İşletme | The Business Journal 2024, 5(2), 197-211
https://doi.org/10.57116/isletme.1530329 e-ISSN: 2757-9433

The Effects of IT and Financial Development on Economic Growth in BRICS-T Countries: Insights from the Solow Growth Model

(BRICS-T Ülkelerinde BT ve Finansal Gelişimin Ekonomik Büyüme Üzerindeki Etkilerinin Araştırılması: Solow Büyüme Modelinden İçgörüler)

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Keywords:
Economic Growth, Financial Development, İnformation Technologies, BRICS-T Countries

Paper type:
Research

Abstract

The aim of the study is to examine the impact of IT and financial development on economic growth in BRICS-T countries for the period 1990-2022 using the panel quantile technique. For this purpose, IT technology and financial development variables were added to the basic Solow model. According to the findings, the impact of physical capital stock on economic growth is positive in all quantiles. The effect of population growth on economic growth is significant starting from 0.4 quantile and the negative effect increases as the quantile level increases. Information technology, which is the subject of the study, positively affects economic growth and this effect decreases as the quantile level increases. The variables we used to represent the level of financial development, financial institutions have a positive but statistically insignificant coefficient sign, while financial markets have a statistically significant but negative coefficient sign. This negative effect increases as the quantile level increases.

Anahtar Kelimeler:
Ekonomik Büyüme, Finansal Gelişme, Bilgi Teknolojileri, BRICS-T Ülkeleri

Makale türü:
Araştırma

Öz

Çalışmanın amacı, BT teknolojisinin ve finansal gelişmenin BRICS-T ülkelerinde ekonomik büyüme üzerindeki etkisini 1990-2022 dönemi için panel kantil tekniğini kullanılarak araştırmaktır. Bunun için temel Solow modeline BT teknolojisi ve finansal gelişme değişkenleri ilave edilmiştir. Elde edilen bulgulara göre fiziki sermaye stokunun ekonomik büyüme üzerine etkisi tüm kantilllerde pozitiftir. Nüfus büyümesinin ekonomik büyüme üzerindeki etkisi 0.4 kantilden itibaren anlamlı olmakta ve kantil düzeyi arttıkça da negatif etki artmaktadır. Çalışmanın konusunu oluşturan bilgi teknolojisi ekonomik büyümeyi pozitif etkilemekte ve bu etki kantil düzeyi arttıkça azalmaktadır. Finansal gelişme düzeyini temsilen kullanmış olduğumuz değişkenlerden finansal kurumlar pozitif ancak istatiksel olarak anlamsız, finansal piyasalar ise istatiksel olarak anlamlı fakat negatif katsayı işaretine sahiptir. Bu negatif etki ise kantil düzeyi arttıkça artmaktadır.

Başvuru/Received: 08.08.2024 | Kabul/Accepted: 20.09.2024 , iThenticate benzerlik oranı/similarity report: %3

Atıf/Citation: Demirtaş, C. (2024). The effects of IT and financial development on economic growth in BRICS-T countries: Insights from the Solow growth model, *İşletme*, 5(2), 197-211.

Introduction

Over the past five decades, there has been a significant expansion of information and communication technology (ICT), resulting in a swift alteration of the worldwide economy (Verma & Giri, 2022). ICT has played a crucial role in expediting socio-economic progress in the 21st century. Its utilization in various sectors such as healthcare, education, business, banking, and finance has proven to be highly effective (Behera, et al. 2024). ICT, which gained popularity in the 1980s and brought about significant changes in several sectors of human life (Hussain, et al. 2024), is a comprehensive term that encompasses a range of technological tools and resources utilized for the purpose of generating, communicating, storing, sharing, and exchanging information. ICT encompasses all electronic devices capable of storing, accessing, controlling, transmitting or receiving data in a digital format (Islam, et al. 2024).

ICT has a crucial role in the development of the information society and can actively contribute to human progress, enhanced social unity and the expansion of the national economy (Yahyaoui, 2024). Hence, the advancement of ICT is frequently acknowledged as the primary catalyst and essential element for fostering economic expansion (Tang & Rosidi, 2024; Horvey & Odei-Mensah, 2024). The progress in ICT is believed to enhance worker productivity and efficiency, enable quick access to information for decision-making, and lower production costs (Hussain, et. al., 2024; Tang & Rosidi, 2024). Additionally, it enhances the clarity of financial transactions, streamlines various corporate operations, and expedites business interactions (Islam, et. al., 2024). Many economies have been pushed to consistently enhance their current IT structures due to the consequent advantages. Furthermore, in the present era of the Fourth Industrial Revolution (IR4.0), it is considered imperative to incorporate Artificial Intelligence (AI), Internet of Things, Metaverse, and other intricate data-driven techniques (Tang & Rosidi, 2024). Consequently, ICT has become absolutely essential in our everyday existence (Horvey & Odei-Mensah, 2024). Emerging economies like BRICS (Brazil, Russia, India, China & S.Africa) and Turkey have embraced the widespread use of innovative technologies, aiming to mirror the progress made by more developed economies in terms of ICT adoption.

The proliferation of ICT is widely recognized as a significant catalyst for economic growth (EG) in both developed and developing countries (Horvey & Odei-Mensah, 2024). It exerts both direct and indirect influences on the economy. The direct effects encompass the attraction of further foreign direct investment (FDI) into the ICT industry, the acquisition of economies of scale on the demand side through network effects, the facilitation of education and innovation, consequently augmenting the competitive advantage of the economy. ICT also has many indirect effects on other areas of the economy. ICT plays a crucial role in enhancing the profitability of foreign investments in many sectors of a country and also facilitates the assimilation of knowledge and benefits from international investments (Behera, et al. 2024). Additionally, it offers effortless access to a diverse array of economic products and services that enhance financial inclusion and promote financial development (FD) in the economy (Verma & Giri, 2022; Wang, et al. 2023). This results in the advancement of corporate, financial, and economic sectors (Horvey & Odei-Mensah, 2024). ICT fosters corporate innovation, enhances government openness, and supports private investment (Behera, et al. 2024). Conversely, the financial system facilitates trade, diversification, risk pooling, resource allocation, savings mobilization, and exchange of goods and services. These activities, in turn, foster growth by accumulating capital, primarily through technological innovations (Levine, 1997). Furthermore, financial institutions promote and encourage innovation and creativity. Therefore, they select investments that prove to be beneficial for society and subsequently provide funding for them, thereby enhancing potential growth (Schumpeter, 1911). ICT is increasingly recognized for its impact on EG through a diverse range of tools (Verma & Giri, 2022). Nevertheless, for developing countries, the contemporary digital transformation offers both advantage and disadvantage to propel them towards sustainable and comprehensive economic expansion. Hence, the realization of the potential advantages of ICT and the attainment of the Sustainable Development Goals (SDGs) rely on the presence of several macroeconomic elements, including ICT infrastructure, FD, research and development expenditures, and the quality of governance in countries (Behera, et al., 2024).

Neoclassical growth models highlight the significance of information technology (IT) as a catalyst for financial and economic progress in emerging nations, as stated in the literature (Horvey & Odei-Mensah, 2024). Nevertheless, there are multitude of divergent perspectives regarding the economic ramifications of ICT. In his 1987 study, Solow posited that the ICT revolution, in contrast to earlier technological revolutions, possesses a lesser magnitude and exerts a limited influence on productivity and growth. Recent studies have reached a consensus that the advantages of ICT in terms of productivity and growth require several years to be fully appreciated. Nevertheless, some empirical research indicate that ICT has little impacts on EG (Behera, et al. 2024). Given the contradictory results, it is crucial to examine the influence of IT and FD on growth in order to ascertain its potential effectiveness as a significant economic driver in developing nations like the BRICS-T. Previous research has mostly focused on analyzing the effects of technology diffusion on EG, as demonstrated by studies conducted by Majeed & Khan (2019), Hussain et al. (2024), and Islam et al. (2024). The relationship between the development of the financial sector and EG has been explored by several researchers (Ahmed and Ansari 1998, Hassan et al. 2011, Tian et al. 2024, Asteriou et al. 2024, Öncel et al. 2024). However, the relationship between the utilization of ICT, the development of the financial sector, and the EG in BRICS-T countries has not been investigated. Hence, the primary aim of this study is to address this deficiency and investigate the influence of IT dissemination and financial sector development on EG in BRICS-T nations from 1990 to 2022. In order to do this task with great attention to detail, the study used the Panel Quantile approach. The study provides essential additions to the current body of literature on the relationship between IT, finance, and EG in three distinct manners. Firstly, this study employs the Panel Quantile approach, which yields more robust findings in non-linear series. Furthermore, this study is the initial investigation of the influence of IT spread and FD on growth specifically in the BRICS-T countries. This analysis is founded on the most recent data from BRICS-T countries. Consequently, the discoveries will assist policymakers in formulating policies in alignment with the findings.

The study is outlined in Section 1 as an introduction, followed by a literature review in Section 2, then the data and methods are presented in Section 3, followed by the empirical findings in Section 4 and finally, the conclusion and policy implications are discussed in Section 5.

1. Literature Review

The use of ICT is growing in industries such as finance, e-commerce, banking, education, and others due to the rapid rise in digitalization (Behera, et al. 2024). The progress of technology in ICT industry has important effects on the overall economy, resulting in the emergence of the "New Economy" idea. ICT investment has a positive impact on macroeconomic performance by boosting productivity and enhancing market flexibility and transparency. Financial markets have a significant impact on fostering robust EG by facilitating the transfer of financial resources from unproductive to productive sources, hence enhancing economic efficiency through diversification. In addition, the ICT infrastructure can be viewed as a crucial factor in expediting FD. Enhancing ICT infrastructure can result in cost reduction by improving the communication system (Verma & Giri, 2022).

FD and ICT diffusion have been widely recognized as influential factors in EG, as demonstrated by numerous theoretical and empirical research. Several studies have examined the relationship between the diffusion of ICT and EG. Notable studies include those conducted by Majeed & Khan in 2019, Hussain et al. in 2024, and Islam et al. in 2024. The relationship between finance and EG has been studied by several researchers, including Ahmed & Ansari (1998), Hassan et al. (2011), Tian et al. (2024), Asteriou et al. (2024), and Öncel et al. (2024). Nevertheless, there are only a limited number of studies that investigate the correlation between the spread of ICT, the advancement of the financial sector and the expansion of the economy.

The existing literature on the topic has been categorized based on the examination of income levels and geographical disparities among the countries. The study conducted by Andrianaivo and Kpodar (2012) on 44 African nations revealed that mobile phone adoption enhances financial inclusion and positively impacts economic growth, based on a classification that considers regional variations. The research underscores the significance of ICT, particularly mobile technologies, in fostering economic development by enhancing financial inclusion in Africa. A separate investigation conducted by Wang et al. (2023) analyzed the impact of ICT diffusion, trade openness, foreign direct investment (FDI), and financial inclusion on inclusive growth in African nations from 2000 to 2020. The findings demonstrate that these variables enhance economic growth, but inflation hampers these beneficial benefits. Ultimately, Horvey and Odei-Mensah (2024) examined the impact of the spread of ICT and the level of insurance coverage on the economic development in Sub-Saharan Africa (SSA). The results indicate that the penetration of ICT and insurance has a favorable impact on growth, and that ICT enhances the contribution of the insurance sector to market growth.

The research undertaken by Aziz et al. (2023) investigated the influence of ICT spread and financial development on the economic growth of 10 Asian economies during the period of 2001-2017. The results indicate a direct correlation between financial development and economic growth. However, it is seen that ICT in isolation has a detrimental impact on economic growth, but it has a more pronounced beneficial influence when integrated with financial development. This underscores the fact that the combination of ICT and financial development generates a synergistic impact on economic growth. A separate investigation conducted by Verma and Giri (2022) explored the correlation between the spread of ICT and the development of financial systems with economic growth in SAARC countries located in South Asia. The findings indicate that robust financial development facilitates the spread of ICT and thereby enhances economic growth. Yet, no substantial causal relationship was established between financial development and ICT dissemination.

The study undertaken by Sassi and Goaied (2013) investigated the influence of financial development and ICT on the economic growth of Middle East and North African Countries (MENA). The study revealed that financial development exerts a detrimental influence on growth, whereas ICT has a direct and beneficial association with growth. Furthermore, the link between ICT and financial development generates a beneficial effect on economic expansion. Clearly, ICT facilitates financial development and enhances growth once it attains a satisfactory threshold.

Another distinction is that countries are classified according to their development levels. In their research on Developing Countries, Verma et al. (2023) investigated the correlation between the spread of ICT, the development of financial systems, and Economic growth from 2005 to 2019. The results indicate that the dissemination of ICT, the development of financial systems, and the openness of trade have a favorable impact on growth, but inflation has a negative impact on growth. Furthermore, a reciprocal causal link was discovered between ICT and financial progress. A separate study conducted by Behera et al. (2024) investigated the impact of ICT on economic growth by considering its interaction with financial development, R&D expenditures, and FDI throughout the period of 2000-2020 in 13 newly emerging economies. The research indicates that the usage of ICT has a beneficial impact on economic growth. Furthermore, it establishes that ICT facilitates growth when it interacts with financial development and R&D spending.

The study conducted by Cheng et al. (2021) investigate the correlation between ICT, financial development, and economic growth in 72 nations from 2000 to 2015. Research findings indicate that financial development has a detrimental impact on economic growth. However, ICT promotes growth in high-income countries, but its impact is uncertain in low income and middle income countries. Nevertheless, the synergistic impact of ICT and financial development has a beneficial influence on the growth trajectory of all income brackets. Kumari and Singh (2023) examined the impact of ICT infrastructure, financial development, and trade openness on economic growth in 85 nations, consisting of 27 low-income countries and 58 high-income countries. The analysis included the time span from 2000 to 2019. The findings indicate that there is a positive correlation between ICT infrastructure, financial development, and trade openness with economic growth in low-income nations. However, this relationship is inverted in high-income countries.

In the previous literature on the subject, the relationships between ICT, financial development and economic growth have been addressed by taking into account the income levels and regional differences of the countries. The synergistic effects between ICT and financial development are prominent in Africa, MENA, Asia and developing countries, but it is understood that this effect differs in high-income and low-income countries. While ICT and financial development accelerate growth in developing countries, the interaction of these two elements plays a decisive role on growth. Although the previous literature provides important findings on the relationship between ICT use, financial sector development and economic growth, there is no study specifically examining BRICS-T countries in the mentioned studies. In addition, the studies use more traditional and normally distributed techniques (such as GMM). Therefore, the need for additional analysis arises to examine the relationship between the three variables. In light of the research gap identified in the literature, the current research explores the link between ICT use, financial sector development and economic growth for BRICS-T economies.

2. Model, Dataset, Methodology and Empirical Results

The main aim of this study is to examine the influence of telecommunication technology and FD on EG in BRICS-T countries from 1990 to 2022, utilizing panel quantile techniques. In order to accomplish this goal, we employ the neoclassical steady-state (long-run) development model formulated by Solow (1956) as depicted in Equation (1). The Solow (1956) model is the growth model that is commonly used in empirical growth applications. The Solow growth model, often known as the neoclassical growth model, is highly influential in EG research and serves as the foundation for many recent advancements in the field. This model, established by Robert Solow, specifically examines the determinants of sustained economic expansion. The fundamental constituents of the model in its initial manifestation are the accumulation of capital and the employment of workers. Subsequently, the conceptual framework was broadened by including advancements in technology and human resources. Capital accumulation is a prerequisite for economic growth in the established model. Nevertheless, the rate of growth decelerates beyond a certain threshold as a result of the dropping benefits of accumulating capital. One further factor to consider is population growth. Increase in the availability of employed workers enhances the expansion of the economy. Nevertheless, for situations when the pace of increase in the labor force surpasses the rate of increase in capital, the per capita capital starts to decline. In the Solow model, technological advancement is regarded as an external factor and is represented as a fruit originating from heaven. The paradigm posits that the long-term sustainability of economic growth relies heavily on technical advancement. In the absence of technological advancement, the expansion of an economy may decelerate. Therefore, throughout the long run, economies achieve a state of equilibrium. Per capita income remains unchanged in this scenario unless there is technological advancement and a deceleration in industrial growth (Mankiw et al., 1992; Polimeni et al., 2007; Islam, 1995). According to the Solow model, investment has a transitory impact on growth, whereas technical progress is the only external factor that drives long-term growth (Moradi & Kebryaee, 2010). This study expands the traditional Solow growth model to incorporate internet usage and FD. Thus, it serves as the fundamental structure for examining the connections between the variables being analyzed.

$$ln\left[\frac{Y(t)}{L(t)}\right] = lnA(O) + gt + \frac{\alpha}{1-\alpha}\ln(s_k) - \frac{\alpha}{1-\alpha}\ln(n + g + \delta) + \varphi \ln W + \varepsilon_t \quad (1)$$

In this context, "ln" represents the natural logarithm, "ε_t" refers to the error term, "(Y_t/L_t)" represents production per capita, "s_k" denotes the capital stock per capita, "n" represents the labor force growth rate, "g" stands for the technology growth rate, and "d" represents the depreciation rate. Mankiw et al. (1992) proposed that the sum of the growth rate of income and the depreciation rate, represented as (g + d), is equal to 0.05. This conclusion is based on the observation that the average growth rate of income per person is roughly 2% and the ratio of capital to output is approximately 3%. Consequently, 0.05 is included in the population growth rate. W symbolizes the intersection of FD and information technology. In this study, the first step involves presenting information and descriptive statistics of the variables. Subsequently, the Breusch-Pagan (1980) CD lm and Pesaran et al. (2008) LM adj tests were utilized to examine the presence of cross-sectional dependence. The stationarity levels of the variables were examined using the CADF unit root test, which was established by Pesaran (2007). The homogeneity test proposed by Pesaran & Yagamata (2008) was employed to ascertain if there were any variations in the slope coefficients across the units. Ultimately, the MM-QR model devised by Machado & Silva (2019) was employed to estimate the data, yielding more complete outcomes. The factors utilized to investigate the aforementioned impact, together with their explanations and sources, are provided in Table 1.

Table 1. Description of Data

Variable	Definition (Measurement)	Sources
KGDP	EG (Gdp Per Capita, Constant 2015 US$)	World Bank
Capital Stock (s_k)	Capital (Gross Fixed Capital Formation, Constant 2015 US$)	World Bank
n+g+d	The labor growth rate (n)+ the technology growth rate (g)+ the rate of depreciation (d)	World Bank
IT	Individuals using the internet (% of population)	World Bank
Financial Development	Financial institution index	IMF
	Financial market index	IMF

Note: In order to obtain more robust and robust results, the variables are transformed in natural logarithmic form.

The findings of the Jarque-Bera test can be used to evaluate if the variables have a normal distribution. The variables' correlation matrix and descriptive statistics are shown in Table 2. The statistically non-normal distribution of lnsk is found at a significance level of 5% in the Jarque-Bera test results, whereas the statistically non-normal distribution of the other variables is found at a significance level of 1%. As a result, the quantile approach was applied, which produces stronger results in non-normally distributed series.

Table 2. Summary Statistics

	lnkgdp	lns_k	ln(n+g+d)	lntec	lnFI	lnFM
Mean	3.658226	1.369511	-1.223466	0.694346	-0.363977	-0.335004
Median	3.784954	1.344451	-1.214272	1.125579	-0.356408	-0.289793
Maximum	4.147834	1.648543	-1.090109	1.956255	-0.097219	-0.085059
Minimum	2.723372	1.120038	-1.342845	-3.953474	-1.092732	-0.910671
Std. Dev.	0.361565	0.134377	0.049547	1.321021	0.190202	0.168830
Skewness	-1.153694	0.343333	-0.525072	-1.446318	-0.875298	-1.442612
Kurtosis	3.182926	2.216542	2.806904	4.611535	3.577599	4.930539
Jarque-Bera	44.19937	8.953863	9.405723	84.06035	27.18568	96.41203
Probability	0.000000	0.011368	0.009069	0.000000	0.000001	0.000000
Sum	724.3287	271.1631	-242.2462	127.7597	-69.88355	-64.32086
Sum Sq. Dev.	25.75365	3.557277	0.483613	319.3525	6.909779	5.444178
Observations	198	198	198	184	192	192
lnkgdp	1.0000					
lns_k	-0.2970	1.0000				
ln(n+g+d)	-0.4089	0.0097	1.0000			
lntec	0.5474	0.0067	-0.3425	1.0000		
lnFI	0.2587	0.1797	-0.2540	0.4540	1.0000	
lnFM	-0.0512	0.5299	-0.4045	0.3661	0.1730	1.0000

To improve the validity of the regression, a multicollinearity test was run (Table 3). Regression models may have multicollinearity issues since this could lead to a scenario in which the independent variables have a high degree of correlation and the probability values are skewed. Using the Variance Inflation Factors (VIF) test, multicollinearity was verified.

Table 3. Multicollinearity Test (dependent variable: lnKGDP)

Variables	VIF	1/VIF
lns_k	2.50	0.400402
lnFM	2.17	0.460336
lntec	1.73	0.579038
lnFI	1.55	0.644181
ln(n+g+d)	1.40	0.716119
Mean VIF	1.96	

There is no multicollinearity, based on Table 3's analysis of the independent variables' individual VIFs and average VIF (1.96). Every variable's VIF value is less than 5. This demonstrates that the model is no longer problematic with multicollinearity.

The cross-sectional dependence of the variables is investigated in the following phase. This is due to the fact that there are two types of tests that should be employed for panel data analyses: first-generation tests, which do not account for cross-sectional dependence, and second-generation tests, which do. Consequently, we examine cross-sectional reliance using Pesaran's cross-sectional dependence (CD) test. The LM (Breusch & Pagan, 1980), LMadj (Pesaran et al., 2008), and CDLM (Pesaran, 2004) tests were utilized to investigate cross-sectional dependence because the temporal dimension is greater than the cross-sectional dimension (T > N). Results With the exception of the CDLM test, the significance threshold of $p<0.05$ led to the rejection of the null hypothesis that precludes cross-sectional dependency, and it was shown that there existed cross-sectional dependence between the series. The outcomes are displayed in Table 4.

Table 4. Cross-Sectional Dependence

Test	Statistic	Prob.
LM (Breusch & Pagan, 1980)	40.59	0.000
LM_{adj} (Pesaran et al., 2008)	11.07	0.000
CD_{LM} (Pesaran, 2004)	0.953	0.340

The second issue in panel data research is figuring out if the slope coefficients are homogeneous (after correcting for cross-sectional dependence). When common limitations are given to the full panel, the strong null hypothesis states that there is no causal association between any two variables (Granger, 2003). Furthermore, the assumption of parameter homogeneity cannot reflect variability because of region-specific traits (Breitung 2005). To investigate the homogeneity of the cointegration coefficients, the delta tilde and corrected delta tilde tests by Pesaran & Yamagata (2008) and Blomquist-Westerlund (2013) were employed (Table 5).

Table 5. Homogeneity Tests

Test	Pesaran-Yamagata (2008)		Blomquist-Westerlund (2013)	
	Value	Prob.	Value	Prob.
Delta (Δ)	7.880	0.000	7.494	0.000
Delta Adjusted (Δ_{adj})	9.000	0.000	8.559	0.000

As the null hypothesis is rejected at the 5% significance level, Table 5's results support the existence of country-specific slope heterogeneity among the chosen nations. The second generation unit root test, which controls for reliance and heterogeneity and yields more consistent findings, can be used to verify the series' stationarity if cross-sectional dependence and heterogeneity have been established using the appropriate tests. In order to do this, CADF panel unit root tests (Pesaran 2007) were carried out, and Table 6 presents the findings.

Table 6. Panel Unit Root Tests

Variable	CADF	
	Z [t-bar]	**P-value**
At level (intercept and trend)		
lnkgdp	-2.616	0.015
lncap	-2.311	0.083
ln(n+g+d)	-1.632	0.650
lntec	-1.735	0.041
lnFI	-2.951	0.001
lnFM	-2.444	0.042
First difference		
ln(n+g+d)	-2.453	0.040

Although the maximum lag length of two is recommended by the CADF test, the Schwarz information criteria was used to determine the ideal lag duration. At a significance level of 0.05, the null hypothesis is rejected. The results of the unit root test indicate that all of the series are stationary at the level and do not contain a unit root, with the exception of ln(n+g+d). The ln(n+g+d) variable indicates that it is stationary when I(1) is used as the first difference.

3. Model for Estimating Moment Quantile Regression Method (MM-QR)

In this work, the MM-QR estimation approach created by Machado and Silva (2019) was used to assess the distribution function along various quantiles in order to examine the impact of independent variables on the dependent variable. When doing MM-QR, the distribution function along various quantiles is taken into account, along with the possibility of fixed effects.

For panel data sets, quantile regression techniques explore correlations by alternating between several variable quantiles. The process of assessing the coefficients derived from the dependent variable's quantile asymmetries, which are concurrently impacted by the means of several explanatory factors, was proposed by Koenker & Hallock (2001). Additionally, it appears that this method works well for handling potential outliers that could skew the data's overall distribution. Even if it is found that the conditional measures have negligible or no effects, this method can nevertheless yield reliable results. Furthermore, the dependent variable's distribution is inaccurate in classic quantile regressions since they are unable to transition between sections at different quantile levels throughout the calculation (Machado & Silva, 2019). In this study, a brand new estimation technique called "method of moments quantile regression" (MMQR) developed by Machado & Silva (2019) is used. It also discusses the difficulties posed by endogeneity and heterogeneity. Since Equation (2) provides quantile evaluations that depend on a scale for a specific place, the 10% quantile is used in the current paper.

$$\boldsymbol{Q_{y_{i,t}Ix_{i,t}} = \alpha_\tau + Z'_{i,t}\beta_\tau + \varepsilon_{i,t,\tau}} \quad \ldots\ldots\ldots\ldots\ldots\ldots..(2)$$

The dependent variable in the equation, lnkgdp, is represented by $y_{i,t}$, while the independent variables vector, lnsk, ln(n+g+d), lnIT, lnFI, and lnFM, is represented by $Z_{i,t}$.The conditional quantile of interest is denoted by τ. The quantile-specific intercept and coefficient parameters are denoted by α_τ and β_τ, respectively, while the error term is represented by $\varepsilon_{i,t,\tau}$ (Cutcu, et al., 2024; Hieu & Mai, 2023).

Table 8. MM-QR Estimation Results

	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
lnsk	.831** (.389)	.866** (.340)	.895** (.303)	.916** (.278)	.971** (.232)	1.01*** (.218)	1.06*** (.229)	1.11*** (.272)	1.198** (.385)
ln(n+g+d)	-.899 (.948)	-1.07 (.827)	-1.21 (.737)	-1.31** (.680)	-1.576** (.569)	-1.756*** (.540)	-2.00*** (.567)	-2.258*** (.672)	-2.677** (.963)
lntec	.099*** (.029)	.096** (.025)	.093** (.023)	.091*** (.021)	.086*** (.017)	.082*** (.016)	.077*** (.017)	.071*** (.020)	.063** (.029)
lnFI	.036 (.214)	.034 (.187)	.032 (.166)	.031 (.153)	.027 (.127)	.024 (.119)	.021 (.125)	.017 (.148)	.011 (.209)
lnFM	-.323** (.155)	-.329** (.135)	-.333* (.120)	-.335** (.110)	-.343** (.092)	-.347*** (.086)	-.354*** (.090)	-.361*** (.108)	-.372** (.153)

Note: The symbols ***, **, and * represent 1%, 5%, and 10%, respectively and the standard deviation values in parenthesis.

Upon examining the results in Table 8, it is evident that the variable lnsk has a large and positive impact on the variable lnKGDP across all quantiles. It has been noted that the impact is minimal in countries belonging to the lower quantile groups (0.1, 0.2, and 0.3), but the favorable impact becomes more pronounced as the quantile level rises. This association aligns with the anticipated outcome. The reason for this is that the accumulation of physical capital is the fundamental component of production and is therefore expected to lead to an increase in EG.

Similarly, the impact of the ln(n+g+d) variable on lnKGDP similarly aligns with the theoretical prediction. Nevertheless, it has been shown that this phenomenon lacks statistical significance in countries belonging to the first quantile groups (0.1, 0.2, and 0.3). However, the detrimental impact becomes more pronounced as the quantile level rises.

The variables being studied are lnIT, lnFI, and lnFM. The anticipated impact of the natural logarithm of IT (lnIT) variable on the natural logarithm of KGDP (lnKGDP) is positive. The findings corroborate the anticipated outcome. Nevertheless, it was noted that when the quantile level of this phenomenon rises, the beneficial impact diminishes. Consequently, nations must enhance their IT strategies and enhance the utilization of cutting-edge Information Technology.

Although the variable lnFI, which represents the level of FD, has a positive value, it is not statistically significant. On the other hand, the variable lnFM has a statistically significant coefficient with a negative sign. It was noted that as the quantile level rises, the detrimental impact likewise intensifies.

4. Conclusion

The objective of the study is to examine the influence of IT technology and FD on EG in BRICS-T countries from 1990 to 2022, utilizing the panel Quantile technique. In order to achieve this objective, the basic Solow model was enhanced by incorporating IT technology and FD variables, which were subsequently examined. The findings indicate that physical capital stock has a substantial and favorable impact on EG across all quantiles. The favorable effect was found to be more pronounced as the quantile level increased. In the same manner, the impact of the ln(n+g+d) variable on EG aligns with the theoretical prediction. However, it lacks statistical significance in countries belonging to the first quantile groups (0.1, 0.2, and 0.3). It only becomes significant starting from the 0.4 quantile, and this negative effect intensifies as the quantile level rises. The anticipated influence of the information technology (IT) variable, which is the focus of the study, on the logarithm of the knowledge-based gross domestic product (KGDP) is positive. The findings corroborate the anticipation. However, it was noted that the beneficial impact diminishes as the quantile level of this effect rises. Although the variable lnFI, which represents the level of FD, has a positive value, it is not statistically significant. On the other hand, the variable lnFM has a statistically significant coefficient with a negative sign. It has been noted that the magnitude of this adverse impact grows as the quantile level rises.

The study's findings provide evidence of connections between the diffusion of ICT, the development of the financial sector, and EG. These findings align with previous studies conducted by Andrianaivo and Kpodar (2012), Sassi & Goaied (2013), Verma & Giri (2022), Verma, et al. (2023), Wang, et al. (2023), Behera, et al. (2024), Horvey & Odei-Mensah (2024), Tang & Rosidi (2024), all of which suggest that ICT is essential for enhancing a country's overall productivity. Nevertheless, the research conducted by Aziz, et al. (2023) and Kumari & Singh (2023) fails to substantiate the claim that ICT technology has a detrimental impact on growth. Furthermore, the study conducted by Cheng et al. (2021) lacks clarity and does not provide conclusive evidence. Based on the findings, the study by Verma & Giri, 2022, highlights several recommendations. In order to assure sustained economic expansion in these countries, it is imperative to enhance the ICT infrastructure and encourage the adoption of electronic finance (e-finance). This approach offers several advantages, including widespread accessibility, transparent pricing, and user ease. Given that the analyzed country group comprises the most populous nations globally, it is crucial to prioritize policies that involve substantial investment in the financial sector. This investment should aim to facilitate easy access to financial services for a significant portion of the population, particularly those residing in rural and remote areas. Additionally, it is important to provide incentives and subsidies to ensure that IT services are affordable for vulnerable communities. To maximize the impact of these efforts, it is advisable to coordinate public and private investments in order to create synergistic effects in the development of IT infrastructure. Furthermore, education programs should be implemented with a specific focus on enhancing digital literacy. This will empower all segments of society to embrace digital platforms for financial services.

Contribution Rate and Conflict of Interest Statement

All stages of the study were designed by the author(s) and contributed equally. There is no conflict of interest in this article.

Ethics Statement and Financial Support

Ethics committee principles were followed in the study. Ethics Committee Report is not required in the study. There has been no situation requiring permission within the framework of intellectual property and copyrights.

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