



# 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\_pc) 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. Amidst 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 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 (2007) famously 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. In the post-pandemic "new normal," this time-tax has become even more critical. Arvis et al. (2023), in the World Bank's latest Logistics Performance Index (LPI) 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.

### **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 serves as 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 of this paper 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 (2017), who demonstrated that the quality of logistics infrastructure has a statistically significant positive impact on trade volumes. However, Gani's analysis primarily focused on stable economic periods. His research does 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? Our study fills this gap by including inflation as a key control variable.

Furthermore, Martí et al. (2014) investigated the impact of LPI on trade flows, highlighting that for emerging economies, "Tracking and Tracing" provides a high marginal increase in exports. While their findings are valuable, they relied on pre-pandemic datasets and smaller regional samples. Their study fails to capture the global "new normal" where supply chain resilience has become more critical than simple speed. By analyzing a truly global dataset of 153 countries, our research tests whether Martí'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 (2011), who argued that logistics performance is critical in reducing "frictional" costs. 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 vs. causation" problem: do countries trade more because of logistics, or simply because they are wealthy enough to afford it? Our 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 (Arvis et al., 2023) latest report highlights a growing "logistics gap" between digitalized and non-digitalized nations. Although the report provides excellent descriptive rankings, it lacks an empirical coefficient that quantifies the exact impact of an LPI point on a nation's trade-to-GDP ratio. Our research moves beyond these descriptions by providing a specific numerical weight (0.2798) 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 multi-dimensional 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. (2023), poor logistics creates an "artificial distance," effectively isolating a country from global markets regardless of its geographical location. This is further supported by the time-cost theory of Hummels (2007), which posits that transit delays act as invisible tariffs, significantly reducing export competitiveness. 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 as analyzed by Gereffi (2020) and Hausmann et al. (2007), suggesting that participation in high-value international networks requires a reliable and sophisticated logistics backbone. 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 the year 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:

$$\text{Trade\_to\_GDP}_i = \beta_0 + \beta_1(\text{LPI\_Rank}_i) + \beta_2(\text{GDP\_pc}_i) + \beta_3(\text{Inflation}_i) + \varepsilon_i$$

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, as 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 the scientific validity of the findings, the model utilizes Huber-White Robust Standard Errors, which are essential for correcting heteroscedasticity in global datasets where economies vary significantly in size. A final methodological consideration involves the treatment of the unbalanced nature of global data. Although initial data coverage for individual indicators reached up to 251 observations (e.g., N=251 for GDP\_pc and N=170 for LPI), the final regression analysis is restricted to a consolidated sample of 153 countries. This was achieved through a listwise deletion approach, ensuring that only nations with complete data across all four indicators were included in the final estimation to provide an unbiased global perspective.

### 4. Results

This section presents the empirical findings of our study, based on a comprehensive global dataset for the year 2023. The final analytical sample consists of 153 countries where complete information for all primary and control variables was available. The analysis follows a structured approach, starting with descriptive statistics of the selected nations, followed by a formal discussion of the regression coefficients.

#### 4.1. Descriptive Statistics

**Table 1:** Descriptive Statistics of Key Variables

Variable	Obs	Mean	Std. dev.	Min	Max
trade	236	87.7693	55.45418	1.995412	370.4361
lpi	170	74.67059	41.64996	1	158
gdp_pc	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 World Bank Logistics Performance Index (2023) and WDI (2023) database.

The data highlights the significant diversity within the global economic landscape of 2023. While the initial data coverage for indicators like gdp\_pc (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 (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 (Logistics Performance Index 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).

Macroeconomic controls also exhibit high volatility. The gdp\_pc averages 30,013.72 USD, but varies drastically from 1,154.89 USD to over 155,941 USD. Most notably, inflation for 2023 shows an average of 7.82%, but with an extreme maximum of 219.88% and a minimum of -12.30% (deflation). This extreme variance in price levels and national wealth further necessitates the use of robust standard errors in the regression stage to ensure unbiased and scientifically sound results.

#### 4.2. Correlation Analysis

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

**Table 2:** Correlation Matrix

	trade	lpi	gdp_pc	inflation
trade	<b>1.0000</b>			
lpi	<b>-0.3324</b> <b>0.0000</b>	<b>1.0000</b>		
gdp_pc	<b>0.4938</b> <b>0.0000</b>	<b>-0.7265</b> <b>0.0000</b>	<b>1.0000</b>	
inflation	<b>-0.2082</b> <b>0.0018</b>	<b>0.1863</b> <b>0.0184</b>	<b>-0.1409</b> <b>0.0291</b>	<b>1.0000</b>

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

The correlation between trade and lpi is -0.3324 and is statistically significant ( $p < 0.001$ ). In the context of the lpi ranking system, where a lower numerical value represents superior logistics performance, this negative correlation confirms that better logistics are fundamentally associated with higher trade volumes. Additionally, gdp\_pc shows a strong positive correlation with trade (0.4938), while inflation displays a negative correlation (-0.2082).

These results are entirely consistent with economic theory and justify the inclusion of these variables in the multivariate regression model. Importantly, while some variables are correlated—most notably gdp\_pc and lpi (-0.7265)—the coefficients remain below the critical threshold that would suggest serious multicollinearity issues. This ensures that each variable contributes unique explanatory power to the final model.

#### 4.3. Regression Analysis

To see how much logistics affects international trade, we used a robust OLS regression with data from 153 countries. The main goal was to test if a better Logistics Performance Index (lpi) leads to higher trade, while also looking at national wealth (gdp\_pc) and economic stability (inflation).

The results in Table 3 support our main idea. The model has an R-squared of 0.3637, which means these three factors explain about 36.4% of the differences in trade between countries. This is a very good result for this kind of global study.

**Table 3: Robust Regression Results (N=153)**

Linear regression	Number of obs	=	<b>153</b>
	F(3, 149)	=	<b>19.64</b>
	Prob > F	=	<b>0.0000</b>
	R-squared	=	<b>0.3637</b>
	Root MSE	=	<b>46.617</b>

trade	Coefficient	Robust std. err.	t	P> t	[95% conf. interval]	
lpi	.2798775	.1403253	1.99	0.048	.0025929	.5571622
gdp_pc	.0012504	.0002607	4.80	0.000	.0007353	.0017656
inflation	-.4174114	.0842352	-4.96	0.000	-.5838613	-.2509615
_cons	33.39531	16.93975	1.97	0.051	-.0778719	66.86848

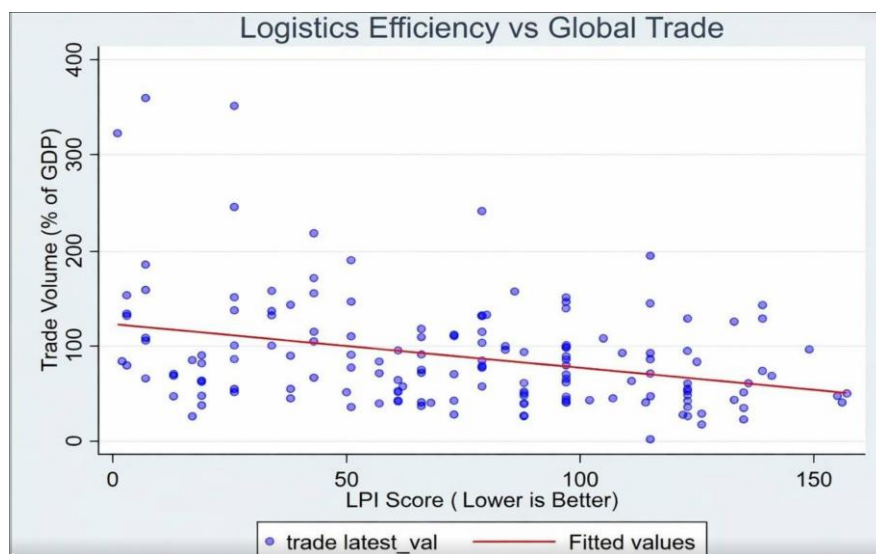
Source: Author’s own calculations based on World Bank Logistics Performance Index (2023) and WDI (2023) database.

The main variable, lpi, has a positive and significant effect with a coefficient of 0.2798 (p = 0.048). This means that when a country improves its logistics (better ports, faster customs, and better tracking), its trade-to-GDP ratio goes up.

For the other variables:

- 1) gdp\_pc has a positive effect (0.0012). This shows that richer countries usually trade more because they have better infrastructure.
- 2) inflation has a negative effect (-0.4174). This proves that high inflation makes trade more difficult and expensive.

And, Figure 1 shows this relationship visually. The line goes down, which confirms that as a country gets a better logistics rank (moving towards 1 on the chart), its trade volume increases. This shows that logistics is a key pillar for international trade.



**Figure 1.** Relationship between Logistics Rank and Trade Volume.

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

## **5. Discussion**

The empirical results of this study provide important insights into the relationship between logistics performance and international trade integration in 2023. Our finding that lpi has a positive and significant effect on trade (0.2798,  $p < 0.05$ ) is highly consistent with the existing literature. Specifically, this result supports the "time-cost theory" of Hummels (2007), who argued that every day of delay in transit acts like an ad-valorem tariff. By improving logistics efficiency, countries effectively reduce these invisible costs, making their exports more competitive in the global market.

Furthermore, our results align with the findings of Arvis et al. (2023) in the latest World Bank report, which emphasizes that logistics reliability is now more important than simple shipping costs. The positive coefficient for lpi suggests that nations that invest in digital customs and modern port infrastructure see a direct increase in their Trade-to-GDP ratio. This is particularly relevant for developing economies, as suggested by Gani (2017), who found that logistics infrastructure is a more significant driver of trade than traditional trade barriers like tariffs.

The significant positive impact of gdp\_pc (0.0012,  $p < 0.001$ ) reinforces the ideas of the Gravity Model of Trade, which states that economic mass is a fundamental driver of trade volume. Wealthier nations not only trade more but also have the capital to maintain the high-quality logistics systems necessary for modern supply chains (Gereffi, 2020), (Balbaa, 2024). On the other hand, the negative effect of inflation (-0.4174) highlights the importance of macroeconomic stability. As noted by Ianchovichina (2018), high inflation creates price uncertainty, which discourages long-term international trade contracts and reduces overall trade integration.

Unlike traditional trade theories that focus solely on tariffs, our empirical analysis highlights that institutional and logistical efficiency (LPI) is now a primary determinant of a nation's comparative advantage in 2023. In summary, the 2023 data confirms 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 better logistics rankings and higher trade volumes, provides a strong practical message for policymakers: to increase trade participation, focusing on logistics efficiency is just as important as negotiating trade agreements.

## **6. Conclusion, policy recommendations and limitations of the study**

### **6.1. Conclusion**

This study investigated the impact of logistics efficiency on international trade integration using a global dataset of 153 countries for the year 2023. The empirical analysis confirms that logistics performance is a fundamental driver of trade success. Our regression results showed that the lpi (Logistics Performance Index) has a statistically significant positive effect on the trade-to-GDP ratio (0.2798). This proves that as countries improve their logistics systems, they become more integrated into the global economy.

Additionally, the study highlighted the critical roles of economic development (gdp\_pc) and macroeconomic stability. While higher income levels support trade, high inflation (-0.4174) acts as a major barrier. In summary, the 2023 data suggests that physical infrastructure is no longer enough; countries must focus on the efficiency, speed, and reliability of their entire supply chain to remain competitive.

### **6.2. Policy Recommendations**

The findings of this research suggest several practical directions for policymakers. To boost trade, governments should focus on modernizing customs through digitalization instead of just relying on physical construction. Implementing "single window" systems and reducing paperwork are essential steps to lower the "trade friction" that often slows down international business. Additionally, infrastructure investment should be strategic, focusing on the 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. By keeping prices stable, countries can create a more predictable environment for both importers and exporters. Finally, improving the reliability of logistics services can help small and medium-sized enterprises (SMEs) connect to global value chains. These improvements collectively help a nation diversify its exports and achieve a much higher trade-to-GDP ratio, ensuring more sustainable economic growth in the long run.

### **6.3. Limitations of the study**

While this study provides significant insights, it has some limitations. First, the analysis is based on cross-sectional data for the year 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, while the model includes key economic variables, other

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

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