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# Impact of FDI on Human Capital Development in BRICS. Does Technology Infrastructure Matter?

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**Abstract**: **Objectives:** The paper studied the influence of FDI on human capital development and also if technology infrastructure is a channel or an absorption capacity influencing FDI's impact on human capital development in BRICS. **Prior Work**: There is no consensus in the results and findings relating to empirical research on FDI's impact on human capital development. **Approach:** Fixed effects and fully modified ordinary least squares (FMOLS) are the two-panel data (1995-2021) analysis methods employed. **Results:** Fixed effects (models 1 and 2) observed a significant positive relationship running from FDI towards human capital development. Fixed effects (model 3) shows that FDI had a significant negative effect on human capital development. All the three models under FMOLS noted an insignificant deleterious effect of FDI on human capital development. Models 1and 3 (fixed effects and FMOLS) and model 2 (fixed effects) noted that the complementarity between FDI and technology significantly improved human capital development. **Implications**: BRICS countries are therefore urged to develop and implement policies which are geared towards improving FDI inflows and strengthening technology infrastructure to ensure human capital development. **Value:** The study indicates that technological diffusion is important in ensuring that FDI's positive effect on human capital development in BRICS is significant.

**Keywords:** Foreign Direct Investment; Technology; Human Capital; BRICS

**JEL Classification:** F21; J24; N7; P2

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## 1. Introduction and Background of the Study

Endogenous growth theory as postulated by Romer (1986) argues that human capital which is embodied by knowledge, skills and technological advancement is an integral part of economic growth and development. Abbas (2001) also noted that economic growth and development without a developed human capital base is too far-fetched. According to Borensztein (1998), foreign direct investment (FDI) aids the development of human capital through its ability to bring skills, technology, training and physical capital into the host country. Nguyen (2020) even argued that no meaningful human capital development can occur in the host country without substantial amount of FDI inflow.

Endogenous growth theory also argued that FDI inflow into the host country results in knowledge spill overs, managerial skills and new advanced technology, all of which leads to enhanced human capital development (Javorcik, 2004). This endogenous growth theory's explanation of the impact of FDI on human capital development has been widely supported by researchers such as Kokko (2002), Slaughter (2002), Romer (1986), Subbarao (2008), and Hoffman (2003). The explanation was contradicted by Markusen and Venables (1999) who noted that FDI crowds out domestic investment by displacing it thereby stifling not only economic growth, but investment efforts earmarked at human capital development. They further argued that most developing countries lacks necessary absorption capacities required to ensure FDI enhances human capital development. In response to these theoretical contradictions, several empirical research works have been done to help resolve this conundrum.

Findings from empirical research on the influence of FDI on human capital development falls into five categories. Firstly, is the category which supports the view that FDI enhances human capital development (Emako et al., 2023; Ramashu, 2021; Azam et al., 2015; Henok & Kaulihowa, 2021; Liu, 2022; Mbang, 2022). Secondly, the perspective that FDI negatively affect human capital development was supported by empirical researchers such as Ibarra-Olivo (2024), Henok and Haulihowa (2021), Mbang (2022), Zhuang (2017), and Ehi (2022). Thirdly, FDI and human capital development were found to have influenced each other by Miyamoto (2003). Fourthly, empirical researchers such as Emako et al. (2023), Gupta et al. (2017), Djokoto and Wongnaa (2023), and Nguyen et al. (2020) found no relationship between FDI and human capital development. Fifthly, Shakirudeen and Sodik (2024) and Nguyen et al. (2024) found results which shows that certain absorption capacities are required in the host country before FDI can have any meaningful influence on human capital development. These diverging, conflicting and mixed results shows that the influence of FDI on human capital development is far from being a settled matter in development finance.

Nguyen et al. (2024) and Shakirudeen and Sodik (2024) produced results which supports that presence of absorption capacities is critical to enable significant FDI's enhancing influence on human capital development to occur. Lee et al. (1994) noted that one of these absorption capacities is technology infrastructure transfer. The technology infrastructure as an absorption capacity is also in line with endogenous growth theorists such Solow (1956) and Romer (1986). Empirical research work which included technology infrastructure as a channel or an absorption capacity that facilitates FDI's positive influence on human capital development are quite scant. To the author's best knowledge, there is only a single study done by Lee et al. (1994) which investigated if technology transfer was a channel through which FDI affects human capital development. The study done by Lee et al. (1994) is now outdated as the research was done three decades ago. It focused strictly on developing countries. This study focuses on BRICS countries and uses most recent panel data (1995-2021).

The paper is organized as follows in the ensuing sections. Section 2 is literature discussion and analysis. Section 3 presents, describes and justifies the research methodological framework used. Section 4 is trend analysis and pre-estimation diagnostics. Section 5 presents and discusses main results of the study. Section 6 concludes the study and proposes areas which still requires attention on the subject matter. Reference list is summarized in section 7.

## 2. Literature Review

Consistent with Henok and Kaulihowa (2022), two theories that anchor the discussion of FDI's impact on human capital development include the neoclassical and endogenous theories. The neo classical theory regards FDI as foreign savings or additional capital stock channelled towards a host country and is meant to bring along short term economic growth and development (Solow, 1956). The theory also argued that the inflow of FDI brings increased capabilities and technological advancements that eventually results in improved human capital development.

According to Kokko (2002) and Slaughter (2002), the endogenous theory postulates that FDI provides direct funding to enhance human capital development in host countries. Romer (1986) argued that foreign knowledge spill over associated with FDI inflow enhances human capital development, which is pivotal to long term economic growth of the host country. In other words, FDI brings along with it advanced technology, new knowledge and skills transferred to the local workforce hence boosting human capital development efforts in the host country, argued Henok and Kaulihowa (2022). Consistent with Subbarao (2008), FDI demands that the local workforce must acquire more technical skills commensurate with high level technology used. The fact that skilled labour force is then handsomely compensated

gives the local workforce incentives to acquire more education, training and skills thereby boosting human capital development (Henok & Kaulihowa, 2022, p. 270).

Hoffman (2003) argued that foreign direct investors (multinational companies) provide funding and technical support to local institutions of higher learning, promotes on the job training and avails technical assistance, all of which enhances employee productivity and human capital development. Additionally, tax revenue base collected from multinational companies can be used by the government not only to promote human capital development earmarked projects but to spur economic growth processes of the host country.

Theoretical literature on the influence of FDI on human capital development is not without its own mixed signals. Markusen and Venables (1999) argued that FDI can also crowd out domestic investment via the displacement channel, hence not favourable to the long-term economic growth of the host country. In some instances, some host countries lack various capacities that enable FDI to be used to stir productive economic growth processes. It is for this reason that the net influence of FDI requires further econometric introspection.

Empirical research on the influence of FDI on human capital development is discussed in the next few paragraphs. Emako et al. (2023) employed the dynamic panel data (2005-2018) research methodology to examine FDI's impact on human capital development in developing countries. Results of the study show that developing countries experienced a surge in human capital development in direct response to an increase to FDI. Moreover, disaggregated data indicates that FDI in the primary and tertiary economic sectors had a very minimal and negligent effect on human capital development. Employing multi-regression analysis with time series data (2006-2016) analysis, Ibarra-Olivo (2024) examined the nexus between human capital development and FDI in Indonesia and Vietnam. The study noted that FDI in production and headquarters contributed in the decline of human capital development (technical skills) in these South-eastern Asian nations. The same study also observed that FDI in sales, logistics and support services led to accelerated levels of human capital development in both Vietnam and Indonesia.

Employing the spatial Durbin model with panel data (1996-2019), Ramushu (2021) studied the effect of FDI on human capital development in Sub-Saharan Africa (SSA). The non-spatial model produced results which supported the FDI-led human capital development hypothesis. Using the two-stage approach for managing endogeneity, FDI was observed to have had a deleterious influence on human capital development in SSA. Kheng et al. (2017) examined the interrelationship between FDI and human capital development in developing nations with panel data spanning from 1980 to 2011. A feedback relationship between human capital development and FDI was supported by the results of the study.

Gupta et al. (2017) studied the relationship between human capital development and FDI using panel data analysis with time series data (1975-2013) in Indian States. The results show that FDI had no influence on human capital development. They also indicate that human capital development had not impact on FDI distribution across the various states of India. Rajab et al. (2022) employed panel data (1995-2019) analysis to estimate the FDI-human capital development-growth nexus in Arab Maghreb nations. The interaction between FDI and human capital development was observed to have had an enhancing influence on economic growth in these Arab Maghreb nations.

Using developing economies as a unit of analysis, Azam et al. (2015) examined the relevance of FDI-led human capital development hypothesis. The study employed fixed effects approach with panel data starting from 1981 to 2013. A statistically positive influence of FDI on human capital development was confirmed in the case of developing economies. Henok and Kaulihowa (2021) used feasible general least squares with panel data (1990-2018) to examine how human capital development in Southern African Customs Union (SACU) countries is affected by FDI. FDI enhanced human capital development in SACU countries when school enrolment at primary level is used as a proxy. When secondary education enrolment was used as a measure of human capital development, FDI negatively affected human capital development in SACU nations. The study also noted that a threshold level of human capital development is necessary in the FDI-led human capital development hypothesis.

Djokoto and Wongnaa (2023) studied the relationship between FDI and human capital development in developed, emerging and developing countries using panel data (1990-2019) analysis. FDI's impact on human capital development was found to be neutral in developed and transition economies. For developing economies, FDI's influence on human capital development was positive and significant. Employing panel city level data (1990-2005), Liu (2022) examined the influence of FDI on human capital accumulation in China. The study noted that manufacturing FDI data accelerated the accumulation of human capital in China. Specifically, FDI was found to have contributed to university and high school enrolment because of its influence on salaries of skilled and educated personnel.

Employing vector error correction model (VECM) with time series data (1995-2019), the nexus between FDI and human capital development was explored in Cameroon by Mbang (2022). In the long run, FDI enhanced human capital development through its ability to open up new access to international markets. In the short run, FDI negatively affected the development of human capital mainly because at that stage, export revenues are not yet utilized for development of human capital. The FDI's impact on human capital development through technology transfer channel in East Asia was also examined by Zhuang (2017) using panel data

(1985-2010) analysis. The study observed FDI's positive influence on secondary schooling whereas tertiary education was deleteriously affected by FDI in the same study. What was unique about the study is that FDI emanating from OECD group of nations enhanced both secondary and tertiary schooling in East Asian countries.

Miyamoto (2003) discussed the theoretical literature on the relationship between FDI and human capital development in developing countries. The study noted that FDI-led human capital view, feedback view and neutral hypothesis were supported. Lee et al. (1994) used panel data analysis to examine FDI's relationship with technology transfer, human capital development and economic growth in developing countries. FDI's influence on human capital development and economic growth was positive and enhanced through technology transfer.

Ehi (2022) examined the influence of FDI on human capital development in Nigeria using autoregressive distributive lag (ARDL) with time series data (1986-2020). The study observed a statistically insignificant negative influence of FDI on human capital development in Nigeria. Economic growth, exchange rate, trade openness and inflation rate were also found to have significantly improved human capital development in Nigeria during the period under study. Employing ARDL with time series data (1990-2017), Vinh (2019) studied the relationship between human capital, FDI and labour productivity in Vietnam. Both in the short and long run, labour productivity and human capital development in general were found to have been positively enhanced by FDI. Nguyen et al. (2020)'s investigation of the impact of FDI on human capital development in ASEAN nations using panel data (1990-2019) analysis methods. The study observed that FDI was a catalyst that triggered human capital development in ASEAN nations. Whilst increased life expectancy had a neutral impact on human capital, investment in education was directly involved in enhancing human capital development in ASEAN countries.

Employing the dynamic panel data (1970-2010) analysis, Hills (2013) explored the paradox between FDI and human capital development in developing nations. The study confirmed that FDI positively improved the various types of human capital development such as primary school average years, educational attainment, secondary schooling average years and higher education to total population ratio. Sharma and Gani (2004) used fixed effects to examine FDI's impact on human capital development in both low income and middle-income nations. Panel data used by the study ranged from 1975 to 1999. In both set of countries, the study produced results which show a statistically positive influence of FDI on human capital development. Sozuer (2023) examined the impact of FDI on labour productivity in Turkey's industrial firms (27 industries) using multi-sectional data (2011-2019) analysis. The study noted that FDI into Turkey enhanced intra-industry spill overs and consequently overall labour productivity in the whole economy.

Shakirudeen and Sodik (2024) studied influence of FDI on human capital development at firm level in Nigeria using panel data analysis approach. The study noted that FDI spill overs were of paramount importance in enhancing human capital and skills development. The study also noted that country related conditions were important in deciding the host county readiness to enjoy FDI related human capital development spill overs. Critical literature review analysis was used by Naros (2019) to explore the linkage between FDI and human capital development. The study noted that the productivity of FDI enhanced labour intensity and quality. Nguyen et al. (2024) examined FDI, employment and human capital development nexus in Asia-Pacific countries using dynamic system generalized methods of moments (GMM) with panel data which ranged from 1990 to 2020. The study noted that FDI was instrumental in enhancing employment and quality of human capital development. It also observed that labour quality played a moderating role in improving FDI's impact on human capital development.

## 3. Methodology

The study used panel data (1995-2021) obtained from World Development Indicators. The database's advantage is that it is publicly accessible, reliable and cheaper to extract data. BRICS was used as a focal point in this study because of its geo-political importance in global economics. Equation 1 sums up the general model representation of the human capital development function, consistent with Emako et al. (2023), Nguyen et al. (2024), Naros (2019), Shakirudeen and Sodik (2024), Sharma and Gani (2004), Hills (2013), Nguyen et al. (2020), and Ehi (2022).

$$HCD = f(FDI, TECH, REMIT, OPEN, FIN, SAV, INFL) \quad [1]$$

Where human capital development is the dependent variable (HCD), FDI is the independent variable whereas TECH (technology infrastructure), REMIT (personal remittances), OPEN (trade openness), FIN (financial development), SAV (savings) and INFL (inflation) are control variables in the model. Empirical studies such as Vinh (2019), Mbang (2022), Zhuang (2017), Djokoto and Wongnaa (2023), Liu (2022), Azam et al. (2015), Gupta et al. (2017), and Ibarra-Olivo (2024) played an influencing role in determining the choice of control variables inclusion.

Table 1 summarizes the theoretical rationale of each control variable.

**Table 1. Control variables' theoretical rationale**

| Variable | Theoretical rationale | Direction of impact |
|---|---|---|
| Technology infrastructure | Technology infrastructure platforms facilitates education, training and acquiring of skills in schools and workplaces (Zaborovskaia et al., 2020). The | + |

| | | |
|---|---|---|
| | authors also noted that technology infrastructure and digitalization enable the efficient utilization of human capital resources within the firm. | |
| Personal remittances | Personal remittances inflow into households is mostly directed towards training, health, education, argued Acharya and Leon-Gonzalez (2014). The same author noted that remittances inflow ensures that more children spent majority of their time in schools and training institutions. On the contrary, Mansuri (2006) argued that despite remittance inflows send by the parents from abroad, guardians channel away these financial resources from education and training of children towards their own preferences. | +/- |
| Trade openness | A positive impact of trade openness on human capital development was confirmed by Binder and Georgiadis (2011). Its influence on human capital development was noted to exceed that of physical capital, government consumption and economic growth. | + |
| Financial development | Kargbo et al. (2016) explained that developed financial markets offer meaningful educations and skills development loans hence promoting human capital development. The effective utilization of these human capital development tailored loans is higher in countries characterised by developed financial markets. | + |
| Savings | Bacha (1990) argued that savings promotes investment and economic growth through its ability to increase the amount of liquidity in the economy. The same author noted that savings leads to more lending towards investment related activities such as human capital investment. | + |
| Inflation | Temple (2000) noted that in a high inflation environment, people's focus tends to shift towards financially related speculative activities and shun away from long term social investment such as human capital development. De Gregorio (1992) also argued that high inflation constrains people from investing in human capital development because of weaker purchasing power of their earnings. | - |

*Source: Author*

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

Human capital development function is econometrically shown in equation 2. The equation includes the influence of complementary variable (FDI x TECH) on human capital development, as confirmed by Lee et al. (1994) that FDI improved human capital development and economic growth in developing countries through the technology transfer channel. Theoretically, technology transfer as a channel through which FDI enhances human capital development has been argued and supported by Solow (1956), Romer (1986), Henok and Kaulihowa (2022), Subbarao (2008), and Hoffman (2003) - see section 2 on theoretical literature review.

If the coefficient of the complementary variable ($\beta_3$) is significantly positive, the interpretation is that human capital development is significantly enhanced by the interaction between FDI and technology infrastructure in BRICS. It also implies that FDI enhances human capital development through the technology infrastructure channel. Equation 2 was estimated by fixed effects approach because it is superior in allowing researchers to manage omitted variables due to time invariance (Boateng et al., 2017). The FMOLS panel research method was employed for robustness checks which can manage simultaneity bias and improving heterogeneity checks in co-integrated panels.

Consistent with Boateng et al. (2017), the choice between using random or fixed effects was done using the Hausman test (refer to Table 8). The Hausman methodology tests the alternative hypothesis that estimated coefficients of fixed effects are different from the random effects estimation coefficients (Boateng et al., 2017, p. 310). The positive and insignificant value of Wald test (see Table 8) indicated absence of heteroscedasticity in the fixed effects model whilst the opposite is true for random effects, in line with Boateng et al. (2017). These results provided the basis for choosing fixed effects ahead of random effects.

## 4. Trend Analysis and Pre-Estimation Diagnostics

Figure 1 presents trends for FDI net inflows, from the year 1995 to 2021.

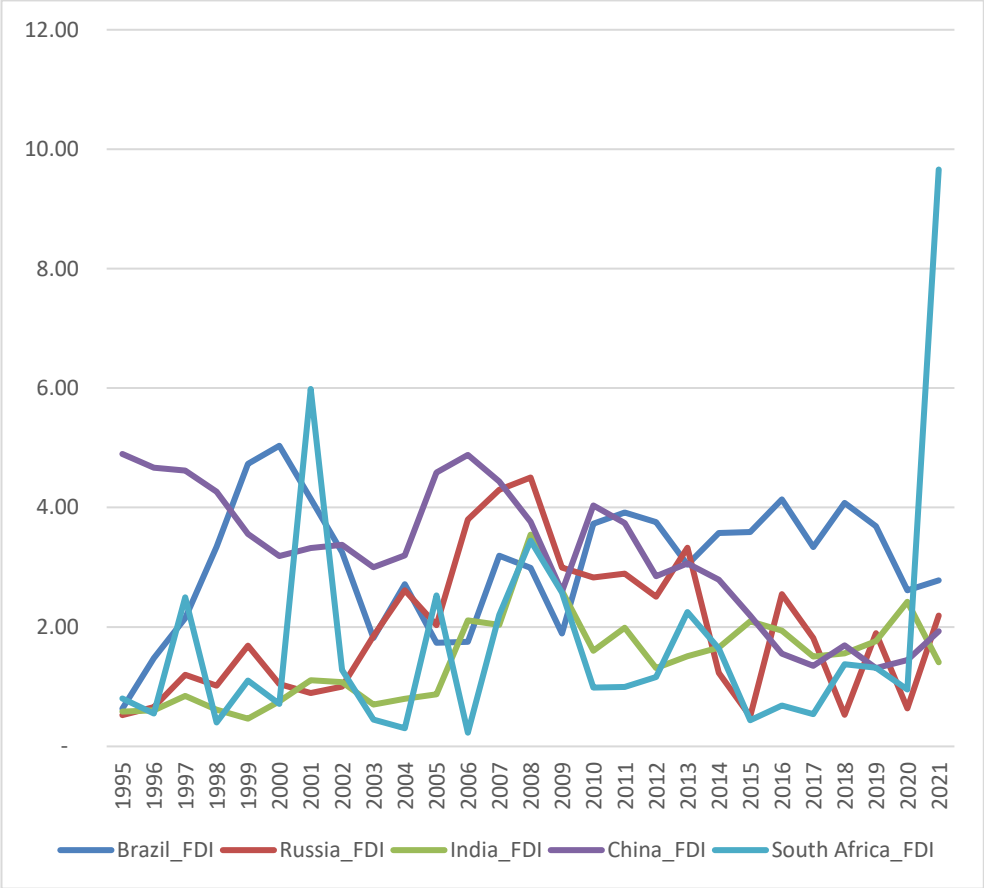


**Figure 1. Net foreign direct investment inflows for BRICS countries (1995-2021)**

South Africa's net FDI inflow went up from 0.80% of GDP in 1995 to 5.98% of GDP in 2001, declined by 3.78 percentage points between 2001 and 2007 and marginally increased by 0.05 percentage points during the six-year period, from 2007 to 2013. Net FDI inflow for South Africa plummeted from 2.25% of GDP in 2013 to 1.32% of GDP in 2019 before massively going up by 8.34 percentage points during the subsequent two-year period (2019-2021) to end the year 2021 at 9.66% of GDP.

Regarding China's net FDI inflow, it went down from 4.90% of GDP in 1995 to 3.32% of GDP in 2001, increased by 1.11 percentage points between 2001 and 2007, declined by 1.37 percentage points between 2007 and 2013, further went down by 1.75 percentage points between 2013 and 2019 before making a rebound of 0.62 percentage points between 2019 and 2021 to end the period at 1.93% of GDP.

For India's net FDI inflow, it increased from 0.58% of GDP in 1995 to 1.11% of GDP in 2001, further went up by 0.93 percentage points between 2001 and 2007 before plummeting by 0.52 percentage points during the subsequent six-year period (2007-2013). India's net FDI inflow went up from 1.51% of GDP in 2013 to 1.76% of GDP in 2019 before registering a negative growth of 0.35 percentage points between 2019 and 2021.

Net FDI inflow for Russia increased from 0.52% of GDP in 1995 to 0.90% of GDP in 2001, went up by 3.40 percentage points between 2001 and 2007, declined by 0.97 percentage points between 2007 and 2013 before further decreasing by 1.43 percentage points during the subsequent six-year period (2013-2019). Russia's net FDI inflow then experienced a rebound, from 1.89% of GDP in 2019 to 2.19% of GDP in 2021.

Brazil's net FDI inflow went up from 0.63% of GDP in 1995 to 4.15% of GDP in 2001, declined by 0.96 percentage points between 2001 and 2007 before experiencing a further negative growth of 0.15 percentage points during the subsequent six-year period (2007-2013). Net FDI inflow for Brazil increased from 3.04% of GDP in 2013 to 3.68% of GDP in 2019 and then declined by 0.90 percentage points during the two-year period, from 2019 (3.68% of GDP) to 2021 (2.78% of GDP).

Figure 2 diagrammatically presents human capital development trends for BRICS, from the year 1995 to 2021.

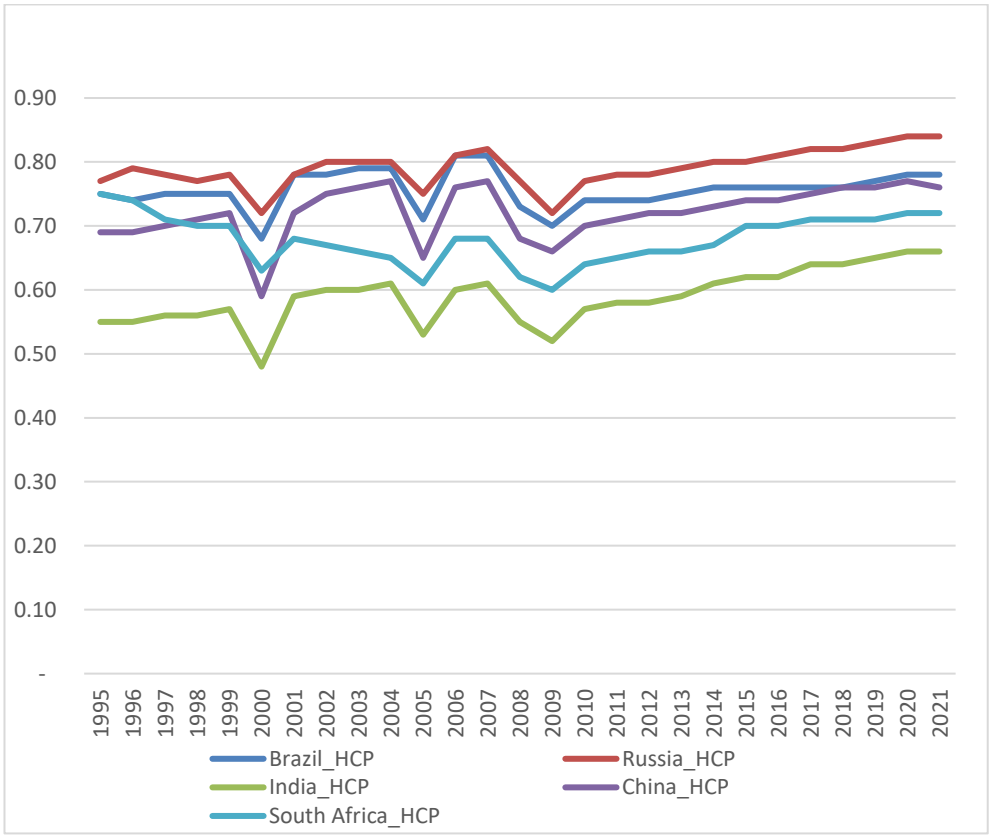


**Figure 2. Human capital development trends for BRICS countries (1995-2021)**

What is clear looking at Figure 2 is that the human capital development trends for BRICS nations followed a similar pattern during the period from 1995 to 2021. In other words, Figure 2 shows that human capital development for all BRICS nations took a slump around the years 2000 and 2001, 2005 and 2006 and then 2009 and 2010.

What is also visible in Figure 2 is that all BRICS nations experienced a steady growth in human capital development index between the year 1995 and 2000. Another steady increase in human capital development index was observed between year (1) 2001 and 2005 and (2) 2006 and 2009. Figure 2 indicates that from 2011 until 2021, human capital development index has been on a steady rise for all BRICS nations.

Table 2 shows correlation results, whose weakness is that they do not indicate the direction of causality between variables. It is clear in Table 2 that multi-collinearity

problem does not exist as all the correlations were below 70%, consistent with Stead (2007).

**Table 2. Analysis of correlation results**

| | HCD | FDI | TECH | REMIT | OPEN | FIN | SAV | INFL |
|---|---|---|---|---|---|---|---|---|
| HCD | 1.00 | | | | | | | |
| FDI | 0.21** | 1.00 | | | | | | |
| TECH | 0.48*** | 0.09 | 1.00 | | | | | |
| REMIT | -0.7*** | -0.26*** | -0.27*** | 1.00 | | | | |
| OPEN | 0.05 | -0.06 | 0.04 | -0.05 | 1.00 | | | |
| FIN | -0.05 | -0.08 | 0.31 | -0.29 | 0.17* | 1.00 | | |
| SAV | 0.02 | 0.16 | -0.02 | 0.07 | 0.33*** | -0.06 | 1.00 | |
| INFL | 0.13 | -0.17** | -0.20** | -0.07 | 0.14 | -0.26*** | -0.05 | 1.00 |

*Source: Author*

**Table 3. Statistics of descriptive in nature**

| | HCD | FDI | TECH | REMIT | OPEN | FIN | SAV | INFL |
|---|---|---|---|---|---|---|---|---|
| Mean | 0.71 | 2.29 | 27.41 | 0.79 | 42.44 | 65.02 | 28.14 | 9.15 |
| Median | 0.72 | 2.03 | 15.23 | 0.25 | 45.64 | 52.74 | 28.09 | 5.68 |
| Maximum | 0.84 | 9.66 | 88.21 | 4.17 | 69.39 | 266.61 | 51.09 | 197.41 |
| Minimum | 0.48 | 0.23 | 0.01 | 0.03 | 15.64 | 13.67 | 14.87 | 0.01 |
| Standard. deviation | 0.08 | 1.46 | 27.22 | 1.13 | 12.85 | 39.62 | 10.25 | 19.25 |
| Skewness | -0.60 | 1.21 | 0.65 | 1.63 | -0.24 | 1.48 | 0.59 | 7.73 |
| Kurtosis | 2.58 | 6.35 | 1.98 | 3.96 | 2.10 | 6.73 | 2.30 | 71.36 |
| Jarque-Bera | 9.22 | 96.14 | 15.25 | 64.63 | 5.76 | 127.46 | 10.71 | 27631 |
| Probability | 0.01 | 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*

According to Table 3, all the data for the variables used is not normally distributed. This is because the Jarque-Bera criterion's probability values are zero, in line with Tsaurai (2018). The use of data in natural logarithms for main data analysis was done to address the effects of extreme values, abnormally distributed data and multi-collinearity problem, consistent with Aye and Edoja (2017).

## 5. Results Presentation and Discussion

Results of panel stationary tests are shown in Table 4. Not all variables were stationary at first difference whilst the data for all the variables used was integrated of order 1. This is consistent with Odhiambo (2015).

**Table 4. Panel stationarity tests - Individual intercept**

| Level stage | | | | |
|---|---|---|---|---|
| | Levin et al. (2002) | Im et al. (2003) | ADF (Augumented Dick Fuller) | PP (Phillip Perron) |
| LHCD | -2.97*** | -2.52*** | 23.25*** | 33.10*** |
| LFDI | -1.42* | -2.38*** | 22.79** | 40.01*** |
| LTECH | -8.91*** | -6.58*** | 59.62*** | 94.98*** |
| LREMIT | -14.41*** | -9.83*** | 54.91*** | 47.34*** |
| LOPEN | -1.56* | -0.86 | 11.06 | 8.93 |
| LFIN | -1.33 | 0.80 | 7.00 | 6.04 |
| LSAV | -1.41* | -1.68** | 17.57* | 10.96 |
| LINFL | -2.45*** | -3.78*** | 33.40*** | 52.92*** |
| First difference stage | | | | |
| LHCD | -9.86*** | -9.72*** | 89.08*** | 108.39*** |
| LFDI | -4.14*** | -6.98*** | 62.72*** | 106.87*** |
| LTECH | -2.04** | -2.05** | 19.21** | 34.44*** |
| LREMIT | -7.81*** | -8.24*** | 74.10*** | 75.97*** |
| LOPEN | -3.62*** | -4.34*** | 38.34*** | 73.40*** |
| LFIN | -5.27*** | -1.98** | 18.22* | 56.36*** |
| LSAV | -2.59*** | -3.75*** | 34.70*** | 58.74*** |
| LINFL | -7.55*** | -7.91*** | 71.88*** | 131.22*** |

*Source: Author*

Results of panel co-integration test (see Table 5) indicates that at most seven co-integrating relationships were observed. Paving for main data analysis to occur, the results confirm the existence of a long run relationship among the variables, consistent with Ayenew (2022, p. 6).

**Table 5. Johansen Fisher's approach**

| Hypothesised number of co-integrating equations | Fisher's trace test | Probability | Fisher's max-eigen test | Probability |
|---|---|---|---|---|
| None | 760.6 | 0.0000 | 138.3 | 0.0000 |
| At most 1 | 268.7 | 0.0000 | 294.1 | 0.0000 |
| At most 2 | 228.3 | 0.0000 | 121.0 | 0.0000 |
| At most 3 | 139.4 | 0.0000 | 66.72 | 0.0000 |
| At most 4 | 89.06 | 0.0000 | 51.40 | 0.0000 |
| At most 5 | 47.12 | 0.0000 | 28.66 | 0.0014 |
| At most 6 | 28.77 | 0.0014 | 21.91 | 0.0156 |
| At most 7 | 23.69 | 0.0085 | 23.69 | 0.0085 |

*Source: Author*

Fixed effects (Table 6) and Table 7 (FMOLS) presented main data analysis next.

**Table 6. Fixed effects**

| | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| FDI | 0.02*** | 0.03** | -0.02** |
| TECH | 0.04*** | 0.06*** | 0.04*** |
| FDI.TECH | 0.09*** | 0.09*** | 0.003* |
| REMIT | -0.002 | 0.005 | -0.01** |
| OPEN | 0.01 | 0.004 | -0.02 |
| FIN | 0.01 | 0.01 | 0.06*** |
| SAV | 0.07** | 0.10*** | 0.06* |
| INFL | 0.001 | -0.003** | 0.002 |
| Prob F-statistic | 0.00 | 0.00 | 0.00 |
| F-statistic | 100.07 | 55.90 | 82.29 |
| Adjusted R-squared | 0.64 | 0.57 | 0.67 |

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

*Source: E-Views*

The difference between model 1, 2 and 3 is that they each used a different proxy of technology infrastructure. Model 1 used individuals using the internet (% of population), model 2 employed fixed telephone subscriptions (per 100 people) whilst model 3 used mobile cellular subscriptions (per 100 people).

Under fixed effects, in model 1 and 2, FDI significantly enhanced human capital development, consistent with the endogenous theorists (Slaughter, 2002; Kokko, 2002) who argued that FDI avails funds that are directly used to improve human capital development in host countries. The results also resonate with Romer (1986)'s assertion that foreign knowledge spill over which comes along FDI improves human capital development in the host country. Model 3 however observed that FDI had a significant negative influence on human capital development, in line with literature which says that FDI crowds outs domestic investment and it cannot not lead to human capital development if the host country does not have certain absorption capacities (Markusen & Venables, 1999). Across all the three panel methods, technology infrastructure had a significant enhancing effect on human capital development, in support of Zaborovskaia et al. (2020) who argued that technology infrastructure platforms facilitate education, training and acquiring of skills in schools and workplaces.

The interaction between FDI and technology infrastructure had a significant positive influence on human capital development across all the three models. The results mean that technological infrastructure was found to be a channel through which FDI improved human capital development in BRICS. In other words, technology infrastructure is an absorption capacity in BRICS which enhanced FDI's positive impact on human capital development. The findings resonate with Lee et al. (1994)'s findings whose study noted that technology transfer was an avenue through which FDI enhanced human capital development in developing nations.

Under FMOLS, FDI had an insignificant negative impact on human capital development across all the three models. The results mean that FDI's influence on human capital development was negative, consistent with Markusen and Venables (1999)'s crowding out theoretical perspective. Model 1 and 3 indicates that technology infrastructure significantly enhanced human capital development whilst model 2 shows that technology infrastructure had a non-significant positive effect on human capital development. The results are in line with Zaborovskaia et al. (2020) whose study noted that technology and digitalization not only facilitated training, education and skills acquisition and retention but also ensured that human capital resources available are efficiently utilized.

The complementarity between FDI and technology infrastructure significantly improved human capital development in model 1 and 3. Model 2 indicates that the complementarity variable non-significantly enhanced human capital development. These results support Lee et al. (1994)'s findings and theorists (Romer, 1986; Solow, 1956; Hoffman, 2003) who explained that FDI flows along with it some technological advancement, technical skills and spill overs, which all facilitates the development of human capital in the host country.

**Table 7. FMOLS**

| | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| FDI | -0.001 | -0.02 | -0.02 |
| TECH | 0.02*** | 0.003 | 0.02*** |
| FDI.TECH | 0.08** | 0.07 | 0.003* |
| REMIT | -0.02 | 0.01 | -0.02 |
| OPEN | 0.02 | 0.07** | -0.01 |
| FIN | 0.03 | 0.04 | 0.08* |
| SAV | 0.08* | -0.06* | -0.12* |
| INFL | 0.01* | 0.002 | 0.01* |
| Prob | 0.005 | 0.0001 | 0.003 |
| Observations | 135 | 135 | 135 |
| Number of countries | 5 | 5 | 5 |
| Adjusted R-squared | 0.71 | 0.57 | 0.65 |

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

*Source: E-Views*

Model 1 under both fixed effects and FMOLS and model 3 under FMOLS shows that personal remittances non-significantly reduced human capital development whilst model 3 under fixed effects indicates that personal remittances significantly decreased human capital development. The results are in line with Mansuri (2006) whose study noted that personal remittances stifle human capital development if the guardians choose to divert the personal remittances inflow from education and training of the children into their own preferences. Model 2 under both fixed effects and FMOLS shows a non-significant positive relationship running from personal

remittances towards human capital development, in line with Acharya and Leon-Gonzalez (2014) who noted that personal remittances is in most instances meant for health, training and education of the children who remained back home.

A non-significant positive impact of trade openness on human capital development was observed in model 1 (fixed effects and FMOLS) and in model 2 under fixed effects approach. Model 2 under FMOLS revealed that trade openness significantly improved human capital development. These results resonate with Binder and Georgiadis (2011)'s findings. In contradiction with available literature, model 3 under both fixed effects and FMOLS observed that trade openness had a non-significant negative influence on human capital development.

Model 1 and 2 (fixed effects and FMOLS) shows that financial development's positive impact on human capital development was non-significant whilst model 3 (fixed effects and FMOLS) observed a significant positive relationship running from financial development towards human capital development. The results resonate with Kargbo et al. (2016) who argued that a developed financial system is better able to enhance human capital development through availing education and training loans at reasonable interest rates.

Model 1 (fixed effects and FMOLS), model 2 and 3 (fixed effects) produced results which show that savings had a significant positive effect on human capital development, consistent with Bacha (1990) who explained that savings leads to more lending towards investment related activities such as human capital investment. Contrary to available literature, model 2 and 3 under the FMOLS model indicates a significant negative influence of savings on human capital development.

Model 2 revealed that inflation's negative influence on human capital development was significant, in line with De Gregorio (1992) who explained that high inflation environment constrains people from investing in human capital development because of weaker purchasing power of their earnings. Model 1 (fixed effects), model 2 (FMOLS) and model 3 (fixed effects) showed that inflation had a non-significant positive impact on human capital development. Model 1 and 3 under FMOLS observed a significant positive relationship running from inflation towards human capital development. The results contradict the available literature.

**Table 8**

| | Fixed effects | | | Random effects | | | FMOLS | | |
|---|---|---|---|---|---|---|---|---|---|
| Test | Model 1 | Model 2 | Model 3 | Model 1 | Model 2 | Model 3 | Model 1 | Model 2 | Model 3 |
| Hausman (Chi2) | 11.36 *** | 24.83 *** | 42.17 *** | 12.11 *** | 21.43 *** | 44.25 *** | | | |
| Wald tests (Chi 2) | 8.25 | 15.84 | 14.36 | 6.48 ** | 51.44 *** | 26.99 *** | | | |

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

*Source: E-Views*

The probability value of 0.0000 shows that the alternative hypothesis, which says fixed effects should not be rejected in favour of random effects, was adopted (Table 6). The regression models used fitted well with data employed because of the 0.00 probability values of their F-statistics. Table 8 shows that the null hypothesis which says fixed effects model should be used was not rejected (because of 0.00 probability values).

## 6. Conclusion

The paper studied the influence of FDI on human capital development in BRICS countries using panel data (1995-2021) methods such as fixed effects and fully modified ordinary least squares (FMOLS). The second objective of the study was to investigate how the interaction between FDI and technology infrastructure influences human capital development in BRICS. In other words, the study explored if technology infrastructure is a channel or an absorption capacity influencing FDI's impact on human capital development in BRICS. Model 1 and 2 under fixed effects observed a significant positive relationship running from FDI towards human capital development in BRICS. Model 3 under fixed effects produced results which shows that FDI had a significant negative effect on human capital development in BRICS. All the three models under FMOLS noted an insignificant deleterious effect of FDI on human capital development in BRICS. Models 1and 3 (fixed effects and FMOLS) and model 2 (fixed effects) noted that the complementarity between FDI and technology infrastructure significantly improved human capital development in BRICS countries. Put differently, technology infrastructure was found to have enabled FDI to significantly enhance human capital development in BRICS. BRICS countries are therefore urged to develop and implement policies which are geared towards improving FDI inflows and strengthening technology infrastructure to ensure human capital development. In further empirical research, panel threshold regression analysis needs to be introduced in examining FDI-technology infrastructure-human capital development nexus.

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