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E-GOVERNMENT DEVELOPMENT AND BUSINESS TRANSACTIONAL EXPENDITURE: CROSS-COUNTRY EVIDENCE ON INTEREST RATE SPREAD DISTORTIONS, LOGISTICS PERFORMANCE, AND SERVICES TRADE RESTRICTIVENESS

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ABSTRACT. Digital transformation of the public sector is increasingly relevant because it can reshape the costs firms face in finance, logistics, and cross-border service provision. This study investigates how e-government development and its human-capital, online-service, and telecommunication components influence interest rate spread distortions, logistics performance, and services trade restrictiveness across countries, and whether these effects are linear or non-linear. The analysis uses three unbalanced country panels covering 1,299 observations for 130 countries, 906 observations for 163 countries, and 306 observations for 51 countries, estimated with two-way fixed-effects models and Driscoll–Kraay standard errors, with robustness checks and quadratic specifications implemented in R. The results show that a 0.1-point increase in EGDI is associated with an approximately 0.45-point reduction in the absolute interest rate spread, while the robustness coefficient remains negative at -0.677. Human capital and telecommunication infrastructure are especially important in this dimension, with baseline coefficients of -3.921 and -1.910, respectively. In the logistics specification, aggregate EGDI is insignificant, but HCI is positive and significant ($\beta = 0.372$), and a 0.1-point increase in HCI raises the Logistics Performance Index by about 0.037 points. In the services-trade specification, EGDI reduces STRI by -0.095. At the same time, HCI shows a U-shaped effect with a turning point at 0.975, indicating that digital human capital lowers restrictiveness up to very high levels before the relationship turns upward.

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Introduction

The relevance of this topic has increased sharply because digital government is no longer merely an administrative modernisation agenda; it has become an important determinant of business efficiency, investment conditions, and national competitiveness. The World Bank has shown that digital public services can substantially lower transaction costs compared with traditional channels, noting that digital transactions may be many times cheaper than interactions conducted by phone, post, or face-to-face. This means that the quality of e-government is directly linked to the costs firms incur when interacting with the state, including compliance costs, access to information, registration, payments, and administrative procedures. In this context, studying whether e-government development reduces business transactional expenditure is highly topical for both developed and developing economies (World Bank, 2020; 2022).

The issue is especially important because digitalisation remains uneven across economies and across firms. According to Eurostat, in 2024, 74% of all EU businesses and 73% of SMEs had reached at least a basic level of digital intensity, leaving SMEs around 20 percentage points below the EU's 2030 target. At the same time, the European Commission's work on the Once-Only Principle stresses that citizens and businesses should not be required to provide the same data repeatedly to public authorities. In contrast, public bodies should exchange such data themselves where permitted by law. These policy priorities underline that digital public administration is expected not only to improve state capacity but also to reduce repetitive administrative burdens, save time, and simplify firms' interaction with regulators (European Commission, 2025).

Continuing frictions in logistics and finance further reinforce the actuality of the topic. The World Bank's Logistics Performance Index 2023 report describes logistics as the "lifeblood of international trade". At the national level, logistics performance is also shaped by the quality of transport infrastructure and its alignment with EU regulatory standards, as demonstrated by studies on smart logistics centre development and electric vehicle charging infrastructure optimization along international transport corridors in Ukraine (Vovk et al., 2025a; Vovk et al., 2025b). It reports that, on average, 44 days elapse from the moment a container enters the exporting country's port until it leaves the destination port. Such evidence shows that inefficiencies in trade-related procedures, information exchange, and border management continue to impose substantial costs on business activity. In parallel, the World Bank has argued that digital financial services can lower costs while increasing the speed, security, and transparency of transactions, which makes the link between digital public-sector development and financial intermediation conditions especially relevant. For this reason, analysing e-government in relation to interest rate spread distortions and logistics performance is highly timely (Arvis et al., 2023).

The services-trade dimension makes the research even more significant. The OECD reports that the Services Trade Restrictiveness Index (STRI) provides comparable evidence on regulatory barriers across 51 countries and 22 sectors, and its 2026 report shows that, in 2025,

new restrictive measures outweighed liberalising reforms, signalling stagnation in the modernisation of services trade policy. At the same time, the OECD emphasises that digital services are the fastest-growing segment of international trade, while fragmented regulations, local-presence requirements, and restrictions on cross-border data flows continue to constrain growth. Under these conditions, investigating whether more advanced e-government systems are associated with lower services trade restrictiveness is highly relevant for understanding how digital state capacity may support a more open, predictable, and business-friendly regulatory environment.

1. Literature review

Digitalisation of the public sector is increasingly understood not as a narrow technological upgrade, but as a broader institutional transformation that reshapes governance models, managerial roles, organisational resilience, and the state's capacity to support socio-economic development. Recent research shows that effective digital governance depends on renewed public management competences, adaptive and antifragile public organisations, and leadership capable of combining ethical orientation with dynamic capability-building (Androniceanu & Treimikiene, 2025; Bartuseviciene & Butkus, 2024; Bian & Wang, 2024). The same literature also stresses that digital reform is shaped by behavioural incentives, innovation in public administration, and broader concerns about transparency and security in the digital era (Crăciun et al., 2025; Stănescu, 2024; Zámek & Zakharkina, 2024). At the macro level, digital transformation remains uneven across countries and regions, reflecting persistent digital divides, structural disparities in readiness, and differences in public-sector reform trajectories (Kovac et al., 2024; Valaskova et al., 2025a; Valaskova et al., 2025b). These asymmetries are further reinforced by country-specific development paths, institutional constraints, and socio-political conditions that shape the pace and quality of e-government evolution (Huseynov et al., 2025; Kuanaliyev et al., 2024; Pakhnenko et al., 2025). Broader comparative evidence also indicates that digital and sustainable transitions, the socio-economic and political determinants of e-government, and the role of transparency and trust are central to understanding why digital public transformation generates stronger benefits in some settings than in others (Paraschiv et al., 2024; Samarkhanov et al., 2025; Vasylieva et al., 2023).

A second major strand of the literature points to human and institutional capabilities as the main transmission channels through which digital government can affect economic outcomes. Human resource adaptability, leadership innovation, and the development of national human capital potential are repeatedly identified as decisive preconditions for effective digital transformation in both public and private organisations (Kuziv et al., 2025; Zhilkishbayeva, 2025; Yarovenko et al., 2025). The importance of advanced digital readiness is also evident in studies showing that government AI preparedness shapes strategic capacity in other sectors, while intelligent automation broadens the scope for more sustainable, data-driven decision-making (Kuzior & Sira, 2025; Lyeonov et al., 2025; Topazly et al., 2026). At the same time, the literature warns that weak accountability, rent-seeking, and declining institutional quality may undermine the economic returns to digital maturity, even where technologies themselves are available (Ugulava, 2026; Zahorodnia et al., 2026; Vasylieva et al., 2023). Debates on artificial intelligence also show that digital transformation is not purely technical, but socially mediated through expectations, trust, and public perceptions, which may condition how governments and firms use digital systems in practice (Yarovenko et al., 2024; Topazly et al., 2026; Androniceanu & Treimikiene, 2025). This body of work suggests that any effect of e-government on business transactional expenditure is likely to depend not only on the digital

tools themselves, but also on the human capital and institutional environment in which those tools are embedded.

The literature further indicates that digital transformation can alter the financial and informational environment in which firms operate, thereby affecting transaction-related costs more directly. Digitalisation has been associated with stronger firm performance under crisis conditions, improved credit supply, and more adaptive financial behaviour in turbulent markets, which implies that the digital economy may reduce frictions in information processing, resource allocation, and business financing (Aluchna et al., 2025; Chen & Cheng, 2024; Hossain et al., 2025; Sartamorn et al., 2025). Related research shows that transparency, cybersecurity, anti-money laundering efficiency, and modern public financial reforms reinforce the institutional conditions for more efficient economic transactions (Kuzior et al., 2022; Ntuli et al., 2025; Vasa et al., 2023; Vasylieva et al., 2023). Empirical evidence from emerging banking markets further confirms that stability and market valuation are closely interrelated with the institutional environment that digital public reforms seek to improve, reinforcing the use of interest rate spreads as a proxy for transactional costs (Abbas & Hassouni, 2024). The growing role of digital assets and data-based value creation also indicates that digital transformation affects the way firms are evaluated, financed, and integrated into modern value chains (Junejo et al., 2024; Shen et al., 2025; Wang & Zeng, 2025; Chen & Cheng, 2024). Taken together, these studies provide an important conceptual basis for treating interest rate spread distortions as a proxy for transactional expenditure, because they imply that digital development may lower the costs associated with information asymmetry, administrative inefficiency, and weak institutional intermediation.

Operational and market-facing transaction costs are also strongly represented in the literature, particularly through studies of supply chains, competitiveness, entrepreneurship, and service innovation. Digital technologies and artificial intelligence have been shown to improve supply-chain efficiency, while broader national digitalisation is linked to stronger competitiveness and better technological adaptation among SMEs (Golubtsov et al., 2025; Jarzębowski et al., 2024; Korcsmáros et al., 2025). The wider business environment matters as well: entrepreneurial ecosystems, digital entrepreneurship, and digital inclusion can catalyse growth, social sustainability, and economic equity, suggesting that digital public capacity may influence firms through the ecosystem in which they operate (Chopra et. al., 2024; Iddouch & Jaoual, 2025; Khatami et al., 2024; Ruthvika & Hedau, 2025). Evidence from retail, tourism, and crisis-response settings further shows that digital innovative services, co-creation, and public communication infrastructures shape service quality, responsiveness, and firms' willingness to engage with changing market conditions (Mardosaite et al., 2024; Rita et al., 2024; Selaković, 2025). Softer relational factors also remain relevant, as social support and public-private collaboration can strengthen organisational performance and regional revitalisation in the face of digital change (Maziriri et al., 2025; Oe et al., 2025; Khatami et al., 2024). This literature is highly relevant to logistics performance as a proxy of transactional expenditure, because it shows that digital capability influences coordination quality, delivery efficiency, ecosystem resilience, and the broader costs of moving goods and services through complex economic systems.

A more specific, but still fragmented, body of work addresses the regulatory and service-delivery dimensions closest to service trade restrictiveness. Sectoral studies in health and emergency management indicate that digital government can improve expenditure effectiveness, public service transformation, and crisis response coordination, which supports the broader argument that public digitalisation can reduce institutional frictions and improve operational efficiency (Hrytsenko et al., 2026; Kuzior et al., 2024; Mercer-Bey, 2025). At the same time, research on barriers to digital services trade demonstrates that regulatory

restrictiveness remains a measurable and economically meaningful obstacle in its own right, rather than a simple by-product of general digital progress (Wang et al., 2025). The existing scientific landscape strongly suggests that digital governance matters for competitiveness, financing conditions, organisational efficiency, and regulatory environments. However, the evidence remains dispersed across sectors, countries, and outcome variables, and only rarely compares financial, logistical, and regulatory proxies of transactional expenditure within a unified cross-country framework. The literature, therefore, leaves a clear gap for research that jointly evaluates whether e-government development, and especially its human-capital, online-service, and telecommunication dimensions, systematically influences business transactional expenditure across countries and whether these effects are linear or non-linear.

This study aims to examine how e-government development and its human-capital, online-service, and telecommunication components affect key proxies of business transactional expenditure (interest rate spread distortions, logistics performance, and services trade restrictiveness) across countries, and to determine whether these relationships are linear or non-linear.

2. Methodological approach

This study examines whether e-government development is associated with lower transactional expenditure for business by estimating three separate unbalanced country-panel datasets, each built around a different proxy of transaction costs. The first dataset links the E-Government Development Index (EGDI) and its subindices to the interest rate spread and covers 1,299 country-year observations for 130 countries over 2003–2024. The second dataset relates EGDI to logistics performance and contains 906 observations for 163 countries over 2010–2022. The third dataset focuses on services trade restrictiveness and includes 306 observations for 51 countries over 2014–2024. The composition of each sample is reported in Appendix A, which lists the countries included in the analyses of interest-rate spreads, logistics, and services trade.

The explanatory variables are the overall EGDI and its three components, namely the Human Capital Index (HCI), the Online Services Index (OSI), and the Telecommunication Infrastructure Index (TII). EGDI and its subindices were obtained from the World Bank's Data360 platform based on the UN E-Government Survey (World Bank, n.d.-a). The dependent variables were drawn from different sources according to the conceptual dimension of transactional expenditure under study: the Logistics Performance Index (LPI) was taken from the World Bank(n.d.-b), the Services Trade Restrictiveness Index (STRI) from the OECD (n.d.), and the interest rate spread together with GDP per capita from the World Bank (n.d.-c). GDP per capita (current US$) was included as a control variable in all specifications to account for differences in economic development across countries, also collected from the World Bank (n.d.-c).

The composition of the country samples differs across the three empirical specifications because the availability of comparable cross-country data varies by indicator and year. For the LPI, the 2023 observations were treated as 2022 in the panel structure to align the dataset with the timing of the underlying survey wave and ensure temporal consistency with the other variables.

Before estimation, the variables were transformed where necessary to reflect their distributional properties and substantive meaning. GDP per capita was converted to its natural logarithm in all three datasets due to strong right skewness. In the first dataset, the interest rate spread was transformed to its absolute deviation from zero, since zero represents the optimal benchmark and both positive and negative deviations indicate greater inefficiency. An

additional robustness specification used the inverse hyperbolic sine of this absolute spread to reduce the influence of extreme observations while retaining zero values. In the second dataset, the LPI was kept at levels because its distribution was sufficiently regular for linear panel estimation. In the third dataset, the STRI was used at levels in the baseline models, while a logit transformation of STRI served as a robustness check given the bounded nature of that indicator.

The empirical strategy is based on two-way fixed-effects panel regression models with country and year effects, which control for time-invariant national characteristics and common shocks affecting all countries in a given period. The baseline specification can be written as

$$Y_{it} = \alpha_i + \lambda_t + \beta X_{it} + \gamma \ln\ GDPpc_{it} + \varepsilon_{it},$$

where Y_{it} denotes one of the three transaction-cost proxies, X_{it} denotes either EGDI or one of its subindices, $\alpha_i$captures country fixed effects, and λ_t captures year fixed effects. Each model was estimated separately for EGDI, HCI, OSI, and TII to avoid multicollinearity between the aggregate index and its components. Driscoll–Kraay standard errors were used throughout to address heteroskedasticity, serial correlation, and cross-sectional dependence. To assess possible non-linearities, quadratic specifications were additionally estimated by mean-centring the digital-government indicators and including their squared terms. Turning points were calculated only where the sign pattern and statistical significance justified interpretation of U-shaped or inverted-U-shaped relationships; otherwise, the quadratic terms were interpreted more cautiously as evidence of convexity or threshold-type non-linearity.

All data preparation, transformations, descriptive statistics, econometric estimations, and robustness checks were performed in the R statistical environment.

3. Conducting research and results

3.1. EGDI and interest rate spread as a proxy of transactional expenditures

The descriptive statistics for the first dataset (*Table B1, Appendix B*) indicate that the analysis is based on 1,299 country-year observations spanning 2003–2024. The mean value of EGDI is 0.48, with a standard deviation of 0.20, suggesting a moderate overall level of e-government development alongside considerable cross-country and intertemporal variation, with the OSI (0.41) and the TII (0.32) showing similar levels. This pattern implies that, on average, countries in the sample demonstrate relatively stronger human-capital foundations for digital government than the institutional and infrastructural components required for effective online service delivery. At the same time, the notably lower mean values for OSI and, especially, TTI suggest that deficiencies in service digitalisation and telecommunications infrastructure remain more pronounced than those in human capital.

The distributional properties of these indicators also provide useful insights. EGDI itself appears relatively symmetric (skewness = 0.10) and moderately dispersed, indicating that the sample includes countries at different stages of digital public-sector development without extreme concentration at either end of the scale. By contrast, HCI is negatively skewed (-1.07), suggesting that a substantial share of observations is concentrated at higher levels of human-capital readiness. OSI and TTI are positively skewed, particularly the latter (0.67), implying that many countries remain at relatively low levels of digital service provision and telecommunications capacity. At the same time, only a smaller group has reached more advanced levels. These statistics point to an uneven structure of e-government development, where progress in human capital appears to have outpaced improvements in digital infrastructure and service provision.

The dependent variable, interest rate spread, has a mean of 7.33% but a median of 6.03%, indicating a right-skewed distribution. This is confirmed by the very high skewness (3.97) and kurtosis (29.06), together with the wide range from -13.9 to 97.09. These results suggest substantial heterogeneity across countries and years, with several extreme observations likely reflecting episodes of financial instability, banking-sector inefficiency, or macroeconomic distress. Since an interest rate spread of zero represents the most favourable benchmark. At the same time, both positive and negative deviations indicate increasing inefficiency; the variable was transformed into its absolute value. This approach allows the dependent variable to capture distance from the optimal benchmark, regardless of direction. To account for the strong skewness of the distribution and the presence of extreme values, an additional robustness specification used the inverse hyperbolic sine of the absolute spread. GDP per capita exhibits a similarly non-normal distribution: its mean (USD 9,987) is more than twice its median (USD 4,425), while skewness (3.10) and kurtosis (11.13) point to a strong concentration of observations at lower income levels and a relatively small number of very high-income country-years. This confirms the presence of pronounced development asymmetries within the sample and supports the use of a logarithmic transformation of GDP per capita in subsequent regression analyses to reduce the influence of extreme values and improve model interpretability.

The two-way fixed-effects estimates reported in *Table 1* indicate that higher levels of e-government development are associated with a statistically significant reduction in the absolute deviation of the interest rate spread from zero. Since the dependent variable is defined as the absolute distance from the optimal benchmark, a negative coefficient implies an improvement in banking intermediation conditions and, by extension, lower transaction costs for businesses. In the baseline specification, the coefficient on EGDI is -4.542 ($p = 0.011$), which suggests that, within countries over time and controlling for common period effects, an increase in digital government development is associated with a narrowing of the spread's deviation from the optimal level. In substantive terms, a 0.1-point increase in EGDI is associated with a decline of approximately 0.45 points in the absolute spread, which is economically meaningful given the average level of the dependent variable.

Table 1. Two-way fixed-effects estimates with Driscoll–Kraay standard errors: digital government and the absolute interest rate spread

Variables	Model 1: EGDI	Model 2: EGDI_HCI	Model 3: EGDI_OSI	Model 4: EGDI_TII
EGDI	-4.542**			
	(1.786)			
EGDI_HCI		-3.921***		
		(1.388)		
EGDI_OSI			-1.071	
			(0.672)	
EGDI_TII				-1.910***
				(0.707)
ln_gdp_pc	-2.636***	-2.880***	-2.655***	-2.668***
	(0.650)	(0.638)	(0.661)	(0.652)
Observations	1,299	1,299	1,299	1,299
Country fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Standard errors	DK	DK	DK	DK

Note: *The dependent variable is the absolute deviation of the interest rate spread from zero. Driscoll–Kraay standard errors are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*

A more disaggregated view reveals that this overall effect is not uniform across the components of digital government. As shown in Table 1, the HCI exerts a negative and statistically significant effect on the absolute spread ($\beta = -3.921$, $p = 0.005$), indicating that improvements in education, digital skills, and broader human-capital readiness are associated with more favourable financial intermediation conditions. The TII also demonstrates a significant negative association ($\beta = -1.910$, $p = 0.007$), suggesting that better digital infrastructure reduces transaction-related distortions in the banking environment. By contrast, the coefficient on the OSI is negative but statistically insignificant ($\beta = -1.071$, $p = 0.111$). This suggests that although the expansion of online public services may move in the expected direction, its direct contribution to reducing interest-spread deviations is weaker and less robust than that of human capital and telecommunications infrastructure.

These findings imply that the transmission mechanism from digital government to lower business-related transaction costs is likely to operate primarily through structural and capacity-related channels rather than through the mere availability of online administrative services. Put differently, digital government appears more effective at improving the financial environment when supported by a skilled workforce and a reliable technological base. This interpretation is consistent with the relative strength of the coefficients for HCI and TII in Table 1, which point to the importance of foundational conditions for the broader efficiency effects of digital transformation. The insignificance of OSI may also reflect the fact that improvements in online public service provision do not immediately translate into narrower financial spreads unless they are embedded in a broader ecosystem of digital capabilities and infrastructure.

The control variable behaves consistently across all specifications. In every model presented in Table 1, the coefficient on the logarithm of GDP per capita is negative and highly significant, ranging from -2.635 to -2.880. This indicates that higher levels of economic development are systematically associated with smaller deviations of the interest rate spread from zero. Thus, more affluent economies tend to exhibit more efficient, less distorted financial intermediation. This result is important because it suggests that the beneficial role of digital government is not simply a reflection of development level; rather, even after controlling for income, e-government indicators retain explanatory power in several specifications. At the same time, the stability of the GDP per capita coefficient confirms that macroeconomic development remains a central structural determinant of business transaction costs.

The robustness results reported in Table 2 confirm and strengthen the main findings obtained from the baseline specification. When the dependent variable is measured as the inverse hyperbolic sine of the absolute interest rate spread, the coefficient on the overall EGDI remains negative and statistically significant ($\beta = -0.677$, $p = 0.002$), indicating that improvements in e-government development are associated with a lower deviation of the spread from its optimal benchmark of zero. Since the inverse hyperbolic sine transformation reduces the influence of extreme observations while preserving zero values, this result suggests that the negative association observed in the baseline model is not driven by outliers or a small number of unusually volatile country-year observations. In substantive terms, the robustness model supports the conclusion that digital government development is associated with lower transactional inefficiencies in the financial sector.

The disaggregated estimates in Table 2 further show that all three subindices become statistically significant once the dependent variable is transformed. The strongest effect is observed for the HCI ($\beta = -0.434$, $p < 0.001$), followed by the TII ($\beta = -0.327$, $p = 0.003$) and the OSI ($\beta = -0.190$, $p = 0.047$). This pattern indicates that the human-capital component of digital government is the most powerful and stable predictor of reduced interest-spread distortions. At the same time, telecommunications infrastructure also plays an important supporting role. Importantly, unlike in the baseline model, the OSI reaches statistical

significance in the robustness specification, which suggests that its effect may have been partially obscured earlier by the strong skewness and extreme values of the untransformed dependent variable.

Table 2. Robustness check: Two-way fixed-effects estimates with Driscoll–Kraay standard errors using the inverse hyperbolic sine transformation of the absolute interest rate spread

Variables	Model 1: EGDI	Model 2: EGDI_HCI	Model 3: EGDI_OSI	Model 4: EGDI_TII
EGDI	-0.677***			
	(0.219)			
HCI		-0.434***		
		(0.106)		
EGDI_OSI			-0.190**	
			(0.095)	
EGDI_TII				-0.327***
				(0.111)
ln_gdp_pc	-0.249***	-0.280***	-0.250***	-0.252***
	(0.036)	(0.033)	(0.036)	(0.036)
Observations	1,299	1,299	1,299	1,299
Country fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Standard errors	DK	DK	DK	DK

Note: *The dependent variable is the inverse hyperbolic sine transformation of the absolute deviation of the interest rate spread from zero. Driscoll–Kraay standard errors are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*

These findings imply that the relationship between digital government and lower business transaction costs is broad-based but differentiated in magnitude across dimensions of digitalisation. The particularly strong role of HCI suggests that improvements in education, skills, and administrative capacity are central to translating digital transformation into more efficient financial intermediation. At the same time, the significance of TII and OSI in Table 2 indicates that both technological infrastructure and digital service provision also contribute to reducing deviations of interest rate spreads from the optimal level. However, their effects appear less pronounced than those of human capital. Taken together, the robustness estimates reinforce the interpretation that digital government supports a more efficient financial environment through a combination of capacity-building, infrastructure, and service-delivery channels.

The control variable remains highly stable across all specifications in Table 2. The coefficient on the logarithm of GDP per capita is negative and highly significant across all models, ranging from -0.249 to -0.280. This confirms that higher levels of economic development are systematically associated with smaller deviations of the interest rate spread from zero, even after accounting for country- and year-fixed effects. Thus, while macroeconomic prosperity remains an important structural determinant of financial efficiency, the persistent significance of EGDI and its components demonstrates that digital government retains an independent explanatory role. The evidence from Table 2 provides strong robustness support for the conclusion that better e-government development is associated with lower transactional expenditure in the banking environment.

The evidence presented in Tables 1 and 2 indicates a stable inverse relationship between digital government development and the magnitude of interest rate spread distortions, with human capital and telecommunications infrastructure playing particularly strong roles.

The quadratic specifications provide no evidence of a statistically meaningful U-shaped or inverted U-shaped relationship between e-government development and the absolute deviation of the interest rate spread from zero.

3.2. EGDI vs LPI as a proxy of transactional expenditures

The descriptive statistics for the second dataset, reported in Appendix B, Table B2, indicate that the analysis is based on 906 country-year observations spanning the period 2010–2022. The mean value of the E-Government Development Index is 0.53, with a standard deviation of 0.22, suggesting a moderate average level of digital government development combined with substantial variation across countries and over time. Among the subdimensions, HCI shows the highest mean (0.70), followed by OSI (0.49) and TII (0.39). This pattern suggests that, on average, countries in the sample are relatively stronger in the human-capital foundations of digital transformation than in the infrastructural and service-delivery dimensions of e-government. The lower average TII value, in particular, points to the continuing importance of telecommunications capacity as a constraint on broader digital-government advancement.

The distributional characteristics of the digitalisation indicators indicate a fairly balanced sample, though some asymmetries remain. EGDI itself is almost perfectly symmetric (skewness = -0.04), indicating that observations are spread relatively evenly around the mean. HCI is moderately negatively skewed (-0.84), suggesting that many countries are clustered at higher levels of human-capital readiness. By contrast, OSI is nearly symmetric (0.06), while TII shows a moderate positive skew (0.33), suggesting that a larger share of observations remains concentrated at lower levels of telecommunications infrastructure. These statistics indicate that the sample captures countries at markedly different stages of digital development, with the greatest weaknesses still concentrated in the infrastructural dimension.

Regarding the economic variables, GDP per capita shows substantial cross-country heterogeneity. Its mean value is USD 15,431.61, whereas the median is considerably lower at USD 6,000.23, indicating a strongly right-skewed distribution driven by a limited number of high-income observations. This is confirmed by the skewness coefficient of 2.17 and kurtosis of 5.03, which indicate a clear departure from normality and justify the use of the logarithmic transformation in subsequent regressions. The dependent variable, the LPI, has a mean of 2.89, a median of 2.75, and a standard deviation of 0.57. Its moderate positive skewness (0.53) and slightly negative kurtosis (-0.58) suggest a relatively well-behaved distribution with no pronounced concentration of extreme values. Thus, compared with GDP per capita, the logistics indicator appears substantially more stable and better suited to panel estimation in levels.

The two-way fixed-effects estimates with Driscoll–Kraay standard errors reported in Table 3 suggest that the relationship between digital government and logistics performance is selective rather than uniform across all dimensions of e-government development. The coefficient on the overall EGDI is positive but statistically insignificant ($\beta = 0.123$, $p = 0.330$), indicating that within-country improvements in aggregate digital government are not robustly associated with a significant increase in the LPI, even after controlling for time-invariant country characteristics, common period effects, and income differences. A similarly null result is observed for OSI ($\beta = 0.002$, $p = 0.983$), suggesting that changes in the availability of online public services, taken in isolation, do not directly translate into measurable improvements in logistics performance.

Table 3. Two-way fixed-effects estimates with Driscoll–Kraay standard errors: digital government and logistics performance

Variables	Model 1: EGDI	Model 2: EGDI_HCI	Model 3: EGDI_OSI	Model 4: EGDI_TII
EGDI	0.123			
	(0.126)			
EGDI_HCI		0.372***		
		(0.126)		
EGDI_OSI			0.002	
			(0.075)	
EGDI_TII				0.096*
				(0.058)
ln_gdp_pc	0.134***	0.138***	0.137***	0.134***
	(0.011)	(0.013)	(0.010)	(0.012)
Observations	906	906	906	906
Country fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Standard errors	DK	DK	DK	DK

Note: *The dependent variable is the LPI. Driscoll–Kraay standard errors are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*

By contrast, the HCI shows a positive, statistically significant effect (β = 0.372, p = 0.003), indicating the importance of education, skills, and administrative capacity for the functioning of the logistics environment. Substantively, a 0.1-point increase in HCI is associated with approximately a 0.037-point increase in the LPI, holding other factors constant. The TII also shows a positive association, though its significance is weaker and reaches only the 10% level (β = 0.096, p = 0.095). Taken together, these results suggest that logistics performance is shaped less by digital government in its aggregate form and more by the underlying capacity conditions that enable economic actors to use digital tools effectively, particularly human capital and, to a lesser extent, telecommunications infrastructure.

A further important finding from Table 3 is the highly stable role of economic development. Across all specifications, the coefficient on the logarithm of GDP per capita remains positive and highly significant, ranging from 0.134 to 0.138. This indicates that higher-income countries tend to experience systematically better logistics performance, even after controlling for country- and year-fixed effects. Thus, while some dimensions of digital government matter, broader economic development remains a central structural determinant of logistics quality. The evidence suggests that improvements in logistics performance are more closely linked to the human-capital and infrastructural foundations of digital transformation than to the overall EGDI score or online service expansion alone.

The quadratic specifications reported in Table 4 provide only limited evidence of non-linearity in the relationship between e-government development and logistics performance. For the overall EGDI, the linear term is positive but statistically insignificant (β = 0.123, p = 0.288), while the squared term is positive and only marginally significant at the 10% level (β = 0.179, p = 0.058). This pattern does not support a clear U- or inverted U-shaped relationship. Still, it may indicate a weak convex relationship in which the positive effect of e-government on logistics performance becomes stronger at higher levels of digital development. For the HCI, the linear term is positive and statistically significant (β = 0.347, p = 0.007), whereas the squared term is negative but not statistically significant (β = -0.124, p = 0.410). This suggests

that the relationship between human capital and logistics performance is best interpreted as predominantly positive and approximately linear rather than genuinely non-linear.

Table 4. Two-way fixed-effects quadratic estimates with Driscoll–Kraay standard errors: testing for non-linear effects of digital government on logistics performance

Variables	Model 1: EGDI	Model 2: EGDI_HCI	Model 3: EGDI_OSI	Model 4: EGDI_TTI
c_EGDI	0.123			
	(0.116)			
c_EGDI_sq	0.179*			
	(0.094)			
c_EGDI_HCI		0.347***		
		(0.129)		
c_EGDI_HCI_sq		-0.124		
		(0.151)		
c_EGDI_OSI			-0.012	
			(0.073)	
c_EGDI_OSI_sq			0.167***	
			(0.056)	
c_EGDI_TTI				0.079
				(0.050)
c_EGDI_TTI_sq				0.113
				(0.083)
ln_gdp_pc	0.135***	0.138***	0.138***	0.137***
	(0.011)	(0.012)	(0.011)	(0.012)
Observations	906	906	906	906
Country fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Standard errors	DK	DK	DK	DK

Note: *The dependent variable is the Logistics Performance Index. The digital-government variables are mean-centred before squaring. Driscoll–Kraay standard errors are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*

A more distinctive result emerges for the OSI. As shown in Table 4, the linear term is close to zero and statistically insignificant ($\beta = -0.012$, $p = 0.874$). Still, the squared term is positive and statistically significant ($\beta = 0.167$, $p = 0.003$), pointing to a convex, non-monotonic association between online service development and logistics performance. This implies that changes in online public services around the average level do not produce an immediate linear effect. In contrast, improvements at more advanced stages may be associated with disproportionately greater gains in logistics performance. By contrast, no meaningful non-linear pattern is observed for the TII, since neither the linear term ($\beta = 0.079$, $p = 0.115$) nor the squared term ($\beta = 0.113$, $p = 0.173$) is statistically significant. Across all models in Table 4, the coefficient on logged GDP per capita remains positive and highly significant, confirming that economic development is a stable and powerful determinant of logistics performance. The evidence suggests that non-linearity is not a general feature of the relationship. However, the effect of online public services appears to grow stronger as digital service provision advances.

The estimated turning point for the OSI is 0.525 on the original scale, which lies well within the observed range of the variable (0 to 1). This indicates that the identified non-linear pattern is empirically relevant for the sample and not driven by an extrapolated threshold outside the data range.

Substantively, the result suggests that the relationship between online public service development and logistics performance changes around a moderate level of OSI. Given the positive and significant squared term reported in the model, this points to a convex relationship in which gains in online service development become more strongly associated with improvements in logistics performance once the index exceeds roughly 0.53.

3.3. EGDI vs LPI as a proxy of transactional expenditures

The descriptive statistics for the third dataset, presented in Appendix B, Table B3, show that the analysis is based on 306 country-year observations covering the period 2014–2024. The sample is characterised by relatively high average levels of digital government development. The mean value of the EGDI is 0.80, with a standard deviation of 0.12, while the subindices also display comparatively elevated averages: 0.85 for the HCI, 0.81 for the OSI, and 0.73 for the TII. This pattern indicates that the countries included in this sample are, on average, considerably more digitally advanced than those observed in the previous datasets. At the same time, the negative skewness of EGDI and its components suggests that most observations are concentrated at the upper end of the distribution, with fewer country-years exhibiting lower levels of digital government development. Thus, the sample appears to represent a relatively advanced group of economies, though still with some meaningful variation in digital capacity.

The economic and dependent variables further support this interpretation. GDP per capita has a high mean value of USD 34,061.58, although the distribution remains right-skewed, as indicated by the mean exceeding the median and by a skewness coefficient of 1.10. This confirms the presence of income disparities even within this more developed sample and supports the use of a logarithmic transformation in the regression analysis. The STRI has a mean of 0.22 and a median of 0.20, indicating a generally low to moderate level of services trade restrictions across the observed countries. However, the variable is positively skewed (1.33) and moderately leptokurtic (1.63), indicating that while most observations cluster around lower levels of restrictiveness, a smaller group of country-years exhibits substantially higher barriers to trade in services. The descriptive evidence suggests that the sample comprises relatively affluent, digitally mature economies in which variation in trade restrictiveness is more limited, yet still sufficient to justify a panel analysis of the association between digital government and barriers to services trade.

The baseline two-way fixed-effects estimates reported in Table 5 indicate a consistent inverse relationship between digital government development and trade restrictiveness in services. The coefficient on the overall EGDI is negative and highly significant ($\beta = -0.095$, $p < 0.001$), indicating that within-country improvements in digital government are associated with lower STRI values. Given that higher STRI scores reflect more restrictive regulatory conditions, this result suggests that digital transformation in the public sector is linked to a more open and less burdensome environment for trade in services. In substantive terms, a 0.1-point increase in EGDI is associated with a reduction of roughly 0.0095 points in STRI, which is economically meaningful relative to the sample mean of 0.22.

Table 5. Two-way fixed-effects estimates with Driscoll–Kraay standard errors: digital government and services trade restrictiveness

Variables	Model 1: EGDI	Model 2: EGDI_HCI	Model 3: EGDI_OSI	Model 4: EGDI_TTI
EGDI	-0.095*** (0.027)			
EGDI_HCI		-0.139*** (0.018)		
EGDI_OSI			-0.035** (0.017)	
EGDI_TTI				-0.046*** (0.004)
ln_gdp_pc	0.019* (0.010)	0.013* (0.007)	0.015* (0.009)	0.019** (0.009)
Observations	306	306	306	306
Country fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Standard errors	DK	DK	DK	DK

Note: *The dependent variable is the STRI. Driscoll–Kraay standard errors are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*

The disaggregated models in Table 5 show that this relationship is evident across all three subdimensions of e-government, although the strength of the association differs. The HCI has the largest negative coefficient ($\beta = -0.139$, $p < 0.001$), suggesting that improvements in education, digital skills, and administrative capacity are particularly important for reducing regulatory restrictiveness in services trade. The TII also exhibits a strong, highly significant negative effect ($\beta = -0.046$, $p < 0.001$), while the OSI shows a negative, statistically significant effect at the 5% level ($\beta = -0.035$, $p = 0.036$). Taken together, these findings suggest that lower services trade restrictiveness is associated not only with the overall development of digital government, but also with its underlying capacity-building and infrastructural components, with human capital appearing especially important.

An additional result from Table 5 is that the coefficient on logged GDP per capita is positive in all specifications and statistically significant at the 10% level or higher. This indicates that, within this relatively affluent sample, higher income is associated with slightly higher levels of services trade restrictiveness. Such a pattern may reflect the fact that richer economies often maintain more complex regulatory regimes in services markets, including licensing, professional standards, and sector-specific compliance rules. Thus, while economic development may increase regulatory sophistication, digital government development appears to operate in the opposite direction by reducing administrative and institutional barriers to trade in services.

The robustness estimates using the logit transformation of the dependent variable, presented in Table 6, reinforce the main conclusions. The coefficients on EGDI, HCI, and TTI remain negative and statistically significant, with values of -0.373 ($p = 0.002$), -0.751 ($p < 0.001$), and -0.176 ($p < 0.001$), respectively. This confirms that the negative association between digital government and services trade restrictiveness is not sensitive to the bounded nature of the STRI variable. The coefficient on OSI also remains negative, although it falls short of conventional significance levels in the robustness specification ($\beta = -0.118$, $p = 0.100$), suggesting that the effect of online service provision is less stable than those of human capital and telecommunications infrastructure.

Table 6. Robustness check: two-way fixed-effects estimates with Driscoll–Kraay standard errors using the logit transformation of the STRI

Variables	Model 1: EGDI	Model 2: EGDI_HCI	Model 3: EGDI_OSI	Model 4: EGDI_TTI
EGDI	-0.373*** (0.120)			
EGDI_HCI		-0.751*** (0.108)		
EGDI_OSI			-0.118 (0.072)	
EGDI_TTI				-0.176*** (0.020)
ln_gdp_pc	0.113** (0.049)	0.089** (0.037)	0.095** (0.044)	0.114** (0.047)
Observations	306	306	306	306
Country fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Standard errors	DK	DK	DK	DK

Note: *The dependent variable is the logit transformation of the STRI. Driscoll–Kraay standard errors are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*

The evidence from Tables 5 and 6 indicates a robust inverse relationship between digital government development and services trade restrictiveness, with the strongest and most stable effects associated with human capital and digital infrastructure.

The quadratic specifications reported in Table 7 indicate that the relationship between digital government and services trade restrictiveness is non-linear. Still, the nature of that non-linearity differs across the components of e-government. For the overall EGDI, the linear term is negative but statistically insignificant, whereas the squared term is positive and highly significant ($\beta = 0.222$, $p < 0.001$). This pattern points to a convex relationship: improvements in digital government are associated with lower services trade restrictiveness at lower or moderate levels of digitalisation, but this favourable effect weakens as digital maturity rises and may eventually reverse at very high levels. A clearer U-shaped pattern is observed for the HCI, where the linear term is negative and highly significant ($\beta = -0.107$, $p < 0.001$) and the squared term is positive and highly significant ($\beta = 0.423$, $p < 0.001$). This suggests that improvements in human-capital readiness initially reduce restrictions in services trade, but the marginal liberalising effect diminishes and ultimately turns upward at advanced levels of digital human-capital development.

Table 7. Two-way fixed-effects quadratic estimates with Driscoll–Kraay standard errors: testing for non-linear effects of digital government on services trade restrictiveness

Variables	Model 1: EGDI	Model 2: EGDI_HCI	Model 3: EGDI_OSI	Model 4: EGDI_TTI
c_EGDI	-0.029			
	(0.032)			
c_EGDI_sq	0.222***			
	(0.046)			
c_EGDI_HCI		-0.107***		
		(0.025)		
c_EGDI_HCI_sq		0.423***		
		(0.095)		
c_EGDI_OSI			-0.022	
			(0.015)	
c_EGDI_OSI_sq			0.071**	
			(0.024)	
c_EGDI_TTI				0.000
				(0.010)
c_EGDI_TTI_sq				0.105***
				(0.019)
ln_gdp_pc	0.021**	0.017**	0.017*	0.016*
	(0.009)	(0.006)	(0.008)	(0.009)
Observations	306	306	306	306
Country fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Standard errors	DK	DK	DK	DK

Note: *The dependent variable is the STRI. The digital-government variables are mean-centred before squaring. Driscoll–Kraay standard errors are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*

The results for the OSI and the TII also support the presence of convexity, though less strongly than for human capital. For OSI, the linear term is negative but insignificant. In contrast, the squared term is positive and significant ($\beta = 0.071$, $p = 0.004$), indicating that a simple linear specification does not well capture the effect of online public services. Rather, reductions in trade restrictiveness appear to be concentrated at lower stages of online service development, with the relationship flattening and turning upward at higher levels. A similar pattern is found for TTI, where the linear term is effectively zero and insignificant, but the squared term is positive and highly significant ($\beta = 0.105$, $p < 0.001$). Thus, the data suggest that a convex association with service trade restrictiveness also characterises telecommunications infrastructure. However, the absence of a significant linear term suggests this should be interpreted more cautiously as a non-linear or threshold-type pattern rather than a fully established U-shape. Across all baseline models in Table 7, the coefficient on logged GDP per capita is positive and statistically significant, indicating that within this sample, higher income levels are associated with somewhat greater services trade restrictiveness.

The robustness estimates in Table 8, which use the logit transformation for the dependent variable, strongly confirm the baseline conclusions. The overall EGDI again shows a positive, highly significant squared term ($\beta = 1.162$, $p < 0.001$). In contrast, the linear term remains insignificant, reinforcing the interpretation of a convex rather than a strictly linear relationship. The HCI once more exhibits the clearest U-shaped pattern, with a negative, highly significant linear term ($\beta = -0.599$, $p < 0.001$) and a positive, highly significant squared term (β

= 2.002, p < 0.001). The OSI also retains a positive and significant squared term (β = 0.254, p = 0.010), whereas the TII shows a positive and highly significant squared term (β = 0.570, p < 0.001) alongside an insignificant linear term. The positive and significant coefficients on logged GDP per capita across all robustness models indicate that the income effect is robust to alternative transformations of the dependent variable.

Table 8. Robustness check: two-way fixed-effects quadratic estimates with Driscoll–Kraay standard errors using the logit transformation of the STRI

Variables	Model 1: EGDI	Model 2: EGDI_HCI	Model 3: EGDI_OSI	Model 4: EGDI_TTI
c_EGDI	-0.030			
	(0.171)			
c_EGDI_sq	1.162***			
	(0.234)			
c_EGDI_HCI		-0.599***		
		(0.149)		
c_EGDI_HCI_sq		2.002***		
		(0.440)		
c_EGDI_OSI			-0.072	
			(0.069)	
c_EGDI_OSI_sq			0.254**	
			(0.098)	
c_EGDI_TTI				0.076
				(0.055)
c_EGDI_TTI_sq				0.570***
				(0.088)
ln_gdp_pc	0.122**	0.107**	0.102*	0.097*
	(0.044)	(0.033)	(0.042)	(0.047)
Observations	306	306	306	306
Country fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Standard errors	DK	DK	DK	DK

Note: *The dependent variable is the logit transformation of the STRI. The digital-government variables are mean-centred before squaring. Driscoll–Kraay standard errors are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*

The evidence from Tables 7 and 8 suggests that the relationship between digital government and services trade restrictiveness is not monotonic. The strongest and most consistent evidence of a genuine U-shaped effect is found for the HCI. In contrast, the other digital-government dimensions are better described as exhibiting convex or threshold-like patterns. Substantively, this implies that digital transformation may initially contribute to liberalising and simplifying the regulatory environment for services trade. Still, at very advanced levels, it may also become associated with the introduction of more sophisticated, data-intensive, or compliance-heavy regulatory frameworks. In this sense, the results point not to a simple liberalisation effect of digital government, but to a more complex process in which digital maturity reshapes the form and intensity of regulation.

The turning-point calculations confirm that the non-linear effects identified in the quadratic models are empirically relevant, as all estimated thresholds lie within the observed ranges of the respective explanatory variables. The clearest and most substantively meaningful result concerns the HCI, for which the turning point is estimated at 0.975 in the baseline STRI

model and 0.998 in the robustness logit-STRI model. This indicates a pronounced U-shaped relationship: improvements in digital human capital are associated with lower services trade restrictiveness up to very high levels of HCI, after which the relationship turns upward, suggesting that at the highest levels of human-capital readiness, digitalisation may become associated with more complex or demanding regulatory regimes. The optional threshold estimates for the other indicators also fall within the sample range, with turning points of 0.861 and 0.808 for EGDI, 0.959 and 0.947 for OSI, and 0.730 and 0.665 for TTI in the baseline and robustness models, respectively. However, because these models did not consistently display a significant linear term, these thresholds should be interpreted more cautiously as indicative minima of convex relationships rather than as strong evidence of fully established U-shaped effects.

3.4. Discussion

The results for the financial dimension strongly support the view that digital transformation can reduce transaction-related frictions in the business environment, particularly when it is grounded in human capital and infrastructure rather than in service digitalisation alone. The negative association between EGDI and interest rate spread distortions, together with the especially strong roles of HCI and TII, is consistent with studies showing that digitalisation improves credit conditions, supports more adaptive financial behaviour, and strengthens the institutional setting for more efficient economic transactions. In this respect, the present findings reinforce the arguments that digital maturity reduces information asymmetry and coordination costs in financial intermediation, while also showing that the most robust effects arise from foundational capabilities rather than from online services in isolation (Aluchna et al., 2025; Chen & Cheng, 2024; Sartamorn et al., 2025; Kuzior et al., 2022; Ntuli et al., 2025; Vasylieva et al., 2023). At the same time, the insignificant baseline coefficient for OSI suggests that the financial effects of e-government are narrower than a purely technology-centred reading of digital transformation might imply, which aligns with the broader literature emphasising that digital tools yield benefits only when embedded in an adequate human-capital and governance environment.

The logistics results point to a more selective transmission mechanism, thereby nuancing the broader literature linking digitalisation to competitiveness and supply-chain efficiency. The finding that aggregate EGDI is not significant. In contrast, HCI is clearly positive, and TII only weakly so, indicating that logistics performance depends less on the formal breadth of e-government and more on whether countries possess the skills and infrastructure needed to translate digital tools into operational efficiency. This is broadly consistent with studies showing that supply-chain performance, SME adaptability, and national competitiveness improve when digital capability is coupled with organisational readiness and technological development (Golubtsov et al., 2025; Jarzębowski et al., 2024; Korcsmáros et al., 2025). However, it only partially supports the broader expectation that digital transformation should uniformly enhance business conditions, because in the present study, aggregate EGDI does not directly improve LPI. The convex effect of OSI further refines the literature by suggesting that online public services become economically meaningful only after a country reaches a moderate threshold of service maturity, rather than delivering immediate gains from low initial levels.

The services-trade results are the most consistent with the expectation that digital government can reduce regulatory burdens faced by firms. The negative and robust effects of EGDI, HCI, and TII on STRI align well with the literature, arguing that digital governance improves service efficiency, reduces institutional frictions, and supports a more predictable

business environment. They are also consistent with studies showing that barriers to trade in digital services remain economically meaningful and that more efficient state capacity may help reduce regulatory restrictiveness (Hrytsenko et al., 2026; Kuzior et al., 2024; Mercer-Bey, 2025; Wang et al., 2025). At the same time, the finding that GDP per capita is positively associated with STRI suggests that more advanced economies may combine digital sophistication with more complex regulatory regimes, which adds an important nuance to the literature on digitalisation and openness. Rather than implying that digital maturity always leads to deregulation, the results suggest that it may lower procedural frictions even in settings where formal regulation remains relatively elaborate.

The non-linear results deepen this interpretation and highlight where the present study extends previous research most clearly. The U-shaped relationship found for HCI in the services-trade models suggests that digital human capital reduces restrictiveness up to very high levels, after which the relationship turns upward. At the same time, OSI and TII display more cautious convex patterns. This partly confirms the literature that places human and institutional capabilities at the centre of digital transformation. However, it also qualifies the often implicit assumption that more digital readiness is always associated with a proportionally more business-friendly regulatory environment. In this sense, the findings are more closely aligned with studies stressing uneven digital transformation, institutional asymmetries, and the possibility that advanced digital maturity may coexist with more complex, compliance-intensive governance frameworks rather than simple liberalisation (Androniceanu & Treimikiene, 2025; Valaskova et al., 2025b; Topazly et al., 2026; Ugulava, 2026). Overall, the discussion suggests that e-government reduces business transactional expenditure. However, its effects are domain-specific, capability-dependent, and in some cases non-monotonic, which helps explain why previous studies have often produced fragmented rather than uniform conclusions.

This study has several limitations that should be acknowledged. First, although the analysis covers a broad cross-country sample, the country composition differs across the three specifications due to uneven data availability, limiting strict comparability across all dependent variables. Second, the use of proxies such as interest rate spread distortions, logistics performance, and services trade restrictiveness captures important dimensions of business transactional expenditure, but does not fully encompass all micro-level costs faced by firms, such as compliance time, informal costs, or sector-specific regulatory burdens. Third, the empirical design is based on panel data and fixed-effects estimation, which strengthens inference but, by itself, does not establish strict causality, especially in the presence of potential reverse relationships between digital development and economic performance. Fourth, some indicators, particularly EGDI and LPI, are available only at relatively sparse intervals, which constrains dynamic modelling and lag analysis. Future research could address these limitations by using firm-level or sector-level data, incorporating additional direct measures of transactional costs, testing causal identification strategies, and exploring regional, income-group, or institutional heterogeneity in greater detail. It would also be valuable to examine the role of complementary factors such as regulatory quality, corruption control, cybersecurity, and institutional trust in mediating the relationship between e-government development and business transactional expenditure.

Conclusion

This study set out to assess whether, and through which dimensions, e-government development influences business transactional expenditure across countries, using interest rate spread distortions, logistics performance, and services trade restrictiveness as complementary

proxies. It therefore focused not only on the aggregate effect of EGDI, but also on the separate roles of human capital, online public services, and telecommunication infrastructure, while additionally examining whether these relationships are linear or non-linear.

The analysis was based on three separate unbalanced country-panel datasets: 1,299 observations for 130 countries in the interest-rate-spread specification, 906 observations for 163 countries in the logistics-performance specification, and 306 observations for 51 countries in the services-trade-restrictiveness specification. EGDI and its subindices were taken from the World Bank Data360 platform; LPI from the World Bank; STRI from the OECD; and the interest rate spread, together with GDP per capita, from the World Bank. The empirical strategy relied on two-way fixed-effects models with Driscoll–Kraay standard errors, while robustness checks used the inverse hyperbolic sine transformation of the absolute interest rate spread and the logit transformation of STRI; all calculations were performed in R.

The findings show that digital government is most clearly associated with lower financial transaction-related inefficiencies: in the baseline model, a 0.1-point increase in EGDI reduced the absolute deviation of the interest rate spread from zero by about 0.45 points, while the corresponding coefficient on EGDI was -4.542 ($p = 0.011$), and the robustness coefficient remained negative at -0.677 ($p = 0.002$). Human capital and telecommunication infrastructure proved especially important in this dimension, with coefficients of -3.921 ($p = 0.005$) and -1.910 ($p = 0.007$) in the baseline model. At the same time, in the robustness specification, HCI, OSI, and TII all became significant, at -0.434, -0.190, and -0.327, respectively. For logistics performance, the aggregate EGDI effect was not statistically significant. Still, HCI had a positive and significant coefficient of 0.372 ($p = 0.003$). At the same time, TII was positive at 0.096 and weakly significant at the 10% level, indicating that logistics performance depends more on foundational capacities than on digital government in the aggregate. The non-linear analysis for logistics showed no broad U-shaped pattern. Still, OSI displayed a convex relationship, with a positive squared term of 0.167 ($p = 0.003$) and a turning point of 0.525, implying that gains in online public services become more strongly associated with better logistics performance once a moderate level of service digitalisation has been reached. In the services-trade dimension, the results were again strong: EGDI reduced STRI in the baseline model by -0.095 ($p < 0.001$), the robustness coefficient was -0.373 ($p = 0.002$), and HCI showed the clearest non-linearity, with a U-shaped pattern marked by coefficients of -0.107 and 0.423 in the baseline model and a turning point at 0.975, rising to 0.998 in the robustness model.

These results imply several policy priorities. First, governments should treat digital transformation not simply as a service digitisation agenda, but as a broader institutional reform strategy aimed at lowering the informational, administrative, logistical, and regulatory frictions faced by firms. Second, the strongest and most consistent results for HCI indicate that investments in digital skills, education, administrative competence, and public-sector absorptive capacity should be prioritised, as digital tools deliver the greatest business-environment gains when users and institutions can employ them effectively. Third, the importance of TII in the financial and services-trade specifications suggests that digital infrastructure remains a core enabling condition; without reliable connectivity, interoperability, and technical capacity, the cost-reducing potential of e-government remains incomplete. Fourth, the weaker and sometimes non-linear effects of OSI indicate that expanding online public services alone is insufficient: policymakers should move beyond simple digitisation of forms and portals towards integrated, user-oriented, interoperable systems that reduce procedural duplication and compliance burdens. Fifth, the U-shaped and convex patterns observed in the services-trade and logistics models imply that digital maturity can eventually coexist with more complex compliance frameworks, so advanced digital reform should be accompanied by systematic regulatory simplification, ex ante burden assessment, and

continuous monitoring of unintended administrative burdens on businesses. The policy message is that digital government can reduce transactional expenditure, but only when technological progress is embedded in human-capital development, infrastructure modernisation, and institutionally coherent regulatory design.

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References

Abbas, A. A., & Hassouni, A. A. K. (2024). Exploring the nexus between banking stability and market value: Evidence from the Iraqi banking sector. Economics, Management and Sustainability, 9(1), 21–42. https://doi.org/10.14254/jems.2024.9-1.2

Aluchna, M., Bosek-Rak, D., Kamiński, B., & Kaszyński, D. (2025). Digital ambidexterity and financial performance in times of COVID-19 pandemic. the case of companies listed on Warsaw stock exchange. *Polish Journal of Management Studies*, *32*(2), 23–38. https://doi.org/10.17512/pjms.2025.32.2.02

Androniceanu, A., & Treimikiene, D. (2025). Reinventing public managers in the digital age: competencies and innovative governance models across the European Union. *Administratie si Management Public*, (45), 69–90. https://doi.org/10.24818/amp/2025.45-04

Arvis, J.-F., Ojala, L., Shepherd, B., Ulybina, D., & Wiederer, C. (2023). *Connecting to compete 2023: Trade logistics in an uncertain global economy – The logistics performance index and its indicators*. World Bank. https://lpi.worldbank.org/sites/default/files/2023-04/LPI_2023_report.pdf

Bartuseviciene, I., & Butkus, M. (2024). The effect of digital governance to stimulate the antifragile capabilities of public sector organizations. *Economics and Sociology*, 17(3), 41-61. doi:10.14254/2071-789X.2024/17-3/3

Bian, X., & Wang, B. (2024). Enabling Innovative Governance: Ethical Leadership and Dynamic Capabilities in Government Digital Transformation. *Business Ethics and Leadership, 8*(4), 186-200. https://doi.org/10.61093/bel.8(4).186-200.2024

Chen, X., & Cheng, X. (2024). How does the digital economy affect corporate business credit supply? *Journal of Business Economics and Management*, *25*(4), 685–708. https://doi.org/10.3846/jbem.2024.22027

Chopra, R., Agrawal, A., Sharma, G.D., Kallmuenzer, A., Vasa, L. (2024). Uncovering the organizational, environmental, and socio-economic sustainability of digitization: evidence from existing research. *Rev Managerial Sci*ence *18*(2), 685–709. https://doi.org/10.1007/s11846-023-00637-w

Crăciun, M.A., Dudian, M., and Lazăr, D.A. (2025). Nudging digital transformation: behavioral economics approaches to e-government adoption in the European Union with implications for Romania. *Administratie si Management Public*, 44, 60-74. https://doi.org/10.24818/amp/2025.44-04

European Union. (2025). *Digitalisation in Europe – 2025 edition* (Interactive publication). Eurostat. https://doi.org/10.2785/3102705

Golubtsov, D., Kedziora, J., Kozhakhmetova, A., & Kedziora, D. (2025). Assessing the impact of digital technologies and artificial intelligence (AI) on the efficiency of supply chain. *Economics and Sociology*, 18(1), 149-173. doi:10.14254/2071-789X.2025/18-1/8

Hossain, MB., Rahman, MU., Čater, T., Vasa, L. (2025), Determinants of SMEs' strategic entrepreneurial innovative digitalization: examining the mediation role of human capital. *European Journal of Innovation Management*, *28*(7), 2733–2760. https://doi.org/10.1108/EJIM-02-2024-0176

Hrytsenko, L., Sheliemina, N., & Latysh, D. (2026). Digital Government and Health System Performance: Does Digitalization Improve the Effectiveness of Health Expenditure?. *Health Economics and Management Review*, *7*(1), 21-40. https://doi.org/10.61093/hem.2026.1-02

Huseynov, A., Balsalobre-Lorente, D., Hamidova, L., & Samedova, E. (2025). Challenges and opportunities of digital economy development: Case of Azerbaijan. *Problems and Perspectives in Management*, *23*(2), 265–276. https://doi.org/10.21511/ppm.23(2).2025.18

Iddouch, K., & Jaoual, O. (2025). Entrepreneurial ecosystem as a catalyst for economic growth: a global empirical evidence using a novel composite index. *International Journal of Entrepreneurial Knowledge*, *13*(1), 106–141. https://doi.org/10.37335/ijek.v13i1.309

Jarzębowski, S., Bozhenko, V., Didorenko, K., Tkachenko, O., Blyznyukov, A., Melnyk, M., & Cieslik, J. (2024). The Impact of Digitalisation on the Competitiveness of European Countries. *SocioEconomic Challenges*, *8*(3), 238-261. https://doi.org/10.61093/sec.8(3).238-261.2024

Junejo, I., Hossain, MD. B., Abid, S., Janjua, Q. R., Ejaz, S., Vasa, L. (2024). Supply chain integration and supply chain performance: evidence from the textile industry. *Industria Textila*, *75*(4), 396-404. https://doi.org./10.35530/IT.075.04.2023110

Khatami, F., Ferraris, A., Palmucci, D. N., & Dabić, M. (2024). Impact Analysis of the Digital Entrepreneurial Ecosystem to Improve the Tourism Industry and Social Sustainability. *Journal of Tourism and Services*, *15*(29), 176–205. https://doi.org/10.29036/jots.v15i29.831

Korcsmáros, E., Seres Huszárik, E., Tóbiás Kosár, S., Gódány, Z., & Csinger, B. (2025). Technological development as a key in various sectors of SMEs. *Journal of International Studies*, 18(2), 120-137. doi:10.14254/2071-8330.2025/18-2/7

Kovac, N., Żmija, K., Roy, J. K., Kusa, R., & Duda, J. (2024). Digital divide and digitalization in Europe: A bibliometric analysis. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, *19*(2), 463-520. https://doi.org/10.24136/eq.2899

Kuanaliyev, A., Taubayev, A., Kunyazov, Y., Ernazarov, T., Mussipova, L., & Saduakassova, A. (2024). Digital and economic transformation in the public administration system. *Montenegrin Journal of Economics*, *20*(3), 63–78. https://doi.org/10.14254/1800-5845/2024.20-3.5

Kuzior, A., & Sira, M. (2025). Sustainable Digital Economy Transformation Through Intelligent Automation: A Multi-Environmental Framework for Strategic Decision-Making. *Sustainability*, *17*(17), 7723. https://doi.org/10.3390/su17177723

Kuzior, A., Marszałek-Kotzur, I., Kurovska, Y., & Chvankin, Y. (2024). The Role of Digital Economy in Transformation of Public Health: Modeling and Analysis. *Health Economics and Management Review*, *5*(4), 91-109. https://doi.org/10.61093/hem.2024.4-06

Kuzior, A., Vasylieva, T., Kuzmenko, O., Koibichuk, V., & Brożek, P. (2022). Global Digital Convergence: Impact of Cybersecurity, Business Transparency, Economic Transformation, and AML Efficiency. *Journal of Open Innovation: Technology, Market, and Complexity*, *8*(4), 195. https://doi.org/10.3390/joitmc8040195

Kuziv, R., Sarkisian, N., Urbanskyi, M., Vasić, S., Kuvik, V., & Gliebova, N. (2025). Innovative Leadership in Human Resource Management: Adaptive Models for the Digital Economy. *Business Ethics and Leadership, 9*(4), 85-105. https://doi.org/10.61093/bel.9(4).85-105.2025

Lyeonov, S., Mielczarek, L., Krawczyk, D., & Popp, J. (2025). The role of government AI readiness in shaping renewable electricity capacity and output. *Human Technology, 21*(3), 668–693. https://doi.org/10.14254/1795-6889.2025.21-3.9

Mardosaite, V., Jasinskas, E., & Romeika, G. (2024). The Transformation of Digital Innovative Services in Retail Trade Due to the COVID-19 Pandemic: A Systematic Review. *Amfiteatru Economic, 26*(67), 885. https://doi.org/10.24818/ea/2024/67/885

Maziriri, E. T., Mapuranga, M., & Chuchu, T. (2025). Navigating the entrepreneurial journey: the role of social support in enhancing well-being and performance. *International Journal of Entrepreneurial Knowledge*, *13*(1), 142–164. https://doi.org/10.37335/ijek.v13i1.316

Mercer-Bey, Y. (2025). Digital Transformation in Public Health and Safety: Integrating Drones, GIS, and Satellite Technology in Emergency Wildfire Response. *Health Economics and Management Review, 6*(3), 17-27. https://doi.org/10.61093/hem.2025.3-02

Ntuli, F., Ntshangase, B. A., & Msosa, S. K. (2025). Innovative Financial Management Reforms: A Catalyst of Good Governance in the South African Public Sector. *Financial Markets, Institutions and Risks, 9*(4), 16-29. https://doi.org/10.61093/fmir.9(4).16-29.2025

Oe, H., Yamaoka, Y., & Weeks, M. (2025). Public-Private Partnerships in Traditional Industries: A Comparative Governance Framework for Regional Revitalization in Japan and Central Europe. *Public Governance, Regulation and Law, 1*(1), 1-15. https://doi.org/10.61093/pgrl.1(1).1-15.2025

OECD (2026). *OECD Services Trade Restrictiveness Index 2026: Policy Trends*, OECD Publishing, Paris, https://doi.org/10.1787/db87d74e-en.

OECD. (n.d.). *OECD data explorer*. https://data-explorer.oecd.org/

Pakhnenko, O., Yarovenko, H., Semenog, A., Mordan, Y., & Tarasenko, O. (2025). Uncovering patterns of digital transformation of European economies using self-organizing maps. *Problems and Perspectives in Management, 23*(3), 581–596. https://doi.org/10.21511/ppm.23(3).2025.42

Paraschiv, D. M., Atif, M., Petrariu, I.-R., Gheorghe, M., Dieaconescu, R. I., & Istudor, M. (2024). Shaping Europe's Digital and Sustainable Future: Analysis of the Digital Economy and Society Index in the Pre- and Post-Pandemic Period. *Amfiteatru Economic*, *26*(Special 18), 1012. https://doi.org/10.24818/ea/2024/s18/1012

Rita, P., Borges Tiago, M. T., & Sousa, N. (2024). Empirical Insights into Co-Creation, Satisfaction, and Willingness to Pay in Sustainable Tourism. *Journal of Tourism and Services*, *15*(29), 133–152. https://doi.org/10.29036/jots.v15i29.804

Ruthvika, J., & Hedau, A. (2025). Digital Inclusion and Economic Equity: Evaluating the Role of Business Analytics in Overcoming Socioeconomic Challenges. *SocioEconomic Challenges, 9*(4), 150-164. https://doi.org/10.61093/sec.9(4).150-164.2025

Samarkhanov, A., Junusbekova, G., Kenzhin, Z., & Yesmagambetov, D. (2025). The impact of socio-economic and political factors on the development of e-government in developed and developing countries. *Problems and Perspectives in Management, 23*(4), 554–565. https://doi.org/10.21511/ppm.23(4).2025.38

Sartamorn, S., Oe, H. & Yamaoka, Y. (2025). Financial Stratification and Digital Transformation Under Market Disruption: Evidence from Thai SMEs. *Financial*

Markets, Institutions and Risks, *9*(3), 49-63. https://doi.org/10.61093/fmir.9(3).49-63.2025

Selaković, M. (2025). Government Crisis Communications and Business Crisis Response during 2024 Dubai Floods. *European Journal of Interdisciplinary Studies*, *17*(2), 23–32. https://doi.org/10.24818/ejis.2025.11

Shen, J., Fang, Q., Zhang, T., & Peng, Y. (2025). Research on the valuation of internet enterprise data assets based on value chain theory. *Journal of Business Economics and Management*, *26*(5), 1175–1200. https://doi.org/10.3846/jbem.2025.25477

Stănescu, R.-D. (2024). The Endeavor to Develop the Public Administration: Innovation as an Alternative Approach for Future Advancements. *European Journal of Interdisciplinary Studies*, *16*(2), 144–154. https://doi.org/10.24818/ejis.2024.16

Topazly, R., Stadniichuk, R., Liubokhynets, L., Shuprudko, M., Zhosan, H., & Plietnov, M. (2026). Institutional Trust and Governance Effectiveness as Mediators in Transforming Digital Maturity into Post-War Infrastructure Recovery. *Business Ethics and Leadership, 10*(1), 188-206. https://doi.org/10.61093/bel.10(1).188-206.2026

Ugulava G. (2026). Two Faces of Decline in Public Governance: Accountability Erosion and Rent-Seeking. *Public Governance, Regulation and Law*, *2*(1), 20-32. https://doi.org/10.61093/pgrl.2(1).20-32.2026

Valaskova, K., Juracka, D., Nagy, M., & Chaudhuri, S. (2025a). Digital readiness across the European Union: A multidimensional empirical assessment of structural determinants, intra-regional disparities, and strategic implications in the era of Industry 5.0. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, *20*(3), 1035-1086. https://doi.org/10.24136/eq.3886

Valaskova, K., Nagy, M., Figura, M., & Rousek, P. (2025b). Res publica digitalis: The uneven digital transformation of the European public sector and the impact of policy disparities on governance, service efficiency, and socioeconomic inclusion. *Oeconomia Copernicana*, *16*(3), 1177-1260. https://doi.org/10.24136/oc.3866

Vasa, L., Kireyeva, AA., Nurbatsin, A., Kredina, A. (2023). Analysis of the Impact of ICT on Economic Growth: Empirical Data from 16 Regions of Kazakhstan. *Acta Polytechnica Hungarica*, *20*(3), 29-44. https://doi.org/10.12700/APH.20.3.2023.3.3

Vasylieva, T., Kasperowicz, R., Tiutiunyk, I., & Lukács, E. (2023). Transparency and trust in the public sector: Targets and benchmarks to ensure macroeconomic stability. *Journal of International Studies*, 16(4), 117-135. doi:10.14254/2071- 8330.2023/16-4/8

Vovk, Y., Vovk, I., Plekan, U., Tson, O., & Oleksyuk, V. (2025). Sustainable and smart logistics centers: Challenges and opportunities for Ukraine's transport system. *Journal of Sustainable Development of Transport and Logistics, 10*(1), 116–124. https://doi.org/10.14254/jsdtl.2025.10-1.8.

Wang, J., & Zeng, D. (2025). Research on the impact of digital economy on high-quality development of manufacturing industry. *Polish Journal of Management Studies*, 31(2), 258-271. https://doi.org/10.17512/pjms.2025.31.2.16.

Wang, X., Wang, Z., & Li, G. (2025). Barriers to digital services trade: Evaluation of their restrictiveness with application of Brier Score. *Oeconomia Copernicana*, *16*(1), 197-245. https://doi.org/10.24136/oc.3435

World Bank. (2020). *GovTech: The new frontier in digital government transformation*. https://documents1.worldbank.org/curated/en/898571612344883836/pdf/GovTech-The-New-Frontier-in-Digital-Government-Transformation.pdf

World Bank. (2022). *GovTech maturity index, 2022 update: Trends in public sector digital transformation* (Equitable Growth, Finance and Institutions Insight—Governance). World Bank. http://hdl.handle.net/10986/38499

World Bank. (n.d.-a). *E-Government Development Index (EGDI)*. World Bank Data360. https://data360.worldbank.org/en/dataset/UN_EGDI

World Bank. (n.d.-b). *Logistics Performance Index (LPI)*. https://lpi.worldbank.org/

World Bank. (n.d.-c). *World Bank Open Data*. https://data.worldbank.org/indicator

Yarovenko, H., Kuzior, A., Norek, T., & Lopatka, A. (2024). The future of artificial intelligence: Fear, hope or indifference?. *Human Technology, 20*(3), 611–639. https://doi.org/10.14254/1795-6889.2024.20-3.103

Yarovenko, H., Ohol, D., Ashirbekova, L., & Popp, J. (2025). Digital transformation and economic development in Europe: Classical and machineoriented approaches. *Journal of International Studies*, 18(4), 256-284. doi:10.14254/2071-8330.2025/18-4/13

Zahorodnia, K., Tverdovska, Z., Yarovenko, H., & Shubenko, M. (2026). Transformational Interlinkages between Ukraine's Economic and Demographics Potential: Implications for Public Governance Based on the Analysis of Migration, Public Health, and Citizens' Well-Being Shifts. *Public Governance, Regulation and Law*, *2*(1), 80-129. https://doi.org/10.61093/pgrl.2(1).80-129.2026

Zámek, D., & Zakharkina, Z. (2024). Research Trends in the Impact of Digitization and Transparency on National Security: Bibliometric Analysis. *Financial Markets, Institutions and Risks, 8*(1), 173-188. https://doi.org/10.61093/fmir.8(1).173-188.2024

Zhilkishbayeva, G. (2025). Formation and Assessment of the Country's Human Resources Potential in the Context of Digital Transformation of the Economy. *Montenegrin Journal of Economics*, *21*(4), 73–86. https://doi.org/10.14254/1800-5845/2025.21-4.6

Appendixes

Appendix A. List of countries included in the analysis

The empirical analysis of the impact of EGDI and its subindexes on the rate spread as a proxy of transactional expenditures covers 130 countries:

Albania; Algeria; Angola; Antigua and Barbuda; Argentina; Armenia; Australia; Azerbaijan; Bahamas, The; Bahrain; Bangladesh; Barbados; Belarus; Belize; Benin; Bhutan; Bolivia; Bosnia and Herzegovina; Botswana; Brazil; Brunei Darussalam; Bulgaria; Burkina Faso; Cabo Verde; Canada; Chile; China; Colombia; Comoros; Congo, Dem. Rep.; Costa Rica; Cote d'Ivoire; Croatia; Czechia; Dominica; Dominican Republic; Egypt; Eswatini; Ethiopia; Fiji; Gambia, The; Georgia; Grenada; Guatemala; Guinea-Bissau; Guyana; Haiti; Honduras; Hungary; Indonesia; Iran, Islamic Rep.; Iraq; Israel; Jamaica; Japan; Jordan; Kenya; Korea, Rep.; Kuwait; Kyrgyz Republic; Lao PDR; Lebanon; Lesotho; Liberia; Libya; Madagascar; Malaysia; Maldives; Mali; Mauritania; Mauritius; Mexico; Micronesia, Fed. Sts.; Moldova; Mongolia; Montenegro; Mozambique; Myanmar; Namibia; Netherlands; New Zealand; Nicaragua; Niger; Nigeria; North Macedonia; Norway; Oman; Pakistan; Papua New Guinea; Paraguay; Peru; Philippines; Qatar; Romania; Russian Federation; Rwanda; Samoa; San Marino; Sao Tome and Principe; Senegal; Serbia; Seychelles; Sierra Leone; Singapore; Solomon Islands; South Africa; Sri Lanka; St. Kitts and Nevis; St. Lucia; St. Vincent and the Grenadines; Suriname; Sweden; Switzerland; Tajikistan; Tanzania; Thailand; Timor-Leste; Togo; Tonga; Trinidad and Tobago; Uganda; Ukraine; Uruguay; Uzbekistan; Vanuatu; Venezuela, RB; Viet Nam; Yemen, Rep.; Zambia; Zimbabwe.

The empirical analysis of the impact of EGDI and its subindexes on the logistics performance as a proxy of transactional expenditures covers 163 countries:

Afghanistan; Albania; Algeria; Angola; Argentina; Armenia; Australia; Austria; Azerbaijan; Bahamas, The; Bahrain; Bangladesh; Belarus; Belgium; Benin; Bhutan; Bolivia; Bosnia and Herzegovina; Botswana; Brazil; Bulgaria; Burkina Faso; Burundi; Cambodia; Cameroon; Canada; Central African Republic; Chad; Chile; China; Colombia; Comoros; Congo, Dem. Rep.; Congo, Rep.; Costa Rica; Cote d'Ivoire; Croatia; Cuba; Cyprus; Czechia; Denmark; Djibouti; Dominican Republic; Ecuador; Egypt; El Salvador; Equatorial Guinea; Estonia; Ethiopia; Fiji; Finland; France; Gabon; Gambia, The; Georgia; Germany; Ghana; Greece; Guatemala; Guinea; Guinea-Bissau; Guyana; Haiti; Honduras; Hungary; Iceland; India; Indonesia; Iran, Islamic Rep.; Iraq; Ireland; Israel; Italy; Jamaica; Japan; Jordan; Kazakhstan; Kenya; Korea, Rep.; Kuwait; Kyrgyz Republic; Lao PDR; Latvia; Lebanon; Lesotho; Liberia; Libya; Lithuania; Luxembourg; Madagascar; Malawi; Malaysia; Maldives; Mali; Malta; Mauritania; Mauritius; Mexico; Moldova; Mongolia; Montenegro; Morocco; Mozambique; Myanmar; Namibia; Nepal; Netherlands; New Zealand; Nicaragua; Niger; Nigeria; North Macedonia; Norway; Oman; Pakistan; Panama; Papua New Guinea; Paraguay; Peru; Philippines; Poland; Portugal; Qatar; Romania; Russian Federation; Rwanda; Sao Tome and Principe; Saudi Arabia; Senegal; Serbia; Sierra Leone; Singapore; Slovak Republic; Slovenia; Solomon Islands; Somalia; South Africa; Spain; Sri Lanka; Sudan; Sweden; Switzerland; Syrian Arab Republic; Tajikistan; Tanzania; Thailand; Togo; Trinidad and Tobago; Tunisia; Türkiye; Turkmenistan; Uganda; Ukraine; United Arab Emirates; United Kingdom; United States; Uruguay; Uzbekistan; Venezuela, RB; Viet Nam; Yemen, Rep.; Zambia; Zimbabwe.

The empirical analysis of the impact of EGDI and its subindexes on the services trade restrictiveness covers 51 countries:

Australia; Austria; Belgium; Brazil; Canada; Chile; China; Colombia; Costa Rica; Czechia; Denmark; Estonia; Finland; France; Germany; Greece; Hungary; Iceland; India; Indonesia; Ireland; Israel; Italy; Japan; Kazakhstan; Korea, Rep.; Latvia; Lithuania; Luxembourg; Malaysia; Mexico; Netherlands; New Zealand; Norway; Peru; Philippines; Poland; Portugal; Russian Federation; Singapore; Slovak Republic; Slovenia; South Africa; Spain; Sweden; Switzerland; Thailand; Türkiye; United Kingdom; United States; Viet Nam.

Appendix B

Table B1. Descriptive statistics of the variables in the rate spread analysis

Variable	Observations	Mean	Standard deviation	Median	Minimum	Maximum	Skewness	Kurtosis
EGDI	1,299	0.48	0.20	0.47	0.00	0.97	0.10	-0.42
EGDI_HCI	1,299	0.71	0.19	0.75	0.00	1.42	-1.07	1.31
EGDI_OSI	1,299	0.41	0.25	0.38	0.00	1.00	0.35	-0.74
EGDI_TII	1,299	0.32	0.26	0.25	0.00	1.00	0.67	-0.68
Interest rate spread (lending rate minus deposit rate, %)	1,299	7.33	7.47	6.03	-13.90	97.09	3.97	29.06
GDP per capita (current US$)	1,299	9,987.05	15,458.43	4,424.99	116.80	109,269.52	3.10	11.13

Note: *The table reports descriptive statistics for the variables used in the empirical analysis of the effect of e-government development on interest rate spreads. GDP per capita is measured in current US dollars. EGDI denotes the E-Government Development Index; EGDI_HCI is the Human Capital Index; EGDI_OSI is the Online Services Index; and EGDI_TII is the Telecommunication Infrastructure Index.*

Table B2. Descriptive statistics of the variables used in the logistics performance analysis

Variable	Obser-vations	Mean	Standard deviation	Median	Minimum	Maximum	Skewness	Kurtosis
EGDI	906	0.53	0.22	0.53	0.00	0.97	-0.04	-1.01
EGDI_HCI	906	0.70	0.21	0.75	0.00	1.00	-0.84	0.05
EGDI_OSI	906	0.49	0.27	0.48	0.00	1.00	0.06	-1.08
EGDI_TII	906	0.39	0.26	0.36	0.00	0.98	0.33	-1.12
GDP per capita (current US$)	906	15,431.61	21,484.35	6,000.23	219.20	123,719.66	2.17	5.03
Logistic performance index	906	2.89	0.57	2.75	1.34	4.30	0.53	-0.58

Note: *The table reports descriptive statistics for the variables used in the analysis of the relationship between e-government development and logistics performance. EGDI denotes the E-Government Development Index; EGDI_HCI is the Human Capital Index; EGDI_OSI is the Online Services Index; and EGDI_TII is the Telecommunication Infrastructure Index. GDP per capita is measured in current US dollars.*

Table B3. Descriptive statistics of the variables used in the services trade restrictiveness analysis

Variable	Obser-vations	Mean	Standard deviation	Median	Minimum	Maximum	Skewness	Kurtosis
EGDI	306	0.80	0.12	0.82	0.38	0.98	-0.91	0.46
EGDI_HCI	306	0.85	0.09	0.87	0.47	1.00	-0.97	1.10
EGDI_OSI	306	0.81	0.14	0.83	0.36	1.00	-0.89	0.56
EGDI_TTI	306	0.73	0.19	0.78	0.14	1.00	-0.83	0.04
GDP per capita (current US$)	306	34,061.58	27,462.93	25,940.36	1,553.88	137,781.68	1.10	0.98
Services Trade Restrictiveness Index	306	0.22	0.08	0.20	0.11	0.48	1.33	1.63

Note: *The table reports descriptive statistics for the variables used in the analysis of the relationship between e-government development and services trade restrictiveness. EGDI denotes the E-Government Development Index; EGDI_HCI is the Human Capital Index; EGDI_OSI is the Online Services Index; and EGDI_TTI is the Telecommunication Infrastructure Index. GDP per capita is measured in current US dollars.*