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# Exploring the Dynamic Interplay Between FDI, TFP, Human Capital, Infrastructure, and Governance in African Economies: Evidence from Panel Vector Autoregression Analysis

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**ABSTRACT**

Foreign direct investment (FDI), human capital, infrastructure, and governance have been argued to enhance Total Factor Productivity (TFP). However, their low levels in Africa raise doubts about their effectiveness in boosting the TFP. This study investigates the dynamic relationship between TFP, FDI, human capital, infrastructure, and governance in 30 selected African countries from 1996 to 2019 using a Panel Vector Autoregression (PVAR) approach. The results show that FDI positively correlates with TFP, while governance initially decreases TFP, indicating the need for stable institutions to mitigate the negative impacts on productivity. The PVAR-Granger causality analysis reveals a significant bidirectional causality between FDI and TFP, signifying the mutual importance of FDI and TFP growth. Governance also influences TFP, emphasizing the role of efficient governance in enhancing TFP. The forecast error variance decomposition shows that TFP is mainly influenced by innovations in the short term, with FDI and human capital becoming more influential over longer horizons. The impulse response functions indicate that FDI shocks boost TFP significantly, whereas the effects of governance on TFP vary. These findings suggest that improving human capital, governance, and infrastructure is essential to creating a conducive environment for FDI and driving TFP growth in Africa.

**Keywords:** Foreign Direct Investment, Total Factor Productivity, Human Capital, Infrastructure, Governance, Panel Vector Autoregression
**JEL Classifications:** F21, F23, O55, O430

## 1. INTRODUCTION

The recent Total Factor Productivity (TFP)–Foreign Direct Investment (FDI) nexus and development initiatives in Africa emphasize human capital, infrastructure, and good governance as prerequisites for growth (Adegoke et al., 2023; Rehman and Islam, 2023). FDI has long been recognized as a significant economic factor (Paul and Feliciano-Cestero, 2021). Africa, which predominantly comprises developing countries, faces challenges such as low savings rates, insufficient domestic capital, and socioeconomic issues (Akanle et al., 2022). Consequently, FDI presents a promising avenue for advancing regional economic development (Calamita, 2020). Substantial FDI inflows are crucial for developing countries to progress economically, as FDI enhances domestic capital, facilitates job creation, and increases income (Arthur and Addai, 2022; Chaudhury et al., 2020). As a result, African governments have prioritized FDI for sustainable economic development, implementing liberal and market-oriented policies, such as the African Continental Free Trade Area (AfCFTA) Agreement, to attract FDI. By 2023, FDI inflows into the region reached $48 billion, representing only 3.5% of global FDI (United Nations Conference on Trade and Investment, 2024).

FDI offers significant development opportunities for developing countries but may also hinder their economic progress. Studies have shown that FDI can exacerbate inequality, displace local investments, deplete foreign reserves, and fail to improve TFP. Studies in Southeast Asia, Latin America, and Eastern Europe reveals FDI's dual impact of FDI on TFP (Alfaro and Chauvin, 2017; Herzer and Donaubauer, 2018). This study empirically examines the causal relationship between FDI, TFP, human capital, infrastructure, and good governance in Africa, addressing limited research in this area. Existing studies indicate that FDI's positive effects of FDI depend on the host country's absorptive capacities, such as human capital, infrastructure, and governance. For instance, studies in Southeast Asia emphasize infrastructure and skilled labour (Ayub et al., 2020), while Latin American research highlights governance reforms (David et al., 2020). These findings suggest that FDI alone does not guarantee economic growth and that other factors must be present. A study by Kariuki and Kabaru (2022) and Li and Tanna (2019) indicates insufficient evidence that FDI universally benefits host countries. They argue that FDI's positive impact of FDI on economic growth in Sub-Saharan Africa (SSA) and the Economic and Monetary Community of Central Africa (CEMAC) depends on favourable domestic conditions. This study fills this gap by employing a generalized method of moments GMM-panel panel vector autoregression (PVAR) model to analyse a panel of 30 African countries from 1996 to 2019, providing insights into the complex relationship between FDI, TFP, human capital, infrastructure, and governance in Africa.

This study contributes to the existing literature by examining the complex relationship between FDI and TFP in selected African countries, extending beyond the conventional focus on Gross Domestic Product (GDP) per capita as the sole economic progress indicator. This comprehensive approach ensures the robustness and applicability of the findings across various African contexts, providing valuable insights for policymakers seeking to leverage FDI for sustainable productivity and economic development through FDI, infrastructure development, and effective governance. The paper is structured as follows. Section 2 reviews the empirical literature on the relationships between TFP, FDI, human capital, infrastructure, and governance. Section 3 describes the methodology, details the data, and outlines the empirical estimation techniques. Section 4 present the empirical results and the findings. Finally, Section 5 present the conclusion and policy recommendation based on the study's findings.

## 2. REVIEW OF LITERATURE

The literature on the relationship between FDI and TFP has evolved, with an increasing emphasis on the moderating roles of human capital, infrastructure, and governance, particularly in developing economies, such as those in Africa. From a theoretical perspective, this study draws upon several frameworks, including neoclassical growth theory, endogenous growth theory, the Lucas paradox, and investment development path (IDP). The neoclassical growth model, which posits diminishing returns to capital and underscores the significance of technological progress in sustained growth, provides a foundation for understanding the impact of FDI on TFP. According to this model, FDI is conceptualized as a mechanism for transferring technology and capital, which, in the short term, can enhance productivity but may result in diminishing returns without concomitant improvements in human capital and infrastructure.

However, endogenous growth theory incorporates an additional dimension by positing that factors such as human capital, innovation, and knowledge spillovers are crucial for sustained productivity growth, rendering FDI's impact on TFP potentially long-lasting if supported by robust absorptive capacities such as governance and education. This theoretical framework asserts that nations with more developed infrastructure and human capital are better positioned to leverage the benefits of FDI for productivity gains. The Lucas paradox further elucidates why, despite the theoretical advantages of FDI, developing countries, particularly those in Africa, do not attract as much foreign capital as anticipated. This paradox underscores the significance of governance and institutional quality in explaining why certain regions fail to realise the full potential of FDI for productivity growth. IDP theory complements these frameworks by delineating how the relationship between FDI and economic development evolves over time, with countries progressing through stages of development, during which FDI initially contributes to growth through capital accumulation, but subsequently transitions towards knowledge transfer and productivity enhancements as the host economy matures.

This study adds to the existing literature on the FDI-TFP nexus by assessing TFP's response to shocks emanating from FDI, and further determines the influence of human capital, infrastructure, and governance. Therefore, it is crucial to draw attention to studies in the literature, particularly those examining the impulse response between FDI and TFP/growth. Studies on the impact of FDI shocks on TFP has employed diverse approaches to examine various periods and geographical areas. One study, Chitambara (2015) analysed 47 African countries from 1980 to 2012, utilizing impulse response functions (IRFs) and panel cointegration tests to assess FDI's influence of FDI on domestic investment and TFP. The results indicated that FDI displaced domestic investment but also emphasized how institutional quality and trade openness could alleviate this effect. Another study, focusing on Bangladesh from 1975 to 2017, Qamruzzaman and Jianguo (2019) discovered that positive shocks in financial development had beneficial effects on FDI and economic growth. This finding suggests that complementary factors such as financial innovation can modify FDI's impact of FDI on growth. Their use of the ARDL and NARDL techniques underscores the significance of considering both linear and nonlinear dynamics when evaluating FDI shocks on TFP.

An examination of these findings revealed both commonalities and distinctions. Chitambara (2015) highlighted the significance of open trade policies and robust institutions in reducing the negative impacts of FDI while Qamruzzaman and Jianguo (2019) focusing on financial innovation as a key moderating element in Bangladesh. Both investigations indicate that FDI's effect on TFP is dependent on the broader economic and institutional landscape, although they diverge in identifying the specific factors driving these outcomes. These observations are particularly relevant for African economies as they can enhance the positive effects of FDI on productivity by bolstering their institutional structures and financial systems.

Similarly, Adebayo and Oluwaseun (2020) employed Structural VAR models to investigate the dynamic impacts of FDI on economic growth in SSA between 1990 and 2018, focusing on impulse response and variance decomposition. Their research indicates that FDI, when accompanied by stable macroeconomic conditions, contributes to economic growth. However, macroeconomic instability negates this positive effect. This is in contrast to Olusanya (2020), who utilized both linear and nonlinear autoregressive distributed lag (ARDL) models to examine Nigeria's manufacturing sector and discovered that, while FDI boosts short-term growth, it has detrimental long-term consequences. The discrepancy between these two studies underscores the context-dependent nature of FDI's influence of FDI on productivity. Although African countries such as Nigeria may experience short-term benefits, the long-term viability of FDI-driven growth is contingent upon a stable macroeconomic environment.

The complex relationship between FDI and productivity growth has been further elucidated through research on human capital. Using ARDL models, Ghosh and Parab (2021) and Okşak and Koyuncu (2021) demonstrated the enduring positive effects of FDI on productivity through human capital in India and Turkey, respectively. These results are consistent with those of Joshua et al. (2021), who proposed that liberalizing economic borders in SSA could boost FDI inflows and improve productivity. The key insight from these studies is that human capital and macroeconomic stability are crucial prerequisites for FDI to foster sustainable productivity growth. In the absence of these conditions, FDI may be short lived or potentially detrimental.

The literature frequently highlights the asymmetric impact of FDI shocks on TFP. For example, Obiakor et al. (2022), Nigeria's research revealed that positive FDI shocks lead to decreased economic growth, whereas negative shocks result in increased growth. This asymmetry contrasts with Ghana's findings, Nsor-Ambala and Anarfo (2022) in which a bidirectional relationship between FDI and economic growth is identified. These contrasting results indicate that FDI can act as a stabilizing factor in some environments while potentially amplifying volatility in others. Such variations underscore the need to consider each country's unique institutional and macroeconomic landscapes when evaluating the long-term influence of FDI on productivity and economic expansion.

## 3. METHODOLOGY AND DATA

### 3.1. Data and Variable Measurement

The dependent variable, TFP, was sourced from Penn World Tables (PWT) version 10.1. The preference for the PWT TFP index is based on three reasons: It measures real GDP considering trade term variations among countries, it uses the US as a comparison benchmark, and version 10.1 includes average hours worked data across countries, unlike earlier versions. These factors make the PWT's TFP index suitable for the analysis. This study primarily examines the impact of FDI, with inward FDI inflow data taken from the UNCTAD database and the FDI-to-GDP ratio as the key independent variable. FDI data, reported net of credits and debits between investors and foreign affiliates, can be negative because of reverse investment or disinvestment. Control variables were selected based on existing research on TFP determinants, focusing on human capital, infrastructure, and governance. Li and Tanna (2019) found that FDI's positive impact on growth is significant when interacting with human capital, which is supported by Li et al. (2015). Infrastructure and governance indicators were developed using principal component analysis (PCA). The infrastructure variable includes the number of mobile telephone subscribers per 100 people, internet penetration rate, fixed telephone subscribers per 100 people, and population access to electricity. Dodman et al. (2017) noted Africa's longstanding issues of poor governance and inadequate infrastructure. Good governance is measured using six variables: Political stability and absence of violence, rule of law, governance effectiveness, control of corruption, voice accountability, and regulatory quality. Li and Tanna (2019) demonstrated that effective governance significantly enhances the role of FDI in economic growth. Following Espoir and Sunge (2021) this study conducted a preliminary data analysis of good governance indicators before presenting and discussing the regression results of the effects of FDI on TFP in Africa. This study presents the governance index (GOV) variable as one of the control variables in the regression. PCA was constructed mainly because of the significantly high collinearity among the six governance components. The following linear combination exists.

$$GOV = \delta_1\mathrm{PSV}+\delta_2\mathrm{GE}+\delta_3\mathrm{CC}+\delta_4\mathrm{VA}+\delta_5\mathrm{RQ}+\delta_6\mathrm{RL} \tag{1}$$

Where $\delta_1$, $\delta_2$, $\delta_3$, $\delta_4$, $\delta_5$, and $\delta_6$, are eigenvectors (weights) from PCA, and Political Stability and Violence (PSV), Governance Effectiveness (GE), Control of Corruption (CC), Voice Accountability (VA), Regulatory Quality (RQ), and Rule of Law (RL) represent six syntheses of governance. To construct infrastructure variable, this study measures the infrastructure using the proxy variable of information and communication technology (ICT). This study follows Saba and David (2020) and uses PCA to compute the index using four dimensions. These dimensions include mobile telephones, fixed-line telephones, internet access subscriptions, and access to electricity. The following linear combination is the effect:

$$INFRA = \varphi_1 MT+\varphi_2\mathrm{FLT}+\varphi_3 IAS \tag{2}$$

Where $\varphi_1$, $\varphi_2$ and $\varphi_3$ are eigenvectors (weights) from PCA; mobile telephones (MT), fixed-line telephone (FLT), and Internet access subscriptions (IAS) represent infrastructure development. Details of the variables and sources are provided in Table A1 in the Appendix. The panel dataset covers 30 African countries over 24 years (1996-2019) and is used for econometric estimation. The summary statistics of the mean of each variable are listed in Table A1. The analysis revealed substantial variability in the mean numbers of all selected variables, indicating their suitability for exploratory investigation.

### 3.2. Estimation Technique and Model Specification

This study uses a PVAR model within a GMM framework to examine the dynamic relationships between TFP, FDI, human capital, infrastructure, and governance in African countries.

PVAR, an extension of the VAR model from Sims (1980), is suitable for multivariate time-series data, where variables are interdependent and influence each other over time. The PVAR model treats all variables endogenously, explaining each by its own and others' lagged values, capturing the dynamic and reciprocal relationships between FDI and TFP and the roles of human capital, infrastructure, and governance. The rationale for selecting the PVAR model over alternative econometric techniques such as a traditional panel data regression model is its capacity to account for unobserved heterogeneity, dynamic interactions, and potential endogeneity issues. PVAR is particularly suitable for contexts in which feedback loops and lagged effects play a significant role, as is evident in macroeconomic variables such as FDI and TFP. Furthermore, by employing the GMM estimation framework, the model addresses endogeneity bias, which occurs when the explanatory variables correlate with error terms. This characteristic is especially pertinent to this study, as variables such as FDI and TFP are frequently subject to reverse causality, wherein FDI inflows may not only influence TFP but could also be affected by changes in productivity.

The PVAR model enables advanced analytical techniques such as Granger causality tests, IRFs, and variance decomposition analysis, which are essential for understanding short- and long-term variable interactions. Granger causality tests determine the direction of influence between variables, while IRFs show how changes in one variable (e.g., FDI) affect others (e.g., TFP) over time. This capability makes the PVAR model ideal for analysing the FDI-TFP relationship in African countries, offering more comprehensive insights than static models by capturing temporal and cross-variable effects. The functional form of the PVAR model is as follows:

$$y_{i,t} = \beta_1 y_{i,t-1} + \beta_2 y_{i,t-2} + \ldots + \beta_k y_{i,t-k} + \delta_i + \varepsilon_{i,t}, (i=1,\ldots N;\ t=1,\ldots,T) \tag{3}$$

Where $y_{i,t-q}$, $(q = 0,\ldots,k)$, and $\delta_i$ and $\varepsilon_{i,t}$ represent K×1 vectors that signify unobserved individual fixed effects and the stochastic error term, respectively. The $\beta_r$ $(r = 0,\ldots,K)$ are K×K coefficient matrices associated with the lagged variables are denoted by $\boldsymbol{y}_{i,t-k}$ and $k$ while indicates the lag order (VAR order). This study incorporated models utilizing forward orthogonal deviations (FODs), as described in the groundbreaking work of Arellano and Bover (1995). To accomplish this, the study employs a first-difference transformation, which eliminates $\boldsymbol{\delta}_i$ individual fixed effects in equation (3). This transformation is expressed as follows:

$$y^*_{i,t} = \beta_1 y^*_{i,t-1} + \beta_2 y^*_{i,t-2} + \ldots + \beta_k y^*_{i,t-k} + \int^*_{i,t}, \left(i=1,\ldots,N; t=1,\ldots,T_1\right) \tag{4}$$

Where $y^*_{i,t-q} = c_t\left[y_{i,t-q} - \frac{y_{i,t-q+1} + y_{i,t-q+1} + \ldots y_{i,T-q}}{T-t}\right]$,

$$\left(q = 0,1,2\ldots k\right), \varepsilon^*_{i,t} = c_t\left[\varepsilon_{i,t} - \frac{\varepsilon_{i,t+2} + \ldots + \varepsilon_{i,T}}{T-t}\right]$$

with $c_t^2 = (T-t)(T-t+1)$

Hayakawa et al. (2016) assert that when the initial error term exhibits serial uncorrelation and homoscedasticity, these characteristics are preserved in the transformed stochastic error term. Consequently, this research employs an AR(1) PVAR model incorporating five variables: the logarithm of TFP (LnTFP), FDI (LnFDI), human capital (LnHC), infrastructure (LnINFRA), and governance indicators (LnGOV). The PVAR model encompasses these five variables.

$$\begin{aligned}\Delta Ln(TFP_{i,t}) &= \sum\nolimits_{j=1}^{q} \beta_1 \Delta Ln(TFP_{i,t-1}) \\ &+ \sum\nolimits_{j=1}^{q} \beta_2 \Delta Ln\left(FDI_{i,t-j}\right) + \sum\nolimits_{j=1}^{q} \beta_3 \Delta Ln(HC_{i,t-j}) \\ &+ \sum\nolimits_{j=1}^{q} \beta_4 \Delta Ln(INFRA)_{i,t-1}) + \sum\nolimits_{j=1}^{q} \beta_5 \Delta Ln(GOV)_{i,t-1}) + \varepsilon_1\end{aligned} \tag{5}$$

$$\begin{aligned}\Delta Ln(FDI_{i,t}) &= \sum\nolimits_{j=1}^{q} \beta_1 \Delta Ln(FDI_{i,t-1}) \\ &+ \sum\nolimits_{j=1}^{q} \beta_2 \Delta Ln\left(TFP_{i,t-j}\right) + \sum\nolimits_{j=1}^{q} \beta_3 \Delta Ln(HC_{i,t-j}) \\ &+ \sum\nolimits_{j=1}^{q} \beta_4 \Delta Ln(INFRA)_{i,t-1}) + \sum\nolimits_{j=1}^{q} \beta_5 \Delta Ln(GOV)_{i,t-1}) + \varepsilon_1\end{aligned} \tag{6}$$

$$\begin{aligned}\Delta Ln(HC_{i,t}) &= \sum\nolimits_{j=1}^{q} \beta_1 \Delta Ln(HC_{i,t-1}) \\ &+ \sum\nolimits_{j=1}^{q} \beta_2 \Delta Ln\left(TFP_{i,t-j}\right) + \sum\nolimits_{j=1}^{q} \beta_3 \Delta Ln(FDI_{i,t-j}) \\ &+ \sum\nolimits_{j=1}^{q} \beta_4 \Delta Ln(INFRA)_{i,t-1}) + \sum\nolimits_{j=1}^{q} \beta_5 \Delta Ln(GOV)_{i,t-1}) + \varepsilon_1\end{aligned} \tag{7}$$

$$\begin{aligned}\Delta Ln(INFRA_{i,t}) &= \sum\nolimits_{j=1}^{q} \beta_1 \Delta Ln(INFRA_{i,t-1}) \\ &+ \sum\nolimits_{j=1}^{q} \beta_2 \Delta Ln\left(TFP_{i,t-j}\right) + \sum\nolimits_{j=1}^{q} \beta_3 \Delta Ln(FDI_{i,t-j}) + \\ &\sum\nolimits_{j=1}^{q} \beta_4 \Delta Ln(HC)_{i,t-1}) + \sum\nolimits_{j=1}^{q} \beta_5 \Delta Ln(GOV)_{i,t-1}) + \varepsilon_1\end{aligned} \tag{8}$$

$$\begin{aligned}\Delta Ln(GOV_{i,t}) &= \sum\nolimits_{j=1}^{q} \beta_1 \Delta Ln(GOV_{i,t-1}) \\ &+ \sum\nolimits_{j=1}^{q} \beta_2 \Delta Ln\left(TFP_{i,t-j}\right) + \sum\nolimits_{j=1}^{q} \beta_3 \Delta Ln(FDI_{i,t-j}) \\ &+ \sum\nolimits_{j=1}^{q} \beta_4 \Delta Ln(HC)_{i,t-1}) + \sum\nolimits_{j=1}^{q} \beta_5 \Delta Ln(INFRA)_{i,t-1}) + \varepsilon_1\end{aligned} \tag{9}$$

In this study, the GMM estimator is utilized to obtain consistent parameter estimates for Equations (5-9). To assess the short-term causal relationships among the five variables, the Panel VAR Granger causality Wald test was implemented. Furthermore, the study adheres to the methodology outlined by Abrigo and Love (2016) to compute the forecast error variance decomposition (FEVD) and the IRF.

## 4. DISCUSSION

In the field of macroeconomics, researchers often encounter cross-sectional dependence (CD) and non-stationarity in variables, which can lead to inaccurate results in panel-data econometric studies. To address these challenges, researchers recommend utilizing second-generation econometric techniques, as highlighted in various studies (Espoir and Ngepah, 2020; Bersvendsen and Ditzen, 2021; Espoir and Sunge, 2021). Given the growing interconnectedness of global economies, it is crucial to examine CD in panel datasets. Econometric research consistently indicates that panel datasets are prone to significant CD (Pesaran et al., 2004). This study begins with an empirical investigation of variable CD using semiparametric tests proposed by Friedman (1937) and the residual-based CD test developed by Pesaran et al. (2004). These tests evaluate the null hypothesis of cross-sectional independence and are suitable for both limited and extensive samples. Table 1 presents the CD test outcomes, revealing CD in all variables, as the null hypothesis was strongly rejected at conventional significance levels. The rejection of the null hypothesis suggests that a second-generation panel unit-root test yields more reliable conclusions (Espoir and Ngepah, 2020).

Due to the presence of cross-sectional dependence (CD) in the panel data, it is advisable to conduct a panel unit root test, specifically the cross-sectionally augmented IPS (CIPS) test introduced by Pesaran (2007). This method enhances the traditional augmented Dickey-Fuller (ADF) test by incorporating cross-unit averages of lagged levels and first differences, allowing for the identification of CD in panel unit roots. The study encompasses both cross-country augmented ADF (CADF) statistics and their arithmetic means. The null hypothesis posits that the variable lacks stationarity. Two models were investigated: one with a constant term and another including both constant and trend components. Table 2 displays the results of the CIPS and CADF panel unit root tests for both models.

The results indicate that, at this level, several variables, such as LnTFP, LnGOV, and LnHC, are non-stationary in both the constant and trending models, as shown by the CIPS test statistics (−1.604 for LnTFP and −1.013 for LnGOV). However, when first differenced, these variables became stationary, as evidenced by the significant test statistics (−4.681*** for LnTFP and −2.831*** for LnGOV). Similarly, the CADF test results show non-stationarity at the level of most variables in both models. For example, LnTFP has test statistics of −1.072 (level) and −2.206*** (first difference) and LnGOV has test statistics of −1.134 (level) and −0.245*** (first difference). In accordance with the findings of this study, most of the variables appear to be integrated of order one, denoted as I (1), as they display non-stationarity at levels and stationarity after being subjected to first differencing. However, some variables exhibit stationarity at level I(0), as shown in Table 3. The presence of this mixed integration order necessitates an examination of panel cointegration to determine whether a long-run equilibrium relationship exists among the I(1) variables while simultaneously considering the I(0) variables.

**Table 1: Cross-sectional dependence test**

| Test | Variable | CD Test |
|---|---|---|
| Pesaran | LnTFP | 4.83*** (0.000) |
| | LnFDI | 8.01*** (0.000) |
| | LnHC | 86.58*** (0.000) |
| | LnINFRA | 25.57 *** (0.000) |
| | LnGOV | 19.12*** (0.000) |
| Breusch-Pegan LM test | | |
| | LnTFP | 4.83*** (0.000) |
| | LnFDI | 8.01*** (0.000) |
| | LnHC | 86.58*** (0.000) |
| | LnINFRA | 91.35*** (0.000) |
| | LnGOV | 1 0.62*** (0.000) |

***,**, and * denote the rejection of the null hypothesis ($H_0$) regarding cross-sectional independence at significance levels of 1%, 5%, and 10%, respectively.
Source: Authors' computations using Stata 18 package

The study employs Westerlund's (2008) error correction-based panel cointegration test to examine the presence of a long-term relationship. Hossfeld (2010) suggests that the Westerlund test offers greater reliability due to its consideration of structural breaks and CD. The test's statistics ($G_a$, $G_t$, $p_a$, and $P_t$) assess error correction for individual panel units or the entire panel, assuming no cointegration as the null hypothesis. While and evaluate cointegration in at least one panel unit $G_a$ and $G_t$ examine cointegration across the whole panel. A robust p value was calculated using 100 bootstrap replications. The results, presented in Table 3, show all four outcomes as statistically significant at the 1% level, leading to the rejection of the null hypothesis.

The four outcomes are statistically significant at the 1% level, thus rejecting the null hypothesis. Therefore, despite the combination of the I(0) and I(1) variables, the empirical characteristics require estimating the model in first differences for robustness, as cointegration is present among the I(1) variables. This mixed integration order requires careful handling, but the cointegration among the I(1) variables justifies the first difference estimation (Westerlund, 2008; Hossfeld, 2010; Pesaran, 2015).

### 4.1. PVAR Results and Discussion

In this section, we present and discuss the outcomes of the PVAR model estimation as specified in the equations. (5-9). The GMM approach was employed to estimate the PVAR model. Table 4 presents the first-order PVAR results of the samples.

The short-run results of the TFP equation indicate that Africa's current TFP level is positively correlated with FDI, and negatively correlated with governance. A 1% increase in FDI leads to a 0.002% increase in TFP, whereas a 1% increase in governance results in a 0.009% decrease in TFP. Okunade and Ajisafe (2022) suggested that authorities should address institutional loopholes in African countries to ensure stable governance environments, including political, legal, regulatory, and economic institutions, to mitigate risks that may impede long-term TFP growth. The small positive coefficient of TFP on FDI suggests a feedback loop in which higher productivity attracts more FDI, although FDI's impact on TFP is positive in the short run.

The negative effect of FDI on TFP (−2.8509%) indicates that increased FDI correlates with reduced TFP in the short term. This finding suggests that FDI in these countries may be concentrated in sectors that do not immediately enhance productivity, possibly focusing on extractive industries or low-productivity sectors. These findings support Herzer and Donaubauer (2018) and Li and Tanna (2019) findings that FDI does not promote TFP in low-income and middle-income countries. The absence of a positive FDI-TFP relationship is

**Table 2: Results of Second-generation (S-G) unit root test**

| Variables | CIPS | | CADF | |
|---|---|---|---|---|
| | level | First difference | Level | First difference |
| LnTFP | −1.604 | −4.681*** | −1.072 | −2.206*** |
| LnFDI | −3.587*** | −5.828*** | −2.124** | −2.952*** |
| LnHC | −2.556*** | −1.495*** | −2.335*** | −1.758 |
| LnINFRA | −3.154*** | −4.763*** | −1.799 | −3.249*** |
| LnGOV | −1.013 | −2.831*** | −1.134 | −0.245*** |

*, **, and ***denote the variables statistically significant at the 1%, 5%, and 10% levels, respectively. (b) Critical values of the CIPS test at the 10%, 5%, and 1% significance levels.
Source: Authors' computations using Stata 18 package

**Table 3: Westerlund ECM panel cointegration test results**

| Statistic | Value | z-value | P-value |
|---|---|---|---|
| $G_t$ | −2.799*** | −6.225 | 0.000 |
| $G_a$ | −13.329*** | −6.225 | 0.000 |
| $P_t$ | −15.621*** | −7.737 | 0.000 |
| $P_a$ | −12.408*** | −10.090 | 0.000 |

***,**, and *denote the rejection of cross-sectional independence at significance levels of 1%, 5%, and 10%, respectively. The P values are robust critical values obtained through a bootstrapping process involving 100 replications
Source: Authors' computations using Stata 18 package

largely due to low absorptive capacity, which hampers knowledge transfers from foreign companies (Abdullah and Chowdhury, 2020). Without the ability of local firms to invest in absorbing foreign technologies, knowledge spillovers may be minimal or non-existent. This suggests that FDI in African host countries may be driven by the pursuit of natural resources rather than market or efficiency. Evidence shows that market and efficiency seeking FDI are more likely to promote growth than resource-seeking FDI (Mohamed Kargbo and Paul Dunne, 2017). This underscores the fact that FDI alone, without favourable local conditions, is insufficient to resolve the challenges of promoting growth in Africa. Foreign businesses may choose not to hire local workers, exploit natural resources or drive local firms out of business (Caner and Hansen, 2004). Moreover, foreign businesses can limit local firms' access to finance because of increased competition (Yang and Meyer, 2020). The self-reinforcing impact of infrastructure improvements implies that, once infrastructure projects commence, they tend to continue or expand. This finding implies that African countries must invest more in infrastructure, particularly the internet, communication, and electricity infrastructure, to make it conducive for foreign businesses to transfer skills and knowledge that will enable them to operate productively in the local economy.

The negative short-term impact of governance improvements on TFP and human capital (0.1172%) suggests that while governance reforms are essential, they may incur adjustment costs. Policymakers must implement governance reforms gradually and provide support measures to mitigate short-term negative consequences. This could involve retraining programs for the workforce and temporary subsidies, or support for businesses adjusting to new regulations. Therefore, it is vital to make long-term investment in education and health. To address this issue, policies should focus on enhancing the quality of education and vocational training, thereby equipping the workforce with the skills necessary to meet the demands of the ever-changing job market.

## 4.2. Robustness Check

This study assessed the sensitivity of the PVAR results to another TFP measure, real welfare TFP. This measure was used to verify the robustness of the results, as presented in Table 5. The table shows that the impact of TFP changes on other variables remains largely consistent with the original PVAR results, thereby reinforcing the robustness and reliability of the initial findings. For instance, the statistically significant negative impact of TFP on FDI (coefficient: −2.9833, significant at the 5% level) suggests that higher TFP may initially deter FDI, possibly because of short-term adjustments or reallocation effects within the economy. This result aligns with the initial findings, suggesting that the relationship between TFP and FDI is stable across TFP measures.

Further examination reveals that changes in human capital and infrastructure exhibit significant relationships with the other variables. Specifically, human capital's positive effect on TFP (coefficient: 0.0048) and its significant negative association with governance (coefficient: −0.1172, significant at the 10% level) suggest intricate dynamics where improvements in human capital can enhance productivity but may also face challenges in governance contexts. The positive and significant impact of infrastructure (coefficient: 0.1202, significant at the 10% level) underscores the importance of sustained investments in infrastructure for long-term benefits (Calderón et al., 2015). These results, consistent with the original PVAR model, confirm that the alternative measure of TFP (real welfare TFP) does not substantially alter the inferred dynamic interactions between TFP, FDI, human capital, infrastructure, and governance. Consequently, the robustness and reliability of the initial findings in Table 5 are supported.

Selecting the appropriate lag length is crucial, as it directly affects the model's predictive accuracy and balances model complexity with goodness of fit, preventing underfitting or overfitting. Reliable econometric modeling and inferences are essential. Various factors were considered to determine the optimal lag length, with findings based on the cross-dependence (CD), J Statistic (J), Modified Bayesian Information Criterion (MBIC), Modified Akaike Information Criterion (MAIC), and Modified Quasi-likelihood Information Criterion (MQIC) presented in Table 6.

The degree of correlation between the cross-sectional units in the residuals of the PVAR model is indicated by CD statistics. The CD value was the highest at lag 1 (0.9906674), indicating a significant CD at this lag. This high dependence may be attributed to common shocks or interactions between countries

**Table 4: Results for the five-variable PVAR model**

| Variables | $\Delta LnTFP_t$(1) | $\Delta LnFDI_t$(2) | $\Delta LnHC_t$(3) | $\Delta LnINFRA_t$(4) | $\Delta LnGOV_t$(5) |
|---|---|---|---|---|---|
| $\Delta LnTFP_t$ | −0.0406 | −2.8509*** | −0.0088 | 0.0252 | −0.0039 |
| $\Delta LnFDI_t$ | 0.0024* | −0.0641 | −0.0001 | 0.0029 | −0.0002 |
| $\Delta LnHC_t$ | 0.01164 | 0.4379 | 0.0013 | 0.0191 | −0.1172* |
| $\Delta LnINFRA_t$ | −0.00004 | 0.2713 | 0.0013 | 0.1249* | −0.0995 |
| $\Delta LnGOV_t$ | −0.0091** | −0.1690 | 0.0001 | −0.0164 | −0.0040 |
| Observations | 630 | 630 | 630 | 630 | 630 |

Standard error in parentheses, ***P<0.01, P<0.05, P<0.1
Source: Authors' computations using Stata 18 package

**Table 5: Results for the three-variable PVAR model**

| Variables | $\Delta LnTFP_t$(1) | $\Delta LnFDI_t$(2) | $\Delta LnHC_t$(3) | $\Delta LnINFRA_t$(4) | $\Delta LnGOV_t$(5) |
|---|---|---|---|---|---|
| $\Delta LnTFP_t$ | −0.0243 | −2.9833** | 0.0002 | −0.0497 | 0.3120 |
| $\Delta LnFDI_t$ | 0.0022 | −0.0646 | −0.0001 | 0.0030 | −0.0005 |
| $\Delta LnHC_t$ | 0.0048 | 0.0916 | 0.0003 | 0.0213 | −0.1172* |
| $\Delta LnINFRA_t$ | −0.0070 | 0.2562 | 0.0013 | 0.1202* | −0.0844 |
| $\Delta LnGOV_t$ | −0.0068 | −0.1582 | 0.0000 | −0.0149 | −0.0067 |
| Observations | 630 | 630 | 630 | 630 | 630 |

Standard error in parentheses, ***P<0.01, P<0.05, P<0.1
Source: Authors' computations using Stata 18 package

**Table 6: Optimal lag**

| Lag | CD | J | J value | MBIC | MAIC | MQIC |
|---|---|---|---|---|---|---|
| 1 | 0.9906674 | 64.6125 | 0.7983 | 411.3102 | 85.3875 | 212.5526 |
| 2 | 0.9889716 | 33.5288 | 0.9644 | −283.753 | 66.4712 | 151.2479 |
| 3 | 0.956439 | 12.5756 | 0.9813 | 146.0653 | 37.4244 | 79.8127 |
| 4 | 0.8285834 | | | | | |

Source: Authors' computations using Stata 18 package

in the panel. As the lag length increases, the CD values decrease, suggesting that incorporating higher lags may help mitigate the effects of CD and provide a more robust model for analyzing dynamic interactions among variables. Hansen's J-test is critical for evaluating the validity of instruments used in the PVAR model. The J-test P-values across different lags indicate that the instruments are valid, and the model is correctly specified, as none of the P-values are below the threshold of 0.05. The highest J-test P-value was observed at lag three (0.9812904), suggesting that the instruments were the most valid at this lag. However, given that all lags have sufficiently high p-values, there is no evidence to reject the null hypothesis of valid instruments across all lags considered. This finding supports the robustness of the PVAR model specifications regardless of the chosen lag length. The MBIC, MAIC, and MQIC criteria were used to determine the optimal lag length by balancing goodness of fit and model complexity. Lag 2 emerged as the optimal lag length, with the lowest values for all three criteria: MBIC (−283.753), MAIC (66.47119), and MQIC (151.2479). These values indicate that a model with two lags provides the best fit, while maintaining a manageable complexity level. The information criterion values for lags 1 and 3 are higher, suggesting that these lag lengths are less optimal for the PVAR model. Based on the assessment of multiple evaluation criteria, lag 2 was determined to be the optimal lag length for the PVAR model. Although Lag 1 exhibited the highest CD value, its elevated information criterion values rendered it unsuitable. Lag 2, with the lowest MBIC, MAIC, and MQIC values, offers a favorable balance between model fit and complexity. Additionally, the high J-test P-value at this lag length reinforced the validity of the instruments used in the model. While lag 3 also presents a high J-test P-value, its increased information criteria values make it a less optimal option than lag 2 does. Lag 4 was not considered because of insufficient information possibly resulting from computational or data constraints.

The stability of the PVAR model was assessed by examining the roots of the companion matrix, as presented in Table 7 and Figure 1. Table 7 provides the real and imaginary components of the roots, along with their moduli and the corresponding stability conditions. The results demonstrate that all roots possess moduli less than one, thus fulfilling the stability condition. This conclusion is also visually supported by Figure 1, which plots the roots within the unit circle in the complex plane. The arrangement of these roots within the unit circle verifies the VAR model's stability.

Figure 1 further clarifies the stability analysis by showing that all roots are located within the unit circle, suggesting that the system will return to equilibrium following any disturbances. This stability verifies that the PVAR model is solid and suitable for additional empirical analysis. For the panel causality relationship analysis, this study use the PVAR Granger causality Wald test. This method was employed to explore the causal connections between variables within the PVAR model framework. The Wald test specifically assesses whether one variable Granger causes another. Table 8 presents the results of the analysis.

The null hypothesis ($H_0$) for the Panel VAR-Granger causality Wald test posits that the lagged values of a given independent variable do not Granger-cause the dependent variable. The results of the Granger causality test indicate no significant evidence that FDI Granger causes TFP. The $\chi^2$statistic was 3.261 with a P-value of 0.196, leading to the failure to reject the null hypothesis at the

**Table 7: Eigenvalue stability condition**

| Real | Modulas | Stability condition met |
|---|---|---|
| 0.8166 | 0 | 0.8166 |
| 0.4630 | 0 | 0.4630 |
| −0.3828 | 0 | 0.3828 |
| −0.2243 | −0.2302 | 0.3213 |
| −0.2243 | 0.2302 | 0.3213 |
| 0.1214 | −0.2507 | 0.2785 |
| 0.1214 | 0.2507 | 0.2785 |
| 0.1214 | 0.0855 | 0.1529 |
| −0.1267 | 0.0855 | 0.1529 |
| 0.0042 | 0 | 0.0042 |

Source: Authors' computations using Stata 18 package

**Table 8: Panel VAR-Granger causality Wald test results**

| Null Hypothesis | $\chi 2$ | df | P-value | Conclusion |
|---|---|---|---|---|
| *ΔLnTFP* | | | | |
| *ΔLnTFP→ΔLnFDI* | 3.261 | 2 | 0.196 | Fail to reject at 5% |
| *LnTFP → ΔLnHC* | 1.386 | 2 | 0.500 | Fail to reject |
| *LnTFP → ΔLnINFRA* | 3.969 | 2 | 0.137 | Fail to reject |
| *LnTFP →ΔLnGOV* | 5.077 | 2 | 0.079* | Reject at 10% |
| *ΔLnFDI* | | | | |
| *ΔLnFDI→LnTFP* | 8.960 | 2 | 0.011** | Reject at 5% |
| *ΔLnFDI →ΔLnHC* | 1.369 | 2 | 0.504 | Fail to reject |
| *ΔLnFDI → ΔLnINFRA* | 3.167 | 2 | 0.205 | Fail to reject |
| *ΔLnFDI → ΔLnGOV* | 2.670 | 2 | 0.263 | Fail to reject |
| *ΔLnHC* | | | | |
| *ΔLnHC→LnTFP* | 1.986 | 2 | 0.370 | Fail to reject |
| *ΔLnHC → ΔLnFDI* | 1.967 | 2 | 0.374 | Fail to reject |
| *ΔLnHC →ΔLnINFRA* | 1.552 | 2 | 0.460 | Fail to reject |
| *ΔLnHC →ΔLnGOV* | 0.462 | 2 | 0.794 | Fail to reject |
| *ΔLnINFRA* | | | | |
| *ΔLnINFRA→LnTFP* | 0.640 | 2 | 0.726 | Fail to reject |
| *ΔLnINFRA →ΔLnFDI* | 1.721 | 2 | 0.423 | Fail to reject |
| *ΔLnINFRA →ΔLnHC* | 1.712 | 2 | 0.425 | Fail to reject |
| *ΔLnINFRA →ΔLnGOV* | 4.425 | 2 | 0.817 | Fail to reject |
| *ΔLnGOV* | | | | |
| *ΔLnGOV→LnTFP* | 0.022 | 2 | 0.989 | Fail to reject |
| *ΔLnGOV → ΔLnFDI* | 1.154 | 2 | 0.562 | Fail to reject |
| *ΔLnGOV →ΔLnHC* | 4.430 | 2 | 0.109 | Fail to reject |
| *ΔLnGOV →ΔLnINFRA* | 0.672 | 2 | 0.715 | Fail to reject |

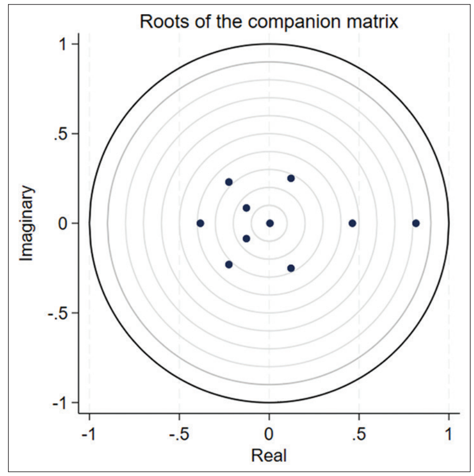
The three stars ***,**, and *indicates the rejection of $H_0$ at 1, 5 and 10% signifcance level

Source: Authors' computations using Stata 18 package

5% significance level. This finding suggests that within the study period and sample, FDI inflows do not have a direct and immediate impact on enhancing productivity in the selected African countries. Nevertheless, governance demonstrates a weak predictive effect on TFP, with a $\chi^2$statistic of 5.077 and P = 0.079. This result implies that improvements in governance could potentially foster productivity, although the evidence is significant only at the 10% level. These findings highlight the intricacy of the factors driving productivity gains and imply that while FDI alone may not be sufficient, the role of governance reforms could be crucial (Asongu and Odhiambo, 2020).

In contrast, the analysis reveals significant causality running from TFP to FDI. The $\chi^2$statistic of 8.960 and P = 0.011 allow for the rejection of the null hypothesis at the 5% significance level, indicating that higher productivity levels can attract more foreign investments. This relationship underscores the importance of productivity improvements as magnets of FDI. Other variables

**Figure 1:** Graph of eigenvalue stability condition




Source: Authors' construction using Stata 18 package

such as human capital, infrastructure, and governance do not exhibit significant Granger-causal effects on FDI, indicating the dominant role of TFP in influencing foreign investment decisions. This finding suggests that policies aimed at enhancing productivity, perhaps through technological advancements and educational improvements, could be instrumental in attracting FDI (Mahmoodi and Mahmoodi, 2016).

The Granger causality tests for human capital did not reveal any statistically significant relationships with TFP, FDI, infrastructure, or governance. This lack of significant causality suggests that the factors included in the model do not have immediate or direct short-term effects on human capital accumulation. The development of human capital may depend on sustained and long-term investments in education, health, and social services, which are not captured within the immediate dynamic framework of the PVAR model. Therefore, policymakers should consider adopting sustained and long-term strategies to improve human capital, which is critical to broader economic development (Hanushekc and Woessmann, 2020).

Similarly, the results of the Granger causality tests indicate no significant causality from TFP, FDI, human capital, or governance to infrastructure. This finding suggests that changes in TFP, FDI, and governance do not immediately translate into infrastructure improvements. Infrastructure development typically involves substantial investments and longer gestation periods, which may not be adequately captured in the short-term dynamics of the model. Consequently, strategic and long-term infrastructure development plans are essential and potentially supported by domestic resources, international aid, and investment (Calderón et al., 2015).

The analysis also found no significant causality from TFP, FDI, human capital, or infrastructure to governance. This result implies that the determinants of governance quality are likely to be more structural and deeply rooted rather than driven by short-term economic changes in the variables considered. Therefore, efforts to improve governance may need to focus on institutional reforms, enhancing transparency and promoting accountability, which are likely to yield results over a longer horizon. Given the weak evidence that governance changes Granger-cause TFP, reinforcing the quality of governance remains a vital component of policy strategies aimed at boosting productivity and, by extension, economic growth (Rodrik et al., 2017; Keping, 2018).

Although FDI does not significantly affect TFP, improvements in TFP have been shown to attract FDI, thus emphasizing the importance of productivity-enhancing policies. Additionally, the weak predictive effect of governance on TFP suggests that governance reform can enhance productivity. Therefore, policymakers should focus on improving governance structures to create an environment that is conducive to productivity gains. In addition, long-term investments in human capital and infrastructure are necessary, because their immediate effects are not captured in short-term dynamics. A comprehensive and multifaceted policy approach that addresses productivity, governance, human capital, and infrastructure development is crucial for fostering sustainable economic growth in African countries.

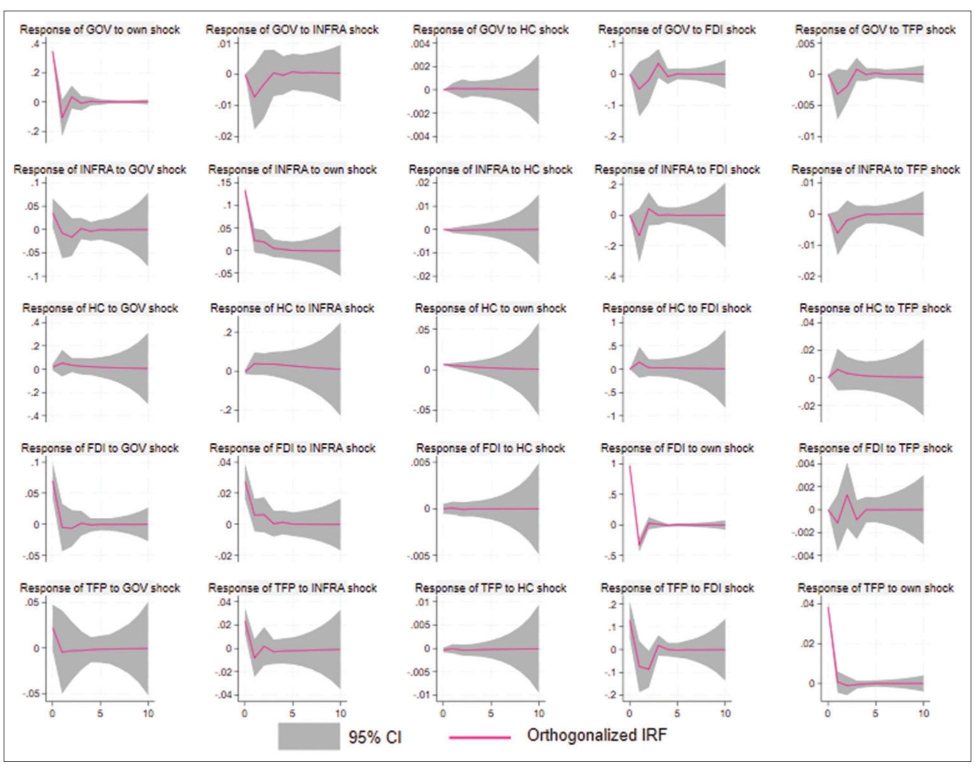
To gain a more comprehensive understanding of the causal relationships among the five variables, this study employed two additional methods. The first method, forecast error variance decomposition (FEVD), assesses the intensity of causal connections between pairs of variables (Abrigo and Love, 2016) The second method examines how a shock to one predictor variable affects the predicted variable (Koop et al., 1996). Both techniques were applied using the unrestricted VAR estimation process with the orthogonalized Cholesky ordering approach. The results of the variance decomposition for all five variables, encompassing both short-term and long-term effects over 10 timeframes, are presented in Table 9 and Figure 2.

Following the evaluation of the IRFs, we conducted an in-depth analysis of the five variables of interest. Specifically, this study focused on the IRFs shown in Figure 2. The IRFs regression includes confidence intervals represented by the lower and upper lines in the figure. The lines in the center illustrate the actual response functions, showing the dynamic interplay between the variables in response to the shocks. It is crucial to mention that IRFs offer valuable insights into the time-dependent importance of each response and shed light on the short-term dynamics of these influences.

The analysis of IRFs reveals that a one-standard-deviation shock to governance significantly and immediately impacts governance negatively, although this effect diminishes over time, indicating stabilization. Initially, a governance shock positively affected infrastructure, but this influence weakened over time. Human capital's response to a governance shock is initially negative, but becomes positive and stabilizes, suggesting potential long-term benefits. FDI initially reacts negatively to governance shocks, but this effect fades over time. TFP showed an initial negative response to governance shocks that gradually diminished, underscoring the complex relationship between governance and productivity. These findings align with the existing empirical research, confirming the essential role of governance quality in TFP and economic growth (Sunge and Ngepah, 2020). Additionally, the results underscore that improving governance quality is vital for attracting foreign investment (Oduola et al., 2022).

Infrastructure shocks initially harmed governance, but this effect decreased over time. Infrastructure responds positively to its own shocks, stabilizing in the long term and showing the

**Figure 2:** Graphs of orthogonalized IRFs




Source: Authors' construction using Stata 18 package

**Table 9: Forecast-error variance decomposition results**

| Forecast Horizon | TFP | FDI | HC | INFRA | GOV |
|---|---|---|---|---|---|
| Response toΔLnTFP | | | | | |
| Period | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | 0 | 0 | 0 | 0 |
| 2 | 0.9454 | 0.0008 | 0.0231 | 0.0242 | 0.0065 |
| 3 | 0.9337 | 0.0019 | 0.0293 | 0.0264 | 0.0088 |
| 4 | 0.9297 | 0.0023 | 0.0319 | 0.0269 | 0.0091 |
| 5 | 0.9287 | 0.0023 | 0.03300 | 0.0269 | 0.0091 |
| 6 | 0.9280 | 0.0023 | 0.0336 | 0.0269 | 0.0091 |
| 7 | 0.9276 | 0.0023 | 0.0341 | 0.0269 | 0.0091 |
| 8 | 0.9273 | 0.0023 | 0.0343 | 0.0269 | 0.0091 |
| 9 | 0.9272 | 0.0023 | 0.0345 | 0.0269 | 0.0091 |
| 10 | 0.9271 | 0.0023 | 0.0346 | 0.0269 | 0.0091 |
| Response toΔLnFDI | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0.0198575 | 0.9825869 | 0 | 0 | 0 |
| 2 | 0.0198575 | 0.9426817 | 0.019514 | 0.0159169 | 0.0020299 |
| 3 | 0.0262241 | 0.9339497 | 0.0202198 | 0.0172814 | 0.0023249 |
| 4 | 0.0264474 | 0.9320455 | 0.0208716 | 0.0172449 | 0.0033906 |
| 5 | 0.0264251 | 0.9313058 | 0.0216021 | 0.0172334 | 0.0034334 |
| 6 | 0.0264187 | 0.9308357 | 0.022085 | 0.0172276 | 0.0034331 |
| 7 | 0.0264108 | 0.9305286 | 0.0224064 | 0.0172222 | 0.0034321 |
| 8 | 0.026407 | 0.9303177 | 0.022625 | 0.0172188 | 0.0034315 |
| 9 | 0.026404 | 0.9301795 | 0.0227689 | 0.0172165 | 0.0034311 |
| 10 | 0.026402 | 0.9300865 | 0.0228655 | 0.017215 | 0.0034309 |
| Response toΔ*L*nHC | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0.0025 | 0.0000 | 0.9975 | 0 | 0 |
| 2 | 0.0015 | 0.0001 | 0.9962 | 0.0020 | 0.0002 |
| 3 | 0.0025 | 0.0001 | 0.9949 | 0.0023 | 0.0002 |
| 4 | 0.0032 | 0.0001 | 0.9941 | 0.0023 | 0.0003 |
| 5 | 0.0034 | 0.0001 | 0.9938 | 0.0023 | 0.0004 |
| 6 | 0.0036 | 0.0001 | 0.9936 | 0.0023 | 0.0004 |
| 7 | 0.0037 | 0.0001 | 0.9935 | 0.0023 | 0.0004 |
| 8 | 0.0038 | 0.0001 | 0.9934 | 0.0023 | 0.0004 |
| 9 | 0.0038 | 0.0001 | 0.9934 | 0.0023 | 0.0004 |
| 10 | 0.0038 | 0.0001 | 0.9933 | 0.0023 | 0.0004 |
| Response toΔLnINFRA | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0.02913 | 0.0400 | 0.0009 | 0.9299 | 0 |
| 2 | 0.0294 | 0.0377 | 0.0698 | 0.8606 | 0.0025 |
| 3 | 0.0273 | 0.0365 | 0.1220 | 0.8114 | 0.0028 |
| 4 | 0.0261 | 0.0345 | 0.1694 | 0.7673 | 0.0026 |
| 5 | 0.0253 | 0.0332 | 0.2016 | 0.7374 | 0.0025 |
| 6 | 0.0247 | 0.0323 | 0.2236 | 0.7169 | 0.0025 |
| 7 | 0.0244 | 0.0317 | 0.2382 | 0.7034 | 0.0024 |
| 8 | 0.0241 | 0.0313 | 0.2478 | 0.6944 | 0.0024 |
| 9 | 0.0240 | 0.0310 | 0.2542 | 0.6884 | 0.0024 |
| 10 | 0.0239 | 0.0308 | 0.2584 | 0.6845 | 0.0024 |
| Response toΔ*L*nGOV | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0.0040 | 0.0393 | 0.0024 | 0.0101 | 0.9442 |
| 2 | 0.0038 | 0.0354 | 0.0208 | 0.0094 | 0.9306 |
| 3 | 0.0038 | 0.0350 | 0.0288 | 0.0112 | 0.9213 |
| 4 | 0.0038 | 0.0349 | 0.0330 | 0.0111 | 0.9172 |
| 5 | 0.0038 | 0.0348 | 0.0359 | 0.0112 | 0.9143 |
| 6 | 0.0038 | 0.0347 | 0.0377 | 0.0112 | 0.9126 |
| 7 | 0.0038 | 0.0346 | 0.0389 | 0.0112 | 0.9114 |
| 8 | 0.00382 | 0.0346 | 0.0398 | 0.0112 | 0.9107 |
| 9 | 0.0038 | 0.0346 | 0.0402 | 0.0112 | 0.9102 |
| 10 | 0.0038 | 0.0346 | 0.0406 | 0.0112 | 0.9099 |

Source: Authors' computations using Stata 18 package

self-reinforcing nature of infrastructure investment. Human capital benefits from infrastructure shocks, although the impact decreases over time, indicating the initial advantages that stabilize. FDI also reacts positively to infrastructure shocks, with subsequent stabilization. TFP shows a slightly positive response to infrastructure shocks, stabilizing over time and highlighting the importance of infrastructure for productivity gains. Human capital shocks had a minor negative effect on governance, suggesting initial disruptions. Infrastructure responds positively to human capital shocks and stabilizes over time. Human capital initially benefits from its own shocks, stabilizing later and underscoring the importance of sustained development. FDI shows a small positive response to human capital shocks, indicating that improvements in human capital can attract foreign investments. TFP exhibits a slightly positive response to human capital shocks, thus emphasizing the role of human capital in productivity. FDI shocks have a slightly negative impact on governance, with the effects stabilizing over time. Infrastructure initially responds positively to FDI shocks and then stabilizes, highlighting the importance of FDI in infrastructure development. Human capital shows a small positive response to FDI shocks, which suggests that FDI can enhance human capital. FDI initially reacts positively to its own shocks and stabilizes over time, reflecting the self-reinforcing dynamics. TFP responds positively to FDI shocks with stabilizing effects, thus highlighting FDI's role of FDI in boosting productivity. TFP shocks negatively affect governance. Infrastructure responds positively to TFP shocks and stabilizes over time, suggesting that productivity improvements can enhance infrastructure. Human capital shows a slightly positive response to TFP shocks, linking productivity to human capital development. FDI initially responds positively to TFP shocks, stabilizing later, indicating that higher productivity can attract more foreign investment. TFP responds positively to its own shocks and stabilizes over time, reflecting self-reinforcement in productivity improvement.

In the short term (Periods 0 and 1), the TFP variation is solely due to itself, accounting for 100% of its variance. Over a ten-period forecast, TFP's contribution slightly decreases but remains above 92%. Minor contributions from FDI, human capital, infrastructure, and governance emerge, but are insignificant. This high self-explanation underscores TFP's robustness of TFP, suggesting that intrinsic factors, such as technological advancements and efficiency improvements, are critical for its variance. The variance decomposition of FDI shows that it explains approximately 98% of its own forecast error variance in the short term (Period 1), decreasing to around 93% in Period 10. Contributions from TFP, human capital, infrastructure, and governance are minimal, indicating that FDI is primarily influenced by its dynamics. This underscores the need for a favorable investment climate and stable policies to sustain FDI inflows, as external shocks minimally impact its variance. Human capital almost fully explains its own forecast error variance, nearing 100% in the short term and remaining above 99% in Period 10. This suggests that human capital variance is driven mainly by internal factors such as education and training systems. Hence, policies that enhance human capital should improve these internal mechanisms for sustained development. Infrastructure initially explained about 93% of its variance in Period 1, but this dropped to around 68% in Period 10. The increasing contributions from human capital, alongside minor influences from TFP, FDI, and governance, highlight the growing interconnectedness between infrastructure and other economic variables. This suggests that, while infrastructure development is crucial, its effectiveness increasingly relies on improvements in human capital and other areas, necessitating a comprehensive approach that integrates both. Governance explains roughly 94% of its own forecast error variance in the short term (Period 1), slightly decreasing to approximately 91% in Period 10. Minor contributions from TFP, FDI, human capital, and infrastructure indicate that governance has been influenced by a broader set of factors over time. This implies that, while governance structures are largely self-determined, they are not entirely insulated from external shocks. Strengthening governance policies can significantly impact overall economic stability, thus emphasizing the importance of robust institutional frameworks.

## 5. CONCLUSION AND POLICY RECOMMENDATIONS

This study examines the relationship between FDI and TFP in selected African countries, focusing on human capital, infrastructure, and governance as moderating factors using a PVAR approach. The results reveal a significant impact of FDI on productivity, with bidirectional causality between FDI and TFP, highlighting the strong link between foreign investments and productivity improvements. The variance decomposition and impulse response functions indicate that while TFP is initially driven by innovation, the long-term effects of FDI and human capital become more significant over time.

This finding suggests that policymakers should focus on long-term strategies to attract FDI and improve their educational and infrastructural capacities. The role of governance in moderating the FDI-TFP relationship was variable, with efficient public resource allocation crucial for positive outcomes. Several policy recommendations have been derived. African countries should create stable and investor-friendly environments by reducing bureaucratic barriers, strengthening legal frameworks, and ensuring transparent governance. Enhancing human capital investments is essential to develop a skilled workforce that can leverage FDI for productivity growth. Infrastructure development should be prioritized with public-private partnership financing and large-scale project management. Improved governance through increased transparency and accountability can ensure that FDI and public investments are directed towards sectors that yield substantial productivity gains. While this study provides insights into the FDI-TFP nexus in Africa, it has some limitations. The focus on specific variables suggests that future research could include additional macroeconomic factors such as inflation, trade openness, and sector specific FDI flows. Given governance variability, future studies should explore institutional quality differences across African countries and their interactions with FDI. Expanding the dataset to include more recent years or additional African countries would offer a more comprehensive understanding of these dynamics. Addressing these limitations and expanding the literature can help future research explore the evolving roles of FDI, human capital, infrastructure, and governance in shaping Africa's economic trajectory.

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# APPENDIX

**Table A1: Descriptive statistics**

| Variable | Obs | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| Total factor productivity | 720 | 0.4985 | 0.2637 | 0.1152 | 1.3925 |
| Foreign direct investment | 720 | 2.9319 | 4.5137 | −11.1917 | 40.1673 |
| Human capital index | 720 | 1.8079 | 0.4561 | 1.0533 | 2.9388 |
| Infrastructure index | 720 | −0.0113 | 0.8803 | −2.0531 | 4.0662 |
| Governance index | 720 | −0.0016 | 2.2017 | −8.6100 | 5.4174 |

Source: Authors' computations using Stata 18 package