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Can stronger governance and institutional quality drive growth through inward foreign direct investments in BRICS nations?

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Background: This research focusses on the significance of institutional quality (INSQ) and governance in shaping the relationship between foreign direct investments (FDI) and growth. It specifically examines the BRICS nations (Brazil, Russia, India, China and South Africa) because of their economic significance in the global economy.

Aim: This study aims to analyse the impact of INSQ and governance on sustainable growth, with a particular focus on its effects through the channels of FDI in the BRICS countries.

Setting: Annual panel data from the Organisation for Economic Cooperation and Development (OECD) statistics, the United Nations Conference on Trade and Development (UNCTAD) statistics and the World Bank indicators spanning two decades (2000–2022) are used to analyse BRICS nations.

Methods: The research study employed the Bayesian time-varying coefficient vector autoregression (BTVC-VAR) model to achieve the objective of the study.

Results: The findings indicate that there is no long-term relationship between FDI, INSQ and economic growth in the BRICS countries. However, there is a noticeable co-movement among these variables in the short run.

Conclusion: Given the obtained results, the policymakers should prioritise efforts to strengthen institutional capacity in the short term while focussing on the Sustainable Development Goals (SDG-8 and SDG-16).

Contribution: The existing studies have assumed static economic, social and political conditions, potentially failing to accurately depict the complexities of an actual economy. This study offers methodological innovation by employing Bayesian time-varying coefficient vector autoregression (BTVC-VAR), enabling coefficients to adapt to evolving economic conditions over time. This effectively captures the dynamic nature of variables and provides reliable estimates.

Keywords: Bayesian TVC-VAR; BRICS countries; economic development; FDI; institutional quality; sustainable growth.

Introduction

Globalisation has increased accessibility among world economies by breaking down barriers to capital, trade and investments (Belloumi 2014; Sunde 2017). Foreign direct investments (FDI) have emerged as a significant feature associated with this phenomenon. It offers developed and emerging countries prospects for expansion, diversification and integration into international markets (Iqbal et al. 2018). In their pursuit of sustainable growth, developing nations actively seek foreign investments through a range of government policies, such as tax reductions, subsidies and the ratification of bilateral investment treaties (Fadhil & Almsafir 2015). These host nations strategically adopt pro-investment policies to attract greater levels of FDI within their borders (Hayat 2019). Well-known theories such as the Solow-Swan model and endogenous growth theory offer theoretical underpinnings for these policies. The Solow-Swan theory posits that capital accumulation is a fundamental driver of economic growth. Foreign direct investments contribute to this capital accumulation by injecting much-needed capital investment into host countries, thereby increasing their productive capacity. On the other hand, endogenous growth theory suggests that knowledge and technological progress play a central role in facilitating long-term economic growth. Foreign direct investments serve as a channel through which multinational enterprises transfer technologies, managerial expertise and

knowledge spillovers to domestic firms (Aziz 2022; Herzer 2012). The objective of the host countries is to harness the advantages brought by incoming investment from advanced nations. By leveraging FDI, the countries aim to bolster economic sustainability. It is viewed as a pivotal factor in fostering long-term growth and development (Banday, Murugan & Maryam 2021; Omri 2014).

However, despite the consistent positive findings in theoretical studies regarding the impact of FDI on the host nation's economy, empirical research continues to present contradictory outcomes. Although many studies confirm the positive impact of inward FDI on economic growth (Biørn & Han 2017; Kumari et al. 2023; Mehic, Silajdzic & Babic-Hodovic 2013; Rao et al. 2023; Pegkas 2015; Sunde 2017; Yimer 2023), other researchers have highlighted a negative correlation between the two variables (Alvarado, Iñiguez & Ponce 2017; Anyanwu & Yameogo 2015; Herzer 2012). Some studies have also demonstrated a weak or insignificant relationship between FDI and economic growth (Bermejo Carbonell & Werner 2018; Choi & Baek 2017; Mahembe & Odhiambo 2016).

Based on the recent literature, this inconsistency in empirical studies is attributed to the fact that gains from FDI inflows are contingent on specific domestic conditions or absorptive capacities present in the host countries. These factors include determinants like trade openness (TO) (Alam et al. 2022; Cantah et al. 2018), human capital (HC) (Abbas, Moosa & Ramiah 2021; Kottaridi, Louloudi & Karkalakos 2019), technology spillover (Alvarez & Marin 2013; Newman et al. 2015) and level of domestic investments (Miao et al. 2021). More recent studies have highlighted the importance of information and technology communication (ICT) as a measure of infrastructural capabilities to attract more FDI and strengthen inclusive growth in developing countries (Sinha & Sengupta 2022).

This research supports the notion of absorptive capacity and its role in shaping the relationship between economic growth and FDI inflows. However, the current article focusses on another important yet less explored aspect in the literature: the significance of institutional quality (INSQ) and governance in shaping the relationship between FDI and growth. This perspective emphasises the importance of INSQ in determining the benefits that FDI can bring to a host country. Effective institutions, such as a stable political environment, robust legal frameworks and efficient regulatory systems, are crucial for attracting FDI and ensuring that its benefits are widely distributed across the economy (Jung 2020). Good governance practices can enhance the positive spillovers from FDI by ensuring that foreign investments contribute to Sustainable Development Goals (SDG), such as poverty reduction and environmental sustainability (Amal 2016).

However, there are not many studies on the role of institutions and governance in the FDI–growth relationship, particularly within the context of BRICS nations – Brazil, Russia, India, China and South Africa, given their significant contributions to the world economy. The term 'BRIC' originally referring to Brazil, Russia, India and China, was coined in 2001. Eventually, South Africa joined the group in 2010, which led to renaming the organisation to BRICS, reflecting South Africa's inclusion (Liu 2016). During the recent 15th BRICS summit hosted by South Africa (2023), the member countries agreed to strengthen their economic partnership by welcoming five new nations: the United Arab Emirates, Saudi Arabia, Iran, Ethiopia and Egypt. The incorporation of new nations into the BRICS group is effective from January 2024 onwards. With the inclusion of these new members, the BRICS economies now collectively represent nearly one-third of the global gross domestic product (GDP) and encompass approximately half of the global population. The per-day oil production share of BRICS countries has almost doubled from 20% to nearly 43%, with Saudi Arabia producing approximately 12 000 barrels of oil per day. The summary of the expansion of the BRICS group is provided in Table 1.

Within this group, China is anticipated to account for approximately 23% of the growth in global GDP, with India following closely behind at approximately 13% over the next 5 years. By the year 2028, the collective contribution of BRICS economies is projected to account for nearly 40% of the global growth (Siddiqui 2016). Clearly, the BRICS nations have increased their economic influence over the years by significantly contributing to the production of goods and services on a global scale (Nayyar 2018).

Further, the real GDP growth rate forecasts by the International Monetary Fund (IMF) published annually in their World Economic Outlook report (International Monetary Fund [IMF] 2024) are displayed in Figure 1. Based on the data, BRICS countries are anticipated to achieve a higher average growth rate compared to the G7 countries.

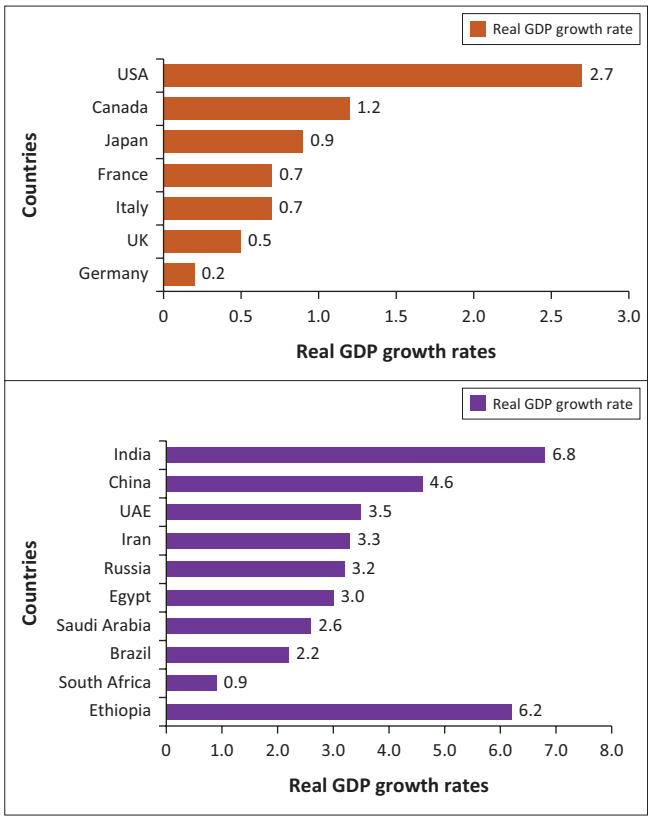
The G7 nations are projected to achieve an average of 1% real GDP growth in 2024, whereas BRICS countries are expected to outperform the G7 nations with an average growth forecast of 3.6%. Additionally, the real GDP growth rates for India and China are 6.8% and 4.6%, respectively. This disparity in growth rates is the underlying factor attracting global investors to the BRICS nations (Bandyopadhyay & Chakraborty 2024). Moreover, FDI statistics presented in Figure 2 reveal that the BRICS countries collectively witnessed an increase of over four times in their annual FDI inflows, rising from 84 billion dollars in 2001 to 355 billion dollars in 2021. The FDI inflows grew at a rate of 13.5% annually during the first decade,

TABLE 1: Comparison of BRICS member countries (2024).

Variables	Original members (%)	New members (%)
GDP	25.8	29.0
Global exports	18.3	20.6
Oil production	20.4	43.1
Population	40.9	46.0

Source: UN Trade and Development, 2023, *BRICS investment report*, viewed 03 December 2023, from https://unctad.org/publication/brics-investment-report

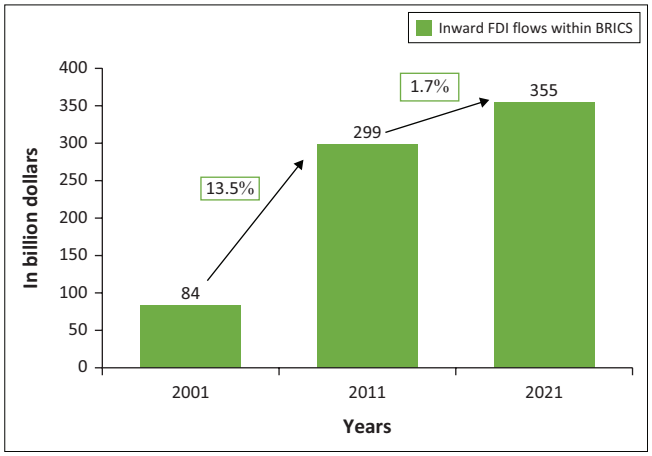
GDP, Gross domestic product.



Source: International Monetary Fund (IMF), 2024, 'Steady but slow: Resilience amid divergence', in P.-O. Gourinchas (ed.), *World Economic Outlook*, IMF, Washington, D.C

GDP, gross domestic product.

FIGURE 1: Real gross domestic product growth rate forecasts for G7 and BRICS countries.



Source: UN Trade and Development, 2023, *BRICS investment report*, viewed 03 December 2023, from https://unctad.org/publication/brics-investment-report

FDI, foreign direct investments.

FIGURE 2: Inward foreign direct investment flows within BRICS nations (2001–2021).

exhibiting a robust growth trajectory. This substantial rise can be attributed to these countries' large populations, fast-paced economic expansion, promising consumer markets and extensive land areas, making them the preferred destination for investors (Radulescu, Panait & Voica 2014). Over the next two decades, the collective BRICS economy is anticipated to become the largest in the world (Nandy & Islam 2024). This consistent growth highlights the transformation of BRICS nations into an economic powerhouse (Chhabra, Giri & Kumar 2023).

Furthermore, the study is structured as follows: the 'Literature review' section provides a comprehensive review of the literature and conceptual framework; the 'Research methodology and data' section outlines the data and methodologies employed in the article; the 'Empirical results and discussion' section discusses the outcomes of the study and finally, the 'Conclusion and policy suggestions' section summarises the findings and provides policy recommendations.

Literature review

High-quality institutions, characterised by effective governance, rule of law and low levels of corruption, create an environment conducive to economic activities, thereby promoting growth (Hayat 2019). Fazio and Talamo (2008) explored the importance of governance in stimulating the FDI influx in comparison to incentives such as tax reductions and lower wage costs. The findings have highlighted the need for better governance in order to improve the overall investment climate (Gangi & Abdulrazak, 2012). Hayat (2019) also presented evidence suggesting that both FDI inflows and INSQ are significant drivers of economic growth based on a dataset of 104 developing nations. Similarly, Jude and Levieuge (2017) studied 93 lower-income and middle-income nations from 1984 to 2009; Kechagia and Metaxas (2022) focussed on a group of six nations (Colombia, Indonesia, Vietnam, Egypt, Turkey and South Africa - CIVETS) from 2002 to 2019; Hamid et al. (2023) examined eight South Asian countries (Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka - SAARC) from 1996 to 2017 using panel autoregressive distributed lag (ARDL); and Patel, Mohapatra and Yadav (2024) conducted research specifically on India from 1996 to 2021 using nonlinear ARDL. All of these studies obtained similar results. Yeboua (2021) emphasised that FDI fosters economic growth in countries where there is a certain level of institutional development. In a more recent study, Aziz (2022) highlighted the significance of INSQ in augmenting economic growth through its indirect effect, primarily by absorbing spillovers from FDI inflows. Another major study by Gupta, Yadav and Jain (2023) used time-series analysis to study the impact of governance indicators on individual BRICS countries from 1996 to 2019 using ARDL methodology, assessing both FDI inflows and outflows. The results indicated that control of corruption significantly influences FDI in Brazil, India and South Africa, but is less relevant for Russia and China.

Further, Mehmood et al. (2023) focussed on South Asian countries, analysing the impact of INSQ on economic growth using a dynamic heterogeneous panel approach. The study pointed out that governance indicators such as corruption control, accountability and the rule of law positively affect economic growth. The results highlighted the importance of consistent governance reforms across these nations to sustain long-term economic growth. Additionally, Pradhan et al. (2023) investigated the interrelationships between INSQ, financial development and economic growth in lower-income countries using the Vector Error Correction Model (VECM). Their study revealed that INSQ has a stronger positive effect

on economic growth compared to financial development. The findings emphasise the need for co-development policies that enhance both INSQ and financial systems to achieve sustainable economic growth. Wani, Yasmin and Soudager (2023) explored the impact of INSQ on economic growth in India, using the ARDL-bound testing approach. Their findings indicated that improvements in INSQ have a significant positive effect on economic growth, suggesting that policies aimed at enhancing INSQ can spur economic development. Similarly, the study by Uddin et al. (2023) examined the impact of INSQ on economic development in 70 developing countries. Their study highlighted that INSQ positively influences the Human Development Index (HDI) and suggested that improving transparency and combating corruption are crucial for enhancing INSQ and economic development. Likewise, Kumeka et al. (2024) pointed out the direct and indirect positive effects of globalisation on inclusive growth through INSQ.

However, the existing studies have often assumed static economic, social and political conditions, which may not reflect the dynamic nature of the real economy. In contrast, this study introduces methodological advancement through the implementation of Bayesian time-varying coefficient vector autoregression (BTVC-VAR) estimation. This innovative approach allows coefficients to vary over time, providing a more comprehensive understanding of the evolving interactions among key factors. This novel methodology, which, to the best of our knowledge, is being utilised for the first time, sets our study apart from the existing research studies and represents a major value addition to the literature. By capturing the dynamic and temporal variations in the relationships between variables, our approach provides deeper insights and more accurate representations of the complex economic environment. This contribution not only enhances the robustness of our findings but also offers a new framework for future research in the area, thereby significantly advancing the existing body of knowledge.

The significance of INSQ in improving a country's economic growth and development is widely acknowledged (Aziz 2022; Hayat 2019; Mehmood et al. 2023; Wani et al. 2023). This article delves into the impact of INSQ on sustainable growth, with a particular focus on its influence through the mechanism of FDI inflows within the context of BRICS nations: Brazil, Russia, India, China and South Africa. This study contributes to SDG-16 and offers valuable insights into fostering inclusive economic growth (SDG-8). The article explicitly examines the evolution of the relationship between INSQ, sustainable growth and FDI within the context of changing global economic dynamics, notably during the COVID-19 pandemic. This is a valuable addition to the current literature, especially considering the utilisation of a more extensive dataset.

Hence, based on a comprehensive review of the available literature, this research study has formulated two main hypotheses:

H_1: There is no long-term dynamic relationship between FDI, INSQ and economic growth in BRICS countries.

H_2: There is no co-movement between FDI, INSQ and economic growth in BRICS countries.

Research methodology and data

The objective of this empirical research is to examine the evolving relation between inward FDI flows, INSQ and economic growth within the BRICS countries. To achieve this aim, panel datasets spanning from 2000 to 2022 were gathered from various secondary sources, including the Organisation for Economic Cooperation and Development (OECD) statistics, the United Nations Conference on Trade and Development (UNCTAD) statistics and the World Bank indicators. The choice of this specific time period was influenced by the availability of consistent and comprehensive data for all the variables involved in the analysis, particularly the lack of data for INSQ before the year 2000 for BRICS economies. Panel data estimation techniques were employed to capture the dynamic nature of the parameters. This will enhance the efficiency of estimation while providing richer insights into these parameters. Drawing from the existing literature, the study identified a set of potential variables as key factors influencing both economic growth and FDI inflows across BRICS nations. Table 2 provides a comprehensive overview of the selected variables, including their sources of data and measurement. Further, to ensure consistency and enhance the statistical properties of the data, all variables were converted to their natural logarithmic form. Consequently, the resulting dataset represents a balanced panel data, providing a robust foundation for analysis.

The BTVC-VAR is employed in this research to estimate the panel data. The BTVC-VAR is a statistical model that analyses the relationships between multiple variables by

TABLE 2: Overview of variables used in the study.

Symbol	Factors	Data origin	Measurement
FDI	FDI inflows	WDI	Total FDI inflows (in US dollar millions)
GDP	Gross domestic product	OECD statistics	Gross domestic product (in US dollars, 2015 constant prices)
HC	Human capital	UNCTAD statistics	Index of education, life expectancy and per-capita income
ICT	Information and communication technology	UNCTAD statistics	Includes mobile phone and fixed line users, server security and Internet accessibility within the population
INSQ	Institutional quality	UNCTAD statistics	Measures efficiency and political stability through its regulatory quality, effectiveness, fighting corruption, terrorism and criminality, and safeguarding of citizens' freedom of association and expression
TO	Trade openness index	WDI	Ratio of the sum of exports and imports to the GDP

FDI, foreign direct investments; OECD, organization for economic cooperation and development; UNCTAD, united nations conference on trade and development; WDI, World Bank indicators.

incorporating the Bayesian inference principles. Unlike traditional VAR models, where coefficients are assumed to be constant over time, the TVC-VAR model allows coefficients to vary over different time periods. In simpler terms, the TVC-VAR model recognises that the relationships between variables may change over time because of various factors such as economic conditions, policy changes or external shocks. By allowing coefficients to vary, the TVC-VAR model captures the dynamic nature and nonlinearities in these relationships. This provides us with more accurate and flexible estimates, adding a novelty feature to this empirical study. The TVC-VAR literature is still in its infancy, with limited utilisation among researchers and a scarcity of available studies.

Further, in the Bayesian estimation of the TVC-VAR model, prior distributions are specified for the coefficients. Given the observed data, Bayesian methods are used to update these prior distributions and obtain posterior distributions for the coefficients. This allows for uncertainty to be quantified and incorporated into the analysis, resulting in more reliable parameter estimates. Furthermore, the TVC-VAR represents a generalisation of VAR models in which the coefficients are allowed to change over time. Let X_t represent a vector of time series. We posit that X_t satisfies Equation 1:

$$X_t = C_{0,t} + C_{1,t} X_{t-1} + \ldots + C_{p,t} X_{t-p} + \epsilon_t \quad \text{[Eqn 1]}$$

where ϵ_t denotes Gaussian white noise characterised by a mean of zero and a covariance matrix that varies over time, denoted as Δ_t.

Consider $C_t = [C_{0,t}, C_{1,t} \ldots, C_{p,t}]$ and $\phi_t = \text{vec}(C_t')$, where vec $(\cdot)$ symbolises the stacking operator for the column. We propose the following (Equation 2):

$$\phi_t = \phi_{t-1} + \mu_t \quad \text{[Eqn 2]}$$

where μ_t denotes Gaussian white noise characterised by a mean of zero and a covariance matrix denoted as Γ_t.

Further, consider the equation $\Pi_t = L_t Q_t L_t'$, where L_t is a lower triangular matrix with unit elements on the main diagonal. Here, Q_t represents a diagonal matrix. The vector φ_t comprises the diagonal elements extracted from $Q_t^{1/2}$, while $\sigma_{i,t}$ for i = 1, …, n − 1 denotes the column vector formed by the non-unit, non-zero elements of the (i + 1)-th row of L_t^{-1}. We posit Equation 3 and Equation 4:

$$\log \varphi_t = \log \varphi_{t-1} + \psi_t \quad \text{[Eqn 3]}$$

$$\sigma_{i,t} = \sigma_{i,t-1} + \xi_{i,t} \quad \text{[Eqn 4]}$$

where ψ_t and $\xi_{i,t}$ are Gaussian white noises characterised by the mean of zero and covariance matrix Ψ and Ξ_i, respectively.

Consider $\sigma_t = [\sigma_{1,t}', \ldots, \sigma_{n-1,t}']$, $\xi_t = [\xi_{1,t}', \ldots, \xi_{n-1,t}']$ and Ξ as the covariance matrix of ξ_t. We posit independence between $\xi_{i,t}$ and $\xi_{j,t,}$ for $j \neq i$ and that ψ_t, ξ_t, ϵ_t, μ_t are mutually uncorrelated across all time intervals.

Next, the TVC-VAR model comprises two fundamental elements. Firstly, the observation equation describes how the observed variables at each time period are related to their lagged values and potentially other exogenous variables, with the unique feature of allowing the coefficients to vary over time. Secondly, the process equation that governs the evolution of these coefficients provides a dynamic model for their temporal change. Further, prior distributions are assigned to the initial state of the coefficient process and other model parameters. This encapsulates our prior beliefs or uncertainties about these quantities before observing any data. By incorporating observed data with prior distributions using Bayes' theorem, the posterior distribution is derived. This offers updated insights into the model parameters given both observed data and prior beliefs. Thus, the Bayesian TVC-VAR model integrates time-varying coefficients with prior distribution for a consistent stochastic model.

Observation equation

Consider X_t as the Π-vector representing the endogenous variables observed at time *t*, where *t* =1,2,3,…., *T*. Beginning with the foundational vector autoregression (VAR) model, the VAR equation can be formulated as Equation 5:

$$X_t' = Z_t' \Gamma_t + E_t' \quad \text{[Eqn 5]}$$

Here, Z_t represents the covariate matrix comprising k lags of X_t and potentially exogenous variables, while Γ_t signifies the time-varying coefficient matrix. The error vector E_t adheres to a multivariate normal distribution characterised by a mean of 0 and a covariance matrix denoted by Σ.

Process equation

To alleviate the challenge of over-parameterisation, a stochastic process is introduced to govern the evolution of the coefficients (see Equation 6):

$$\Gamma_t = \Gamma_{t-1} + \Lambda_t \quad \text{[Eqn 6]}$$

In this equation, Λ_t denotes the process error, which conforms to a multivariate normal distribution with a mean of 0 and a covariance matrix denoted by Ω.

Prior equation

In the Bayesian framework, prior distributions are formed based on available information before observing the data. The prior is often used to achieve shrinkage towards a simpler or stylised version of the model. For the BTVC-VAR model, a prior distribution is established over the initial coefficient matrix Γ_0, observation covariance matrix Σ and process covariance matrix Ω. This prior distribution typically encompasses a composite of individual prior distributions over each component.

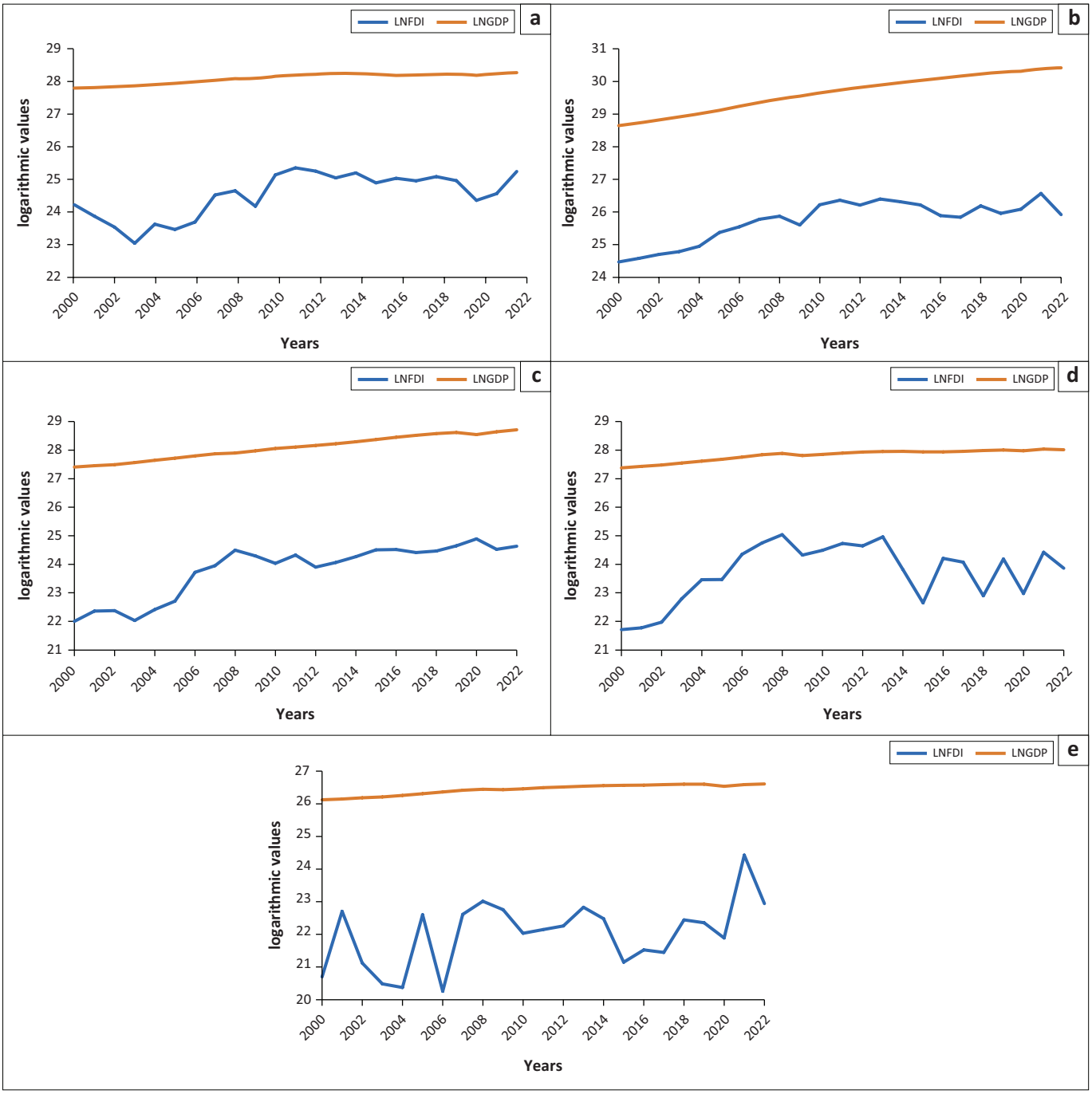
Posterior equation

The prior distribution combines with the likelihood function derived from the observation and process equations to form

the posterior distribution, which serves as the basis for inference and predictions. A Bayesian point estimate is often obtained as the mean or median of the posterior distribution. The posterior distribution of the unknowns in the model, which includes coefficient matrices Γ_t, observation covariance matrix Σ, and process covariance matrix Ω, is obtained by combining the prior distribution with the likelihood function.

Empirical results and discussion

This section provides an overview of all the research tools and methodologies utilised, and the resultant findings of this study. Panel data analysis techniques were adopted within this article to assess the factors influencing economic growth and FDI inflows in the BRICS economies. Prior to conducting the Bayesian TVC-VAR analysis, the research undertook various preliminary tests. These included a correlation matrix heatmap, a cross-sectional dependency test and a slope homogeneity test. Additionally, Figure 3 shows the graph plots for FDI and GDP for all the BRICS countries. Panel A in Figure 3 illustrates the GDP trend for Brazil, which has remained relatively flat or stagnant at a consistent level over the past two decades. In contrast, the line plot representing FDI exhibits significant variability. Initially, Brazil experienced a decline in FDI inflows



Source: World Bank, 2024, *World Development Indicators*, viewed 22 February 2024, from https://databank.worldbank.org/source/world-development-indicators
Note: The X-axis represents the years (2000–2022), while the Y-axis displays the logarithmic values of foreign direct investments and gross domestic product.

FIGURE 3: Log foreign direct investments and log gross domestic product plots for BRICS nations.

from the onset of the 21st century until 2003. Subsequently, there was a positive trend in FDI over the following years. However, FDI witnessed another downturn during the COVID-19 period (Chattopadhyay et al. 2022).

Similar patterns can be observed for India in Panel C. As for China in Panel B, the GDP trend has steadily increased over the years, while the growth in FDI was gradual until 2008. Following 2008, FDI experienced a decline in its shares for 2 years because of the Great Recession of 2008 (Li, Willett & Zhang 2012). Further, both Russia and South Africa have a similar GDP trend line, demonstrating a slow, gradual rise over the period of 22 years. The FDI trend in Russia in Panel D has shown an ascending slope in the first decade, while the second decade experienced high volatility. Similarly, South Africa in Panel E has exhibited volatile trends in FDI from 2000 to 2022, likely resulting from unclear policies towards FDI in the region (Dupasquier & Osakwe 2006; Tien, Duc & Kieu 2022).

Correlation test

Figure 4 illustrates the correlation matrix heatmap for the given variables. This heatmap allows for the graphical representation of correlation coefficients, ranging from -1 to 1, through colour gradients. Each cell represents the correlation coefficient between two given variables. The intensity of the colour reflects the strength of the correlation. The results reveal a low correlation among all the independent variables, except for FDI with GDP and HC with ICT.

However, the values of the variance inflation factor (VIF) for GDP, HC and ICT were 1.672094, 4.040697 and 3.962372, respectively, as presented in Table 3. Hence, it is evident that there was low multicollinearity between the given independent variables, as VIF values fall below the threshold of 10 (Kim 2019).

Cross-sectional dependence and Hsaio slope homogeneity test

Additionally, the cross-sectional dependence (CD) test is utilised to examine whether cross-sectional dependency exists in the given panel data for BRICS nations. Table 4 presents the outcomes of three tests: the Breusch-Pagan LM test, the Pesaran scaled LM test and the Pesaran CD test. The findings indicate the presence of cross-sectional dependency in the data. Consequently, employing a second-generation unit root test for stationarity is deemed suitable because of the identified issue of cross-sectional dependency.

The Hsaio slope homogeneity test is used to assess whether the slopes of regression coefficients are homogeneous across individuals or entities in a panel dataset. In other words, it tests whether the relationship between the independent and dependent variables is consistent or varies systematically across different entities. The results are based on three standard Fisher tests given in Table 4. The findings reveal that the given panel data for BRICS economies is totally homogeneous.

H_a: Null hypothesis: the panel is homogeneous versus alternative hypothesis: H_b.

H_b: Null hypothesis: H_c versus alternative hypothesis: the panel is heterogeneous.

H_c: Null hypothesis: the panel is homogeneous versus alternative hypothesis: the panel is partially homogeneous.

Second-generation panel unit root test

The Bai and Ng panel analysis of non-stationarity in idiosyncratic and common components (PANIC) test is a second-generation unit root test designed for panel data. It is used to investigate the presence of unit roots in a panel dataset by distinguishing between idiosyncratic (entity-specific) and common (shared across entities) components of the variables under consideration.

Mathematically, the null and alternative hypothesis for the PANIC test can be expressed as:

H_0: Both idiosyncratic and common components are non-stationary.

H_1: At least one of the idiosyncratic or common components is stationary.

The null hypothesis posits that the idiosyncratic (individual-specific) and common components of the panel data series follow a unit root process, indicating non-stationarity with a stochastic trend. On the other hand, the alternative hypothesis typically assumes that at least one of these components is stationary, suggesting the absence of a unit root.

The results of the PANIC test in Table 5 suggest that the null hypothesis is rejected at the 5% level of significance. This means that all the variables, namely, FDI, GDP, HC, ICT, INSQ and TO are stationary at their level.

Pedroni test for cointegration

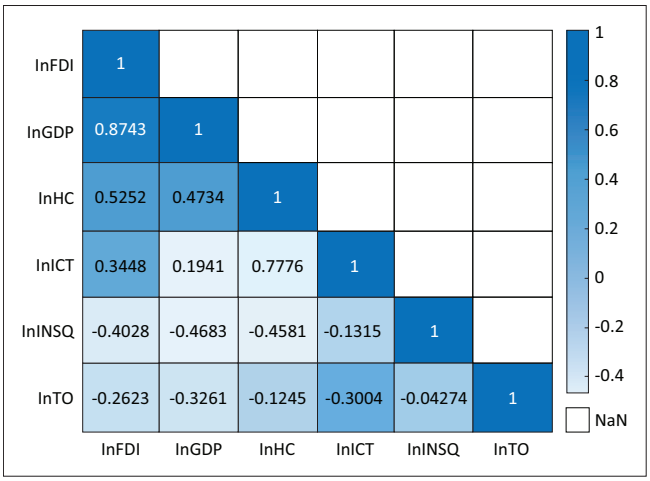
The primary purpose of the Pedroni cointegration test is to address the issue of spurious regression, a problem that arises when dealing with non-stationary data.

The results of the Pedroni test for cointegration are summarised in Table 6. The findings suggest that, at the 5% level of significance, there is insufficient evidence to reject the null hypothesis (H_1), implying that no long-run association exists between inward FDI flows, INSQ and economic growth within the BRICS countries. Consistent results have been observed earlier by Dang (2013); Shah, Ahmad and Ahmed (2016); Sabir, Rafique and Abbas (2019) and lately by Lee (2021) for developing nations. This further implies that there is no consistent pattern observed between long-term variations in FDI inflows and long-term variations in GDP across BRICS nations (Malik & Sah 2023).

Vector autoregression lag order

It is critical to determine the correct lag length in a VAR model. This is because it directly impacts the accuracy of the

model. A low number of lags increases the possibility of errors because of poor forecasting and biased estimates whereas an excessive number of lags leads to over-fitting and reduced accuracy in the model. For this purpose, the study has used five criteria for optimal lag selection: LR, FPE, AIC, SC and HQ.



Note: lnFDI, log of foreign direct investment; lnGDP, log of gross domestic product; lnHC, log of human capital; lnICT, log of information and communication technology; lnINSQ, log of institutional quality; lnTO, log of trade openness.

FIGURE 4: Correlation matrix heatmap.

TABLE 3: Variance inflating factor.

Variable	Coefficient variance	Centred VIF
lnGDP	0.005727	1.672094
lnHC	0.691561	4.040697
lnICT	0.116617	3.962372
lnINSQ	0.381242	2.378120
lnTO	0.093162	2.610320
C	32.587520	NA

lnGDP, log of gross domestic product; lnHC, log of human capital; lnICT, log of information and communication technology; lnINSQ, log of institutional quality; lnTO, log of trade openness; C, Constant; VIF, variance inflating factor; NA, not applicable.

TABLE 4: Cross-sectional dependence test and Hsaio test results.

Variable	CD test		Hsaio slope homogeneity test	
	T-statistic	Prob.	*F*-statistic	*p*-value
Breusch-Pagan LM test	21.57905	0.0174	-	-
Pesaran scaled LM test	2.589155	0.0096	-	-
Pesaran CD test	3.681069	0.0002	-	-
H_1	-	-	3.637154	5.76E-06
H_2	-	-	2.361287	0.003397
H_3	-	-	7.954061	1.22E-05

Prob., probability; LM, lagrange multiplier; CD, cross-sectional dependence; CD, cross-sectional dependence; H, Hypothesis.

TABLE 5: Bai and Ng (panel analysis of non-stationarity in idiosyncratic and common) test.

Variable	*T*-statistic	*p*-value	Decision
lnFDI	-0.23748	0.81228	I(0)
lnGDP	-0.18214	0.85547	I(0)
lnHC	-0.88007	0.37882	I(0)
lnICT	-0.04966	0.96040	I(0)
lnINSQ	-1.31169	0.18963	I(0)
lnTO	-1.95733	0.05031	I(0)

lnFDI, log of foreign direct investment; lnGDP, log of gross domestic product; lnHC, log of human capital; lnICT, log of information and communication technology; lnINSQ, log of institutional quality; lnTO, log of trade openness.

The findings from the VAR lag order selection, presented in Table 7, suggest that a lag order of 1 was deemed suitable for the estimation of the BTVC-VAR model. This implies that employing 1 lag was sufficient to capture the dynamics and interrelations among the variables under consideration.

Bayesian time-varying coefficient vector autoregression

In Bayesian TVC-VAR, the coefficients vary for each observation in the estimation sample. Consequently, it is not feasible to generate a table of coefficients, which is a rather common practice in a standard or Bayesian VAR model. Instead, the results are presented through charts that depict the evolution of coefficients over time in the case of Bayesian TVC-VAR model estimation.

The results for the BTVC-VAR equations are presented in Figure 5. The values of the prior hyperparameters used in the estimation are $T_0 = 0$, $\tau_0 = 5$, $\tau_1 = 1$, $\tau_2 = 0.01$, $\nu_1 = 7$ and $\nu_2 = 6$, respectively. The burn-in size is 1000, while the posterior sample size is set to 5000 following a Cholesky factor algorithm (CFA) smoothing method. The thinning size is set to $r = 1$ because no thinning is applied to burn-in draws. To enforce stable VAR coefficients at each date within the data sample, the Cogley and Sargent option under the stability method is chosen to run the BTVC-VAR estimation. The FDI equation parameters in Panel 1 appear to be more stable over time relative to the parameters in the other five panels. The FDI equation has remained near zero throughout the sample period (2000–2022). This supports the contention that FDI has become more stable over time because of lower dependence on its past outcomes. The same is true in the case of GDP equation parameters in Panel 2 for BRICS nations. The HC equation coefficients in Panel 3 have shown some variations

TABLE 6: Pedroni test for cointegration.

Category	Newey–West automatic bandwidth selection and Bartlett Kernel null hypothesis: No cointegration				
	Variable	Dimension (between)		Dimension (within)	
		T-statistic	*p*-value	Statistic (weighted)	*p*-value
Group	rho-statistic	0.468359	0.6802	-	-
	ADF-value	0.449856	0.6736	-	-
	PP-statistic	-4.916191	0.0000	-	-
Panel	rho-value	-0.780551	0.2175	-0.498881	0.3089
	v-value	-0.408220	0.6584	-0.100968	0.5402
	ADF-value	-0.121065	0.4518	0.262110	0.6034
	PP-value	-5.578358	0.0000	-4.976865	0.0000

ADF, augmented dickey-fuller; PP, phillips-perron.

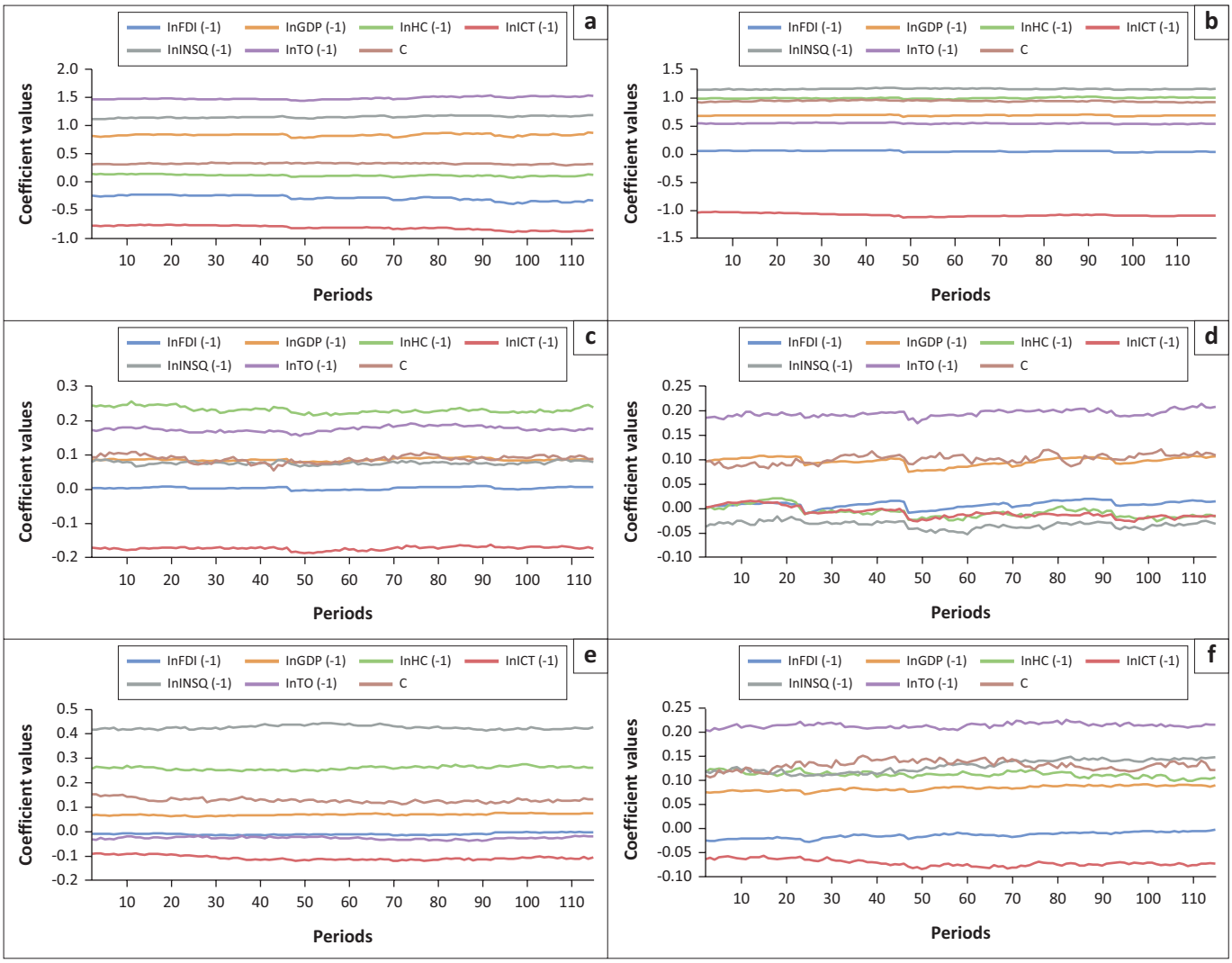
TABLE 7: Vector autoregression lag order selection criteria.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-106.6449	NA	3.83E-07	2.252898	2.409208	2.316160
1	983.8055	2028.23800	2.66E-16*	-18.836110*	-17.741940*	-18.393280*
2	1014.8700	54.05161*	2.96E-16	-18.737390	-16.705360	-17.914990
3	1033.9110	30.84638	4.24E-16	-18.398210	-15.428320	-17.196240

Note: Each test a 5% level.

LR, sequential modified LR test statistic; FPE, final prediction error; AIC, akaike information criterion; SC, schwarz information criterion; HQ, hannan–quinn information criterion.

*, Indicates lag order selected by the criterion.



LNFDI, log of foreign direct investment; LNGDP, log of gross domestic product; LNHC, log of human capital; LNICT, log of information and communication technology; LNINSQ, log of institutional quality; LNTO, log of trade openness.

FIGURE 5: Bayesian time-varying coefficient vector autoregression model equations: Equation coefficients posterior medians (a) LNFDI; (b) LNGDP; (c) LNHC; (d) LNICT; (e) LNINSQ; (f) LNTO.

over time. The FDI coefficient has remained near zero while following an oscillatory pattern, while the HC coefficient line increases and decreases irregularly, depicting random fluctuations in Panel 3. In the case of ICT equation parameters in Panel 4, the FDI and GDP coefficients follow a wave-like pattern, increasing and decreasing at regular intervals, while the ICT equation appears to have drifted away from zero in the latter part of the sample. The INSQ equation parameters in Panel 5 have relatively fewer variations than the TO equation parameters in Panel 6. The FDI coefficient appears to be approaching near zero with increasing time periods, whereas the INSQ coefficient seems to be drifting away in Panel 6 for TO equation parameters. Overall, there is co-movement observed among FDI, INSQ and economic growth in the case of BRICS countries in the short run.

Impulse response function

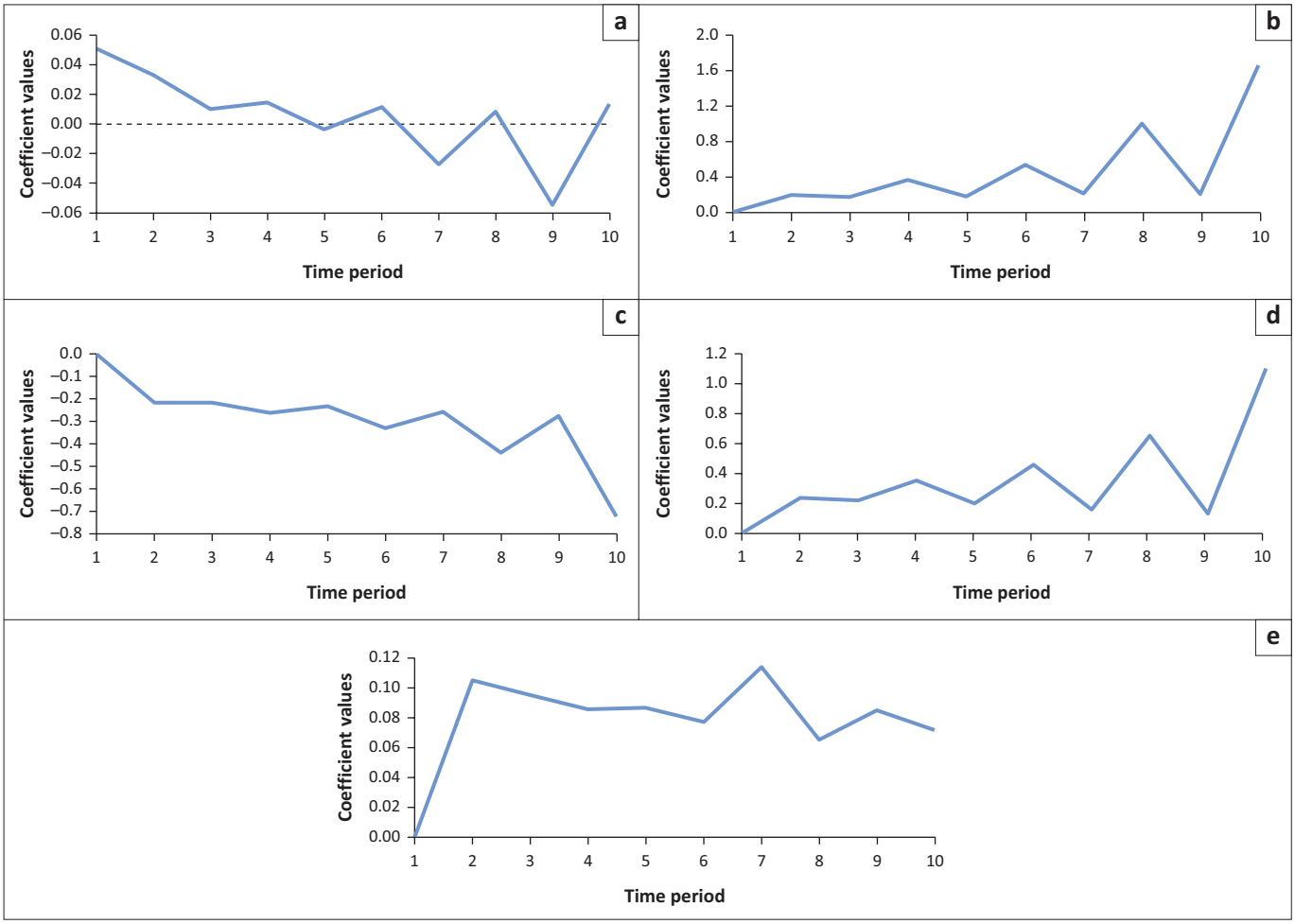
The IRF or impulse response function depicts the response of a dependent variable to an unexpected change or shock in one or more independent variables. In a standard VAR model, the effect remains consistent throughout the estimation sample because the coefficients are constant over time. However, for Bayesian TVC-VAR estimation, the effect fluctuates depending upon the impact date because the coefficients can vary at each date. For this purpose, the year 2022 is selected to analyse the after-effects of COVID-19 on FDI inflows and GDP in BRICS countries for the given sample. Figure 6 exhibits the impulse response function, revealing that an initial shock of one standard deviation (s.d.) in FDI led to an immediate decline in GDP, following a downward-sloping curve with a brief rise in the seventh and tenth periods. A similar curve was witnessed in the case of ICT. On the contrary, when INSQ experienced a shock equal to one s.d., GDP witnessed a steep rise in the initial period, accompanied by a gradual surge in the subsequent periods. Analogous zig-zag patterns can be observed in the case of HC. In addition, the impulse response of GDP to TO revealed that FDI sharply rose in the first period but subsequently declined from the following period through the sixth period. The seventh period experienced a brief increase, followed by a decrease in the next period.

Furthermore, the impulse response function presented in Figure 7 demonstrates that one s.d. shock to GDP in the initial period caused an immediate surge in FDI, which then fell from the following period onwards, exhibiting a zig-zag pattern up to the tenth period. An analogous oscillatory trend was observed for FDI following one s.d. shock to TO. The FDI showed an instantaneous increase in the initial period, which was succeeded by a sudden drop in the second period. This pattern continued until the tenth period. The impulse response of FDI showed high volatility across all periods.

Next, following a shock equal to one s.d. in HC, the impulse response function demonstrated an initial increase in FDI in the first period. This was followed by a sharp rise in FDI during the second period, maintaining stability until the third period. Subsequently, FDI increased again in the fourth period, continuing on a similar upward trajectory until the tenth period. In the case of ICT, FDI experienced a decrease starting from the first period, persisting throughout all subsequent periods. Conversely, when INSQ experienced a shock equal to one s.d., FDI rose instantaneously and exhibited a gradual increase from the second period onwards, following an upward slope.

Conclusion and policy suggestions

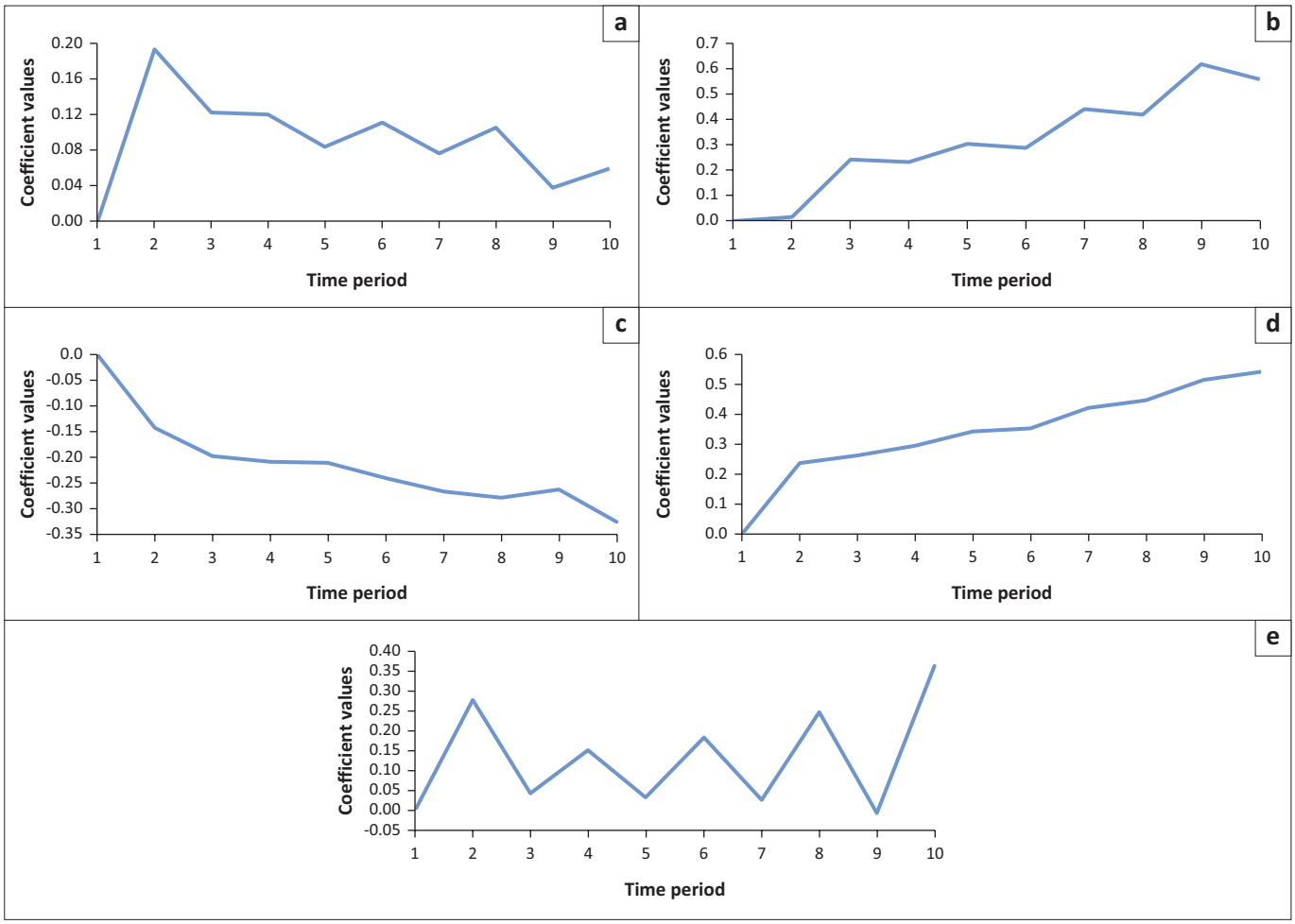
This research article primarily investigates the influence of INSQ on sustainable growth, with particular attention to its impact through the mechanism of FDI inflows in the context of BRICS countries. The objective of this study is to address a notable research gap in the existing literature by examining this key group of developing countries and recognising their pivotal role in the global landscape. The annual data for a period of two decades (2000–2022) were gathered from multiple databases, such as the OECD statistics, the UNCTAD statistics and the World Bank indicators. With an extended time frame, the study could thoroughly investigate the trends and fluctuations in the BRICS economies against the backdrop of the COVID-19 pandemic. The research introduced a methodological innovation by employing BTVC-VAR estimation. This approach allows coefficients to vary over time, given the continuous changes in economic, social and political conditions. This helps capture the dynamic effects of variables in a real economy and provides more reliable estimates. The study also generated a correlation matrix heatmap using MATLAB software. This facilitates the visualisation of correlation among the given



Note: Response to cholesky factor one S.D. innovations posterior medians.

LNFDI, log of foreign direct investment; LNGDP, log of gross domestic product; LNHC, log of human capital; LNICT, log of information and communication technology; LNINSQ, log of institutional quality; LNTO, log of trade openness; S.D., Standard deviation.

FIGURE 6: Impulse response function graphs for gross domestic product (2022): Response of LNGDP to (a) LNFDI innovation; (b) LNHC innovation; (c) LNICT innovation; (d) LNINSQ innovation; (e) LNTO innovation.



Note: Response to cholesky factor one S.D. innovations posterior medians.

LNFDI, log of foreign direct investment; LNGDP, log of gross domestic product; LNHC, log of human capital; LNICT, log of information and communication technology; LNINSQ, log of institutional quality; LNTO, log of trade openness.

FIGURE 7: Impulse response function graphs for foreign direct investment inflows (2022): Response of LNFDI to (a) LNGDP innovation; (b) LNHC innovation; (c) LNICT innovation; (d) LNINSQ innovation; (e) LNTO innovation.

variables using colour gradients. Further, the Pedroni residual cointegration test was employed to examine whether a long-term relationship exists between the given variables in the BRICS economies. The research findings indicate a lack of evidence supporting the long-term relationship among these variables. Contrary to the initial hypothesis, the empirical analysis suggests that FDI and INSQ do not exert a sustained influence on economic growth within the BRICS context. However, in the short run, there is co-movement witnessed among FDI, INSQ and economic growth.

The findings of this research offer insights into potential policy measures that can support the pursuit of economic growth, in line with SDG-8 and SDG-16. To achieve this, governments should prioritise efforts to strengthen institutional capacity in the short term. This includes improving regulatory frameworks, enhancing transparency and reducing legal hurdles to attract more FDI and promote economic growth in BRICS countries. This will encourage accountability in governance which will foster trust in institutions. The governments can also leverage technology to enhance transparency and streamline bureaucratic processes which will make the business environment more attractive to foreign investors. Governments should also focus on implementing stringent anti-corruption measures by enhancing the efficiency of judicial systems. Additionally, policymakers can enhance and expand skill development programmes to further improve workforce productivity and attract more FDI in sectors requiring skilled labour. Short-term initiatives such as vocational training and apprenticeship programmes can address immediate skill gaps and support sustainable economic growth. Furthermore, governments should invest in infrastructure projects, such as energy grids, transportation networks and digital infrastructure. This is crucial for enhancing productivity, connectivity and competitiveness. The BRICS nations should focus on infrastructure development to attract investment, stimulate economic activity and create employment opportunities. By implementing these strategies, BRICS economies can achieve the SDG of economic growth through channels of FDI and strong institutions. However, it is crucial that all policies be adapted to the unique circumstances and needs of each nation to ensure effectiveness and relevance. Recognising the heterogeneity among BRICS countries, it is essential to develop tailored strategies that account for each country's specific context, initial conditions and institutional capacities

to achieve the desired outcomes. Also, this study has excluded the newly added member countries, namely, Egypt, Ethiopia, Iran, Saudi Arabia and the United Arab Emirates from the analysis because of resource and time constraints. Therefore, the findings of this study may not be generalisable to the recently expanded BRICS group. Future research can benefit from incorporating data and analysis from these newly included members to ensure a more comprehensive understanding of the BRICS dynamics. This study empirically established that there exist significant short-term benefits of FDI inflows and INSQ on the overall economic growth of the BRICS economies. It further emphasises the necessity of implementing strategies to maximise these effects. By optimising INSQ, fostering global governance and promoting an environment conducive to foreign investors, BRICS nations can harness their potential for accelerated growth and development. It is imperative that policymakers capitalise on the immediate advantages of FDI, while also prioritising sustainable economic development goals with the help of a flexible and responsive approach.

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Competing interests

The authors declare that they have no financial or personal relationship(s) that may have inappropriately influenced them in writing this article.

Authors' contributions

A.M. drafted the manuscript, conducted a literature review, collected data, performed analysis and interpreted the results. A.N.S. significantly contributed to the research design and assisted in data analysis and final editing. Both authors have read and agreed to the submitted version of the manuscript.

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Ethical considerations

This article does not contain any studies involving human participants conducted by any of the authors.

Data availability

The data used in the study are available on OECD statistics, UNCTAD statistics and the World Bank Database. The data that support the findings of this study are available on request from the corresponding author, A.M.

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