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The Present and Future of Logistics: an Analysis of Logistics Performance and Innovation of Logistics Service Providers in EU-Member Countries

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Summary: Logistics has rapidly grown in the recent years not only in terms of scope but also of significance for companies and economies. It has evolved from a concept covering only transportation and physical distribution to a wide interdisciplinary field of study that is involved in all activities and functions related to product and information flows such as warehousing and storage, cargo handling, distribution, terminal operations, customs brokerage, and data management, among others. As logistics grows, so are the challenges to keep it efficient and reliable. For this reason, it is essential for companies and countries to encourage innovation and collaboration to make logistics effective, sustainable, and resilient. To understand the role of innovation in improving logistics performance, the study examined the relationship between the Logistics Performance Index (LPI) scores of European Union member states and new innovations introduced by enterprises in the Transport and Storage sector. Further analysis was also conducted on the impact of the productivity of innovative enterprises on LPI scores. Using correlation analysis, the study found that a country's number of enterprises with innovations (i.e., new methods of providing service, new supporting activities for processes, and improved logistics) and number of enterprises engaged in collaborations are significantly correlated with its LPI score. Moreover, a linear regression analysis conducted showed that the labor productivity of innovative enterprises has a significant impact on LPI scores. These results mean that encouraging innovation and collaboration in firms within the Transport and Storage Sector have positive effects in improving LPI scores.

Keywords*: Logistics Performance Index, European Union, Community Innovation Survey, Gross Value Added, Government Expenditure, Transport and Storage Sector*

1 Introduction

Logistics as a field of discipline has significantly expanded in the recent decades. Between 1950s to 1990s, logistics was originally viewed to be related only to transportation and physical distribution of goods. Today, logistics is now an important business function that is involved in procurement, production, transportation, distribution, and even information management. Hence, companies are working to ensure that logistics is always efficiently working as it is directly related to minimizing operational costs and building competitive advantage (Christopher, 2006).

Presently, logistics is a popular topic because of the increased globalization, international trade, and outsourcing (Ballou, 2007). Also, the world is now characterized by a rapid and ever-changing customer demand, distribution channels, and products (PROTRANS, 2003). On the other

hand, logistics is also a common part of discourse because of the severe and frequent global supply chain disruptions that are happening since the COVID-19 pandemic started.

Thus, companies and governments are both investing extensive resources in implementing innovations and methods to make efficient and customer-centric logistics solutions.

According to Speranza (2018), the internet and the availability of vast data provide tremendous opportunities for logistics. These trends have made it possible to use advanced technologies such as blockchain, big data, robotics, and artificial intelligence in various logistics functions. Meanwhile, there are also other types of innovations and strategies that help improve logistics performance such as supporting activities for processes, improved logistics (e.g., inventory management systems and reverse logistics), e-procurement, and logistics collaboration.

The effectiveness of logistics in domestic and international trade is crucial to a nation's competitiveness, hence, the logistics industry is widely acknowledged as one of the core pillars that contributes to economic progress (Wiederer, 2018). To determine a country's logistics performance, the most common instrument being used is the World Bank's Logistics Performance Index (LPI). It is a benchmarking tool that measures a nation's logistics efficiency (Arvis et al., 2018 as cited in Beysenbaev and Dus, 2020). Considering the lack of a global standard method of measuring logistics performance, the LPI rankings are thus important for policymakers and the private sector in assessing the challenges and opportunities in their logistics sector.

Currently, there are several existing literatures which compares LPI with technology and innovation factors. For instance, Anuşlu and Firat (2019) conducted a clustering analysis using the LPI and the Global Innovation Index (GII), Kurniawan et al. (2018) studied the impact of information technology in logistics performance of Indonesia, Wang, Kang and Valentine (2020) examined the influence of ICT penetration on national logistics performance, and Göçer, Özpeynirci and Semiz (2021) analyzed the impact of logistics strategies on the LPI scores of Turkey.

With the limitedness of available scientific papers studying the relationship of logistics performance with innovation components, there is, therefore, an opportunity to contribute to this topic. This study was conducted to compare the relationship of LPI scores with the innovation tendencies of innovative enterprises in the transport and storage sector. Moreover, since innovation is also directly related to increased productivity, the research then compared the impact of labor productivity of innovative enterprises in the transport and storage sector to a country's logistics performance.

To supplement the existing research on logistics performance and innovation, this research aims to answer the following hypotheses by conducting a correlation and regression analyses:

- H1: There is a significant relationship between LPI scores and percentage of innovative enterprises in the population.
- H2: There is a significant relationship between LPI scores and the number of enterprises that introduced new innovations (i.e., new methods of providing service, new supporting activities for processes, and improved logistics).
- H3: There is a significant relationship between LPI scores and the number of enterprises engaged in collaboration.
- H4: There is a significant relationship between LPI scores and the Gross Value Added (GVA) of innovative enterprises in the Transport and Storage Sector.
- H5: Labor productivity of innovative enterprises has a significant and positive impact to LPI scores.

The analyses will utilize publicly available data from the World Bank's LPI report and Eurostat's datasets collected from the Community Innovation Survey (CIS). The third section of this paper talks about these two reports extensively and the proposed analytical methods.

Summary results and discussion are presented in the fourth section while the fifth section covers the derived conclusions.

2 Review of Related Literature

2.1 History of Logistics

Logistics has a long history, and it is traditionally a concept commonly associated with mathematics and military. The origin of the word logistics can be traced back to both Greek and Latin words logistikos and logisticus, which means "skilled in calculating" (Rider, 1970). Later, the concept of logistics would be used predominantly in military and would be popularized by a French military thinker named Antoine-Henri Jomini. In his Summary of the Art of War (1838), he used the French word logistique to define "the practical art of moving armies." He referred to this word as a concept that encompasses a wide range of functions necessary for the movement and maintenance of military forces, including planning, administration, supply management, bridge and road construction, and intelligence gathering, among others (Leighton, 1999).

It is not until after more than a century before logistics will become an integral subject in business and economy. In his personal account of the history of logistics between the 1950s to 2000s, Southern (2011) summarized how the logistics field has evolved in the past half century. In the 1950s, the word logistics was not yet in the mainstream, instead, transportation was the common buzzword. In the following decade, the study of transportation grew, and the concept of physical distribution was developed. The 1970s was a major turning point for logistics as a discipline. This is when logistics became a popular topic in universities, academic journals, and textbooks. The next decade was then characterized by transportation deregulation and dwindling use of the term physical distribution in lieu of the word logistics. In the 1990s, business logistics became more prominent, and companies realized many opportunities for cost savings through logistics strategies. However, despite this development, there was still very little coordination and information flow in areas of logistics such as purchasing and physical distribution (Ballou, 2007). Finally, at the start of the 21st century, logistics has become integrated into supply chain management.

2.2 Logistics in the Present

Logistics has now grown tremendously since its inception. It has now become an extensive interdisciplinary field of study that involves several functions and activities. As defined by Wiederer (2018), logistics is a comprehensive system of services and activities that facilitates the movement of goods and trade across and within the borders of countries. Contrary to the past, logistics is no longer just about transportation and physical distribution. Rather, it now covers all tasks between the forward and reverse flow of goods and between the point of origin and the point of consumption, which includes warehousing and storage, cargo handling, order management, postal and express delivery, and even information management. Logistics is involved in all modes of transportation, specifically land, sea, air, and pipeline.

With the advent of globalization, the role of logistics is now more important than ever. Particularly, global production chains require a competitive logistics sector that can move goods across borders swiftly, reliably, and affordably while coordinating all activities from product development, production, assembly, and distribution to end customers (Wiederer, 2018).

There are several trends currently being observed in the field of logistics. One is the increase in the use of multimodal transport. According to Handfield, Straube, Pfohl, Wieland (2013), multimodal transport chains utilize various modes of transportation such as rail, sea, inland

waterway, air, and road. On the other hand, intermodal transport chains, particularly in freight transport, involve the transportation of freight within an intermodal load unit.

Another trend is the growing consideration for green logistics and reverse logistics. Reverse logistics refers to the logistics procedures involved in the return of products and materials from their final destination. These procedures include planning, implementation, and control, and are carried out with the aim of recapturing value or ensuring proper disposal (Handfield, Straube, Pfohl, Wieland, 2013).

2.3 Future of Logistics

Due to the global supply chain disruptions caused by the COVID-19 pandemic and the armed conflict between Russia and Ukraine, companies and governments are scrambling to develop their logistics capabilities to strengthen supply chain resilience. Many experts and logisticians are predicting that the future of logistics will be characterized by higher levels of collaboration, customer-centric logistics strategies, increased logistics outsourcing, and more applications of advanced technologies in logistics functions.

The first future trend is increased logistics collaboration. This cooperation occurs either between two manufacturing companies or between a manufacturing company and an LSP. Two distinct parties collaborate to enhance the efficiency of logistics processes, for instance, in transportation and warehousing (Ecorys et al., 2015).

Meanwhile, the transport and storage sector's competitiveness will rely more and more on its capacity to provide customized logistics services to customers promptly and punctually. A highly competitive image requires the logistics system to meet several demands. Additionally, management's attitude towards the significance of logistics as a competitive parameter is crucial (PROTRANS, 2003).

Another future trend in the logistics sector is the usage of Industry 4.0 technologies. Handfield, Straube, Pfohl, Wieland (2013) said that ICT is highly relevant, and it is expected to be widely used in the logistics sector. The role of technology in modernizing logistics operations will continue to be transformative. The logistics industry has been transformed by technological advancements such as artificial intelligence (AI), machine learning, Internet of Things (IoT), and automation. These technologies allow for the tracking of shipments in real-time, optimize route planning and delivery schedules, improve warehouse management through the use of robotics and smart inventory systems, and enable data-driven decision-making to enhance operational efficiency.

Lastly, logistics outsourcing will continue to grow as more businesses realize the importance of focusing on main business operation and outsourcing other processes with which they have no expertise. As such, firms have the better option of outsourcing their logistics operations to an LSP. (Razzaque and Sheng, 1998 as cited in Bourlakis and Melewar (2011).

3 Methodology

3.1 Data Collection

This study used secondary data sourced from the World Bank and Eurostat. The variables collected from the online datasets are presented in Table 1. To make the analyses accurate and fair, all data will be compared against the same period. In this case, all data are from 2016. Both the data from the World Bank LPI 2023 and 2018 cannot be used because there are some unavailable data on the same period from Eurostat.

3.1.1 World Bank's Logistics Performance Index (LPI)

In a World Bank publication, Wiederer (2018) said that the LPI measures logistics performance across multiple dimensions. There are six important indicators that determine the effectiveness of logistics performance. These include the effectiveness of customs and border management control, trade and transport infrastructure quality, the convenience of arranging shipments, the competence of logistics services, the capability to track and trace, and timeliness.

In the 2016 edition of the LPI report, around 7,000 country assessments were made by 1,051 logistics professionals (global freight forwarders and express carriers), covering 160 countries in the international LPI and 125 countries in the domestic LPI.

For this research, only the international LPI will be used in the analyses. Also, LPI scores instead of LPI ranks will be utilized.

3.1.2 Eurostat's Community Innovation Survey (CIS)

According to Eurostat (no date), the Community Innovation Survey (CIS) is a survey that focuses on the innovation activities carried out by enterprises. The survey aims to assess the level of innovation across different types of businesses, the nature of their innovations, and the factors that contribute to the development of these innovations. This includes examining the objectives of the innovations, the sources of information used, the use of public funds, and the associated costs. This survey is conducted twice a year.

The CIS provides statistics broken down by countries, types of innovators, economic activities and size classes. For this research, the data covers only enterprises under the Transportation and Storage Sector (i.e., land transport, transport via pipelines, water transport, air transport, warehousing and support activities, and postal and courier activities) from 27 EU-member countries, regardless of type of innovators and size of companies.

The term "innovation" refers to the introduction of a new or substantially improved product (good or service), process, marketing method, or operational method in business procedures, company organization, or external relations.

Table 1 Variables

Variable Group	Variable	Label	Source
Logistics performance	Logistics performance index (LPI) scores	LPI	World Bank
Population of innovative enterprises	Percent of innovative enterprises in the Transportation & Storage Sector	POP	Eurostat
Number of enterprises by type of innovation introduced	Innovative enterprises that introduced new or improved methods for producing goods or providing services	MTHD	Eurostat
	Innovative enterprises that introduced supporting activities for processes	PROC	Eurostat
	Innovative enterprises that introduced new or improved logistics, delivery or distribution methods	LOG	Eurostat
	Innovative enterprises engaged in cooperation	COOP	Eurostat
Basic economic information on the innovative enterprises	Gross value added per employee (in thousand euros)	GVA	Eurostat
	Labor productivity (in thousand euros)	PRDTV	Eurostat
Total government expenditure	Total government expenditure in Transport and Storage Sector (in million euros)	GVEXP	Eurostat

3.2 Data Analysis

3.2.1 Correlation Analysis

Correlation analysis is a statistical method that is utilized to evaluate the strength and direction of the linear association between two or more variables (Senthilnathan, 2019). Determining the extent and nature of the relationship between variables is aided by this approach. It is unnecessary to differentiate between the dependent and independent variables since the analysis is not intended to establish causation. The variables that are suitable for correlation analysis are restricted to scale or continuous variables.

A correlation analysis will yield a Pearson's correlation coefficient, which is also referred to as Pearson's r or the correlation coefficient. This coefficient measures the strength of the relationship between two variables (Onwuegbuzie and Daniel, 1999). The correlation coefficient can take values between -1 and +1. A positive correlation coefficient signifies a positive association between two variables. This implies that when one variable increases, the other variable also tends to increase. On the other hand, a negative correlation coefficient signifies a negative association between two variables. This means that as one variable increases, the other variable tends to decrease. A correlation coefficient of zero signifies that there is no relationship between the variables. Finally, a correlation analysis is considered significant if the p-value is less than 0.05 Escudero-Gómez, García-González and Martínez-Navarro (2023).

3.2.2 Simple Linear Regression Analysis

The statistical technique of simple linear regression analysis is utilized to model and examine the connection between a single dependent variable and a single independent variable (Huang, 2023). This method involves predicting the value of a dependent variable by considering the value of the independent variable. In addition, it enables the estimation of the impact of the independent variables on the dependent variable. The regression equation's coefficients demonstrate how the dependent variable changes when each independent variable changes by one unit while keeping other variables constant.

The analysis of simple linear regression assumes that there is a linear relationship between the variables. This means that any changes in the independent variable are directly associated with changes in the dependent variable in a linear manner.

In simple linear regression, there is only one independent variable, and according to Liu and Chen (2006), the relationship is modeled using a linear equation:

$$Y = \beta_0 + \beta_1 X + \varepsilon$$

In the equation, the variable Y is the dependent variable, which is the variable being predicted or explained. The variable X represents the independent variable, which is the variable used to predict or explain the dependent variable. The intercept, represented by β_0, is the value of Y when X is 0. The slope, represented by β_1, is the change in Y for a unit change in X.

To evaluate the adequacy of a regression model, two measures are required. The first measure is the R-squared, which is also referred to as the coefficient of determination. The term "R-squared" refers to the percentage of the variance in the dependent variable that can be accounted for by the independent variables included in the model (Marill, 2004). The R-squared value ranges between 0 and 1, where higher values indicate a better fit.

The ANOVA (Analysis of Variance) is another measure utilized to evaluate the overall fit, usefulness, and significance of the regression model. ANOVA is a statistical tool that is utilized to compare the variability that is explained by the independent variables in a regression model to the unexplained variability, which is represented by the residuals. The ANOVA table presents

details about the sources of variation, degrees of freedom, sums of squares, mean squares, and F-statistic.

The F-statistic is a tool utilized to ascertain the significance of the impact of the independent variable on the dependent variable. When the p-value of the F-statistic is less than a predetermined significance level, such as 0.05, it indicates that the regression model is statistically significant. This suggests that the model is a better fit for the data than a model without independent variables.

4 Results and Discussion

4.1 Correlation Analysis

Table 2 presents the results of the correlation analysis. The empirical results show a significant and strong positive correlation between LPI scores and the percent of innovative enterprises in the population (Pearson coefficient 0.620; p-value: < 0.01), therefore, H1 is accepted. The strong positive correlation indicates that when the percent of innovative enterprises in the population increases, LPI score also increases. Figure 1 is the scatterplot showing the relationship of the two variables.

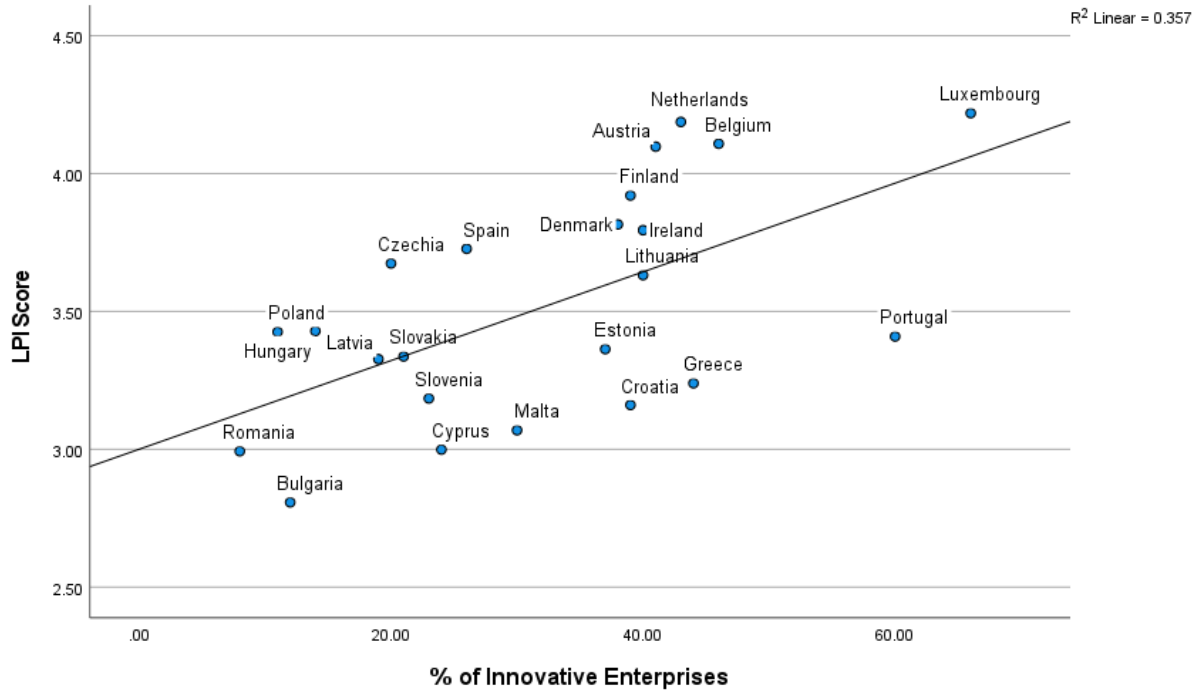

Figure 1 *Correlation between LPI scores and % of innovative enterprises in the population*

Further analysis also shows that there is significant and moderate positive correlation between LPI scores and the number of innovative enterprises that introduced new methods of providing services (Pearson coefficient 0.434; p-value: <0.05), support activities for processes (Pearson coefficient 0.465; p-value: <0.05), and improved logistics (Pearson coefficient 0.486; p-value: <0.05). Therefore, H_2 is accepted. The moderate positive correlation indicates that when the number of innovative enterprises that introduced innovations increases, LPI score also increases.

The result of the correlation analysis also shows that there is a significant and moderate positive correlation between LPI scores and the number of innovative enterprises engaged in cooperation (Pearson coefficient 0.513; p-value: <0.01), therefore, H_3 is accepted. The moderate

positive correlation indicates that when the number of innovative enterprises engaged in cooperation increases, LPI score also increases.

The result likewise shows that there is a significant and strong positive correlation between LPI scores and the GVA of innovative enterprises in the Transport and Storage Sector (Pearson coefficient 0.705; p-value: <0.01), therefore, H_4 is accepted. The strong positive correlation indicates that when the GVA of innovative enterprises increases, LPI score also increases.

As an additional analysis, it can be seen from the results that there is a significant and moderate positive correlation between LPI scores and the total government expenditure in the Transport and Storage Sector (Pearson coefficient 0.526; p-value: <0.01). However, based on further observation, the result show that there is also a significant and very strong correlation between total government expenditure and number of enterprises that introduced innovation (i.e., MTHD, PROC, and LOG) and those that are engaged in cooperation. This means that government support is correlated to introduction of innovations.

Table 2 Results of Correlational Analysis on LPI Score, Innovation Metrics, GVA, and Government Expenditure

	LPI	**POP**	**MTHD**	**PROC**	**LOG**	**COOP**	**GVA**	**GVEXP**
LPI	1							
POP	0.620**	1						
MTHD	0.434*	0.251	1					
PRC	0.465*	0.272	0.936**	1				
LOG	0.486*	0.292	0.969**	0.983**	1			
COOP	0.513**	0.341	0.790**	0.811**	0.821**	1		
GVA	0.705**	0.603**	0.14	0.135	0.119	0.152	1	
GVEXP	0.526**	0.206	0.878**	0.908**	0.925**	0.864**	0.221	1

*** Correlation is significant at the 0.01 level (2-tailed).*

** Correlation is significant at the 0.05 level (2-tailed).*

4.2 Simple Linear Regression Analysis

Considering the notion that innovation improves labor productivity, the study decided to also conduct a simple linear regression analysis between LPI scores and labor productivity of innovative enterprises in the Transport and Storage Sector. First, Table 3 shows that there is a significant and strong positive correlation between LPI score and labor productivity (Pearson coefficient 0.739; p-value: <0.01). This indicated that when labor productivity increases, LPI score also increase.

Table 3 Correlations

		LPI Score	Productivity
Pearson Correlation	LPI Score	1.000	.739
	Productivity	.739	1.000
Sig. (1-tailed)	LPI Score	.	.000
	Productivity	.000	.
N	LPI Score	26	26
	Productivity	26	26

Following this, Table 4 shows that the R Square is 0.546. This number shows that the regression model is a good fit and that 54.6% of the LPI score variance is explained by labor productivity.

Table 4 Model Summary

Model	R	R Square	Adjusrted R Square	Std. Error of the Estimate
1	.739[a]	.546	.527	.29051

a. Predictors: (Constant), Productivity

Furthermore, Table 5 shows the overall fit, usefulness, and significance of the regression model using ANOVA. As can be seen in the table, the p-value of the F-statistic is 0.00, which means that the regression model is statistically significant.

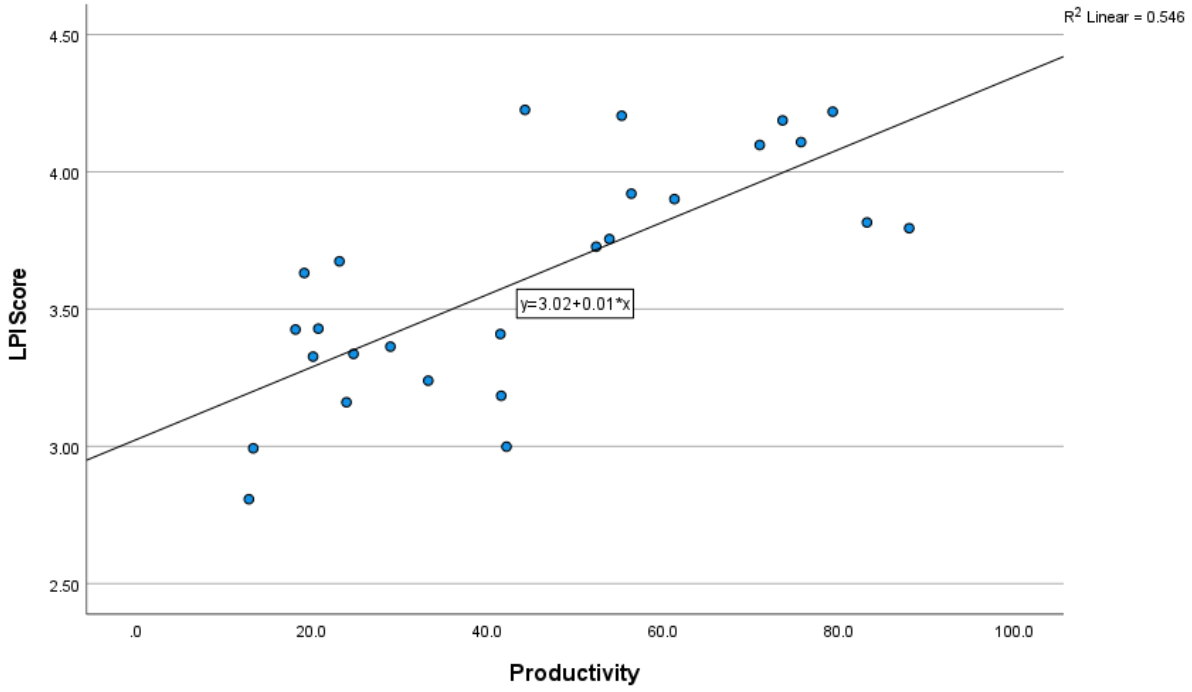

Figure 2 *Simple Linear Regression Model of LPI Score vs. Labor Productivity*

Table 5 ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.436	1	2.436	28.862	.000[b]
	Residual	2.026	24	.084		
	Total	4.461	25			

a. Dependent Variable: LPI Score
b. Predictors: (Constant), Productivity

Finally, Table 6 shows the coefficients of the regression equation. This estimated the magnitude of the effect of the independent variable (i.e., labor productivity) on the dependent variable (LPI scores). As can be seen in the table, there is an estimated 0.013 increase in LPI score for every one-unit increase in labor productivity. Therefore, H_5 is accepted.

Table 6 Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	B
1	(Constant)	3.023	.124		24.450	1	(Constant)	3.023
	Productivity	.013	.002	.739	5.372	.000	Productivity	.013

a. Dependent Variable: LPI Score

5 Conclusion

Taking into account the pace of changes in technology and customer demand and expectations, logistics service providers must constantly innovate and collaborate to improve logistics performance. As demonstrated by the statistical analyses conducted in this study, innovations by enterprises in the Transport and Storage Sector have significant and positive relationship to LPI scores. Hence, it is strongly suggested for governments and the private sector to encourage and introduce innovations as a means to improve LPI scores. Innovation is known to be a helpful factor in improving productivity. In this study, it was proven that higher levels of productivity have significant impact on LPI scores. As such, it can be concluded that the introduction of innovations trickles down to better labor productivity, and finally to higher LPI scores. Likewise, government expenditure in the Transport and Storage Sector are also positively related to LPI scores, thus, any boost in government investments can translate to considerable gains in LPI scores.

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