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Relationship between Technology Penetration, Financial Development and Poverty Nexus in Emerging Markets

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Abstract: Objectives: The study investigated the impact of technological penetration on poverty alleviation in emerging markets (BRICS). The study also investigated if the financial development facilitated the impact of technology on poverty in BRICS. **Prior Work:** Previous empirical research on the technology penetration-financial development-poverty nexus failed to agree, their results are divergent and conflicting. **Approach**: The study employed panel data analysis methods such as FMOLS (fully modified ordinary least squares), pooled OLS (ordinary least squares) and fixed effects. Panel data ranging from 1995 to 2021 was used in this study. **Results**: Technology penetration reduced poverty in most cases except under FMOLS, under which technology was found to have increased mortality rate. Poverty was also found to have been significantly reduced by financial development under pooled OLS (model 1 and 3), FMOLS and fixed effects (model 2 and 3). All the three panel methods show that financial development improved technology's ability to significantly reduce poverty. **Implications**: BRICS should therefore implement financial system development and technology enhancing policies to be able to decisively address poverty and all its ramifications. **Value:** The study clearly shows that developed financial markets enhances technology penetration's ability to contribute towards poverty alleviation in BRICS.

Keywords: Technology; Poverty; Financial Markets; Panel Data; BRICS

JEL Classification: C33; G15; I3; N7; P2

1. Introduction

According to IGI Global (2021), technological penetration refers to technology adaptability by the people in their everyday lives whilst Bellu and Liberati (2005) noted that poverty is the failure by the people to reach a socially acceptable standard of living. Muller (2021) argued that technological penetration alongside international trade and foreign direct investment were some of the key pillars of economic growth. In general, the benefits of technological penetration are multi-faceted, consistent with Afzal et al. (2022). From economic growth and development point of view, technological penetration promotes paperless environment thereby enhancing international trade and economic growth. Bartels et

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al. (2007) argued that technological diffusion boosts productivity through efficiency and customised based information technology equipment. Kocsis (2020) revealed that technology penetration helps to reduce poverty and income inequality between rural and urban set ups. It is therefore without doubt that technological penetration is a key driver of economic growth, from a theoretical point of view.

Several empirical researches have been done to explore the impact of technology on poverty. They produced conflicting and divergent findings. Some supported the technology-led poverty reduction (Afzal et al., 2022; Muchdie, 2016; Mateko, 2024; Dunga, 2019; Zhao et al., 2025; Jin & Deng, 2024; Das & Chatterjee, 2023; Awad, 2023; Dzator et al., 2023; Kakeu et al., 2024; Garg et al., 2025; Huang et al., 2023). Others noted that technology increases poverty, namely Xiao et al. (2024), Dirk (2021), and Malika (2022). The feedback view between technology and poverty reduction was also supported by Mateko and David (2022). Some empirical research noted that the impact of technology on poverty happens through some channels such as the financial sector, economic growth, employment, among others. The view was supported by Ahsan and Afzal (2022), Mushtaq and Bruneau (2019), and May et al. (2014). These mixed results indicate that more empirical investigations still need to be carried out on the subject matter.

This study contributes towards literature in the following ways. This is the first study to explore the role of financial development in the technology-poverty nexus in BRICS. This study used more recent data set available (1995-2021). Majority of existing research on technology-led poverty hypothesis focused on individual countries. This study exclusively focused on BRICS countries. This study complements extant literature on technology-poverty nexus by exclusively focusing on technological penetration's impact on poverty. Current empirical research which considered this conditional effect on the influence of technology on poverty are quite scant. There is also a paucity of empirical research exploring technological penetration's influence on poverty in BRICS. Technological penetration in BRICS is still below the desired levels whilst poverty is still high, therefore such a study contributes not only towards literature but also on the development of sustainable economic development policies. Moreover, majority of the existing empirical research on technological penetration led poverty reduction did not use internet penetration as the proxy of technology. May et al. (2014) noted that the indirect ways in which technological penetration influences poverty have not been fully probed in the literature. This study fills in these gaps.

Section 2 describes and analyse literature review, Section 3 explains research methodology whilst Section 4 presents results of trend analysis, correlation and descriptive statistics. Section 5 is the discussion of results. Section 6 concludes. The reference list is Section 7.

2. Literature Review

There are four theoretical perspectives explaining the influence of technological penetration on poverty, in line with Afzal et al. (2022). Technological penetration reduces per capita cost of keeping a certain level of standard of living thereby enabling households to escape poverty. Orokpo and Ochanja (2017) argued that technological penetration aids the creation of a value chain, widens employment opportunities and enhances income generation, all of which results in poverty alleviation. Aklin et al. (2018) noted that technological penetration spurs not only rural development but also the narrowing of

rural-urban technology gaps and income inequality. The increase in the use of nanotechnology is paramount in increasing per capita income and poverty reduction, consistent with Abid et al. (2019).

According to Dzator et al. (2023), two schools of thought on the influence of technological penetration on poverty emerges. Firstly, technological penetration enhances poverty reduction, and this was supported by several authors. Technology induced economic growth helps to reduce poverty through its ability to enhance employment opportunities, domestic investment and household consumption (Anyanwu, 2014). Yang et al. (2021) also noted that technological advancement and penetration spurs the creation and uptake of employment opportunities by cutting information asymmetry in the job market. Employment opportunities triggered by technology enhances household income figures hence improving wealth, welfare and poverty alleviation (Ma & Wang, 2020).

According to Cheng et al. (2021), technology advancement reduces transaction costs and information asymmetry in the financial market thereby allowing easy access to credit for developmental projects among the people. Challenges such as logistical, information and credit constraints in the market are easily addressed at a low cost in an environment characterised by technological advancement thereby quickening poverty alleviation (Yang et al., 2021). The same author noted that financial knowledge acquisition is facilitated by technological advancement thereby preserving the people from asset poverty. Technology advancement facilitates easy and fast acquisition of employable skills through online platforms, argued Zheng and Lu (2021).

Secondly, also widely supported is the school of thought which says that technological penetration increases poverty. For example, Moll et al. (2022) argued that technological penetration can sharply push up returns on wealth thereby widening income inequality and increasing poverty among the people. Their study also noted that new technology brings along income and wage stagnation at the lower end of income distribution thereby increasing poverty among the people. Galperin and Viecens (2017) argued that technological advancement pushes forward the skilled bias perspective, where technological penetration result in the increased demand for skilled labour force whilst unskilled labour is displaced. Income for skilled labour goes up whilst income of non-skilled labour declines, a scenario which increases not only income inequality but poverty as well.

Several empirical studies on technology-led poverty have been undertaken. They produced varied results as shall be seen next. Afzal et al. (2022) examined internet-poverty-income inequality nexus in developing countries using the system generalized methods of moments with panel data spanning from 2005 to 2020. Technology penetration increased both poverty and income inequality in low-income countries. In middle income countries, poverty and income inequality went down in response to technological penetration. Using dynamic system generalised method of moment (GMM) with panel data ranging from 2010 to 2019, Dzator et al. (2023) investigated whether leveraging technology for poverty alleviation happened in Sub-Saharan African countries. Information and communication technology (ICT) goods imported, mobile phone and telephone penetration led to poverty alleviation whilst ICT goods exported, broadband and internet penetration were found to have contributed towards poverty increase across all age groups and gender.

A study by Muchdie (2016) examined the role of technology on poverty reduction in Indonesia using SEM-Path analysis techniques with annual time series data spanning from 2004 to 2013. The first path noted that the positive influence of technology change on poverty decrease was not significant. The

second, third and fourth paths revealed that technological change had a significant positive influence on poverty reduction. Employing principal component analysis with panel data spanning between 2008 and 2019, Kakeu et al. (2024) examined the role of technology innovation on poverty reduction in SSA countries. Four different set of results were observed. The use of aggregate data shows that technology innovation reduced poverty in SSA countries. Technology innovation led to poverty reduction in countries characterised by low urbanization rates whilst the opposite was true for countries with high urbanization levels. In 30 percent of the cases, technological innovation's positive influence on poverty alleviation occurred through the productivity improvement of the industrial sector. In 62.5 percent of the cases, poverty reduction triggered by technological innovation happened through the agricultural sector productivity channel.

A study by Xiao et al. (2024) on the role of technological change on income inequality, poverty and human interactions in developing and developed countries used the common correlated effect mean group approach. Panel data used ranged from 1995 to 2020. The study used panel causality test and augmented mean group approach for robustness checks of the results. Technological innovation was found to have increased poverty and the effect was more pronounced in developed countries. The study also noted that the interaction between technology and variables such as globalization, economic growth and international trade exacerbated poverty in both developing and developed countries. Using auto-regressive distributive lag (ARDL) with time series (annual) data ranging from 1992 to 2020, Mateko (2024) explored the linkage between information and communication technology and poverty in Nigeria. The study noted that information and communication technology had a fifty percent chance of contributing towards poverty alleviation in Nigeria both in the short and long run.

Garg et al. (2025) examined the influence of digital technology on poverty using a bibliometric review approach with a sample of two hundred and fifty-eight publications extracted from scopus database (1982-2023). The existence of mixed information on digital technology's influence on poverty implies that there is still a lot of empirical investigation to be done. The study also noted that lack of access to information and communication technology inhibits opportunities for social networking, work and entrepreneurship hence directly affecting people's livelihoods. Employing multi-regression model with 2017 household survey data, Dunga (2019) studied the role of technology on poverty in South Africa. The study noted that technology managed to contribute towards poverty reduction in South Africa.

Huang et al. (2023) examined the long-term effect of internet on poverty among smallholder farmers in China using a multi-regression model with survey data of the H province extracted between October and November 2021. Internet information and penetration was found to have long term positive effects on poverty alleviation among smallholder farmers in China. Both formal and informal social support played a key role in mediating internet technology's impact on poverty alleviation in China. Using multi-regression model and 2020 China rural revitalization survey data, Zhao et al. (2025) carried out a study to investigate the nexus between digital technology and rural poverty in China. Digital technology played a big role in positively influencing poverty reduction efforts in rural China. Entrepreneurial activity was found to be effective in enabling digital technology to reduce poverty among the poor in rural China. The study also noted that digital technology contributed more towards poverty vulnerability in the plains and eastern regions of rural China.

Jin and Deng (2024) used China's 2018 household survey data and multi-regression analysis to investigate the impact of digital technology on poverty among urban households. The study noted that

failure to keep up with the dictates of digital technology lead to digital technology gap, income inequality and higher chances of living in poverty among the urban households in China. High level of family financial support and households headed by low education individual were found to more likely succumb to digital poverty in urban China. Employing a two-step system GMM methodology with panel data ranging from 2003 to 2019, Awad (2023) examined the mechanisms through which information technology influences poverty in SSA countries. The study noted that technology development and innovation managed to reduce poverty through per capita income and employment mechanisms whilst environmental mechanism influenced technology innovation's negative impact on poverty alleviation in SSA countries.

Das and Chatterjee (2023) studied the nexus between technology innovation, income inequality and poverty in India using the ordered probit model. The digital finance's influence on the relationship between the variables was also explored. Information and communication technology were found to have reduced poverty levels in both rural and urban areas. Banking sector development in the form of digital finance was found to have facilitated technological innovation induced poverty reduction in India in both urban and rural areas.

Employing an extensive literature review analysis, Dasanayaka (2013) explored the history of technology development and the relationship between technology and poverty in the context of Sri Lanka. The study concluded that in many ways, technological innovation and penetration in Sri Lanka played a massive role in contributing towards poverty eradication. Rizqulloh and Firmansyah (2021) examined the relationship between poverty and information technology in the thirty-four provinces of Indonesia. Fixed effects and ordinary least squares (OLS) were used in this study. Across all provinces of Indonesia studied, information and communication technology were found to have meaningfully contributed to poverty alleviation.

Uzair et al. (2024) explored the role of technological change on employment levels in Pakistan using fully modified least squares (FMOLS). The study used time series data spanning from 2000 to 2020. It was revealed that technological changes and innovation was critical in improving employment levels and poverty reduction in Pakistan. The study also noted that research and development is of paramount importance in terms of smoothening technology's role in generating employment opportunities. A study done by Dirk (2021) noted that digital technology was exploited by foreign powers to destabilise less developed countries thereby exacerbating poverty. Some governments in Africa cut off access to these digital technologies during elections time to facilitate rigging thereby entangling their countries in never ending political disputes.

Using fixed effects and panel data spanning from 2000 to 2019, Malika (2022) examined the nexus between ICT and poverty in the MENA (middle east and north African) region. The study revealed that information and communication technology had a negative effect on poverty reduction because of the prevalence of civil wars, political instabilities and technological delays in the MENA region. Asongu and Agyemang-Mintah (2025) examined the nexus between poverty, internet penetration and income inequality in fifty-seven developing countries using panel data (2012-2016) analysis. Income inequality was found to have increased poverty levels in developing countries. However, internet penetration and virtual social networks facilitated income inequality to have a positive influence on poverty reduction efforts.

Ye et al. (2022) employed quantile regression with data ranging from 2011 to 2020 to explore the financial technology-led poverty reduction in the thirty-one provinces of China. Financial technology reduced poverty in all the thirty-one provinces of China, even though financial development index for the regions were uneven. Employing panel data (1990-2019) analysis, Lechman and Popowska (2022) examined the influence of digital technology on poverty in lower-middle and low-income countries. Information and communication technology penetration in schools was found to have driven poverty downward during the period under study. Employing the multinomial endogenous switching model with 2012, 2014 and 2016 survey data, Biru et al. (2020) explored the influence of agricultural technologies on poverty alleviation among smallholder farmers in Ethiopia. The usage of multiple complementary technologies by smallholder farmers resulted in an increase in consumption expenditure and consequently poverty reduction. Household poverty and vulnerability was sharply decreased because of the use of multiple complementary technology by the smallholder farmers.

Sahu and Das (2015) employed cross sectional data analysis and 2014 household survey data to investigate agricultural technology's impact on poverty in India. Sensitivity analysis was used for robust tests and found out that agricultural technology led to poverty reduction in rural India. Tsaurai and Chimbo (2020) examined the nexus between technology, education and poverty in BRICS using panel data (1994-2015) analysis. Information and communication technology reduced poverty under fixed effects. Mateko and David (2022) examined the nexus between technological innovation and poverty reduction in Zimbabwe using ARDL approach. The study used time series data (1989-2019). Information and communication technology were found to have enhanced economic growth in Zimbabwe. A bi-directional relationship between information and communication technology and poverty reduction in Zimbabwe.

Oshota (2019) explored the linkage between technology access and poverty alleviation in Nigeria using error correction model (ECM) with time series data (1980-2024). Access to technology had a significant positive influence on poverty alleviation and inclusive growth in Nigeria. Employing multi-regression model with household survey (2018-2019), Ahsan and Afzal (2022) studied the nexus between information technology, women empowerment and poverty in Pakistan. The empirical investigation noted that information technology played a key role in reducing poverty. Internet access led to poverty alleviation through creating entrepreneurial and employment opportunities. Roongsrisoothiwong (2024) examined the impact of financial technology on poverty in Southeast Asian countries. The study used Pearson correlation and linear regression and panel data spanning from 2018 to 2021. Financial technology was found to have led to poverty reduction in both low and middle-income countries. In summary, empirical research produced findings which are mixed, divergent and different. This is evidence that more empirical investigation on the relationship between technological penetration and innovation on poverty alleviation.

3. Methodology

The study used secondary panel data for BRICS (Brazil, Russia, India, China, South Africa) countries spanning from 1995 to 2021. International Monetary Fund, World Development Indicators, Reserve Bank of South Africa and Africa Development Bank are the databases from which the data was

extracted. The major advantages of these databases are that they are reliable, always up to date, data is publicly viewable and consistency.

Equation 1 summarises the general model specification, whose dependent variable is poverty (POV). Explanatory variables include technology (TECH), financial development (FIN), foreign direct investment (FDI), trade openness (OPEN), human capital development (HCD), remittances (REMIT) and savings (SAV).

POV=f (TECH, FIN, FDI, OPEN, HCD, REMIT, SAV) [1]

Empirical research done by Afzal et al. (2022), Roongsrisoothiwong (2024), Oshota (2019), Mateko and David (2022), Sahu and Das (2015), Biru et al. (2020), Lechman and Popowska (2022) influenced the inclusion of these explanatory variables in equation 1. In this study, poverty was measured by life expectancy at birth, total (years), household consumption expenditure (% of gross national product) and infant mortality rate (per 1,000 live births), consistent with an earlier study done by Ye et al. (2022). Individuals using the internet (% of population) is the proxy of technology used.

Financial development was measured by domestic credit to private sector as a ratio of GDP whereas trade openness was proxied by total trade as a ratio of GDP. Human capital development index is the proxy of human capital development employed whilst remittances were measured using personal remittance received as a ratio of GDP. Gross domestic savings as a ratio of GDP was used as a measure of savings. The use of these proxies is consistent with earlier studies done by Ye et al. (2022), Asongu and Agyemang-Mintah (2025), Dirk (2021), Uzair et al. (2024), Rizqulloh and Firmansyah (2021).

Control variables are summarised in Table 1.

Table 1. Control variables

Variable	Theory explanation	Expected direction of influence
FIN	Stiglitz (1998) argued that financial development allows the financially excluded people to get access small loans to enable self-employment and commencement of entrepreneurial projects. This reduces poverty levels among the people.	-
FDI	Nguyen (2003) noted that FDI alleviates poverty through foreign capital injection, skills improvement and employment creation (Nguyen, 2003). On the contrary, Amin (1974) argued that over dependence on FDI in the long run retards economic growth, distorts income distribution and increases poverty.	+/-
OPEN	Trade openness spur national income and poverty reduction through its ability to open new markets, promote trade, introduce new products and remove international trade barriers (Pradhan & Mahesh, 2024). One of the results that Maluleke and Vacu-Ngqila (2024) observed is that trade openness increased poverty (proxied by household consumption expenditure)	-
HCD	Chaudhry and Rehman (2009) argued that human capital development enables the people to get employment and decent salary through its ability to promote education, skills acquisition and good health. On the other hand, Afzal et al. (2010) noted that in the short run, human capital development increases poverty. This is because the money channelled towards human capital development should have been directed towards social security programmes in the short run.	-

REMIT	Anyanwu and Erhijakpor (2010) noted that remittances reduce poverty because it facilitates the inflow of liquidity towards poor households in the labour sending country (for education, skills development and entrepreneurial projects). On the other hand, Cattaneo (2005) argued that remittances promote laziness and overreliance among recipients hence leading to economic growth stagnation in the long run.	+/-
SAV	Karlan et al. (2017) argued that savings if invested can enable the people to have a steady passive income hence reducing poverty levels. Savings can be channeled towards paying school fees, supplement food expenditure and useful during rainy days.	-

Source: Author

When transformed into an econometric equation, equation 1 becomes equation 2. The uniqueness of equation 2 is that it includes the complementarity function (TECH x FIN) as one of the explanatory variables affecting poverty. Earlier studies which included the complementarity variable include Cheng et al. (2021). It helps to explore whether technology influence poverty through the financial development channel, consistent with Yang et al. (2021).

$$POV_{it} = \beta_0 + \beta_1 TECH_{it} + \beta_2 FIN_{it} + \beta_3 (TECH_{it} . FIN_{it}) + \beta_4 FDI_{it} + \beta_5 OPEN_{it} + \beta_6 HCD_{it} + \beta_7 REMIT_{it} + \beta_8 SAV_{it} + \mu + \varepsilon \quad [2]$$

The interaction variable (TECH x FIN) captures the fact that financial development accelerates the technology penetration triggered poverty reduction. A significant negative value of β_4 means that financial development increased technology's influence on poverty reduction, in line with Mateko (2024). The latter argued that domestic credit assist to avail capital and liquidity to upcoming businesses, small scale business sector and even to established ones so that they can easily acquire advanced and modern technological equipment for their production purposes. The result is that ICT linked small business and wider business sector can expand, create jobs, increase employment opportunities, enhance distribution and poverty reduction. According to Cheng et al. (2021), technology advancement reduces transaction costs and information asymmetry in the financial market thereby allowing easy access to credit for developmental projects among the people.

4. Trend Analysis, Correlation Analysis and Descriptive Statistics

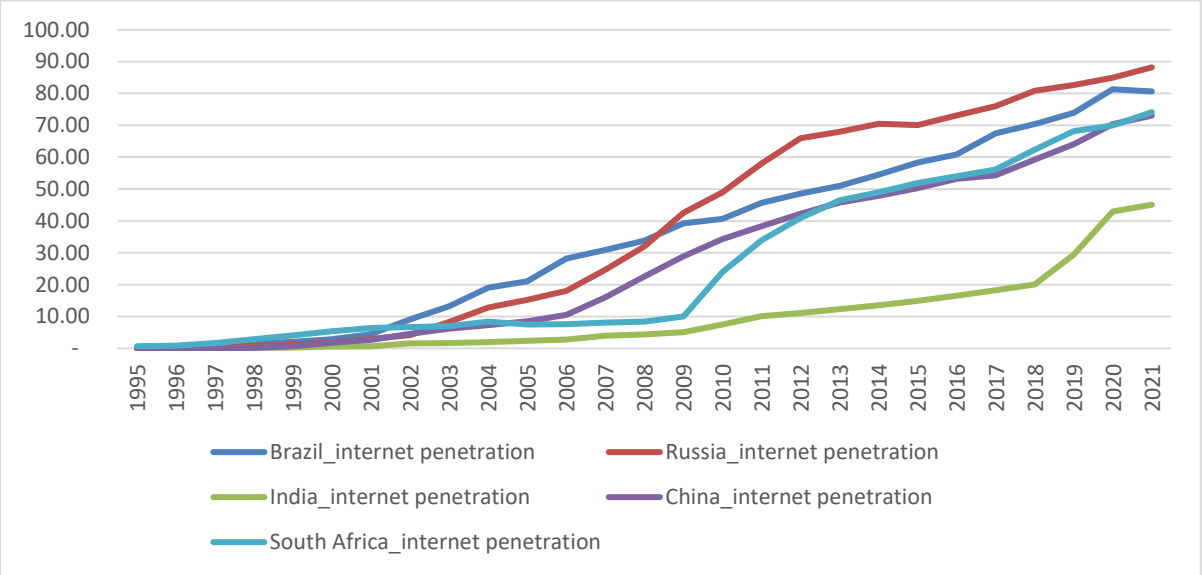

Figure 1. Individuals using the internet (% of population) trends for BRICS

As can be seen in Figure 1, internet penetration for all the BRICS countries show a gradual increasing trend from 1995 to 2009. BRICS countries then began to experience a sharp increase in internet penetration from the year 2009 to 2021. Between 2009 and 2021, it is also clear that Russia experienced the highest level of internet penetration, followed by Brazil, then South Africa, China and India, in that chronological order. Between 2009 and 2012, China's internet penetration rate was higher than in South Africa, before South regained the lead from the year 2013 to 2021. Another point to note is that India's internet penetration rate consistently lagged other BRICS countries from the year 2000 to 2021. However, the biggest gap in internet penetration between India and its peers is evidently (see Figure 1) between year 2009 and 2021.

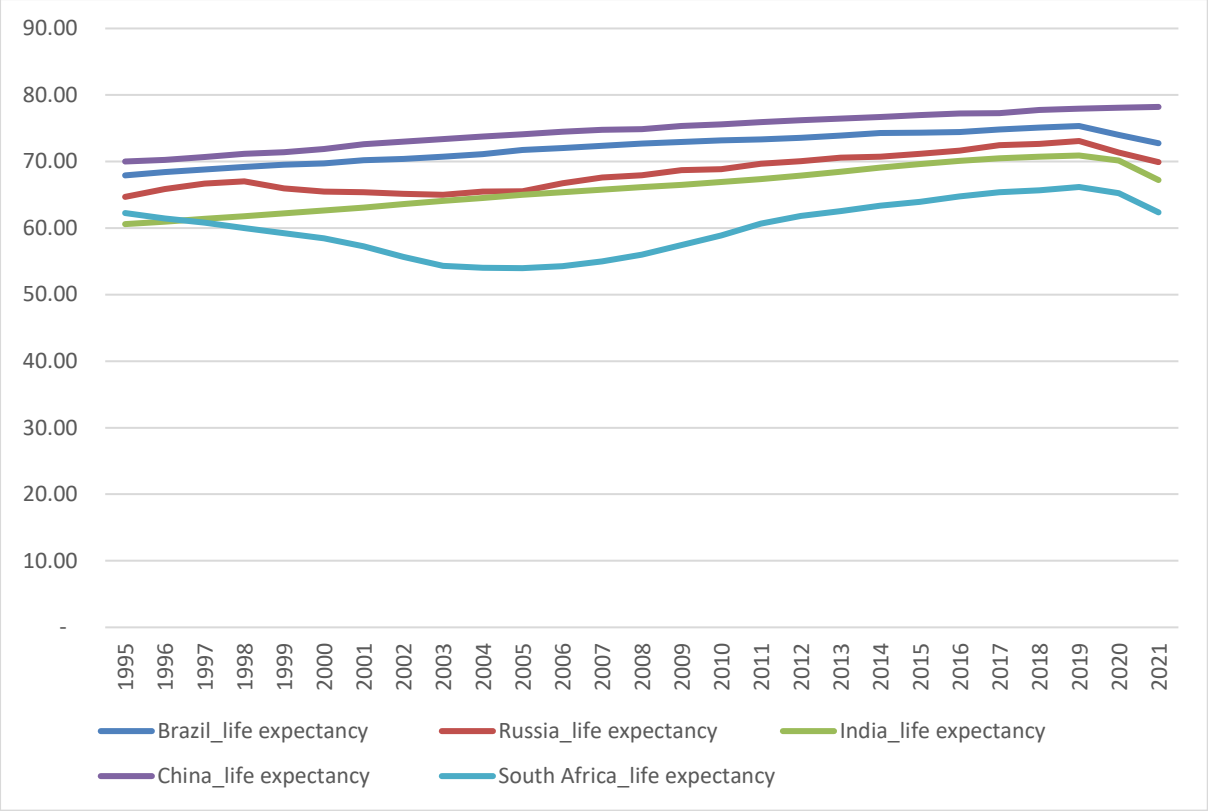

Figure 2. Life expectancy at birth, total (years) trends for BRICS

Looking at Figure 2, it is evident that China's life expectancy consistently was above that of its BRICS peers between the period from 1995 to 2021. China's life expectancy ranged from 70 years and above whilst life expectancy for the remaining BRICS countries was less than 70 years during the entire period between 1995 and 2021. Consistently during the period between 1995 and 2021, China had the highest life expectancy, followed by Brazil, then Russia, India and then South Africa, in that chronological order. Also, worthwhile to note is that South Africa's life expectancy was slightly above 60 years between 1995 1997 and then dropped below 60 years between 1998 and 2021. Life expectancy for Brazil, India and Russia ranged between 60 years and 70 years. Life expectancy for all BRICS countries during the period between 1995 and 2021 is showing a consistent marginal increase.

Both technology (proxied by internet penetration) and life expectancy for BRICS countries show a positive upward trend during the period under study (1995-2021). The major weakness of trend analysis is that it is unable to precisely determine whether technology development is related to the general drop in poverty (increase in life expectancy) in BRICS countries. To address this weakness, the study carried out statistical investigations as shown in the following sections.

Table 2 presents correlation results. There is no multi-collinearity in the data set because all the correlation values are below 70%, in line Stead (2007)'s argument.

Table 2. Correlation

	POV	TECH	FIN	FDI	OPEN	HCD	REMIT	SAV
POV	1.00							
TECH	0.47***	1.00						

FIN	-0.16*	0.31***	1.00					
FDI	0.35***	0.09	-0.08	1.00				
OPEN	-0.25***	0.04	0.17*	-0.06	1.00			
HCD	0.46***	0.48	-0.05	0.21**	0.05	1.00		
REMIT	-0.15*	-0.27***	-0.29***	-0.26***	-0.05	-0.70***	1.00	
SAV	0.50***	-0.02	-0.06	0.16*	0.33	0.02	0.08	1.00

Source: Author

Descriptive statistical results are presented in Table 3. Data is not normally distributed, in line with the Jarque-Bera criterion's corresponding probabilities.

Table 3. Descriptive statistics

	POV	TECH	FIN	FDI	OPEN	HCD	REMIT	SAV
Mean	68.24	27.41	65.02	2.29	42.44	0.71	0.79	28.14
Median	69.19	15.23	52.74	2.03	45.64	0.72	0.25	28.09
Maximum	78.21	88.21	266.61	9.66	69.39	0.84	4.17	51.09
Minimum	53.98	0.01	13.67	0.23	15.64	0.48	0.03	14.87
Standard. deviation	5.89	27.22	39.62	1.46	12.85	0.08	1.13	10.25
Skewness	-0.51	0.65	1.48	1.21	-0.24	-0.60	1.63	0.59
Kurtosis	2.67	1.98	6.73	6.35	2.11	2.58	3.96	2.30
Jarque-Bera	6.49	15.25	127.46	96.14	5.76	9.22	64.63	10.71
Probability	0.04	0.00	0.00	0.00	0.06	0.00	0.00	0.00
Observations	135	135	135	135	135	135	135	135

Source: Author

5. Discussion of Results

Transforming all data sets into natural logarithms to address the problem of abnormal distribution of data is consistent with Aye and Edoja (2017). This is what was done before panel unit root tests and main data analysis was performed.

Table 4. Panel stationarity - Individual intercept

Level stage				
	Levin et al (2002)	Im et al (2003)	ADF (Augumented Dick Fuller)	PP (Phillip Perron)
POV	-3.64***	-1.16	14.49	17.85
TECH	-8.91***	-6.58***	59.62***	94.96***
FIN	-1.33*	0.80	7.00	6.04
FDI	-1.42*	-2.38***	22.79**	40.01***
OPEN	-1.56*	-0.86	11.06	8.93
HCD	-2.97***	-2.52***	23.25***	33.10***
REMIT	-14.41***	-9.83***	54.91***	47.34***
SAV	-1.41*	-1.68**	17.57*	10.96
First difference stage				
POV	-5.24***	-4.19**	22.47**	45.66***
TECH	-2.04**	-2.05**	19.21**	34.44***
FIN	-7.38***	-1.98**	18.22*	56.36***
FDI	-4.14***	-6.98***	62.72***	106.87***
OPEN	-3.62***	-4.34***	38.34***	73.40***
HCD	-9.86***	-9.72***	89.08***	108.39***

REMIT	-7.81***	-8.24***	74.10***	75.97***
SAV	-2.59***	-3.75***	34.70***	58.74***

Source: Author

All data sets were stationary at first difference (integrated of order 1).

Table 5. Johansen Fisher's approach

Hypothesised number of co-integrating equations	Fisher's trace test	Probability	Fisher's max-eigen test	Probability
None	781.2	0.0000	123.7	0.0000
At most 1	280.9	0.0000	249.5	0.0000
At most 2	260.8	0.0000	135.0	0.0000
At most 3	170.0	0.0000	86.30	0.0000
At most 4	112.3	0.0000	49.75	0.0000
At most 5	73.66	0.0000	43.10	0.0000
At most 6	46.11	0.0000	37.26	0.0001
At most 7	26.88	0.0027	26.88	0.0027

Source: Author

Table 5 confirmed the existence of a long run relationship among the variables studied. Such results paved way for main data analysis whose results are presented in Table 6, 7 and 8.

The main results are arranged according to model 1, model 2 and model 3. Model 1 used life expectancy, model 2 employed infant mortality rate whilst model 3 used household consumption expenditure as proxies for poverty.

Table 6. Fixed effects

	Model 1	Model 2	Model 3
TECH	0.01	0.02	0.001
FIN	0.004	-0.08*	0.05***
TECH.FIN	0.001*	-0.05***	0.75**
FDI	0.0002**	0.02	0.001
OPEN	0.04***	0.31	0.002
HCD	0.45***	-0.46***	0.1
REMIT	-0.001	-0.04*	-0.02
SAV	-0.06***	-0.70***	-0.38***
Prob (F-statistic)	0.0000	0.0000	0.0000
F-statistic	82.39	197.21	199.38
Adjusted R-squared	0.64	0.59	0.67

****, ** and * denote 1%, 5% and 10% levels of significance, respectively.*

Source: E-Views

Technology had a non-significant positive impact on life expectancy (model 1) and household consumption expenditure (model 3) under the fixed effects and FMOLS. Pooled OLS shows that technology significantly improved both household consumption expenditure and life expectancy in models 1 and 2. These results indicates that technology reduced poverty in BRICS nations, consistent with Anyanwu (2014) whose study argued that technology induced economic growth helps to reduce poverty through its ability to enhance employment opportunities, domestic investment and household consumption.

Fixed effects indicate that technology non-significantly increased infant mortality whilst FMOLS and pooled OLS observed that infant mortality rate was pushed up by technology in a significant manner. These results show that technology led to an increase in poverty, in line with an argument put forward by Moll et al. (2022) whose study revealed that technological penetration can sharply push up returns on wealth thereby widening income inequality and increasing poverty among the people.

Financial development's impact on life expectancy under fixed effects and FMOLS was found to be positive and non-significant whilst a bi-directional relationship running from financial development towards life expectancy under the pooled OLS was found to be significant. Financial development had a significant deleterious effect on infant mortality under fixed effects and FMOLS. These results show that financial development reduced poverty, in agreement with an argument by Stiglitz (1998) who argued that financial development allows the financially excluded people to get access small loans to enable self-employment and commencement of entrepreneurial projects. In contradiction to available literature, financial development significantly increased infant mortality under the pooled OLS, results which means that the financial system led to poverty increase.

Table 7. Fully modified ordinary least squares (FMOLS)

	Model 1	Model 2	Model 3
TECH	0.006	0.20***	0.06
FIN	0.02	-0.22***	0.06***
TECH.FIN	0.002*	-0.09***	0.56*
FDI	0.0005	0.01	0.001
OPEN	0.05*	0.29**	0.01
HCD	0.26***	-1.46***	0.02
REMIT	-0.01	-0.01	-0.01
SAV	-0.13***	-0.36**	-0.37***
Prob (F-statistic)	0.0000	0.0000	0.0000
Adjusted R-squared	0.71	0.68	0.60

****, ** and * denote 1%, 5% and 10% levels of significance, respectively.*

Source: E-Views

The complementarity between technology and financial development had a significant enhancing influence on both household consumption expenditure and life expectancy under the fixed effects, FMOLS and pooled OLS. On the other hand, the complementarity variable had a significant deleterious influence on infant mortality across all the three econometric methods used. All these results show that the complementarity between technology and financial management significantly reduced poverty, in support of an argument proffered by Mateko (2024). They also resonate with Cheng et al. (2021) who noted that technology advancement reduces transaction costs and information asymmetry in the financial market thereby allowing easy access to credit for developmental projects among the people.

Table 8. Pooled ordinary least squares (POLS)

	Model 1	Model 2	Model 3
TECH	0.32***	0.38***	0.44***
FIN	0.27***	0.45***	0.38***
TECH.FIN	0.64***	-0.14***	0.02**
FDI	-0.02	0.04	-0.07
OPEN	0.26***	0.58***	0.57***

HCD	0.81	-0.54***	0.07***
REMIT	-0.08**	-0.03	-0.05
SAV	0.55***	-0.61***	0.01
Prob (F-statistic)	0.0000	0.0000	0.0000
Adjusted R-squared	0.55	0.59	0.64

****, ** and * denote 1%, 5% and 10% levels of significance, respectively.*

Source: E-Views

FDI's influence on life expectancy was found to be positive and significant under fixed effects. A non-significant positive relationship running from FDI towards (1) life expectancy (FMOLS) and (2) household consumption expenditure under fixed effects and FMOLS. The results mean that FDI reduced poverty levels in BRICS, in agreement with Nguyen (2003) whose study argued that international foreign capital reduce poverty through skills improvement, foreign capital injection and employment creation (Nguyen, 2003).

According to pooled OLS, FDI non-significantly influenced life expectancy and household consumption expenditure in a negative manner whilst FDI's impact on infant mortality (model 2) was found to be positive and non-significant. These results are consistent with Amin (1974) whose study noted that FDI contributes towards an increase in poverty if it is over relied on.

Trade openness's impact on life expectancy was positive and significant across all three econometric methods. On the other hand, trade openness non-significantly enhanced household consumption expenditure under fixed effects and FMOLS whilst pooled OLS indicates a significant positive relationship running from trade openness towards household consumption expenditure. The results resonate with Pradhan and Mahesh (2024) whose study noted that trade openness enhances poverty reduction. Trade openness had a significant positive effect on infant mortality under FMOLS and pooled OLS whilst fixed effects shows a non-significant enhancing influence of trade openness on infant mortality. These results show that trade openness increases poverty, an argument that was supported by Maluleke and Vacu-Ngqila (2024)'s findings.

Fixed effects and FMOLS show that human capital development significantly enhanced life expectancy whilst pooled OLS indicates a non-significant positive relationship running from human capital development towards life expectancy. Human capital development's impact on household consumption expenditure was found to be positive and significant under the pooled OLS. FMOLS and fixed effects produced results which show a non-significant positive relationship running from human capital development towards household consumption expenditure. All the three econometric methods noted that human capital development significantly reduced infant mortality in BRICS countries. The results agree with Chaudhry and Rehman (2009) argued whose empirical research noted that human capital development is necessary for poverty alleviation.

Fixed effects and FMOLS shows that remittances non-significantly affected life expectancy in a negative way whilst pooled OLS indicates a significant negative relationship running from remittances towards life expectancy. Remittances also negatively influenced household consumption expenditure in a non-significant manner across all three econometric methods. These results support views which says that remittances increase poverty, in line with Cattaneo (2005) whose study noted that remittances

promote laziness and overreliance among recipients hence leading to economic growth stagnation in the long run.

Fixed effects show that remittances had a significant negative impact on infant mortality whereas FMOLS and pooled OLS indicates that infant mortality rate was negatively affected by remittances in an insignificant way. These results support theoretical arguments which says that remittances reduce infant mortality rates and poverty, in line with Anyanwu and Erhijakpor (2010).

FMOLS and fixed effects shows that savings had a significant negative influence on both life expectancy and household consumption expenditure. These results mean that savings reduced household consumption expenditure and life expectancy, hence increasing poverty in BRICS countries. These results contradict the available literature. Pooled OLS observed that savings significantly improved life expectancy and non-significantly increased household consumption expenditure, in line with a theoretical argument put forward by Karlan et al. (2017) argued that savings if invested can enable the people to have a steady passive income hence reducing poverty levels.

6. Conclusion

The study had two objectives. Firstly, it investigated the impact of technological penetration on poverty alleviation in BRICS. Secondly, it explores if technological penetration affects poverty through the financial sector channel. In other words, the study investigated if the financial development facilitated the impact of technology on poverty in BRICS. The study employed panel data analysis methods such as FMOLS, pooled OLS and fixed effects. Panel data ranging from 1995 to 2021 was used in this study. Across all three econometric methods, technology penetration reduced poverty in most cases except under FMOLS, under which technology was found to have increased mortality rate. Poverty was also found to have been significantly reduced by financial development under pooled OLS (model 1 and 3), FMOLS and fixed effects (model 2 and 3). All the three panel methods show that financial development improved technology's ability to significantly reduce poverty. BRICS should therefore implement financial system development and technology enhancing policies to be able to decisively address poverty and all its ramifications. A study focused on examining threshold levels of technology necessary to significantly influence poverty reduction in BRICS is an area recommended for further study.

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