior logistics performance, and proved our assumption to be correct (H1).

We analyzed logistics performance as an effect, also when correlating the growth of motorization rate to logistics performance (H4). The results of our study showed that the logistics performance of a country affects the motorization rate to a moderate extent.

We could not validate our third research hypothesis (H3), where logistics performance acted as a cause of transport prices. Logistics performance of a country has either no impact or its impact is of low intensity in same cases. Our research results revealed that a country's high logistics performance has a very low impact on the volume of goods transported by rail (H2a) and also on transport prices (H3).

In a rapidly changing environment, innovation is a key success factor, which can provide competitive advantage. Although, considered to be growth engines of society, in logistics, innovations are not analyzed and their importance is still underestimated. Innovative logistics services, however, could provide new business models in trade and industry, the chance to operate on new markets (Pfohl, 2007). Therefore, it is of vital relevance to consider the cause and effects of logistics innovation.

Acknowledgement

This work was co-financed from the European Social Fund through Sectorial Operational Programme Human Resources Development 2007-2013, project number POSDRU/159/1.5/S/142115 „Performance and excellence in doctoral and postdoctoral research in Romanian economics science domain".

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