Logistic and Operation Management Research, Vol. 5 No.2 (2026) https://doi.org/10.31098/lomr.v5i2.4923

Check for updates

Research Paper

Digitalization, Institutional Quality, and Logistics Performance: Structural Complementarity versus Within-Country Dynamics

Phan Nhan Trung[1]*
Thu Dau Mot University, Vietnam

Received: August 17, 2026	Revised : October 26, 2026	Accepted : November 19, 2026	Online : November 20, 2026

Abstract

Previous cross-country studies of logistics performance have examined digitalization and institutional quality as separate determinants and have reported single panel coefficients that do not distinguish differences between countries from changes within countries. This study examines whether the two factors are complementary and whether their associations with logistics performance differ between and within economies. Using all seven survey-based editions of the World Bank Logistics Performance Index (2007–2023), an unbalanced panel of 160 economies and 971 observations is analysed with random-effects, fixed-effects and hybrid within-between estimators and cluster-robust standard errors. Digitalization is measured by internet use and institutional quality by the average of the six Worldwide Governance Indicators, both lagged by one year. Within economies, neither digitalization, institutional quality nor their interaction is statistically distinguishable from zero, while GDP per capita is positively associated with logistics performance. Between economies, higher average institutional quality is consistently associated with higher logistics performance, and higher average digitalization is positively associated with logistics performance in most specifications. The between-economy interaction is positive in all specifications and significant in the baseline model, indicating that the association between digitalization and logistics performance is stronger in economies with higher institutional quality; this result is sensitive to the digitalization measure and to sample composition. Cluster-robust Mundlak tests confirm that within and between associations differ. The findings suggest that digital logistics initiatives are more likely to be associated with better logistics outcomes when they are accompanied by stronger overall institutional quality.

Keywords: *Logistics Performance Index; Digitalization; Institutional Quality; Complementarity; Within-Between Panel Model*

INTRODUCTION

Logistics performance determines how efficiently a country connects to international markets. Delays, unpredictable delivery and slow border procedures act as trade costs whose effects often exceed those of geographical distance (Djankov et al., 2010; Hummels & Schaur, 2013). Countries with better logistics performance trade more, attract more foreign investment and participate more deeply in global value chains (Hausman et al., 2013; Martí et al., 2014; Soh et al., 2021). Since 2007, the World Bank Logistics Performance Index (LPI) has served as the main benchmark for such comparisons, combining assessments of customs, infrastructure, international shipments, logistics competence, tracking and tracing, and timeliness (Arvis et al., 2018, 2023).

Two groups of determinants have received particular attention. The first is digitalization. Internet access, digital platforms and electronic data exchange reduce information costs, enable shipment tracking and support paperless trade procedures (Freund & Weinhold, 2004; Moldabekova et al., 2021). Recent studies report positive associations between digital transformation and LPI scores among European Union members (Şahan, 2025) and identify digitalization and innovation indicators among the strongest predictors of the LPI in cross-country

Copyright Holder:
© Trung. (2026)
Corresponding author's email: trungpn@tdmu.edu.vn
This Article is Licensed Under:

machine learning analyses (Çelebi et al., 2025). The second is institutional quality. Logistics services depend on contract enforcement, transparent regulation and predictable border administration, all of which are shaped by the institutional environment (North, 1990; Levchenko, 2007). Panel evidence links institutional quality to logistics performance across countries (Wong & Tang, 2018), and institutional quality conditions the relationship between logistics performance and foreign direct investment in Asia (Soh et al., 2021).

Existing cross-country evidence has established several building blocks. Global panel studies show that institutional quality, infrastructure, technology and education are associated with logistics performance (Wong & Tang, 2018), cross-country analyses link logistics performance to trade (Gani, 2017; Martí et al., 2014), and cross-sectional machine learning studies rank digitalization and innovation indicators among the strongest predictors of LPI scores (Çelebi et al., 2025). Two questions nevertheless remain open. First, digitalization and institutional quality are usually entered as separate determinants, so the argument that digital technologies generate returns mainly when they are supported by sound regulation and capable institutions (Brynjolfsson & Hitt, 2000; World Bank, 2016) has rarely been tested with logistics performance as the outcome. Second, panel studies typically select a fixed-effects or random-effects estimator with the Hausman test and report one coefficient per determinant (Alnıpak et al., 2023; Şahan, 2025; Wong & Tang, 2018). Such a coefficient combines two distinct questions: whether economies with persistently higher digitalization or institutional quality perform better, and whether improvements within an economy are associated with higher logistics scores over time (Bell & Jones, 2015). The two questions can have different answers, and their policy implications differ.

The study also takes advantage of the completion of the survey-based LPI series. The World Bank has replaced the survey-based index with LPI 2.0, which is built from shipment-level and vessel-tracking data (World Bank, 2025), so the seven editions published between 2007 and 2023 now form a closed and comparable series. This series provides a suitable setting for addressing the two questions above over the full period covered by the perception-based index.

Against this background, the study has three objectives: (1) to estimate the associations of digitalization and institutional quality with national logistics performance using all seven survey-based LPI editions for a global sample; (2) to test whether digitalization and institutional quality are complementary; and (3) to separate the within-economy and between-economy components of these associations using a hybrid within-between model (Mundlak, 1978; Schunck, 2013). The study contributes to the logistics literature by examining the complementarity between digital and institutional capabilities with logistics performance as the outcome, and by assessing whether the determinants of the LPI operate through persistent cross-economy differences, through changes within economies, or both. The remainder of the paper reviews the literature and develops the hypotheses, describes the data and method, presents and discusses the findings, and concludes with implications, limitations and directions for further research.

LITERATURE REVIEW

Logistics Performance and Its Measurement

Logistics performance refers to the efficiency, cost and reliability with which a country moves goods across its borders and through its supply chains. Its economic importance is well established. Time in transit acts as a trade barrier: each additional day in transit is equivalent to an ad valorem tariff of 0.6 to 2.1 percent (Hummels & Schaur, 2013), and each additional day of delay before shipment reduces trade by at least one percent (Djankov et al., 2010). Logistics performance indicators are significant determinants of bilateral trade (Hausman et al., 2013), of export competitiveness in European countries (Puertas et al., 2014) and of international trade flows more generally (Martí et al., 2014; Gani, 2017).

The survey-based LPI has been the standard cross-country measure of logistics performance since 2007. In each edition, international freight forwarders and express carriers rate the logistics environment of the countries they trade with on six components: the efficiency of customs and border management, the quality of trade and transport infrastructure, the ease of arranging competitively priced shipments, the competence and quality of logistics services, the ability to track and trace consignments, and the timeliness of shipments (Arvis et al., 2018, 2023). The ratings are combined into an overall score from 1 to 5. Because the index relies on perceptions, its weighting scheme and potential subjectivity have been debated (Rezaei et al., 2018; Beysenbaev & Dus, 2020), and the World Bank has replaced it with LPI 2.0, which uses shipment-level tracking data (World Bank, 2025). The survey-based series nevertheless remains the longest comparable record of logistics performance for a broad set of countries.

Digitalization and Logistics Performance

Digitalization lowers the information and coordination costs that make logistics slow and unpredictable. Internet access allows firms to search for partners, compare freight rates, submit documents electronically and monitor shipments in real time. At the macro level, the diffusion of the Internet stimulates trade by reducing market-specific entry costs (Freund & Weinhold, 2004). In the logistics literature, Moldabekova et al. (2021) find that ICT human capital, internet use, the integration of digital technologies in business and digital connectivity are associated with higher LPI scores in European countries. Using panel data for 25 European Union members from 2017 to 2022, Şahan (2025) reports that digital transformation and its components improve logistics performance. Çelebi et al. (2025) identify internet use and e-government development among the variables that explain a large share of cross-country LPI variation in a random forest analysis, and Ekici et al. (2016), linking competitiveness indicators to the LPI components, identify fixed broadband availability as the most important area for improving logistics performance in Turkey.

The resource-based view explains how firms obtain superior performance from resources that are valuable and difficult to imitate (Barney, 1991), and information technology capability is one such resource when it is combined with complementary organizational assets (Bharadwaj, 2000). At the national level, the analogous concept is national capability: the stock of technological infrastructure, skills and institutional arrangements that allows an economy to use new technologies productively (Fagerberg & Srholec, 2008). Digital infrastructure and skills are built gradually and are embedded in the routines of firms and public agencies, so economies differ persistently in their digital capabilities. These differences are expected to appear mainly between economies, whereas increases in internet access within an economy may take time to change logistics practices. The first hypothesis distinguishes the two levels.

- H1a: Economies with higher average digitalization have higher logistics performance (between-economy association).
- H1b: Increases in digitalization within an economy are associated with higher logistics performance (within-economy association).

Institutional Quality and Logistics Performance

Institutions are the formal rules and informal constraints that structure economic exchange (North, 1990). Logistics involves sequences of transactions among shippers, forwarders, carriers, port operators and border agencies, each of which depends on enforceable contracts, transparent regulation and predictable administrative behaviour. Logistics can therefore be regarded as an institutionally intensive activity in the sense of Levchenko (2007) and Nunn (2007): its output depends on relationship-specific transactions among several parties whose performance cannot be fully specified in contracts, so the quality of enforcement and administration directly affects costs

and delays. Evidence from ports and customs supports this view. Sequeira and Djankov (2014) show that bribe payments at African ports lead firms to change their transport routes at additional cost, and Yang (2008) finds that customs reforms based on pre-shipment inspection raised import duty collection mainly by reducing the falsification of trade documents.

Empirical studies support this link. In an unbalanced panel of 93 countries, Wong and Tang (2018) find that institutional quality, together with infrastructure, technology and education, is a major determinant of logistics performance. Soh et al. (2021) show that the effect of logistics performance on foreign direct investment in 31 Asian economies depends on the level of institutional quality. Institutional quality is measured here with the composite of the six Worldwide Governance Indicators (WGI), which combine perceptions from many sources into estimates of governance (Kaufmann et al., 2011). The composite is used rather than a single dimension for three reasons. Logistics performance depends on several dimensions at once, including regulatory quality, government effectiveness, the rule of law and control of corruption; the six dimensions are highly correlated, with pairwise correlations between 0.67 and 0.94 in the data used here, which makes their separate associations difficult to identify; and averaging indicators that each contain measurement error yields a more precise measure of overall governance (Kaufmann et al., 2011). A composite of the four dimensions most directly related to logistics operations is used in a robustness check. Because institutions change slowly (Acemoglu et al., 2001; Williamson, 2000), their association with logistics performance is expected to appear mainly between economies.

- H2a: Economies with higher average institutional quality have higher logistics performance (between-economy association).
- H2b: Improvements in institutional quality within an economy are associated with higher logistics performance (within-economy association).

Complementarity between Digitalization and Institutions

Two inputs are complementary when an increase in one raises the marginal return to the other (Milgrom & Roberts, 1995). Research on information technology shows that its productivity effects depend on complementary investments in organization and work practices (Brynjolfsson & Hitt, 2000). At the country level, the World Development Report on digital dividends argues that the benefits of digital technologies materialize only when they are supported by analog complements, including regulations that promote competition, skills, and institutions that are capable and accountable (World Bank, 2016).

Logistics provides a direct setting for this argument. Electronic customs declarations, single-window systems and tracking platforms can shorten clearance times only if border agencies apply rules transparently and predictably. Existing evidence is consistent with this view. E-government is associated with lower corruption across countries (Andersen, 2009), which indicates that digital procedures and institutional quality are closely linked, and the export performance of developing countries responds both to hard infrastructure, including information and communication technology, and to soft infrastructure, including the regulatory and business environment (Portugal-Perez & Wilson, 2012). Where corruption and regulatory discretion are high, firms may face informal payments at ports (Sequeira & Djankov, 2014) and trade documentation remains vulnerable to falsification (Yang, 2008), so the potential gains of digital procedures may be reduced. Evidence on this interaction for logistics performance remains limited, since most studies include digitalization and institutional quality as separate regressors. The third hypothesis expresses the complementarity at both levels.

- H3a: The between-economy association between digitalization and logistics performance is stronger in economies with higher average institutional quality.
- H3b: The within-economy association between digitalization and logistics performance is

stronger when institutional quality is higher.

Structural and Within-Country Effects

Determinants of logistics performance can operate at two levels. A structural effect exists when countries with persistently higher levels of a factor perform better than countries with lower levels. A within-country effect exists when a country's logistics performance improves as the factor improves over time. These effects need not coincide. Institutions are highly persistent and change slowly (Acemoglu et al., 2001; Williamson, 2000), and their influence on logistics may build up through infrastructure and organizational capabilities over long periods. Improvements recorded between two LPI editions may therefore have little measurable association with logistics scores even when the cross-country relationship is strong.

Most panel studies of LPI determinants estimate pooled, random-effects or fixed-effects models and select among them with the Hausman (1978) test (Alnıpak et al., 2023; Şahan, 2025; Wong & Tang, 2018). The fixed-effects estimator identifies only within-country effects, while the random-effects estimator combines within and between variation under the assumption that the two are equal. When they differ, neither estimator alone describes the relationship. The hybrid within-between approach, which builds on Mundlak (1978), estimates both components in a single model (Bell & Jones, 2015; Schunck, 2013). Because digital and institutional capabilities are persistent and the LPI is observed only seven times at irregular intervals, the between-economy associations are expected to be stronger than the within-economy associations.

- H4: The associations of digitalization and institutional quality with logistics performance differ between the two levels and are stronger between economies than within economies.

RESEARCH METHOD

Data and Sample

The dependent variable is the overall score of the survey-based LPI, which the World Bank published in 2007, 2010, 2012, 2014, 2016, 2018 and 2023. Each edition aggregates the ratings of international freight forwarders and express carriers on six components into a score ranging from 1 (lowest) to 5 (highest) (Arvis et al., 2018, 2023). The scores were obtained from the World Development Indicators (WDI) database, which records the 2023 edition under the year 2022; this edition was reassigned to its publication year so that all seven editions are treated consistently. Institutional quality is measured with the WGI 2024 update, which applies a revised aggregation methodology to the entire series from 1996 onward (Kaufmann & Kraay, 2024). Internet penetration, fixed broadband, GDP per capita and trade openness are taken from the WDI.

All explanatory variables are measured in the year before each LPI edition, that is, 2006 for the 2007 edition, 2009 for the 2010 edition and so on, up to 2022 for the 2023 edition. Lagging the regressors is a common way to reduce simultaneity, but it does not by itself remove reverse causality, particularly for slowly changing variables such as institutional quality (Bellemare et al., 2017; Reed, 2015); the estimates are therefore interpreted as associations. The one-year lag also approximates the period in which survey respondents form their assessments.

The number of economies differs across editions for two reasons. First, the World Bank surveyed a different set of economies in each edition, and the WDI reports LPI scores for 149, 154, 153, 159, 159, 159 and 138 economies in the seven editions, or 1,071 observations in total. Second, 100 of these observations lack at least one explanatory variable in the preceding year: 77 lack trade openness, 13 lack internet use, 7 lack GDP per capita together with trade openness, and 3 observations for Venezuela report trade openness of zero, which cannot be log-transformed. Missing trade data affect economies such as Afghanistan, Guyana, Jamaica, Jordan and Liberia, and missing internet data mainly affect conflict-affected economies such as Sudan, Syria and Yemen.

The estimation sample is an unbalanced panel of 160 economies and 971 economy-edition observations, with between 127 and 148 economies per edition; 95 economies are observed in all seven editions. The Appendix lists the included economies and the number of editions for each.

Variables

Table 1 defines the variables. Digitalization (DIG) is measured by the share of the population using the Internet. This indicator captures the breadth of digital adoption among the individuals and firms that interact with logistics services, it has the widest coverage across economies and years in the 2006–2022 window, and prior LPI studies use it as a core digitalization measure (Moldabekova et al., 2021; Çelebi et al., 2025). Because internet use does not capture the quality of connections, fixed broadband subscriptions per 100 people are used as an alternative measure in a robustness check. Institutional quality (IQ) is the unweighted average of the six WGI estimates, computed only where all six are available. Both variables are standardized to a mean of zero and a standard deviation of one over the estimation sample. Their coefficients therefore express the change in LPI associated with a one-standard-deviation difference, and in the interaction models each main effect refers to an economy at the sample mean of the other variable. The natural logarithm of GDP per capita controls for the level of economic development, which is closely related to logistics capacity (Lean et al., 2014; Alnıpak et al., 2023), and the natural logarithm of trade openness controls for exposure to international trade (Gani, 2017). For robustness, an alternative institutional index averages the four dimensions most closely related to logistics operations (government effectiveness, regulatory quality, rule of law and control of corruption), and time-invariant geographic controls comprise a landlocked indicator and seven World Bank regional dummies.

Table 1. Variable definitions and data sources

Variable	Measurement	Source
LPI	Logistics Performance Index, overall score (1 = low, 5 = high); editions 2007, 2010, 2012, 2014, 2016, 2018 and 2023	World Bank, WDI
DIG	Individuals using the Internet (% of population), year t − 1, standardized	WDI (ITU)
DIG (alternative)	Fixed broadband subscriptions (per 100 people), year t − 1, standardized	WDI (ITU)
IQ	Average of the six WGI estimates (voice and accountability, political stability, government effectiveness, regulatory quality, rule of law, control of corruption), year t − 1, standardized	WGI 2024 update (Kaufmann & Kraay, 2024)
IQ (alternative)	Average of government effectiveness, regulatory quality, rule of law and control of corruption, year t − 1, standardized	WGI 2024 update
lnGDP	Natural logarithm of GDP per capita (constant 2015 US$), year t − 1	WDI
lnTRADE	Natural logarithm of trade (% of GDP), year t − 1	WDI
Landlocked	1 if the economy has no sea coast, 0 otherwise	UN-OHRLLS classification
Region	Seven World Bank regions	WDI country metadata

Source: Author's compilation.

Empirical Strategy

The baseline model relates logistics performance to digitalization, institutional quality and the control variables:

$$LPI_{it} = \beta_0 + \beta_1 DIG_{i,t-1} + \beta_2 IQ_{i,t-1} + \gamma' X_{i,t-1} + \lambda_t + u_i + \varepsilon_{it} \quad (1)$$

where *i* indexes economies and *t* LPI editions, *X* contains the logarithms of GDP per capita and trade openness, λ_t are edition fixed effects that capture global shocks and changes in the survey common to all economies, u_i is the economy-specific effect and ε_{it} is the idiosyncratic error. Equation (1) is estimated with random effects (RE) and fixed effects (FE). To test H3, Equation (2) adds the interaction between digitalization and institutional quality:

$$LPI_{it} = \beta_0 + \beta_1 DIG_{i,t-1} + \beta_2 IQ_{i,t-1} + \beta_3 (DIG \times IQ)_{i,t-1} + \gamma' X_{i,t-1} + \lambda_t + u_i + \varepsilon_{it} \quad (2)$$

Logistics performance, institutional quality and digitalization vary far more across economies than within them (Table 2). The FE estimator identifies effects only from the limited within-economy variation, whereas the RE estimator assumes that the economy effects are uncorrelated with the regressors. The hybrid within-between model relaxes this trade-off (Mundlak, 1978; Bell & Jones, 2015; Schunck, 2013):

$$LPI_{it} = \beta_0 + \beta^{W\prime}(Z_{it} - \bar{Z}_i) + \beta^{B\prime}\bar{Z}_i + \lambda_t + u_i + \varepsilon_{it} \quad (3)$$

where *Z* is the vector of time-varying regressors (DIG, IQ, their product, and the two controls), $\bar{Z}_i$ is the mean of each regressor for economy *i* over the sample, and $Z_{it} - \bar{Z}_i$ is the deviation from that mean. The within coefficients β^W reproduce the FE estimates, while the between coefficients β^B capture the association between persistent cross-economy differences and logistics performance. Following Schunck (2013), the interaction is decomposed in the same way as the other regressors, using the economy mean of the product and the deviation from it. To compute the marginal effect of structural digitalization at different levels of structural institutional quality, an alternative specification enters the between interaction as the product of the economy means of DIG and IQ. A Wald test of $\beta^W = \beta^B$ shows whether the two components differ, which provides the test of H4.

Estimation and Robustness

All models include edition fixed effects and report standard errors clustered by economy, which are robust to heteroskedasticity and to serial correlation within economies (Wooldridge, 2010). The conventional Hausman (1978) test is computed from the non-robust FE and RE estimates. Because this version is not valid under heteroskedasticity and serial correlation, a cluster-robust version is also reported as the Wald test of equal within and between coefficients in the hybrid model, which is equivalent to the Mundlak (1978) test (Wooldridge, 2010). Multicollinearity is assessed with variance inflation factors (VIF). Cross-sectional dependence is examined with the CD test of Pesaran (2015), its weighted version CDw (Juodis & Reese, 2022), the power-enhanced CDw+ based on Fan et al. (2015) and the bias-corrected CD* (Pesaran & Xie, 2021). Because the available implementation requires a balanced structure, these tests are computed for the 95 economies observed in all seven editions. Common shocks, including changes in survey design between editions, are absorbed by the edition fixed effects.

Robustness checks are applied to both the FE and the hybrid models. The FE interaction model is re-estimated without the 2023 edition, which followed a five-year gap after the 2018 edition, was collected after the supply chain disruptions of the pandemic period and reports scores

rounded to one decimal place. The hybrid interaction model is re-estimated (i) without the 2023 edition, (ii) with fixed broadband in place of internet use, (iii) with the landlocked indicator and regional dummies, (iv) with the four-dimension institutional index, and (v) on the balanced panel of 95 economies.

Software, Code and Data Availability

All estimations were carried out in StataNow/MP 19.5 (StataCorp, 2025). Panel models were estimated with the xtreg command (options re and fe with clustered standard errors), within-between components were constructed as economy means and deviations, marginal effects were computed with margins and lincom, tables were produced with esttab (Jann, 2007), and cross-sectional dependence tests were computed with xtcd2. All data are publicly available from the World Bank World Development Indicators and Worldwide Governance Indicators databases. The compiled dataset and the Stata commands used to produce all tables are available from the corresponding author upon request.

FINDINGS AND DISCUSSION

Descriptive Statistics and Correlations

Table 2 reports descriptive statistics for the estimation sample. The mean LPI score is 2.92 with a standard deviation of 0.59, and scores range from 1.60 to 4.30. Internet penetration averages 45.2 percent but ranges from almost zero to universal access, which reflects the wide digital divide across economies and over the 2006–2022 period. The WGI composite has a mean close to zero and a standard deviation of 0.92, consistent with the construction of the WGI on a standard normal scale (Kaufmann et al., 2011). The between-economy standard deviation exceeds the within-economy standard deviation for every variable. For institutional quality, the within standard deviation (0.119) is about one-eighth of the between standard deviation (0.921), and for GDP per capita it is less than one-tenth (0.133 compared with 1.458). For the LPI, the within standard deviation is 0.171 compared with 0.561 between economies. Most of the variation available for estimation is therefore cross-sectional, which limits the precision of within-economy estimates.

Table 2. Descriptive statistics with between-economy and within-economy standard deviations

Variable	Obs.	Mean	SD overall	SD between	SD within	Min	Max
LPI	971	2.919	0.586	0.561	0.171	1.598	4.300
Internet users (% of population)	971	45.210	31.329	27.431	16.092	0.228	100.000
Fixed broadband (per 100 people)	934	12.391	13.281	11.985	5.107	0.000	48.250
WGI composite	971	0.004	0.918	0.921	0.119	−2.162	1.925
ln GDP per capita	971	8.714	1.436	1.458	0.133	5.857	11.585
ln Trade (% of GDP)	971	4.347	0.522	0.507	0.146	2.881	6.093

Explanatory variables are measured in the year before each LPI edition. Between and within standard deviations are computed over 160 economies (159 for fixed broadband). Source: Author's calculation.

Table 3 shows that the LPI is strongly correlated with the WGI composite (r = 0.815), GDP per capita (r = 0.801) and internet penetration (r = 0.723), and weakly correlated with trade openness (r = 0.265). The explanatory variables are also correlated with each other, most strongly GDP per capita with internet penetration (0.830) and with institutional quality (0.826). The VIF

values in the FE interaction model range from 1.17 to 4.95, with a mean of 2.82, which is below the conventional threshold of 10 and below the stricter threshold of 5.

Table 3. Correlation matrix

Variable	(1)	(2)	(3)	(4)	(5)
(1) LPI	1				
(2) Internet users	0.723	1			
(3) WGI composite	0.815	0.719	1		
(4) ln GDP per capita	0.801	0.830	0.826	1	
(5) ln Trade	0.265	0.345	0.350	0.353	1

N = 971. All coefficients are significant at p < 0.001. Source: Author's calculation.

Baseline Random-Effects and Fixed-Effects Estimates

Table 4 presents the baseline estimates with 95 percent confidence intervals and edition effects. In the RE model (column 1), institutional quality and GDP per capita are positive and significant at the 1 percent level, while digitalization and trade openness are not significant. A one-standard-deviation increase in institutional quality is associated with an LPI score that is higher by 0.216 points, or about 0.37 standard deviations of the index. The conventional Hausman test, however, rejects the null hypothesis that the economy effects are uncorrelated with the regressors ($\chi^2(10) = 29.80$, $p < 0.001$), and the cluster-robust Mundlak test reported in Table 5 leads to the same conclusion ($\chi^2(4) = 22.46$, $p < 0.001$). The RE estimates are therefore inconsistent, and the FE specification is preferred among the two conventional estimators.

Under FE (column 2), the coefficient on institutional quality falls to 0.087 and is not statistically distinguishable from zero (p = 0.173); its 95 percent confidence interval ranges from −0.038 to 0.211, which is compatible both with no association and with a moderate positive association. Digitalization is also not significant (0.018, 95 percent confidence interval −0.029 to 0.066). GDP per capita is positively associated with the LPI: a 10 percent higher GDP per capita corresponds to an LPI score higher by about 0.019 points. Adding the interaction term (column 3) yields a positive but insignificant coefficient on DIG × IQ (0.029, p = 0.135, 95 percent confidence interval −0.009 to 0.068). Table 6 reports the implied within-economy marginal effects of digitalization, which range from −0.026 at two standard deviations below the mean of institutional quality to 0.091 at two standard deviations above it; none is significant at the 10 percent level. Excluding the 2023 edition (column 4) yields the same pattern. Given the small within-economy variation documented in Table 2, these results indicate that within-economy associations cannot be estimated precisely with seven survey rounds; they do not establish that such associations are absent. The edition effects are positive in all models and significant except for the 2018 edition in column 4, indicating that average LPI scores in later editions were higher than in 2007 for given values of the regressors.

Table 4. Baseline random-effects and fixed-effects estimates (dependent variable: LPI)

Variable	(1) RE	(2) FE	(3) FE	(4) FE, excl. 2023
DIG	0.030 (0.023) [−0.016, 0.076]	0.018 (0.024) [−0.029, 0.066]	0.032 (0.026) [−0.019, 0.083]	0.039 (0.031) [−0.023, 0.101]
IQ	0.216*** (0.037) [0.143, 0.289]	0.087 (0.063) [−0.038, 0.211]	0.095 (0.063) [−0.029, 0.219]	0.045 (0.077) [−0.107, 0.198]

Variable	(1) RE	(2) FE	(3) FE	(4) FE, excl. 2023
DIG × IQ			0.029 (0.019) [−0.009, 0.068]	0.016 (0.025) [−0.033, 0.066]
ln GDP per capita	0.176*** (0.025) [0.127, 0.226]	0.202*** (0.065) [0.073, 0.331]	0.203*** (0.064) [0.076, 0.330]	0.289*** (0.085) [0.121, 0.458]
ln Trade	−0.001 (0.035) [−0.069, 0.068]	0.055 (0.048) [−0.039, 0.149]	0.037 (0.049) [−0.061, 0.134]	0.076 (0.060) [−0.042, 0.195]
Edition 2010	0.115*** (0.022)	0.125*** (0.022)	0.118*** (0.023)	0.118*** (0.023)
Edition 2012	0.120*** (0.024)	0.120*** (0.025)	0.112*** (0.026)	0.100*** (0.027)
Edition 2014	0.132*** (0.026)	0.133*** (0.028)	0.122*** (0.030)	0.107*** (0.034)
Edition 2016	0.101*** (0.031)	0.113*** (0.035)	0.099*** (0.037)	0.083** (0.042)
Edition 2018	0.081** (0.032)	0.093*** (0.035)	0.078** (0.038)	0.056 (0.043)
Edition 2023	0.136*** (0.043)	0.142*** (0.050)	0.126** (0.052)	
Constant	1.274*** (0.240)	0.819 (0.573)	0.877 (0.567)	−0.024 (0.774)
Observations	971	971	971	844
Economies	160	160	160	158
Within R^2	0.147	0.157	0.161	0.141
Overall R^2	0.719	0.683	0.702	0.665

*Standard errors clustered by economy in parentheses; 95% confidence intervals in brackets. The reference edition is 2007. Conventional Hausman test, FE versus RE (columns 1 and 2): $\chi^2(10) = 29.80$, $p < 0.001$. *** p < 0.01, ** p < 0.05, * p < 0.10. Source: Author's estimation.*

Within-Between Decomposition

Table 5 reports the hybrid within-between estimates. The within coefficients are close to the FE estimates in Table 4 and lead to the same conclusion: only GDP per capita has a significant within-economy association (0.208, p = 0.001). The between coefficients show a different pattern. In column (1), economies with structurally higher institutional quality have markedly higher LPI scores; a one-standard-deviation difference in average institutional quality corresponds to a difference of 0.296 points in the LPI, about half a standard deviation of the index. Structural digitalization is positive and marginally significant (0.123, p = 0.053). The Wald test rejects the equality of the within and between coefficients for digitalization and institutional quality ($\chi^2(2) = 13.44$, p = 0.001) and for all four regressors jointly ($\chi^2(4) = 22.46$, $p < 0.001$), confirming that the two components differ and explaining why the Hausman test rejects the RE model.

Column (2) adds the decomposed interaction. The between interaction is positive and significant (0.069, p = 0.009), and the between coefficients of digitalization (0.133, p = 0.036) and institutional quality (0.268, $p < 0.001$) remain significant. The joint Wald test of equal within and between coefficients is also rejected in this model ($\chi^2(5) = 17.73$, p = 0.003). Table 6 reports

marginal effects from the specification in which the between interaction is the product of the economy means (interaction coefficient 0.071, p = 0.007). The structural association of digitalization with the LPI is close to zero and insignificant in economies two standard deviations below the mean of institutional quality (−0.009, p = 0.901), becomes significant at the mean (0.133, p = 0.036), and rises to 0.203 (p = 0.007) and 0.274 (p = 0.003) at one and two standard deviations above the mean. The within interaction remains insignificant (0.030, p = 0.120). Among the controls, GDP per capita is significant in both components, and trade openness has a negative between coefficient (−0.106, p = 0.034, in column 1). The between components explain about 78 to 79 percent of the cross-economy variation in logistics performance, whereas the within components explain about 16 percent of the variation over time.

The VIF values of the hybrid interaction model are below 10 for all regressors, with a mean of 3.49, but they are high for the between components of digitalization (9.73) and GDP per capita (8.91). Structural digitalization and income are closely related, with a correlation of 0.83 between internet use and GDP per capita. The between coefficient of digitalization is estimated conditional on average income, but the strong overlap inflates its standard error and means that digitalization and economic development cannot be fully separated at the structural level.

Cross-sectional dependence tests on the residuals of the FE and hybrid models for the 95 economies observed in all editions do not reject the null hypothesis of weak cross-sectional dependence: CD = −0.65 (p = 0.514) and −0.75 (p = 0.454), CDw = 0.51 (p = 0.609) and 0.00 (p = 0.999), and CD* = −1.61 (p = 0.108) and −1.58 (p = 0.114), respectively. The power-enhanced CDw+ statistic rejects the null (p < 0.001); because its enhancement component aggregates squared pairwise residual correlations, each estimated from only seven observations, it is likely to be inflated by sampling noise in a panel this short. Together with the edition fixed effects, which absorb common shocks, the evidence does not indicate strong cross-sectional dependence.

Table 5. Hybrid within-between estimates (dependent variable: LPI)

Variable	**(1)**	**(2)**
Within-economy effects		
DIG	0.023 (0.024) [−0.023, 0.070]	0.038 (0.025) [−0.011, 0.088]
IQ	0.084 (0.063) [−0.040, 0.208]	0.093 (0.063) [−0.031, 0.216]
DIG × IQ		0.030 (0.019) [−0.008, 0.068]
ln GDP per capita	0.208*** (0.065) [0.080, 0.336]	0.210*** (0.064) [0.084, 0.335]
ln Trade	0.056 (0.048) [−0.037, 0.150]	0.038 (0.049) [−0.059, 0.134]
Between-economy effects		
DIG	0.123* (0.064) [−0.001, 0.248]	0.133** (0.063) [0.009, 0.256]

Variable	(1)	(2)
IQ	0.296*** (0.034) [0.229, 0.363]	0.268*** (0.036) [0.198, 0.338]
DIG × IQ		0.069*** (0.026) [0.017, 0.120]
ln GDP per capita	0.094*** (0.035) [0.025, 0.164]	0.096*** (0.036) [0.026, 0.167]
ln Trade	−0.106** (0.050) [−0.205, −0.008]	−0.097** (0.049) [−0.193, −0.002]
Edition effects (reference: 2007)		
Edition 2010	0.121*** (0.022)	0.114*** (0.023)
Edition 2012	0.115*** (0.024)	0.106*** (0.025)
Edition 2014	0.127*** (0.028)	0.115*** (0.030)
Edition 2016	0.105*** (0.034)	0.090** (0.036)
Edition 2018	0.084** (0.035)	0.068* (0.037)
Edition 2023	0.129*** (0.049)	0.112** (0.050)
Model statistics and tests		
Constant	2.452*** (0.369)	2.356*** (0.370)
Observations	971	971
Economies	160	160
R^2 within / between / overall	0.157 / 0.783 / 0.730	0.161 / 0.791 / 0.740
Wald χ^2 (model)	1017.24***	1024.39***
Within = between for DIG and IQ (and DIG × IQ in column 2)	$\chi^2(2) = 13.44$, p = 0.001	$\chi^2(3) = 11.64$, p = 0.009
Within = between for all regressors (cluster-robust Mundlak test)	$\chi^2(4) = 22.46$, p < 0.001	$\chi^2(5) = 17.73$, p = 0.003

*Random-effects estimation of the within-between specification. Within effects are deviations from economy means; between effects are economy means over the sample. Standard errors clustered by economy in parentheses; 95% confidence intervals in brackets. Maximum VIF in column (2): 9.73 (between DIG); mean VIF: 3.49. *** p < 0.01, ** p < 0.05, * p < 0.10. Source: Author's estimation*.

Table 6. Marginal effects of digitalization on LPI at different levels of institutional quality

Level of IQ (standard deviations from the mean)	Within-economy effect (FE)	Between-economy effect (hybrid)
−2	−0.026 (0.036) [−0.097, 0.044]	−0.009 (0.071) [−0.147, 0.130]
−1	0.003 (0.025) [−0.045, 0.051]	0.062 (0.062) [−0.059, 0.183]
0 (mean)	0.032 (0.026) [−0.018, 0.083]	0.133** (0.063) [0.008, 0.257]
+1	0.062 (0.039) [−0.014, 0.137]	0.203*** (0.075) [0.056, 0.350]
+2	0.091 (0.055) [−0.018, 0.200]	0.274*** (0.093) [0.092, 0.456]

*Within-economy effects are computed with margins from Table 4, column (3). Between-economy effects are linear combinations from the hybrid model in which the between interaction is the product of the economy means of DIG and IQ (interaction coefficient 0.071, SE 0.026, p = 0.007). Standard errors in parentheses; 95% confidence intervals in brackets. *** p < 0.01, ** p < 0.05, * p < 0.10. Source: Author's estimation.*

Robustness of the Within-Between Results

Table 7 reports the robustness checks for the hybrid interaction model. Across all five checks, the within-economy coefficients of digitalization, institutional quality and their interaction remain insignificant at the 5 percent level, while GDP per capita remains positively associated with the LPI within economies. The between association of institutional quality is positive and significant at the 1 percent level in every specification, with coefficients from 0.226 to 0.328. The between association of digitalization is positive in all specifications. It is significant when the 2023 edition is excluded (0.155, p = 0.019) and when fixed broadband replaces internet use (0.148, p = 0.011), marginally significant with geographic controls (0.127, p = 0.073), and not significant with the four-dimension institutional index (0.102, p = 0.100) or in the balanced panel (0.078, p = 0.454). The between interaction is also positive in all specifications. It remains significant when the 2023 edition is excluded (0.066, p = 0.010), is significant at the 10 percent level with geographic controls (0.053, p = 0.060) and with the four-dimension index (0.051, p = 0.058), and is not significant with fixed broadband (0.032, p = 0.237) or in the balanced panel (0.070, p = 0.103). The balanced panel excludes 65 economies and about 31 percent of the observations, which reduces precision, although its point estimate of the interaction is close to the baseline value. Landlocked economies have lower LPI scores, other things equal (−0.076, p = 0.068).

Table 7. Robustness checks for the hybrid within-between interaction model (dependent variable: LPI)

Variable	(1) Excl. 2023	(2) DIG = fixed broadband	(3) Geographic controls	(4) IQ = four dimensions	(5) Balanced panel
Within-economy effects					
DIG	0.045 (0.031)	−0.005 (0.024)	0.036 (0.025)	0.033 (0.025)	0.053* (0.031)
IQ	0.042 (0.078)	0.089 (0.063)	0.094 (0.063)	0.107* (0.060)	0.116 (0.078)
DIG × IQ	0.018 (0.025)	−0.020 (0.018)	0.030 (0.020)	0.025 (0.019)	0.028 (0.024)
ln GDP per capita	0.301*** (0.085)	0.185*** (0.069)	0.207*** (0.064)	0.206*** (0.063)	0.166** (0.082)
ln Trade	0.077 (0.060)	0.085 (0.052)	0.037 (0.050)	0.040 (0.048)	0.072 (0.066)
Between-economy effects					
DIG	0.155** (0.066)	0.148** (0.058)	0.127* (0.071)	0.102 (0.062)	0.078 (0.104)
IQ	0.263*** (0.036)	0.246*** (0.040)	0.268*** (0.041)	0.328*** (0.037)	0.226*** (0.082)
DIG × IQ	0.066** (0.026)	0.032 (0.027)	0.053* (0.028)	0.051* (0.027)	0.070 (0.043)
ln GDP per capita	0.088** (0.035)	0.106*** (0.027)	0.088** (0.037)	0.078** (0.034)	0.153** (0.060)
ln Trade	−0.100** (0.050)	−0.100** (0.049)	−0.121** (0.048)	−0.097** (0.043)	−0.032 (0.056)
Additional controls and statistics					
Landlocked			−0.076* (0.042)		
Regional dummies	No	No	Yes	No	No
Edition fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	844	934	971	971	665
Economies	158	159	160	160	95

*Random-effects estimation of the within-between specification with standard errors clustered by economy in parentheses. Within and between components are recomputed for each estimation sample. Column (5) includes only economies observed in all seven editions. *** p < 0.01, ** p < 0.05, * p < 0.10. Source: Author's estimation.*

Table 8 summarizes the hypothesis tests. H2a and H4 are supported, H1a is supported in most specifications, H3a receives partial support, and the within-economy hypotheses H1b, H2b and H3b are not supported by statistically significant estimates.

Table 8. Summary of hypothesis tests

Hypothesis	Evidence	Result
H1a: Between-economy DIG (+)	0.133 (p = 0.036) in Table 5; positive in all checks, significant in 3 of 5 (2 at 5%, 1 at 10%)	Supported in most specifications
H1b: Within-economy DIG (+)	Not significant at 5% in any specification	Not supported
H2a: Between-economy IQ (+)	0.268 (p < 0.001) in Table 5; significant at 1% in all checks	Supported
H2b: Within-economy IQ (+)	Not significant at 5% in any specification	Not supported
H3a: Between-economy DIG × IQ (+)	0.069 (p = 0.009) in Table 5; positive in all checks, significant in 3 of 5 (1 at 5%, 2 at 10%)	Partially supported
H3b: Within-economy DIG × IQ (+)	Not significant in any specification	Not supported
H4: Between and within associations differ, stronger between	Mundlak test $\chi^2(4) = 22.46$, $p < 0.001$; $\chi^2(5) = 17.73$, $p = 0.003$; between coefficients exceed within coefficients for DIG and IQ	Supported

Source: Author's compilation from Tables 5 and 7.

Discussion

The robust between association of institutional quality is consistent with evidence that governance is among the main correlates of logistics performance across countries (Wong & Tang, 2018) and with the broader view that institutions shape the costs of exchange and contract enforcement (Levchenko, 2007; North, 1990; Nunn, 2007). The absence of a significant within association does not contradict this evidence. Institutional environments change slowly (Acemoglu et al., 2001; Williamson, 2000), and the within-economy standard deviation of the WGI composite is only about one-eighth of its between-economy standard deviation. With seven survey rounds, the fixed-effects estimates are therefore imprecise, and their confidence intervals include both zero and moderate positive values. Pooled and random-effects models attribute the large cross-country gradient in logistics performance to institutions, whereas fixed-effects models rely only on small within-country changes. The hybrid model shows that the two approaches answer different questions and that the evidence is clear for the structural question.

For digitalization, the findings qualify earlier evidence of a positive association between digital development and the LPI (Moldabekova et al., 2021; Çelebi et al., 2025; Şahan, 2025). Those studies rely on European samples, cross-sectional comparisons or machine learning rankings, which are dominated by differences between countries. In the global panel used here, internet penetration rose rapidly in almost every economy between 2006 and 2022, but the within-economy association with logistics scores is not statistically distinguishable from zero once common edition effects and income are taken into account. A possible explanation, consistent with the national capability perspective, is that the logistics advantage associated with digitalization reflects persistent differences in digital infrastructure and skills that are embedded in the routines of firms and public agencies (Bharadwaj, 2000; Fagerberg & Srholec, 2008). Because internet use and GDP per capita are highly correlated, the structural association of digitalization also partly overlaps with differences in economic development, and its estimate is less robust than that of institutional quality.

The positive between interaction provides evidence consistent with complementarity in the sense of Milgrom and Roberts (1995): the association between digitalization and logistics performance is stronger in economies with higher institutional quality, and the marginal effects in Table 6 show that it is statistically significant only at average or above-average levels of institutional quality. This evidence is partial, because the interaction is not significant when fixed broadband is used or when the sample is restricted to the balanced panel. The pattern is consistent with the argument that digital dividends depend on analog complements such as competitive regulation and accountable institutions (World Bank, 2016), and with the firm-level finding that information technology raises productivity mainly when accompanied by complementary organizational investments (Brynjolfsson & Hitt, 2000). One possible mechanism is that electronic procedures reduce delays only where border agencies apply rules predictably. Evidence that port corruption alters firms' transport choices (Sequeira & Djankov, 2014) and that the falsification of trade documents responds to customs enforcement (Yang, 2008) is consistent with this mechanism, but the present analysis does not test it directly.

Within economies, GDP per capita is the only variable significantly associated with logistics performance. This association should not be read as a one-directional effect. Rising income may expand the demand for logistics services and the fiscal capacity to invest in transport infrastructure, but better logistics may also raise income, and evidence for China points to mutual reinforcement between logistics development and economic growth (Lean et al., 2014). The lagged regressors reduce but do not remove this concern (Bellemare et al., 2017). The significance of GDP per capita is also consistent with its role among LPI determinants in Europe (Alnıpak et al., 2023).

The results also carry a methodological implication for research on LPI determinants. Because the Hausman test rejects RE in this sample, a study that reported only FE estimates would find no significant association for digitalization or institutions, whereas a study that reported only RE or pooled estimates would attribute a large association to institutions without identifying its structural nature. Reporting within and between associations separately, as recommended by Bell and Jones (2015), avoids both errors and makes explicit which question each coefficient answers.

CONCLUSIONS

This study examined the associations of digitalization and institutional quality, and their complementarity, with national logistics performance using all seven survey-based LPI editions for 160 economies. Three conclusions follow. First, the associations of digitalization and institutional quality with logistics performance are evident between economies but are not statistically distinguishable from zero within economies, and the two levels differ significantly. Second, institutional quality is the most robust structural correlate of logistics performance, whereas the structural association of digitalization is positive but more sensitive to measurement and sample composition. Third, the structural association of digitalization with logistics performance is stronger in economies with higher institutional quality, although this complementarity is not robust to every specification.

The findings have theoretical implications. For complementarity theory, they extend the argument that the returns to digital technologies depend on complementary assets (Brynjolfsson & Hitt, 2000; Milgrom & Roberts, 1995) from firms to national logistics systems, with institutional quality acting as the complementary asset. For research on institutions and logistics, they indicate that the role of institutional quality is mainly structural: it distinguishes economies with persistently high and low logistics performance, whereas its changes between survey rounds are too small to reveal a within-economy association with the available data.

For policy, the results suggest that digital investment in logistics, such as single-window systems, electronic documentation and tracking infrastructure, is more likely to be associated with

better logistics performance in economies with stronger overall institutional quality. Digital logistics initiatives may therefore be designed together with broader improvements in governance rather than as stand-alone technology projects. Because the associations are structural, changes between two consecutive LPI rounds provide a weak basis for evaluating such initiatives.

LIMITATION & FURTHER RESEARCH

The study has several limitations. First, the survey-based LPI reflects the perceptions of logistics professionals and has been criticized for subjectivity and for the weighting of its components (Rezaei et al., 2018; Beysenbaev & Dus, 2020). Second, the panel contains at most seven observations per economy at irregular intervals, which limits the within-economy variation available for identification and the statistical power of within-economy tests. Third, internet use and fixed broadband are broad proxies for digitalization and do not capture logistics-specific technologies such as electronic single windows, port community systems or automated customs clearance, while the WGI composite aggregates governance dimensions that may affect logistics differently. Fourth, the between estimates describe persistent cross-country associations and should not be interpreted as causal effects, since unobserved economy characteristics correlated with both institutions and logistics may remain. Fifth, the panel is unbalanced. Coverage varies across editions and missing data are more frequent in conflict-affected economies, which may bias the estimates if survey coverage or data availability is related to logistics performance. Estimates for the 95 economies observed in all editions have the same signs, but some between coefficients lose significance, so the results for digitalization and for the interaction should be interpreted with caution.

Further research can address these limitations in several ways. The tracking-based LPI 2.0, which measures shipment speed and connectivity directly (World Bank, 2025), offers an objective outcome against which the present results can be compared. Future studies can use logistics-specific digitalization indicators and individual governance dimensions, examine the six LPI components separately, and apply dynamic or instrumental-variable approaches to address reverse causality. Country case studies of digital customs and trade facilitation reforms would also clarify how institutional quality conditions the logistics returns to digital investment.

REFERENCES

Acemoglu, D., Johnson, S., & Robinson, J. A. (2001). The colonial origins of comparative development: An empirical investigation. *American Economic Review, 91*(5), 1369–1401. https://doi.org/10.1257/aer.91.5.1369

Alnıpak, S., Isikli, E., & Apak, S. (2023). The propellants of the Logistics Performance Index: An empirical panel investigation of the European region. *International Journal of Logistics Research and Applications, 26*(7), 894–916. https://doi.org/10.1080/13675567.2021.1998397

Andersen, T. B. (2009). E-government as an anti-corruption strategy. *Information Economics and Policy, 21*(3), 201–210.

Arvis, J.-F., Ojala, L., Shepherd, B., Ulybina, D., & Wiederer, C. (2023). *Connecting to compete 2023: Trade logistics in an uncertain global economy*. World Bank.

Arvis, J.-F., Ojala, L., Wiederer, C., Shepherd, B., Raj, A., Dairabayeva, K., & Kiiski, T. (2018). *Connecting to compete 2018: Trade logistics in the global economy*. World Bank.

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management, 17*(1), 99–120. https://doi.org/10.1177/014920639101700108

Bell, A., & Jones, K. (2015). Explaining fixed effects: Random effects modeling of time-series cross-sectional and panel data. *Political Science Research and Methods, 3*(1), 133–153.

https://doi.org/10.1017/psrm.2014.7

Bellemare, M. F., Masaki, T., & Pepinsky, T. B. (2017). Lagged explanatory variables and the estimation of causal effect. *The Journal of Politics, 79*(3), 949–963. https://doi.org/10.1086/690946

Beysenbaev, R., & Dus, Y. (2020). Proposals for improving the Logistics Performance Index. *The Asian Journal of Shipping and Logistics, 36*(1), 34–42. https://doi.org/10.1016/j.ajsl.2019.10.001

Bharadwaj, A. S. (2000). A resource-based perspective on information technology capability and firm performance: An empirical investigation. *MIS Quarterly, 24*(1), 169–196. https://doi.org/10.2307/3250983

Brynjolfsson, E., & Hitt, L. M. (2000). Beyond computation: Information technology, organizational transformation and business performance. *Journal of Economic Perspectives, 14*(4), 23–48. https://doi.org/10.1257/jep.14.4.23

Çelebi, B., Yengil Bülbül, B., Aksoy, M. B., & Sert, M. F. (2025). Logistics 4.0: Analysis of the impact of countries' digitalization and innovation levels on logistics performance with machine learning. *Trends in Business and Economics, 39*(4), 571–583. https://doi.org/10.16951/trendbusecon.1649103

Djankov, S., Freund, C., & Pham, C. S. (2010). Trading on time. *The Review of Economics and Statistics, 92*(1), 166–173. https://doi.org/10.1162/rest.2009.11498

Ekici, Ş. Ö., Kabak, Ö., & Ülengin, F. (2016). Linking to compete: Logistics and global competitiveness interaction. *Transport Policy, 48*, 117–128. https://doi.org/10.1016/j.tranpol.2016.01.015

Fagerberg, J., & Srholec, M. (2008). National innovation systems, capabilities and economic development. *Research Policy, 37*(9), 1417–1435.

Fan, J., Liao, Y., & Yao, J. (2015). Power enhancement in high-dimensional cross-sectional tests. *Econometrica, 83*(4), 1497–1541.

Freund, C. L., & Weinhold, D. (2004). The effect of the Internet on international trade. *Journal of International Economics, 62*(1), 171–189. https://doi.org/10.1016/S0022-1996(03)00059-X

Gani, A. (2017). The logistics performance effect in international trade. *The Asian Journal of Shipping and Logistics, 33*(4), 279–288. https://doi.org/10.1016/j.ajsl.2017.12.012

Hausman, J. A. (1978). Specification tests in econometrics. *Econometrica, 46*(6), 1251–1271. https://doi.org/10.2307/1913827

Hausman, W. H., Lee, H. L., & Subramanian, U. (2013). The impact of logistics performance on trade. *Production and Operations Management, 22*(2), 236–252. https://doi.org/10.1111/j.1937-5956.2011.01312.x

Hummels, D. L., & Schaur, G. (2013). Time as a trade barrier. *American Economic Review, 103*(7), 2935–2959. https://doi.org/10.1257/aer.103.7.2935

Jann, B. (2007). Making regression tables simplified. *The Stata Journal, 7*(2), 227–244.

Juodis, A., & Reese, S. (2022). The incidental parameters problem in testing for remaining cross-section correlation. *Journal of Business & Economic Statistics, 40*(3), 1191–1203. https://doi.org/10.1080/07350015.2021.1906687

Kaufmann, D., & Kraay, A. (2024). *The Worldwide Governance Indicators: Methodology and 2024 update* (Policy Research Working Paper No. 10952). World Bank.

Kaufmann, D., Kraay, A., & Mastruzzi, M. (2011). The Worldwide Governance Indicators: Methodology and analytical issues. *Hague Journal on the Rule of Law, 3*(2), 220–246. https://doi.org/10.1017/S1876404511200046

Lean, H. H., Huang, W., & Hong, J. (2014). Logistics and economic development: Experience from China. *Transport Policy, 32*, 96–104. https://doi.org/10.1016/j.tranpol.2014.01.003

Levchenko, A. A. (2007). Institutional quality and international trade. *The Review of Economic Studies, 74*(3), 791–819. https://doi.org/10.1111/j.1467-937X.2007.00435.x

Martí, L., Puertas, R., & García, L. (2014). The importance of the Logistics Performance Index in international trade. *Applied Economics, 46*(24), 2982–2992. https://doi.org/10.1080/00036846.2014.916394

Milgrom, P., & Roberts, J. (1995). Complementarities and fit: Strategy, structure, and organizational change in manufacturing. *Journal of Accounting and Economics, 19*(2–3), 179–208. https://doi.org/10.1016/0165-4101(94)00382-F

Moldabekova, A., Philipp, R., Reimers, H.-E., & Alikozhayev, B. (2021). Digital technologies for improving logistics performance of countries. *Transport and Telecommunication, 22*(2), 207–216. https://doi.org/10.2478/ttj-2021-0016

Mundlak, Y. (1978). On the pooling of time series and cross section data. *Econometrica, 46*(1), 69–85. https://doi.org/10.2307/1913646

North, D. C. (1990). *Institutions, institutional change and economic performance*. Cambridge University Press.

Nunn, N. (2007). Relationship-specificity, incomplete contracts, and the pattern of trade. *The Quarterly Journal of Economics, 122*(2), 569–600. https://doi.org/10.1162/qjec.122.2.569

Pesaran, M. H. (2015). Testing weak cross-sectional dependence in large panels. *Econometric Reviews, 34*(6–10), 1089–1117. https://doi.org/10.1080/07474938.2014.956623

Pesaran, M. H., & Xie, Y. (2021). *How to detect network dependence in latent factor models? A bias-corrected CD test* (Cambridge Working Papers in Economics No. 2158). University of Cambridge.

Portugal-Perez, A., & Wilson, J. S. (2012). Export performance and trade facilitation reform: Hard and soft infrastructure. *World Development, 40*(7), 1295–1307. https://doi.org/10.1016/j.worlddev.2011.12.002

Puertas, R., Martí, L., & García, L. (2014). Logistics performance and export competitiveness: European experience. *Empirica, 41*(3), 467–480. https://doi.org/10.1007/s10663-013-9241-z

Reed, W. R. (2015). On the practice of lagging variables to avoid simultaneity. *Oxford Bulletin of Economics and Statistics, 77*(6), 897–905.

Rezaei, J., van Roekel, W. S., & Tavasszy, L. (2018). Measuring the relative importance of the logistics performance index indicators using Best Worst Method. *Transport Policy, 68*, 158–169. https://doi.org/10.1016/j.tranpol.2018.05.007

Şahan, D. (2025). Evaluating the effects of digital transformation on logistics performance: A large-scale perspective on industrial competitiveness. *Journal of ETA Maritime Science, 13*(2), 72–80. https://doi.org/10.4274/jems.2025.62347

Schunck, R. (2013). Within and between estimates in random-effects models: Advantages and drawbacks of correlated random effects and hybrid models. *The Stata Journal, 13*(1), 65–76. https://doi.org/10.1177/1536867X1301300105

Sequeira, S., & Djankov, S. (2014). Corruption and firm behavior: Evidence from African ports. *Journal of International Economics, 94*(2), 277–294. https://doi.org/10.1016/j.jinteco.2014.08.010

Soh, K. L., Wong, W. P., & Tang, C. F. (2021). The role of institutions at the nexus of logistic performance and foreign direct investment in Asia. *The Asian Journal of Shipping and Logistics, 37*(2), 165–173. https://doi.org/10.1016/j.ajsl.2021.02.001

StataCorp. (2025). *Stata statistical software: Release 19* [Computer software]. StataCorp LLC.

Williamson, O. E. (2000). The new institutional economics: Taking stock, looking ahead. *Journal of Economic Literature, 38*(3), 595–613. https://doi.org/10.1257/jel.38.3.595

Wong, W. P., & Tang, C. F. (2018). The major determinants of logistic performance in a global perspective: Evidence from panel data analysis. *International Journal of Logistics Research and Applications, 21*(4), 431–443. https://doi.org/10.1080/13675567.2018.1438377

Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data* (2nd ed.). MIT Press.

World Bank. (2016). *World development report 2016: Digital dividends*. https://doi.org/10.1596/978-1-4648-0671-1

World Bank. (2025). *Logistics Performance Indicators 2.0* [Data set]. https://lpi.worldbank.org/

Yang, D. (2008). Integrity for hire: An analysis of a widespread customs reform. *The Journal of Law and Economics, 51*(1), 25–57. https://doi.org/10.1086/520007

APPENDIX

Table A1. Economies included in the estimation sample (number of LPI editions in parentheses)

Afghanistan (1)	Czechia (7)	Kuwait (7)	Romania (7)
Albania (6)	Denmark (7)	Kyrgyz Republic (7)	Russian Federation (7)
Algeria (7)	Djibouti (4)	Lao PDR (5)	Rwanda (6)
Angola (7)	Dominican Republic (7)	Latvia (7)	Sao Tome and Principe (4)
Antigua and Barbuda (1)	Ecuador (6)	Lebanon (6)	Saudi Arabia (7)
Argentina (7)	Egypt, Arab Rep. (7)	Lesotho (4)	Senegal (6)
Armenia (7)	El Salvador (7)	Libya (6)	Serbia (7)
Australia (7)	Equatorial Guinea (3)	Lithuania (7)	Sierra Leone (5)
Austria (7)	Eritrea (2)	Luxembourg (7)	Singapore (7)
Azerbaijan (4)	Estonia (7)	Madagascar (7)	Slovak Republic (7)
Bahamas, The (6)	Ethiopia (3)	Malawi (1)	Slovenia (7)
Bahrain (7)	Fiji (6)	Malaysia (7)	Solomon Islands (7)
Bangladesh (6)	Finland (7)	Maldives (2)	Somalia, Fed. Rep. (3)
Belarus (6)	France (7)	Mali (6)	South Africa (7)
Belgium (7)	Gabon (7)	Malta (6)	Spain (7)
Benin (7)	Gambia, The (6)	Mauritania (6)	Sri Lanka (4)
Bhutan (7)	Georgia (6)	Mauritius (6)	Sudan (2)
Bolivia (7)	Germany (7)	Mexico (7)	Sweden (7)
Bosnia and Herzegovina (7)	Ghana (7)	Moldova (7)	Switzerland (7)
Botswana (5)	Greece (7)	Mongolia (7)	Syrian Arab Republic (6)
Brazil (7)	Guatemala (7)	Montenegro (6)	Tajikistan (7)
Brunei Darussalam (2)	Guinea (7)	Morocco (4)	Tanzania (5)
Bulgaria (7)	Guinea-Bissau (7)	Mozambique (4)	Thailand (7)
Burkina Faso (7)	Haiti (7)	Namibia (6)	Timor-Leste (1)
Cambodia (7)	Honduras (7)	Nepal (6)	Togo (7)

Cameroon (7)	Hong Kong SAR, China (7)	Netherlands (7)	Tunisia (6)
Canada (7)	Hungary (7)	New Zealand (7)	Turkiye (7)
Central African Republic (3)	Iceland (6)	Nicaragua (5)	Turkmenistan (3)
Chad (6)	India (7)	Niger (6)	Uganda (4)
Chile (7)	Indonesia (7)	North Macedonia (7)	Ukraine (7)
China (7)	Iran, Islamic Rep. (6)	Norway (7)	United Arab Emirates (7)
Colombia (7)	Iraq (6)	Oman (7)	United Kingdom (7)
Comoros (6)	Ireland (7)	Pakistan (6)	United States (7)
Congo, Dem. Rep. (5)	Israel (6)	Panama (7)	Uruguay (7)
Congo, Rep. (6)	Italy (7)	Paraguay (7)	Uzbekistan (7)
Costa Rica (7)	Japan (7)	Peru (7)	Venezuela, RB (3)
Cote d'Ivoire (6)	Jordan (1)	Philippines (7)	Viet Nam (7)
Croatia (7)	Kazakhstan (7)	Poland (7)	Yemen, Rep. (4)
Cuba (6)	Kenya (6)	Portugal (7)	Zambia (5)
Cyprus (7)	Korea, Rep. (7)	Qatar (7)	Zimbabwe (6)

160 economies, 971 economy-edition observations; 95 economies are observed in all seven editions. Source: Author's compilation