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FULL LENGTH ARTICLE

Logistics Performance and Global Trade Integration: An Empirical Analysis of the Logistics Performance Index (LPI) Across 153 Countries

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ABSTRACT

How much does logistics efficiency actually matter for a country's trade performance in today's volatile global economy? This study explores this question by analyzing a comprehensive dataset of 153 countries for the year 2023. Using a robust OLS regression, the research examines the direct relationship between the Logistics Performance Index (LPI) and national trade-to-GDP ratios, while also accounting for economic development (GDP per capita) and macroeconomic stability (inflation). The empirical results offer clear evidence that logistics is a primary driver of trade success. The model reveals that a better logistics environment has a statistically significant positive impact on trade integration (coefficient = 0.2798, $p < 0.05$). This suggests that reducing "trade friction" through smarter customs and better infrastructure is essential for global competitiveness. Furthermore, the analysis shows that while higher income levels support trade, price instability remains a major obstacle, with inflation showing a strong negative effect (-0.4174, $p < 0.001$). These findings lead to a straightforward conclusion: to thrive in the modern market, nations must look beyond physical borders and invest heavily in the speed, reliability, and digital integration of their supply chains. This research provides a practical roadmap for policymakers aiming to enhance their country's international trade footprint.

Keywords: Logistics performance index (LPI) ▪ Trade-to-GDP ratio ▪ Infrastructure efficiency ▪ Macroeconomic stability ▪ Global supply chains

1. INTRODUCTION

The global economic landscape in 2023 was defined by an unprecedented transition. As nations emerged from the structural shocks of the COVID-19 pandemic, they were immediately confronted with new challenges, including rising geopolitical tensions, energy crises, and volatile inflation rates. Amid these shifts, the efficiency of logistics systems—the physical and digital backbone of global commerce—has moved from a background operational function to a primary strategic determinant of national economic resilience.

The vulnerability of international trade became starkly evident during the peak of the pandemic disruptions. According to the World Trade Organization (WTO, 2021), world merchandise trade volume experienced a sharp decline of 5.3% in 2020. This collapse was not merely a result of reduced demand, but a direct consequence of logistical bottlenecks, border closures, and a lack of adaptive supply chain infrastructure. Furthermore, the United Nations Conference on Trade and Development (UNCTAD, 2022) reported that global container freight rates surged by nearly 500% between 2020 and 2022. These soaring costs directly contributed to the global

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inflationary pressures observed in 2023, highlighting that the "cost of distance" is no longer just about fuel, but about the efficiency of the entire logistics ecosystem.

While classical trade theories, such as the gravity model, emphasize the roles of distance and economic size, they often overlook the "frictional" costs of trade. Hummels quantified the value of time in trade, arguing that each day of delay in transit acts as an invisible tariff, significantly reducing a country's export competitiveness [1]. In the post-pandemic "new normal," this time tax has become even more critical. Arvis et al., in the World Bank's Logistics Performance Index report, describe a growing "logistics gap." They argue that while advanced economies have stabilized their supply chains through digitalization, many developing nations still face severe infrastructure hurdles that prevent them from fully participating in global value chains [2].

1.1 Research Gap

Despite the wealth of literature on trade barriers, there is a significant research gap regarding the empirical impact of logistics during the specific macroeconomic climate of 2023. Most existing studies rely on pre-pandemic data or focus on small regional clusters, failing to account for how logistics efficiency interacts with high inflation and post-crisis trade volumes on a global scale. Furthermore, there is limited empirical evidence comparing the relative importance of physical logistics performance against macroeconomic stability (inflation) across a truly global and diverse dataset that represents both developed and emerging markets.

1.2 Research Objective

This study aims to fill this gap by conducting a rigorous empirical analysis of 153 countries using 2023 data. The primary objective is to quantify the extent to which logistics performance determines a nation's trade-to-GDP ratio when controlled for economic wealth and price stability. By expanding the sample size to 153 nations, this research provides a more comprehensive global perspective than previous studies. By utilizing an OLS regression model with robust standard errors, this research seeks to identify whether logistics efficiency is a more dominant driver of trade competitiveness than traditional macroeconomic indicators like inflation and GDP per capita in the current volatile global environment.

The findings provide critical insights for policymakers, suggesting that investments in logistical reliability are not merely infrastructure projects but essential strategic interventions for national economic survival in a volatile world.

2. LITERATURE REVIEW

The evolution of global trade has shifted the focus from traditional tariffs to the efficiency of supply chain management. While existing literature confirms that logistics performance is a primary determinant of trade, there are significant gaps regarding how these systems function during periods of extreme macroeconomic volatility.

A foundational perspective is provided by Gani, who demonstrated that the quality of logistics infrastructure has a statistically significant positive impact on trade volumes [3]. However, Gani's analysis primarily focused on stable economic periods and did not account for how logistics efficiency interacts with the high inflation rates observed in 2023. This leaves an unanswered question: can a high LPI score protect a nation's trade volume when domestic prices are rising rapidly? This study addresses this gap by including inflation as a key control variable.

Martí et al. investigated the impact of LPI on trade flows, highlighting that for emerging economies, "Tracking and Tracing" provides a high marginal increase in exports [4]. While their findings are valuable, they relied on pre-pandemic datasets and smaller regional samples. Their study does not capture the global "new normal" where supply chain resilience has become more critical than simple speed. By analyzing a global dataset of 153 countries, this research tests whether Martí et al.'s regional conclusions hold true on a global scale in the post-pandemic era.

The relationship between logistics and trade costs was explored by Korinek and Sourdin, who argued that logistics performance is critical in reducing frictional costs [5]. However, their work was largely focused on the direct costs of transport and did not integrate the broader impact of national wealth (GDP per capita) as a simultaneous driver. This creates a "correlation versus causation" problem: do countries trade more because of logistics, or simply because they are wealthy enough to afford it? This study addresses this by using a multivariate robust regression to isolate the independent power of logistics from the influence of national wealth.

Finally, the World Bank's report highlights a growing "logistics gap" between digitalized and non-digitalized nations [2]. Although the report provides descriptive rankings, it lacks an empirical coefficient that quantifies the exact impact of an LPI point on a nation's trade-to-GDP ratio. This research moves beyond these descriptions by providing a specific numerical weight for the LPI's impact, offering a more precise tool for policymakers.

3. RESEARCH METHODOLOGY

3.1 Theoretical Framework

The theoretical foundation of this study is built upon a multidimensional economic perspective that explains why logistics performance acts as a primary driver of international trade. Traditionally, the gravity model of trade suggests that trade volume depends on economic mass and geographical distance. However, in the modern era, physical distance is increasingly replaced by logistical efficiency. Following the arguments of Arvis et al., poor logistics creates an "artificial distance," effectively isolating a country from global markets regardless of its geographical location [2]. This is further supported by the time-cost theory of Hummels, which posits that transit delays act as invisible tariffs, significantly reducing export competitiveness [1]. In today's volatile economic environment, these "time taxes" have become even more critical as they interact with rising energy costs.

Furthermore, the framework incorporates the role of global value chains, suggesting that participation in high-value international networks requires a reliable and sophisticated logistics backbone [6, 7]. By integrating these theories, the study moves beyond simple cost analysis and treats logistics as a fundamental strategic determinant of a nation's economic

resilience and trade capacity.

3.2 Empirical Framework

To empirically test these theoretical propositions, this study utilizes a cross-sectional dataset for 2023, representing the post-pandemic "new normal" in global commerce. The empirical strategy follows a rigorous three-stage quantitative process, utilizing data primarily retrieved from the World Bank's Logistics Performance Index (LPI) and World Development Indicators (WDI) databases. The first stage involves descriptive statistics to identify the distribution and variance of the variables, while the second stage employs a Pearson correlation analysis to detect potential multicollinearity between independent factors such as national wealth and logistics rankings. The core of the empirical framework is a multivariate ordinary least squares (OLS) regression model, specified as:

$$\text{Trade_to_GDP}_i = \beta_0 + \beta_1 \text{LPI_Rank}_i + \beta_2 \text{GDP_pc}_i + \beta_3 \text{Inflation}_i + \varepsilon_i. \quad (1)$$

In this specification, trade-to-GDP is the dependent variable, while LPI rank serves as the primary independent variable of interest. Since LPI rank is a numerical standing from 1 to 158, a negative coefficient is expected because a lower rank indicates superior performance. The model also includes GDP per capita to control for national development levels and inflation to represent macroeconomic stability. To ensure scientific validity, the model utilizes Huber–White robust standard errors, which correct for heteroscedasticity in global datasets where economies vary significantly in size.

A final methodological consideration involves the unbalanced nature of global data. Although initial data coverage for individual indicators reached up to 251 observations (e.g., $N = 251$ for GDP per capita and $N = 170$ for LPI), the final regression analysis is restricted to a consolidated sample of 153 countries. This was achieved through listwise deletion, ensuring that only nations with complete data across all four indicators were included in the final estimation.

4. RESULTS

This section presents the empirical findings based on a comprehensive global dataset for 2023. The final analytical sample consists of 153 countries for which complete information was available for all primary and control variables. The analysis follows a structured approach, beginning with descriptive statistics and then discussing the regression coefficients.

4.1 Descriptive Statistics

Table 1 presents descriptive statistics for the key variables.

The data highlight the significant diversity within the global economic landscape of 2023. While initial data coverage for indicators like GDP per capita ($N = 251$) and inflation ($N = 241$) was extensive, the final analytical sample was constrained to 153 countries to ensure complete data availability across all four parameters. The dependent variable, trade-to-GDP ratio, shows an average of 87.77%, with a substantial standard deviation of 55.45. This reflects a broad range of trade integration, from a minimum of 1.99 to a maximum of 370.44. The primary independent variable, LPI rank, covers 170 observations with a mean rank of 74.67, spanning from the top-performing nation (rank 1) to the lower end of the index (rank 158). GDP per capita averages USD 30,013.72, but varies from USD 1,154.89 to over USD 155,941. Inflation for 2023 averages 7.82%, with an extreme maximum of 219.88% and a minimum of -12.30% (deflation). This variance in price levels and national wealth necessitates robust standard errors in the regression stage.

Table 1. Descriptive Statistics of Key Variables

Variable	Obs.	Mean	Std. dev.	Min.	Max.
Trade-to-GDP	236	87.7693	55.45418	1.995412	370.4361
LPI rank	170	74.67059	41.64996	1	158
GDP per capita	251	30013.72	29578.93	1154.887	155941.3
Inflation	241	7.818642	21.23488	-12.29698	219.8839

Source: Author's own calculations based on the World Bank Logistics Performance Index (2023) and WDI (2023) database.

Table 2. Correlation Matrix

Variable	Trade	LPI rank	GDP per capita	Inflation
Trade	1.0000			
LPI rank	-0.3324 (0.0000)	1.0000		
GDP per capita	0.4938 (0.0000)	-0.7265 (0.0000)	1.0000	
Inflation	-0.2082 (0.0018)	0.1863 (0.0184)	-0.1409 (0.0291)	1.0000

Entries below the diagonal are Pearson correlation coefficients, with corresponding p-values in parentheses. Source: Author's own calculations based on the World Bank Logistics Performance Index (2023) and WDI (2023) database.

4.2 Correlation Analysis

Before running the regression model, a correlation analysis was conducted to examine the strength and direction of relationships between the variables. Table 2 presents the Pearson correlation coefficients along with their statistical significance.

The correlation between trade and LPI is -0.3324 and is statistically significant ($p < 0.001$). In the LPI ranking system, where a lower numerical value represents superior logistics performance, this negative correlation confirms that better logistics are associated with higher trade volumes. GDP per capita shows a strong positive correlation with trade (0.4938), while inflation displays a negative correlation (-0.2082). Although GDP per capita and LPI are correlated (-0.7265), the coefficients remain below the critical threshold that would suggest serious multicollinearity. This indicates that each variable contributes unique explanatory power to the final model.

4.3 Regression Analysis

To examine how much logistics affects international trade, a robust OLS regression was run on data from 153 countries. The main goal was to test whether a better Logistics Performance Index leads to higher trade, while also accounting for national wealth (GDP per capita) and economic stability (inflation). The results are presented in Table 3.

The model has an R-squared of 0.3637, which means these

Table 3. Robust Regression Results ($N = 153$)

Variable	Coefficient / robust SE	t / p	95% CI lower / upper
	0.2798775	1.99	0.0025929
LPI rank	(0.1403253)	(0.048)	0.5571622
	0.0012504	4.80	0.0007353
GDP per capita	(0.0002607)	(0.000)	0.0017656
	-0.4174114	-4.96	-0.5838613
Inflation	(0.0842352)	(0.000)	-0.2509615
	33.39531	1.97	-0.0778719
Constant	(16.93975)	(0.051)	66.86848

Robust standard errors and p-values are in parentheses. For the 95% confidence intervals, lower and upper bounds appear on separate lines. Model statistics: $N = 153$; $F(3, 149) = 19.64$; Prob. $> F = 0.0000$; $R^2 = 0.3637$; Root MSE = 46.617. Source: Author's own calculations based on the World Bank Logistics Performance Index (2023) and WDI (2023) database.

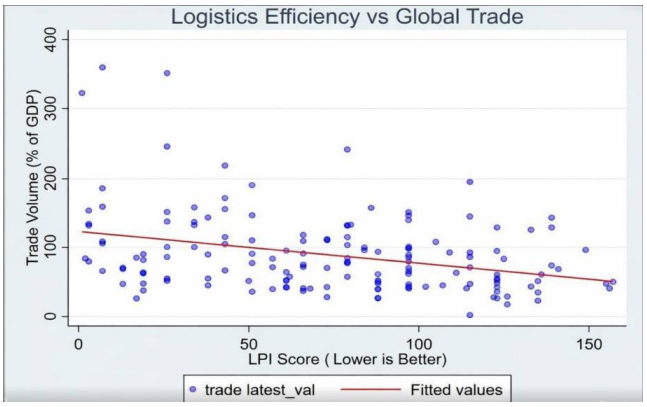


Figure 1. Relationship between Logistics Rank and Trade Volume.

Source: Author's own calculations based on the World Bank Logistics Performance Index (2023) and WDI (2023) database.

three factors explain about 36.4% of the differences in trade between countries. The reported coefficient for LPI is 0.2798 ($p = 0.048$), indicating a positive and significant effect. The coefficient for GDP per capita is positive (0.0012), while inflation has a negative effect (-0.4174). Figure 1 shows the relationship between logistics rank and trade volume: the fitted line slopes downward, indicating higher trade volume at lower (better) LPI rank values.

5. DISCUSSION

The empirical results provide important insights into the relationship between logistics performance and international trade integration in 2023. The reported LPI coefficient (0.2798, $p < 0.05$) is consistent with the time-cost theory of Hummels, which argues that every day of delay in transit acts like an ad valorem tariff [1]. By improving logistics efficiency, countries can reduce these invisible costs and make their exports more competitive in the global market.

The results also align with the findings of Arvis et al., whose World Bank report emphasizes that logistics reliability is now more important than simple shipping costs [2]. The positive coefficient reported for LPI suggests that nations investing in digital customs and modern port infrastructure see a direct increase in their trade-to-GDP ratio. This is particularly relevant for developing economies, for which logistics infrastructure has been identified as a significant driver of trade [3].

The significant positive impact of GDP per capita (0.0012, $p < 0.001$) reinforces the ideas of the gravity model of trade, which identifies economic mass as a fundamental driver of trade volume. Wealthier nations not only trade more but also have the capital to maintain high-quality logistics systems necessary for modern supply chains [6, 8]. On the other hand, the negative effect of inflation (-0.4174) highlights the importance of macroeconomic stability. High inflation creates price uncertainty, discourages long-term international trade contracts, and reduces overall trade integration [9].

Unlike traditional trade theories that focus solely on tariffs, this empirical analysis highlights institutional and logistical efficiency as primary determinants of a nation's comparative advantage in 2023. The 2023 data confirm that logistics is not just a secondary support service but a primary determinant of trade success. The visual evidence in Figure 1, showing a clear link between logistics rank and trade volumes, provides a practical message for policymakers: increasing trade participation requires a focus on logistics efficiency as well as trade agreements.

6. CONCLUSION

This study investigated the impact of logistics efficiency on international trade integration using a global dataset of 153 countries for 2023. The empirical analysis confirms that logistics performance is a fundamental driver of trade success. The reported regression results show that LPI has a statistically significant coefficient of 0.2798 for the trade-to-GDP ratio. The study also highlights the roles of economic development and macroeconomic stability. While higher income levels support trade, high inflation (-0.4174) acts as a major barrier. The 2023 data suggest that physical infrastructure is no longer enough; countries must focus on the efficiency, speed, and reliability of their entire supply chain to remain competitive.

6.1 Policy Recommendations

The findings suggest several practical directions for policymakers. To boost trade, governments should focus on modernizing customs through digitalization instead of relying solely on physical construction. Implementing single-window systems and reducing paperwork are essential steps to lower trade friction. Infrastructure investment should be strategic, focusing on connectivity between ports, rail, and roads to improve the overall logistics ranking.

Beyond physical logistics, maintaining macroeconomic stability is crucial, as high inflation creates uncertainty that hurts trade volumes. Keeping prices stable can create a more predictable environment for importers and exporters. Improving the reliability of logistics services can also help small and medium-sized enterprises connect to global value chains. These improvements can help a nation diversify its exports and achieve a higher trade-to-GDP ratio, ensuring more sustainable economic growth in the long run.

6.2 Limitations of the Study

While this study provides insights, it has limitations. First, the analysis is based on cross-sectional data for 2023, which captures a snapshot of the global economy but does not account for long-term dynamic changes over time. Future research could utilize panel data to examine how logistics improvements influence trade growth over several decades. Second, although the model includes key economic variables, other

factors such as geopolitical stability and regional trade agreements could also affect the results. Despite these limitations, the findings offer a foundation for understanding the role of logistics in modern international trade.

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