

Nach, Marida; Ncwadi, Ronney

Article

Evaluating BRICS as an optimum currency area: insights from SVAR modeling

Cogent Economics & Finance

Provided in Cooperation with:

Taylor & Francis Group

Suggested Citation: Nach, Marida; Ncwadi, Ronney (2024) : Evaluating BRICS as an optimum currency area: insights from SVAR modeling, Cogent Economics & Finance, ISSN 2332-2039, Taylor & Francis, Abingdon, Vol. 12, Iss. 1, pp. 1-25,
<https://doi.org/10.1080/23322039.2024.2399321>

This Version is available at:

<https://hdl.handle.net/10419/321588>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<https://creativecommons.org/licenses/by/4.0/>

Evaluating BRICS as an optimum currency area: insights from SVAR modeling

Marida Nach & Ronney Ncwadi

To cite this article: Marida Nach & Ronney Ncwadi (2024) Evaluating BRICS as an optimum currency area: insights from SVAR modeling, Cogent Economics & Finance, 12:1, 2399321, DOI: [10.1080/23322039.2024.2399321](https://doi.org/10.1080/23322039.2024.2399321)

To link to this article: <https://doi.org/10.1080/23322039.2024.2399321>



© 2024 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group



Published online: 06 Sep 2024.



Submit your article to this journal [↗](#)



Article views: 1251



View related articles [↗](#)




View Crossmark data [↗](#)



Citing articles: 2 View citing articles [↗](#)

Evaluating BRICS as an optimum currency area: insights from SVAR modeling

Marida Nach  and Ronney Ncwadi

Development and Tourism, School of Economics, Nelson Mandela University, Gqeberha, South Africa

ABSTRACT

The study evaluates the feasibility of BRICS (Brazil, Russia, India, China, and South Africa) countries to form an Optimum Currency Area (OCA) through the analysis of shock correlation within the OCA framework. Employing a structural vector auto regression (SVAR) model proposed by Blanchard and Quah, the analysis encompasses both external and domestic shocks affecting individual countries. The study employs four variables: world real GDP, domestic real GDP as a proxy for output, the real effective exchange rate, and the inflation rate as a proxy for price level, to estimate the shocks. Subsequent analysis includes ANOVA, impulse response function (IRF), and variance decomposition to discern shock magnitudes, adjustment dynamics, and underlying determinants of variability. Empirical results show that BRICS countries display symmetric responses to external shock, however, with overall different sources of variation in the responses to domestic supply, demand, and monetary shocks. The results of the analysis using the ANOVA test, IRF, and variance decomposition also highlight the nuanced disparities across BRICS countries in terms of demand, and monetary shocks, indicative of differences in transmission mechanisms and policy responses. The study underscores the implication of aligning exchange rate mechanisms and monetary policies in facilitating the convergence of shock levels, thereby fostering economic stability among BRICS countries.

IMPACT STATEMENT

This study provides a critical analysis of the feasibility of BRICS countries forming an Optimum Currency Area (OCA) through the application of Structural Vector Auto Regression (SVAR) modeling. By analyzing the correlation and dynamics of both external and domestic macroeconomic shocks, the research highlights significant disparities in how these shocks affect BRICS countries. Despite these differences, the study identifies a strong symmetric response to external shocks. These findings underscore the challenges of aligning exchange rate mechanisms and monetary policies among these diverse economies, yet also reveal the potential for economic stability through coordinated policy responses to symmetric external shocks. This work is pivotal in informing policy decisions on deeper economic integration within the BRICS bloc. It also suggests that with careful policy design, particularly focusing on strengthening economic interdependencies and mitigating asymmetric shock, the BRICS bloc could enhance its economic stability and global influence. Therefore, the study also offers valuable insights into the feasibility of a common currency or enhanced economic integration for emerging economies considering monetary unions in a complex global financial landscape. The study's recommendations provide a roadmap for BRICS countries to navigate the complexities of economic integration, making it a significant contribution to the field of international economics and regional development strategies.

ARTICLE HISTORY

Received 5 March 2024
Revised 22 July 2024
Accepted 23 August 2024

KEYWORDS



Optimum currency area (OCA); structural vector auto regression (SVAR); shock dynamics; BRICS

SUBJECTS

Development Economics;
International Economics;
International Finance;
Economic Forecasting;
Econometrics; Regional
Development; Economics;
Economics and
Development

1. Introduction

The acronym BRICS represents a coalition of emerging economies encompassing Brazil, Russia, India, China, and South Africa. These nations have garnered significant attention due to their combined influence on the global financial landscape. There is a growing recognition of the need for a new global

CONTACT Marida Nach  maridanach@gmail.com  Development and Tourism, Faculty of Business and Economics Sciences, School of Economics, Nelson Mandela University, University Way, Gqeberha, Summerstrand 6001, South Africa

© 2024 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group

This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. The terms on which this article has been published allow the posting of the Accepted Manuscript in a repository by the author(s) or with their consent.

financial framework that is both more inclusive and adaptable to the needs of emerging and developing economies. The leaders of the BRICS nations have addressed concerns such as increasing debt burden, financial crises, and the sluggish pace of reform in the international monetary system. As discussions on the necessity of reforms arise against the backdrop of shortcomings in the global financial system, the BRICS alliance emerges as a key player in shaping the direction of international financing (Cynthia et al., 2017; Kirton & Larionova, 2022; Larionova & Kirton, 2018). BRICS is serving as a model for emerging and developing economies seeking to establish themselves in the global financial arena. BRICS alliance presents of a hopeful direction in confronting these challenges, given it comprises diverse economies with significant growth prospects, thereby positioning itself as a central point of discussion on the global financial landscape (Lowe, 2016; Xing, 2016).

Although BRICS nations experience different growth paths, their collective influence on the global economy remains undeniable. To underscore their significance in the global economy, it's essential to highlight their share of global GDP, trade, and investment activities. Together, BRICS nations contribute to over 25% of the global economic output and represent 42% of the global population (Richter, 2023; United Nations Conference on Trade and Development, 2023). As a group, they make up over 17% of global imports and exports. This combined trade volume reflects their increasing participation in the global supply chain and their importance as major trading partners in various regions. For instance, China's rapid rise, driven by its manufacturing prowess and innovation, has transformed the global supply chains and investment patterns. India, with its thriving technology sector and large population, stands as the another economic driving force within BRICS. BRICS nations' trade have also experienced expansion due to factors like complementary production capabilities, infrastructure development, and initiatives to boost trade (Iqbal, 2022; Yarygina et al., 2020).

Moreover, the collective importance of the BRICS nations can be further exemplified by their increasing involvement as recipients and providers of foreign direct investment (FDI). These countries have progressively emerged as appealing recipients for investment and have been actively engaging in overseas investments, seeking to access to new untapped markets, and technology transfer (Hooijmaaijers, 2021a, 2021b). Additionally, over the past two decades, the FDI to and from these nations have grown significantly, thereby playing a substantial role in bolstering the overall gross fixed capital formation (United Nations Conference on Trade and Development, 2023).

Furthermore, the BRICS nations are actively asserting their influence in global economic governance forums and institutions. Apart from their yearly summits, they have set up significant institutions such as the New Development Bank (NDB) and the Contingent Reserve Arrangement (CRA), exemplifying their commitment to fostering economic collaboration. The NDB, which a financing capacity of \$32.8 billion, mainly focuses on backing sustainable development projects that are in line with the objectives of the Paris Agreement. Its main goal is to provide financial support for projects on climate changes, that are resilient to disasters, technological advancements focus, and socially inclusive (Abdenur & Folly, 2015; Cooper, 2017; Dixon, 2015). The CRA, supported by a dedicated resource pool of \$100 billion, plays an important role in enhancing financial stability through the provision of liquidity and precautionary instruments to address the short-term balance of payments challenges (Cattaneo et al., 2015; UNFCCC, n.d.). These initiatives highlight the BRICS' commitment to shaping the global economy and addressing global challenges. With a growing share of global GDP, trade, and investment, BRICS nations collectively represent a significant force in the global economy, with their influence extending across various sectors.

Given the foregoing discourse on the noteworthy position of BRICS in the global economy landscape, it is important to delve into the fiscal and monetary strategies prevalent in these countries. The BRICS nations exhibit diverse approaches toward fiscal and monetary policies, reflecting their distinct economic conditions, institutional structures, and policy objectives (Duggan et al., 2022). Brazil and South Africa have faced challenges associated with fiscal deficits and public debt, prompting them to implement measures such as austerity programs and fiscal reforms to stabilize their economies. In contrast, Russia has opted to utilize monetary policy tools to manage inflation and stabilize its currency, often relying on interest rate adjustments and foreign exchange interventions. India, on the other hand, has pursued a combination of fiscal stimulus and monetary easing to support economic growth, with a particular focus on investing in infrastructure and expanding credit. China, with its centrally planned economy, employs

a blend of fiscal policies aimed at targeted investment and monetary policies geared towards maintaining stability in financial markets and controlling inflation (Jawadi et al., 2014; Tendengu et al., 2022). Monetary policies of these nations have increasingly shifted towards the use of interest rates as the primary monetary instrument, accompanied by the adoption of inflation targets as a key objective of monetary policy. Both fiscal and monetary policies in the BRICS nations are flexible and tailored to address their specific economic needs and challenges (Jawadi et al., 2011; Mbangata & Kanayo, 2017). Despite these differences, BRICS nations have increased efforts to collaborate through platforms such as the BRICS Summits and initiatives like the CRA and the NDB, as stated above (Akalpler & Hove, 2022).

Rationale for BRICS as an OCA

In the context of continuous discussions about global financial reform, the 15th BRICS summit held in Johannesburg in 2023 has sparked growing interest in establishing a common currency for the BRICS nations (Council of Councils, n.d.). Progressing towards this goal, BRICS countries have initiated the use of their national currencies in trade through currency swaps and bilateral payment agreements. This strategy aims to improve the efficiency of international trade and investment activities, both within the BRICS bloc and with external partners, thus helping to address trade deficits and other economic challenges faced by these and similar countries (Karataev et al., 2017; Kregel, 2015).

A common currency for BRICS nations presents a unique opportunity to enhance economic integration and global influence. By eliminating the need for currency exchange, businesses and consumers would experience reduced transaction costs, facilitating smoother and more efficient trade across the bloc. This increase in trade efficiency would lead to greater price transparency, fostering competition and potentially lowering costs for goods and services (De Grauwe, 2020, pp. 101–110). Moreover, a unified monetary policy could stabilize exchange rates among member countries, creating a more predictable economic environment that is attractive to foreign investors (Frankel & Rose, 1998). Therefore, the collective economic power of a unified BRICS currency would amplify the bloc's influence in international financial institutions, enhancing its ability to negotiate favourable terms and advocate for policies that benefit its member countries.

Despite the geographic and economic diversity among BRICS nations, a common currency could provide a framework for mitigating external economic shocks. Mundell (1961) expresses a view that by pooling economic resources and diversifying risks, member countries could achieve greater economic stability and resilience (Alessina et al., 2002; Barro & Tenreyro, 2007; Mundell, 1961). It is against this background that a collaborative approach would also enable the BRICS countries to share best practices and support each other in times of economic difficulty. The potential benefits of enhanced trade, investment, and global influence make the pursuit of a common currency a worthwhile endeavour for BRICS, promising a more integrated and robust economic future for its member nations.

The establishment of a BRICS currency for global settlements could bring benefits such as mitigating the effects of currency fluctuations, lessening currency risks for participating nations, and improving the effectiveness of international transactions (De Grauwe, 2020, pp. 55–70). These microeconomic benefits of a unified currency need to be compared with the macroeconomic challenges of managing shocks that affect individual countries differently. Evaluating the shock alignment among BRICS countries is essential for determining the feasibility of a unified currency system and formulating effective policy measures for the future. This discussion provides a robust basis for the empirical analysis.

The theory of optimum currency area (OCA), introduced by Mundell (1961) posits that if nations face symmetric shocks, implementing a uniform monetary policy will be more suitable. However, if there are structural disparities and variations in shocks, a uniform monetary policy may not be suitable (Mundell, 1961). According to De Grauwe (1996, 2020), a currency union can enhance the stability of monetary policy, leading to deeper integration in the global economy (De Grauwe, 1996, 2020). The distinctive features of the BRICS nations including their economic heterogeneity, exposure to various economic shocks, intra-regional trade and investment linkages, policy mechanisms, and geopolitical considerations, make the group a compelling case study of an OCA analysis.

Therefore, this paper aims to evaluate the feasibility of BRICS countries as an Optimum Currency Area through the correlation and dynamics of both external and domestic macroeconomic (supply, demand

and monetary) shocks. Our analysis draws on prior empirical studies that underscore the relevance of shock correlation within the OCA framework.

The structure of the paper is as follows: [Section 2](#) presents in the literature review a comprehensive analysis of shock symmetry within the OCA framework, along with a review of prior studies exploring this context. [Section 3](#) describes the data and the methodology employed in this study. The empirical results are presented in [Section 4](#). [Section 5](#) offers a discussion on the results and their implications. Lastly, [Section 6](#) concludes the paper.

2. Literature review

2.1. *The OCA theory and the shocks symmetry*

Macroeconomic shocks are unexpected occurrences that have substantial effects on an economy. These shocks can arise from various sources, such as fluctuations in commodity prices, changes in exchange rates, shifts in interest rates, or alterations in economic growth patterns. They can be classified into two main types: short-term shocks, which quickly return to a state of balance with limited consequences, and persistent shocks, which stem from underlying vulnerabilities within an economy (Nchor, 2020). Evaluating whether these shocks exhibit asymmetry or symmetry plays a crucial role in influencing the formation of an OCA.

The Optimum Currency Area (OCA) theory provides a theoretical framework for comprehending currency unifications and elucidates the rationale behind their establishment on a global scale, encompassing various regions such as Europe, Asia, Africa, and Latin America. By examining the asymmetry and symmetry of macroeconomic shocks, the OCA theory aids in evaluating the efficiency of currency unions, the appropriateness of a common currency, and the monetary policy for participating nations. Initially introduced by Mundell (1961), further developed by McKinnon (1963) and (Kenen, 1969), the OCA theory outlines the different conditions under which countries should adopt a unified currency to enhance economic integration. The main difference between symmetric and asymmetric shocks lies in their impact. Symmetric shocks have a uniform or synchronized effect on all regions or sectors, while asymmetric shocks have a varying impact, affecting certain regions or sectors more than others (Apazidis & Eliasson, 2019). In cases where exchange rate adjustments, which serve as a mechanism for mitigating shocks, are not available due to the adoption of a common currency, asymmetric shocks become particularly problematic as they pose challenges to monetary unions. The inability of the nominal exchange rate to fluctuate in a monetary union hinders adjustment to specific shocks, increasing the costs of surrendering control over monetary policy. The absence of a nominal exchange rate as a means of adapting to shocks amplifies the costs linked to surrendering autonomy over monetary policy (Bayoumi, 1994; Bayoumi & Eichengreen, 1992; Jager & Hafner, 2013). Therefore, shock symmetry is important within the Optimum Currency Area (OCA) framework, indicating synchronized economic fluctuations among member countries, which is favorable for a unified currency and monetary policy. Conversely, asymmetric shocks pose challenges to currency unions, potentially leading to economic imbalances and difficulties for specific member countries (Campos & Macchiarelli, 2018; Omotor & Niringiye, 2011).

Moreover, literature highlights the economic consequences of shocks within monetary unions, as demonstrated by historical events like the oil price shocks of the 1970s and the 2009 financial (Baas & Belke, 2023; Filippidis et al., 2020; Jones & Leiby, 1996; Kilian & Lewis, 2011). Moreover, the lack of flexibility in adjusting exchange rates within such unions exacerbates the challenges in responding to asymmetric shocks, thereby escalating the costs associated with relinquishing control over monetary policy autonomy. Conversely, a flexible exchange rate system allows for adjustments in exchange rates, facilitating the absorption of asymmetric shocks and enabling adaptation to country-specific economic disturbances. This adaptability can mitigate the costs related to asymmetric shocks and strengthen individual countries' ability to effectively tackle economic challenges (Khatat et al., 2020). Therefore, understanding the nature of economic shocks is imperative in evaluating the feasibility and effectiveness of currency unions. This comprehension informs the efficacy of a unified monetary policy in addressing diverse economic circumstances and the challenges faced by member states.

2.2. Empirical literature review

Supply shocks and demand shocks are both important factors in shaping economic outcomes, as highlighted in economic literature (Shapiro, 1987). Early studies by Blanchard and Quah (1989) as well as (Bayoumi & Eichengreen, 1992) and (Bayoumi, 1994) emphasized the significant impact of symmetric shocks on output, particularly in assessing the suitability of countries for monetary unions. These studies have laid the groundwork for extensive research on monetary unions, guiding decisions on country selection, monetary policy, and related initiatives.

In the context of the BRICS countries, Saji (2019) used the Markov Regime-Switching Model (MRSRM) to examine the possibility of a currency union among BRICS countries, focusing on with a specific focus on comparing the behavior of their real exchange rate markets. The findings revealed disparities in market behavior prior to the formation of the BRICS, suggesting that strengthening policy cooperation in the region, particularly in terms of monetary management, could enhance the prospects of a robust currency union among BRICS members (Saji, 2019). Quah (2016) Quah's study assessed the feasibility of monetary integration within BRICS applying different OCA theory criteria. While the results were inconclusive, the study hinted at China's potential role in monetary integration (Quah, 2016). These studies have sparked further exploration in the field, emphasizing the need for more rigorous econometric analyses as advocated in this study to understand unique data characteristics in BRICS. The examination of the macroeconomic effects of shocks is just as crucial as understanding the nature of these shocks. In a study by BenMabrouk and HadjMohamed (2022), they used the SVAR model to analyze the effects of oil shocks on the volatility of BRICS and G7 markets. Their research showed that oil shocks had a noticeable influence on both markets, but the impact varied depending on the type of shock and the specific market being studied. They found that the response to market volatilities was more pronounced in the case of demand shocks compared to supply shocks (BenMabrouk & HadjMohamed, 2022). Another study by Naeem et al. (2021) found positive and long-lasting relationships between oil demand shocks and BRIC markets (Brazil, Russia, India, and China). Through their Cross-quantile dependence analysis, they demonstrated a positive and significant correlation between oil demand shocks and BRIC stock returns (Naeem et al., 2021). Li and Guo (2022) focused on the shock impacts of oil price and component shock on inflation in the BRICS countries. They used a novel multiple threshold nonlinear autoregressive distributed lag model (MTNARDL) and discovered significant asymmetries between oil price and inflation, particularly in China in the short term. They also observed that demand shocks had a temporary impact during periods of extreme (Li & Guo, 2022).

The following studies delved into the concept of shock symmetry within the OCA framework to assess the feasibility of currency union in different regions. Dongfack and Ouyang (2020) evaluated the performance of the Central African Economic and Monetary Community (CAEMC) as a currency union, focusing on member countries' vulnerability to asymmetric shocks. Using a SVAR model, they identified structural macroeconomic shocks and observed output growth and inflation impulse responses. Their findings highlighted the asymmetric effects of aggregate demand and supply shocks, highlighting potential adjustment costs due to the absence of monetary sovereignty (Dongfack & Ouyang, 2020). Khezri et al. (2019) examined the responses of supply, demand, and external shocks on the Shanghai Cooperation Organization (SCO) countries. They employed a global vector autoregression (GVAR) approach, with quarterly data of price levels, interest rates, exchange rates, and GDP. Their finding revealed asymmetric responses of central banks and variations in macroeconomic indicators depending on the type of shock (Khezri et al., 2019).

Moreover, Basnet and Pradhan (2017) investigated the economic interdependence within MERCOSUR countries. Employing the serial correlation common features test, their finding revealed a strong long-term co-movement in key macroeconomic variables namely, exchange rate, real output, investment, and intra-regional trade, indicating strong macroeconomic interdependence. These findings support the idea of deepening integration within Mercosur countries (Basnet & Pradhan, 2017). In another study, Kazerooni and Razzaghi (2014) employed a three-variable SVAR model to assess the possibility of a common currency area among members of the D-8 group. Their findings reveal significant and symmetrical shocks, suggesting a currency union formation within subgroups of Malaysia, Turkey, Nigeria, and Pakistan (Kazerooni & Razzaghi, 2014). Lastly, Sheikh et al. (2013) evaluated the shocks nature and business cycle synchronization among East African Community (EAC) countries to assess its OCA suitability.

Using the SVAR model, their findings showed that the EAC was mainly influenced by external supply shock and domestic demand shock, with symmetry between domestic supply and monetary shocks (Sheikh et al., 2013).

The foregoing theoretical and empirical literature review presented the basis for the evaluation of the feasibility of BRICS as an OCA. The literature has provided insights into the appropriate models and crucial variables to consider when analyzing shock within the BRICS framework.

3. Methodology

3.1. Data

The dataset utilized in this study was obtained from the *World Development Indicators* (WDI), the *International Financial Statistics* (IFS), and the *Federal Reserve of ST Louis Economic Data*, provided by the World Bank, and the International Monetary Fund (IMF) and the Federal Reserve of ST Louis Economic Data, respectively. The dataset spans annually from 1993 to 2022. The selection of this timeframe ensures the availability of a robust dataset with ample observations for all variables for all BRICS countries required for econometric modelling. The dataset consists of four variables: world real GDP which serves as a proxy for world output, each country's domestic real GDP, a proxy for domestic output, inflation rate as presenting the price level, and real effective exchange rate for the five BRICS countries.

3.2. Structural vector auto regression (SVAR)

The SVAR model, originally introduced by Sims (1980), serves as a tool for analyzing macroeconomic shocks dynamics. It is widely in assessing economic theories and understanding the transmission of various shocks and provide flexibility by incorporating contemporaneous variables, conducting individual shock analysis, and estimating unobservable parameters, thus overcoming the limitations of non-structural VAR models (Gottschalk, 2001). Built upon economic theory, SVAR integrates short-term (Bayoumi & Eichengreen, 1992) and long-term constraints (Blanchard & Quah, 1989), allowing for a deeper understanding of economic connections. Furthermore, Blanchard and Quah (1989) model, rooted in Aggregate Demand and Aggregate Supply (AD-AS) theory, converts reduced-form VAR equations into structural equations, enabling the extraction of economic structure (Fernández-Villaverde & Rubio-Ramírez, 2010; Ouliaris & Pagan, 2016; Rubio-Ramírez et al., 2010; Stock & Watson, 2016).

However, despite its effectiveness, the SVAR model is not without limitations. Implicit constraints and assumptions within the model can potentially result in misinterpretations and restricted assumptions (Gottschalk, 2001; Lippi & Reichlin, 1993). But its capacity to analyze monetary transmissions and non-policy shocks makes it a valuable tool in economic research. Therefore, this model remains widely utilized in empirical analyses of monetary and fiscal policy and the study OCAs.

In this study, the SVAR model employs the following AD-AS economic theory to impose long-run restrictions:

- Aggregate supply shocks are the sole source of permanent movement in output in the long run,
- Aggregate supply and demand shocks both can affect the real exchange rates in the long run, and finally,
- Monetary shocks have no real effect on both output and real exchange rate.

Whenever there is no indication of restrictions according to the AD-AS theory framework, the structure shocks do not affect a variable. Consequently, the absence of long-run restrictions on price level reflects the silent stance of the AD-AS theory framework on this variable.

3.3. Model specification

The study uses a multivariate structural vector autoregression (SVAR) model. Moreover, we refine previous methodologies by incorporating four macroeconomic variables instead of two variables. This study

has used E-Views13 to conduct the SVAR modelling. The model is expressed in both reduced and matrix forms, enabling the expression of each endogenous variable solely as a function of predetermined variables. Comprising one external shock, represented as the global supply shock, and three domestic shocks (supply, demand and monetary), the model encapsulates the dynamics of the economy. Upon identifying these shocks, assumptions are imposed on variables to enable the measurement the shock symmetry or asymmetry. This assessment is conducted through four analytical approaches:

- Correlation Analysis: Examining the correlation of external global supply shock, domestic supply, demand, and monetary shocks.
- One-Way ANOVA and Coefficient of Variance Analysis: using statistical methods to analyze the non-linear dependence of underlying these macroeconomic shocks
- Impulse Response Analysis: Examining the response of these variables to identified shocks over time.
- Variance Decomposition Analysis: Assessing the relative contribution of each shock to the variability of these variables.

The applicability of these analytical techniques relies on the stationarity and logarithmic transformation of global real GDP (y_t^*), domestic real GDP (y_t), the inflation rate (inf_t), and real effective exchange rate (ex_t). By ensuring the stationarity of these variables and their log transformation, the analysis maintains robustness and enhances the interpretability of results. The outlined analytical process above is symbolically represented as follows:

Consider a K-dimension time series:

$$y_t, t = 1, \dots, T.$$

y_t can be a vector auto-regression of finite order p .

$$y_t = (x_{1t}, x_{2t}, x_{3t}, x_{4t}) \quad (1)$$

The Equation (1) be a vector of the four endogenous variables where:

x_{1t} is the world economic growth rate, (y_t^*),

x_{2t} is the domestic growth rate (y_t),

x_{3t} is the domestic inflation rate (inf_t), and

x_{4t} is the domestic real effective exchange rate (ex_t).

The dynamic structural of the model is represented as following:

$$A(L)y_t = u_t \text{ or } Ay_t = u + \sum_{i=1}^p A_i y_{t-i} + v_t \quad (2)$$

A is a 4*4 matrix of Structural coefficients among endogenous variables.

u_t is a zero mean serial uncorrelated error term, also called structural shocks.

v_t is a vector of orthogonal structural shocks to the system so at:

$$i = 1, \dots, p \quad (3)$$

The variance co-variance matrix of the structural error-term is:

$$\sum_u \varepsilon = (v_t v_t') = (u_t \ u_t') = I_k \quad (4)$$

(k) the number of variables

This means that: There are as many structured shocks as variables in the model, structural shocks are uncorrelated, implying \sum_u is diagonal, variance of all structural shocks are normalized to one.

The next step is to derive a reduced for of Equation (2), meaning expressing y_t as a function of logged y_t only. The reduced form of Equation (2) is:

$$y_t = A_1 y_{t-1} + \dots + A_p y_{t-p} + \varepsilon_t \quad (5)$$

Compactly the model can be written as:

$$A(L)y_t = \varepsilon_t \text{ or } y_t = A^{-1}u + \sum A^{-1}B_t y_{t-j} + A^{-1}v_t \quad (6)$$

Equation can be rewritten as:

$$y_t = v + \sum_{j=1} \theta_j y_t + \varepsilon_t \quad (7)$$

where, $A^{-1}u$, $\theta_j = A_j^{-1}B_j$ and $\varepsilon_t = A^{-1}v_t$.

Equation (7) can be rewritten as:

$$y_t = v + \theta(L)y_t + \varepsilon_t \quad (8)$$

where,

$$\theta(L) = L + L^2 + \dots + L^p.$$

The corresponding structural vector moving average (VMA) representation is:

$$y_t = B(L)^{-1}u_t = \theta(L)u_t \quad (9)$$

The corresponding reduced-form vector moving average (VMA) representation is:

$$y_t = A(L)^{-1}\varepsilon_t = \phi(L)\varepsilon_t \quad (10)$$

Next is to orthogonalize the reduced form errors, meaning making the errors uncorrelated by defining the lower triangular $k \times k$ matrix p with positive main diagonal such that $pp' = \sum_{\varepsilon}$.

By definition:

$$\varepsilon_t = B_0^{-1}u_t, \quad (11)$$

$$\sum_{\varepsilon} = B_0^{-1}B_0^{-1} \quad (12)$$

$B_0^{-1} = p$ being one possible way to recover u_t .

p is the lower triangle. It has $k(k+1)/2$ parameter so that all p 's parameters are identified. Where it is imposed that, $\sum_u = I_k = I_4$

The above process can be represented by an infinite moving average representation as follows:

$$\Delta X_t = A_0\varepsilon_t + A_1\varepsilon_{t-1} + A_2\varepsilon_{t-2} + \dots = \sum_{i=0}^{\infty} L^i A \varepsilon_{t-i} \quad (13)$$

where,

L is the lag operator determined by Shoartz Beyzian criteria.

A_i is 4×4 matrix representing the response of variables to the structural shock (the elements of the vector X_t).

ε_{t-1} shows the structural shocks which is assumed to be serially uncorrelated with a variance-covariance matrix normalized to the identity matrix: $\text{Var}(u_t) = I$ This means that it transmits the effects of the shocks to the variables. It is the matrix that defines the responses of these endogenous variables to the structural shocks.

The reduced matrix form of the Equation (13) is:

$$\Delta X_t = A(L)\varepsilon_t \quad (14)$$

Where, X_t is the vector of variables; ε_t , the vector of structural shocks, so that the variables (the world economic growth rate (y_t^*), the growth rate (y_t), the inflation rate (inf_t), and the real exchange rate (ex_t) of each BRICS country) in the model are represented as:

$$\Delta X_t = (\Delta y_t^*, \Delta y_t, \Delta \text{ex}_t, \Delta \text{inf}_t) \quad (15)$$

The structural model decomposition process of variables is as follows:

$$\Delta y_t^* = A_{11}(L)\varepsilon_t^{s*} + A_{12}(L)\varepsilon_t^s + A_{13}(L)\varepsilon_t^d + A_{14}(L)\varepsilon_t^m \quad (16)$$

$$\Delta y_t = A_{21}(L)\varepsilon_t^{s*} + A_{22}(L)\varepsilon_t^s + A_{23}(L)\varepsilon_t^d + A_{24}(L)\varepsilon_t^m \quad (17)$$

$$\Delta ex_t = A_{31}(L)\varepsilon_t^{s*} + A_{32}(L)\varepsilon_t^s + A_{33}(L)\varepsilon_t^d + A_{34}(L)\varepsilon_t^m \quad (18)$$

$$\Delta inf_t = A_{41}(L)\varepsilon_t^{s*} + A_{42}(L)\varepsilon_t^s + A_{43}(L)\varepsilon_t^d + A_{44}(L)\varepsilon_t^m \quad (19)$$

With 4*4, A matrix: $\begin{bmatrix} \Delta y_t^* \\ \Delta y_t \\ \Delta ex_t \\ \Delta inf_t \end{bmatrix}$ and $\varepsilon_t = \begin{bmatrix} \varepsilon_t^{s*} \\ \varepsilon_t^s \\ \varepsilon_t^d \\ \varepsilon_t^m \end{bmatrix}$.

Where, Δ is the first-difference operator, the letters A_{11} , A_{21} , A_{31} , A_{41} , etc... represent the weights that could be attached to the structural shocks. The structural shocks (ε_t^{s*} , ε_t^s , ε_t^d and ε_t^m) are the independent white noise (uncorrelated) external global supply shock, domestic supply shock, domestic demand shock and monetary shock, respectively.

Furthermore, world output (y_t^*) is exogenous so that country specific (domestic) supply, demand and monetary: ε_t^s , ε_t^d and ε_t^m shocks, respectively, do not affect the world GDP (y_t^*) in the long run. That is:

$$\sum_{i=0}^{\infty} A_{12i} = \sum_{i=0}^{\infty} A_{13i} = \sum_{i=0}^{\infty} A_{13i} \sum_{i=0}^{\infty} A_{14i} = 0 \quad (20)$$

Then, domestic GDP, y_t is only affected by domestic supply shocks and neither demand shock (ε_t^d) nor monetary shock ε_t^m have long run effect on domestic GDP y_t . That is,

$$\sum_{i=0}^{\infty} A_{22i} \neq 0, \sum_{i=0}^{\infty} A_{23i} = \sum_{i=0}^{\infty} A_{24i} = 0 \quad (21)$$

Lastly, monetary shock ε_t^m has no long run effect on the real exchange rate ex . That is,

$$\sum_{i=0}^{\infty} A_{34i} = 0 \quad (22)$$

Now, each reduced-form shock is a weighted average of selected structural shocks. The letters A_{11} , A_{21} , A_{31} , A_{41} , A_{22} , A_{32} , A_{42} , A_{33} , A_{43} , A_{44} represent the weights attached to the structural shocks.

These restrictions system can be rewritten as following in a matrix form as:

$$\begin{bmatrix} \Delta y_t^* \\ \Delta y_t \\ \Delta ex_t \\ \Delta inf_t \end{bmatrix} = \sum_{t=0}^{\infty} \begin{bmatrix} A_{11(L)} & 0 & 0 & 0 \\ A_{21(L)} & A_{22(L)} & 0 & 0 \\ A_{31(L)} & A_{32(L)} & A_{33(L)} & 0 \\ A_{41(L)} & A_{42(L)} & A_{43(L)} & A_{44(L)} \end{bmatrix} \begin{bmatrix} \varepsilon_{t-i}^{s*} \\ \varepsilon_{t-i}^s \\ \varepsilon_{t-i}^d \\ \varepsilon_{t-i}^m \end{bmatrix}$$

The equations derived from the variance decomposition are derived by performing matrix multiplication with each term on the right-hand side. Within these equations, the external variable adheres to an autoregressive process, while the domestic variables are represented as functions of their respective lags (Gottschalk, 2001).

4. Results

4.1. Stationary tests

The statistical characteristics of the variables were verified by conducting unit root tests based on the studies of Phillips and Perron (1988) and (Dickey & Fuller, 1979). The Unit Root test examines the presence of a unit root in autoregressive (AR) time series models. The null hypothesis suggests the existence of a unit root, while the alternative hypothesis indicates stationarity at a 5% significance level. The selection of lag lengths was conducted using the Akaike Information Criteria (AIC) to ensure the reliability of SVAR estimations (Akaike, 2011).

Results from the unit root tests indicate that initially, some variables across countries exhibited unit roots at the level. However, stationarity was achieved upon first differencing, thereby confirming the absence of a unit root. Tables 1–5 present the unit root test results for Brazil, Russia, India, China, and

Table 1. Unit root test-Brazil.

Phillips-Perron Stationary (PP) Test					
		WRGDP	RGDP	EX	INF
With Constant	t-Statistic	-5.9001	-4.1096	-0.6909	-16.7277
	<i>Prob.</i>	0.0000 ***	0.0035 ***	0.8337 No	0.0001 ***
With Constant & Trend	t-Statistic	-6.1974	-4.3199	-1.5484	-13.0742
	<i>Prob.</i>	0.0001 ***	0.0098 ***	0.7884 No	0.0000 ***
Without Constant & Trend	t-Statistic	-1.7375	-2.7218	1.6239	-18.3455
	<i>Prob.</i>	0.0780 *	0.0083 ***	0.9715 No	0.0000 ***
At First Difference					
		d(WRGDP)	d(RGDP)	d(EX)	d(INF)
With Constant	t-Statistic	-25.5705	-10.0269	-4.0063	-5.5790
	<i>Prob.</i>	0.0001 ***	0.0000 ***	0.0047 ***	0.0001 ***
With Constant & Trend	t-Statistic	-24.7886	-9.8895	-3.9902	-6.1465
	<i>Prob.</i>	0.0000 ***	0.0000 ***	0.0211 **	0.0001 ***
Without Constant & Trend	t-Statistic	-25.3336	-10.2036	-3.6924	-5.4656
	<i>Prob.</i>	0.0000 ***	0.0000 ***	0.0006 ***	0.0000 ***
Dickey-Fulller (ADF) Test					
		WRGDP	RGDP	EX	INF
With Constant	t-Statistic	-5.8147	-4.0840	-0.4988	-4.6665
	<i>Prob.</i>	0.0000 ***	0.0037 ***	0.8777 No	0.0008 ***
With Constant & Trend	t-Statistic	-5.8268	-4.3257	-1.6551	-4.1709
	<i>Prob.</i>	0.0003 ***	0.0096 ***	0.7441 No	0.0137 **
Without Constant & Trend	t-Statistic	-0.5756	-2.8432	1.8772	-4.9190
	<i>Prob.</i>	0.4582 no	0.0061 ***	0.9830 No	0.0000 ***
At First Difference					
		d(WRGDP)	d(RGDP)	d(EX)	d(INF)
With Constant	t-Statistic	-5.1550	-5.9466	-4.0063	-5.5895
	<i>Prob.</i>	0.0003 ***	0.0000 ***	0.0047 ***	0.0001 ***
With Constant & Trend	t-Statistic	-5.0980	-5.8739	-3.9851	-6.2291
	<i>Prob.</i>	0.0019 ***	0.0003 ***	0.0213 **	0.0001 ***
Without Constant & Trend	t-Statistic	-5.2614	-6.0526	-3.6997	-5.4692
	<i>Prob.</i>	0.0000 ***	0.0000 ***	0.0006 ***	0.0000 ***

(*) Significant at the 10%; (**) Significant at the 5%; (***) Significant at the 1%. and (no) Not Significant *(MacKinnon, 1996) one-sided *p*-values.

Source: Authors' own computation using EViews 13.

South Africa. The evidence from Tables 1–5 below show that all variables were stationary at 1st difference. Succeeding Tables 6–10 display results of lag length test. The asterisk (*) indicates the lag order selected by the criterion: Akaike information criterion (AIC).

4.2. Shocks correlation

The study conducted cross-country correlation analysis to assess the macroeconomic co-movements of shocks within BRICS countries. This involved extracting residuals from the SVAR models of each country, which gave us the correlation coefficients. The decision criterion is determined by the fact that positive correlation coefficients indicate symmetry, while negative correlation coefficients suggest asymmetric shocks at a significance level of 5%.

Table 2. Unit root test-Russia.

Phillips-Perron Stationary (PP) Test					
		WRGDP	RGDP	EX	INF
With Constant	t-Statistic	−5.9001	−3.2523	−0.6663	−32.9736
	Prob.	0.0000	0.0269	0.8399	0.0001
		***	**	no	***
With Constant & Trend	t-Statistic	−6.1974	−2.9557	−2.0757	−50.6779
	Prob.	0.0001	0.1611	0.5371	0.0000
		***	no	no	***
Without Constant & Trend	t-Statistic	−1.7375	−2.9848	1.2633	−28.4485
	Prob.	0.0780	0.0042	0.9437	0.0000
		*	***	no	***
At First Difference					
		d(WRGDP)	d(RGDP)	d(EX)	d(INF)
With Constant	t-Statistic	−25.5705	−8.1157	−3.8568	−23.9147
	Prob.	0.0001	0.0000	0.0067	0.0001
		***	***	***	***
With Constant & Trend	t-Statistic	−24.7886	−15.6703	−3.7228	−29.1936
	Prob.	0.0000	0.0000	0.0373	0.0000
		***	***	**	***
Without Constant & Trend	t-Statistic	−25.3336	−8.1797	−3.7195	−22.6482
	Prob.	0.0000	0.0000	0.0006	0.0000
		***	***	***	***
Dickey-Fuller (ADF) Test					
		WRGDP	RGDP	EX	INF
With Constant	t-Statistic	−5.8147	−3.3710	−0.6529	−7.6404
	Prob.	0.0000	0.0206	0.8432	0.0000
		***	**	n0	***
With Constant & Trend	t-Statistic	−5.8268	−3.1666	−2.8914	−7.3932
	Prob.	0.0003	0.1108	0.1829	0.0000
		***	n0	n0	***
Without Constant & Trend	t-Statistic	−0.5756	−3.0892	1.4079	−25.7097
	Prob.	0.4582	0.0032	0.9568	0.0000
		no	***	no	***
At First Difference					
		d(WRGDP)	d(RGDP)	d(EX)	d(INF)
With Constant	t-Statistic	−5.1550	−4.3560	−4.2580	−14.9538
	Prob.	0.0003	0.0022	0.0026	0.0000
		***	***	***	***
With Constant & Trend	t-Statistic	−5.0980	−4.8658	−4.1354	−14.0692
	Prob.	0.0019	0.0032	0.0157	0.0000
		***	***	**	***
Without Constant & Trend	t-Statistic	−5.2614	−4.4189	−3.6746	−15.5167
	Prob.	0.0000	0.0001	0.0007	0.0000
		***	***	***	***

(*) Significant at the 10%; (**) Significant at the 5%; (***) Significant at the 1%. and (no) Not Significant *(MacKinnon, 1996) one-sided p-values.

Source: Authors 'own computation using EViews 13.

4.2.1. External (supply) shock

4.2.2. Domestic supply shock

4.2.3. Monetary shock

4.2.4. Demand shock

4.3. One-way ANOVA analysis

The analysis of one-way ANOVA and Levene aims to ascertain if the observed variations exhibit heterogeneity, which may imply substantial costs linked to establishing a monetary union, or homogeneity,

Table 3. Unit Root Test-India.

Phillips-Perron Stationary (PP) Test					
		WRGDP	RGDP	LEX	INF
With Constant	t-Statistic	-5.9001	-4.8336	-0.6941	-2.4999
	Prob.	0.0000 ***	0.0005 ***	0.8329 no	0.1258 no
With Constant & Trend	t-Statistic	-6.1974	-4.8128	-1.9251	-2.6046
	Prob.	0.0001 ***	0.0031 ***	0.6158 no	0.2810 no
Without Constant & Trend	t-Statistic	-1.7375	-1.1146	2.9882	-0.8118
	Prob.	0.0780 *	0.2343 no	0.9988 no	0.3556 no
At First Difference					
		d(WRGDP)	d(RGDP)	d(LEX)	d(INF)
With Constant	t-Statistic	-25.5705	-22.4518	-4.7776	-6.7227
	Prob.	0.0001 ***	0.0001 ***	0.0007 ***	0.0000 ***
With Constant & Trend	t-Statistic	-24.7886	-21.5242	-4.6901	-6.6176
	Prob.	0.0000 ***	0.0000 ***	0.0043 ***	0.0000 ***
Without Constant & Trend	t-Statistic	-25.3336	-23.1567	-3.7007	-6.8190
	Prob.	0.0000 ***	0.0000 ***	0.0006 ***	0.0000 ***
Dickey-Fulller (ADF) Test					
		WRGDP	RGDP	LEX	INF
With Constant	t-Statistic	-5.8147	-4.8315	-0.6483	-5.7888
	Prob.	0.0000 ***	0.0006 ***	0.8444 no	0.0001 ***
With Constant & Trend	t-Statistic	-5.8268	-4.8262	-1.6799	-5.5441
	Prob.	0.0003 ***	0.0030 ***	0.7343 no	0.0008 ***
Without Constant & Trend	t-Statistic	-0.6215	-0.7932	3.2965	-0.9051
	Prob.	0.4387 no	0.3630 no	0.9994 no	0.3157 no
At First Difference					
		d(WRGDP)	d(RGDP)	d(LEX)	d(INF)
With Constant	t-Statistic	-6.2491	-5.7381	-4.7501	-6.7360
	Prob.	0.0000 ***	0.0001 ***	0.0007 ***	0.0000 ***
With Constant & Trend	t-Statistic	-6.1331	-5.5790	-4.6580	-6.6162
	Prob.	0.0002 ***	0.0006 ***	0.0046 ***	0.0000 ***
Without Constant & Trend	t-Statistic	-6.3843	-5.8476	-3.6384	-6.8443
	Prob.	0.0000 ***	0.0000 ***	0.0007 ***	0.0000 ***

(*) Significant at the 10%; (**) Significant at the 5%; (***) Significant at the 1%; and (no) Not Significant *(MacKinnon, 1996) one-sided *p*-values.

Source: Authors' own computation using EViews 13.

indicating comparatively lower costs. If the *p*-value derived fall below the 5% significance level, it leads to infer there is evidence of a statistically significant difference. The result is displayed through the F-test and Levene-test in Table 15.

4.4. Impulse response function

The magnitude of the shocks is estimated through the IRF analysis. Analyzing the impulse response function (IRF) aims to determine the scale of the response exhibited by each economy to external, domestic supply, monetary, and demand shocks (shock 1, 2, 3, and 4, respectively).

The results in Table 16 indicate which shocks is dominant in each country. For space purposes, the paper limits the analysis to real domestic to each shock within each country during the 1st and 10th year.

Table 4. Unit root test-China.

Phillips-Perron Stationary (PP) Test					
		WRGDP	RGDP	EX_B	INF
With Constant	t-Statistic	−5.9001	−1.9816	−4.9196	−2.3519
	Prob.	0.0000 ***	0.2928 no	0.0005 ***	0.1636 no
With Constant & Trend	t-Statistic	−6.1974	−3.0702	−5.5856	−1.9656
	Prob.	0.0001 ***	0.1319 no	0.0006 ***	0.5949 no
Without Constant & Trend	t-Statistic	−1.7375	−1.6415	−0.1260	−2.5235
	Prob.	0.0780 *	0.0941 *	0.6307 no	0.0136 **
At First Difference					
		d(WRGDP)	d(RGDP)	d(EX_B)	d(INF)
With Constant	t-Statistic	−25.5705	−7.9441	−12.6609	−5.5943
	Prob.	0.0001 ***	0.0000 ***	0.0000 ***	0.0001 ***
With Constant & Trend	t-Statistic	−24.7886	−7.7257	−12.0851	−6.0624
	Prob.	0.0000 ***	0.0000 ***	0.0000 ***	0.0002 ***
Without Constant & Trend	t-Statistic	−25.3336	−7.7160	−13.0383	−5.4669
	Prob.	0.0000 ***	0.0000 ***	0.0000 ***	0.0000 ***
Dickey-Fuller (ADF) Test					
		WRGDP	RGDP	EX_B	INF
With Constant	t-Statistic	−5.8147	−1.5502	−4.9055	−2.8810
	Prob.	0.0000 ***	0.4940 no	0.0006 ***	0.0624 *
With Constant & Trend	t-Statistic	−5.8268	−1.9185	−5.5439	−2.6549
	Prob.	0.0003 ***	0.6183 no	0.0007 ***	0.2618 no
Without Constant & Trend	t-Statistic	−0.5756	−1.6395	−0.1700	−4.1210
	Prob.	0.4582 no	0.0945 *	0.6144 no	0.0002 ***
At First Difference					
		d(WRGDP)	d(RGDP)	d(EX_B)	d(INF)
With Constant	t-Statistic	−5.1550	−7.8981	−6.7806	−4.2658
	Prob.	0.0003 ***	0.0000 ***	0.0000 ***	0.0026 ***
With Constant & Trend	t-Statistic	−5.0980	−7.6882	−6.6135	−4.5084
	Prob.	0.0019 ***	0.0000 ***	0.0001 ***	0.0068 ***
Without Constant & Trend	t-Statistic	−5.2614	−7.7162	−6.9477	−4.2901
	Prob.	0.0000 ***	0.0000 ***	0.0000 ***	0.0001 ***

(*) Significant at the 10%; (**) Significant at the 5%; (***) Significant at the 1%; and (no) Not Significant *(MacKinnon, 1996) one-sided *p*-values.

Source: Authors' own computation using EViews 13.

4.5. Variance decomposition

The variance decomposition analysis quantifies the contribution of individual shocks on the fluctuations observed in the endogenous variables of the SVAR model. Different sources of variability imply different transmission mechanisms and necessitate tailored policy strategies in each nation.

5. Discussion and implications

5.1. Shock correlation

5.1.1. External (supply) shock

Table 11 presents the correlation of external shock among the BRICS nations with respect to the world output. The coefficients indicate a strong positive correlation and statistical significance of external

Table 5. Unit root test-South Africa.

Phillips-Perron Stationary (PP) Test					
		WRGDP	RGDP	EX	INF
With Constant	t-Statistic	-5.9001	-4.3327	-0.0251	-3.1506
	Prob.	0.0000 ***	0.0020 ***	0.9486 no	0.0338 **
With Constant & Trend	t-Statistic	-6.1974	-4.9594	-2.0421	-3.4134
	Prob.	0.0001 ***	0.0021 ***	0.5548 no	0.0691 *
Without Constant & Trend	t-Statistic	-1.7375	-2.4076	2.5214	-1.1178
	Prob.	0.0780 *	0.0179 **	0.9961 no	0.2332 no
At First Difference					
		d(WRGDP)	d(RGDP)	d(EX)	d(INF)
With Constant	t-Statistic	-25.5705	-20.9381	-4.8648	-7.2146
	Prob.	0.0001 ***	0.0001 ***	0.0005 ***	0.0000 ***
With Constant & Trend	t-Statistic	-24.7886	-20.0926	-5.0173	-9.1523
	Prob.	0.0000 ***	0.0000 ***	0.0020 ***	0.0000 ***
Without Constant & Trend	t-Statistic	-25.3336	-21.9680	-4.2804	-7.0620
	Prob.	0.0000 ***	0.0000 ***	0.0001 ***	0.0000 ***
Dickey-Fuller (ADF) Test					
		WRGDP	RGDP	EX	INF
With Constant	t-Statistic	-5.8147	-4.3154	-0.3400	-3.8431
	Prob.	0.0000 ***	0.0021 ***	0.9069 no	0.0069 ***
With Constant & Trend	t-Statistic	-5.8268	-4.9671	-1.9273	-4.2974
	Prob.	0.0003 ***	0.0021 ***	0.6147 no	0.0106 **
Without Constant & Trend	t-Statistic	-0.6215	-2.5869	1.6814	-1.5491
	Prob.	0.4387 no	0.0116 **	0.9746 no	0.1119 no
At First Difference					
		d(WRGDP)	d(RGDP)	d(EX)	d(INF)
With Constant	t-Statistic	-6.2491	-5.4751	-4.7905	-5.5360
	Prob.	0.0000 ***	0.0001 ***	0.0007 ***	0.0001 ***
With Constant & Trend	t-Statistic	-6.1331	-5.3064	-4.7296	-5.6619
	Prob.	0.0002 ***	0.0011 ***	0.0039 ***	0.0006 ***
Without Constant & Trend	t-Statistic	-6.3843	-5.5791	-4.3028	-5.4108
	Prob.	0.0000 ***	0.0000 ***	0.0001 ***	0.0000 ***

(*) Significant at the 10%; (**) Significant at the 5%; (***) Significant at the 1%. and (no) Not Significant *(MacKinnon, 1996) one-sided *p*-values.

Source: Authors' own computation using EViews 13.

Table 6. Lag length-Brazil.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-206.9349	NA	71.76760	15.62481	15.81678	15.68189
1	-154.0031	86.25913 ^a	4.734638 ^a	12.88912	13.84900 ^a	13.17454 ^a
2	-137.1338	22.49240	4.850793	12.82473 ^a	14.55251	13.33849

^aIndicates lag order selected by the criterion: AIC: Akaike information criterion; SC: Schwarz information criterion; HQ: Hannan-Quinn information criterion.

Source: Authors' own computation using EViews 13.

shocks across all BRICS countries at a 5% significance level. This finding implies the presence of a structural symmetric shock and similarity in the response to external shocks among BRICS. The highest coefficient (0.9218) is observed between India and Brazil, followed by (0.8789) between Russia and Brazil,

Table 7. Lag length-Russia.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	−354.6428	NA	4052155	26.56613	26.75811 ^a	26.62322
1	−335.1746	31.72598 ^a	3188341 ^a	26.30923 ^a	27.26911	26.59465 ^a
2	−321.1338	18.72105	4027949	26.45435	28.18214	26.96811

^aIndicates lag order selected by the criterion: AIC: Akaike information criterion; SC: Schwarz information criterion; HQ: Hannan-Quinn information criterion.

Source: Authors' own computation using EViews 13.

Table 8. Lag length-India.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	−145.4820	NA	0.756817	11.07274	11.26472 ^a	11.12982
1	−122.1810	37.97203	0.448300	10.53192	11.49180	10.81735
2	−99.39497	30.38133 ^a	0.296316 ^a	10.02926 ^a	11.75704	10.54302 ^a

^aIndicates lag order selected by the criterion: AIC: Akaike information criterion; SC: Schwarz information criterion; HQ: Hannan-Quinn information criterion.

Source: Authors' own computation using EViews 13.

Table 9. Lag length-China.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	−186.3587	NA	91.09525	15.86322	16.05956	15.91531
1	−158.6100	43.93531 ^a	35.07267	14.88417	15.86588 ^a	15.14462 ^a
2	−140.6111	22.49861	33.78161 ^a	14.71760 ^a	16.48468	15.18640

^aIndicates lag order selected by the criterion: AIC: Akaike information criterion; SC: Schwarz information criterion; HQ: Hannan-Quinn information criterion.

Source: Authors' own computation using EViews 13.

Table 10. Lag length-South Africa.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	−191.6284	NA	23.09505	14.49099	14.68297 ^a	14.54808 ^a
1	−174.6198	27.71773 ^a	21.80334 ^a	14.41628 ^a	15.37616	14.70170
2	−159.5080	20.14902	25.44421	14.48207	16.20986	14.99583

^aIndicates lag order selected by the criterion: AIC: Akaike information criterion; SC: Schwarz information criterion; HQ: Hannan-Quinn information criterion.

Source: Authors' own computation using EViews 13.

and India and Russia (0.8292). On the other hand, the lowest correlation coefficient (0.5288) is found between South Africa and China. This result highlights the potential for mutual benefits through symmetric adjustments in relation to external shocks. The symmetric nature of external shock across the BRICS countries suggests that adopting a single currency would mitigate bilateral exchange rate distortions caused by this type of shocks.

5.1.2. Domestic supply shock

Table 12 displays a predominantly negative and statistically insignificant correlation for domestic real output, suggesting that there are asymmetric responses to domestic supply shock. These findings underscore the presence of asymmetric domestic supply shocks within the BRICS nations. The dissimilarity observed in the degree of these shocks may be attributed to the unique nature of their exports, which necessitate requiring different adjustment strategies.

5.1.3. Monetary shock

The result presented in Table 13 indicates that only two out of ten country pairings exhibit a positive and statistically significant correlation in response to monetary shock. Specifically, Russia and Brazil (0.3981) and South Africa and Russia (0.4834) demonstrate such a relationship. Conversely, the other pairs show no evidence of correlation to domestic demand shock, as indicated by *p*-values exceeding 5%. This underscores an overall asymmetric adjustment to monetary shock at the exception of Russia, Brazil, and South Africa.

Table 11. Correlation of the external (supply) shock.

		Correlation	t-Statistic	Probability
BRAZIL	BRAZIL	1.000000	-----	-----
RUSSIA	BRAZIL	0.878965	9.215657	0.0000
RUSSIA	RUSSIA	1.000000	-----	-----
INDIA	BRAZIL	0.921839	11.89245	0.0000
INDIA	RUSSIA	0.829286	7.419914	0.0000
INDIA	INDIA	1.000000	-----	-----
CHINA	BRAZIL	0.715823	4.808248	0.0001
CHINA	RUSSIA	0.655945	4.076068	0.0005
CHINA	INDIA	0.739831	5.157781	0.0000
CHINA	CHINA	1.000000	-----	-----
SOUTH_AFRICA	BRAZIL	0.610511	3.854202	0.0007
SOUTH_AFRICA	RUSSIA	0.792997	6.637127	0.0000
SOUTH_AFRICA	INDIA	0.681839	4.660535	0.0001
SOUTH_AFRICA	CHINA	0.528894	2.923021	0.0079
SOUTH_AFRICA	SOUTH_AFRICA	1.000000	-----	-----

Source: Authors 'own computation using EViews 13.

Table 12. Correlation of the domestic supply shock.

		Correlation	t-Statistic	Probability
BRAZIL	BRAZIL	1.000000	-----	-----
RUSSIA	BRAZIL	0.060611	0.303611	0.7639
RUSSIA	RUSSIA	1.000000	-----	-----
INDIA	BRAZIL	-0.496408	-2.859198	0.0084
INDIA	RUSSIA	-0.344849	-1.836923	0.0781
INDIA	INDIA	1.000000	-----	-----
CHINA	BRAZIL	-0.088469	-0.416588	0.6810
CHINA	RUSSIA	-0.140080	-0.663574	0.5139
CHINA	INDIA	0.161771	0.768900	0.4501
CHINA	CHINA	1.000000	-----	-----
SOUTH_AFRICA	BRAZIL	0.168570	0.855087	0.4006
SOUTH_AFRICA	RUSSIA	-0.023734	-0.121056	0.9046
SOUTH_AFRICA	INDIA	0.075748	0.379830	0.7073
SOUTH_AFRICA	CHINA	0.199427	0.954570	0.3502
SOUTH_AFRICA	SOUTH_AFRICA	1.000000	-----	-----

Source: Authors 'own computation using EViews 13.

Table 13. Correlation of the monetary shock.

		Correlation	t-Statistic	Probability
BRAZIL	BRAZIL	1.000000	-----	-----
RUSSIA	BRAZIL	0.398126	2.170023	0.0397
RUSSIA	RUSSIA	1.000000	-----	-----
INDIA	BRAZIL	0.033700	0.168596	0.8675
INDIA	RUSSIA	0.225685	1.158308	0.2577
INDIA	INDIA	1.000000	-----	-----
CHINA	BRAZIL	-0.176769	-0.842384	0.4086
CHINA	RUSSIA	-0.122631	-0.579565	0.5681
CHINA	INDIA	-0.165722	-0.788204	0.4390
CHINA	CHINA	1.000000	-----	-----
SOUTH_AFRICA	BRAZIL	0.339972	1.807527	0.0827
SOUTH_AFRICA	RUSSIA	0.483470	2.816238	0.0091
SOUTH_AFRICA	INDIA	0.342701	1.823958	0.0801
SOUTH_AFRICA	CHINA	-0.002515	-0.011796	0.9907
SOUTH_AFRICA	SOUTH_AFRICA	1.000000	-----	-----

Source: Authors 'own computation using EViews 13.

Table 14. Correlation of the demand shock.

		Correlation	t-Statistic	Probability
BRAZIL	BRAZIL	1.000000	-----	-----
RUSSIA	BRAZIL	-0.107835	-0.542337	0.5924
RUSSIA	RUSSIA	1.000000	-----	-----
INDIA	BRAZIL	-0.327508	-1.733124	0.0954
INDIA	RUSSIA	0.017200	0.086013	0.9321
INDIA	INDIA	1.000000	-----	-----
CHINA	BRAZIL	-0.198036	-0.947638	0.3536
CHINA	RUSSIA	0.080740	0.379944	0.7076
CHINA	INDIA	0.080924	0.380817	0.7070
CHINA	CHINA	1.000000	-----	-----
SOUTH_AFRICA	BRAZIL	0.318021	1.677179	0.1060
SOUTH_AFRICA	RUSSIA	0.173134	0.896350	0.3783
SOUTH_AFRICA	INDIA	0.133724	0.674679	0.5061
SOUTH_AFRICA	CHINA	0.004579	0.021478	0.9831
SOUTH_AFRICA	SOUTH_AFRICA	1.000000	-----	-----

Source: Authors' own computation using EViews 13.

Table 15. ANOVA and coefficient of variance.

Source of shocks	One-way ANOVA (F-test)		Coefficient of variance (Levene-test)	
	Value	p value	Value	p value
Global Shock	6.8314e-30	1.0000	0.3143	.8680
Supply Shock	8.5446e-30	1.0000	0.1858	.9454
Demand Shock	3.1997e-30	1.0000	0.3651	.8331
Monetary Shock	1.6100e-30	1.0000	0.344591	.8474

Source: Authors' own computation using EViews 13.

Table 16. Size of domestic output for 10 periods.

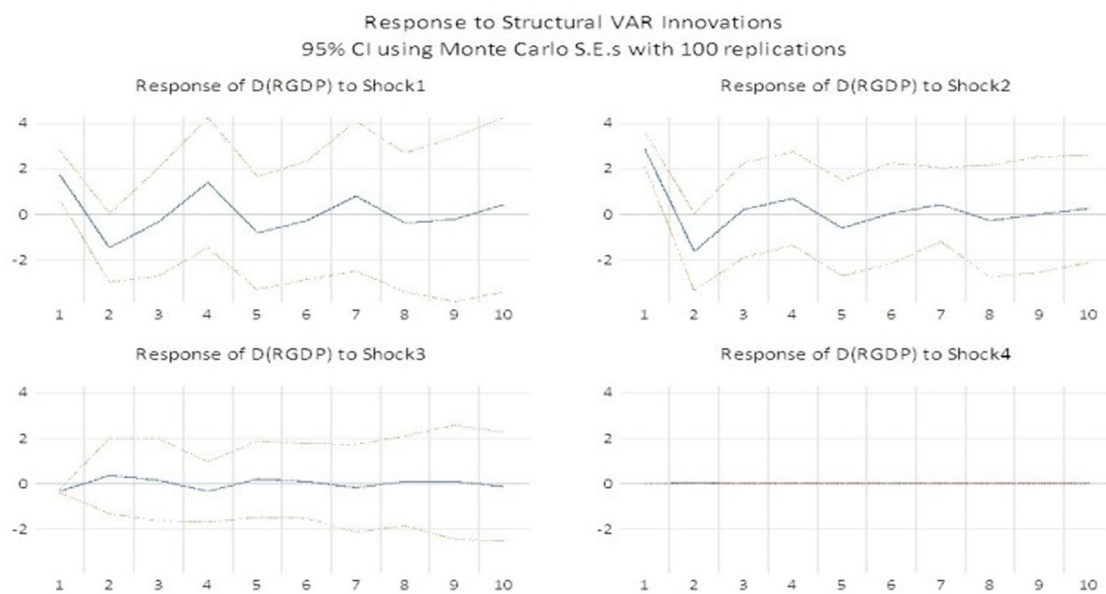
Countries	Periods	External Supply Shocks	Domestic Supply Shocks	Monetary Shocks	Demand Shocks
Brazil	1st	1.6999	2.8457	-0.3296	-0.0004
	10th	0.6923	1.7513	-0.0525	0.0002
Russia	1st	3.3173	3.2991	-1.8011	0.4533
	10th	2.0340	3.1373	-3.0336e-05	-3.0514e-06
India	1st	1.6435	0.9184	0.6779	-0.7272
	10th	1.0573	1.1535	1.4399	-0.0652
China	1st	1.5810	1.3065	-0.0656	0.2026
	10th	0.9484	1.4154	-0.0543	0.0308
South Africa	1st	2.0420	1.3895	0.4273	0.8800
	10th	1.5972	0.7341	-0.0006	-0.0002

Source: Author's EViews 13 results.

5.1.4. Demand shock

The results in Table 14 present no evidence of correlation with regard to price level among the BRICS group. This implies asymmetry responses to demand shock and highlights structural differences in relation to demand shocks, revealing limited economic interdependencies and uneven adjustments across the BRICS nations.

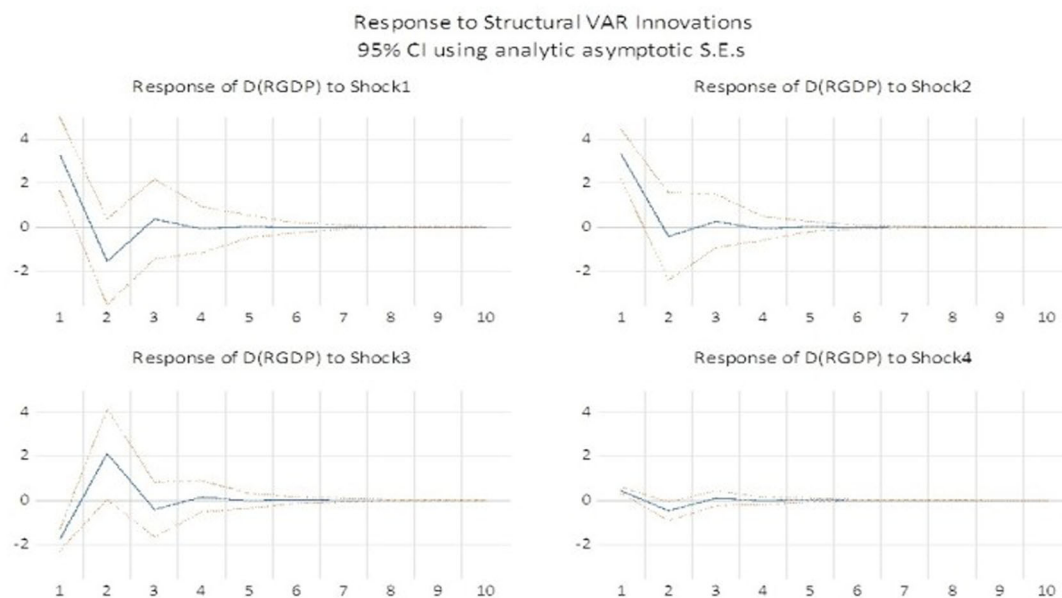
According to existing literature, supply, demand, and monetary shocks are pertinent in evaluating the viability of an OCA and the symmetry of the shocks within countries that are part of a currency area is of utmost importance. While all types of shocks are prevailing, the symmetry of monetary shock holds significant importance in judging whether a group of countries should optimally form an effective currency area. This symmetry impacts economic stability and policy synchronization within a group. In the context of BRICS, the overall asymmetric nature of supply, demand and monetary shocks currently influences its position to establish an effective OCA.



Source: Author's EViews 13 results.

Figure 1. Impulse response of domestic output to the shocks: Brazil.

Source: Authors' own computation using EViews 13.



Source: Author's EViews 13 results.

Figure 2. Impulse response of domestic output to the shocks: Russia.

Source: Author's EViews 13 results.

5.2. One-way ANOVA and IRF

One-way ANOVA in shocks analysis assesses whether there are significant differences in the impact of different shocks. Impulse response function (IRF) analysis assesses the level of synchronization in shocks across countries, including the extent to which these shocks are shared or unique among member nations. In the context of BRICS impulse response analysis helps in comprehending how the different shocks (Supply, monetary, and demand). propagate through their economies over time

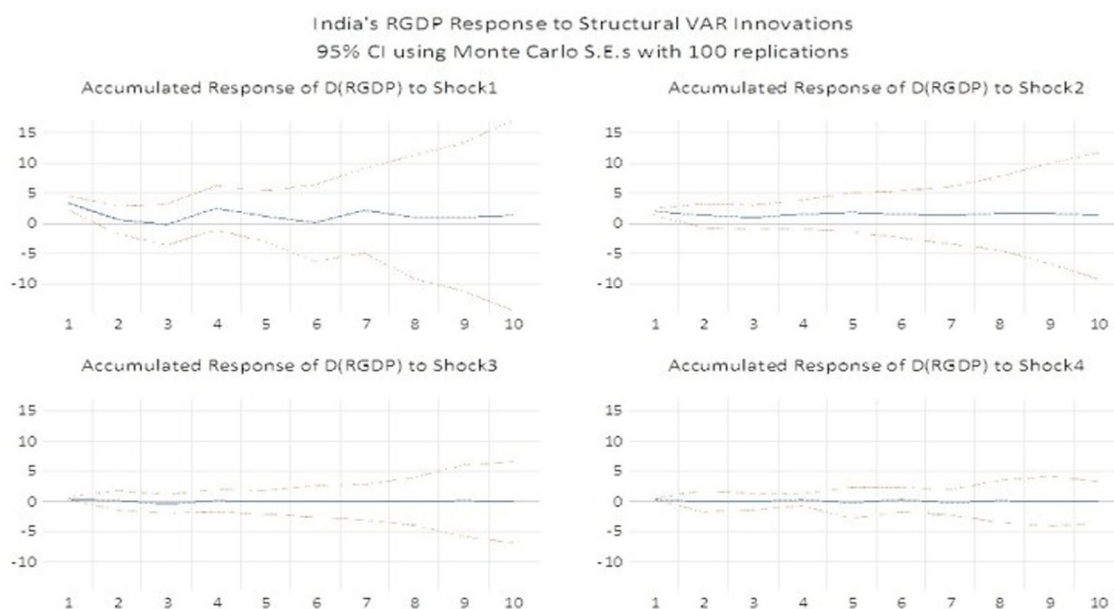


Figure 3. Impulse response of domestic output to the structural shocks: India.

Source: Author's EViews 13 results.

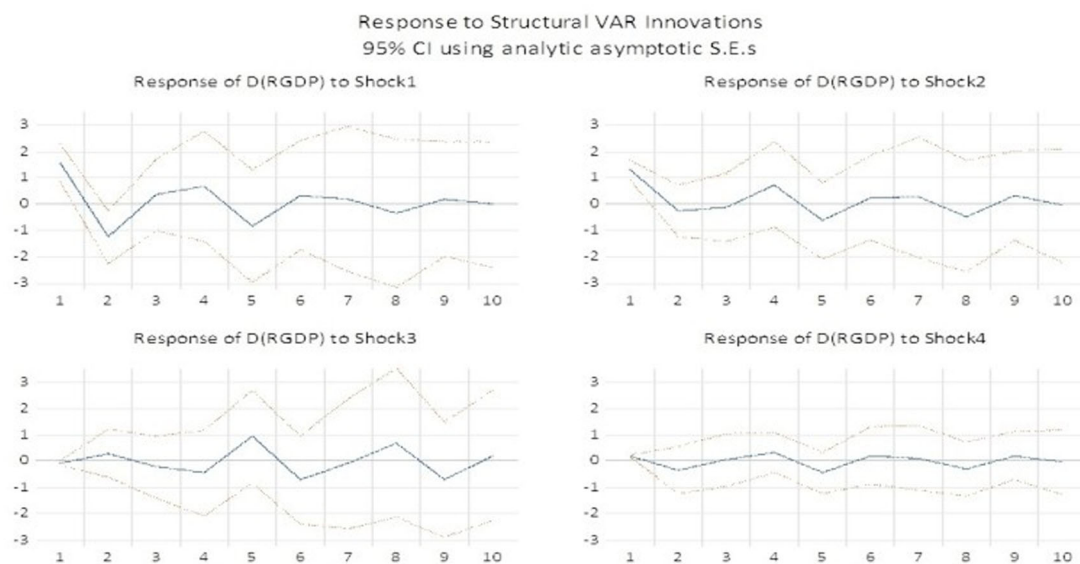


Figure 4. Impulse response of domestic output to the macroeconomics shocks: China.

Source: Author's EViews 13 results.

The results in Table 15 indicate that there is no substantial evidence to support the presence of significant differences among the shocks within the BRICS countries. Therefore, we still fail to reject the null hypothesis that the shocks are heterogeneous. Similarly, the results of the Levene test confirm that although the values (cv) are below 1, we still fail to reject the null hypothesis that the shocks are heterogeneous. However, it is important to note that this finding does not imply that there are no differences among the shocks within BRICS, as suggested by the SVAR model. Any differences that may exist are likely attributable to random error.

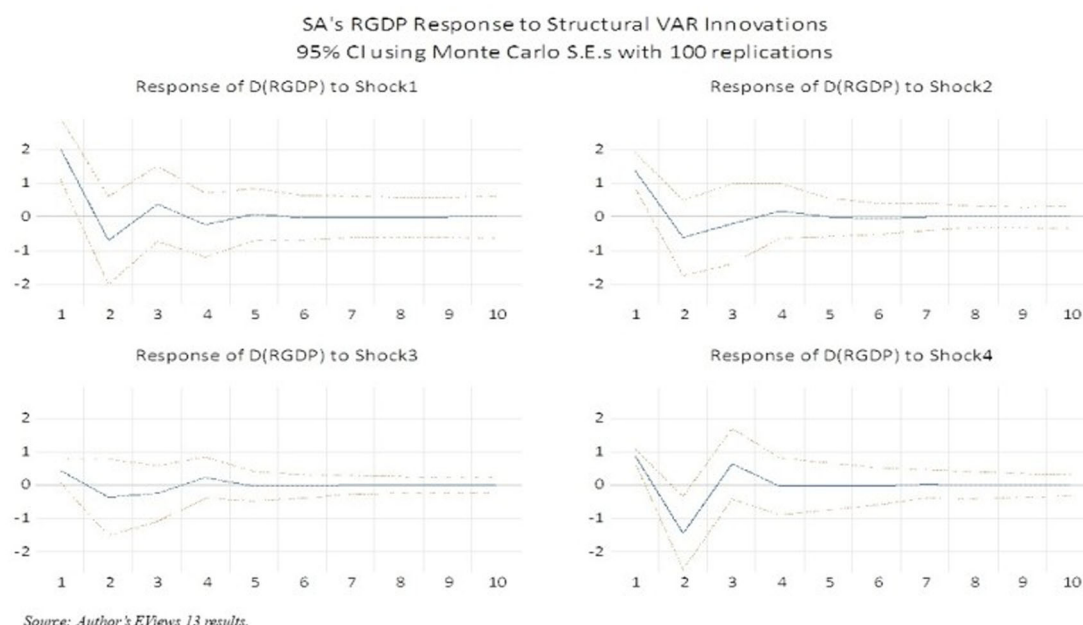


Figure 5. South Africa impulse response of domestic output to the macroeconomics shocks.

Source: Author's EViews 13 results.

Table 17. Variance decomposition of the changes in domestic real output.

Countries	External (Supply) Shocks	Domestic Supply Shocks	Monetary Shocks	Demand Shocks
Brazil	41.685	55.941	2.374	0.0003
Russia	41.123	33.731	23.72	1.425
India	83.146	12.031	2.444	2.379
China	46.325	25.835	22.370	5.470
South Africa	44.453	21.834	3.954	29.757

Source: Author's EViews 13 results.

Table 18. Variance decomposition of the changes in real exchange rate.

Countries	Global supply shocks	Domestic supply shocks	Monetary shocks	Demand shocks
Brazil	11.31	27.97.913	60.768	0.004
Russia	5.328	8.591	86.014	0.068
India	27.146	35.243	33.106	4.504
China	10.263	24.926	60.048	4.762
South Africa	44.862	4.989	47.468	2.679

Source: Author's EViews 13 results.

Table 19. Variance decomposition of the changes in inflation.

Countries	Global supply shocks	Domestic supply shocks	Monetary shocks	Demand shocks
Brazil	32.987	26.281	16.918	23.814
Russia	0.661	36.047	5.873	57.419
India	57.752	14.482	10.104	17.660
China	37.683	15.905	25.632	20.780
South Africa	6.819	16.713	10.281	66.186

Source: Author's EViews 13 results.

5.3. IRF and variance decomposition

Impulse response analysis and variance decomposition analysis are essential tools for understanding the dynamics of shock transmission. In the context of assessing an OCA, variance decomposition analysis helps identify the importance of different shocks in driving fluctuations in key macroeconomic variables.

The blue lines in [Figures 1–5](#) represent the impulse response function analysis, while the red lines indicate the 95% confidence intervals. Looking at [Figure 1](#), it can be observed that the real GDP of Brazil does not exhibit a response to demand shock. This means that a one standard deviation changes in demand shock (Shock 4) does not have a significant impact on Brazil's output. On the other hand, external and domestic supply shocks (Shocks 1 and 2), emerge as crucial factors in accounting for fluctuations in Brazil's output. Despite the negative effect of monetary shock (3) on RGDP, its influence on RGDP is not significant. [Figure 2](#) shows that monetary shock has the least influence on explaining variations in real GDP, with domestic supply shock being more significant in Brazil. In the cases of India and South Africa, external shock is the main factor explaining changes in domestic real output ([Figure 3](#) and [5](#)), while China's real output fluctuations are predominant attributed to domestic and external supply shocks, respectively ([Figure 4](#)).

The results in [Table 16](#) indicating the size of shocks are added to the understanding of nominal rigidities and adjustment speed. [Table 16](#) reveals that domestic supply shock was predominant in the 1st period (2.84) and 10th period (1.75) in Brazil. In contrast, Russia experienced external shocks as the dominant factor during the 1st period (3.37) and domestic supply shocks during the 10th period (1.75). External shocks were prevalent during the 10th period in India (1.64), China (1.41), and South Africa (1.59).

[Tables 17–19](#) display the results of the variance decomposition, showing the impact of individual shocks on domestic output, exchange rate, and inflation in the 10th year. The variance decomposition for world real GDP is omitted, given the assumption of exogenous evolution that neither shocks domestic supply, demand, and monetary have a long-term impact on changes in global real GDP.

As [Table 17](#) shows, the variations in Real GDP are predominantly explained by supply shocks, both domestic and external, in India (83%) and Brazil (55.94). On the other hand, less than 50% of GDP fluctuation in other BRICS nations can be attributed to supply shocks. This implies differences in real output variations within the BRICS group. [Table 18](#) reveals that fluctuations in the real exchange rates of China (61%), Brazil (60%), and Russia (86%) are primarily driven by monetary shocks, highlighting the significant role of monetary policy in the variability of real exchange rates among these countries. Lastly, [Table 19](#) shows that demand shocks are predominant in explaining inflation variability in South Africa (66.18%), Russia (57.41%), while external shocks are predominant in India (57.75%).

Overall, the findings indicate that there are various factors contributing to the differences in macro-economic variables among the BRICS countries. Specifically, it is observed that monetary shocks have a more pronounced effect on fluctuations in the real exchange rates in Brazil, Russia, and China compared to the impact of demand shocks. Additionally, demand shocks play a major role in explaining changes in inflation rates in South Africa and Russia, whereas supply shocks primarily account for variations in domestic output in Brazil and India.

6. Conclusion

The aim of this study was to evaluate the feasibility of the BRICS group as an optimal currency area (OCA), employing an SVAR model. According to OCA theory, if economic shocks are symmetric, a shared monetary policy can effectively manage these shocks. However, in the case of asymmetric shocks where member countries experience different degrees of disturbances, a uniform monetary policy may not be appropriate. This could exacerbate existing economic imbalances. According to empirical findings, there is a strong positive correlation of shock associated with external (supply) shock within BRICS countries, indicating that symmetric adjustments in response to external disturbances. However, when it comes to domestic supply, demand, and monetary shocks, there is no substantial evidence of correlation, except for Russia, South Africa and Brazil with regard to monetary shock. This highlights the presence of notable important economic disparities that need to be addressed before the BRICS nations could be suitable for an OCA. These Disparities across BRICS countries can stem from differences in the sources of variability, reflecting different transmission mechanisms of various shocks and the accompanying policies implemented by each country (Hooijmaaijers, 2021a, 2021b). Consequently, these disparities could

potentially impede the establishment of a common currency area. As a result, this could potentially hinder the establishment of a common currency area.

The study highlights the importance of strengthening policy integration to promote the move towards increased shock symmetry. It suggests aligning fiscal, exchange rate, and monetary policies across BRICS nations through consistent communication and cooperation, which could result in improved stability, decreased shocks asymmetry, and minimized economic disparities. Policymakers are urged to establish procedures for ongoing policy discussions and information exchange, acknowledging that deeper economic integration may enhance shock symmetry over time. This study paves the way for future empirical studies in the BRICS context, especially considering the bloc's expansion. Hence, forthcoming research should explore the impacts of including new members on regional convergence.

Authors contributions

- **Contribution and Design:**
Marida Nach and Ronney Ncwadi equally contributed to the study's conception and design.
- **Data Analysis and Drafting:**
Both authors were involved in analysing and interpreting the data and drafting the paper.
- **Editing:**
Marida Nach performed the final draft editing.
- **Critical Revision:**
Both authors critically revised the content for important intellectual aspects.
- **Final Approval:**
Marida Nach provided for the final draft of this version to be published.
- **Accountability:**
All authors agree to be accountable for all aspects of the work.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by the Nelson Mandela University under the Nelson Mandela Post-doctorate fellowship 2023–2024.

About the authors

Dr. Marida Nach holds a PhD in Development Finance from Nelson Mandela University (NMU) and is currently a Postdoctoral Researcher in Economics at NMU. Her research focuses on Macroeconomics, particularly in International Economics, Trade, Development Finance, Geopolitical integration within the BRICS framework, trade integration of the African Continental Free Trade Area (AfCFTA), and the digital economy. Dr. Nach is also a Contract Economist Lecturer at NMU and contributes to various research projects as a Postdoctoral Fellow.

Prof Ncwadi holds a PhD in Economics from Nelson Mandela Metropolitan University (NMMU); His research interest is in Macroeconomics, Public Finance, International Finance, and Applied Econometrics. He has published both in local and international journals and has read papers at academic conferences both in South Africa and abroad. He was a Director in the Macroeconomic analysis Unit of the Eastern Cape Provincial Treasury between 2008 and 2010. He was also an Associate Professor and a Deputy Dean of the Faculty of Management and Commerce at Fort Hare University. Prof Ncwadi is currently a Full Professor of Economics and Director of the School of Economics, Development and Tourism at Nelson Mandela University in Port Elizabeth.

ORCID

Marida Nach  <http://orcid.org/0000-0003-2452-6464>

Data availability statement

The data that support the findings of this study are available and were derived from the following resources available in the public domain:

- The World Development Indicators (WDI) of the World Bank, (World Bank, n.d.)
- The *International Financial Statistics* (IFS) of the International Monetary Fund, (IFS, n.d.)
- The Federal Reserve Economic Data (FRED) Federal Reserve of ST Louis Economic Data (FRED, n.d.).

The data that support the findings of this study are available from the corresponding author, Marida Nach, upon reasonable request.

References

- Abdenur, A. E., & Folly, M. (2015). The new development bank and the institutionalization of the BRICS. *BRICS-Studies and Documents*, 77–111.
- Akaike, H. (2011). Akaike's information criterion. In: Lovric, M. (Ed.), *International Encyclopedia of Statistical Science* (p.25). Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-04898-2_110
- Akalpler, E., & Hove, S. (2022). Monetary policy and capital flow implications on economic growth in BRICS countries. *International Journal of Economic Policy Studies*, 16(1), 253–274. <https://doi.org/10.1007/s42495-021-00076-z>
- Alessina, A., Barro, R., & Tenreyro, S. (2002). Optimal currency unions. NBER Working Paper, 9072.
- Apazidis, N., & Eliasson, V. (2019). Converging shocks. In N. Apazidis & V. Eliasson (Eds.), *Shock focusing phenomena* (pp. 35–143). Springer International Publishing.
- Baas, T., & Belke, A. (2023). Oil price shocks and current account imbalances within a currency union. *The Energy Journal*, 44(4), 223–240. <https://doi.org/10.5547/01956574.44.4.tbaa>
- Barro, R., & Tenreyro, S. (2007). Economic effects of currency unions. *Economic Inquiry*, 45(1), 1–23. <https://doi.org/10.1111/j.1465-7295.2006.00001.x>
- Basnet, H. C., & Pradhan, G. (2017). Regional economic integration in Mercosur: The role of real and financial sectors. *Review of Development Finance*, 7(2), 107–119. <https://doi.org/10.1177/0972150917721835>
- Bayoumi, T. (1994). A formal model of optimum currency areas. IMF Staff Papers, 1994/004.
- Bayoumi, T., & Eichengreen, B. (1992). Shocking aspects of European monetary unification (Working Paper 1. p. 3949). National Bureau of Economic Research (NBER).
- BenMabrouk, H., & HadjMohamed, W. (2022). Oil shocks and the volatility of BRICS and G7 markets: SVAR analysis. *Cogent Economics & Finance*, 10(1), 2068241. <https://doi.org/10.1080/23322039.2022.2068241>
- Blanchard, O. J., & Quah, D. (1989). The dynamic effects of aggregate demand and supply disturbances. *The American Economic Review*, 79(4), 655–673.
- Campos, N. F., & Macchiarelli, C. (2018). Symmetry and convergence in monetary unions. LEQS Paper, 131.
- Cattaneo, N., Biziwick, M., & Fryer, D. (2015). The BRICS contingent reserve arrangement and its position in the emerging global financial architecture. *Policy Insights*, 10. South African Institute for International Affairs. pp. 1–7.
- Cooper, A. F. (2017). The BRICS' new development bank: Shifting from material leverage to innovative capacity. *Global Policy*, 8(3), 275–284. <https://doi.org/10.1111/1758-5899.12458>
- Council of Councils. (n.d.). *The BRICS summit 2023: Seeking an alternate world order?* Council of Councils. Retrieved 12 June 2024, from <https://www.cfr.org/councilofcouncils/global-memos/brics-summit-2023-seeking-alternate-world-order>
- Cynthia, R., Armijo, L., & Katada, S. (2017). Global power shift: The BRICS, building capabilities for influence. In C. Roberts, L. Armijo, & S. Katada (Eds.), *The BRICS and collective financial statecraft*. Oxford University Press.
- De Grauwe, P. (1996). Monetary union and convergence economics. *European Economic Review*, 40(3-5), 1091–1101. [https://doi.org/10.1016/0014-2921\(95\)00117-4](https://doi.org/10.1016/0014-2921(95)00117-4)
- De Grauwe, P. (2020). *Economics of the monetary union* (13th ed.). Oxford University Press.
- Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, 74(366), 427–431. <https://doi.org/10.2307/2286348>
- Dixon, C. (2015). The new BRICS bank: Challenging the international financial order? *Global Policy Institute Policy Paper*, 28, 1–13. <https://repository.londonmet.ac.uk/id/eprint/343>
- Dongfack, L. P. S., & Ouyang, H. (2020). Dynamic risk sharing in the Central African Economic and monetary community. *Journal of Economics and Political Economy*, 7(2), 80–100.
- Duggan, N., Hooijmaaijers, B., Rewizorski, M., & Arapova, E. (2022). Introduction: 'The BRICS, global governance, and challenges for South–South cooperation in a post-Western world'. *International Political Science Review*, 43(4), 469–480. <https://doi.org/10.1177/01925121211052211>
- Fernández-Villaverde, J., & Rubio-Ramírez, J. F. (2010). Structural vector autoregressions. In: Durlauf, S.N., & Blume, L. E. (Eds.), *Macroeconometrics and time series analysis* (pp. 303–307). The New Palgrave Economics Collection. Palgrave Macmillan, London. https://doi.org/10.1057/978020280830_33

- Filippidis, M., Filis, G., & Kizys, R. (2020). Oil price shocks and EMU sovereign yield spreads. *Energy Economics*, 86, 104656. <https://doi.org/10.1016/j.eneco.2019.104656>
- Frankel, J. A., & Rose, A. K. (1998). The endogeneity of the optimum currency area criteria. *The Economic Journal*, 108(449), 1009–1025. <https://doi.org/10.1111/1468-0297.00327>
- FRED. (n.d). Federal reserve economic data. Retrieved 16 July 2024, from <https://fred.stlouisfed.org/>
- Gottschalk, J. (2001). An introduction into the SVAR methodology: Identification, interpretation and limitations of SVAR models. Kiel Working Paper.
- Hooijmaaijers, B. (2021a). China, the BRICS, and the limitations of reshaping global economic governance. *The Pacific Review*, 34(1), 29–55. <https://doi.org/10.1080/09512748.2019.1649298>
- Hooijmaaijers, B. (2021b). The BRICS Countries' bilateral economic relations, 2009 to 2019: Between rhetoric and reality. *SAGE Open*, 11(4), 215824402110541. <https://doi.org/10.1177/21582440211054128>
- International Financial Statistics (IFS). (n.d). International Financial Statistics (IFS). Retrieved 16 July 2024, from <https://data.imf.org/?sk=4c514d48-b6ba-49ed-8ab9-52b0c1a0179b>
- Iqbal, B. A. (2022). BRICS as a driver of global economic growth and development. *Global Journal of Emerging Market Economies*, 14(1), 7–8. <https://doi.org/10.1177/09749101211067096>
- Jager, J., & Hafner, K. A. (2013). The optimum currency area theory and the EMU: An assessment in the context of the eurozone crisis. *Intereconomics*, 48(5), 315–322. <https://doi.org/10.1007/s10272-013-0474-7>
- Jawadi, F., Mallick, S. K., & Sousa, R. M. (2011). Monetary policy rules in the BRICS: How important is nonlinearity? (Working Paper 18). Universidade Do Minho. <https://core.ac.uk/reader/55613460>
- Jawadi, F., Mallick, S. K., & Sousa, R. M. (2014). Fiscal policy in the BRICs. *Studies in Nonlinear Dynamics & Econometrics*, 18(2), 201–214. <https://doi.org/10.1515/snde-2013-0044>
- Jones, D. W., & Leiby, P. N. (1996). The macroeconomic impacts of oil price shocks: A review of literature and issues. *Oak Ridge National Laboratory*, 25(2), 1–32.
- Karataev, S., Troshin, N., Bazhenov, I., & Josie, J. (2017). Use of national currencies in international settlements: Experience of the BRICS countries. <http://hdl.handle.net/20.500.11910/11740>
- Kazerooni, A., & Razzaghi, S. (2014). Assessing the feasibility of common currency area among D-8 group members: Structural VAR model approach. *The International Journal of Applied Economics and Finance*, 8(1), 17. <https://doi.org/10.3923/2014.17.28>
- Kenen, P. (1969). *The theory of optimum currency areas: An eclectic view [w:] monetary problems of the international economy*, red. University of Chicago Press.
- Khatat, M. E. H., Buessings-Loercks, M., & Fleuriel, V. (2020). Monetary policy under an exchange rate anchor. *IMF Working Papers*, 20(180), 47. <https://doi.org/10.5089/9781513556383.001>
- Khezri, M., Zulkhibri, M., & Ghazal, R. (2019). Regional integration, monetary cooperation: Evidence from global VAR models for the member states of the shanghai cooperation organization. *Global Journal of Emerging Market Economies*, 11(1–2), 65–79. <https://doi.org/10.1177/0974910119874634>
- Kilian, L., & Lewis, L. T. (2011). Does the fed respond to oil price shocks? *The Economic Journal*, 121(555), 1047–1072. <https://doi.org/10.1111/j.1468-0297.2011.02437.x>
- Kirton, J., & Larionova, M. (2022). The first fifteen years of the BRICS. *International Organisations Research Journal*, 17(2), 7–30. <https://doi.org/10.17323/1996-7845-2022-02-01>
- Kregel, J. A. (2015). Emerging markets and the international financial architecture: A blueprint for reform. (SSRN Scholarly Paper 2563721). <https://doi.org/10.2139/ssrn.2563721>
- Larionova, M., & Kirton, J. J. (2018). *BRICS and global governance*. Taylor & Francis
- Li, Y., & Guo, J. (2022). The asymmetric impacts of oil price and shocks on inflation in BRICS: A multiple threshold nonlinear ARDL model. *Applied Economics*, 54(12), 1377–1395. <https://doi.org/10.1080/00036846.2021.1976386>
- Lippi, M., & Reichlin, L. (1993). The dynamic effects of aggregate demand and supply disturbances: Comment. *The American Economic Review*, 83(3), 644–652.
- Lowe, P. (2016). The rise of the BRICS in the global economy. *Teaching Geography*, 41(2), 50–53. <https://www.jstor.org/stable/26455170>
- MacKinnon, J. G. (1996). Numerical distribution functions for unit root and cointegration tests. *Journal of Applied Econometrics*, 11(6), 601–618. [https://doi.org/10.1002/\(SICI\)1099-1255\(199611\)11:6<601::AID-JAE417>3.0.CO;2-T](https://doi.org/10.1002/(SICI)1099-1255(199611)11:6<601::AID-JAE417>3.0.CO;2-T)
- Mbangata, T., & Kanayo, O. (2017). A review of the macroeconomic policy frameworks adopted by the BRICS countries (2000–2015). *Journal of Economics and Behavioral Studies*, 9(3(J), 202–211. [https://doi.org/10.22610/jeb.v9i3\(J\).1759](https://doi.org/10.22610/jeb.v9i3(J).1759)
- McKinnon, R. I. (1963). Optimum currency areas. *The American Economic Review*, 53(4), 717–725.
- Mundell, R. A. (1961). A theory of optimum currency areas. *The American Economic Review*, 51(4), 657–665.
- Naeem, M., Pham, L., Senthilkumar, A., & Karim, S. (2021). Oil shocks and BRIC markets: Evidence from extreme quantile approach. *SSRN Electronic Journal*. 1–17. <https://doi.org/10.2139/ssrn.3957368>
- Nchor, D. (2020). Labour mobility as an adjustment mechanism to asymmetric shocks in Europe: Evidence from the Czech Republic, Hungary, Poland and Slovakia. *Journal for Labour Market Research*, 54(1), 16. <https://doi.org/10.1186/s12651-020-00282-w>
- Omotor, D. G., & Niringiye, A. (2011). Optimum currency area and shock asymmetric: A dynamic analysis of the West African Monetary Zone (WAMZ). *Journal for Economic Forecasting*, 3, 71–82.

- Ouliaris, S., & Pagan, A. (2016). A method for working with sign restrictions in structural equation modelling. *Oxford Bulletin of Economics and Statistics*, 78(5), 605–622. <https://doi.org/10.1111/obes.12137>
- Phillips, P. C., & Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika*, 75(2), 335–346. <https://doi.org/10.1093/biomet/75.2.335>
- Quah, C.-H. (2016). Economic feasibility of a BRICS monetary union. *Global & Local Economic Review*, 20(2), 1–29. http://www.gler.it/archivio/ISSUE/gler_20_2.pdf
- Richter, F. (2023). Infographic: The rise of the BRICS. Statista Daily Data. <https://www.statista.com/chart/30638/brics-and-g7-share-of-global-gdp>
- Rubio-Ramírez, J. F., Waggoner, D. F., & Zha, T. A. O. (2010). Structural vector autoregressions: Theory of identification and algorithms for inference. *Review of Economic Studies*, 77(2), 665–696. <https://doi.org/10.1111/j.1467-937X.2009.00578.x>
- Saji, T. G. (2019). Can BRICS form a currency union? An analysis under Markov regime-switching framework. *Global Business Review*, 20(1), 151–165. <https://doi.org/10.1177/0972150917721835>
- Shapiro, M. D. (1987). Supply shocks in macroeconomics. In: Vernengo, M., Caldentey, E. P., & Ghosh, J. (Eds), *The New Palgrave dictionary of economics* (pp. 1–7). Palgrave Macmillan. https://doi.org/10.1057/978-1-349-95121-5_1831-1
- Sheikh, K. A., Yusuf, Z., & Aslam, M. (2013). Feasibility of a monetary union in the East African community: A structural vector autoregression model. *Journal of Economics, Business and Management*, 1(1), 102–105. <https://doi.org/10.7763/JOEBM.2013.V1.24>
- Sims, C. A. (1980). Macroeconomics and reality. *Econometrica*, 48(1), 1–48. <https://doi.org/10.2307/1912017>
- Stock, J. H., & Watson, M. W. (2016). Dynamic factor models, factor-augmented vector autoregressions, and structural vector autoregressions in macroeconomics. In Taylor, J. B., & Uhlig, H. (Eds.), *Handbook of macroeconomics* (Vol. 2, pp. 415–525). Elsevier.
- Tendengu, S., Kapingura, F. M., & Tsegaye, A. (2022). Fiscal policy and economic growth in South Africa. *Economies*, 10(9), 204. <https://doi.org/10.3390/economies10090204>
- UNFCCC. (n.d.). The Paris agreement. Retrieved 18 March 2024, from <https://unfccc.int/process-and-meetings/the-paris-agreement>
- United Nations Conference on Trade and Development. (2023). *BRICS Investment Report*.
- World Bank. (n.d.). World Development Indicators: DataBank. Retrieved 29 June 2024, from <https://databank.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG/1ff4a498/Popular-Indicators#>
- Xing, L. (2016). *The BRICS and beyond: The international political economy of the emergence of a new world order*. Routledge.
- Yarygina, I. Z., Zhiglyayeva, A. V., Vershinina, O. V., & Kuvshinova, Y. A. (2020). Trade and economic cooperation of BRICS: Problems and prospects. *Academic Journal of Interdisciplinary Studies*, 9(6), 89. <https://doi.org/10.36941/ajis-2020-0114>