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The Dynamic Relationship Between FDI, ICT, Trade Openness, and Economic Growth: Evidence from BRICS Countries

Ahmed Nawaz SOOMRO[1], Jai KUMAR[2], Joti KUMARI[3]

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Abstract

Information and communication technology (ICT) is one of the primary zones that stimulates economic development in today's globalized world. It promotes technological developments in worldwide communication and manufacturing systems, as well as economic growth and development. Many economic activities, such as international trade and foreign direct investment, rely heavily on contemporary information and communications technologies (FDI). The goal of this study is to look at the dynamic relationship between FDI, ICT, trade openness, and economic growth in the context of BRICS countries from 2000 to 2018, with Gross Domestic Product as the dependent variable and Telephone subscriptions, Mobile subscriptions, Broadband subscriptions, Internet subscribers, Secure internet servers, Trade, and Foreign direct investment as the independent variables.Two variables are used as proxies to manage the macroeconomic environment, while five variables are used as proxies for ICT infrastructures. The outcomes of this study are analyzed using Generalized Methods of Movements (GMM). According to this study, ICT has a positive impact on the economic growth of a few countries. Trade openness and foreign direct investment, on the other hand, have a negative impact on economic growth. As growing countries, the BRICS must participate in economic reform and liberalization measures. This report suggests policy proposals for improving ICT standards, focusing especially on economic growth, trade openness, and increasing foreign investment in the BRICS countries.

Keywords: Information Communication Technology, Foreign Direct Investment, Economic Growth, GMM Analysis

JEL Classification Code: D80, F10, F40

1. Introduction

Literature suggests that ICT is the most critical factor for economic growth, as it has a significant impact on productivity, employment, and growth. The GDP of an economy increases by 0.75 percent with the 10 percent increase in digitization at the same unemployment rate, which will decrease by 1.02 percent. As reported by OECD, information communication technology reduces poverty by introducing new job opportunities, and it also helps to access health and education services at low costs. Advances in technology can reduce poverty by introducing new job opportunities and it also helps to access health and education services at low costs. Various components of ICT include "collecting, storing, processing, transmitting hardware, software, networks and multimedia, and displaying data (audio, data, text, images)" (World Bank, 2002).

ICT has been viewed as a vital factor for economic growth in recent years for a variety of reasons, including the ability of diverse economic players to swiftly access information and expertise through ICT. Firms have been increasing their productivity with the help of ICT by lowering their manufacturing costs through communication (Chen et al., 2018). Internet connection contributes to the long-term development of businesses and SMEs by lowering financial barriers for them by reducing information asymmetry and lowering agency costs. A considerable link between ICT and

[1]First Author. Ph.D. Scholar, School of Management and Economics (MBA Education Center), North China University of Water Resources and Electric Power, Zhengzhou, China.
Email: ahmednawazsoomoro1@gmail.com
[2]Correspond Author. Ph.D. Scholar, School of International & Public Affairs, Jilin University, Changchun, China. ORCID ID: 0000-0002-9331-7327. [Postal Address: No.2699 Qianjin Street, Changchun City, Jilin Province, 130012, China]
Email: jaikumarlohano8@gmail.com
[3]Ph.D. Scholar, Business School, Sichuan University, Chengdu, China. ORCID ID: 0000-0002-8723-2669.
Email: jotikumari1603@gmail.com

economic growth has been discovered by several academics (Bahrini&Qaffas, 2019). The ICT sector's rapid growth has boosted the economy's overall productivity by increasing the efficiency and productivity of different industries.

This research contributes to the current body of knowledge in two ways. First, the relationship between ICT development and economic growth is explored using five unique ICT development indicators, whereas most previous studies only used one or two. Second, this study focuses on developing countries; there are just a few recent studies that have looked at the relationship between ICT and economic growth in developing countries.

Our research primarily contributes in two directions. First, to reflect the whole region's scenario and not the chosen countries, we consider the latest available panel data set for BRICS nations from 2000 to 2018. These countries have a combined GDP of $37.5 trillion, which is more than 30 percent of global GDP. The reason for selecting BRICS countries (Brazil, India, China, Russia, and South Africa). By 2050, these regions' GDP is estimated to surpass that of the G7 countries.

Furthermore, there is a substantial ICT infrastructure. Second, we used the two-step GMM method proposed by Arellano and Bover (1995) and Blundell and Bond (1998), which monitors the inconsistencyand biasness of the country effect results. The GMM system is thought to be more trustworthy, systematic, and compliant when it comes to producing robust regression analysis results. Furthermore, the GMM system organizes instruments using busing level and first difference equations, which provide detailed sample size information while simultaneously increasing the number of instruments available. Even in the presence of endogenous regressors, a two-step GMM technique allows performance to be informative and acceptable in the early stages.

2. Literature Review

ICT involves using digital and electronic technology for processing knowledge, which is used to link which collaborate with the rest of the world. Numerous tests have been carried over the last two decades to examine the influenceof ICT technology on productivity growth and also on economic activities expansion and growth (Mansell & Wehn, 1998; Mtar & Belazreg, 2021). Results of the mentioned studies suggested that ICT expansion promotes the economic growth rate of different nations. Nevertheless, the findings of these studies can be grouped into two categories, with one category being the studies advocated in the context of developed nations. In contrast, the second category includes the studies carried out in the context of the developing nation. There is a considerable discrepancy between the developing and developed economies. This study focuses on the effect of ICT developments on the developing economy growth. According to the results of these studies, ICT advancement has significant and positive effects across the developed economies. On the contrary, the findings of research undertaken in the setting of middle and low-income nations around the world do not support the conclusion that there is a consistent, direct, or inverse relationship between the development of ICT financial development and economic growth (Pilat & Lee, 2001).

However, the aspect of ICT expansion in stimulating the economic growth cycle in developing economies is uncertain. This view is supported by Mtar and Belazreg (2021) in their study. Bekhet and Othman (2011) examined the relationship between ICT expansion and FDI inflow in the context of various country settings.The study's empirical findings proved that the development of ICT investment positively and significantly impacts FDI inflows. However, Veeramacheneni et al. (2007) found that increasing ICT investment had negative consequences on labor market outcomes and employment. This is due to a lack of resources available to impoverished people for the adoption of current information technology, according to Asamoah et al. (2016). As a result, more investment in ICT contributes to rising poverty and income inequities. As a result, an increase in ICT investment has a greater positive impact on developed economies than it does on developing economies. Various types of conclusions can be noticed when looking at research conducted to evaluate the relationship between FDI inflows, technology transmission, and economic growth.

Hejazi and Safarian (1999) found that foreign investment inflows play a substantial impact in growth diffusion throughout the Organization for Economic Co-operation and Development (OECD) member countries. Pilat and Lee (2001) examined the economy of the OECD and non-OECD countries from 1970 to 1990. Using techniques such as panel data regression and time series regression. The empirical findings revealed that the impact of capital inflows on indirect investment in GDP growth is dependent on the interchangeability or complementarity of domestic and foreign capital in the panel of the selected region. From 1985 to 1996, Hejazi andSafarian(1999) examined panel data collection of 24 Chinese provinces. The empirical findings indicate that the foreign capital inflow has a substantial direct effect on economic development growth, that is, on economic development. De Mello (1999) found that FDI had a direct impact on economic development in a sample of 24 developing countries around the world. In contrast, Nair-Reichert and Weinhold (2001) found no direct effects of FDI inflows on economic growth in a group of developing countries. Similarly, Alfaro (2003) stated that an increase in FDI inflow does not guarantee an increase in a country's GDP. The empirical data, in particular, showed that there were both positive and negative effects on primary and manufacturing sector production. Nair-Reichert and Weinhold (2001) found a direct impact on the growth of FDI and exports in the 66 developing countries studied. Hsiao and Hsiao (2006) looked

at data from a number of East and Southeast Asian nations and found that FDI inflows have a one-way, direct, and indirect impact on GDP through exports.

Many studies have been conducted to look at the connections between ICT and international trade. Clarke and Wallsten (2006) looked at country-level statistics to see if the availability of the internet encourages trade. As a result, they compared the economies of developed and developing countries. According to empirical findings, higher Internet penetration in developing economies is associated with more significant exports to industrial nations, but not with trade between developing economies or exports from industrial nations.In the context of selected transition economies in Eastern Europe and Central Asia, Croissant and Millo (2008) suggested that enterprises with access to the internet encourage exports more than enterprises without it.This research backs with the argument that the Internet supports globalization by making it easier for firms to connect with overseas customers and enhancing market and consumer information availability.

3. Data and Model Specification

3.1. Data

For this study, the data for developing economies-Brics was taken from the World Bank Development Indicators (WDI) from 2000 to 2018 based on post-globalization ICT data availability. Information and communication technologies likelaptops, cell phones, the Internet, ATMs, POS machines, and other electronic sources reached the members of all BRICS nations around the early 2000s is the reason for selecting the period. Table 1 presents the variable definitions, measurements, and sources of the data.

3.2. The Econometric Model

The study attempts to define the economic growth relationship between ICT infrastructures. Five variables are employed as proxies for ICT infrastructures, while two variables were used as proxies to control the macroeconomic environment (CME).

This research's major goal is to test this study's null hypothesis that there is no impact on information and communications technologies' economic growth. Nonetheless, the alternative hypothesis is that information and communications technologies significantly impact economic growth.

Based on our discussion, the given general linear regression model for panel data has been considered

$$EG_{i,t} = \alpha + \beta_1 ICT_{j,i,t} + \beta_2 CME_{k,i,t} + \mu_i + \varepsilon_{i,t}$$

Eight variables have been considered in the model: one dependent variable, five interest variables, and two control variables that are described as follows. GDP per capita (US dollars at current prices and PPPs) is a dependent variable denoted by $EG_{i,t}$ is used as a substitute for the relationship between ICT infrastructure and economic growth.

Factors of interest, which count the $ICT_{j,i,t}$ development in country i at time t, for $j = 1, \ldots, 4$, are as follows:

(1) Fixed-broadband users per 100 inhabitants (lnfbs 100), for $j = 1$;
(2) Mobile cellular users per 100 people (lnmcs100), for $j = 4$ (see details on the selected variables and the sources of data in Table 1), for $j = 2$;
(3) Fixed telephone subscriptions per 100 people, for $j = 3$;

Table 1: Description of Variables

Variables	Symbols	Measurement	Data Sources
Dependent Variable			
Per capita economic growth	PGDP	GDP per capita growth (annual percent)	WDI
Independent Variable			
Telephone subscriptions	TEL	Fixed telephone subscriptions (per 100 people)	WDI
Mobile subscriptions	MOB	Mobile cellular subscriptions (per 100 people)	WDI
Broadband subscriptions	FBB	Fixed broadband subscriptions (per 100 people)	WDI
Internet subscribers	INT	Individuals using the internet (per 100 people) (% of the population)	WDI
Secure internet servers	ISS	Secure internet servers (per 1 million people)	WDI
Trade	TR	Trade (percent of GDP)	WDI
Foreign direct investment	FDI	Foreign direct investment, net inflows (percent of GDP)	WDI

(4) Individuals using the Internet (% of population), for $j = 4$;
(5) Secure Internet servers per 1 million people, for $j = 5$;
Two control variables considered as a proxy for the macroeconomic development (CME) of country i, at time t, for $k = 1, ..., 7$ are:
(6) Foreign direct investment, net inflows (% of GDP), for $k = 1$;
(7) Trade (% of GDP), for $k = 2$;

The predicted, β_1, and β_2 are vectors incorporating the coefficients from the equations related to our four ICT interest variables. Ln prefix has been used in all coded variables, implying that the natural logarithm was used to convert the data.

4. Results and Discussion

4.1. Descriptive Statistics and Correlation Analysis

Table 2's descriptive statistics results and correlation matrix are discussed in this section. There were no concerns with the repressor correlation test (which was used to filter out strongly associated variables) (correlation coefficients were found to be below 0.8, as recommended by econometric studies). We found that GDP was positively correlated with all ICT proxies, which was consistent with our expectations. As a result, changes in ICT correlations lead to increased GDP.

Table 3 shows the Hausman test findings, which show a probability value of less than 5%, allowing us to firmly infer the fixed-effect model's application. The study used panel fixed effect regression and published the results after validating the model specification with the Hausman test; the results are listed in Table 5. The findings revealed that advances in ICT had a positive and significant impact on the economic growth of selected sample countries, with ICT proxy variables increasing by 0.04 percent (fixed broadband subscriptions), 0.56 percent (mobile cell subscriptions), 0.50 percent (fixed telephone subscriptions), and 0.01 percent (fixed telephone subscriptions) for every one percent increase in GDP per capita (secure Internet servers).

The macroeconomic variables, including trade (% of GDP) and foreign direct investments (% of GDP), negatively influence the per capita GDP. Surprisingly, the

Table 2: Descriptive Statistics Correlation Analysis

Panel A: Descriptive Statistics								
Variables	***N***	**Mean**	**Minimum**	**Maximum**	**Std. Dev.**	**Skewness**	**Kurtosis**	
GDP	95.00	6636.07	826.59	11993.48	3698.45	–0.21	1.72	
FDI	95.00	2.37	0.23	5.98	1.28	0.30	2.33	
FTS	95.00	15.89	1.62	31.79	9.15	–0.09	1.76	
FBS	95.00	5.52	0.22	28.54	7.08	1.40	4.11	
MCS	95.00	77.02	0.34	165.66	50.92	0.13	1.78	
ISI	95.00	26.42	0.52	80.86	23.15	0.62	2.11	
SIS	95.00	415.86	1.19	12034.28	1683.75	5.47	34.05	
TR	95.00	45.73	22.11	72.87	13.23	–0.31	1.99	
Panel B: Correlation Matrix								
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
LNGDP (1)	1.00							
LN(FDI) (2)	0.14	1.00						
LN(FTS) (3)	0.76	0.36	1.00					
LN(FBS) (4)	0.55	0.26	0.41	1.00				
LN(ISI) (5)	0.63	0.17	0.43	0.74	1.00			
LN(SIS) (6)	0.38	–0.16	–0.01	0.53	0.50	1.00		
LN(MCS) (7)	0.62	0.17	0.26	0.72	0.78	0.56	1.00	
LN(TR) (8)	–0.10	–0.22	–0.09	–0.03	–0.05	–0.04	0.17	1.00

Table 3: Results of Panel Fixed Effect Regression

Variables	Coefficient	Std. Error	*t*-statistic	Prob.
C	3.06	0.19	16.02	0.00***
LN(FTS)	0.50	0.08	6.45	0.00***
LN(FDI)	–0.28	0.06	–4.58	0.00***
LN(FBS)	0.04	0.04	1.05	0.30
LN(MCS)	0.56	0.06	8.95	0.00***
LN(ISI)	0.01	0.07	0.12	0.90
LN(SIS)	0.09	0.04	2.55	0.01***
LN (TR.)	–0.52	0.11	–4.53	0.00***
R-squared	0.90		Note: dependent variable: ln(GDP)	
Adjusted *R*-squared	0.86			
F statistics	24.67			
Prob. *F* statistics	0.00			
The Result of the Hausman Test				
Test Summary	**Chi-Sq. Statistic**	**Chi-Sq. Degree of Freedom**	**Prob.**	
Model: Real GDP per Capita	39.25	7	0.00	

Note: *** means significant at 10%, ** at 5%, and * at 1% level of significance.

results presented in Table 3 do not reflect the theoretical predictions made earlier in the study: FDI would be one of the major players in the growth of the economy. The same view is supported by the findings of several empirical studies (Alfaro, 2003; Hsiao & Hsiao, 2006).

The sample featured a wide range of GDP per capita at market prices, with India's lowest being 826.59 in 2000 and Brazil's highest being 11993.48 in 2013. The ICT infrastructure proxies show a large cross-country variation. Fixed broadband subscribers (FBS100) ranged from 0.22 percent in 2006 in South Africa to 28.54 percent in 2018 in Russia, with a 5.52 percent average. Fixed-broadband subscriptions per 100 people (FBS100) ranged from 0.22 percent in 2006 in South Africa to 28.54 percent in 2018 in Russia, with a mean of 5.52 percent. Fixed phone subscriptions (per 100 persons) ranged from 1.62 percent in China in 2018 to 31.79 percent in Russia in 2008, with a mean of 15.89 percent. Based on raw data, a logarithmic function was applied to all variables. The logarithmic summary statistics show that skewness and kurtosis levels have decreased, indicating that data normality is not an issue.

Table 4 shows the diagnostic tests that show the variance inflation factor (VIF) and tolerance are two statistics that are closely related when diagnosing collinearity in multiple regression. The *R*-squared value is derived by regressing a predictor on all other predictors in the analysis. The reciprocal of VIF is tolerance. VIF is less than 3, and it is even acceptable if its value is less than 10, as it shows that lower VIF values suggest little correlation among variables under ideal conditions. It can be seen from the table that all the variable values are less than 10.

Table 4: Diagnostic Test

Variables	VIF	1/VIF
LNTRADE	144.120	0.007
LNGDP	96.410	0.010
LNMCS	33.700	0.030
LNISI	14.460	0.069
LNFTS	13.750	0.073
LNSIS	3.250	0.307
LNFBS	2.730	0.366
LNFDI	2.430	0.412
Mean VIF	38.860	

4.2. Panel Unit Root Tests

Because our data set is time-series, our variables are vulnerable to the unit root process. As a result, we employ

the Im, Pesaran, Shin (IPS) and ADF - Fisher Chi-square measures, as shown in Table 5, to check for unitroots in the panel data and analyze the structure of the series' integration. Im, Pesaran, and Shin (IPS) and ADF - Fisher Chi-square tests' null hypotheses are that the underlying series have unit root (non-stationary). All variables, including GDP, FDI, TR, FTS, ISI, SIS, and MCS, were shown to be stationary at the first difference I level (1). In contrast, at the level I, the solitary variable, such as FBS, is stationary (0).

4.3. GMM Results

Our variables' robustness is tested using the GMM estimator, and all of the data is presented in Table 6. In contrast to one-step system GMM, two-step GMM results are widely considered as reliable. Furthermore, the GMM system structures instruments by using both degree and first difference equations. This technique provides detailed sample size information while simultaneously increasing the number of instruments available. The effectiveness of a two-step GMM technique provides for informative and acceptable initial conditions even in the presence of endogenous regressors. Finally, based on equations of level and difference and validity of over-identification constraint, Hansen J-test, and second-order autocorrelation tests are employed to assess the instrument's quality.

Two–step system GMM shows that FDI has a significant negative relationship with GDP per capita, indicating that

Table 5: Results of Unit Root Test

Variables	Im, Pesaran and Shin *W*-stat				A.D.F. Fisher Chi-square				Results
	Level		First Difference		Level		First Difference		
	T-stat	*P*-value	*T*-stat	*P*-value	*T*-stat	*P*-value	*T*-stat	*P*-value	
LNGDP (1)	**2.941**	0.998	–2.481	0.007	2.826	0.985	21.335	0.019**	I(1)
LN(FDI) (2)	**–1.301**	0.097	–6.122	0.000	15.890	0.103	51.534	0.000***	I(1)
LN(FTS) (3)	**–0.401**	0.344	–4.556	0.000	20.886	0.022	40.447	0.000***	I(1)
LN(FBS) (4)	**–12.009**	0.000	–13.122	0.000	58.695	0.000	52.453	0.000***	I(0)
LN(ISI) (5)	**1.620**	0.947	–3.295	0.001	20.631	0.024	30.821	0.001***	I(1)
LN(SIS) (6)	**3.942**	1.000	–3.894	0.000	2.141	0.995	30.748	0.001***	I(1)
LN(MCS) (7)	**0.704**	0.759	46.767	0.000	17.185	0.070	45.484	0.000***	I(1)
LN(TR) (8)	**1.217**	0.888	–4.452	0.000	7.945	0.634	35.588	0.000***	I(1)

Note: *** means significant at 10%, ** at 5%, and * at 1% level of significance.

Table 6: GMM Estimations Results

LnGDP	Coef.	Std. Err.	*z*	*P* > *z*	95% Conf.	Interval
LNGDP	–0.103	0.035	–2.940	0.003**	–0.172	–0.035
LNFDI	–0.376	0.033	–11.490	0.000***	–0.441	–0.312
LNTRADE	0.289	0.134	2.150	0.031**	0.026	0.553
LNMCS	0.517	0.766	6.700	0.000***	0.367	0.668
LNFBS	0.034	0.303	1.110	0.266	–0.026	0.093
LNFTS	0.568	0.360	15.760	0.000***	0.497	0.638
LNISI	–0.151	0.703	–2.150	0.031**	–0.289	–0.014
LNSIS	0.028	0.283	0.980	0.325	–0.028	0.083
_cons	2.303	0.149	15.490	0.000***	2.011	2.594

Note: *** means significant at 10%, ** at 5%, and * at 1% level of significance.

FDI decreases GDP per capita in the BRICS countries. If all other factors remain unchanged, a one percent increase in FDI reduces GDP per capita by 0.376 percent. All other variables, with the exception of SIS and FBS, show a significant positive link with GDP per capita, whereas ISI shows a significant negative relationship. To be more specific. Trade boosts the BRICS nation's GDP per capita, and all ICT indicators, such as MCS, FTS, and ISI expansion, boost the region's GDP per capita. However, the expansion of SIS and FBS in these countries will lower GDP per capita.

Table 7 shows the number of lags used to test the causality of pairwise Granger. In general, the concept is that because all preceding data is important, it is often better to have more lags than fewer. You should choose a lag period based on reasonable expectations for how long one variable may predict the other. We can't rule out the possibility that LNFTS causes LNGDP to granger, but we can rule out the possibility that LNGDP causes LNSIS to granger. As a result, it appears that causality from GDP to SIS is one-way in granger. Table 4 shows that LNTRADE does not cause LNSIS to

Table 7: Pair-wise Granger Causality Test

Null Hypothesis	Obs	*F*-statistic	Prob.
LN(FTS) does not Granger Cause LNGDP	85	5.72206	0.00
LNGDP does not Granger Cause LNFTS		0.65508	0.52
LN(FDI) does not Granger Cause LNGDP	85	0.22496	0.80
LNGDP does not Granger Cause LN(FDI)		2.58742	0.08
LN(FBS) does not Granger Cause LNGDP	85	0.33161	0.72
LNGDP does not Granger Cause LN (FBS.)		1.30829	0.28
LN(MCS) does not Granger Cause LNGDP	85	0.51757	0.60
LNGDP does not Granger Cause LN (MCS.)		2.40578	0.10
LN(ISI) does not Granger Cause LNGDP	85	0.32547	0.72
LNGDP does not Granger Cause LN (ISI.)		1.97973	0.14
LN(SIS) does not Granger Cause LNGDP	85	1.90314	0.16
LNGDP does not Granger Cause LN(SIS.)		9.21744	0.00
LN(TR) does not Granger Cause LNGDP	85	3.15604	0.05
LNGDP does not Granger Cause LN(TR.)		2.54047	0.09
LN(FDI) does not Granger Cause LNFTS	85	0.81603	0.45
LN(FTS) does not Granger Cause LN(FDI)		1.57989	0.21
LN(FBS) does not Granger Cause LNFTS	85	2.63017	0.08
LN(FTS) does not Granger Cause LN(FBS.)		1.75682	0.18
LN(MCS) does not Granger Cause LNFTS	85	2.72161	0.07
LN(FTS) does not Granger Cause LN(MCS.)		0.63711	0.53
LN(ISI) does not Granger Cause LNFTS	85	2.86819	0.06
LN(FTS) does not Granger Cause LN(ISI.)		4.73466	0.01
LN(SIS) does not Granger Cause LNFTS	85	3.81812	0.03
LN(FTS) does not Granger Cause LN(SIS.)		0.48981	0.61
LN(TR) does not Granger Cause LNFTS	85	0.36110	0.70
LN(FTS) does not Granger Cause LN(TR.)		4.12964	0.02
LN(FBS) does not Granger CauseLN(FDI)	85	1.90155	0.16
LN(FDI) does not Granger Cause LN(FBS)		3.72156	0.03
LN(MCS) does not Granger CauseLN(FDI)	85	0.05358	0.95
LN(FDI) does not Granger Cause LN(MCS)		1.69808	0.19

Table 7: (Continued)

Null Hypothesis	Obs	*F*-statistic	Prob.
LN(ISI) does not Granger Cause LN(FDI)	85	0.27486	0.76
LN(FDI) does not Granger Cause LN(ISI)		3.81006	0.03
LN(SIS) does not Granger Cause LN(FDI)	85	0.68330	0.51
LN(FDI) does not Granger Cause LN(SIS)		0.70040	0.50
LN(TR) does not Granger CauseLN(FDI)	85	0.57603	0.56
LN(FDI) does not Granger Cause LN(TR)		3.14632	0.05
LN(MCS) does not Granger Cause LN(FBS)	85	5.12895	0.01
LN(FBS) does not Granger Cause LN(MCS)		0.06895	0.93
LN(ISI) does not Granger Cause LN(FBS)	85	7.36542	0.00
LN(FBS) does not Granger Cause LN(ISI)		0.93796	0.40
LN(SIS) does not Granger Cause LN(FBS)	85	0.08703	0.92
LN(FBS) does not Granger Cause LN(SIS)		2.88363	0.06
LN(TR) does not Granger Cause LN(FBS)	85	0.51184	0.60
LN(FBS) does not Granger Cause LN(TR)		4.03567	0.02
LN(ISI) does not Granger Cause LN(MCS)	85	3.74301	0.03
LN(MCS) does not Granger Cause LN(ISI)		0.16953	0.84
LN(SIS) does not Granger Cause LN(MCS)	85	0.35674	0.70
LN(MCS) does not Granger Cause LN(SIS)		4.25889	0.02
LN(TR) does not Granger Cause LN(MCS)	85	1.43531	0.24
LN(MCS) does not Granger Cause LN(TR)		2.78237	0.07
LN(SIS) does not Granger Cause LN(ISI)	85	5.78755	0.00
LN(ISI) does not Granger Cause LN(SIS)		3.63691	0.03
LN(TR) does not Granger Cause LN(ISI)	85	0.63012	0.54
LN(ISI) does not Granger Cause LN(TR)		3.57700	0.03
LN(TR) does not Granger Cause LN(SIS)	85	12.5702	0.00
LN(SIS) does not Granger Cause LN(TR)		0.10695	0.90

Granger, but we reject this hypothesis because it provides a significant value and a probability of 0.000.Directly run the test regressions if you want to execute Granger causality tests with multiple other exogenous factors (e.g., seasonal dummy variables or linear trends) or likelihood ratio (LR) tests using equation objects.

5. Conclusion

The goal of this study is to empirically analyzethe influence of ICT infrastructure use on economic growth in BRICS countries for19 years (2000–2018). Based on GDP per capita in our study, we empirically explored how different ICT infrastructure variables affect economic growth using panel-data estimates. Foreign direct investment (FDI) and trade are two macroeconomic control variables that we used in our analysis. As a proxy for ICT development, four variables were examined: telephone subscriptions, mobile subscriptions, broadband subscriptions, internet subscribers, and secure Internet servers.

The empirical estimates reveal a positive and highly significant relationship between per capita ICT growth and GDP, but the degree of the effect varies depending on the type of technology studied. According to the findings, a 1% increase in ICT development would lead to a 0.04to 0.56 percent growth in GDP per capita(fixed-broadband subscriptions, mobile broadband subscriptions, and mobile cell subscriptions). Similarly, the results of the other three

variables used as proxies for ICT development show that ICT development has a strong and significant impact on per capita GDP growth.

Similarly, the empirical data imply that two macroeconomic variables, namely trade and FDI, have a considerable impact on per capita GDP growth at the BRICS level. These findings back up the conclusions of prior research (Nguyen, 2020; Tariq et al., 2020; Nguyen et al., 2021). According to the findings of this study, government policies should promote easy access to technology to encourage higher investment. The study's disadvantage is that it is limited to only BRICS countries. As a result, researchers will need to expand their analysis to include data from additional developing countries, such as those in the Middle East and North Africa, as well as Asia and Africa.

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