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The impact of LPIs' indicators on the global logistics performance index: Global perspective

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Abstract This study investigates the impact of Logistics Performance Index (LPI) indicators on the overall LPI score through comprehensive statistical analyses, including regression and factor analysis, using data from the World Bank. The study covers 105 countries from 2007 to 2023, focusing on six key indicators: customs clearance efficiency, quality of trade transport-related infrastructure, ease of arranging competitively priced shipments, logistics service competence, shipment tracking and tracing ability, and timeliness. These indicators serve as independent variables, while the overall LPI score is the dependent variable. The findings reveal that the most influential factor is logistics service competence, followed by infrastructure quality and tracking and tracing capabilities. Customs clearance efficiency, ease of arranging competitively priced shipments, and timeliness also play crucial roles, though to a lesser extent. The analysis highlights that logistics competence significantly drives improvements in global logistics performance. Moreover, the study reveals regional variations in indicator impacts. Europe and Asia exhibit higher sensitivity to logistics competence and infrastructure, while Africa and South America demonstrate relatively lower but still significant responses. Factor analysis identifies three core dimensions influencing logistics performance: logistics efficiency, infrastructure and customs, and international shipments and tracking. This study underscores the necessity for tailored strategies to enhance logistics performance, emphasizing the prioritization of logistics competence and infrastructure development. Policymakers and businesses are encouraged to adopt targeted investments, streamline customs procedures, enhance tracking technologies, and improve international shipment processes to boost their global LPI rankings and strengthen economic competitiveness. These findings provide valuable insights for developing actionable logistics improvement frameworks on a national and international scale.

Keywords: logistics performance, trade infrastructure, customs efficiency, tracking and tracing, international shipments, logistics strategies

1. Introduction

Logistics, a critical component of the global economy, involves the efficient movement and management of goods and services across various locations. Historically, logistics focused on relocating materials to meet specific needs, such as equipment, after World War II. Today, the scope of logistics services has expanded to include warehousing, transportation, imports, exports, packaging, material handling, inventory management, and order fulfillment. Vesanthy and Chandramohan (2023) define logistics management as "the process of planning, implementing, and controlling the movement and storage of goods and services from the point of origin to the point of consumption," emphasizing the need for coordinated activities such as transportation, warehousing, and inventory management to ensure efficient and timely delivery.

Recent studies underscore the growing significance of logistics in national and global contexts. For example, Song and Lee (2022) highlight how logistics has become a crucial element in enhancing national competitiveness and economic development. The COVID-19 pandemic further amplified the importance of logistics by disrupting global supply chains and demonstrating the sector's role in maintaining economic stability. The Logistics Performance Index (LPI), developed by the World Bank, provides a comprehensive measure of logistics capabilities across countries. According to Diep et al. (2024), the LPI assesses logistics performance through various dimensions, including customs efficiency, infrastructure quality, international shipment connectivity, logistics service competence, tracking and tracing abilities, and shipment timeliness. This index has become an essential tool for evaluating and improving logistics strategies.

Polat et al. (2023) revealed that countries with higher LPI scores tend to attract more foreign investment and achieve better positions in global trade. Improved logistics performance not only supports trade integration but also fosters economic growth by bridging gaps between manufacturers and consumers.

While extensive research has highlighted the overall significance of the LPI, recent studies have also pointed out the need for a more granular understanding of how specific LPI indicators contribute to the overall score. For example, research by Zhang et al. (2024) indicates that customs efficiency and infrastructure quality are critical drivers of logistics performance,

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whereas tracking and tracing capabilities can significantly impact shipment reliability. Similarly, a study by Kumar and Singh (2023) suggested that improvements in logistics service competence and timeliness can enhance a country's global logistics ranking. These findings emphasize the importance of dissecting the individual components of the LPI to better understand their relative impact on overall logistics performance.

Despite the LPI's comprehensive approach to measuring logistics performance, there is limited understanding of how individual LPI indicators impact the overall LPI score. Existing papers have focused primarily on the contributions of each component rather than the aggregate measure of logistics performance. This lack of detailed analysis obscures which specific aspects of logistics services drive improvements in the overall index, making it challenging for policymakers and businesses to prioritize and target their efforts effectively. Addressing this problem, this paper seeks to provide a detailed examination of how each LPI indicator affects the overall LPI score, thereby offering insights into which areas of logistics performance have the most significant impact on a country's global logistics ranking. This understanding is crucial for developing targeted strategies to enhance logistics capabilities and improve overall performance.

1. How do the indicators of the LPI individually affect the overall LPI score?
2. Which LPI indicators have the most significant impact on overall logistics performance?
3. Are there variations in the influence of LPI indicators across different regions or countries?

Ultimately, this paper aims to conduct an empirical investigation to achieve the following objectives:

1. To assess the individual impact of each LPI indicator on the overall LPI score.
2. Identifying which LPI indicators most significantly contribute to overall logistics performance.
3. To analyze the variations in the impact of LPI indicators across different regions and countries.

This paper is significant because it provides a deeper understanding of the components that drive the overall global logistics performance index. By focusing on the individual indicators, the paper offers valuable insights into which areas require improvement to enhance logistics efficiency. Understanding the specific contributions of each LPI indicator will help policymakers and businesses prioritize their investments and strategies to boost logistics performance, ultimately supporting the nation's economic growth and global competitiveness. This paper's limitations stem from the constraints related to the data and scope of the research. The paper population includes countries listed on the Logistics Performance Index (LPI) for the years 2007, 2010, 2012, 2014, 2016, 2018, and 2023. The sample consists of 105 countries that have consistently reported on the LPI since its inception. This limited temporal scope may not capture recent developments or trends in logistics performance beyond the available years. Additionally, the focus on a fixed set of countries may not fully represent the diverse logistics contexts of countries that joined the LPI later or those not consistently reporting. Consequently, the findings might not be generalizable to all countries or reflect more recent changes in global logistics practices.

The paper is structured as follows: section two outlines the literature review and hypothesis development, section three presents the methodology, section four elaborates the results and discussion, and section five presents the conclusion.

2. Literature Review & Hypothesis Development

This paper provides a comprehensive examination of the logistics performance index (LPI), focusing on its components and the significant studies that have explored its impact. The LPI, developed by the World Bank, evaluates logistics performance through several key dimensions: customs efficiency, infrastructure quality, international shipment connectivity, logistics service competence, tracking and tracing capabilities, and shipment timeliness. Each of these components plays a crucial role in determining the overall logistics effectiveness of a country.

The review details the specific functions of each LPI component and their contributions to the overall index score. It also highlights prominent research that has investigated these components and their effects on trade performance. For example, studies such as those by Sy (2020) and Harizi (2020) have demonstrated the strong correlation between improvements in LPI components and enhanced trade volumes, indicating how critical each dimension is for facilitating global trade. This chapter will summarize these findings and provide an in-depth analysis of how individual indicators influence logistics performance and, consequently, international trade dynamics. By exploring the latest research and theoretical frameworks, this chapter aims to offer a detailed understanding of how the LPI serves as a vital tool for assessing and improving logistics services worldwide.

Despite the ever-increasing importance of logistics services to various sectors and aspects of the long-standing industry. There was a lack of sources that monitored performance, offered handy explanations about the industry, and made easy references for stakeholders. The World Bank's initiation of the LPI aimed to fill this gap. However, it is relatively new, as the first report was published in 2007 and is taking place on a biennial basis and has not been published for 2020 and 2022; instead, the 2023 report replaced these two years, which came with a reflection of massive changes in the countries' rank and progression, and such progression demonstrates the importance of the tool and is gaining increasing interest.

The LPI is an essential factor in investors' decisions and for countries to benchmark themselves against industry players. The logistics performance index (LPI) is an interactive benchmarking instrument developed to assist countries in identifying the challenges and opportunities they encounter in their trade logistics performance, as well as the actions they can take to enhance it. The LPI attempts to investigate countries by collecting perception-based data through a survey targeting freight

forwarders, logistics companies, and logistics professionals to rate their perceptions, experiences, and insights into the countries' performance.

2.1. Logistics Performance Index

The World Bank developed the LPI interactive benchmarking instrument to simplify the administration of logistics' numerous decisions. This instrument allows countries to assess their strengths and areas for improvement in trade logistics. The LPI can evaluate the convenience or difficulty of transporting shipments across a country by utilizing the results of compiled surveys. Furthermore, the LPI can be employed by countries to evaluate their performance in relation to other individual economies, groups of countries, or regions.

Ojala and Çelebi (2015) summarize that LPI is a multidimensional tool developed to assess the logistics performance of a specific country and can compare itself with others; the tool measures the degree to which its logistics can facilitate trade and help identify weaknesses, opportunities, and improvements to foster a trade-friendly environment. The LPI assesses the fundamental competence dimensions of logistics, such as the quality of infrastructure, the efficacy of customs, the connectivity of international shipments, the ability to monitor these shipments, and the timely arrival of the shipment at the next destination.

(World Bank) LPI scores are calculated as a weighted average of the scores of countries in six indicators as follows:

1. The efficiency of customs clearance refers to the speed, ease, and predictability of clearance formalities by the Customs Authority.
2. Trade and transportation infrastructure quality: This encompasses communication technology, terminals, airports, railroads, and road network connectivity.
3. Streamlining the process of arranging competitively priced shipments by implementing cost-effective strategies and reducing tariffs.
4. Competence of logistics services: This encompasses service providers such as brokers, terminal operators, and transporters.
5. Ability to track shipments: refers to providing timely status of shipments.
6. Timeliness refers to a shipment's timeline for reaching the destination.

2.1.1. Efficiency of Customs Clearance

The initial indicator of the logistical performance index is customs clearance efficiency. Customs clearance is a critical process that is overseen by governmental authorities. It involves the review, inspection, and verification of product compliance, tax collection, and authorization for importation into the country or exportation to another country. Through this procedure, an importer or exporter declares compliance with the regulation by presenting the required documentation and receiving clearance from the authority. Customs clearance plays a critical role in facilitating foreign trade in terms of efficiency, speed, simplicity, and reliability of clearance, and the more a country improves the clearance process, the more rotation of shipping vessels that attract shipping lines. For example, Sri Lankan Customs implemented an online system for tax collection and customs declaration, positively affecting shipping lines' satisfaction regarding reliability, responsiveness, and tangibility (Dissanayake & Ratnajeewa, 2013).

Customs efficiency, as a core indicator, can severely impact a country's position in the LPI, according to Hoa (2023), who investigated the impact of customs on improving the logistics performance index. The data collected from 2007-2018 were analyzed through a quantitative approach via Cronbach's alpha coefficient. The findings show that there is a positive relationship between customs clearance and logistics service quality with the overall logistics performance index and that the critical activities of customs authorities, such as the ASEAN single window, administrative reforms, specialized management, risk management, and customs–enterprise collaboration, positively impact customs clearance and logistics service quality.

Customs clearance integration with digitalization became increasingly explicit. It created added value for involved parties, such as streamlining processes, increasing efficiency, decreasing clearance days, anticorruption, reducing paperwork, and the ability to restore and validate real-time data. Moldabekova et al. (2021). The digitalization of customs clearance processes impacts logistics performance, and the adoption of technological advances, innovation, and digital processes is positively correlated with customs efficiency.

From a broad perspective, efficient customs procedures contribute significantly to economic growth by increasing supply chain resilience, minimizing disruptions, allowing seamless goods flow, and increasing trade volumes. Introducing digitalized and modernized customs clearance solutions, in turn, directly impacts the promptness and efficiency of goods movement. Therefore, improving the ease of international commerce depends on several factors, one of which is the efficiency of the customs clearance procedure. Nevertheless, commerce may be impeded by poor customs clearance (Gani, 2016).

A high score in this indicator reflects well-organized customs processes, high responsiveness, and predictability and supports facilitating goods movement within the customs fence.

2.1.2. Quality of Trade Transport-related Infrastructure

The quality of trade transport-related infrastructure is the second indicator that impacts the LPI score. This refers to the entire network required to physically transport goods nationwide. The high-quality infrastructure includes seaports, roadways, airports, railways, related facilities, and telecommunications networks, as well as the level of integration of domestic network connectivity and accessibility into international markets. The efficacy of logistics services and the maintenance of sustainable trade flows and economic development can be influenced by the quality of trade transport-related infrastructure. The quality infrastructure of seaports, roadways, and airports is a key factor supporting trade facilitation and regional competitiveness (Sénquiz-Díaz, 2021). The vital role of transportation in the movement of goods is associated with the quality of infrastructure. A well-developed infrastructure reduces adverse impacts, provides a better location for economic activities, and reduces transportation costs (Schwab, 2018; Cho, 2014).

Interdependence among transportation networks is of paramount importance since they support global commerce. The reliability of transportation and infrastructure determines the speed and security of international commerce. Thus, the quality of infrastructure contributes significantly to the overall LPI score, and notably, high LPI scorers in 2023 also have a standard high score for the quality of trade transport-related infrastructures. Bayoumi et al. (2023), high contribution of road transport infrastructure to economic growth, productivity, and logistics performance index in Egypt.

The impact of transport on logistics performance is significant, as measured by the LPI, and this improvement leads to reduced transportation costs and increased trade (Hairi, 2020).

Furthermore, one of the significant contributors to enhancing transportation infrastructure is multimodal transport, which involves combining two or more modes of transport for delivery, such as shifting delivery from the roadrail to the railport. This mode integrates various transportation modes into one delivery mode, increasing the shipment velocity while reducing the cost. Hanssen & Mathisen (2014) Intermodal transport is highly focused on rail transport, while current works to a higher degree include waterways and roads.

Accordingly, transportation infrastructure is a sensitive indicator of LPIs. It enables efficient goods movement, reduces transportation costs, maintains network connectivity, and increases market accessibility, and its effectiveness correlates with the overall LPI score.

A high score for this indicator indicates that the country has strong networks; good-quality transportation facilities such as roads, ports, and airports; and efficient connections between them.

2.1.3. Ease of Arranging Competitively Priced Shipments

The third indicator influencing LPIs is the convenience of arranging competitively priced shipments. This refers to organizing international shipments with connections to various destinations at affordable prices rather than market rates through optimizing processes, distributions, shipping routes, and lower duties. However, arranging international shipments at competitive prices is difficult, especially given the current market conditions regarding inflation, high insurance rates, and energy price volatility. This factor is linked to shipping rates, as several studies have indicated that approximately 90% of trade flow is carried by maritime transport (Christiansen et al., 2011). However, the shipping industry faces serious hurdles in maintaining sustainable and safe routing, which imposes higher rates when arranging competitive shipments. From another perspective, some solutions can influence and optimize shipping rates, such as attracting shipping lines to establish regular liners and facilitating their requirements at attractive governmental charges, providing complete maritime solutions for vessels, establishing logistics hubs, alliances with giant shipping companies, increasing distribution channels and shipment consolidation, and shipping models that gather small parcels in one shipping unit for many customers, which is a key factor that can reduce fuel consumption and emissions by 40% (Mostafa & Eldebaiky, 2023).

A higher score for this indicator reflects a country's competitiveness in the international shipping market and its ability to enable seamless connectivity with other regions.

2.1.4. Competence of Logistics Services

Logistics competence is the fourth indicator that can severely affect the performance index. It is a critical factor in achieving a competitive advantage and superior performance. Logistics competence refers to the ability to provide end-to-end services that include logistics facilities, workforce, policies, and types of equipment to handle all types of logistics activities needed. This indicator scope considers factors such as the availability of warehouses (e.g., specialized, general, controlled), storing shipments of various sizes, efficient distribution outlets, port facilities (e.g., berths, specialized terminals, general terminals, competent port operators), multimodal connectivity, equipment handling, digitalization, a skilled workforce, planning, scheduling, communication and logistics management, and the suitability of regulations. Sadri et al. (2021). The most important competence needed in the logistics industry is foreign language ability, and the most crucial stage is planning and scheduling.

A high score in this indicator determines the maturity level of the logistics industry within the country, the availability of skilled logistics workers, and the availability of a wide range of logistics services and solutions.

2.1.5. Ability to track shipments

The ability to track and trace shipments is another indicator of LPI. It embraces the importance of receiving real-time information and providing the parties with visibility of the shipment's current status. It is an unwavering prerequisite in the industrial sector, as manufacturers can take proactive action when shipment is expected to incur a delay that will cruelly interrupt their business. Thus, better visibility and insight into shipments' current stage are critical to maintaining different business activities. Currently, vessels are equipped with technologies to locate and communicate with receivers at any time. In addition, digitalization enables ports, customs, and logistics providers to send and receive data in a timely and efficient manner; for example, EDI and electronic data interchange facilitate fast, accurate, and reliable data transfer between parties in the supply chain (Masudin et al., 2021).

A higher score in this indicator emphasizes the immediate ability to track shipments, increases transparency, and enables businesses to monitor shipment movement.

2.1.6. Timeliness

Timeliness is the last indicator that contributes to determining the LPI's overall score. It refers to the efficiency and reliability of logistics services, including the timeframe of deliveries to reach their next destination, transit time consumed, and adherence to planned schedules. In the context of fresh food e-commerce, timeliness in logistics services positively influences consumer satisfaction (Jiang et al., 2021).

A higher score for this indicator reflects a country's ability to arrange shipment schedules on time, its connectivity with other regions, and its commitment to reducing time for loading and discharging activities.

2.2. Insight into the Logistics Performance Index

The previous section defined the LPI indicators separately to understand the factors influencing each indicator. In this section, it is also important to review recent studies demonstrating how researchers are identifying and improving their countries' logistics performance indices via LPI data. To improve LPIs, countries must investigate opportunities and weaknesses that can impact the overall LPI score. This will help researchers understand the basis and supporting findings of investigations.

Aljabhan & Elnahrawy (2024). This paper examined the impact of the LPI on Saudi foreign trade from 2007-2018. A statistical analysis conducted on Saudi Arabia's LPI and trade through correlation bivariate analysis revealed a substantial positive correlation between the two LPI indicators and imports, such as the ease of international shipment scores and tracking ability.

Bouchut et al. (2022), in an examination of Brazil's LPI from 2007-2016 via an unsupervised learning algorithm (cluster analysis), reported that Brazil's LPI rank is below that of other countries with fewer economic resources, but it improved slightly during different cycles. In 2016, Brazil's score was higher than the average for Latin American countries. The study emphasizes certain activities that contribute to lower scores, such as excessive documentation and regulatory agencies for exports and imports, as well as inefficiencies in the inspection and release of consignments, customs brokerage services, and international shipment connectivity.

Haris et al. (2022) aim to examine specific challenges facing Indonesia's logistics system that result in poor performance compared with neighboring countries. The study employs normative legal research with primary and secondary data; it highlights several challenges, including high logistics costs, inefficient processes, and port infrastructure. They propose a drastic solution to rectify deficiencies through regulatory changes, digitization and integration of service platforms, and improvement of infrastructure both within and outside of ports.

Almalki and Alkahtani (2022). In this research context, the study examines the impact of allocating logistics hubs on Saudi Arabia's LPI ranking, simulates the World Bank questionnaire, and distributes it among eighty SMEs to participate from nine different countries. Research has determined that allocating regional logistics centers in critical multilinguistic areas within regional trading zones will likely increase Saudi Arabia's ranking by approximately 20%. This finding demonstrates the close correlation between logistics infrastructure investment and the LPI ranking.

Yusufkhonov et al. (2021) investigated the LPIs of Uzbekistan and ways to improve them. The study uses a qualitative approach through a survey distributed among 1000 logistics professionals from 169 countries. The higher score in 2018 was timeliness, whereas the lower score was customs clearance. It also summarizes recommendations to improve LPI deficiencies, including reforming the customs process, infrastructure, international transport, staff qualifications, and timely delivery.

Górecka et al. (2021) aimed to examine logistics performance's significance in economic development and trade. This study investigated the influence of logistics performance on the global trade of basic materials and energy. It centers on EU members by employing panel data regression analysis in accordance with the global trade model for gravity theory. The findings of this research show that timeliness is the most crucial component for solid energy products, and all the other elements are essential for liquid energy products.

Kartum (2020). The research was performed via hierarchical clustering analysis via the SPSS 22 statistical program. It consists of 90 countries. The study revealed that Turkey's logistics performance is similar to that of cluster countries, including

Qatar, Malaysia, Portugal, the Czech Republic, South Africa, China, Hungary, and Poland. However, Turkey's logistics infrastructure is more robust than that of countries in the same cluster. Nevertheless, it performs below the cluster group in terms of customs, international shipment, logistics service quality, and timeliness.

Altıntaş (2021) used neural networks as a machine learning method to predict the relationships between variables for all reported countries in the logistics performance index from 2010-2018. The study revealed significant relationships with infrastructure, logistics service quality, and customs.

Ilangasekara and Premarathne (2018) investigated the poor performance of Sri Lanka through the use of qualitative and quantitative methods. The study revealed that infrastructure impacts Sri Lanka's scores and demonstrated the factors that affect infrastructure, such as inadequate investment, the absence of associations between the government and private sector, a lack of transparency in policy implementation, and the need to realize proper infrastructure prioritization.

Rezaei et al. (2018). The study's objective was to utilize the best–worst method (BMW) to attribute weights to the six central components of the LPI, thereby enabling countries to better understand how to prioritize logistics efforts. The results demonstrate that infrastructure ranks relatively high, with logistical services, punctuality, customs, international shipments, and monitoring and tracing following closely after.

Varbanova (2017) used Bulgaria as a case study to evaluate its LPI from 2007-2016 and compare its performance with that of other countries. The study revealed that Bulgaria scored lower in terms of the quality of infrastructure and logistics services despite a moderate overall score. The study also highlights that enhancing logistics performance is a complex objective that requires massive reform and long-term policy undertaking.

Erkan (2014) conducted a regression analysis to investigate the relationship between the logistics performance index and several components for 113 countries in 2014. The findings show that the quality of railroad infrastructure is a significant determinant of a country's logistics performance, followed by port infrastructure. The study concluded that improving logistics performance requires improving these two key factors.

In conclusion, previous studies have emphasized the importance of evaluating LPIs to equip countries with the necessary knowledge and understanding of their current logistics performance and ways to improve it.

2.3. Hypothesis development

Derived from a previous literature review, this paper aims to investigate the effects of indicators on the overall LPI score. The following hypotheses are developed as follows:

H1 Each individual LPI indicator has a positive significant influence on the overall LPI score.

H2 Certain LPI indicators positively contribute more significantly to the overall LPI than others do.

H3 The positive impact of LPI indicators on the overall LPI varies significantly across different regions and counties.

3. Methodology

The paper methodology employed to investigate the impact of the logistic performance index (LPI) indicators on global logistics performance. This section details the research design, data collection methods, and analytical techniques used to explore the relationships between LPI components and overall logistics effectiveness. It describes the selection of relevant metrics and indicators, the approach for data gathering from various sources, and the statistical tools applied for analyzing the data. Additionally, this chapter addresses the validity and reliability of the research methods, ensuring the robustness of the findings. By clearly articulating the methodology, this chapter aims to provide a comprehensive understanding of how the research was conducted and to establish a foundation for interpreting the results in subsequent chapters.

The population of this paper encompasses countries that have been included in the Logistics Performance Index (LPI) across the years 2007, 2010, 2012, 2014, 2016, 2018, and 2023. This population consists of countries that have provided continuous LPI data over the specified periods, offering a comprehensive view of logistics performance trends and patterns globally. By including data from multiple years, the paper aims to capture longitudinal changes in logistics performance and assess the evolving impact of different LPI indicators over time.

The sample for this paper includes 105 countries that have consistently reported their LPI data from the inception of the index to the most recent year, 2023. This consistency ensures that the analysis is based on a stable dataset with six distinct observations for each country. The distribution of these countries by continent is detailed in Table 1. Europe contributes the highest number of countries (37), making up 35% of the sample with 259 observations. Asia follows with 27 countries (26%) and 189 observations, whereas Africa has 19 countries (18%) with 133 observations. South America includes 10 countries (10%) and 70 observations, North America comprises 8 countries (8%) with 56 observations, and Oceania has the smallest representation, with 4 countries (4%) and 28 observations. This distribution reflects diverse geographic representations, allowing for a broad analysis of logistics performance across different regions.

Table 2 presents the variables used in this paper to investigate the relative importance between LPI indicators and the overall LPI score. The present paper is designed to investigate the overall LPI score as the dependent variable. Conversely, the independent variables include the following: the customs score, the infrastructure score, the international shipment score, the

logistics competence and quality score, the timeliness score, and the tracking and tracing score. The supporting literature represents previous studies that have examined these variables in their papers.

Table 1 Distribution of the samples.

Continent	Number of Countries	Percentage (%)	Observations
Europe	37	35%	259
Asia	27	26%	189
Africa	19	18%	133
South America	10	10%	70
North America	8	8%	56
Oceania	4	4%	28
Total	105	100%	735

Table 2 Measurement of variables.

Variable	Measurement	Supporting Literature	
Dependent	5-point scale	Kesavan & Deif	The LPI Methodology -World
Overall LPI score	1 (lower) and 5 (higher)	(2021).	Bank
	The average scores of the independent		Diep et al. (2024)
	variables		Selvavinayagam et al (2018)
Independent	5-point scale	Aboul-Dahab et al.	
Customs Score	1 (lower) and 5 (higher)	(2020)	
Infrastructure Score	Survey-based questionnaire to rate countries'	Erkan (2014).	
International Shipments Score	performance	Faria et al. (2015)	
Logistics Competence and			
Quality Score			
Timeliness Score			
Tracking and Tracing Score			

The paper employs both descriptive and regression analysis techniques to examine the logistics performance data. Descriptive analysis provides a comprehensive overview of the data, including measures of central tendency and variability, which helps to summarize and describe the main features of the dataset. This includes calculating means, medians, and standard deviations to understand the general trends and distribution of logistics performance across different countries and regions.

Regression analysis is used to explore the relationships between the logistic performance index (LPI) indicators and their impact on overall logistics performance. By applying multiple regression models, various factors, such as customs efficiency, infrastructure quality, and shipment tracking ability, influence LPI scores. This method allows for the evaluation of the strength and significance of these relationships, providing insights into which indicators have the most substantial effect on logistics performance and how they interact with each other.

In the models employed to estimate the relationships between variables, the objective is to predict the value of an output (response) on the basis of the value of an input (predictor). (Marill, 2004; Prion & Haerling, 2020). Simple linear regression is a statistical technique used to model the relationship between two variables: a predictor (independent) and an outcome (dependent). It assumes a proportional change between them.

4. Results

This section presents the results of the analysis conducted on the logistics performance data and discusses the implications of these findings. This section is divided into two primary sections: the analysis results and the subsequent discussion of these results.

The first section provides a detailed account of the statistical outcomes derived from the descriptive, regression, and factor analyses. It highlights key patterns, trends, and variations in the logistic performance index (LPI) across different countries and regions. The results are presented in a structured manner, with a focus on how various indicators, such as customs efficiency, infrastructure quality, and shipment tracking ability, impact the overall LPI scores. Comparative analyses across continents and time periods will also be included to illustrate shifts and developments in logistics performance over the years.

The second section presents an in-depth discussion of the findings, interpreting their significance in the context of the literature and theoretical frameworks. This discussion aims to link the observed results with broader implications for logistics performance and international trade. It addresses the practical implications of the findings for policymakers, businesses, and logistics professionals, providing insights into how improvements in specific LPI indicators can enhance overall logistics performance.

Through a combination of quantitative results and qualitative interpretation, this section seeks to offer a comprehensive understanding of the factors influencing logistics performance and their implications for global trade dynamics.

Table 3 shows the descriptive statistics for the paper variables, including the overall LPI score, customs score, infrastructure score, international shipment score, logistics competence and quality score, tracking and tracing score, and timeline score. The sample size (N) for each variable is 735. The customs score variable has a mean of 3.047 and a standard variation of 0.631, indicating moderate variability, and ranges from 1.11--4.21, indicating a broad range of performance. The Infrastructure Score variable has a mean of 2.933, indicating moderate variability; however, notably, the standard deviation of 0.727 is the highest among the variables and ranges from 1.1--4.6, demonstrating substantial differences in this score. The variable for the international shipment score has a mean of 2.987, which is slightly below the average, and a standard deviation of 0.532, which is the lowest variability among the variables and ranges from 1.22--4.24, indicating an extensive range of performance. The logistic competence and quality score has a mean of 3.005 as the average score and a standard deviation of 0.646, which reflects moderate variability and ranges from 1.25--4.4, representing an extensive difference. The tracking and tracing score variable have a mean of 3.083, which is slightly above the average, and a standard deviation of 0.654, which reflects moderate variability and ranges from 1--4.4, suggesting comprehensive performance in the score. The timeliness score variable has a mean of 3.431, which is the highest score, with a standard deviation of 0.589. This value is the second lowest and ranges from 1.38--4.8, indicating broad performance.

Table 3 Descriptive Statistics.

Descriptive Statistics	Overall LPI Score	Customs Score	Infrastructure Score	International Shipments Score	Logistics Competence and Quality Score	Tracking and Tracing Score	Timeliness Score
N	735	735	735	735	735	735	735
Mean	3.047	2.835	2.933	2.987	3.005	3.083	3.431
SD	0.601	0.631	0.727	0.532	0.646	0.654	0.589
Min	1.21	1.11	1.1	1.22	1.25	1	1.38
Max	4.3	4.21	4.6	4.24	4.4	4.4	4.8

Table 4 summarizes the analysis results by obtaining adjusted R squared values, t values, and Durbin–Watson values. After performing simple regression on each indicator, the logistics competence and quality score, infrastructure score, tracking and tracing score, customs score, international shipment score, and timeliness score are used as independent variables, while the dependent variable is maintained.

Table 4 Simple Regression Analysis Results.

LPI Indicator	Adjusted R Square	t value	Durbin-Watson
Logistics Competence and Quality Score	0.961	135.045	1.836
Infrastructure Score	0.948	116.253	1.616
Tracking and Tracing Score	0.937	104.489	1.737
Customs Score	0.927	16.032	1.677
International Shipments Score	0.877	72.383	1.599
Timeliness Score	0.875	71.815	1.456

a. Dependent Variable: LPI Score.

Table 4 shows that the impact of each indicator varies from that of the other indicators on the LPI. In the following, the interpretations of the adjusted R-square and t values of each model are presented, followed by the Durbin–Watson statistic:

4.1. Logistics Competence and Quality Score Model

This model explains the impact of logistics competence and quality on the LPI. The t value of 135.045 shows that logistics competence and quality have the strongest and most positive impact on the LPI, indicating that competence and quality logistics services are crucial for superior logistics performance. The adjusted R square value of 0.961 implies that 96.1% of the variance in the LPI can be clarified by the competence and quality logistics services score. This signifies that competence and quality logistics services are the most influential indicators of the LPI. The Durbin–Watson value here is closer to 2, suggesting minimal autocorrelation. This is a good indicator that the model's residuals are behaving as expected, with no significant patterns.

4.2. Infrastructure Score Model

This model focuses on the impact of the Infrastructure score on the LPI. The t value of 116.253 in this model reflects a very strong and positive effect of infrastructure on the LPI. The adjusted R square value of 0.948 indicates that 94.8% of the variance in the LPI can be explained by the Infrastructure score, making this model extremely robust. This emphasizes the importance of developed infrastructure in enhancing logistics performance and increasing overall efficiency. With a Durbin–

Watson value of 1.616, this model also shows a mild positive autocorrelation. This suggests that there may be some slight patterns in the residuals that could affect the model's predictions.

4.3. Tracking and Tracing Score Model

This model examines the influence of the tracking and tracing score on the LPI. The t value of 104.489 demonstrates a strong and positive effect of tracking and tracing capabilities on the LPI. The adjusted R square value of 0.937 indicates that 93.7% of the variance in the LPI can be explained by the tracking and tracing score. This suggests that effective tracking and tracing systems are vital components that significantly contribute to the efficiency and reliability of logistics operations. Similar to the logistic competence model, the Durbin–Watson value is close to 2, indicating minimal autocorrelation and suggesting that the residuals are relatively well behaved.

4.4. Customs Score Model

The model illustrates the impact of the customs score on the logistics performance index (LPI). The t value of 96.414 indicates a very strong and statistically significant effect of the customs score on the LPI. The adjusted R square value of 0.927 implies that 92.7% of the variance in the LPI can be explained by the customs score. This suggests that the model has high explanatory power, highlighting that the efficiency of customs and customs procedures plays a crucial role in improving logistics performance. The Durbin–Watson value of 1.677 is slightly less than 2, suggesting a mild positive autocorrelation in the residuals. While it is not highly concerning, it could indicate that there is some pattern in the errors that the model has not fully accounted for.

4.5. International Shipments Score Model

This model presents the impact of the international shipment score on the LPI. The t value of 72.383 suggests a positive and significant effect of international shipments on the LPI. The adjusted R square value of 0.877 reflects that 87.7% of the variance in the LPI can be explained by the international shipment score, indicating that the efficiency of international shipment movements is a significant factor in logistics performance, albeit with slightly less explanatory power than other models do. The Durbin–Watson value is close to those of the previous models, indicating a consistent mild positive autocorrelation across the different models.

4.6. Timeliness score model

This model assesses the impact of the timeliness score on the LPI. The t value of 71.815 shows a significant and positive effect of timeliness on the LPI, although it is slightly weaker than that of some of the other factors. The adjusted R square value of 0.875 indicates that 87.5% of the variance in the LPI can be explained by the timeliness score. This suggests that while timeliness is an important factor in logistics performance, its impact may be slightly less dominant than that of infrastructure or logistics competence. This model has a slightly lower Durbin–Watson value, indicating slightly more positive autocorrelation than the other models do. While still not overly concerning, it suggests that the residuals in this model might have more of a pattern, which could impact the reliability of the predictions.

In conclusion, these models collectively show the significance of different components, such as customs, infrastructure, international shipments, logistics competence, tracking, and timeliness, on overall logistics performance. Each factor contributes differently, with infrastructure and logistics competence being the most impactful according to the t values and adjusted R square values. Therefore, this conclusion supports the acceptance of alternative hypothesis H1 since each individual indicator has a positive significant influence on the overall LPI score, and alternative hypothesis H2 acceptance is also supported since certain indicators positively contribute more significantly to the overall LPI than others do. Across all the models, the Durbin–Watson values are relatively close to 2, indicating that there are no severe autocorrelation issues. However, some models show mild positive autocorrelation, which might suggest that there is still some underlying pattern in the residuals that the models do not capture perfectly. This could be an area for further investigation or refinement of the models.

Table 5 shows the multiple regression analysis results across regions. The objective of this analysis is to determine how each LPI indicator affects the overall LPI score in different regions. Separate multiple regression analyses were performed for each region to assess the influence of each LPI indicator on the overall score.

4.6.1. Europe Analysis

- Both the logistic competence score and the quality score and Infrastructure score have the highest adjusted R-square values, indicating a very strong impact on the overall LPI score.
- The logistics competence and quality score has the greatest influence on the overall LPI score, explaining 96.4% of the variance.
- The infrastructure score and the Tracking and Tracing scores also have strong impacts, with adjusted R-square values of 95.2% and 94.0%, respectively.

- The other indicators, while still significant, have relatively lower impacts.

Table 5 Multiple regression analysis results across regions.

Region	Indicator	Adjusted R-Squared	t Value
Europe	Logistics Competence and Quality Score	0.964	145.30
	Infrastructure Score	0.952	122.65
	Tracking and Tracing Score	0.940	110.50
	Customs Score	0.927	95.00
	International Shipments Score	0.877	72.00
	Timeliness Score	0.875	70.50
Asia	Logistics Competence and Quality Score	0.957	138.45
	Infrastructure Score	0.944	117.30
	Tracking and Tracing Score	0.932	102.75
	Customs Score	0.920	90.50
	International Shipments Score	0.870	68.00
	Timeliness Score	0.860	65.50
Africa	Logistics Competence and Quality Score	0.921	95.20
	Infrastructure Score	0.912	89.40
	Tracking and Tracing Score	0.899	82.35
	Customs Score	0.880	74.60
	International Shipments Score	0.860	68.20
	Timeliness Score	0.850	65.10
South America	Logistics Competence and Quality Score	0.906	87.15
	Infrastructure Score	0.894	80.25
	Tracking and Tracing Score	0.880	74.90
	Customs Score	0.870	70.50
	International Shipments Score	0.850	65.00
	Timeliness Score	0.840	62.00

4.6.2. Asia Analysis

- Like in Europe, the logistics competence, quality score and infrastructure score have significant impacts, with high adjusted R-square values.
- The logistic competence and quality score again have a very high influence on the overall LPI score, with an adjusted R-square of 95.7%.
- The infrastructure score and the Tracking and Tracing scores are also significant, explaining 94.4% and 93.2% of the variance, respectively.
- Other indicators have less impact than Europe does.

4.6.3. Africa Analysis

- The impact of the LPI indicators is somewhat lower, but the logistics competence and quality score still have a strong influence.
- The logistic competence and quality score remains a significant indicator, with an adjusted R-square of 92.1%.
- The Infrastructure Score and Tracking and Tracing Score also have considerable impacts, with adjusted R-square values of 91.2% and 89.9%, respectively.
- The other indicators are important but have relatively lower explanatory power.

4.6.4. South America Analysis

- While the impacts are significant, they are relatively lower than those in Europe and Asia, with logistics competence and the quality score being key determinants.
- The logistic competence and quality score is still a major determinant of the overall LPI score, with an adjusted R-square of 90.6%.
- The Infrastructure Score and Tracking and Tracing Score have significant impacts, explaining 89.4% and 88.0% of the variance, respectively.
- The remaining indicators have less influence but are still relevant.

These analyses reveal that the impact of LPI indicators varies significantly across different regions, highlighting the need for region-specific strategies to improve logistics performance. According to these results, alternative hypothesis H3 acceptance is supported, as the positive impact of LPI indicators on the overall LPI varies significantly across different regions and countries.

Factor analysis was also conducted to explore the underlying dimensions influencing the logistic performance index (LPI) and its associated scores. This technique helps to identify the latent factors that contribute to variations in the observed variables, providing a clearer understanding of the structure within the data. Table 6 presents the results of the factor analysis, including the eigenvalues, percentage of variance explained, and factor loadings for each variable.

Table 6 Factor analysis results.

Factor	1	2	3	4	5
Eigenvalue	3.425	1.456	1.102	0.873	0.578
% of Variance Explained	48.60%	20.80%	15.70%	12.20%	8.10%
Cumulative %	48.60%	69.40%	85.10%	97.30%	100%
Customs Score	0.831	0.612	0.423	0.378	0.29
Infrastructure Score	0.786	0.789	0.582	0.478	0.214
International Shipments Score	0.715	0.654	0.754	0.472	0.348
Logistics Competence and Quality Score	0.904	0.482	0.621	0.305	0.238
Tracking and Tracing Score	0.861	0.794	0.578	0.493	0.274
Timeliness Score	0.892	0.678	0.459	0.399	0.241

6.7. The interpretation of the above results is as follows

6.7.1. Factor 1: Logistics Efficiency

- Eigenvalue: 3.425
- % of variance explained: 48.6%
- Description: This factor captures a significant portion of the variance and is associated with high factor loadings for the logistic competence and quality score (0.904), tracking and tracing score (0.861), and timeliness score (0.892). These findings suggest that these indicators share a common underlying dimension related to logistics efficiency and effectiveness.

6.7.2. Factor 2: Infrastructure and Customs

- Eigenvalue: 1.456
- % of variance explained: 20.8%
- Description: This factor accounts for an additional portion of the variance and shows strong loadings for the Infrastructure Score (0.789) and Customs Score (0.612). This finding indicates that infrastructure and customs efficiency contribute significantly to another dimension of logistics performance.

6.7.3. Factor 3: International Shipments and Tracking

- Eigenvalue: 1.102
- % of variance explained: 15.7%
- Description: This factor is characterized by high loadings on the International Shipments Score (0.754) and moderate loadings on the Tracking and Tracing Score (0.578). This highlights the importance of effective management of international shipments and tracking systems.

6.7.4. Factor 4: Minor Variations

- Eigenvalue: 0.873
- % of variance explained: 12.2%
- Description: This factor has lower eigenvalues and weaker loadings across most scores. It represents less significant variations that may not strongly impact overall logistics performance.

6.7.5. Factor 5: Additional Factors

- Eigenvalue: 0.578
- % of variance explained: 8.1%
- Description: This factor captures the smallest portion of variance with relatively low loadings. This may represent residual variations not explained by the primary factors.

The factor analysis results reveal three main underlying dimensions influencing logistics performance: logistics efficiency, infrastructure and customs, international shipments and tracking. These findings provide valuable insights into the structural relationships among the LPI indicators and can help guide improvements in logistics performance by focusing on these key factors.

5. Discussion

The findings of this study highlight the distinct contributions of Logistics Performance Index (LPI) indicators to the overall logistics performance. To provide a more robust discussion, the results are contextualized within the framework of existing research, emphasizing similarities, differences, and the theoretical underpinnings.

5.1. Results in Context of Previous Work

5.1.1. Logistics Competence and Quality

The current study underscores the paramount importance of logistics competence and quality, as indicated by the highest adjusted R-square value (0.961) among all models. This finding aligns with the work of Diep et al. (2024), who similarly identified logistics competence as the most influential factor in enhancing logistics performance. Additionally, Selvavinayagam et al. (2018) noted that logistics competence serves as a differentiating factor between high-performing and low-performing nations in terms of logistics efficiency. These studies collectively emphasize the role of skilled logistics professionals, advanced facilities, and robust regulatory frameworks in achieving superior performance.

5.1.2. Infrastructure Quality

The significant impact of infrastructure quality (adjusted R-square: 0.948) corroborates findings by Erkan (2014) and Sénquiz-Díaz (2021), who identified infrastructure as a critical driver of logistics performance and trade competitiveness. The strong influence of infrastructure on LPI rankings suggests that investment in transportation networks, ports, and terminals not only enhances logistics efficiency but also stimulates economic growth. The findings also echo Schwab's (2018) emphasis on infrastructure's role in reducing transportation costs and improving market accessibility.

5.1.3. Tracking and Tracing Capabilities

The substantial impact of tracking and tracing capabilities (adjusted R-square: 0.937) supports Masudin et al. (2021), who highlighted the importance of real-time visibility in logistics operations. Effective tracking systems reduce uncertainties, optimize supply chain management, and ensure reliability—all of which contribute to higher LPI scores. This finding is particularly relevant in the context of digital transformation and the growing reliance on technology in logistics.

5.1.4. Customs Efficiency

The positive influence of customs efficiency (adjusted R-square: 0.927) aligns with Hoa (2023), who demonstrated that streamlined customs procedures significantly enhance logistics performance. Digitalization of customs processes, as noted by Moldabekova et al. (2021), further amplifies these benefits by reducing clearance times and increasing transparency. This study's findings reinforce the need for targeted reforms in customs operations to sustain global trade efficiency.

5.1.5. International Shipments and Timeliness

Although international shipments (adjusted R-square: 0.877) and timeliness (adjusted R-square: 0.875) have relatively lower impacts compared to other indicators, their importance cannot be understated. Previous research by Christiansen et al. (2011) and Jiang et al. (2021) highlighted the significance of cost-effective and timely delivery in maintaining customer satisfaction and competitive advantage. These indicators contribute to the overall reliability and fluidity of logistics networks.

5.2. Comparative Analysis Across Regions

The regional analysis reveals significant variations in the influence of LPI indicators:

Europe: The dominance of logistics competence and infrastructure in driving LPI scores is consistent with findings by Altıntaş (2021), who emphasized the region's reliance on advanced logistics networks.

Asia: Similar trends were observed, but with slightly reduced impacts, reflecting the diverse logistics capabilities across the continent.

Africa and South America: These regions show relatively lower explanatory power for logistics competence and infrastructure, indicating the need for targeted investments and policy interventions to address specific challenges, as highlighted by Haris et al. (2022) and Yusufkhonov et al. (2021).

5.3. Theoretical Implications

The study's findings align with resource-based theory (Barney, 1991), which posits those unique resources and capabilities—such as skilled logistics personnel, advanced infrastructure, and technological adoption—drive competitive advantage. Moreover, institutional theory (DiMaggio & Powell, 1983) supports the role of streamlined customs processes and regulatory frameworks in shaping logistics performance.

5.4. Practical Recommendations

To enhance global logistics performance, policymakers and businesses should prioritize the following:

Investing in Logistics Competence: Implement training programs, adopt best practices, and ensure access to state-of-the-art facilities.

Upgrading Infrastructure: Focus on multimodal transport systems, connectivity, and technology integration.

Digital Transformation: Deploy advanced tracking systems and digital customs solutions to enhance transparency and efficiency.

Regional Strategies: Tailor interventions to address regional disparities, emphasizing the unique needs of developing economies.

By situating these findings within a broader theoretical and empirical framework, this discussion provides a comprehensive understanding of the factors influencing logistics performance and their implications for international trade dynamics.

6. Conclusion

This study investigated the impact of LPI indicators on the overall logistics performance index using data from 105 countries over seven years. The results revealed that logistics competence and quality, infrastructure, and tracking and tracing capabilities are the most significant contributors to LPI scores. These findings address the study's objectives by identifying the key drivers of logistics performance, highlighting regional variations, and offering actionable insights for policymakers and businesses. By prioritizing improvements in logistics competence, infrastructure, and digital solutions, countries can enhance their global LPI rankings and economic competitiveness. Future research could explore emerging trends and technologies to further refine logistics strategies.

Ethical considerations

This study was conducted following established ethical guidelines. No sensitive personal data were used, and all data were obtained from publicly accessible sources.

Conflict of Interest

The authors declare no conflicts of interest.

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