Effects of logistics performance distance on wine export: International evidence

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Abstract:

This study examines how differences in logistics performance between trading partners shape bilateral wine exports. Using data for 152 countries over 2007–2021, we construct a multidimensional measure of logistics performance distance based on the World Bank's Logistics Performance Index, capturing gaps in customs efficiency, infrastructure, shipment arrangements, logistics competence, tracking, and timeliness. Bilateral wine trade data are drawn from the BACI–CEPII database. The analysis employs a gravity model estimated using Poisson pseudo-maximum likelihood. The results show that greater logistics performance distance is significantly associated with lower bilateral wine exports, suggesting that logistics asymmetries may represent a persistent source of trade frictions. Decomposition results suggest that differences in customs efficiency, infrastructure, logistics competence, and timeliness account for much of this negative association. The impact is stronger for bottled wine than for bulk wine, consistent with the higher sensitivity of quality-oriented products to logistics conditions. Subsample analysis further indicates that the effect intensifies during periods of global economic stress and in country pairs involving landlocked economies. Robustness checks confirm that the results are not driven by cultural or religious factors, nor by the depth of trade agreements. Although deeper trade agreements are associated with higher exports, they do not eliminate the negative effect of logistics performance distance. These findings highlight the importance of logistics compatibility in international wine trade. Policy efforts should focus on improving customs procedures, infrastructure, and delivery reliability, while also promoting digitalization and deeper trade integration to reduce cross-border frictions.

Keywords: Logistics performance distance; Wine exports; Trade facilitation; Gravity model; International trade

JEL code: F13; F14; R41; Q17

1. Introduction

International wine trade has expanded steadily over recent decades, supported by rising incomes, evolving consumer preferences, and deeper integration of agri-food markets worldwide [1,2]. Wine is now traded across regions with markedly different production conditions, consumption habits, and regulatory environments. At the same time, it remains a highly differentiated product, closely associated with quality, origin, and reputation, and is sensitive to handling, storage, and delivery conditions. These features suggest that, beyond traditional determinants such as market size and geographic distance, the ability to move wine efficiently and reliably across borders may play an important role in shaping trade outcomes.

More recently, global disruptions have further highlighted the importance of logistics in sustaining international trade. The COVID-19 pandemic, in particular, exposed vulnerabilities in global supply chains, leading to delays, increased uncertainty, and reductions in logistics flows [3]. It also had pervasive effects on transportation networks and cross-border coordination, complicating the movement of goods across countries [4]. In this context, differences in logistics capabilities across countries may have become more salient, as exporters increasingly face the challenge of operating across heterogeneous and, at times, strained logistics environments.

Against this background, logistics performance has attracted growing interest in the international trade literature. Efficient customs procedures, well-developed transport infrastructure, reliable logistics services, and predictable delivery times are generally found to reduce trade costs and support export activity [5–7]. Empirical studies often show that countries with stronger logistics performance export more, especially in sectors that are time-sensitive or quality-sensitive, including agri-food products [8,9]. Still, most of this work focuses on the absolute level of logistics performance within individual countries.

In practice, however, international trade involves pairs of countries whose logistics systems may differ in important ways. Even when both partners perform relatively well on average, misalignment in customs procedures, infrastructure quality, or delivery reliability can create additional frictions. These frictions may raise coordination costs, extend transit times, and increase uncertainty for exporters. Despite its intuitive relevance, this relative aspect of logistics performance has received much less empirical attention. Existing studies tend to treat logistics performance as a country-specific characteristic and largely overlook the role of logistics asymmetries between trading partners.

This gap is especially apparent in the literature on wine trade. Gravity-based analyses of wine exports have highlighted the importance of economic size, distance, cultural ties, trade agreements, and product differentiation in shaping bilateral flows [2,10–12]. While transport and trade costs are acknowledged, logistics performance is often captured only indirectly, if at all. When logistics measures are included, they are usually defined at the exporter or importer level, without accounting for how compatible the logistics systems of trading partners actually are. As a result, there is limited evidence on whether and how differences in logistics performance between countries constrain wine exports.

This study seeks to address this gap by examining the effect of logistics performance distance on bilateral wine exports. Rather than relying on logistics levels, we construct a multidimensional measure of logistics performance distance using the World Bank's Logistics Performance Index (LPI). This measure captures gaps between exporting and importing countries in customs efficiency, infrastructure quality, shipment arrangements, logistics service competence, tracking and tracing, and delivery timeliness. From a conceptual perspective, logistics performance distance reflects the degree to which two logistics systems are misaligned, and thus the additional costs exporters may face when operating across heterogeneous logistics environments [13,14].

Wine trade provides a particularly suitable context for this analysis. Wine shipments are often subject to excise controls and inspections, are sensitive to temperature and handling conditions, and depend heavily on reliable delivery, especially for bottled and premium products. Previous research suggests that delivery delays and quality deterioration can have disproportionate effects on exports of differentiated goods [15]. It therefore seems likely that logistics asymmetries matter more for wine than for products that are less sensitive to quality and timing.

Using a large panel of bilateral wine trade flows covering 152 countries from 2007 to 2021, this study estimates a gravity model using Poisson pseudo-maximum likelihood to account for zero trade flows and heteroskedasticity [16]. In addition to examining the overall effect of logistics performance distance, the analysis decomposes this distance into its six underlying components to identify which dimensions of logistics divergence are most relevant. The study also explores time variation by assessing whether the impact of logistics performance distance changes across different periods, including episodes of global economic stress such as the global financial crisis.

This paper contributes to literature in several ways. First, it shifts the focus from the level of logistics performance to the distance between trading partners, providing empirical evidence that asymmetries in logistics systems are associated with lower international wine trade and may constitute a meaningful source of trade frictions. In doing so, it complements and extends existing studies that primarily examine logistics performance at the country level by introducing a relational perspective that captures mismatches in cross-border logistics environments. Second, by decomposing logistics performance distance into its underlying components, the paper identifies the logistics dimensions through which this negative relationship appears to be most pronounced. The results highlight the central role of customs efficiency, infrastructure quality, logistics service competence, and delivery timeliness, thereby offering a more granular understanding of how different dimensions of logistics contribute to shaping bilateral trade flows in a quality-sensitive sector such as wine. Third, the analysis uncovers important heterogeneity across products and over time. The negative association between logistics distance and exports is stronger for bottled wine than for bulk wine, reflecting differences in value, handling requirements, and sensitivity to delivery conditions. Moreover, the estimated relationship becomes more pronounced during periods of global disruption, suggesting that logistics compatibility plays a critical role in supporting trade resilience when supply chains are under stress.

The remainder of the paper is organized as follows. Section 2 reviews the related literature and outlines the conceptual framework. Section 3 describes the data, variable construction, and empirical strategy. Section 4 presents and discusses the estimation results. Section 5 concludes with policy implications and directions for future research.

2. Literature review

2.1. Conceptualization of logistics performance distance

The idea of logistics performance distance is meant to describe how different two countries are in terms of their logistics capabilities across several dimensions. Instead of looking only at how good a country's logistics system is on its own, this approach focuses on the gap between countries. That gap reflects differences in areas such as customs procedures, the quality of transport infrastructure, logistics services, and the reliability of deliveries. These differences may shape how easily goods move across borders and how costly those movements become.

In practice, logistics performance is often summarized by the Logistics Performance Index, which provides a common framework for comparing national trade logistics systems. When two countries have relatively similar logistics systems, meaning the distance between them is small, cross border transactions tend to involve fewer coordination problems and shorter delays. Uncertainty may also be lower. When the distance is larger, this usually points to deeper structural mismatches in logistics capacity, which can raise trade costs and make international supply chains harder to manage.

An important aspect of logistics performance in international trade is not only its absolute level within each country, but also the degree of alignment between trading partners. When logistics systems differ substantially, exporters may face additional coordination costs that arise from operating across heterogeneous institutional and operational environments. These costs can materialize in several ways, including longer clearance times, inconsistent documentation requirements, and reduced reliability in delivery schedules. As a result, even when one country has relatively efficient logistics, trade may still be hindered if its partner operates under significantly different or less efficient conditions.

This asymmetry perspective suggests that logistics performance distance captures a distinct source of trade frictions beyond average logistics quality. In particular, mismatches between highly efficient exporters and less efficient importers may create bottlenecks at critical points in the supply chain, such as customs processing or port handling, where the overall performance is effectively constrained by the weaker system. By contrast, when both trading partners operate at similar levels of logistics performance-even if not at the global frontier-cross-border processes tend to be more predictable and easier to coordinate. In this sense, logistics compatibility, rather than logistics performance alone, becomes a key determinant of bilateral trade outcomes.

There is considerable evidence suggesting that stronger logistics performance supports export competitiveness, mainly by reducing transport costs and easing access to foreign markets. This pattern appears clearly in the case of China, where higher LPI scores have been linked to stronger export outcomes [17]. Still, it is not only the level of logistics performance that matters. Differences in logistics efficiency between trading partners seem to create additional frictions. The LPI makes it possible to identify these gaps and, in doing so, helps highlight specific bottlenecks and asymmetries in cross border logistics systems [13].

Cross border logistics operations are rarely straightforward. They are often affected by differences in regulations, uneven use of technology, and coordination problems among logistics providers, customs authorities, and firms. These institutional and operational differences contribute directly to logistics performance distance. Earlier studies suggest that better alignment of cross border procedures, along with closer coordination between production and logistics activities, can improve distribution performance and reduce some of these frictions [18,14].

From a trade perspective, logistics performance distance appears to play an important role in shaping bilateral trade flows. While efficient logistics systems generally lower trade costs, the effects are not uniform across logistics components or types of goods. Evidence from gravity model studies, particularly in export oriented economies such as South Korea, shows that logistics efficiency is central to maintaining strong trade links, and that large differences in logistics performance can weaken those links [19].

Structural and technological conditions also seem to matter. Countries with weaker logistics systems often struggle with slow customs clearance, poor infrastructure, or limited logistics services, which tends to widen the gap with more advanced economies [9]. Regional initiatives designed to improve connectivity, including large infrastructure and trade facilitation programs, may help reduce logistics performance distance. Their success, however, likely depends on long term coordination and consistent institutional support [20].

Finally, logistics performance distance has implications for risk in international supply chains. When logistics capabilities differ widely across countries, supply chains may become more vulnerable to disruptions. Shocks in one part of the chain are harder to absorb when systems do not align well. Risk management frameworks therefore stress the importance of identifying these structural weaknesses early, as doing so can improve the resilience of cross border logistics networks [21].

2.2. Determinants of wine export

Within the gravity model framework, wine exports seem to be influenced by several overlapping forces. Economic conditions matter, but they are only part of the story. Cultural proximity, geography, trade rules, environmental conditions, and product characteristics also appear to shape export outcomes, sometimes in uneven ways across markets. Although the gravity model was first designed to explain bilateral trade flows using economic size and physical distance, it has gradually been adapted to the wine sector. This adaptation reflects the idea that wine trade depends not only on the economic strength of trading partners, but also on consumer tastes, institutional settings, and the fact that wine is a highly differentiated product.

Economic conditions in importing countries remain an important driver of wine exports. Higher GDP and GDP per capita are often associated with stronger demand for imported wines, as rising incomes tend to increase consumers' willingness to purchase foreign and higher quality products [10,11,22]. Exchange rate movements also appear to matter, although their effects are not uniform. When an exporter's currency depreciates, wines generally become more competitive in foreign markets. This can support export growth, especially for mid range wines that are more sensitive to price changes than premium labels [23,24]. Trade costs continue to shape export performance as well. Distance, tariffs, and non tariff measures affect market access, although recent studies suggest that not all non tariff measures act as binding barriers in the wine trade [24,25].

Cultural and taste related factors also play a noticeable role in bilateral wine trade. Shared language, historical links, and long standing migration patterns often make it easier for wines to enter foreign markets by lowering information and transaction costs and by increasing consumer familiarity with products from exporting countries [26,10,25,12]. In particular, emigrant communities seem to sustain demand for wines from their countries of origin, even when local substitutes are widely available. Geographical distance, which is usually a strong barrier in gravity models, appears to matter less for wine. This is likely related to wine's relatively high value compared to its weight and to the presence of well established shipping and distribution networks that help reduce transport costs [10]. Taste differences, sometimes captured by genetic or cultural distance, may still influence trade patterns, although premium wines often overcome these barriers through reputation and branding [27].

Trade policy and regulation further shape wine export outcomes. Lower tariffs and preferential trade agreements generally make it easier for wines to reach foreign markets by reducing direct trade costs. By contrast, tariff increases can quickly disrupt export flows. Recent discussions around possible U.S. tariff increases on Prosecco imports illustrate how sensitive wine exports can be to policy changes [28]. Beyond tariffs, non tariff barriers such as technical standards and sanitary requirements also matter. These regulations, particularly for still bottled wines, can be costly to meet and may discourage export participation, especially among smaller producers [29].

Environmental and climate related factors have become more visible in recent research on wine exports. Climate variability, including temperature anomalies, affects grape yields and wine quality, which in turn influences export supply. At the same time, climate conditions in importing countries may shape consumption patterns and preferences for certain types of wine [24]. Harvest conditions in exporting countries are especially important, since changes in both quantity and quality directly affect the ability to serve international markets [30].

Finally, product differentiation adds another layer to the gravity model analysis of wine trade. Different categories of wine, such as still wines and fortified wines, tend to respond differently to economic conditions, policy changes, and environmental factors. The growing international demand for high quality and origin specific wines, including Italian and Port wines, suggests that reputation and geographical indication play an increasingly important role in export success. This heterogeneity implies that exporters may benefit from tailored strategies that take into account the specific characteristics of each wine category [31,10,11].

2.3. Impact of logistics performance distance on wine export

In this study, the role of logistics in shaping wine exports is examined through the concept of logistics performance distance, defined as the multidimensional gap in logistics performance between exporting and importing countries. Unlike measures of absolute logistics efficiency, logistics performance distance captures how misaligned two countries are across key logistics dimensions, including customs efficiency, infrastructure quality, shipment arrangements, logistics service competence, and delivery timeliness. A larger logistics performance distance reflects greater asymmetry in logistics systems, which may raise coordination costs, increase delays, and introduce uncertainty into cross-border wine trade.

From a trade-cost perspective, logistics performance distance can be understood as an extension of the distance concept commonly used in gravity models. While geographic distance captures physical separation, logistics performance distance reflects institutional and operational frictions that arise when logistics systems are poorly matched. These frictions are particularly relevant for wine exports, given the product's sensitivity to transport conditions, storage requirements, and delivery reliability. When logistics performance differs substantially between trading partners, exporters may face longer transit times, higher administrative burdens, and greater risks of spoilage, all of which could discourage export activity and be associated with lower traded volumes.

Logistics performance distance may also interact with cultural and preference-related barriers. Differences in logistics performance often coexist with broader institutional and organizational gaps, potentially reinforcing the effects of cultural distance. Existing evidence suggests that part of the negative effect traditionally attributed to geographic distance in wine trade can be explained by differences in preferences and practices, sometimes proxied by genetic or cultural distance [27]. When logistics systems are better aligned, however, these cultural frictions may be less binding, as reliable logistics can facilitate market entry and reduce uncertainty. Premium wines may be particularly able to overcome taste-related barriers when supported by efficient and predictable logistics networks.

Economic and institutional conditions further condition the effect of logistics performance distance on wine exports. Differences in income levels and purchasing power influence the extent to which importing countries can absorb higher logistics-related trade costs. For example, higher purchasing power in destination markets has been shown to sustain exports of high-value wines such as Port wine, even in the presence of trade frictions [24]. Institutional distance, reflected in divergent regulatory frameworks and trade procedures, can amplify the impact of logistics performance distance by increasing compliance costs and uncertainty. In such settings, weak coordination between institutions may further hinder exporters' ability to navigate cross-border logistics processes [32].

Improvements in logistics performance can, in principle, mitigate the disadvantages associated with logistics performance distance. Previous studies show that gains in logistics efficiency are comparable to a reduction in effective distance, leading to substantial increases in exports, particularly in developing countries where logistics constraints are more severe [6]. In the wine sector, narrowing logistics performance distance through improved customs procedures, upgraded infrastructure, and more reliable logistics services can lower transport costs, reduce losses during transit, and improve supply chain efficiency. These improvements may also yield environmental benefits by enabling more efficient routing and lower emissions per shipment [33].

At the same time, the effect of logistics performance distance on wine exports does not operate in isolation. Climate variability in importing countries can influence demand and consumption patterns, as evidenced by findings that temperature anomalies negatively affected port wine exports [24]. Non-tariff measures may also interact with logistics performance, either reinforcing trade frictions through stricter regulatory requirements or easing them through harmonization and standardization. Taken together, these considerations suggest that while multiple factors shape wine exports, differences in logistics performance between trading partners constitute a fundamental source of trade costs.

Based on the above arguments, this study proposes the following hypothesis:

H1: *Greater logistics performance distance between exporting and importing countries is associated with lower wine exports.*

3. Data and Model Specification

This study relies on a balanced panel of bilateral trade data covering 152 countries[1] over the period 2007–2021. Bilateral wine export values, measured in current million U.S. dollars, are obtained from UN Comtrade and constructed following product classifications widely used in the wine trade literature [2,34]. Standard bilateral control variables commonly included in gravity models-geographic distance, common language, contiguity, colonial ties, and regional trade agreements-are sourced from the CEPII gravity dataset, which serves as a benchmark in empirical trade analysis [19,35].

Wine export data are built using bilateral trade flows from the BACI database at the six digit Harmonized System level. As is common in empirical studies of wine trade, exports are identified under HS Chapter 22 and defined using a specific set of HS6 codes that cover the main wine and grape based products traded internationally. Working at this level of detail makes it possible to separate products by packaging format and market segment, while still preserving comparability across countries and over time.

In practical terms, the wine export measure is constructed by distinguishing between bottled and bulk wine using Harmonized System (HS) classifications. Bottled wine is defined to include sparkling wine (HS 220410) and still wine in containers holding two liters or less (HS 220421). These categories broadly capture wines that are typically traded in final-consumption packaging, tend to have higher unit values, and are more sensitive to handling conditions, delivery reliability, and overall logistics quality.

Bulk wine is defined to include still wine in containers holding more than two liters but no more than ten liters (HS 220422), as well as wine shipped in containers exceeding ten liters (HS 220429). These categories generally reflect larger-volume shipments that are less dependent on retail packaging and are typically less sensitive to transport conditions and logistics-related risks compared with bottled wine.

[1] List of countries is reported in Table A1 of the Appendix.

This classification allows us to distinguish between wine products that differ in their exposure to logistics frictions. In particular, bottled wine, as defined above, is expected to be more vulnerable to delays, handling issues, and delivery uncertainty, while bulk wine shipments are relatively more standardized and less sensitive to such constraints. This distinction is central to our analysis of how logistics performance distance affects bilateral wine trade.

For each exporter importer year observation, bilateral wine exports are calculated by aggregating BACI trade values across the six HS6 codes listed above. The resulting variable, denoted $Wtrade_{ijt}$, captures the total value of wine exports from country i to country j in year t. Taken together, this construction reflects the full range of internationally traded wine products, including bottled and bulk wines, and provides a consistent dependent variable for the gravity model analysis.

Logistics performance is captured using the World Bank's LPI, which summarizes six dimensions of national logistics capability: customs efficiency, infrastructure quality, international shipments, logistics service competence, tracking and tracing, and delivery timeliness [7]. Rather than using LPI levels, this study focuses on logistics performance distance (LPID), defined as the multidimensional distance in LPI components between exporting and importing countries. LPID is constructed using a Euclidean-distance framework across the six LPI dimensions, allowing us to quantify the degree of logistics mismatch between trading partners. Higher values of LPID indicate greater divergence in logistics performance, while lower values reflect more similar logistics environments. This construction is consistent with recent approaches that emphasize cross-border logistics compatibility rather than absolute logistics efficiency [13,14].

The empirical analysis is conducted within a gravity-model framework, which remains the standard approach for explaining bilateral trade flows (Anderson & van Wincoop, 2003). The baseline specification is estimated using Poisson pseudo-maximum likelihood (PPML), which is well suited to trade data because it accommodates zero trade flows and is robust to heteroskedasticity [16]. Country-pair fixed effects are included to absorb time-invariant bilateral characteristics, while exporter-year and importer-year fixed effects control for multilateral resistance terms and country-specific shocks, in line with best practice in gravity-model estimation [35].

We begin by estimating a baseline gravity specification in which bilateral wine exports are regressed on LPID. This specification captures the overall effect of differences in logistics performance between exporting and importing countries on wine export flows. By focusing on *LPID* rather than absolute logistics levels, the baseline model isolates the role of logistics asymmetry as a source of trade frictions, conditional on standard gravity controls and fixed effects.

To examine potential heterogeneity across different dimensions of logistics capability, we then estimate a series of alternative specifications in which LPID is constructed using each LPI component separately. Specifically, we compute component-specific logistics distance measures based on differences in customs efficiency, infrastructure quality, international shipments, logistics service competence, tracking and tracing, and delivery timeliness. Each component-specific distance variable is introduced into the gravity equation one at a time, allowing us to assess whether certain dimensions of logistics divergence exert a stronger influence on wine exports than others.

This disaggregated approach makes it possible to identify the particular logistics bottlenecks that are most relevant for wine trade. For example, differences in customs efficiency may increase clearance delays and administrative uncertainty, while divergence in delivery timeliness may raise the risk of quality deterioration for time-sensitive shipments such as wine. By comparing the estimated effects across components, the analysis sheds light on which aspects of logistics alignment matter most for wine export performance. This strategy follows recent studies that emphasize the importance of decomposing aggregate logistics measures to better understand logistics–trade linkages and the underlying transmission channels [9,37].

We specify the baseline empirical model as follows:

$$\mathrm{Wtrade}_{\mathrm{ijt}} = \alpha_{\mathrm{it}} + \alpha_{\mathrm{jt}} + \beta_1 \mathrm{LPID}_{\mathrm{ijt}} + \beta_2 \mathrm{CONTROL}_{\mathrm{ijt}} + \varepsilon_{\mathrm{ijt}}, \quad (1)$$

where subscripts i and j denote the exporting and importing countries, respectively, and t indicates the year. $Wtrade_{ijt}$ represents the value of bilateral wine exports from country i to country j. Data on bilateral wine trade are obtained from the BACI–CEPII database and are constructed using Harmonized System six-digit product classifications as discussed above. All trade values are expressed in current billions of U.S. dollars.

Logistics performance is measured using the World Bank's LPI, which evaluates national logistics capability across six dimensions: the efficiency of customs and border clearance procedures (*Customs*), the quality of trade and transport infrastructure (*Infrastructure*), the ease of arranging competitively priced international shipments (*Intershipments*), the competence and quality of logistics services (*Logistics*), the ability to track and trace consignments (*Tracking*), and the timeliness of shipments reaching their destination as scheduled (*Timeliness*) [7].

To capture differences in logistics performance between trading partners, we construct a measure of LPID using a Euclidean-distance framework:

$$LPID_{ijt} = \sqrt{\sum_{c=1}^{6}\left(Component_{cit} - Component_{cjt}\right)^{\wedge}2}, \qquad (2)$$

where subscript c indexes the six LPI components. To make the construction of the LPID measure more transparent, we explicitly define LPID as the Euclidean distance between exporting and importing countries across the six LPI dimensions. Specifically, for each country pair, LPID is calculated as the square root of the sum of squared differences in customs efficiency, infrastructure quality, international shipment arrangements, logistics service competence, tracking and tracing, and delivery timeliness. This formulation captures the overall degree of mismatch in logistics capabilities between trading partners in a multidimensional space.

The intuition behind this measure is that larger differences across any of these dimensions contribute to greater logistics asymmetry, which may increase coordination costs, delays, and uncertainty in cross-border trade. Importantly, LPID reflects the relative alignment of logistics systems rather than their absolute level. As a result, even countries with relatively strong logistics performance may face frictions when trading with partners whose systems differ substantially in structure or efficiency.

Regarding scaling, the LPI components are used in their original form as reported by the World Bank. These indicators are already normalized on a common scale (ranging from 1 to 5), which ensures comparability across dimensions and countries. Therefore, no additional standardization is applied prior to constructing the Euclidean distance. This approach preserves the relative contribution of each logistics dimension while maintaining consistency with the underlying structure of the LPI.

Applying the same construction, we also compute component-specific distance measures, namely *CustomsD*, *InfrastructureD*, *IntershipmentD*, *LogisticsD*, *TrackingD*, and *TimelinessD*, to examine heterogeneity across different dimensions of logistics capability.

Since the LPI is available only for selected survey years (2007, 2010, 2012, 2014, 2016, 2018, and 2023), we construct annual measures of LPID by interpolating LPI values over time. Specifically, for years between two consecutive survey waves, we apply a linear interpolation procedure to obtain intermediate values. For example, LPI values for 2008 and 2009 are interpolated between the 2007 and 2010 survey rounds, and the same approach is used for subsequent intervals. For the final years in our sample (2019–2021), LPI values are interpolated between the 2018 and 2023 releases.

This interpolation approach allows us to construct a consistent annual panel while preserving cross-country differences in logistics performance. Although interpolation may smooth short-term fluctuations, the LPI is generally understood to reflect relatively persistent structural characteristics-such as customs efficiency, infrastructure quality, and logistics service capacity-which tend to evolve gradually over time. In this context, the use of linear interpolation appears to be a reasonable approximation and is consistent with common practice in literature when higher-frequency data are required. For robustness, we also re-estimate Equation (1) using only observed LPI years without interpolation, and the results remain qualitatively unchanged, confirming the stability of the estimated effect of LPID.

For this reason, the estimated coefficients should be interpreted with appropriate caution. They reflect the relationship between wine exports and medium-term differences in logistics performance between trading partners, rather than the effect of year-to-year logistics shocks. If interpolation attenuates short-run variation in logistics performance, the estimated effect of LPID may be conservative. Overall, however, the consistency of the results using only observed LPI years provides reassurance that the negative association between logistics performance distance and wine exports is not an artifact of interpolation.

The vector $CONTROL_{ijt}$ includes standard bilateral variables commonly used in gravity models. These controls comprise product of natural logarithm of GDP per capita of the importer and exporter, geographic distance, indicators for common contiguity, shared official language, colonial ties, and membership in the same regional trade agreement. The GDP-related variable is included as a standard gravity control and to maintain comparability with previous studies of wine trade. However, its coefficient should be interpreted with caution in the present specification. Because exporter-year and importer-year fixed effects are included, much of the country-year variation in market size, income levels, macroeconomic conditions, and multilateral resistance terms is already absorbed by these fixed effects. As a result, the estimated GDP coefficient does not have the same interpretation as in a conventional gravity model without exporter-year and importer-year fixed effects. It captures only residual variation not absorbed by the fixed effects and may therefore appear unstable or difficult to interpret. For this reason, we do not draw substantive conclusions from the sign or magnitude of the GDP coefficient. The empirical interpretation focuses instead on the coefficient of LPID, which is the main variable of interest in this study. In addition, the regression includes exporter-year and importer-year fixed effects (α_{it} and α_{jt}) to account for multilateral resistance terms and country-specific shocks.

The model is estimated using PPML, which is well suited to trade data as it accommodates zero trade flows and is robust to heteroskedasticity. Following Egger and Tarlea (2015), standard errors are computed using multi-level clustering to account for potential correlation across country pairs and over time.

The dataset consists of 201,435 bilateral observations covering 152 sovereign countries over the period 2007–2021[2]. Data for all control variables are obtained from the CEPII database. Table 2 presents descriptive statistics for the variables used in the analysis. In addition, Figure 1 illustrates the time evolution of the average values of wine exports and logistics performance distance.

As shown in Figure 1, average wine exports increased sharply between 2007 and 2011 and then stabilized at approximately 0.17–0.18 from 2011 to 2017. From 2018 onward, wine exports rose markedly through 2021. Over the same period, the average value of LPID exhibited a modest decline between 2007 and 2015, followed by an increase in 2016 and 2017, and a subsequent decline thereafter.

Table 1 further indicates a clear relationship between logistics performance distance and wine trade. Specifically, country pairs characterized by higher LPID values trade nearly half as much in wine as those with lower logistics distance. This difference is statistically significant at

[2] The data supporting this study's findings are available from the corresponding author upon reasonable request.

the 1 percent level, suggesting that greater divergence in logistics performance is associated with substantially lower wine export volumes.

Table 1: Break-down of wine export by logistics performance distance sample

	Low LPID		High LPID		
Variable	Obs	Mean	Obs	Mean	ttest (p-value)
Wtrade	100,722	0.24	100,713	0.13	0.000

Table 2: Statistical summary

	count	mean	sd	min	max
Wtrade	201435	0.18	1.12	0.00	9.73
LPID	201435	1.65	1.02	0.27	4.30
LnGDP	201435	3.61	2.00	-1.15	7.84
D	201435	8.64	0.81	2.30	9.90
comlang_off	201435	0.13	0.33	0.00	1.00
comcol	201435	0.08	0.27	0.00	1.00
comrelig	201435	0.17	0.26	0.00	0.99
contig	201435	0.02	0.15	0.00	1.00
fta_wto	201435	0.19	0.39	0.00	1.00

Note: *Wtrade* denotes the value of bilateral wine exports (in current million USD). *LPID* refers to logistics performance distance, constructed as the Euclidean distance between the exporter's and importer's LPI scores across six dimensions (customs, infrastructure, international shipments, logistics competence, tracking and tracing, and timeliness). *LnGDP* represents the product of GDP per capita of the exporter and importer (in logarithms). *D* denotes the logarithm of bilateral geographic distance. *comlang_off*, *comcol*, *comrelig*, and *contig* are dummy variables indicating whether trading partners share a common official language, colonial ties, religion, or a common border, respectively. *fta_wto* is a dummy variable equal to one if both countries are members of the same regional trade agreement.

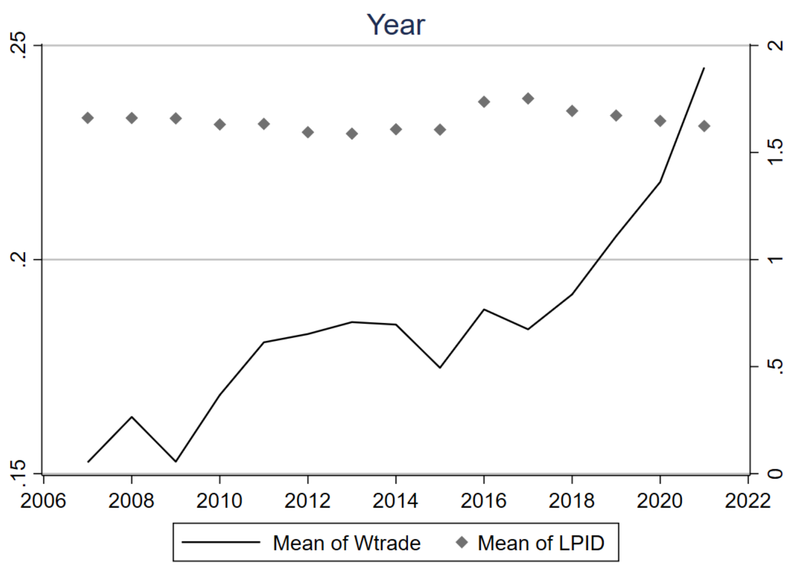

Figure 1: Distribution of average *Wtrade* and *LPID* over year

Note: The mean value of *Wtrade* is on the left-hand scale, and the mean value of *LPID* is on the right-hand scale.

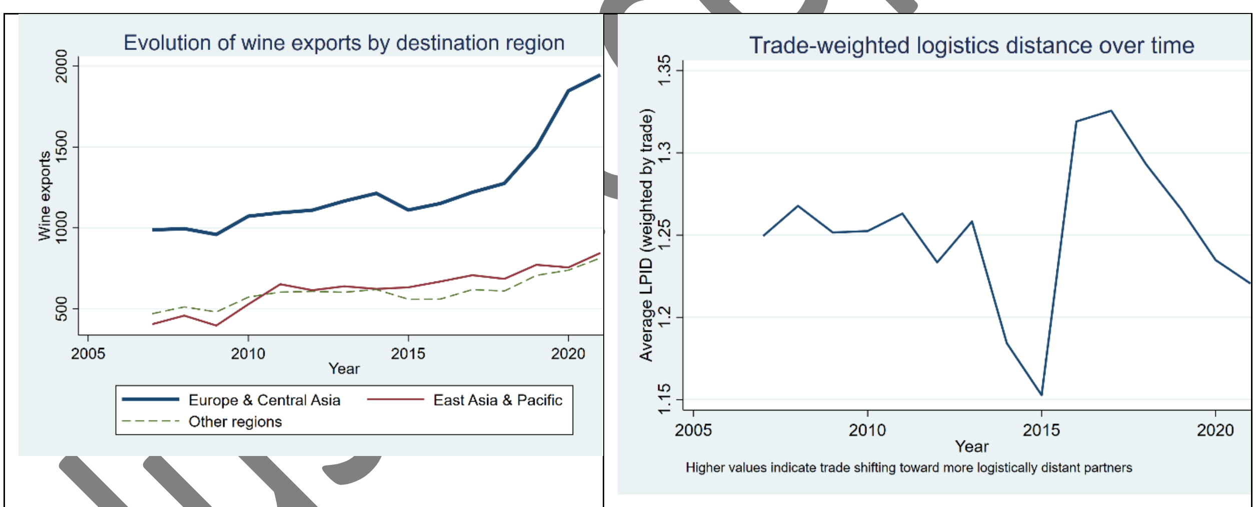

Figure 2: Evolution of wine export by destination and trade-weighted LPID

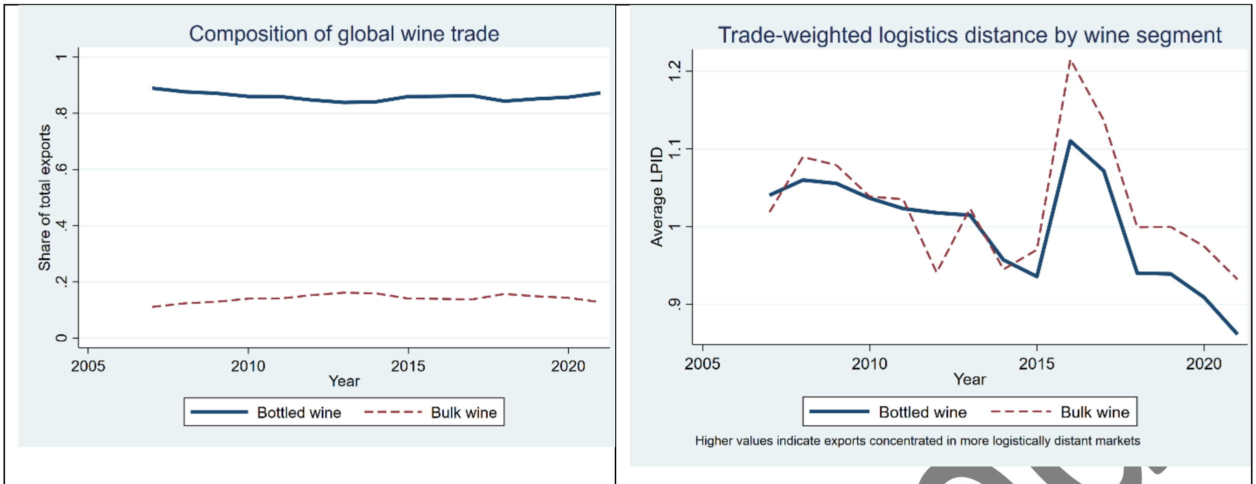

Figure 3: Composition of wine export and trade-weighted LPID over year

Figure 2 provides a descriptive overview of how the destination pattern of global wine exports has evolved over the sample period. The left-hand panel shows that Europe and Central Asia remained the dominant destination region throughout the period, confirming the continued importance of traditional wine trade corridors within and around Europe. At the same time, exports to East Asia and the Pacific increased visibly over time, especially from the mid-2000s onward. This pattern is consistent with the growing role of Asian markets in global wine demand, likely supported by rising incomes, changing consumption preferences, and the gradual internationalization of wine consumption beyond traditional importing countries.

The right-hand panel complements this picture by plotting the trade-weighted average logistics performance distance. It shows that, as wine exports increasingly expanded toward newer and more heterogeneous destination markets, the average logistics distance embodied in trade also tended to rise. In other words, the reorientation of wine trade was not only geographical but also logistical: a growing share of exports was directed toward markets whose logistics systems were less closely aligned with those of major exporting countries. This descriptive pattern provides an economic rationale for focusing on LPID in the econometric analysis, as it suggests that logistics mismatches became more relevant as global wine trade moved beyond its traditional regional base.

Figure 3 shifts attention from destination patterns to product composition. The left-hand panel shows that bottled wine accounts for the dominant share of wine exports over time, while bulk wine represents a smaller and more stable segment. This suggests that the growth of global wine trade has been driven primarily by bottled products rather than by bulk shipments. That distinction matters because bottled wine generally has higher unit value, is more quality-sensitive, and requires more careful handling, storage, and delivery conditions during transport.

The right-hand panel adds a logistics dimension to this composition story by comparing the trade-weighted logistics distance associated with bottled and bulk wine exports. The figure indicates that bottled wine exports are more closely associated with logistically distant trade relationships than bulk wine exports. This means that the expansion of bottled wine trade has increasingly taken place across markets where logistics systems differ more substantially between exporters and importers. Since bottled wine is more exposed to delays, mishandling, and delivery unreliability, this pattern reinforces the idea that logistics-related frictions are economically meaningful in the wine sector. Taken together, Figure 3 helps link product composition to the paper's main argument: logistics performance distance is likely to matter precisely because the most dynamic segment of wine trade is also the segment more exposed to cross-country logistics mismatches.

4. Econometric Results

4.1. Baseline results

Column (1) of Table 3 reports the baseline PPML estimates of the gravity model examining the effect of logistics performance distance on bilateral wine exports. The results provide strong support for the central hypothesis of the study. The coefficient *LPID* is negative and statistically significant at the 1 percent level, indicating that greater divergence in logistics performance between exporting and importing countries is associated with lower wine export values. Quantitatively, this finding suggests that logistics asymmetries appear to be a meaningful source of trade costs in international wine markets. This result is consistent with the notion that misaligned customs procedures, infrastructure quality, logistics services, and delivery reliability may raise coordination costs and increase uncertainty in cross-border supply chains, thereby discouraging trade

The negative effect of *LPID* aligns closely with earlier evidence showing that logistics performance plays a critical role in shaping export competitiveness. Studies using aggregate LPI measures find that improvements in logistics efficiency are comparable to reductions in effective distance and lead to higher export volumes, particularly for time-sensitive or quality-sensitive products [6,17]. By focusing on logistics distance rather than logistics levels, the present results extend this literature by showing that relative mismatches in logistics systems across trading partners constitute an additional barrier to wine trade, beyond traditional geographic distance.

Beyond statistical significance, the estimates in Table 3 also imply economically meaningful effects. In the PPML framework, the coefficient *LPID* can be interpreted as a semi-elasticity, indicating the percentage change in bilateral wine exports associated with a one-unit increase in logistics performance distance, holding other factors constant. The negative coefficient on LPID therefore implies that even moderate increases in logistics divergence between trading partners are associated with sizeable reductions in wine export values. Given that *LPID* captures multidimensional gaps in customs efficiency, infrastructure quality, logistics services, and delivery timeliness, these results suggest that misalignment in logistics systems may impose substantial trade costs on wine exporters. In practical terms, improvements that reduce logistics distance between countries, such as harmonizing customs procedures or improving delivery reliability, are likely to yield non-trivial gains in wine trade. Taken together, the magnitude and direction of the estimated *LPID* coefficient provide strong empirical support for Hypothesis H1, confirming that greater logistics performance distance between exporting and importing countries is associated with lower bilateral wine exports. For robustness, we also re-estimate Equation (1) using only observed LPI years without interpolation, and the results in column (2) of Table 3 remain qualitatively unchanged, confirming the stability of the estimated effect of LPID.

Columns (3) and (4) of Table 3 provide important insights into how the effect of LPID varies across product types, namely bottled and bulk wine. As reported in , the coefficient on LPID is negative and statistically significant at the 1 percent level in both specifications, confirming that logistics asymmetries reduce trade for both categories. However, the magnitude of the effect differs meaningfully across the two product types.

For bottled wine (column 3), the estimated coefficient is −0.25, indicating a relatively strong negative response of exports to logistics performance distance. In contrast, the corresponding coefficient for bulk wine (column 4) is slightly smaller in absolute value (−0.22). Although both effects are economically significant, the larger magnitude for bottled wine suggests that this segment is more sensitive to mismatches in logistics systems between trading partners.

This difference can be explained by the distinct characteristics of the two product types. Bottled wine is typically a higher-value, final-consumption product that is more sensitive to handling conditions, delivery reliability, and time delays. It often requires careful storage, temperature control, and timely delivery to preserve quality and brand reputation. As a result, any misalignment in logistics systems-such as differences in customs procedures, infrastructure quality, or delivery timeliness-can translate into higher risks and costs, leading to a stronger negative impact on trade.

By contrast, bulk wine is generally shipped in larger quantities, often for further processing, blending, or bottling in the destination market. These shipments tend to be more standardized and less sensitive to short-term delays or handling imperfections. Consequently, while logistics performance distance still matters for bulk wine, its effect is relatively less pronounced compared to bottled wine.

Overall, these results highlight an important dimension of heterogeneity: logistics performance distance does not affect all segments of the wine market equally. Instead, its impact is stronger for quality-sensitive and time-dependent products, reinforcing the idea that logistics compatibility is particularly critical for sustaining trade in higher-value segments of international wine markets.

Turning to the control variables, the estimated coefficients largely conform to standard gravity-model predictions. Geographic distance enters with a negative and highly significant coefficient, reflecting higher transport costs and longer delivery times for more distant trading partners. This finding is consistent with long-standing results in the wine trade literature, although distance effects are typically smaller for wine than for low-value bulk commodities due to wine's relatively high value-to-weight ratio [10,25]. The continued significance of distance in the presence of LPID suggests that physical separation and logistics asymmetries capture distinct dimensions of trade frictions.

Cultural and historical ties exert strong positive effects on wine exports. Sharing a common official language, colonial ties, or religious similarity is associated with significantly higher bilateral wine trade. These variables likely proxy for lower information costs, stronger consumer familiarity, and more established commercial networks, all of which are particularly important in markets for differentiated products such as wine [26,27]. The positive and significant coefficient on contiguity further indicates that neighboring countries trade more wine, possibly reflecting shorter delivery times and denser distribution networks.

The coefficient on free trade agreement membership is also positive and statistically significant, confirming that preferential trade arrangements facilitate wine exports by reducing tariffs, harmonizing regulations, and improving market access. This result is consistent with previous findings in the wine trade literature, which show that trade agreements play an important role in shaping bilateral wine flows, especially for bottled wines subject to regulatory requirements [2,11].

The coefficient on the logarithm of GDP appears to have counterintuitive signs. In the presence of exporter-year and importer-year fixed effects, the coefficient on GDP should be interpreted with caution, as it reflects only residual variation beyond country-level economic size. Much of the variation in aggregate GDP is already absorbed by these fixed effects, which may lead to unstable or counterintuitive coefficient estimates. For this reason, the empirical specification focuses on the product of GDP per capita of the exporter and importer, which more directly captures income levels and purchasing power relevant for wine trade. This approach is particularly appropriate in the context of wine consumption, which tends to be more closely associated with income per capita than with total market size.

Overall, the results in Table 3 provide robust empirical evidence that logistics performance distance is a key determinant of bilateral wine exports. Even after controlling for standard gravity variables and multilateral resistance terms, differences in logistics capability between countries significantly reduce trade flows. These findings underscore the importance of logistics compatibility in international wine trade and provide a strong empirical foundation for the subsequent analysis of LPI components and time heterogeneity presented in Tables 4 and 5.

Table 3: Estimation results

	(1)	(2)	(3)	(4)
	Whole sample	Selected years	Bottled wine	Bulk wine
VARIABLES	Wtrade	Wtrade	Wtrade	Wtrade
LPID	-0.09***	-0.10***	-0.25***	-0.22***
	(0.014)	(0.023)	(0.033)	(0.041)
LnGDP	-1.27***	-1.79***	-0.54	-2.67***
	(0.185)	(0.363)	(0.375)	(0.537)
D	-0.56***	-0.56***	-0.46***	-0.57***
	(0.017)	(0.027)	(0.038)	(0.049)
comrelig	0.88***	0.90***	1.39***	1.17***
	(0.059)	(0.098)	(0.125)	(0.205)
comlang_off	0.89***	0.96***	1.40***	2.66***

	(0.032)	(0.052)	(0.085)	(0.106)
comcol	0.66***	0.66***	0.55**	2.78***
	(0.071)	(0.114)	(0.214)	(0.177)
contig	0.51***	0.52***	0.79***	1.35***
	(0.048)	(0.077)	(0.069)	(0.136)
fta_wto	0.26***	0.24***	0.62***	0.61***
	(0.030)	(0.050)	(0.074)	(0.080)
Constant	12.79***	15.87***	10.19***	23.49***
	(1.137)	(2.221)	(2.444)	(3.636)
Observations	174,438	66,627	171,808	125,299
Pair FE	NO	NO	NO	NO
Importer-year FE	YES	YES	YES	YES
Exporter-year FE	YES	YES	YES	YES

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$
Standard errors are clustered at (and may be correlated within) base groups (importer, exporter, and year) and every combination of the three.

4.2. Further results

Panel A of Table 4 presents the estimation results from the gravity model in which logistics performance distance is broken down into its six individual components. Looking at the results this way makes it easier to see which aspects of logistics divergence appear to account for the overall negative relationship between LPID and wine exports reported in Table 3. The findings suggest that logistics differences do not matter equally across dimensions. Instead, aspects related to reliability and operational quality seem to play a more prominent role for wine trade, which is consistent with the nature of wine as a differentiated and quality sensitive product.

Differences in customs efficiency are associated with a negative and statistically significant effect on wine exports. This result suggests that when exporting and importing countries differ substantially in customs procedures and border clearance performance, wine trade tends to be lower. Wine shipments often face inspections, documentation checks, and excise controls, which makes them particularly exposed to clearance delays. When customs systems are poorly aligned, administrative uncertainty may increase and clearance times may lengthen, discouraging exporters from serving those markets. This pattern is in line with earlier evidence showing that customs efficiency is a key determinant of trade in processed food and agricultural products [39,6].

Distance in infrastructure quality also shows a strong and statistically significant negative association with wine exports. Differences in transport infrastructure, such as port facilities, road networks, and storage capacity, are likely to raise handling costs and increase the risk of damage during transit. For wine, which often requires careful handling and, in some cases, temperature control, such mismatches in infrastructure quality can be especially costly. This finding is consistent with previous studies that emphasize the central role of transport infrastructure in shaping export competitiveness, particularly for goods that are sensitive to quality degradation [9].

The coefficient on international shipment distance is also negative, but its magnitude is smaller and, in some specifications, only weakly significant. This suggests that differences in the ease of arranging international shipments do matter for wine exports, but perhaps less than other logistics dimensions. One possible explanation is that shipping services for wine have become relatively standardized at the global level, allowing exporters to rely on specialized logistics providers to overcome some shipment related frictions. Similar findings have been reported in studies where shipment arrangement plays a secondary role compared to customs performance and infrastructure quality [7].

Distance in logistics service competence exhibits a negative and statistically significant effect on wine exports. This component captures differences in the quality and reliability of freight forwarders, customs brokers, and other logistics service providers. When logistics service competence differs widely across countries, coordination costs may rise and the risk of mishandling increases. These issues are particularly relevant for bottled and premium wines, where damage or delays can directly affect product quality and brand reputation. The importance of logistics service quality is well documented in the trade literature, which shows that professional logistics capabilities are critical for maintaining quality and timeliness in international supply chains [37].

Differences in tracking and tracing capability also appear to reduce wine exports, although the estimated effect is smaller than that of infrastructure quality or logistics competence. Tracking and tracing systems improve shipment visibility and reduce uncertainty, which can be especially valuable for high value wine exports. When exporting and importing countries differ in these capabilities, exporters may find it more difficult to monitor shipments and respond to disruptions, which may limit their willingness to trade. This result is consistent with studies highlighting the role of information transparency and digital logistics systems in facilitating international trade [7,13].

Finally, timeliness distance emerges as one of the logistics dimensions most strongly associated with wine exports. Larger differences in delivery reliability between trading partners are associated with substantially lower wine trade flows. Timely delivery is particularly important for wine, especially for premium products and for shipments destined for retail and hospitality channels where inventory management is tight. This finding echoes earlier evidence showing that delivery reliability is among the most important logistics dimensions for exports of time sensitive and quality differentiated goods [9].

An interesting result emerging from Table 4 is that differences in tracking and tracing capabilities appear to have a more limited effect on wine exports compared to customs efficiency and infrastructure quality. One possible explanation is that tracking and tracing technologies have become relatively standardized and widely adopted across countries, particularly within global shipping and logistics networks. As a result, differences in this dimension may generate less additional friction for exporters, as basic shipment visibility and monitoring can often be ensured even when trading partners differ in their overall logistics performance.

By contrast, customs procedures and infrastructure conditions are more institution-specific and less easily harmonized. Wine shipments are often subject to excise controls, certification requirements, and regulatory inspections, which can vary substantially across countries and may introduce delays and administrative uncertainty. Similarly, differences in port facilities, storage conditions, and transport infrastructure directly affect handling quality and delivery reliability. In this context, mismatches in customs systems and infrastructure are likely to represent more binding constraints on wine trade than differences in tracking technology, particularly for bottled and quality-sensitive products.

Taken together, the results in Panel A of Table 4 suggest that the negative effect of overall logistics performance distance on wine exports is driven mainly by divergence in customs efficiency, infrastructure quality, logistics service competence, and delivery timeliness. Differences in shipment arrangement and tracking capabilities appear to play a more limited, though still relevant, role. Overall, these findings reinforce the idea that logistics alignment matters most in dimensions directly linked to reliability, quality preservation, and administrative efficiency, all of which are central to sustaining international wine trade.

Panel B of Table 4 presents the results using an alternative Manhattan-distance measure of logistics performance distance. While the baseline LPID is constructed using Euclidean distance, the Manhattan-distance measure sums the absolute differences between the exporter and importer across the six LPI components. This specification helps assess whether the main results depend on the particular distance metric used to capture logistics asymmetry. The estimated coefficient remains negative and statistically significant, confirming that the adverse effect of logistics performance distance on wine exports is not specific to the Euclidean-distance construction. Rather, the results consistently suggest that larger logistics gaps between trading partners act as a barrier to bilateral wine trade.

Column (1) and (2) of Table 5 reports the estimation results based on subsamples defined by different time periods. This analysis allows us to examine whether the effect of logistics performance distance on wine exports is stable over time or varies across different phases of the global trading environment. Across all subperiods, the coefficient on LPID remains negative, although its magnitude and statistical significance change over time, suggesting meaningful temporal variation in the role of logistics divergence.

In the earlier subperiod, the negative effect of LPID is present but relatively modest. During this time, global trade expanded steadily, and logistics networks benefited from increasing integration as well as improvements in transport and information technologies. Under these conditions, differences in logistics performance across countries may have been partly absorbed by growing trade volumes and expanding distribution networks. This interpretation is consistent with evidence indicating that logistics frictions tend to be less binding during periods of strong global trade growth and relatively stable supply chains [6,7].

The effect of LPID becomes noticeably stronger during the subperiod covering the global financial crisis and its immediate aftermath. Disruptions to trade finance, transport services, and customs operations during this period appear to have increased the importance of reliable and well aligned logistics systems. Countries with larger logistics performance distance experienced sharper declines in wine exports, reflecting greater sensitivity to delays, coordination failures, and uncertainty. This pattern is consistent with broader evidence showing that trade costs rise disproportionately during crises and that firms become more dependent on efficient logistics to sustain export relationships [40,41].

In the most recent subperiod, the negative effect of LPID remains statistically significant, although its magnitude appears to stabilize or decline slightly relative to the crisis years. This may reflect gradual adaptation by firms and logistics providers to a more fragmented and risk aware trading environment. The wider use of digital logistics tools, improved tracking systems, and accumulated experience in managing cross border complexity may have helped soften some of the adverse effects of logistics divergence. Even so, the persistence of a negative LPID coefficient suggests that logistics compatibility continues to be a structural determinant of wine exports, even during periods of recovery and adjustment [42].

To further assess whether the estimated effect of logistics performance distance is sensitive to major global shocks, we conduct additional subsample analyses focusing on periods of disruption and recovery. Columns (3) and (4) of Table 5 report results for the global financial crisis period (2008–2009) and the post-crisis period (2010–2019), respectively. This approach allows us to examine whether the effect of LPID reflects temporary shocks or a more persistent structural relationship.

The results indicate that the negative effect of logistics performance distance remains robust across both subsamples. In column (3), the coefficient on LPID is larger in magnitude during the crisis period, suggesting that logistics asymmetries become more binding when global supply chains are under stress and trade conditions are more fragile. In column (4), which excludes both the crisis years and the COVID-19 period, the coefficient remains negative and statistically significant, although more moderate in size. This pattern suggests that while the impact of LPID varies over time, it does not disappear outside periods of disruption.

Taken together, these findings indicate that the effect of logistics performance distance is not driven by short-term global shocks, such as the financial crisis or pandemic-related disruptions, but instead reflects a more persistent and structurally relevant source of trade frictions. Even in relatively stable periods, differences in logistics performance between trading partners continue to constrain bilateral wine exports.

To examine geographical heterogeneity, we split the sample according to whether trading partners are affected by landlockedness. Columns (5) and (6) of Table 5 report results for country pairs without landlocked countries and for those where at least one partner is landlocked, respectively. A clear pattern emerges: the negative effect of logistics performance distance is substantially stronger in country pairs involving landlocked countries. While the estimated coefficient remains negative and statistically significant for non-landlocked pairs, its magnitude increases markedly when at least one country is landlocked.

This result suggests that the impact of logistics performance distance is not uniform across geographical contexts but is amplified in structurally constrained environments. Landlocked countries typically rely on transit through neighboring countries and depend heavily on external port infrastructure, which increases exposure to delays, coordination challenges, and institutional frictions along the supply chain [43]. In such settings, differences in logistics performance between trading partners translate into higher effective trade costs. This effect is likely to be particularly pronounced for wine, given its sensitivity to handling conditions, storage requirements, and delivery reliability. Overall, the findings indicate that logistics performance distance interacts with geographical constraints, reinforcing its role as a context-dependent determinant of bilateral wine trade.

To account for the increasing complexity of modern trade agreements, we extend the analysis by incorporating measures of trade agreement depth based on the Deep Trade Agreements (DTA 2.0) database. Unlike a simple binary indicator, these measures capture the extent to which agreements include provisions related not only to tariff reductions but also to broader forms of institutional integration [44]. Specifically, we consider two indicators: the total number of provisions included in an agreement (*dta_depth*) and the share of possible provisions that are present (*dta_depth_share*). These variables provide a more nuanced characterization of trade agreements, particularly with respect to provisions that may directly affect logistics, such as customs harmonization and trade facilitation.

The results are reported in Table 6. Both depth measures enter with positive and statistically significant coefficients, indicating that deeper trade agreements are associated with higher levels of bilateral wine exports. This finding is consistent with the view that agreements encompassing a broader set of provisions can reduce trade costs by improving regulatory coordination and facilitating cross-border logistics [45]. At the same time, the inclusion of these variables does not alter the main result of the paper. The coefficient on logistics performance distance remains negative and statistically significant, with a magnitude comparable to the baseline estimates.

These findings suggest that while deeper trade agreements contribute to facilitating wine trade, they do not fully offset the adverse effects of logistics performance distance. In other words, even in the presence of institutional integration, differences in logistics systems between trading partners continue to act as a meaningful barrier to trade. This reinforces the interpretation of logistics performance distance as an independent and structurally relevant source of trade frictions, rather than a proxy for the depth of trade agreements.

Table 4: Estimation results: Subsample by LPI components and alternative measure of LPID

Panel A	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Wtrade	Wtrade	Wtrade	Wtrade	Wtrade	Wtrade
Customs	-0.14***					
	(0.025)					
Infrastructure		-0.17***				
		(0.022)				
Intershipments			-0.14***			
			(0.036)			
QC				-0.16***		
				(0.026)		
TT					-0.20***	
					(0.029)	
Timeliness						-0.16***
						(0.036)
Constant	12.75***	12.80***	13.38***	12.77***	12.89***	13.14***
	(1.145)	(1.133)	(1.133)	(1.143)	(1.132)	(1.137)
Observations	174,438	174,438	174,438	174,438	174,438	174,438
Pair FE	NO	NO	NO	NO	NO	NO
Importer-year FE	YES	YES	YES	YES	YES	YES
Exporter-year FE	YES	YES	YES	YES	YES	YES

Panel B VARIABLES	(1) Wtrade
LPID_Alter	-0.03***
	(0.005)
Constant	12.84***
	(1.139)
Observations	175,465
Pair FE	NO
Importer-year FE	YES
Exporter-year FE	YES

Standard errors are clustered at (and may be correlated within) base groups (importer, exporter, and year) and every combination of the three.
*** p<0.01, ** p<0.05, * p<0.1
Same set of control variables are included.

Table 5: Estimation results: Subsample by years and landlocked countries

	(1)	(2)	(3)	(4)	(5)	(6)
	2007-2017	2018-2021	2008-2009	2010-2019	No landlocked	Any landlocked
VARIABLES	Wtrade	Wtrade	Wtrade	Wtrade	Wtrade	Wtrade
LPID	-0.10***	-0.05**	-0.20***	-0.08***	-0.05***	-0.35***
	(0.017)	(0.024)	(0.042)	(0.017)	(0.015)	(0.034)
Constant	15.35***	11.83***	8.59	14.95***	12.45***	11.29***
	(1.820)	(1.394)	(6.248)	(1.572)	(1.204)	(2.615)
Observations	121,292	53,146	20,798	115,232	116,466	43,373
Pair FE	NO	NO	NO	NO	NO	NO
Importer-year FE	YES	YES	YES	YES	YES	YES
Exporter-year FE	YES	YES	YES	YES	YES	YES

Standard errors are clustered at (and may be correlated within) base groups (importer, exporter, and year) and every combination of the three.
*** p<0.01, ** p<0.05, * p<0.1
Same set of control variables are included.

Table 6: Estimation results with deep trade agreement

	(1)	(2)
VARIABLES	Wtrade	Wtrade
LPID	-0.08***	-0.09***
	(0.019)	(0.019)
LnGDP	-0.86***	-0.87***
	(0.220)	(0.220)
D	-0.67***	-0.68***
	(0.021)	(0.020)
comrelig	0.61***	0.62***
	(0.066)	(0.065)
comlang_off	0.83***	0.83***
	(0.041)	(0.041)
comcol	0.02	0.04
	(0.115)	(0.113)
contig	0.34***	0.34***
	(0.047)	(0.046)
dta_depth	0.05**	
	(0.019)	

dta_depth_share		0.01**
		(0.029)
Constant	11.67***	11.47***
	(1.362)	(1.355)
Observations	46,244	46,244
Pair FE	NO	NO
Importer-year FE	YES	YES
Exporter-year FE	YES	YES

Standard errors are clustered at (and may be correlated within) base groups (importer, exporter, and year) and every combination of the three.

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

4.3. Endogeneity concern

As in many gravity-based studies of international trade, endogeneity may arise when estimating the relationship between LPID and wine exports. A primary concern is reverse causality: higher trade volumes may themselves contribute to improvements in logistics performance through learning effects, increased investment, or policy responses aimed at facilitating trade. In addition, unobserved bilateral factors-such as long-standing commercial relationships or historical ties-may simultaneously influence both logistics performance and trade flows. Measurement error is also a potential issue, as logistics performance is captured through survey-based indicators available only at discrete intervals [7].

To mitigate these concerns, the empirical strategy relies on a comprehensive set of fixed effects. All specifications are estimated using PPML and include exporter-year and importer-year fixed effects. These absorb multilateral resistance terms and control for time-varying country-specific factors such as income, macroeconomic conditions, and institutional quality, in line with best practices in the gravity literature (Anderson & van Wincoop, 2003; Silva & Tenreyro, 2006; Head & Mayer, 2014). As a result, the scope for omitted variable bias is substantially reduced.

To further address reverse causality, we incorporate lagged values of logistics performance distance. Specifically, current wine exports are regressed on past LPID values (Table 7), linking trade outcomes to predetermined logistics conditions. While this approach cannot fully eliminate endogeneity, it reduces the likelihood that contemporaneous trade flows directly influence the measured logistics gap, a strategy commonly adopted in empirical trade studies [6].

The baseline specification includes exporter-year and importer-year fixed effects. These fixed effects control for multilateral resistance terms and time-varying country-specific factors, such as macroeconomic conditions, institutional quality, and country-level trade capacity. At the same time, this specification allows us to estimate the effects of standard time-invariant bilateral variables, including geographic distance, common language, contiguity, and colonial ties. In addition, we test the robustness of our results by introducing country-pair fixed effects, which absorb all time-invariant bilateral characteristics. This specification is more demanding because it absorbs all time-invariant bilateral heterogeneity, including geography, historical ties, cultural proximity, and persistent bilateral trade relationships. The trade-off is that time-invariant bilateral variables cannot be separately estimated once country-pair fixed effects are included. As shown in Table 8, the coefficient on LPID remains negative and statistically significant, with a magnitude comparable to the baseline estimates. This finding indicates that the main results are not driven by unobserved stable trade relationships between country pairs [35]. Therefore, we treat the country-pair fixed effects model as a complementary specification rather than the main baseline model. The persistence of a negative and statistically significant LPID coefficient under this specification provides reassurance that the main result is not driven solely by unobserved time-invariant characteristics of country pairs.

We also account for cultural factors that may affect wine trade by incorporating a bilateral cultural distance index based on the Kogut–Singh framework. This index captures differences in preferences, norms, and consumption patterns that are particularly relevant for alcohol products [46]. The results (Table 9, column 1) show that cultural distance has a negative and statistically significant effect on wine exports, consistent with prior evidence on taste-related trade barriers in the wine sector [27]. Importantly, however, the inclusion of this variable does not alter the estimated impact of LPID, suggesting that logistics performance distance captures a distinct channel of trade frictions beyond cultural differences.

To further examine whether the LPID effect reflects underlying ethical or religious constraints on alcohol consumption, we conduct additional robustness checks by restricting the sample. Specifically, we exclude destination countries with known restrictions on alcohol consumption and then further exclude predominantly Islamic countries (Table 9, columns 2 and 3). Across both specifications, the coefficient on LPID remains negative and statistically significant, although slightly reduced in magnitude. This indicates that the main results are not driven by such restrictions and that logistics performance distance continues to play an independent role in shaping wine trade [12].

To further assess the robustness of the main findings, we employ an instrumental variable approach that uses the exporting country's historical port depth as an instrument for logistics performance distance. Specifically, we rely on port-depth information reported in the 2000 edition of the World Port Index, the earliest report available in the National Geospatial-Intelligence Agency's online database archive [47]. Historical port depth serves as a proxy for predetermined maritime infrastructure capacity, as deeper ports are generally better able to accommodate larger vessels and facilitate more efficient cargo handling. Since the instrument is measured before the main sample period of 2007–2021, it is less likely to be influenced by recent bilateral wine trade flows.

Nevertheless, the exclusion restriction should be interpreted with caution. Historical port depth may be correlated with broader historical patterns of maritime development, trade orientation, infrastructure quality, or long-run economic geography that could affect wine exports through channels other than logistics performance distance. Although exporter-year and importer-year fixed effects help absorb many country-level factors, they cannot fully rule out all possible indirect channels linking historical port characteristics to contemporary trade flows. For this reason, we interpret the IV estimates as an informative robustness check rather than as definitive causal evidence. The IV estimates reported in Table 10 remain negative and statistically significant, suggesting that the baseline relationship between logistics performance distance and bilateral wine exports is not driven solely by contemporaneous reverse causality.

Taken together, these exercises do not eliminate all sources of endogeneity. Rather, they strengthen the credibility and stability of the empirical findings. By combining high-dimensional fixed effects, lagged regressors, country-pair fixed effects, cultural and religion-related controls, and the IV robustness check, the analysis provides consistent evidence that logistics performance distance is negatively associated with international wine exports. However, given the inherent limitations of the exclusion restriction and the observational nature of the data, these results should be interpreted as robust empirical associations rather than definitive causal estimates.

Table 7: Estimation results with lag effects

	(1)	(2)
VARIABLES	Wtrade	Wtrade
$LPID_{t-1}$	-0.12***	

	(0.015)	
LPID $_{t-2}$		-0.13***
		(0.016)
Constant	12.57***	12.62***
	(1.204)	(1.238)
Observations	142,496	125,018
Pair FE	NO	NO
Importer-year FE	YES	YES
Exporter-year FE	YES	YES

Standard errors are clustered at (and may be correlated within) base groups (importer, exporter, and year) and every combination of the three.
*** p<0.01, ** p<0.05, * p<0.1
Same set of control variables are included. $LPID_{t-1}$ and $LPID_{t-2}$ are the first- and second-period lags.

Table 8: Estimation with full fixed effects

VARIABLES	(1) Wtrade
LPID	-0.30***
	(0.012)
LnGDP	-1.83***
	(0.164)
fta_wto	1.15***
	(0.027)
Constant	11.68***
	(0.990)
Observations	70,031
Pair FE	YES
Importer-year FE	YES
Exporter-year FE	YES

Standard errors are clustered at (and may be correlated within) base groups (importer, exporter, and year) and every combination of the three.
*** p<0.01, ** p<0.05, * p<0.1

Table 9: Cultural distance and religion

	(1)	(2)	(3)
VARIABLES	Wtrade	Wtrade	Wtrade
LPID	-0.35***	-0.10***	-0.17***
	(0.021)	(0.014)	(0.018)

cult_dist	-0.16***		
	(0.028)		
Constant	-4.42***	12.89***	13.32***
	(0.223)	(1.186)	(1.498)
Observations	28,400	153,229	77,046
Pair FE	NO	NO	NO
Importer-year FE	YES	YES	YES
Exporter-year FE	YES	YES	YES

Standard errors are clustered at (and may be correlated within) base groups (importer, exporter, and year) and every combination of the three.
*** p<0.01, ** p<0.05, * p<0.1
Same set of control variables are included. Obervations in column (1) are significanlty dropped due to missing.

Table 10: IV estimation

	(1)
VARIABLES	Wtrade
LPID	-0.50***
	(0.039)
LnGDP	0.00
	(0.000)
D	-0.06***
	(0.008)
comrelig	0.21***
	(0.012)
comlang_off	0.15***
	(0.009)
comcol	-0.05***
	(0.013)
contig	0.49***
	(0.020)
fta_wto	0.10***
	(0.009)
Observations	160,492
R-squared	0.100
Pair FE	NO
Importer-year FE	YES
Exporter-year FE	YES

Standard errors are clustered at (and may be correlated within) base groups (importer, exporter, and year) and every combination of the three.
*** p<0.01, ** p<0.05, * p<0.1
Second IV stage is reported

5. Conclusion

This study examines how differences in logistics performance between trading partners shape bilateral wine exports. Using a panel of 152 countries over the period 2007–2021, we construct a multidimensional measure of LPID based on the World Bank's LPI and estimate its effect within a gravity framework using PPML. The results consistently show that greater logistics performance distance is associated with lower wine exports, indicating that asymmetries in logistics systems act as a meaningful and persistent source of trade costs.

A more detailed analysis reveals that not all dimensions of logistics divergence matter equally. Differences in customs efficiency, infrastructure quality, logistics service competence, and delivery timeliness account for much of the negative association, while gaps in shipment arrangement and tracking capabilities appear less influential. The results also highlight important heterogeneity across product types: the negative association between logistics distance and exports is stronger for bottled wine than for bulk wine, consistent with the higher value, quality sensitivity, and handling requirements of bottled products.

Further analysis shows that the impact of logistics performance distance is not constant over time. It becomes more pronounced during periods of global economic stress, such as the global financial crisis, when supply chains are more fragile and exporters are less able to absorb logistics-related frictions. At the same time, the persistence of a negative and significant association outside crisis periods suggests that logistics distance reflects a structural source of trade friction rather than only a temporary disruption. Additional results indicate that this effect is amplified in geographically constrained contexts, particularly for country pairs involving landlocked economies.

Extending the analysis to account for institutional integration, we find that deeper trade agreements-measured using the depth indicators from the DTA 2.0 database-are associated with higher wine exports. However, they do not eliminate the negative effect of logistics performance distance. This suggests that while deeper agreements can facilitate trade through regulatory coordination and customs harmonization, they do not fully substitute for underlying differences in logistics systems. Logistics capacity and institutional integration therefore appear to operate as complementary drivers of trade.

These findings point to several policy implications that are specific to the wine sector. First, improving logistics performance remains essential, particularly in areas such as customs procedures, infrastructure quality, and delivery reliability, which directly affect the handling and quality preservation of wine shipments. Second, reducing procedural "distance" through digitalization offers a concrete and scalable policy lever. The adoption of electronic certification systems, digital customs documentation, and interoperable single-window platforms can help harmonize procedures across countries, reduce clearance times, and improve transparency in cross-border transactions. Such measures are especially relevant for wine trade, where regulatory compliance and certification play a central role.

At the same time, promoting deeper trade agreements that include provisions on trade facilitation, customs cooperation, and regulatory alignment can reinforce these efforts. However, the results suggest that such agreements are most effective when supported by adequate logistics infrastructure and service capacity. In this sense, policies aimed at improving logistics systems and those fostering deeper institutional integration should be viewed as mutually reinforcing rather than as substitutes.

This study nonetheless has several limitations. The LPI is survey-based and available only at discrete intervals, which may limit its ability to capture short-term fluctuations in logistics conditions. In addition, while the analysis distinguishes between bottled and bulk wine, it does not explicitly account for finer product segmentation, such as quality tiers or price segments, which may respond differently to logistics frictions.

Future research could build on these findings by using more granular or higher-frequency logistics data, as well as by further disaggregating wine trade by product characteristics. Extending the analysis to other agri-food sectors would also help assess whether the role of logistics performance distance identified here is specific to wine or reflects a broader pattern affecting quality-sensitive and time-dependent goods.

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Appendix:

Table A1: List of countries

No.	Reporter	Percent	No.	Reporter	Percent	No.	Reporter	Percent	No.	Reporter	Percent
1	AFG	0.47	39	DNK	0.97	77	KGZ	0.57	115	PNG	0.4
2	AGO	0.46	40	DOM	0.76	78	KHM	0.82	116	POL	0.96
3	ALB	0.6	41	DZA	0.73	79	KOR	0.97	117	PRT	0.95
4	ARE	0.88	42	ECU	0.84	80	KWT	0.72	118	PRY	0.76
5	ARG	0.94	43	EGY	0.93	81	LAO	0.61	119	QAT	0.79
6	ARM	0.62	44	ESP	0.98	82	LBN	0.89	120	RWA	0.57
7	AUS	0.97	45	EST	0.89	83	LBR	0.48	121	SAU	0.94
8	AUT	0.97	46	ETH	0.31	84	LBY	0.29	122	SDN	0.02
9	AZE	0.38	47	FIN	0.96	85	LKA	0.79	123	SEN	0.83
10	BDI	0.41	48	FJI	0.44	86	LSO	0.12	124	SGP	0.95
11	BEL	0.2	49	GAB	0.63	87	LUX	0.2	125	SLB	0.29
12	BEN	0.59	50	GBR	0.97	88	LVA	0.92	126	SLE	0.52
13	BFA	0.61	51	GEO	0.65	89	MAR	0.68	127	SLV	0.69
14	BGD	0.74	52	GHA	0.81	90	MDA	0.73	128	SOM	0.22
15	BGR	0.95	53	GIN	0.55	91	MDG	0.8	129	STP	0.27
16	BHR	0.78	54	GMB	0.44	92	MDV	0.32	130	SVK	0.94
17	BHS	0.47	55	GNB	0.25	93	MEX	0.93	131	SVN	0.93
18	BIH	0.79	56	GNQ	0.2	94	MKD	0.71	132	SWE	0.96
19	BLR	0.76	57	GRC	0.95	95	MLI	0.55	133	SYR	0.13
20	BOL	0.67	58	GTM	0.78	96	MLT	0.73	134	TCD	0.39
21	BRA	0.97	59	GUY	0.57	97	MMR	0.74	135	TGO	0.59
22	BRN	0.21	60	HKG	0.97	98	MNG	0.5	136	THA	0.97
23	BTN	0.27	61	HND	0.71	99	MOZ	0.39	137	TJK	0.42
24	CAF	0.26	62	HRV	0.91	100	MRT	0.55	138	TKM	0.25
25	CAN	0.97	63	HTI	0.53	101	MUS	0.72	139	TTO	0.26
26	CHL	0.89	64	HUN	0.95	102	MWI	0.51	140	TUN	0.89
27	CHN	0.97	65	IDN	0.48	103	MYS	0.5	141	TUR	0.97
28	CIV	0.84	66	IRL	0.96	104	NER	0.62	142	TZA	0.6
29	CMR	0.78	67	IRN	0.59	105	NGA	0.82	143	UGA	0.57
30	COG	0.54	68	IRQ	0.4	106	NIC	0.41	144	UKR	0.93
31	COL	0.91	69	ISL	0.66	107	NLD	0.97	145	URY	0.87
32	COM	0.43	70	ISR	0.78	108	NPL	0.68	146	UZB	0.56

33	CRI	0.83	71	ITA	0.13	109	NZL	0.95	147	VEN	0.33
34	CUB	0.46	72	JAM	0.68	110	OMN	0.85	148	VNM	0.46
35	CYP	0.92	73	JOR	0.9	111	PAK	0.48	149	YEM	0.24
36	CZE	0.96	74	JPN	0.97	112	PAN	0.75	150	ZAF	0.2
37	DEU	0.49	75	KAZ	0.72	113	PER	0.87	151	ZMB	0.56
38	DJI	0.38	76	KEN	0.88	114	PHL	0.94	152	ZWE	0.6