

Digital trade and financial development in European transition economies

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Highlight

- We examine the quadratic effects of digital trade on financial development in European transition economies.
- Low level of digital trade benefits financial development, after beyond the peak point, digital trade exacerbates financial development.
- Digital trade has an inverted U-shaped effect on financial institutions, while its effect on financial markets is insignificant.
- Digital trade is growing in transition economies but remains below the level needed to fully drive financial development.

Abstract

In the 2000s, advances in high-speed internet and mobile technology enable companies worldwide to conduct transactions online, fuelling the growth of digital trade. Despite this, the effects of digital trade on financial development, particularly in Eastern Europe, remain underexplored. Financial development levels in European transition economies are notably low, even as digital trade continues to expand. This study examines the impact of digital trade on financial development across 19 European transition economies. Digital trade is measured through four key indicators—exports of ICT services, exports and imports of ICT goods, and internet penetration—while financial development is assessed using three metrics: the financial development index, financial institution index, and financial market index. Our findings reveal an inverted U-shaped relationship between digital trade and financial development, where initial increases in digital trade positively impact financial depth, accessibility, and efficiency. However, beyond a certain

threshold, these benefits begin to diminish. We identify peak points for ICT services and goods exports and imports, which indicate that current digital trade levels are insufficient to maximize financial development. Thus, we recommend further expansion of digital trade to enhance financial systems in these economies.

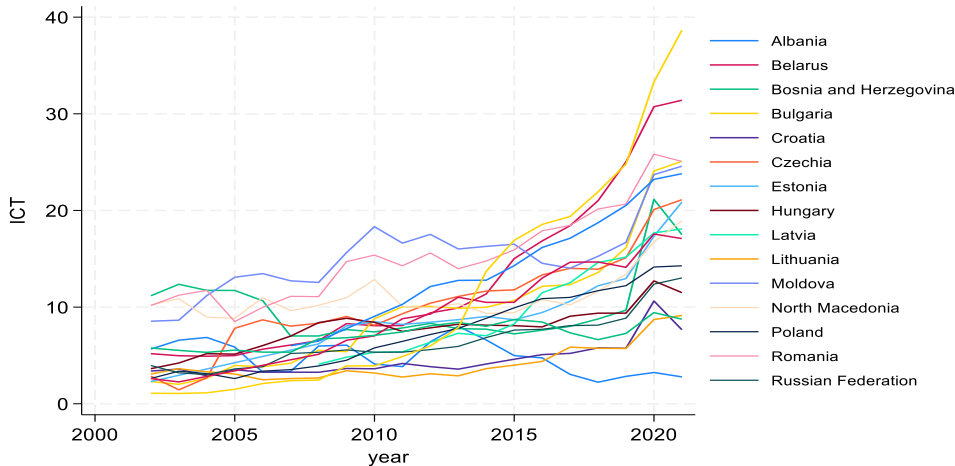
Keywords: Digital trade; European transition economies; Financial development; ICT; Internet penetration

JEL Classification: B27 (International trade and finance), F14 (Empirical studies of trade), F18 (Trade and environment), F31 (Foreign exchange), F41 (Open economy macroeconomics), G01 (Financial crises), G15 (International financial markets)

1. Introduction

Digitalization is reshaping global trade, making it more accessible and cost-effective through advances in Information and Communication Technology (ICT) services and internet penetration. By 2020, digital trade constitutes roughly 25% of global trade, according to OECD¹. Originally emerging in the 1990s with the rise of e-commerce, digital trade expands significantly, driven by continuous advancements in ICT and digital technologies. Today, it encompasses a broad spectrum, including not only e-commerce but also data exchange and digital platforms. This digital transformation is accelerating even in transition economies, where digital trade has seen substantial growth. Figure 1 illustrates the rising trend of ICT service exports, which accounted for approximately 19% of total service exports across transition economies as of 2021.

Figure 1. Trends of digital trade in transition economies



Notes. This figure illustrates trends of digital trade in transition economies from 2002 to 2021. The x-axis denotes the year, and the y-axis denotes ICT services exports, measured as the ratio of ICT

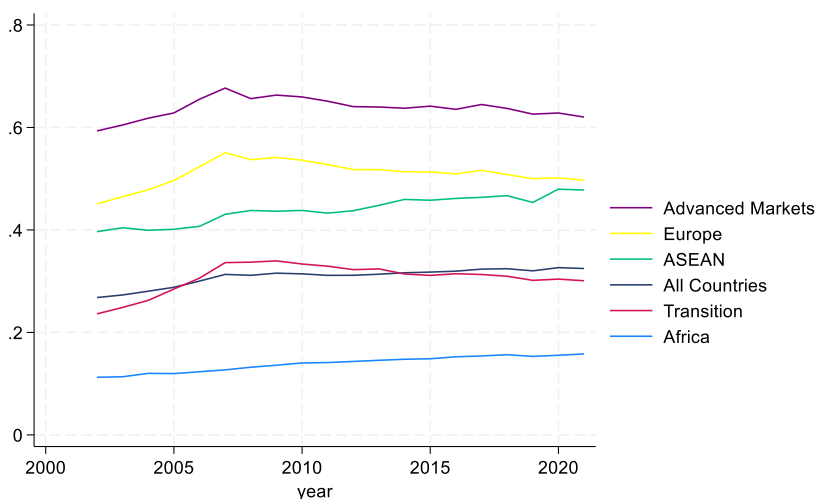
¹ <https://www.oecd.org/en/topics/digital-trade.html>

services exports to services exports. Source: <https://data.imf.org>.

The digital transformation has made trade more affordable and accessible, introducing new dynamics that set digital trade apart from traditional trade in its impact. Recent studies have examined digital trade within the broader context of overall trade, specifically investigating its relationship with financial development, particularly in the fast-growing ICT and internet platform service sectors (Bai, Wu, and Wang, 2023, Gurău, 2002, Herman and Oliver, 2023, Wang, Hu, and Li, 2024). However, research into the unique role of digital trade in influencing financial development—especially in transition economies—remains sparse (Nam, Bilgin, and Ryu, 2024a). This study seeks to fill this gap by examining how digital trade, particularly through ICT trade and internet penetration, may impact financial development. It provides a new perspective that distinguishes digital trade’s effects from those examined in traditional trade and financial development studies.

Financial development in transition economies remains critically low, creating a substantial barrier to overall economic advancement. With underdeveloped banking sectors and financial markets, these economies experience limited access to foreign investment, restricted financing options for local businesses, and slowed economic growth (Asimakopoulos, Simen, and Vivian, 2024; Fetai, 2018; Nam, Ryu, and Szilagyi, 2024). Additionally, these economies contend with intrinsic uncertainties within their financial sectors and regulatory frameworks, which further inhibit financial development (Cuddy, 2019; Nannicini and Billmeier, 2011). Figure 2 illustrates the trends in financial development across regions from 2002 to 2021, highlighting persistently low financial development index scores in European transition economies. As of 2021, the financial development index in these economies remains at only 0.30, underscoring the urgent need to strengthen financial institutions and markets to drive economic progress. Thus, this study seeks to uncover the fundamental drivers of financial development and explore potential strategies to enhance it through digital trade. Addressing these issues is crucial not only for understanding digital trade and financial development but also for promoting economic growth in transition economies (Ahmed and Mmolainyane, 2014; Frankel and Romer, 1999; Menyah, Nazlioglu, and Wolde-Rufael, 2014).

Figure 2. Trends of financial development across regions



Notes. This figure illustrates financial development across regions from 2002 to 2021. The x -axis denotes the year, and the y -axis denotes financial development measured as the financial development index. The dark red, yellow, green, grey, red, and sky-blue lines represent the financial development index in advanced markets, European regions, ASEAN regions, all countries, European transition economies, and Africa, respectively. Source: <https://data.imf.org>.

We aim to identify pathways for strengthening financial institutions and markets by analyzing data from 17 transition economies between 2002 and 2021, utilizing fixed effects (FE), method of moments quantile regression (MMQR), and the generalized method of moments (GMM). The OECD suggests that digital trade includes transactions that are digitally delivered or digitally ordered, encompassing both goods and services.² To capture the full impact of digital trade, we examine several key indicators: ICT service exports, ICT goods exports, ICT goods imports, and internet penetration. These indicators reflect different aspects of digital trade, from digitally ordered but physically delivered transactions (Azmeah, Foster, and Echavarri, 2020; Bunje, Abendin, and Wang, 2022). Thus, we seek to clarify the roles of digital trade indicators in financial development and estimate the level of digital trade needed to fully drive financial development in transition economies.

Our findings reveal a significant quadratic relationship between digital trade and financial development. At lower levels, digital trade fosters financial development; however, as digital trade intensifies, its benefits diminish and can even become detrimental. The initial positive impact of digital trade on financial markets and institutions aligns with various theoretical foundations, highlighting key benefits such as *increased foreign investment*, *broadener access to financial services*, and *enhanced efficiency in financial transactions*. First, the growth of ICT service exports attracts foreign investment, boosting liquidity in the financial system and facilitating broader access to financial services for businesses. As ICT services expand, foreign capital inflows enable banks and financial institutions to extend more loans and investments (Dimelis and Papaioannou, 2010;

² <https://www.oecd.org/en/topics/measuring-digital-trade.html>.

Sinha and Sengupta, 2022), thereby deepening financial markets and improving system efficiency. Second, the export of ICT goods not only supports product sales but also drives technology transfer and innovation across European transition economies (Díaz-Chao, Sainz-González, and Torrent-Sellens, 2015; Xiao, Califf, Sarker, and Sarker, 2013). This technological exchange fosters the adoption of digital finance solutions that bolster financial development. Enhanced technological capabilities in financial institutions contribute to more accurate risk assessments and stronger overall financial stability. Third, internet-based digital trade platforms significantly enhance access to banking, credit, and payment services, breaking down traditional barriers to financial inclusion (Jun and Cai, 2001). By reducing transaction costs, digital trade encourages frequent and high-volume trading activities, which stimulate the growth of local financial markets and institutions.

However, at more advanced levels of digital trade, negative effects emerge, primarily due to *increased reliance on foreign capital, currency volatility, and strain on financial systems*. As ICT service exports grow, firms become increasingly dependent on foreign capital, which exposes them to exchange rate fluctuations and heightens economic vulnerability to currency volatility (Ozcan, 2018; Sepehrdoust, Ahmadvand, and Mirzaei, 2022). Additionally, for transition economies with underdeveloped financial markets, the surge in R&D investment and rapid expansion of digital trade may exacerbate debt levels and strain local financial systems (Lewis and Tan, 2016), restricting financial development. With financial markets still underdeveloped, excessive digital trade can, paradoxically, hinder the resilience and growth of domestic financial institutions, as heightened reliance on external financing undermines financial stability. In summary, while digital trade can stimulate financial development in its early stages, excessive expansion poses potential risks. A balanced approach to digital trade is essential for harnessing its benefits while protecting financial stability in transition economies.

This study makes a significant contribution by providing insights into the current level of digital trade in transition economies and analyzing the extent to which this growing sector contributes to financial development. One of our key contributions is identifying the peak levels of digital trade—points at which its impact on financial development is maximized—to assess whether digital trade should be expanded in the current context. Our findings reveal a critical insight: transition economies remain significantly below the peak levels of digital trade required to fully drive financial development. As of 2021, ICT services exports, ICT goods exports, and ICT goods imports account for approximately 18.6%, 4.5%, and 7.0%, respectively, while their estimated peak points stand at 28%, 16%, and 13%. This substantial gap underscores the importance of enhancing digital trade as a key driver of financial development in transition economies. Digital trade represents a burgeoning industry in these economies, yet its current levels are insufficient to realize its full potential for driving financial growth. Expanding digital trade to reach its peak levels is not just an opportunity but a strategic priority for maximizing its contribution to financial development. By identifying these gaps and emphasizing the importance of targeted strategies, we highlight the pivotal role digital trade can play in accelerating the financial development of transition economies.

This study proposes policy implications by examining the underdeveloped state of financial

markets in transition economies. While digital trade demonstrates a significant inverted U-shaped relationship with financial institutions, its impact on financial markets is notably limited. The financial market index in these economies is considerably lower than the financial institution index. The limited impact of digital trade on financial markets can be attributed to several structural factors inherent in these economies. Capital markets, such as stock and bond markets, are either non-existent or remain in their infancy. In many countries, including Albania, Belarus, Bosnia and Herzegovina, Bulgaria, Estonia, Latvia, Lithuania, Moldova, North Macedonia, Romania, Serbia, Slovenia, and Ukraine, financial market index values are close to zero. This significantly limits the depth and diversity of financial markets. Many transition economies rely heavily on “bank-centered financial systems”, where bank-based lending dominates over capital market financing including stocks and bonds (Allen, Qian, and Qian, 2005; Berglöf and Bolton, 2002; Bonin and Wachtel, 2003). This reliance restricts digital trade’s ability to influence financial markets. To address these challenges, this study provides several policy recommendations aimed at strengthening financial markets in transition economies and enhancing the positive impact of digital trade. Governments should prioritize the development of capital markets, including stock and bond markets (Demirgüç-Kunt and Maksimovic, 1998; Nam, Batten, and Ryu, 2024). Strong legal and institutional frameworks are essential for supporting capital market development and enabling financial markets to function effectively.

2. Literature Review and Hypotheses Development

Research in international finance explores various topics, including capital flows between countries (Ahmed, 2016; Ahn, Amity, and Weinstein, 2011; Hur, Raj, and Riyanto, 2006), foreign exchange markets and exchange rates (Hassan, Loualiche, Pecora, and Ward, 2023; Lane and Shambaugh, 2010; Leibovici, 2021), cross-border investments (Desbordes and Wei, 2017; Osei and Kim, 2020; Nam and Ryu, 2024a), and trade finance (Hajilee and Niroomand, 2019). This field primarily focuses on analyzing financial activities across borders and the factors influencing such transactions. Financial institutions and markets play a vital role in facilitating international trade by providing financing and risk management solutions. Trade finance, in particular, serves as a critical enabler, addressing operational challenges that could otherwise hinder cross-border transactions (Nizam, Dewandaru, Nagayev, and Nkoba, 2019; Liu, Lu, and Woo, 2019; Nam and Ryu, 2024b). The expansion of trade significantly influences financial markets by increasing firms’ demand for capital. To accommodate this growing demand, financial markets provide additional liquidity, reinforcing their capacity to support trade. Countries with robust trade activity often experience parallel development in their capital markets, as revenue from international trade is reinvested into financial systems. This reinvestment fosters growth in financial institutions and markets, enabling them to better support trade-related enterprises and drive broader financial market development.

Building on the well-established relationship between trade and financial development, our

study shifts the focus to digital trade—a rapidly growing dimension of international commerce. Digital trade introduces both unique opportunities and challenges to the traditional trade-finance nexus. By examining its impact on financial development, we aim to provide new insights into how this evolving trade landscape shapes modern financial systems.

Digital trade has a significant impact on financial development and, depending on its scale, can have both positive and negative effects. In the early stages, digital trade—including digital service exports, digital product exports, digital product imports, and Internet platform development—provides a strong foundation for promoting financial development by increasing foreign investment, expanding access to financial services, and improving the efficiency of financial transactions.

First, the growth of ICT service exports attracts foreign capital inflows, enhancing liquidity in the financial system and increasing access to financial services for businesses and individuals. ICT service exports—encompassing areas such as software development, cloud computing, data analytics, IT consulting, and telecommunications—drive demand from international customers. As foreign demand for these services grows, capital flows into exporting economies (Wang, Hu, and Li, 2024), enabling financial institutions and markets to extend more loans and investments (Fiorini and Hoekman, 2018). This infusion of capital broadens and strengthens financial markets, fostering greater financial development. Second, the export of ICT goods not only generates revenue from product sales but also facilitates technology transfer and fosters innovation through global exchange. These interactions enable financial institutions to implement advanced digital financial solutions, such as data analytics, risk management tools, and electronic payment systems (Hunjra, Azam, Bruna, and Taskin, 2022). By adopting these technologies, financial institutions enhance their ability to conduct precise risk assessments, bolstering the reliability and stability of financial systems. Third, as a key factor in financial development, the development of Internet platforms can enhance the efficiency and accessibility of financial services. Internet platforms can dramatically increase access to financial services (Bunje, Abendin, and Wang, 2022). Platforms connect sellers and buyers globally, smoothing trade processes and reducing barriers to entry for smaller players. By leveraging technology, these platforms can offer banking, lending, and investment services remotely, thereby reducing their dependency on traditional bricks-and-mortar institutions. This can expand financial inclusion by enabling a wider range of enterprises to engage actively in economic activities. Internet platforms facilitate real-time data sharing and transactions, which can improve the efficiency of financial markets (Nam and Ryu, 2024c). In addition, the Internet can lower the cost of financial services and enhance accessibility, thereby promoting financial inclusion. As trade volumes grow, the Internet facilitates faster and more efficient processing of trade-related financial transactions. This improves the efficiency of international trade and promotes innovations such as cross-border payment systems, digital payment solutions, and supply chain finance. Such financial innovations can stimulate overall financial development. Internet use thus plays a crucial role in the long-term development of finance and in increasing market efficiency. Additionally, increased internet access drives the growth of digital financial services, such as mobile banking, allowing businesses and individuals to engage in digital trade

and access financial services more conveniently. This accessibility reduces barriers to financial inclusion and encourages the development of local financial markets. These positive effects suggest that, at lower levels, digital trade enhances financial development by improving liquidity, fostering innovation, and expanding access to financial services. As a result, digital trade serves as a critical driver for modernizing financial institutions and markets, particularly in economies seeking to strengthen their financial systems.

However, trade can foster financial development, advanced levels of digital trade, especially in transition economies with underdeveloped financial markets, can introduce significant financial risks: *increased exchange rate volatility*, *heightened dependence on foreign capital*, and *debt accumulation and financial strain*. The rapid expansion of digital trade increases exposure to foreign exchange markets, making economies more susceptible to currency fluctuations. This volatility is particularly concerning for economies with trade imbalances, as it can destabilize financial markets and reduce financial stability (Gelos and Sahay, 2001; Jiang, Liu, and Lu, 2023; Liu, Lu, and Woo, 2019). As digital trade grows, firms in these economies often depend more on foreign capital to finance their operations. This reliance increases vulnerability to external shocks, where, during crises, a sudden outflow of foreign capital can destabilize the financial system. Such dependence also risks creating trade deficits and potential currency shortages, which further strains financial systems (Schwert, 2018). For transition economies with limited financial development, the rapid expansion in digital trade may drive increased R&D investment and borrowing (Hong, 2017). While these investments are necessary for growth, they can result in higher debt levels that strain local financial systems (Maskus, Neumann, and Seidel, 2012). Excessive debt can hinder the resilience and growth of domestic financial institutions, as reliance on external financing undermines financial stability, potentially restricting financial development in the long run (Gornall and Strebulaev, 2018). In summary, while digital trade can initially promote financial development, excessive growth without balancing mechanisms may jeopardize the stability of financial markets, particularly in emerging economies with underdeveloped financial infrastructures.

Given these dynamics, we hypothesize a quadratic relationship between digital trade and financial development: at lower levels, digital trade positively impacts financial development by expanding liquidity, innovation, and accessibility. However, as digital trade intensifies, it introduces risks that may ultimately hinder financial development.

3. Data and Methodology

3.1 Data

This study examines the correlation between digital trade and financial development using data from 19 European transition economies for 2002 to 2021: Albania, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Moldova, North

Macedonia, Poland, Romania, Russia, Serbia, Slovakia, Slovenia, and Ukraine.³ Our theoretical model focuses primarily on digital trade and financial development, with a series of control variables, including institution quality, market capitalization, GDP, government consumption, the inflation rate, the global financial crisis, and the COVID-19 pandemic. The World Bank provides all the data except for those on financial development, which we source from the International Monetary Fund database.

Financial development (*FD*, *FI*, and *FM*) is measured as the financial development index, financial institution index, and financial market index. The financial development index is an amalgamation of the financial institution and market indices. This index, which varies between zero and one, assesses the depth, access, and efficiency of financial institutions and markets (Khan, Khan, Abdulahi, Liaqat, and Shah, 2019). We incorporate four key variables (*ICTSE*, *ICTGE*, *ICTGI*, and *INT*) as proxies for digital trade (Cheng, Chien, and Lee, 2021; Njangang, Beleck, Tadadjeu, and Kamguia, 2022). *ICTSE* is measured as the ratio of ICT service exports to service exports, converted from a percentage by dividing by 10 to express it as a decimal value. ICT service exports include computer and communications services (such as telecommunications and postal and courier services), as well as information services (including computer data and news-related service transactions). *ICTGE* is measured as the ratio of ICT goods exports to total goods exports, also converted from a percentage by dividing by 10 to express it as a decimal value. ICT goods exports consist of items such as computer systems and related hardware, communication devices, electronic consumer products, components used in electronic systems, and various other technology-oriented goods. *ICTGI* is measured as the ratio of ICT goods imports to total goods exports, converted similarly. *ICTSE*, *ICTGE*, and *ICTGI* are expressed as scaled values by dividing the percentage values by 10. *INT* is the proxy for Internet penetration, measured as the ratio of the number of Internet users to the population. *INSTI* is the Worldwide Governance Index, measured as the sum of control of corruption, government effectiveness, political stability and absence of violence, regulatory quality, rule of law, and voice and accountability. *MARC* represents market capitalization, measured as the ratio of share price multiplied by the number of shares outstanding for listed domestic companies to the GDP. *GDP* is measured as gross domestic product, expressed in tens of trillions of USD. *GEXP* is calculated as the ratio of general government final consumption expenditure to GDP. *INFLA* is the inflation rate. *GEXP* and *INFLA* are converted from a percentage to a decimal by dividing by 100. *GFC (Covid)* serves as a proxy for the global financial crisis (COVID-19), coded as one for 2007–2009 (2020–2021) and zero for all the other years.

Table 1 provides an overview of the descriptive statistics for key variables. The Financial Development Index (*FD*), a central variable in the analysis, has a mean value of 0.31 across the 19 countries studied. This index, which ranges from 0 to 1, records a minimum value of 0.08 in 2001

³ Kosovo and Montenegro are excluded because the International Monetary Fund does not provide financial development indices for these countries.

for Bosnia and Herzegovina and a maximum value of 0.58 in 2009 for the Russian Federation. The Financial Institution Index (*FI*) has an average value of 0.41, while the Financial Market Index (*FM*) shows a notably low mean of 0.14. This underscores the stark underdevelopment of financial markets in the region.

The low scores on the Financial Market Index can be attributed to two main factors: underdeveloped capital markets, low trading volumes and regulatory and institutional limitations. First, in many transition economies, capital markets such as stock and bond markets are either nonexistent or remain in their infancy, significantly limiting the depth and diversity of financial markets. Many countries, including Albania, Belarus, Bosnia and Herzegovina, Bulgaria, Estonia, Latvia, Lithuania, Moldova, North Macedonia, Romania, Serbia, Slovenia, and Ukraine, report values close to zero for the financial market index. Second, financial products experience minimal trading activity, resulting in insufficient market liquidity. This discourages investors and hampers the ability to attract global investments. (Bessembinder, Jacobsen, Maxwell, and Venkataraman, 2018). Third, effective financial market operations require a robust legal and regulatory framework. However, in many countries, these frameworks are incomplete or inefficient, undermining market stability and reliability (Modigliani and Perotti, 1997). Financial supervisory and regulatory bodies often face limitations in expertise and independence, reducing their capacity to tackle issues such as bad loans, money laundering, and financial misconduct effectively (Svejnar, 2002). These challenges highlight the need for significant reforms to strengthen both institutional frameworks and the development of financial markets in European transition economies.

Table 1. Descriptive statistics

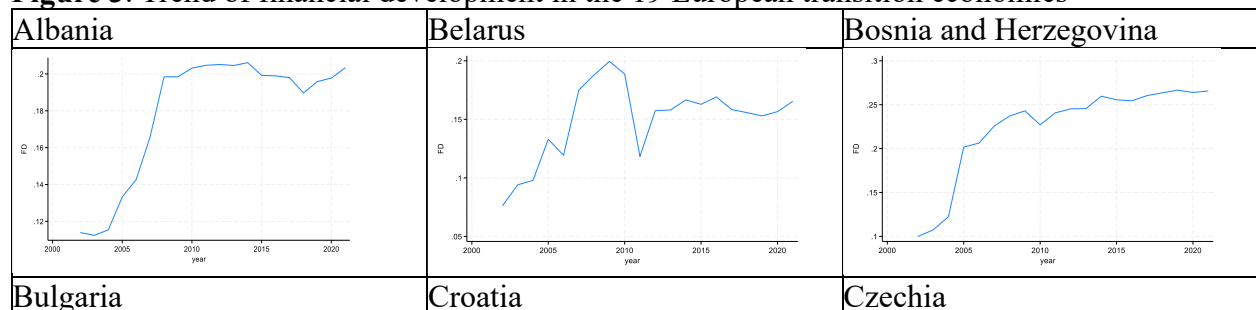
	Obs.	Mean	Std. dev.	Min	Max
FD	380	0.31	0.12	0.08	0.58
FI	380	0.46	0.12	0.13	0.70
FM	380	0.14	0.17	0.00	0.68
ICTSE	393	0.92	0.58	0.06	3.86
ICTGE	386	0.46	0.59	0.00	2.83
ICTGI	386	0.67	0.42	0.10	2.12
INT	395	0.54	0.24	0.00	0.91
<i>INSTI</i>	410	1.03	3.61	-6.24	7.72
<i>MARC</i>	174	0.24	0.18	0.01	1.18
GDP	414	0.01	0.03	0.00	0.23
GEXP	414	0.18	0.03	0.10	0.30
INFLA	402	0.05	0.06	-0.02	0.59
GFC	420	0.15	0.36	0.00	1.00
COVID	420	0.10	0.30	0.00	1.00

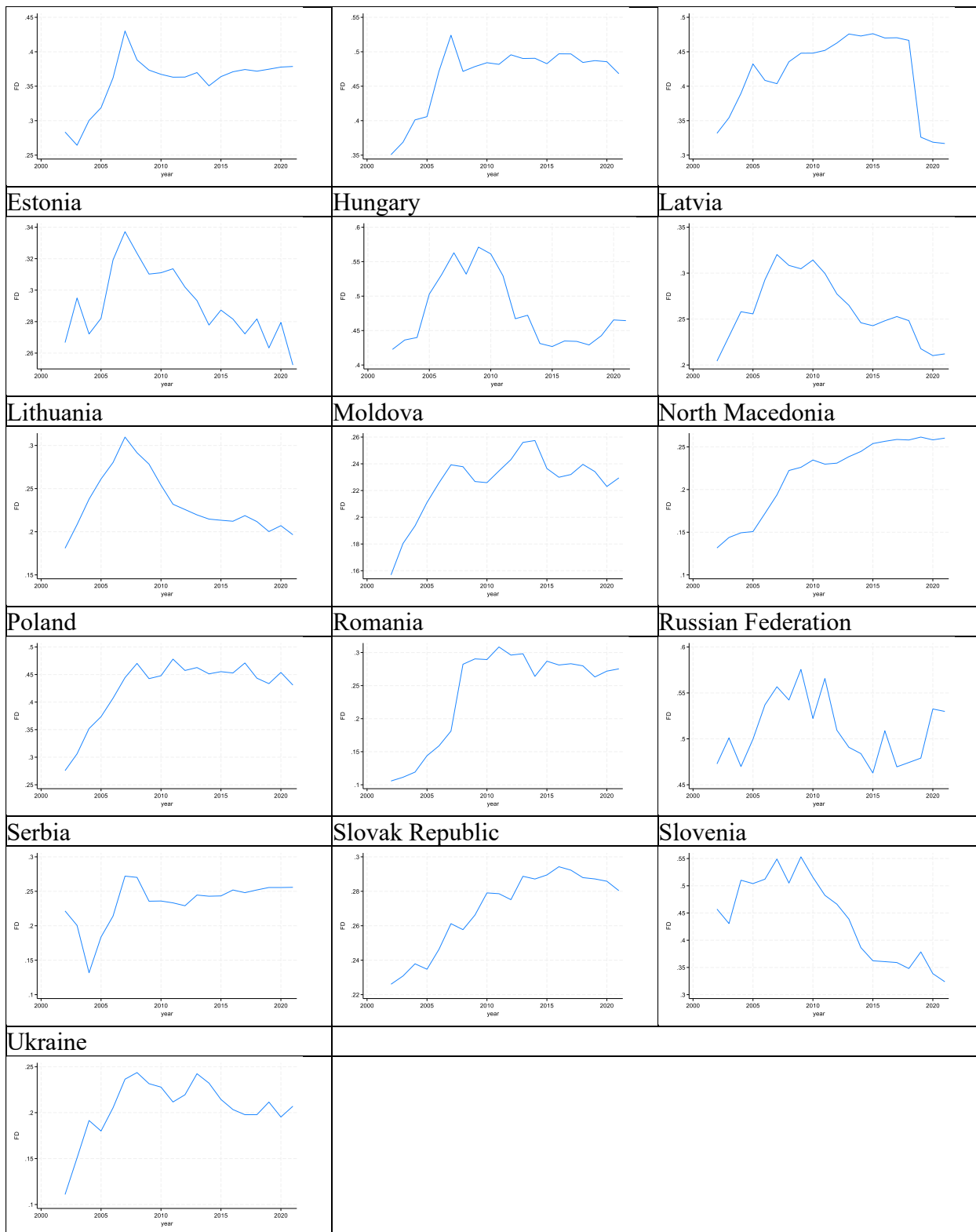
Notes. This table presents the descriptive statistics of the variables. *Obs.*, *Mean*, *Std.*, *Min*, and *Max* represent the country-year observations, mean, standard deviation, minimum value, and maximum

value, respectively. *FD*, *FI*, and *FM* are the financial development index, financial institution index, and financial market index. *ICTSE* is calculated as the proportion of ICT service exports to total service exports. ICT service exports encompass a range of activities, including IT-related services such as software and data services, telecommunications, courier, and postal services, as well as information-based services like data handling and news distribution. *ICTGE* is determined as the ratio of ICT goods exports to overall goods exports. ICT goods exports cover products such as computers, communication devices, electronic consumer products, components for electronics, and other technology-related equipment. *ICTGI* is measured as the ratio of ICT goods imports to total goods imports. *ICTSE*, *ICTGE*, and *ICTGI* are expressed as scaled values by dividing the percentage values by 10. *INT* is the proxy for internet penetration, measured as the ratio of the number of Internet users to the population. *INSTI* is the Worldwide Governance Index, measured as the sum of control of corruption, government effectiveness, political stability and absence of violence, regulatory quality, rule of law, and voice and accountability. *MARC* represents market capitalisation, measured as the ratio of share price multiplied by the number of shares outstanding for listed domestic companies to the GDP. *GDP* is measured as gross domestic product, expressed in tens of trillions of USD. *GEXP* is calculated as the ratio of general government final consumption expenditure to GDP. *INFLA* is the inflation rate. *GovExp* and *Infla* are expressed as decimal values by dividing the percentage by 100. *GFC (Covid)* serves as a proxy for the global financial crisis (COVID-19), coded as one for 2007–2009 (2020–2021) and zero for all the other years.

Figure 3 shows how the financial development index fluctuated in the 19 European transition economies from 2002 to 2021. Albania, Bosnia, Herzegovina, and North Macedonia show clear signs of financial growth, which may indicate effective financial reforms or growing market stability. Belarus, Estonia, and the Russian Federation exhibit volatility, suggesting economic instability or fluctuations in policies and market conditions. Many countries show a pattern of decline, followed by stabilisation or recovery, reflecting the effects of the 2008 global financial crisis and subsequent recovery measures. These observations suggest that while some countries have managed to steadily improve or stabilise their financial sectors, others continue to struggle to enhance their financial development. This disparity may result from differences in government policies, economic resilience, institutional reforms, and integration with global financial markets. As such, low-performing countries may require strategic intervention to foster a more conducive environment for financial development and economic growth.

Figure 3. Trend of financial development in the 19 European transition economies





Notes. This figure illustrates the financial development of the 19 European transition economies from 2002 to 2021. The x-axis denotes the year and the y-axis denotes financial development measured as the financial development index. Source: <https://data.imf.org>.

3.2 Methodology

We assess the nonlinear effect of digital trade on financial development in Equation (1) using the FE regression model. The FE model is particularly effective in controlling for unobserved heterogeneity on within-group variations over time. By accounting for time-invariant characteristics specific to each transition economy, the FE model helps mitigate endogeneity caused by omitted variables that are constant over time. This approach allows us to isolate the impact of digital trade on financial development while holding other country-specific factors constant.

We also conduct the MMQR model in Equation (2), following Machado and Silva (2019) and Nam, Frijns, and Ryu, (2024). As noted by Fatemi, Fooladi, Sy, and Zaman (2024), quantile regression is particularly effective in mitigating the influence of outliers, which can distort results in traditional regression models. With this property, the MMQR model not only reduces outlier effects but also reveals potential nonlinear relationships in the data. The MMQR model in this study examines the conditional distribution of the dependent variable, financial development, given specific economic conditions. These economic conditions refer to the independent variables included in our model, such as digital trade, institutional quality, market capitalization, GDP, government expenditure, inflation, the global financial crisis, and Covid-19, all of which are held constant.

To investigate the nonlinear effects of digital trade on financial development, we specify the following models.

FE regression model:

$$FINAN_{i,t} = \alpha_0 + \beta_0 DIGITAL_{i,t} + \alpha_0 DIGITAK^2_{i,t} + \sum_{j=1}^N \gamma_j Control_{j,i,t} + \delta_i + \varepsilon_{i,t}, \quad (1)$$

MMQR model:

$$FINAN_{i,t} = \alpha_0(\tau) + \beta_0(\tau) DIGITAL_{i,t} + \beta_1(\tau) DIGITAL^2_{i,t} + \sum_{j=1}^N \gamma_j(\tau) Control_{j,i,t} + \varepsilon_{i,t}, \quad (2)$$

where i represents the country, t denotes the year, τ represents the τ^{th} quantile, N represents the number of control variables, $Control_j$ represents the j^{th} control variable, δ denotes country fixed effects. ε is the denotes idiosyncratic errors, and Δ indicates the first-order difference operator. $FINAN_{i,t} = \{FD_{i,t}, FI_{i,t}, FM_{i,t}\}$. $DIGITAL_{i,t} = \{ICTSE_{i,t}, ICTGE_{i,t}, ICTGI_{i,t}, INT_{i,t}\}$. In all models, $Control_{i,t} \in \{INSTI_{i,t}, MARC_{i,t}, GDP_{i,t}, GEXP_{i,t}, INFLA_{i,t}, GFC_{i,t}, COVID_{i,t}\}$.

4. Empirical Results

4.1 Main results

Table 2 presents the results of the nonlinear effects of digital trade on financial development using the FE model. Digital trade is measured as ICT service exports ($ICTSE$) in model (1), ICT goods

exports (*ICTGE*) in model (2), ICT goods imports (*ICTGI*) in model (3), and internet penetration (*INT*) in model (4), while financial development is measured as the financial development index in models (1) to (4). The linear terms—*ICTSE*, *ICTGE*, *ICTGI*, and *INT*—positively affect financial development (*FD*), while the nonlinear terms—*ICTSE*², *ICTGE*², *ICTGI*², and *INT*²—negatively affect *FD*. This finding suggests that digital trade exhibits an inverted U-shaped relationship with financial development. In the initial phases, the digital trade not only drives technology transfer and innovation but also attracts considerable foreign investment (Nam and Ryu, 2023; Xiao, Zhou, and Fang, 2023). Digital trade boosts financial development by leveraging a variety of financial products. For instance, financial tools like letters of credit, factoring, and trade insurance mitigate risks in trade transactions. In these arrangements, the importer’s bank guarantees payment to the exporter, providing financial security. Additionally, exporters can sell accounts receivable arising from exports to financial institutions, improving cash flow and liquidity. Exporters also benefit from trade insurance products, which safeguard against the risk of non-payment for export transactions. Trade finance is a critical financial sector that facilitates smooth international trade operations, significantly influencing global capital flows and foreign exchange markets. It plays a pivotal role in the development of financial systems. By utilizing banking products, digital trade contributes significantly to the advancement of financial systems, supporting both international trade and broader financial development (Ryu and Nam, 2024). These capital inflows strengthen financial systems by enhancing liquidity and fostering financial development. Economies with vibrant trade often develop larger capital markets, and profits generated from international trade are reinvested into the financial system (Nam, Bang, and Ryu, 2023a, 2024b, 2024). Financial institutions, in turn, support trade-oriented firms with capital, further advancing financial markets. However, digital trade demands substantial foreign investment. As trade volumes, particularly those involving ICT services exports and imports, expand, significant capital inflows are needed, which can expose economies to foreign currency risks and heighten financial instability (Nam, Bilgin, and Ryu, 2024b). Such volatility in exchange rates and the heavy financing burden can destabilize financial markets and hinder financial development.

Table 2. Impacts of digital trade on financial development: FE model

	Financial development index			
	(1)	(2)	(3)	(4)
<i>ICTSE</i>	0.08***			
	(3.44)			
<i>ICTSE</i> ²	-0.02*			
	(-1.68)			
<i>ICTGE</i>		0.14***		
		(3.07)		
<i>ICTGE</i> ²		-0.04***		

		(-3.00)		
<i>ICTGI</i>			0.14*	
			(1.76)	
<i>ICTGI</i> ²			-0.05*	
			(-1.80)	
<i>INT</i>				0.70***
				(8.77)
<i>INT</i> ²				-0.59***
				(-7.47)
<i>INSTI</i>	0.02***	0.02***	0.02***	0.02***
	(3.83)	(2.98)	(3.39)	(4.16)
<i>MARC</i>	0.17***	0.18***	0.17***	0.13***
	(5.20)	(5.17)	(4.77)	(5.03)
<i>GDP</i>	0.85***	1.04***	1.17***	0.52*
	(2.72)	(3.25)	(3.54)	(1.97)
<i>GEXP</i>	0.36	0.61	0.26	0.26
	(0.95)	(1.50)	(0.67)	(0.91)
<i>INFLA</i>	-0.07	-0.04	-0.06	0.06
	(-0.81)	(-0.52)	(-0.68)	(0.88)
<i>GFC</i>	0.04***	0.03**	0.03***	0.02**
	(3.73)	(2.46)	(2.97)	(2.03)
<i>COVID</i>	-0.04***	-0.01	-0.01	0.01
	(-2.72)	(-1.09)	(-0.52)	(0.43)
Intercept	0.15*	0.10	0.13	0.06
	(1.89)	(1.12)	(1.37)	(1.03)
Obs.	162	165	165	169
R ²	0.45	0.40	0.37	0.62
F-test	12.84***	10.56***	9.47***	27.09***

Notes. This table presents the effects of digital trade, including ICT services export (*ICTSE*) in M1, ICT goods export (*ICTGE*) in M2, ICT goods import (*ICTGI*) in M3, and internet penetration (*INT*) in M4 on financial development using fixed effect (FE) regression. Financial development index (*FD*) is a dependent variable in all the models. *ICTSE* is measured as the ratio of the ICT service exports to service exports. *ICTGE* is measured as the ratio of the ICT goods exports to total goods exports. *ICTGI* is measured as the ratio of the ICT goods imports to the total goods imports. *INT* is the proxy for internet penetration, measured as the ratio of the number of Internet users to the population. The control variables are *INSTI*, *MARC*, *GDP*, *GEXP*, *INFLA*, *GFC*, and *COVID*. *Obs.* is the number of country-year observations. *R*² is the within R-squared value. *F*-test represents the *F*-test statistic, indicating a test of the null hypothesis that all the coefficients are zero. The numbers

in parentheses are t -statistics. Statistical significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *, respectively.

To determine the peak points of financial development, we estimate digital trade. We refer to Equation (3):

$$\left(\frac{\partial \overline{FINAN}}{\partial L.DIGITAL}\right) = \beta_0 + 2\beta_1 DIGITAL_{i,t}. \quad (3)$$

Using the coefficients from Table 2, we estimate $ICTSE$, $ICTGE$, and $ICTGI$ to determine the peak points of financial development: $ICTSE$ is 2.800; $ICTGE$ is 1.570; and $ICTGI$ is 1.324. Here, $ICTSE$, $ICTGE$, and $ICTGI$ are expressed as scaled values, calculated by dividing the original percentage values by 10. After converting the peak points back to percentage terms, they correspond to $ICTSE$: 28%, $ICTGE$: 16%, and $ICTGI$: 13%. As of 2021, ICT services exports, ICT goods exports, and ICT goods imports account for approximately 18.6%, 4.5%, and 7.0%, respectively. These findings indicate significant room for improvement in digital trade to reach the peak levels that maximize financial development. Thus, we propose promoting digital trade, particularly in ICT services exports, ICT goods exports, and ICT goods imports, to unlock its full potential for driving financial development.

The financial development index is calculated using both the financial institution index and the financial market index. To clearly identify the effect of digital trade on financial development, we examine the impact of digital trade separately on financial institutions and financial markets, split from the overall financial development index. This separation allows us to determine which factors from financial institutions and markets contribute to financial development in Table 3. Table 3 presents the results of the nonlinear effects of digital trade—measured as ICT service exports ($ICTSE$), ICT goods exports ($ICTGE$), ICT goods imports ($ICTGI$) and internet penetration (INT)—on financial institutions (FI) in models (1) to (4) and financial markets (FM) in models (5) to (6) using the FE model. The linear terms— $ICTSE$, $ICTGE$, and INT —positively affect financial institutions (FI), while the nonlinear terms— $ICTSE^2$, $ICTGE^2$, and INT^2 —negatively affect FI , indicating an inverted U-shaped relationship. However, only internet penetration (INT) has an inverted U curved effect on FM.

Table 3. Impacts of digital trade on financial institutions and markets: FE model

	FI				FM			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$ICTSE$	0.20***				-0.03			
	(6.45)				(-0.98)			
$ICTSE^2$	-0.04***				0.01			
	(-3.60)				(0.87)			
$ICTGE$		0.26***				0.00		

		(4.31)				(0.01)		
<i>ICTGE</i> ²		-0.09***				0.01		
		(-4.49)				(0.27)		
<i>ICTGI</i>			0.10				0.18*	
			(0.85)				(1.66)	
<i>ICTGI</i> ²			-0.04				-0.07	
			(-0.92)				(-1.64)	
<i>INT</i>				0.91***				0.46***
				(10.61)				(3.64)
<i>INT</i> ²				-0.62***				-0.55***
				(-7.25)				(-4.31)
<i>INSTI</i>	0.02***	0.03***	0.03**	0.03***	0.02**	0.01	0.02**	0.01*
	(3.00)	(2.87)	(2.57)	(5.12)	(2.58)	(1.34)	(2.19)	(1.67)
<i>MARC</i>	0.07*	0.08	0.05	0.05*	0.26***	0.28***	0.28***	0.21***
	(1.75)	(1.62)	(1.01)	(1.67)	(5.55)	(5.75)	(5.92)	(5.07)
<i>GDP</i>	1.20***	1.57***	1.73***	0.38	0.46	0.47	0.56	0.64
	(3.04)	(3.52)	(3.61)	(1.33)	(1.03)	(1.07)	(1.27)	(1.52)
<i>GEXP</i>	0.12	0.33	-0.66	-0.33	0.59	0.86	1.18**	0.83*
	(0.25)	(0.59)	(-1.16)	(-1.09)	(1.07)	(1.55)	(2.26)	(1.86)
<i>INFLA</i>	-0.42***	-0.35***	-0.42***	-0.11	0.29**	0.26**	0.30**	0.23**
	(-4.07)	(-2.88)	(-3.31)	(-1.54)	(2.48)	(2.19)	(2.61)	(2.12)
<i>GFC</i>	0.04***	0.02	0.03**	0.02*	0.03**	0.03**	0.03**	0.02
	(3.35)	(1.39)	(2.00)	(1.75)	(2.15)	(2.11)	(2.19)	(1.31)
<i>COVID</i>	-0.04*	0.02	0.04**	0.01	-0.04**	-0.05***	-0.06***	0.00
	(-1.93)	(1.25)	(2.23)	(0.45)	(-2.01)	(-2.84)	(-3.19)	(0.23)
Intercept	0.27***	0.24*	0.48***	0.21***	0.02	-0.05	-0.21	-0.09
	(2.75)	(1.98)	(3.35)	3.36)	(0.16)	(-0.40)	(-1.64)	(-1.00)
Obs.	162	165	165	169	162	165	165	169
R ²	0.53	0.37	0.29	0.77	0.38	0.38	0.39	0.46
F-test	17.62***	9.57***	6.56***	56.16***	9.73***	9.96***	10.32***	14.19***

Notes. This table presents the effects of digital trade, including ICT services export (*ICTSE*), ICT goods export (*ICTGE*), ICT goods import (*ICTGI*), and internet penetration (*INT*) on financial institutions in models (1) to (4) and financial markets in models (5) to (8) using fixed effect (FE) regression. Financial development index (*FD*) is a dependent variable in all the models. *ICTSE* is measured as the ratio of the ICT service exports to service exports. *ICTGE* is measured as the ratio of the ICT goods exports to total goods exports. *ICTGI* is measured as the ratio of the ICT goods imports to the total goods imports. *INT* is the proxy for internet penetration, measured as the ratio of the number of Internet users to the population. The control variables are *INSTI*, *MARC*, *GDP*, *GEXP*, *INFLA*, *GFC*, and *COVID*. *Obs.* is the number of country-year observations. *R*² is the

within R-squared value. F -test represents the F -test statistic, indicating a test of the null hypothesis that all the coefficients are zero. The numbers in parentheses are t -statistics. Statistical significance at the 1%, 5%, and 10% levels is indicated by ^{***}, ^{**}, and ^{*}, respectively.

Our results show that ICT service exports, ICT goods exports, and internet penetration each exhibit an inverted U-shaped relationship with financial institutions. This implies that while digital trade initially benefits financial institutions by increasing capital flows and facilitating technology transfer, excessive dependence on foreign capital inflows and external investment may ultimately destabilize financial institutions. In contrast, for financial markets, only internet penetration has a significant positive impact, while other digital trade variables (ICT service and goods exports) show no notable effect. The financial market index in these economies is notably low at an average of 0.14, compared to 0.46 for the financial institution index. This considerable gap suggests that financial markets are underdeveloped, which may explain the limited effect of digital trade on financial markets.

The limited impact of digital trade on financial markets in transition economies can be attributed to the underdeveloped state of these markets. Unlike advanced economies, where capital markets play a central role, transition economies rely predominantly on “bank-centered financial systems”. In this structure, firms depend primarily on bank loans for financing, rather than raising funds through stock or bond markets. As a result, the role of financial markets, including equity and bond issuance, remains minimal. This reliance on banks over capital markets has deep historical and structural roots. During the early stages of industrialization, transition economies typically mobilized capital through banking systems rather than leveraging nascent capital markets. This dependency persists today, reinforced by weak legal and institutional frameworks that hinder the growth of robust financial markets. Such inefficiencies compel firms to rely heavily on banks, limiting opportunities for capital markets to channel investments—including those from digital trade. Allen, Qian, and Qian (2005), Berglöf and Bolton (2002), and Bonin and Wachtel (2003) emphasize that this reliance on bank credit diverts resources away from capital markets, preventing digital trade from meaningfully contributing to their development. Consequently, the benefits of digital trade are largely confined to the banking sector, leaving financial markets underutilized and underdeveloped. This dynamic underscores the critical need for structural and regulatory reforms to transition toward more market-based financial systems (Nam, Bilgin, and Ryu, 2024c). Strengthening capital markets, such as stock and bond markets, is essential for enabling digital trade to play a transformative role in financial market development.

We apply the MMQR method by estimating Equation (2), and Table 4 shows the results across 10% to 90% quantiles. The effects of ICT services exports on financial development index show in Panel A and the effects of internet penetration on financial development index indicate in Panel B. From 30% to 90% in Panel A, $ICTSE$ has a positive effect on financial development and $ICTSE^2$ has a negative effect on financial development. The result indicates that at lower levels of ICT services exports, financial development initially increases, after beyond a turning point, and then it decreases at higher levels of ICT services exports. From 20% to 90% in Panel B, INT has

a positive effect on financial development and INT^2 has a negative effect on financial development. We hold concern an inverted U-shaped effect of internet penetration on financial development. The result indicates that at lower levels of internet penetration, financial development initially increases, after beyond a turning point, and then it decreases at higher levels of internet penetration. The quantile regression results provide valuable insights into how the influence of digital trade on financial development varies across different levels of financial development, even when economic conditions are held constant. This approach highlights the need to consider the full range of financial development levels rather than relying only on average outcomes, as it shows that the impact of economic policies or factors can vary significantly based on a country's specific stage of financial development.

Table 4. Impacts of digital trade on financial development: MMQR model

Panel A

	location	scale	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
<i>ICTSE</i>	0.08**	0.00	0.08	0.08*	0.08**	0.08**	0.08**	0.08**	0.08**	0.08**	0.08**
	(2.37)	(0.02)	(1.61)	(1.84)	(2.11)	(2.26)	(2.37)	(2.39)	(2.34)	(2.22)	(2.08)
<i>ICTSE</i> ²	-0.02*	-0.00	-0.02	-0.02	-0.02*	-0.02*	-0.02*	-0.02**	-0.02*	-0.02*	-0.02*
	(-1.91)	(-0.09)	(-1.25)	(-1.44)	(-1.68)	(-1.81)	(-1.92)	(-1.96)	(-1.93)	(-1.84)	(-1.73)
<i>INSTI</i>	0.02***	0.00	0.01***	0.01***	0.01***	0.01***	0.02***	0.02***	0.02***	0.02***	0.02***
	(6.64)	(1.15)	(3.82)	(4.58)	(5.55)	(6.12)	(6.66)	(7.02)	(7.02)	(6.86)	(6.55)
<i>MARC</i>	0.28***	-0.00	0.28***	0.28***	0.28***	0.28***	0.28***	0.28***	0.28***	0.28***	0.28***
	(6.32)	(-0.03)	(4.33)	(4.94)	(5.65)	(6.04)	(6.34)	(6.37)	(6.22)	(5.89)	(5.50)
<i>GDP</i>	1.22***	-0.10	1.39***	1.34***	1.28***	1.25***	1.21***	1.16***	1.14***	1.10***	1.07***
	(10.32)	(-1.59)	(8.02)	(8.81)	(9.69)	(10.07)	(10.28)	(9.91)	(9.52)	(8.77)	(7.93)
<i>GEXP</i>	1.89***	-0.04	1.96***	1.94***	1.92***	1.90***	1.89***	1.87***	1.86***	1.84***	1.83***
	(6.11)	(-0.25)	(4.33)	(4.89)	(5.54)	(5.88)	(6.12)	(6.09)	(5.93)	(5.57)	(5.17)
<i>INFLA</i>	-0.12	0.14	-0.34	-0.28	-0.21	-0.16	-0.11	-0.04	-0.01	0.04	0.08
	(-0.67)	(1.46)	(-1.36)	(-1.25)	(-1.06)	(-0.88)	(-0.64)	(-0.24)	(-0.05)	(0.19)	(0.39)
<i>GFC</i>	0.01	0.02**	-0.03	-0.02	-0.00	0.00	0.01	0.02	0.03	0.04*	0.04**
	(0.58)	(2.26)	(-1.00)	(-0.68)	(-0.20)	(0.17)	(0.61)	(1.24)	(1.50)	(1.81)	(2.00)
<i>COVID</i>	-0.03	0.02	-0.06*	-0.05*	-0.04*	-0.04*	-0.03	-0.02	-0.02	-0.02	-0.01
	(-1.51)	(1.31)	(-1.84)	(-1.83)	(-1.76)	(-1.66)	(-1.49)	(-1.13)	(-0.95)	(-0.68)	(-0.44)
Intercept	-0.14**	0.05	-0.22**	-0.20**	-0.17**	-0.16**	-0.14**	-0.12*	-0.11	-0.09	-0.08
	(-2.04)	(1.19)	(-2.13)	(-2.18)	(-2.20)	(-2.15)	(-2.02)	(-1.71)	(-1.52)	(-1.25)	(-0.99)
Obs.	162	162	162	162	162	162	162	162	162	162	162

Panel B

	location	scale	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
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<i>INT</i>	0.49***	0.02	0.45**	0.46***	0.47***	0.48***	0.49***	0.50***	0.51***	0.52***	0.53***
	(3.94)	(0.35)	(2.32)	(2.76)	(3.24)	(3.64)	(4.05)	(4.25)	(4.26)	(4.16)	(3.92)
<i>INT</i> ²	-0.37***	-0.04	-0.30	-0.33*	-0.34**	-0.36***	-0.38***	-0.39***	-0.40***	-0.42***	-0.43***
	(-3.00)	(-0.59)	(-1.58)	(-1.95)	(-2.37)	(-2.72)	(-3.12)	(-3.34)	(-3.40)	(-3.37)	(-3.24)
<i>INSTI</i>	0.02***	0.00*	0.01***	0.01***	0.01***	0.02***	0.02***	0.02***	0.02***	0.02***	0.02***
	(7.75)	(1.70)	(3.98)	(4.94)	(6.03)	(6.95)	(7.99)	(8.61)	(8.84)	(8.80)	(8.47)
<i>MARC</i>	0.28***	-0.03	0.33***	0.32***	0.30***	0.29***	0.28***	0.27***	0.26***	0.25***	0.24***
	(7.52)	(-1.38)	(5.65)	(6.24)	(6.83)	(7.24)	(7.52)	(7.44)	(7.19)	(6.69)	(5.94)
<i>GDP</i>	1.12***	0.01	1.11***	1.12***	1.12***	1.12***	1.12***	1.13***	1.13***	1.13***	1.13***
	(9.81)	(0.08)	(6.26)	(7.25)	(8.33)	(9.20)	(10.04)	(10.34)	(10.26)	(9.88)	(9.18)
<i>GEXP</i>	1.43***	0.19	1.11***	1.21***	1.30***	1.37***	1.46***	1.53***	1.59***	1.64***	1.72***
	(5.66)	(1.38)	(2.82)	(3.54)	(4.37)	(5.07)	(5.87)	(6.35)	(6.53)	(6.52)	(6.30)
<i>INFLA</i>	-0.02	0.05	-0.11	-0.08	-0.06	-0.04	-0.02	0.00	0.02	0.03	0.05
	(-0.19)	(0.74)	(-0.56)	(-0.49)	(-0.40)	(-0.29)	(-0.13)	(0.03)	(0.14)	(0.26)	(0.38)
<i>GFC</i>	0.00	0.03**	-0.04	-0.03	-0.02	-0.01	0.01	0.02	0.02	0.03	0.04**
	(0.12)	(2.47)	(-1.39)	(-1.09)	(-0.69)	(-0.28)	(0.32)	(0.87)	(1.26)	(1.63)	(1.97)
<i>COVID</i>	-0.02	0.02	-0.05	-0.04	-0.03	-0.03	-0.02	-0.01	-0.01	-0.01	0.00
	(-1.11)	(1.39)	(-1.53)	(-1.48)	(-1.39)	(-1.25)	(-1.01)	(-0.73)	(-0.51)	(-0.26)	(0.02)
Intercept	-0.16***	0.01	-0.17**	-0.17**	-0.17***	-0.16***	-0.16***	-0.16***	-0.16***	-0.15***	-0.15**
	(-2.94)	(0.25)	(-2.03)	(-2.30)	(-2.58)	(-2.80)	(-2.98)	(-3.01)	(-2.94)	(-2.79)	(-2.54)
Obs.	169	169	169	169	169	169	169	169	169	169	169

Notes. This table presents the effects of digital trade, such as services export (*ICTSE*) in Panel A and internet penetration(*INT*) in Panel B, on financial development using MMQR. Columns Q1 to Q9 show the results for the 10% to 90% quantiles. *Location* refers to central tendency estimates derived via least squares, while *Scale* indicates variability measures based on the spread of the dependent variable. The dependent variable is financial development index in both Panel A and Panel B. *ICTSE* is measured as the ratio of the ICT service exports to service exports. *INT* is the proxy for internet penetration, measured as the ratio of the number of Internet users to the population. The control variables are *INSTI*, *MARC*, *GDP*, *GEXP*, *INFLA*, *GFC*, and *COVID*. *Obs.* is the number of country-year observations. R^2 is the within R-squared value. *F*-test represents the The numbers in parentheses are *t*-statistics. Statistical significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *, respectively.

4.2 Robustness check

We identify the effects of digital trade on financial development using the GMM model as a robustness check. The potential endogeneity of digital trade arises because both digital trade and financial development are shaped within a broader institutional framework in European transition economies. It uses lagged values of the dependent variable as instruments, effectively handling cases where the dependent and independent variables may influence each other. GMM reduces the

issue of omitted variable bias by employing instrumental variables that are correlated with the independent variable but uncorrelated with the omitted variables, enhancing the precision and reliability of the estimation results. Table 5 shows the effect of digital trade, including ICT services exports (*ICTSE*) and Internet penetration (*INT*), on financial development (*FD*), financial institutions (*FI*), and financial markets (*FM*). *ICTSE* and *INT* have a positive effect, while their squared terms have a negative effect, indicating an inverted U-shaped effect of digital trade on financial development index and financial institutions index. Consistent with the findings of main results, we find the quadratic effect of digital trade on financial development.

Table 5. Impacts of digital trade on financial development: GMM model

	FD		FI		FM	
	(1)	(2)	(3)	(4)	(5)	(6)
<i>ICTSE</i>	0.27***		0.32***		0.06	
	(3.64)		(5.60)		(0.25)	
<i>ICTSE</i> ²	-0.14***		-0.11***		-0.04	
	(-3.45)		(-3.71)		(-0.36)	
<i>INT</i>		0.60***		1.17***		-0.37*
		(3.61)		(5.87)		(-1.83)
<i>INT</i> ²		-0.49***		-0.94***		0.27
		(-2.66)		(-4.40)		(1.16)
<i>INSTI</i>	0.02***	0.02***	0.02**	0.01*	0.03**	0.03***
	(3.08)	(2.94)	(2.04)	(1.80)	(2.30)	(3.73)
<i>MARC</i>	0.20***	0.17***	0.10**	0.05	0.31***	0.32***
	(5.88)	(8.69)	(1.93)	(0.79)	(3.98)	(4.37)
<i>GDP</i>	1.51***	1.40***	1.36***	0.82*	2.34***	2.53***
	(3.88)	(4.29)	(2.65)	(1.80)	(3.18)	(5.07)
<i>GEXP</i>	0.76	0.59***	1.36***	0.66***	0.00	0.76***
	(3.36)	(3.57)	(5.66)	(2.59)	(0.00)	(5.28)
<i>INFLA</i>	0.19	-0.03	-0.26	-0.17	1.11***	0.56*
	(0.80)	(-0.17)	(-0.72)	(-1.44)	(3.03)	(1.69)
<i>GFC</i>	0.02**	0.02***	0.05***	0.03***	0.01	0.02
	(2.57)	(2.99)	(3.60)	(3.05)	(0.41)	(1.25)
<i>COVID</i>	0.05	-0.01	-0.03	0.00	-0.01	-0.05
	(1.06)	(-0.70)	(-0.96)	(0.01)	(-0.18)	(-1.26)
Obs.	162	169	162	169	162	169
AR(1)	-0.62	-1.86*	-1.65*	-1.86*	-1.74*	-2.32**
AR(2)	1.66*	-0.56	0.74	1.01	0.64	0.70
Hansen test	6.85	4.63	4.11	3.53	4.38	4.88

Notes. This table presents the effects of digital trade, such as services export (*ICTSE*) and internet penetration (*INT*), on financial development using GMM. The dependent variable is financial development index in all models. *ICTSE* is measured as the ratio of the ICT service exports to service exports. *INT* is the proxy for internet penetration, measured as the ratio of the number of Internet users to the population. The control variables are *INSTI*, *MARC*, *GDP*, *GEXP*, *INFLA*, *GFC*, and *COVID*. *Obs.* is the number of country-year observations. *AR(1)* and *AR(2)* represent results from the AR(1) and AR(2) tests, indicating *P*-values. *Hansen* represents the Hansen *J*-statistic. The numbers in parentheses are *t*-statistics. Statistical significance at the 1%, 5%, and 10% levels is indicated by ***, **, and *, respectively.

In summary, using FE, MMQR, and GMM methods, we reveal the nonlinear impacts of digital trade on financial development in transition economies. Our findings demonstrate a significant quadratic relationship between digital trade and financial development, with digital trade fostering financial growth in its early stages but exhibiting diminishing and potentially negative effects as it intensifies. Transition economies remain significantly below the peak levels of digital trade required to maximize financial development, with current ICT services exports, ICT goods exports, and ICT goods imports falling short of the estimated peak points of 28%, 16%, and 13%, respectively. This highlights the substantial untapped potential of digital trade as a driver of financial development in these economies.

5. Conclusion

This study examines the critical relationship between digital trade and financial development across 19 European transition economies from 2002 to 2021. By analyzing various dimensions of digital trade, including ICT service exports, ICT goods exports, ICT goods imports and internet penetration, the study provides a comprehensive understanding of how digital trade contributes to the growth of financial markets and institutions. Our findings reveal a non-linear relationship between digital trade and financial development, characterized by an inverted U-shape. At lower levels, digital trade positively impacts financial development by enhancing market accessibility, reducing transaction costs, and fostering broader participation in financial systems. ICT service exports, in particular, play a pivotal role in attracting foreign investment, enabling technological advancements, and increasing financial efficiency. These results highlight the transformative potential of digital trade in improving financial infrastructure and expanding access to financial services in underdeveloped economies. However, the benefits of digital trade diminish and can even turn detrimental as it surpasses certain thresholds. The growing reliance on foreign capital, heightened exposure to exchange rate fluctuations, and increased financial vulnerabilities associated with rapid digital trade expansion emerge as significant risks. These findings emphasize the importance of fostering a balanced approach to digital trade growth to avoid overdependence on external financing and ensure long-term financial stability.

The study underscores the pressing need to strengthen financial markets in transition economies, as these remain critically underdeveloped. The disparity between financial institutions, which exhibit moderate development, and financial markets, which often hover near zero, points

to systemic barriers that limit the impact of digital trade on financial market growth. Addressing these structural challenges requires a dual strategy: Governments must prioritize the establishment and maturation of stock and bond markets to diversify financing options and reduce reliance on bank-centered systems. Capital markets are essential for fostering financial resilience and enabling economies to fully leverage the benefits of digital trade. Robust legal and institutional structures are crucial for maintaining market stability and reliability. Strengthening supervisory institutions and creating an investor-friendly environment can mitigate the risks associated with increased foreign capital reliance. Policymakers should also focus on supporting ICT exports and internet-based trade platforms to enhance the efficiency, accessibility, and depth of financial systems. Encouraging technology-driven financial solutions, such as fintech innovations and electronic payment systems, can further accelerate financial development in transition economies.

By identifying the peak points of digital trade that maximize financial development, this study offers practical insights for policymakers to calibrate digital trade strategies. Expanding ICT service exports, digital goods trade, and internet penetration to their optimal levels can significantly enhance financial markets and institutions, fostering broader economic growth. Ultimately, this study contributes to the growing literature on the intersection of digital trade and financial development by highlighting the opportunities and challenges in transition economies. It provides actionable recommendations for policymakers aiming to harness the transformative potential of digital trade while addressing its inherent risks, paving the way for sustainable financial and economic progress.

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