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From Globalization to Innovation: Investigating the impact of R&D, Internet Penetration, and Economic Factors on Digitalization in BRICS

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Abstract
Digitalization has become a pivotal force shaping global trade and economic development, particularly across emerging economies. BRICS nations demonstrate diverse trajectories of digital expansion that reflect varying degrees of globalization, technological adoption, and policy frameworks. This study examines how different dimensions of globalization (economic, social, and political), along with internet penetration, R&D investment, GDP growth, and exchange rate movements, collectively influence digitalization in the BRICS economies. Employing panel data from 2000 to 2022, the analysis uses multiple econometric techniques, panel regression (fixed and random effects), robust least squares, fully modified OLS, dynamic OLS, and panel quantile regression, to capture both short-run and long-run dynamics, as well as distribution-specific impacts on ICT goods exports. Economic globalization, R&D expenditure, and GDP growth consistently show positive and significant effects on digitalization, broader internet penetration is especially critical at early stages. Social and political globalization produce nuanced outcomes depending on institutional and cultural contexts, while currency depreciation exerts a generally negative impact by making technology imports more expensive. The results underscore that BRICS policymakers should stabilize macroeconomic conditions, invest in R&D, expand internet access, and strategically engage with global markets to foster inclusive digital growth. Tailored governance measures and targeted capacity-building efforts are also vital for translating globalization benefits into sustainable digital transformation across these emerging economies.
Keywords: Globalization, Digitalization, Internet Penetration, R&D

1. Introduction

The accelerating pace of digitalization has become a critical global concern, especially in the aftermath of the COVID-19 pandemic. As digital technologies become increasingly entwined with public, private, and individual spheres, numerous stakeholders, from corporations and financial institutions to government agencies have intensified their focus on how this phenomenon reshapes broader economic and societal structures. Public interest further underscores this trend, online queries containing “digit” or “digitalization” have remained high for several years, highlighting widespread curiosity about the role of digital tools in everyday life. Yet, despite this growing attention, the term “digitalization” often lacks a unified definition, and interpretations vary across disciplines (Gong & Ribiere, 2021; Gradillas & Thomas, 2025). What is undeniable, however, is the ubiquitous presence of digital devices smartphones, computers, smartwatches that underpin modern lifestyles. From a historical standpoint, while it took the telephone seventy-five years to reach one hundred million users, the internet achieved the same milestone in just seven years (Tarnoff, 2022; Matt et al., 2023). Enhanced interconnectivity has spurred immense structural shifts, real-time communication, digital commerce, and internet-based services are now integral to how societies function. There is growing acknowledgment that digitalization not only advances economic growth but also fosters societal change, particularly by improving access to services.

Globalization comprises several dimensions (economic, political and social globalization) that jointly govern and shape digital trade (Jawad et al., 2021). Economic globalization, by way of liberalizing trade policies and making capital markets fluid, pours digital sales into the stream through the lowering of tariffs and other cross-country advances in technological investment. Multinational

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corporations center their attention on emerging markets through both the provision of capital and technical expertise that add fuel to the fire of digital evolution (Rajan, 2003; Karhan, 2019; Zekos & Zekos, 2021). In addition, political globalization-in terms of policy coordination and international cooperation-cultivates rather stable conditions under which cross-border digital transactions occur. Harmonized rules such as the unified standards for protection of data are bound to eliminate red tape and lower uncertainties for businesses (Ougaard, 2004; Ilyin, I., & Leonova, 2022; van Zanden, 2023; Hun et al., 2024). Social globalization, on the other hand, intensifies these channels through the facilitation of cultural and informational exchanges that spur widespread adoption of digital solutions (Abbas & Shamim, 2023). The sharing of ideas, lifestyles, and consumer preferences boosts the demand for new digital services. Platforms facilitating the interaction of consumers worldwide can connect even the smallest firms directly with the customer, thereby reducing their marketing expenditures while at the same time expanding their international reach (Stallkamp & Schotter, 2021; Yang & Ron, 2022; Singh et al., 2023). Confluence of these three categories, economic, political, and social, tends to diminish friction in the digitized markets, thereby hastening the trade flow in the digital sense. European Union integration, for instance, has demonstrated how unified policies enhance e-commerce. Likewise, nations deeply engaged in international networks through proactive participation in global bodies, stable diplomatic connections, or liberalized trade regimes create fertile ground for digital sector growth. Simultaneously, digitalization reinforces globalization by boosting the speed and reducing the cost of cross-border communication.

In recent decades, greater global integration has intensified the diffusion of technology and knowledge to developing countries, enabling nations like the BRICS to leverage imported innovations for growth. The BRICS economies now account for a substantial share of global output, with their collective GDP share rising from 18% in 2010 to 26% in 2021 alongside 42% of the world's population (Chatterjee & Naka, 2022). Harnessing digitalization has become a strategic priority for these countries to sustain economic momentum and enhance competitiveness in the information age (Bocean, 2025; Abbas & Uddin, 2025). Figure 1 depicts a clear upward trend in ICT goods exports among the BRICS nations over the last decade. This shift toward more technology intensive exports underscores a strengthening technological base, propelled by strategic policy interventions, trade reforms, and growing foreign investment. Concurrently, technological innovations ranging from global digital platforms to sophisticated data driven services are redefining business processes worldwide, and BRICS countries are no exception. As Khan et al., (2024) predict, advancements in digital solutions could contribute an estimated $15.7 trillion to the global economy by 2030. Beyond economic impacts, digitalization influences industrial and societal realms, prompting transformations in production, consumption, and labor practices (Yener, 2021; Grybauskas et al., 2022; Hernandez, 2024).

Given this context, it is crucial to understand the key factors that enable or hinder digitalization in BRICS nations. Among the critical determinants highlighted in prior studies are a country's research and development (R&D) capacity, the extent of internet penetration, and its broader economic conditions. R&D investment fuels innovation and technological progress, providing the foundation for digital industry growth (Karhan, 2019; Bibi, 2019; Dai et al., 2022; Salleh & Sapengin, 2023; Reich & Reich, 2025). As illustrated in Figure 2, BRICS nations exhibit a sustained increase in R&D expenditures. China exemplifies this linkage, it has rapidly increased its share of global R&D expenditure from just 4% in 2000 to about 26% in 2023, a meteoric rise that underscores its emergence as a global innovation leader. Other BRICS members have also boosted R&D efforts, although at more modest levels, i.e., Brazil's R&D spending remains around 1.15% of GDP, well behind China and the leading advanced economies. Equally important is internet infrastructure. The widening online user base, shown in Figure 3, reflects how surging internet penetration in BRICS, and this widespread internet access is a prerequisite for digital services and commerce, and better connectivity clearly associates to greater economic participation and productivity gains.

Beyond their national boundaries, BRICS countries collectively account for roughly 30% of the world's land area and about 54% of its population. Their size, rapid economic advancements, and increasing digital capacity point to a pivotal role in shaping the global digital economy (Aki,, 2020; Belli et al., 2024). World Bank (2023) indicate that while nearly half the global population now has internet access, around 3.8 billion people remain offline, many residing in emerging and developing

economies. In particular, improving digital networks across BRICS can bolster solutions to pressing challenges, from environmental sustainability and energy conservation to water scarcity and food security (Matli & Malatji, 2024). Previous research in both the United States and Europe indicates that higher levels of investment in ICT encourage greater economic growth (Colecchia & Schreyer, 2002; Fernandez-Portillo et al., 2020; Can, 2021; Maciulyte-Sniukiene, & Butkus, 2022). These investments can have strong multiplier effects when put in priority areas for faster-growing economies such as BRICS. In spite of extensive debates on globalization and digitization, very few studies have sought to understand the combined impacts of R&D spending, internet penetration, and other broader economic factors in the BRICS context. Each country in this bloc has potential to become a major economy by the year 2050, but this aspiration will depend heavily on research and innovation, alongside a greater emphasis on the economic cooperation of science and technology and adoption of new digital solutions. Our study, drawing from perspectives of international trade, innovation policy, and development economics, provides a very wide overview of the determinants and bottlenecks for digitalization in these dynamic markets. The findings will enrich academic discourse while guiding policymakers and industry stakeholders toward actionable strategies that promote inclusive and sustainable digital growth across the BRICS economies.

Figure 1: ICT goods exports in BRICS

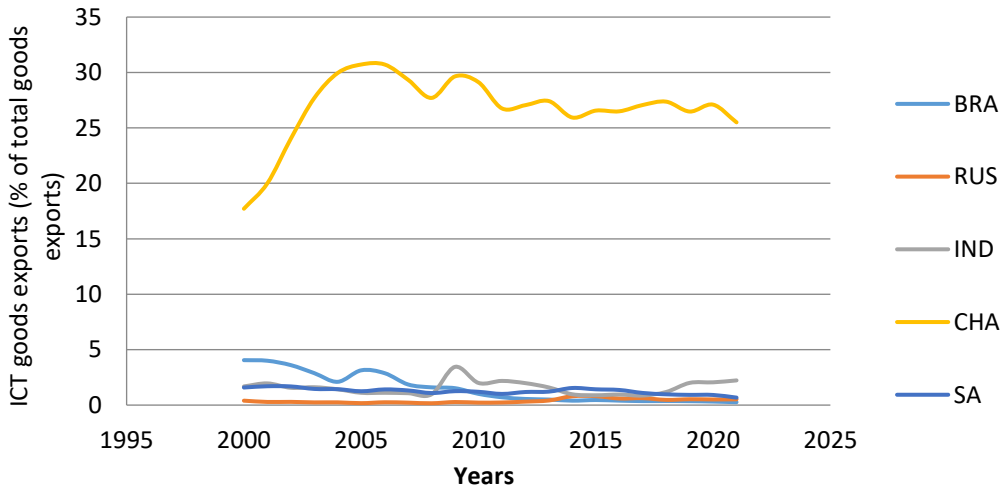


Figure 2: R&D Expenditures in BRICS

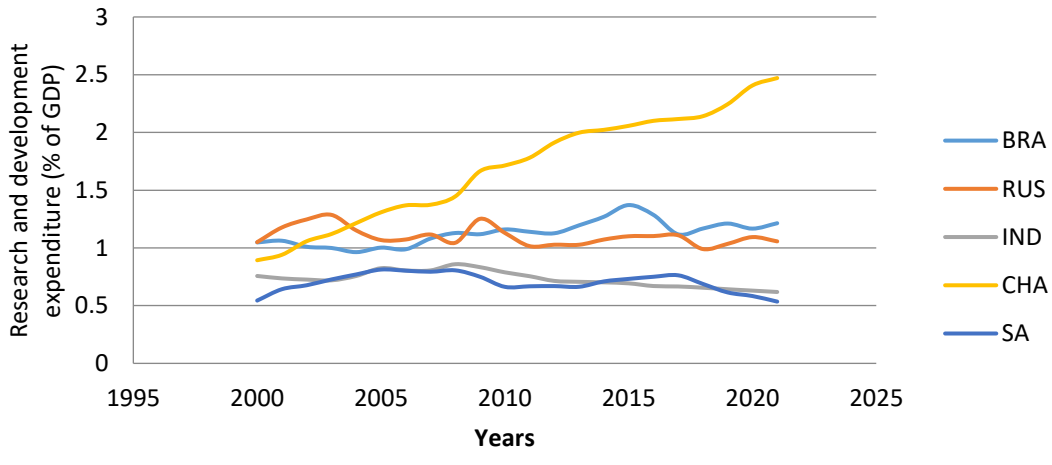
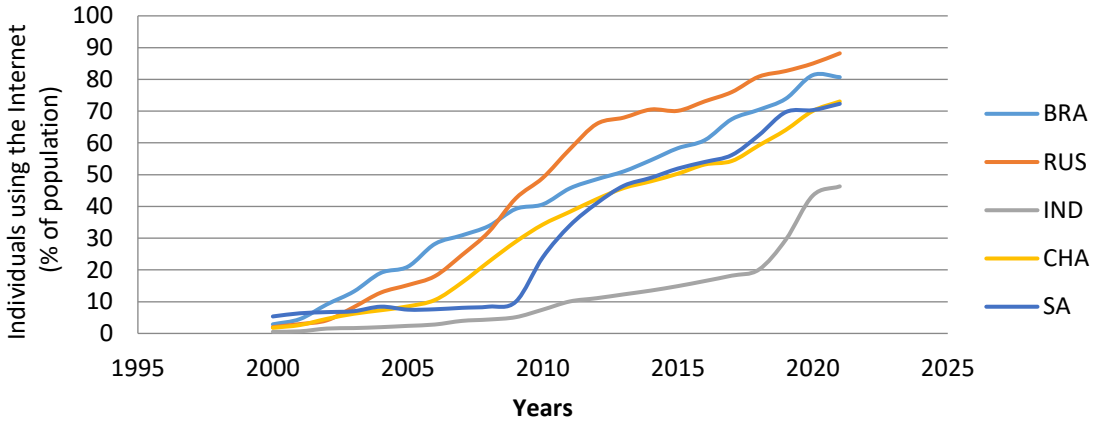


Figure 3: Internet Users In BRICS



2. Literature Review

Literature on digitalization highlights a spectrum of perspectives on how to define and implement this concept. On one end, digital transformation can be viewed as the straightforward digitization of information and processes, migrating traditionally analog content into digital formats (e.g., scanning paper documents) (Neugebauer, 2019; Vrana & Singh, 2025). This, however, captures only a fraction of the broader impact that digitalization can exert on economies and societies. At a more advanced level, digitalization involves applying cutting-edge digital technologies, such as blockchain, big data analytics, or artificial intelligence, to previously analog or partially digitized domains, including finance, health care, and education (Owusu & Novignon, 2021; Krajnık & Foszto, 2023; Khang et al., 2024). This process underscores the continuously evolving nature of digital transformation, as organizations and societies integrate new tools that enhance efficiency, transparency, and global connectivity. Yet, some scholars argue that digitalization should also be understood through the lens of "destabilizing structures," wherein incumbent processes and socioeconomic systems, traditionally reliant on non-digital tools, face disruption from technology-driven solutions (Autio et al., 2021; Tila & Cera, 2021; Tarnoff, 2022; Matt et al., 2023; Gradillas & Thomas, 2025). By adopting this viewpoint, the transformative capacity of digitalization becomes evident, it is not merely a technical or procedural upgrade but a catalyst for reconfiguring how industries, governments, and individuals operate. As new business models and innovative strategies emerge, enabled by data-driven processes, automated decision-making, and improved communication platforms, previously entrenched value chains must adapt or risk obsolescence (William, 2021; Grover et al., 2022).

Synthesizing these diverse perspectives, one can define digitalization as a dynamic, ongoing process wherein the adoption of digital technologies drives the transformation of existing socio-technical systems, creating new or reshaping existing value systems that affect all members of society, individuals, organizations, businesses, and the public sector. In so doing, digitalization expands beyond the mere digitization of data to encompass holistic social and economic change, ultimately reorienting how information flows and value is generated. Individuals and organizations alike become more interconnected and reliant on digital platforms for communication, transaction, innovation, and collaboration (Snow et al., 2017; Hinings et al., 2018; Zhang & Wu, 2020; Aksoy, 2023; Jamel & Zhang, 2024). When linked to the broader framework of international trade, digitalization accelerates cross-border exchanges of knowledge, goods, and services. Its capacity to reduce transaction costs and streamline operations empowers both large and small firms to enter and compete in global markets. As a result, nations that effectively harness digitalization, supported by robust research and development investments, high internet penetration, and progressive policies tend to foster environments conducive to innovation and sustained economic growth (Karhan, 2019; Feng & Qi, 2024). By situating digitalization at the heart of global value creation, policymakers and business leaders can better anticipate and leverage the wave of technological disruption, ensuring that it benefits not just firms at the frontier of innovation but also the broader society. The expanding scope of digitalization challenges conventional analytical frameworks, calling for an interdisciplinary

approach that acknowledges both its technological underpinnings and its sweeping socioeconomic ramifications (Kumar & Gupta, 2023; Yeasmin, 2024; Challoumis, 2025). Understanding the multifaceted nature of digitalization, as delineated in the literature, is therefore crucial for any comprehensive study of global economic integration and development.

Globalization continues to play a crucial role in advancing sustainable growth and development by promoting free trade, the exchange of ideas, and the dissemination of new technologies on a global scale (Ashford & Hall, 2011; Audi et al., 2021). Despite the importance acknowledged in reference to globalization processes and digital trade in modern economies, specialized research on these two areas has been relatively limited. Most of these studies research the influence of information and communications technology on performance generally in the economy. For instance, Bello et al. (2021) examine relationship between ICT and patterns of growth in Sub-Saharan Africa, the study find that ICT had a negative and statistically insignificant effect on the economy's growth performance for the period studied. Ukwuoma (2019), however, found that during the analysis period of 2008-2018, ICT positively impacted economic growth in Nigeria. Although these two studies have different years covered and approaches to methodology, it is evident that their findings are contradictory, hence in such instance, highlighting the continuous challenge of separating and measuring the effect of ICT on economic performance, especially in developing nations where the ICT infrastructure, policy environment, and market conditions can widely differ.

Numerous studies have explored the relationship between technology adoption and trade openness across emerging economies at the level of the firm. For instance, Popkova et al., (2023) notes that FDI is a significant driver of technological innovation and adoption. A few researchers believe globalization along with domestic restrictions could hinder technological adoption, particularly in contemporary digital commerce within the developing countries (Dahlman, 2007; Skare & Soriano, 2021; Audi et al., 2022). According to Ciuriak and Ptashkina (2021), if traditional distribution channels are digitalized, it will foster trade flow. In the case of traditional methods of doing business, such digital innovations are creating more financial transactions and economic growth opportunities, particularly to developing countries, where they can do so by providing new job avenues and improving the competitive structure in the global market. Popkova (2025) stated that the digital transformation could help greatly in trading volume and market presence for SMEs, provided the government offers regulatory support, adequate financial resources, a framework for cybersecurity, and investment in infrastructure. The authorities thus supported comprehensive digital advancement initiatives for empowering SMEs in turn towards the growth of the global economy. Further, the effects of trade liberalization on technology acceptance by small and medium enterprises are much instrumental and the lack of domestic preparedness alongside globalization can hinder the adoption of modern digital trade technology in developing nations.

Hossain (2025) similarly examined the way digital transformation affects trade structures, pinpointing the necessity of a sound digital infrastructure for the sustainable growth of trade in Asian countries. The digital infrastructure is not only bringing improvements toward online user engagement and security of financial transactions but also required for any substantive development. Liang et al., (2025) have more recently examined the impact of digital technology on the quality of exports from China. Their results indicated that technological advancement positively affected export quality, particularly through digital knowledge dissemination and industrial upgrading in China's eastern provinces. Moreover, enhanced digital infrastructure facilitated innovation and international competitiveness, although regional disparities persisted.

Despite the valuable insights offered by previous research on technology adoption, ICT infrastructure, and digital transformation within emerging economies, the literature often focuses on single-country or examines high-income contexts more broadly (Karhan, 2019; Fernandez-Portillo et al., 2020; Gong & Ribiere, 2021; Tarnoff, 2022; Dai et al., 2022; Maciulyte-Sniukiene, & Butkus, 2022; Matt et al., 2023; Gradillas & Thomas, 2025; Liang et al., 2025), thereby overlooking how globalization, R&D investment, and internet penetration jointly shape digitalization in the BRICS nations. While some studies emphasize the need for robust telecommunications infrastructure and faster internet to drive digital commerce, few integrate the multidimensional role of globalization, manifested through economic openness and technology diffusion, alongside R&D expenditure and connectivity within emerging markets. This omission leaves a significant gap in understanding the

interplay between these factors, especially given the heterogeneity of the BRICS economies, where policy, institutional quality, and market conditions vary substantially. In fact, without placing research and development as well as internet penetration into a wider framework of globalization and macroeconomic forces, existing works will not give a complete picture of the underlying intricacies involved in the processes of digitization in all these emerging economies.

3. Theoretical links and Model

Digitalization had become a principal facet in business environments across the globe, affecting the ways in which goods, services, and information cross borders (Teece, 2025). It lessens transaction and coordination costs (Drori et al., 2025) while widening the market reach by allowing more information access, thereby giving smaller firms the bandwidth to compete internationally (Dallocchio et al., 2024; Abbas & Uddin, 2025). The digital technology adoption pathways differ from one BRICS member to another. A highly targeted policy environment combined with heavy investment into infrastructure has seen China emerge as the world leader in e-commerce and mobile payment (Banalieva and Dhanaraj, 2019), while India's burgeoning Internet and smartphone penetration is fast-tracking digital entrepreneurship. For Russia, Brazil, and South Africa, technology sector enhancement has become a process dependent on policy revamping and investment to nurture digital initiatives. In this context, it becomes imperative to analyze just how economic, political, and social globalization, along with internet penetration, GDP growth, R&D expenditure, and exchange rates, jointly affect BRICS' digitalization trajectories.

Globalization and the digital revolution have fundamentally transformed pathways of economic development for emerging economies (Jawad et al., 2021; Zekos & Zekos, 2021; Abbas & Shamim, 2023). The extent of internet penetration significantly influences a nation’s digital landscape. Greater connectivity fosters e-commerce platforms, digital banking systems, and broader online ventures (Otarinia, 2024). As more users come online, they stimulate both supply and demand for digital offerings, fueling expansions in telework, fintech, and cloud services (Wei et al., 2025). These innovations integrate into the broader economy, reinforcing each other’s growth and catalyzing higher ICT exports. In many emerging economies, enhancing internet penetration has encouraged entrepreneurs to explore untapped markets and develop cost-effective digital solutions, resulting in sustainable local start-up ecosystems. In parallel, GDP growth is pivotal for signaling macroeconomic stability and enlarging domestic markets, factors that boost investment in technology-driven exports (Bakari, 2024). Rapidly growing nations often allocate higher budgets to telecommunications networks and digital training programs, essential ingredients for expanding digital trade. R&D costs reinforce such progress further (Eklund, 2022). The endogenous growth theory (Romer, 1994) states that continuous investment in R&D fosters the creation of new goods, services, and processes, thus endowing countries with a competitive edge in digital trade across the globe. By concentrating on advanced fields like AI, advanced encryption, and big data, economies embed technological sophistication into their exports, turning our international competitiveness stronger. And these developments are consistent with diffusion of innovations theory (Rogers & Singhal, 2003; Minishi-Majanja & Kiplang'at, 2003), which posits that the rate at which new technologies are adopted depends on supportive physical and institutional infrastructures. For instance, in the digital context, these infrastructures include stable internet systems, flexible payment gateways, and well-defined legal protections for online transactions, all of which remove barriers for potential adopters. As internet availability increases, people experiment with unfamiliar digital tools and integrate them into everyday life, fueling broader innovation across industries. Institutions also shape adoption by guiding how global networks intersect with domestic markets. Following endogenous growth theory and diffusion of innovations theory, the functional form of our model become as:

$DTR_{it} = f(Eg_{it}, Pg_{it}, Sg_{it}, NU_{it}, GDPg_{it}, RED_{it,} EXC_{it})$

where t signifies the 2000–2022 period and i represents the five BRICS nations.

Table 1: Measurement of Variables and Data Sources

Variables	Definition	Sources
DTR	Digitalization, ICT goods exports (% of total goods exports)	World Development Indicators

GDPg	GDP growth rate	World Development Indicators
EXC	Official exchange rate (LCU per US$, period average)	World Development Indicators
NU	Individuals using the Internet (% of population)	World Development Indicators
RED	Research and development expenditure (% of GDP)	World Development Indicators
Eg	Economic globalization Index	KOF Swiss Economic Institute
Pg	Political globalization Index	KOF Swiss Economic Institute
Sg	Social globalization Index	KOF Swiss Economic Institute

3.1.Econometric Methodologies

Using econometric methodology has become integral to applied economics and other management sciences. In this study, various unit root tests, e.g., Levin, Lin, and Chu test (LLC) (2002), Im, Pesaran, and Shin (IPS) (2003), Breitung (2002), Maddala and Wu (1999) have been employed to assess the stationarity of the variables. A variety of methods have been used to evaluate the influence of regressors on the regressed, including Ordinary Least Squares (OLS), panel robust least squares, fixed effects, random effects, Fully Modified OLS (FMOLS), and Dynamic OLS (DOLS). Panel OLS random effects, and fixed effects models have provided valuable insights into the association between digitalization and selected explanatory variables, whereas panel robust least square, fully modified OLS and dynamic OLS models have been used to investigate the long-run cointegration coefficients for an in-depth examination of coefficient stability. Coefficient stability measures how much a test score varies because of factors like the time and occasion of the test, it can also refer to the stability of a regression coefficient. These coefficients are residual-based or error corrections for heterogeneous data sets.

To address the drawbacks of traditional regression methods, a panel quantile regression model is employed. Due to its focus on mean outcomes, this technique reveals some key relationships that may otherwise go unnoticed by conventional regression. According to Binder and Coad (2011), conventional regression is limited in value and does not satisfactorily explain the relationship between carbon dioxide emissions and other explanatory factors. Panel quantile regression, which builds on Koenker and Bassett (1978), provides a theoretical foundation as coefficients are defined as the partial derivative of the conditional quantile of the dependent variable with respect to specified regressors. According to Yasar et al. (2006), the coefficients represent the effect of marginal change in an explanatory variable upon the dependent variable at the q-th conditional quantile.

In this study, coefficients are estimated at nine quantiles of CO2 emissions via models q10, q20, q30, q40, q50, q60, q70, q80, and q90. Models q10 and q20 assess how each dimension of globalization affects low CO2 emitters, the 50th percentile model (q50) examines medium CO2 emitters, and the 90th percentile model (q90) focuses on high CO2 emitters. The generalized median regression approach can also be applied to other quantiles, as shown below:

$$Q_{yi}(\tau \mid x_i) = x^{T}_{i}\,\beta\tau \qquad (7)$$

A panel quantile regression analyzes how independent variables affect distinct parts of the dependent variable's distribution (not just the mean), while controlling for overlooked individual characteristics by leveraging panel data. This regression also allows for identifying heterogeneous effects across various quantiles. Applying quantile regression is particularly advantageous when heavy distributions are present in the data. Nonetheless, unobserved heterogeneity within a country may not be accounted for using this method. To address this limitation, panel quantile fixed effects were utilized in the current study to examine both conditional and unobserved individual heterogeneity. Prior literature, including Lamarche (2010), Galvao (2011), and Koenker (2004), applied quantile regression for panel data consistent with econometric theory. The fixed-effect panel quantile regression model adopted here is given by:

$$Q_{yi}(\tau_k \mid \alpha_i x_{it}) = \alpha_i + x'_{it}(\tau_k) \qquad (8)$$

When employing panel quantile regression with fixed effects, the incidental parameters problem may arise. This can occur if the number of fixed effects is relatively large compared to observations per cross-section, leading to possible inconsistency as cross-sections expand (Lancaster, 2000;

Neyman & Scott, 1948). Fixed effects help remove unobserved influences, but linearity of expectations may be ill-suited to conditional quantiles (Canay, 2011). Koenker (2004) proposed a procedure that jointly estimates unobservable fixed effects and covariates' impacts across different quantiles, deploying a penalty term to reduce computational complexity during parameter estimation, computable as follows:

$$\min_{(\alpha,\beta)} \sum_{(k=1)}^{K} \sum_{(t=1)}^{T} \sum_{(i=1)}^{N} W_i \, P\tau_k(y_{it} - \alpha_t - x_{it}^T\beta(\tau_k)) + \lambda\sum_i^N|\alpha_t| \quad (9)$$

The equation above represents the fixed-effect panel quantile regression, where i denotes countries (N), T is the number of observations per country, k is the quantile index, and x denotes the matrix of explanatory variables. The quantile loss function is symbolized by $P\tau_k$, and W_k is the weight for the kth quantile in regulating fixed effect estimation. This research adopts equally weighted quantiles, where $W_k = 1/K$, as proposed by Alexander et al. (2011). The tuning parameter λ is employed to refine β and drive individual effects to zero. As λ approaches zero, the penalty term disappears, and the usual fixed effect estimator appears. By contrast, as λ goes to infinity, the model is estimated without individual effects. In this study, λ is set to 1 (Damette & Delacote, 2012). The quantile function for τ of the variables under scrutiny is specified as:

$$DTR_{it}(\tau|\alpha_i,\xi_t,x_{it}) = \alpha_i+\xi_t+\beta_1\tau Eg_{it}+\beta_2\tau Pg_{it}+\beta_3\tau Sg_{it}+\beta_4\tau NU_{it}+\beta_5\tau GDPg_{it}+\beta_6\tau RED_{it}+\beta_7\tau EXC_{it}+\varepsilon t \quad (10)$$

All indicators have been described above, except ε, which denotes the white noise error term.

4. Empirical Results and Discussion

This part of the study provides empirical findings, in our study examining digitalization growth in BRICS nations. The estimate descriptive statistics have been given in table 2, descriptive statistics provide statistical properties, including central tendencies, variability, and distribution shapes, explain the underlying characteristics of the variables analyzed in this study. This study examines digital trade growth in BRICS nations by analyzing key variables and their statistical properties. The digitalization averages 6.317 but has a median of 1.282, indicating a highly skewed distribution (standard deviation of 10.42, skewness of 1.535) and confirmed by the Jarque-Bera test (44.17). Among the globalization indicators, economic globalization shows a mean of 46.467 with moderate dispersion (standard deviation 7.314) and a slight left skew (skewness −0.761). Social globalization (mean 51.841, standard deviation 12.07) also leans left (skewness −0.484). Political globalization (mean 37.921, standard deviation 13.691) is nearly symmetric (skewness 0.145) but exhibits noticeable variability. The exchange rate (local currency per USD) has a mean of 23.172 and ranges broadly from 1.672 to 74.099, with a positive skew (0.913) indicating a few high values. GDP growth averages 4.578 (range −7.794 to 14.230), with moderate variability (standard deviation 3.957) and a slight negative skew (−0.548). Internet usage spans from 0.5272 to 88.213, averaging 33.477 (standard deviation 26.662), reflecting significant differences in digital connectivity. Lastly, research and development spending (mean 1.0711, standard deviation 0.427) is positively skewed (1.436), suggesting most observations cluster at lower values, with a few outliers raising the average.

Table 2: Descriptive Statistic

	DTR	EG	SG	PG	EXC	GDPG	NU	RED
Mean	6.317	46.467	51.841	37.921	23.172	4.578	33.477	1.0711
Median	1.282	45.717	51.659	36.013	8.541	4.868	29.211	1.0314
Maximum	30.76	58.691	72.142	64.531	74.099	14.230	88.213	2.470
Minimum	0.167	22.242	23.210	13.005	1.672	-7.794	0.5272	0.535
Std. Dev.	10.42	7.314	12.070	13.691	22.86	3.957	26.662	0.427
Skewness	1.535	-0.761	-0.484	0.145	0.913	-0.548	0.377	1.436
Kurtosis	3.461	4.339	2.665	2.160	2.405	3.607	1.748	4.748
Jarque-Bera	44.17	18.85	4.823	3.620	16.92	7.211	9.786	51.76
Probability	0.000	0.0081	0.089	0.163	0.021	0.027	0.074	0.060
Observations	110	110	110	110	110	110	110	110

The partial correlation analysis provides insight into the relationships among the eight key variables in the study, accounting for the influence of other factors. Digitalization shows a moderate positive correlation with gross domestic product growth rate (0.5327) and a strong positive association with research and development expenditure (0.7314). These results suggest that, after controlling for other variables, higher economic growth and increased investment in innovation are closely associated with a greater share of information and communication technology goods in total exports. Conversely, digitalization is negatively correlated with social globalization (–0.2556) and political globalization (–0.3842), indicating that greater levels of global social and political integration may correspond to reduced digital trade performance when other influences are accounted for. Economic globalization demonstrates strong positive correlations with both social globalization (0.6816) and political globalization (0.7556), highlighting the interconnected nature of these three globalization dimensions. Furthermore, the very high partial correlation between social and political globalization (0.9359) indicates that these two indices move in near-perfect alignment after adjusting for the effects of other variables. Social globalization shows virtually no relationship with the official exchange rate (0.0013), reflecting its independence from exchange rate movements. Political globalization, on the other hand, has a slight positive association with the exchange rate (0.0480), a moderate negative correlation with gross domestic product growth rate (–0.5429), and a strong positive association with internet usage (0.6843), suggesting that political openness is closely linked to digital connectivity. The official exchange rate is largely uncorrelated with both gross domestic product growth rate (–0.0180) and internet usage (–0.0092), while showing a moderate negative correlation with research and development expenditure (–0.3698). This implies that higher innovation spending is generally associated with lower exchange rate values when other variables are held constant. Gross domestic product growth rate itself exhibits a moderate negative relationship with internet usage (–0.4733) and a modest positive correlation with research and development expenditure (0.2301), reflecting the nuanced interactions between growth, innovation, and digital connectivity. Finally, the positive partial correlation between internet usage and research and development expenditure (0.3323) suggests that greater digital engagement is accompanied by increased investment in innovation-related activities.

Table 3: Partial Correlation Matrix

	DTR	EG	SG	PG	EXC	GDPG	NU	RED
DTR	1							
EG	0.1095	1						
SG	-0.2556	0.6816	1					
PG	-0.3842	0.7556	0.9359	1				
EXC	-0.3551	-0.1492	0.0013	0.0480	1			
GDPG	0.5327	-0.1966	-0.5208	-0.5429	-0.0180	1		
NU	-0.0218	0.3168	0.8263	0.6843	-0.0092	-0.4733	1	
RED	0.7314	-0.0531	0.1072	-0.0872	-0.3698	0.2301	0.3323	1

The panel unit root analysis for variables related to digital trade growth in BRICS nations reveals mixed results at level form, reflecting sensitivity to the choice of test. For the digitalization variable, the Levin–Lin–Chu (LLC) and Im–Pesaran–Shin (IPS) tests do not yield statistically significant results, while the Breitung and Fisher-based tests (ADF and PP) indicate significance. This explains that the stationarity of digitalization at level form is dependent on the specific test applied. A similar divergence appears in the case of economic globalization. While the LLC test statistic is insignificant, the IPS test is more negative and statistically significant. Both the Breitung and Fisher tests strongly reject the null hypothesis of a unit root, providing more consistent evidence of stationarity. Social and political globalization variables exhibit comparable behavior. Despite insignificant LLC results, the IPS, Breitung, and Fisher tests consistently reject the null, indicating stationarity under most

specifications. The official exchange rate also demonstrates this pattern. LLC and IPS tests at level are insignificant, whereas Breitung and Fisher tests provide significant results, suggesting potential stationarity in specific test frameworks. For the GDP growth rate and the percentage of individuals using the internet, the findings again vary. The GDP growth rate shows a significantly negative IPS statistic and strong evidence from Breitung and Fisher tests, implying stationarity in level form according to these methods. In contrast, research and development expenditure does not show significance in LLC and IPS tests, while Breitung and Fisher tests yield mixed outcomes. Upon transforming all variables to their first differences, the results become consistent. All tests—LLC, IPS, Breitung, Fisher ADF, and Fisher PP—uniformly reject the null hypothesis of a unit root. The highly significant test statistics across methods confirm that all variables become stationary after first differencing, indicating that the series are integrated of order one. This robust outcome validates the appropriateness of proceeding with further dynamic panel analysis in the context of digital trade growth in BRICS nations.

Table 4: Results of Panel Unit Root

Test Statics at Level					
	LLI	IPS	Bruiting	Fisher ADF	Fisher PP
DTR	-0.03650	-1.3885	2.86735**	670.9***	686.4***
EG	-0.14355	-2.8968	3.88770	3164.9**	3414.7*
SG	-0.10724	-2.4254	5.65333***	95.141	104.1
PG	-0.06228	-1.7482**	5.07866**	2801.7**	2942.4***
EXC	-0.06231	-1.9098	7.86559***	396.6*	406.7*
GDPG	-0.44817	-5.5587*	3.76433	477.9*	565.0*
NU	-0.14386	-2.8397**	14.4119*	63.55	68.81
RED	-0.10411	-2.3381**	0.20098	33.57	40.81
Test Statics at First Difference					
DTR	-12.887***	-9.1933***	13.841***	124.8***	697.7***
EG	-10.971***	-10.044***	15.435***	874.4***	850.3***
SG	-23.006***	-10.359***	18.057***	297.4***	320.7***
PG	-31.965***	-9.9502***	17.094***	366.9***	669.5***
EXC	-7.9662***	-9.9518***	11.004***	148.6***	308.8***
GDPG	-11.837***	-11.717***	14.471***	427.2***	598.9***
NU	-8.9658***	-9.9494***	20.122***	381.2***	483.8***
RED	-7.0415***	-10.731***	11.291***	446.0***	459.4***

Note: Note: 1) LLC, Breitung and IPS represent the panel unit root tests of Levin et al. (2002), Breitung (2000) Im Pesaran and Shin (2003), respectively. Fisher-ADF and Fisher-PP represent the Maddala and Wu (1999) Fisher-ADF and Fisher-PP panel unit root tests, respectively. *** Statically significance at 1% level.

The empirical outcomes reported in table 5 and table 6 point to a positive relationship between economic globalization and digitalization in BRICS countries, reflecting how deeper global economic ties facilitate technological spillovers, infrastructure enhancements, and knowledge transfer (Audretsch et al., 2014; Zhang et al., 2020). The panel OLS and random effects results highlight the importance of factors such as trade liberalization, foreign direct investment, and international collaborations in advancing digital transformation, while the FMOLS method (0.646548) reinforces the significance of these globalization-driven channels over the long run. However, the fixed effects (0.385471) and robust least squares (0.477532) models indicate that country-specific rigidities, including regulatory barriers or infrastructural gaps, can constrain the impact of economic globalization on digitalization. The statistically insignificant coefficient in the DOLS estimation (0.170654) further demonstrates that once endogeneity and time dynamics are accounted for, additional factors such as institutional capacity, policy support, and human capital accumulation become critical in translating globalization gains into digital progress.

Table 7 expands on these findings by showing that economic globalization exerts an increasingly larger effect on digitalization at higher levels of the dependent variable, consistent with arguments

that global integration accelerates technological adoption and infrastructure growth (Feng & Qi, 2024; Elfaki & Ahmed, 2024). Economies with relatively advanced digitalization benefit more from trade openness, foreign investment, and international knowledge exchanges, as they possess the absorptive capacity to integrate new technologies effectively (Ge & Liu, 2022). At lower quantiles, the weaker effect of globalization demonstrates that developing nations often face structural or institutional barriers preventing them from harnessing the full benefits of cross-border tech diffusion (Matt et al., 2023). This divergence aligns with the digital divide hypothesis, in which globalization can intensify inequalities when foundational capabilities are lacking (Hindman, 2000). Some researchers also argue that overreliance on external digital services risks undermining domestic innovation and heightens vulnerability to cybersecurity threats or regulatory challenges Zheng & Gong, 2024). Taken together, the results in Table 5, Table 6, and Table 7 indicate that while economic globalization offers considerable opportunities for advancing digitalization, its actual impact depends on each nation's policy environment, infrastructure readiness, and capacity to balance international technology adoption with the development of domestic digital industries.

The empirical findings from Table 5 and Table 6 consistently indicate that social globalization exhibits a negative association with digitalization in BRICS countries, explaining that deeper cultural and social integration does not necessarily translate into heightened digital growth. The fixed effects model (-1.053022) and robust least squares model (-0.722889) in table 5 reveal the strongest inverse relationships, and the long-run FMOLS coefficient in table 6 (-0.983365) reinforces the persistence of this negative effect over time. This evaluation explains that increased cultural interactions, migrations, and transnational ties might instead build socio-cultural resistances or foster discrepancies in digital adoption especially in scenarios where more traditional ways still prevail (Aydemir, 2018). This approach is further endorsed by studies that assert that excessive social integration might either detract attention from local digital innovation or worsen inequalities in access to digital resources (Warschauer, 2004; Reisdorf et al., 2022). The fixed effects and FMOLS results clearly point to structural and institutional factors that sustain the negative impact, DOLS provides evidence against this view, reducing the coefficient to -0.193860, with the relationship now statistically insignificant-thereby indicating that other unaccounted variables relating to governance, literacy, and infrastructure might be moderating or even reversing the relationship just stated.

Table 7 makes a very comprehensive representation of the non-linear impact exerted by social globalization across a given level of digital adoption. At the lower quantiles (e.g., 10th), this effect tends to be slightly negative but insignificant, then turns positive at the 20th and 40th quantiles. This means that, at certain minimum levels of digitalization, cross-border cultural flows can give societies some benefits increasing awareness and public engagement through online action (Chen et al., 2021; Brodny et al., 2023). The effect itself at the lower 50th and 70th quantiles implies that those economies have a certain capacity to integrate outside social aspects into domestic digital ecosystems. But then again, the trend uses to become more inconsistent at higher quantiles (80th and 90th) where a higher level of digitalization does not avail much to comprehensive social integration, the reason lies in information overload and fragmentation threats or in holding back the local digital innovation because they are competing with the superior international platforms (Grybauskas et al., 2022). On another dimension, socio-political effects could flow from fast-moving digital content-such as misinformation, privacy, and cyberspace threats-which could dissuade any increased digital uptake by ill-prepared or too-restrictive regulatory structures (Oluoha, 2025). All these clearly tell that the results so far in table 5, table 6, and table 7 would indicate that the effect of social globalization on digitalization is primarily determined by the digital infrastructure that already exists in a country, cultural approaches, and institutional readiness to respond. In some contexts, social integration may spur early digital engagement, though it may also present fragmentation or dependency challenges at higher stages of digital adoption, resulting in heterogeneous outcomes across the BRICS economies.

As for the empirical facts in table 5 and table 6, they display an ambiguous and inconsistent association between political globalization and digitalization across BRICS countries, whereby estimates from the panel OLS and random effects models explain a weak negative association of -0.209506, those from the robust least squares model explain borderline significance of -0.034028, and those from the fixed effects estimate show a positive but statistically insignificant coefficient of 0.378657. The FMOLS approach in table 6 shows no significant effect (0.003152), while the DOLS

approach reports a statistically significant negative coefficient (-0.256620) and explains that the context-dependent conditions of political globalization could either promote or hinder digital advancement. International treaties, diplomacy, and global governance could assist in harmonization of regulations, attracting investment, and increasing knowledge transfer to digital infrastructure (Dahdal & Ghafar, 2025). The negative signs in other models might explain disadvantages due to increased bureaucracy, tie-in policies, and cybersecurity rules that limit the flow of digital services. Such patterns indicate the unseen impact of unobserved heterogeneity and short-lived shocks, confirmed by the coefficients that differ once country-specific traits are controlled for or the dynamic factors are trailed by DOLS (Liu & Tang, 2021). As shown in table 7, the influence of political globalization on digitalization is small and variable at different levels of digital adoption, with weakly negative effects at the low and mid-level quantiles (10th, 20th, 30th, and 50th) explaining that such political incorporation into global institutions does not always directly translate into digital growth when opposite regulations or bureaucratic hurdles are raised. The slight uptick at the 60th and 70th quantiles indicates that moderately digitalized nations can benefit from international collaboration on digital policies, data protection frameworks, and best practices, yet the reemergence of negative coefficients at higher quantiles, such as the 90th, highlights the possibility that overly extensive political integration brings new challenges linked to data sovereignty, compliance obligations, and geopolitical frictions (Zhao, 2024).

The empirical results consistently indicate a positive relationship between internet usage and digitalization across all estimation methods, emphasizing the fundamental role of digital connectivity in advancing digital transformation in BRICS countries. As reported in table 5, the panel OLS and random effects models both yield coefficients of 0.172791, indicating that broader internet access meaningfully contributes to digitalization, while the robust least squares model amplifies this effect to 0.207642, revealing that the impact remains strong even after accounting for potential outliers. The fixed effects model produces a notably lower coefficient of 0.067948, implying that country-specific factors can attenuate the influence of internet usage on digital development. Table 6 reinforces this overall pattern, with the FMOLS estimation providing the strongest long-run effect (0.307111), aligning with existing research that highlights how internet penetration can drive e-governance, digital innovation, and economic modernization (Khan et al., 2024; Balaji, 2025). The positive yet smaller coefficient in the DOLS method (0.132312) explains that once endogeneity and time dynamics are taken into account, internet connectivity remains crucial but is mediated by structural elements such as digital literacy, infrastructure quality, and regulatory frameworks. Some scholars further argue that while internet access provides a foundation for online services and digital engagement, insufficient investments in digital skills and institutional capacity can lead to inefficiencies or digital divides (Lybeck et al., 2024; Vitalis et al., 2025), particularly in contexts where broadband speed, affordability, and cybersecurity measures are unevenly distributed.

The evidence presented in table 7 underscores this relationship by showing that the strongest impact of internet penetration appears at the lower and middle quantiles of digitalization, specifically, the 10th, 20th, 30th, and 40th—where rising internet usage clearly correlates with greater digital development. This aligns with findings that widespread internet access is a foundational driver of digital adoption, enabling broader participation in e-commerce, online education, and other digital platforms. The peak at the 30th quantile reinforces the catalytic role of internet connectivity for emerging digital economies. However, the diminishing effect at higher quantiles points to a saturation phenomenon, once digitalization reaches more advanced stages, simply expanding internet access does not guarantee continued gains. The slight downturn observed at the 80th and 90th quantiles can arise from issues such as digital overload, cyber risks, and productivity losses associated with excessive online activities, as well as the growing importance of factors like data security, AI-driven innovation, and automation over basic internet penetration (Jimmy, 2021; Arif et al., 2024).

The empirical evidence consistently indicates that higher research and development (R&D) investment is a key driver of digitalization in BRICS countries. Table 5 shows that the panel OLS and random effects models produce matching coefficients (14.07698), while the robust least squares (13.20175) and fixed effects (13.843059) estimations remain close, reflecting minimal sensitivity to potential outliers or country-specific variations. Table 6 further reinforces this relationship, as the FMOLS (12.39650) and DOLS (10.78098) methods both yield strong positive effects, indicating that

the benefits of R&D persist even when long-run relationships and endogeneity are taken into account. This consistent pattern across all estimation techniques aligns with literature emphasizing how innovation, technological development, and knowledge creation are critical for digital progress (Tan et al., 2021; Yin et al., 2024). However, studies also warn that the efficiency of R&D spending can vary, especially when commercialization obstacles, weak intellectual property rights, or inadequate technological readiness undermine its potential impact (Pengelly, 2024). The analysis presented in table 7 reveals a nonlinear, distribution-dependent relationship, with strong negative effects at lower quantiles indicating that in economies with limited digitalization, elevated R&D outlays may not immediately translate into digital advancement due to lengthy gestation periods and insufficient absorptive capacity (Yang et al., 2024). The diminishing negative impact around the 50th and 60th quantiles corresponds to a phase where improvements in infrastructure and technological capabilities help R&D expenditures begin to spur digital gains. At the upper quantiles, the shift toward a positive association, particularly at the 90th quantile, aligns with the idea that once a nation reaches a critical threshold of digital maturity, R&D becomes an engine for cutting-edge technologies, deepening digitalization and fostering competitive advantages (Ul Amin & Khan, 2024). Nonetheless, the irregular signs and insignificance at the 70th and 80th quantiles imply that this effect is not uniform even in advanced contexts, possibly due to issues such as market saturation, misaligned R&D strategies, or insufficient regulatory and institutional support.

The empirical evidence shows a strong and consistent positive association between GDP growth and digitalization in BRICS countries, reflecting the crucial role of economic expansion in promoting digital transformation. Table 5 indicates that the panel OLS and random effects models both yield coefficients of 0.603329, revealing that GDP growth makes a meaningful contribution to digitalization, while the robust least squares method amplifies this effect to 0.639086 and the fixed effects model produces an even higher value of 1.224719 once country-specific factors are taken into account. Table 6 FMOLS method reports a sizable long-run impact (0.997858), showing that sustained economic growth aids digitalization over time. The DOLS coefficient (0.422681) remains statistically significant but is notably lower, illustrating that various structural and dynamic factors can moderate the direct influence of GDP growth on digital outcomes (Magoutas et al., 2024). Studies point out that while rising GDP offers the resources necessary for ICT investments, regulatory improvements, and broader consumer demand for digital services (Watanabe et al., 2018; Oliinyk, 2023), economic expansion alone does not ensure evenly distributed or enduring digital benefits. Table 7 adds further nuance by showing that GDP growth exerts a generally positive influence on digitalization across quantiles but varies in magnitude and significance, with a strong impact at the 10th and 20th quantiles, indicating that in lower and moderately digitalized contexts, gains in economic performance tend to be translated into upgrades in digital infrastructure, internet penetration, and online services. The variability in coefficients at the 40th and 50th quantiles and the weaker t-statistics at higher quantiles imply that institutional frameworks, governance conditions, and technological sophistication can shape how effectively economic growth translates into digital progression. Although the rise in the coefficient at the 80th quantile indicates that economic expansion can still advance digitalization in highly developed digital economies, the drop at the 90th quantile points to the potential limits of relying on GDP growth once a certain level of digital maturity is reached. Some scholars further emphasize that if income inequality persists or if growth stems primarily from non-digital sectors, the link between GDP expansion and digitalization may be weakened, leading to uneven adoption and a potential digital divide (Ben et al., 2017; Yin et al., 2024).

The empirical results consistently indicate a negative relationship between currency depreciation (as reflected in the official exchange rate) and digitalization in BRICS countries, implying that weaker exchange rates hinder digital transformation. Table 5 shows that the panel OLS and random effects models both yield coefficients of -0.026226, while the robust least squares model strengthens this negative association to -0.047621. The fixed effects model reports an even larger negative coefficient (-0.110463), explaining that after controlling for country-specific characteristics, currency depreciation exerts a more pronounced impact on reducing digitalization. Table 6 reinforces this long-run negative relationship, with FMOLS (-0.034223) and DOLS (-0.049550) estimations underlining that unfavorable exchange rate movements consistently correlate with lower digitalization. One

explanation for this trend is that a depreciating currency makes importing digital technologies, ICT infrastructure, and high-tech equipment more expensive, constraining the key resources required for digital transformation (Mazaraki et al., 2021; Zhu & Zhu, 2025). This challenge is particularly relevant in BRICS economies reliant on technology imports from more advanced markets, as currency depreciation can also create economic uncertainty, reduce foreign direct investment in digital sectors, and diminish the capacity of domestic firms to invest in digital initiatives (Zheng & Gong, 2024). The higher negative coefficients in the fixed effects and robust least squares models underscore the possibility that macroeconomic instability, inadequate policy frameworks, and weak financial conditions amplify the adverse influence of currency depreciation on digital growth. However, some arguments in the literature explain that a depreciated currency may occasionally stimulate export-driven digitalization by making domestically produced digital goods and services more competitive in global markets (Mazaraki et al., 2021; Zhu & Zhu, 2025). Additionally, well-designed exchange rate policies and financial interventions can mitigate the negative impact of depreciation if they support local technological development and reduce dependence on foreign technologies.

Table 7 shows a consistently negative effect of the official exchange rate on digitalization across all quantiles, though its magnitude varies with different levels of digital adoption. In economies at the lower quantiles of digitalization, the strong negative coefficients reflect the heightened vulnerability to currency fluctuations, as a weaker currency makes essential imported digital tools and services less affordable (Afshan et al., 2024). This constraint is particularly acute for economies in the early stages of digital development, where progress is slowed by limited access to affordable digital solutions (West, 2015). The impact diminishes somewhat at the middle quantiles, indicating that more digitally developed economies are better positioned to cope with exchange rate risks, possibly through domestic ICT production, strategic public investments, or diversification of funding sources. At higher quantiles, the negative effect remains but is typically weaker, suggesting that highly digitalized economies are less dependent on imported technologies and have access to diversified digital infrastructures. Nonetheless, the persistent negative coefficients imply that currency depreciation can still impede digitalization even in advanced contexts, as significant portions of the digital economy depend on global platforms, cloud services, and software priced in foreign currencies. Some studies note that a depreciated currency might occasionally bolster the competitiveness of local digital exports or attract cost-seeking foreign investors (Liu, 2025), but these benefits appear conditional on strong institutional foundations, skilled labor forces, and innovation-oriented economic structures.

Table 5: Panel Results DTR Dependent Variables

	Panel OLS	Panel Robust Least Squares	Panel Fixed Effect	Panel Random Effect
EG	0.621141***	0.477532***	0.385471***	0.621141***
SG	-0.522654***	-0.722889***	-1.053022***	-0.522654***
PG	-0.209506	-0.034028	0.378657	-0.209506
NU	0.172791***	0.207642***	0.067948***	0.172791***
RDE	14.07698***	13.20175***	13.843059***	14.07698***
GDPG	0.603329***	0.639086***	1.224719***	0.603329***
EXC	-0.026226***	-0.047621*	-0.110463**	-0.026226

Note: *** and ** denotes 1% and 5% level of significance.

Table 6: Panel Results DTR Dependent Variables

	(FMOLS)	DOLS
EG	0.646548***	0.170654
SG	-0.983365***	-0.193860
PG	0.003152	-0.256620**
NU	0.307111***	0.132312***
RDE	12.39650***	10.78098***
GDPG	0.997858***	0.422681*

EXC	-0.034223***	-0.049550*

Note: *** and ** denotes 1% and 5% level of significance.

Table 7: Panel Quantile Regression Analysis

Variables	Quantiles								
	10th	20th	30th	40th	50th	60th	70th	80th	90th
EG	0.0762***	0.108***	0.177	0.315*	0.485***	0.536***	.702***	0.661***	0.768**
	[2.845]	[2.250]	[0.998]	[1.618]	[3.017]	[2.995]	[2.558]	[2.632]	[4.066]
SG	-0.017	0.1736**	0.0052**	0.1291***	0.620*	0.0156**	0.2302**	-0.0134	-0.2511
	[-0.39]	[1.721]	[1.822]	[2.532]	[1.323]	[1.532]	[1.502]	[-1.193]	[-1.192]
PG	-0.0436*	-0.037*	-0.0246	-0.065	-0.1182*	0.0191*	0.0121**	0.0413	-0.029*
	[-1.451]	[-1.632]	[-1.231]	[-1.219]	[-1.549]	[1.454]	[1.573]	[1.143]	[1.232]
NU	1.119**	1.0674**	1.4514**	1.2597**	0.6222*	1.1486	1.1463**	-0.0678*	-0.106*
	[1.843]	[2.009]	[2.143]	[1.8764]	[1.135]	[1.323]	[1.517]	[-0.228]	[-0.132]
RDE	-1.335***	-1.193***	-1.062***	-0.930***	-0.0465**	-0.037*	0.9952	0.21681	1.489*
	[-7.41]	[-6.812]	[-4.649]	[-3.74]	[-1.541]	[-1.434]	[0.955]	[0.759]	[1.2011]
GDPG	0.2628***	0.634**	0.453	0.023***	1.637	0.30703	0.468	1.962	0.622
	[2.314]	[0.823]	[1.433]	[1.563]	[0.2073]	[1.042]	[0.043]	[0.205]	[0.695]
EXC	-0.067**	-1.568***	-1.800***	-1.628***	-0.998*	-1.558	-1.368	-0.091	-0.2707
	[-1.561]	[-2.819]	[-2.401]	[-2.123]	[-1.291]	[-1.407]	[-1.367]	[-0.162]	[-0.615]

[ ] represents the t- statics values of the estimated coefficients

***, ** shows the level of significant at 1% and 5% respectively

5. Conclusions

The BRICS countries, Brazil, Russia, India, China, and South Africa, remain committed to advancing digitalization as a key strategy for bolstering economic growth and competitiveness. This study examined how economic, social, and political globalization, alongside R&D expenditure, internet penetration, GDP growth, and exchange rates, influences ICT goods exports over the period from 2000 to 2022. Unlike previous research that often focused on isolated factors, this analysis adopted multiple advanced panel data estimation techniques—including standard and robust regression, fixed and random effects, FMOLS, DOLS, and panel quantile regression—so as to capture both short-run and long-run effects, as well as distribution-specific impacts, on digitalization across these emerging economies. The findings establish a long-run equilibrium among the considered variables, highlighting the complementary or contrasting roles of globalization dimensions. R&D investment, economic globalization, and GDP growth consistently show strong and positive effects, particularly when controlling for country-specific heterogeneity and outliers. Internet penetration likewise emerges as a foundational catalyst for digital transformation at earlier to intermediate stages of development, whereas social and political globalization produce more nuanced outcomes that vary across institutional and cultural contexts. Currency depreciation exerts a negative impact in nearly all specifications, implying that macroeconomic instability undermines the affordability of imported technologies and the attractiveness of digital investments. In comparing coefficient estimates across different methodological approaches, the fixed effects and robust least squares models emphasize country-level rigidities and possible outlier effects. FMOLS and DOLS, in turn, focus on long-run relationships and potential endogeneity. Of these, DOLS emerges as the most comprehensive because it addresses both endogeneity and serial correlation, thereby capturing more robust dynamic feedback processes between variables. Although results remain largely consistent, DOLS reveals subtleties in how certain globalization dimensions affect digitalization once longer-term trends and shocks are taken into account.

Taken together, these insights are directly relevant for policymakers throughout the BRICS nations. Governments seeking to promote digital trade and services should stabilize exchange rates, strengthen research and innovation ecosystems, and continuously improve internet infrastructure to ensure more inclusive and sustainable digital growth. It is equally important to acknowledge that social and political ties with the global community may require well-tailored regulatory frameworks, cultural support, and capacity-building efforts to fully harness their potential for advancing technology adoption. By integrating these considerations, the BRICS countries will be better positioned to navigate the evolving digital landscape, leverage globalization's many spillovers, and foster vibrant, innovation-driven economies.

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