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The nexus between economic growth and conditional exchange rate volatility: evidence from emerging economies

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Abstract

Purpose – The purpose of this paper was to examine the nexus between conditional exchange rate volatility and economic growth in BRICS countries. Further, the dynamic causation between economic growth and exchange rate volatility is also examined.

Design/methodology/approach – We employed three techniques, namely, dynamic panel models, static panel models and Dumitrescu and Hurlin (DH) panel causality test to examine the economic growth–conditional exchange rate volatility nexus in BRICS countries.

Findings – The overall results showed that conditional exchange rate volatility has a negative and significant effect on economic growth. Interestingly, the results showed that whenever the exchange rate volatility exceeds the 0–1.54 range, the economic growth of BRICS is reduced, on average, by 5%. Further, the results of the causality test reconciled with that of ARDL wherein unidirectional causality from exchange rate volatility, exports, labour force and gross capital formation to economic growth was found.

Research limitations/implications – The urgent recommendation is to develop and align fiscal, monetary, trade and exchange rate policies, either through creating a common currency region or through coordinated measures to offset volatility and trade risks in the long run. Further, to offset the impact of excessive exchange rate changes, BRICS economies can set up currency hedging systems, implement temporary capital controls during periods of extreme volatility or create currency swap agreements with other nations or regions. Last, but not least, investment and labour policies that are coherent and well-coordinated can support market stabilisation, promote investment and increase worker productivity and job prospects.

Originality/value – Researchers hold contrasting views regarding the effect of exchange rate volatility on economic growth. Some researchers claim that exchange rate volatility reduces growth, and several shreds of empirical evidence claim that lower exchange rate volatility is linked with an increase in economic growth, at least in the short run. However, the challenge lies in establishing the optimal range beyond which exchange rate volatility becomes detrimental to economic growth. The present study contributes to this aspect by seeking to identify the optimal spectrum beyond which excessive shifts in exchange rate volatility negatively affect economic growth, or endeavors to define the acceptable spectrum within which these fluctuations actually boost growth. To the best of our knowledge, this study is the first to analyse the given research area. The present study used a dummy variable technique to capture the impact of permissible exchange rate band on the economic growth.

Keywords Emerging economies, BRICS, Conditional exchange rate volatility, Homogeneous causality

Paper type Research paper

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1. Introduction

Retrospectively, the world economy has been transformed from a simple financial structure to a complex set of entwined financial networks (Lee-Lee and Hui-Boon, 2007). From the fall of the Bretton Woods system to the advent of flexible exchange rate systems [1] of contemporary times, the international financial markets have experienced profound changes, from the excessive variability of exchange rates, massive capital inflows to the series of financial markets crises (Oskooee-Bahmani and Hegerty, 2007). In general, the discourse of exchange rate variability and macroeconomic performance is still wide open. The existing literature on the subject has often yielded mixed results. The various notable studies (Asseery and Peel, 1991; Polodoo *et al.*, 2011; Adewuyi and Akpokodje, 2013; Katusiime *et al.*, 2016; Eklou, 2023; Ameziane and Benyacoub, 2022; Abdinur and Elmas, 2022; Jayathilaka *et al.*, 2022; Khan, 2021; Touitou *et al.*, 2019) have confirmed that exchange rate flexibility positively impacts economic growth, for it provides a shield against the real asymmetric shocks. In contrast, Akhtar and Hilton (1984), Arize (1995), Bahmani-Oskooee (2002), Barguellil *et al.* (2018), Rapetti (2020), Morina *et al.* (2020), Perazzi and Romero (2022) and Adeleye *et al.* (2022) state that the exchange rate variability can be detrimental to economic growth for it can negatively influence the various crucial macroeconomic aggregates such as exports, FDI, employment, etc. With the euphoria of globalization in the early 1980s, the novel concept of emerging economies came into existence (Donatella, 2017). Broadly economic literature defines them as a group of countries that entered the take-off phase of development much earlier than the rest of developing economies (Arnold and Quelch, 1998). In this context, the problem of defining the emerging economies has been solved by various studies (Hoskisson *et al.*, 2000; Jain, 2006). They unanimously converge and state that a high level of economic growth characterizes these economies. However, emerging economies are recognized as epicenters of exchange rate fluctuations compared to developed economies (Darrat *et al.*, 2000). In these economies, market-oriented reforms, along with financial sector reforms, not only fuelled the economic growth but also increased the exchange rate volatility.

In a nutshell, the relationship between exchange rate volatility and macroeconomic performance gained attention with the introduction of the flexible exchange rate system in 1973 (Abdalla, 2012). Many studies have confirmed that there exists a negative relationship between the exchange rate volatility and various crucial macroeconomic variables – exports, imports, GDP and FDI (Ramoni-Perazzi and Romero, 2022; Morina *et al.*, 2020; Akhtar and Hilton, 1984; Arize, 1995; Bahmani-Oskooee, 2002; Barguellil *et al.*, 2018; Doganlar, 2002). In contrast, various other works provided sufficient evidence for a positive relationship between the two (Rapetti, 2020; Mundell, 1963; Viaene and de Vries, 1992; Franke, 1991; Sercu, 1992; Asseery and Peel, 1991; Polodoo *et al.*, 2011). The discourse became more complicated with the evidence of an insignificant relationship between the said variables (Arize and Shwiff, 1998; Arize *et al.*, 2000).

However, there are not many studies that tried to disentangle the knot between the exchange rate volatility and the economic growth of emerging economies, particularly in the case of BRICS countries. The lack of persistent empirical literature on these economies reveals that the direction of the relationship between economic growth and exchange rate volatility remains unanswered in them. In absolute terms, one can argue that the gross domestic product in such economies increased considerably over the past few decades. But the empirical literature also highlights that exchange rate volatility increased markedly (Botha and Pretorius, 2015). Thus, an exact relationship between the two cannot be drawn based on a simple cursory overview of data. Hence, the present study empirically tried to examine the impact of exchange rate volatility on economic growth in BRICS economies. Further, it becomes apparent from the existing literature that there is a dichotomy among the researchers as for as the impact of exchange rate volatility on economic growth is concerned.

Some researchers claim that exchange rate volatility reduces growth. Several others believe that lower exchange rate volatility is linked with an increase in economic growth, at least in the short run. However, the permissible range within which exchange rate volatility can positively impact economic growth remains unanswered. The present study contributes to this aspect as it attempts to calculate the permissible band of exchange rate volatility within which it favourably impacts economic growth [2]. The establishment of permissible or legitimate band of exchange rate will have many advantages. First, a permissible exchange rate band can function as a buffer against severe speculation and will prevent short-term speculative trades that destabilise currencies and economies. Second, exchange rate enabled bands can provide a balance of flexibility and stability. It will allow economies to capture the benefits of globalisation while mitigating the negative effects of excessive currency volatility, creating a climate favourable to long-term economic growth. Third, exchange rate enabled bands will allow for progressive responses to external shocks, avoiding abrupt and disruptive changes in exchange rates. Fourth, excessive currency depreciation raises the cost of imports, resulting in imported inflation. An acceptable band will serve to minimise these unexpected surges in inflation, supporting price stability. Finally, permissible exchange rate bands will foster trade and boost export-led growth, which will benefit the economy. These benefits of having appropriate exchange rate bands emphasise the importance of defining the acceptable spectrum within which these exchange rate swings really enhance growth.

2. Methodological review

There is no unanimity among economists and researchers as far as the choice of the exchange rate as a proxy variable for measuring exchange rate volatility is concerned. Akram and Rath (2017) and Coleman-Kyereboah and Tetty-Agyire (2008) used real exchange rate as a proxy for measuring exchange rate volatility, and Rashid and Husain (2013) and Darrat *et al.* (2000) used the nominal exchange rate as a proxy. Besides, various studies reassured that the choice of exchange rate volatility does not affect the robustness of the results. Further, the topic becomes even more intricate because of the researchers' dichotomy regarding volatility modeling. Arize *et al.* (2000), Aftab and Rehman (2017) and Srinivasan and Kalaivani (2012) used historical measures like standard deviation and moving averages to model the volatility. But the introduction of GARCH modeling by Bollerslev (1986) changed the narrative as far as modeling of exchange rate volatility is concerned, for it was based on the novel concept of conditional volatility. It is worth mentioning, in contemporary times, many studies employed GARCH and its variants for modeling the volatility of financial time series data like exchange rates (Barguellil *et al.*, 2018). Therefore, due to the non-sensitivity of the results to the exchange rate choice, the present study used the nominal exchange rate as a proxy variable for measuring exchange rate volatility. Besides, GARCH (1, 1) modeling was used to extract the conditional volatility of the exchange rate, for it has numerous advantages over the historical methods such as moving averages and standard deviation.

Further, the straight forward negative relationship between exchange rate volatility and economic growth might not be always valid in different countries and at different circumstances. The countries having well developed and well established exchange rate markets can hedge the exchange rate risk. In fact, many empirical works provide a robust evidence for a positive relationship between exchange rate volatility and major macroeconomic aggregates – GDP, exports etc. (see Mundell, 1963; Franke, 1991; Sercu, 1992). Gosh *et al.* (2002) also found that an exchange rate with low volatility is linked, at least in the short-run, with an increase in economic growth. Similarly, Eichengreen and Leblang (2003) found that lower exchange rate volatility makes it easier to cut budget deficits and stimulate economic growth. Now the questions arises what is the permissible range within which exchange rate volatility can positively impact economic growth. The present study

contributes in this aspect as we tried to calculate the permissible band of exchange rate volatility within which it favourably impacts economic growth. To the best of our knowledge, this study is the first to analyse the given research area. The present study used a dummy variable technique to capture the impact of permissible exchange rate band on the economic growth. We used the Zivot–Andrews structural break test to determine the lower and upper band values of exchange rate volatility [3]. The Zivot–Andrews test identified five structural breaks in the BRICS economies. These breaks, which include one with a lower exchange rate volatility of 0.0007 and another with a higher exchange rate volatility of 1.54, were used to establish the exchange rate band. The band's top and lower boundaries were represented by the higher volatility value and lower volatility value, respectively. Accordingly, the exchange rate volatility band of 0–1.54 was constructed. Then we defined the dummy variable as follows;

$D = 1$; if exchange rate volatility was in the range 0–1.54, and 0 otherwise.

We employed static panel models to capture the impact of this permissible band on the economic growth of BRICS economies.

3. Theoretical framework and research methodology

The present study was intended to examine whether exchange rate volatility has an impact on the economic growth of five BRICS countries. However, we also attempted to analyze the role of exports and FDI in these countries' growth enhancement. To achieve the objectives, the study used a neoclassical production function that has its basis in Ramsey's work (1928). Solow (1956) popularized the neoclassical model. The neoclassical model assumes constant returns to scale, and technology is considered exogenous. The model postulates that labour and capital are substitutable, and their marginal products are assumed to be diminishing. In its basic form, the neoclassical production function can be written as;

$$Y = f(K, L) \tag{1}$$

Where Y is the level of output measured by GDP, K and L are the amount of capital and labour, respectively. The capital formation was used as a proxy for the amount of capital, and the country's total labour force measured the amount of labour.

International trade can be regarded as a type of technology that converts non-specialized production into specialized production and thereby affects economic growth and development (Mankiw, 2004). Hence, export expansion and diversification improve economy-wide efficiency in allocating resources and increasing factor productivity (Barro and Sala-i-Martin, 1995). From the demand side, an inward-oriented policy is not feasible and sustainable since domestic demand is inadequate and domestic resources may remain idle. Hence, domestic economic growth cannot be enhanced (Tiwari and Mutascu, 2011). However, in an outward-oriented policy with free trade, exports act as an engine of growth through the expansion of external demand (Agosin, 1999; Boriss and Herzer, 2006). On the supply side, exports contribute to economic growth by facilitating economies of scale and promoting technical knowledge (Grossman and Helpman, 1991). Keeping the significance of exports in view, the baseline production function has been augmented by including exports as a variable.

Trade openness positively affects economic growth by providing access to a broad basket of goods and services, improving competence in the allocation of resources and enhancing factor productivity through technology dissemination, knowledge diffusion and spillover effects (Barro and Sala-i-Martin, 1997). Hence, the degree of trade openness is a key medium for countries to develop and integrate with the world. However, trade openness may impact economic growth negatively for countries whose exports are vulnerable to terms of trade

shocks (Haussmann *et al.*, 2007; Cooke, 2010). The mixed effects might be attributed to the sample selection, econometric techniques employed and the indicator used as a proxy for trade openness (Keho, 2017). Keeping these mixed results in view, it would be interesting to estimate the impact of trade openness on the growth of five emerging BRICS economies, for these economies have liberalized their economic structures to a great extent. Therefore, we also incorporated trade openness in a standard production function to analyze its impact on growth.

The standard and baseline neoclassical production function has, therefore, been modified, as suggested by Feder (1983) and Ram (1996). Incorporating conditional exchange rate volatility (CVOL), exports (EXP) and trade openness (TOP) in the standard neoclassical production function, equation (1) can be specified as;

$$Y = f(K, L, CVOL, EXP, TOP) \tag{2}$$

3.1 Model specification

Since the conditional volatility of exchange rates has intrinsically different attributes-volatility clustering and leverage effect-it would be inappropriate to estimate our model with static techniques as they might give inconsistent results. Various techniques can be used in such circumstances, but two techniques, namely, dynamic panel ARDL and Generalized Method of Moments (GMM), are considered most feasible in the given situations. However, in a small sample case, the assumptions underlying GMM estimation are inappropriate, and the estimator breaks down. The GMM technique is appropriate and suitable when N is greater than T (Blundell and Bond, 1998); otherwise, the GMM technique could lead to small sample bias and loss of degrees of freedom. Since our panel consisted of a large T (23 years) and small N (5 countries), the panel ARDL framework seemed appropriate and thereby chosen to examine the long-term and short-term cointegration connections among variables under consideration. Further, the framework performs relatively entirely well under circumstances where mutual integration of order zero, I(0), and order one, I(1), exist.

ARDL models are standard least square regressions, which include the lags of both the dependent and independent variables as regressors. The added advantage of the framework is that it offers short-run and long-run results simultaneously and removes omitted variables and autocorrelation problems. ARDL method gives efficient and unbiased estimators to avoid the problems that may arise in the presence of serial correlation and endogeneity (Siddik, 2000; Khatib *et al.*, 2016). For these reasons, we opted for the ARDL method, a cointegration technique introduced by Pesaran *et al.* (1999). The panel ARDL model offers two estimators: the Mean Group Estimator (MG) and the Pooled Mean Group (PMG). The MG model suggested by Pesaran *et al.* (1997) involves estimating a separate regression for each entity and then derives the long-run coefficients as averages of each country. For instance, if the ARDL model follows;

$$Y_t = \alpha_i + \gamma_i Yi_{t-1} + \beta_i X_{it} + \mu_{it} \tag{3}$$

Here, i stands for country where i = 1, 2, 3 . . . N and the long-run parameter θ_i is given by

$$\theta_i = \frac{\beta_i}{1 - \gamma_i}$$

And the MG estimator for whole panel is given by

$$\emptyset = \frac{1}{N} \sum_{i=N}^{N} \theta_i \tag{4}$$

$$\bar{a} = \frac{1}{N}\sum_{i=N}^{N} \alpha_i \tag{5}$$

The above equations show how the model involves estimating a separate regression for each entity and calculates the coefficients as an unweighted mean of the estimated coefficients for the individual entities. The MG estimator allows all the coefficients among countries to vary and, therefore, does not impose restrictions on the coefficients to remain the same. The PMG (Pesaran *et al.*, 1999) estimator, on the other hand, involves pooling and averaging individual regression coefficients. Unlike MG, PMG allows the short-run coefficients, including intercepts, error terms and speed of adjustment to long-run equilibrium values, to vary across countries. Still, long-run coefficients are restricted to be the same (Aswata *et al.*, 2018). The empirical specification of the PMG model can be specified as;

$$Y_{it} = \sum_{j=1}^{p} \lambda_{ij} Y_{i,t-j} + \sum_{j=0}^{q} \delta_{ij} X_{i,t-j} + \epsilon_t + \mu_{it} \tag{6}$$

Where i is the number of cross-sections (i = 1, 2, 3 . . . N) and time t = 1, 2, 3 . . ..T. X_{it} is a vector of K * 1 regressors, ϵ_t is a group-specific effect and λij is a scalar. If the variables follow I(1) order and are cointegrated, then the disturbance term is an I(0) process. A major characteristic of cointegrated variables is their convergence to any deviance from long-run equilibrium. This feature infers from error correction dynamics of the variables in the system, and therefore, it is common to re-parameterize the above equation into an error correction system as;

$$\Delta Y_{it} = \Phi_i Y_{i,t-j} - \theta_i X_{i,t-j} \sum_{j=1}^{p=1} \lambda_{ij} \Delta Y_{i,t-j} + \sum_{j=0}^{q=1} \delta_{ij} \Delta X_{i,t-j} \epsilon_t + \mu_{it} \tag{7}$$

The error correction term Φ_i indicates the speed of adjustment towards long-run equilibrium. The error correction parameter is expected to be negative and statistically significant under the prior assumption that variables signify a convergence towards long-run equilibrium in case of any interruption.

The PMG estimator, in comparison to the MG estimator, offers an increase in the efficiency of estimators (Pesaran *et al.*, 1999). Further, as the period in this study is only 23 years, the MG estimator has no enough degrees of freedom. Therefore, PMG estimations are more relevant for our analysis. However, to choose between PMG and MG estimators, we use the Hausman Test (1978), which says that once the *p*-value is greater than 5%, then PMG estimations will be preferred.

3.2 Panel unit root test (PURT)

For efficient and consistent estimation of the cointegration relationship's, ARDL model requires that variables are stationary at level, at the first difference or variables are mutually integrated. Estimations are not consistent when some variables are integrated of order two. Therefore, we applied Levin *et al.* (LLC) and Im, Pesaran and Shin (IPS) unit root tests to check the order of integration of variables. The LLC test (2002) assumes that there is a common unit root process so that the autoregressive coefficients are homogenous across countries. LLC test is based on ADF regression for the exploratory unit root problem. The common form of LLC test with intercept only is specified as;

$$\Delta Y_{i,t} = \gamma_{0i} + \rho Y_{it-1} + \sum_{i=0}^{p} \gamma_{1i} \Delta Y_{i,t-j} + \mu_{i,t} \tag{8}$$

In equation (8), γ_{0i} is constant term which is supposed to vary across the countries, ρ is the homogenous autoregressive coefficient, γ_i denotes the lag order and $\mu_{i,t}$ is error term which is supposed to be independent across individual entities and follows ARMA stationary process for every cross-section.

$$\mu_{i,t} = \sum_{j=0}^{\infty} \gamma_{1i} \Delta Y_{i,t-j} + \varepsilon_{i,t} \tag{9}$$

The null and alternative hypotheses of the test are as follows;

$$H_0 = \rho_I = \rho = 0$$

$$H_1 = \rho_I = \rho < 0 \, for \, all \, i$$

The Im *et al.* (2003) test, contrary to the LLC test, allows for individual unit root processes and heterogeneous autoregressive coefficients across entities. IPS test is based on the ADF test to individual series, but the overall test value is based on the arithmetic mean of the individual series. A series may be represented by ADF as follows;

$$\Delta Y_{i,t} = \dot{W}_i + \rho Y_{it-1} + \sum_{j=1}^{\rho i} \rho_{ij} \Delta Y_{i,t-j} + V_{i,t} \tag{10}$$

IPS test allows for heterogeneity in V_i; the IPS unit root equation may be specified as;

$$t'_T = \frac{1}{N} \sum_{i=1}^{N} t_{i,t}(\rho_i) \tag{11}$$

ρ_i is the lag order and t'_T is the test statistic which is calculated as follows;

$$A_{t'} = \frac{\sqrt{N(T)}\,[t'_T - E(t_T)]}{\sqrt{Var\,(t_T)}} \tag{12}$$

3.3 Dumitrescu and Hurlin panel causality test

We used the Dumitrescu and Hurlin (DH) panel causality test, which allows for testing for Granger non-Causality in the VAR framework. This test considers the heterogeneity of the causal relationships and regression model used to test for causality. The underlying regression model for the Dumitrescu and Hurlin (2012) is specified as;

$$Y_{i,t} = \delta_i + \sum_{j=1}^{k} \alpha_{1j} Y_{i,t-i} + \sum_{j=1}^{k} \beta_{1j} X_{i,t-i} + \varepsilon_{i,t};\ i = 1, 2, 3 \ldots N \, and \, t = 1, 2, 3 \ldots T \tag{13}$$

Where k is lag order, which is assumed to be identical for all i, $Y_{i,t}$, and $X_{i,t}$ are two stationary variables for country i at time t and δ_i signifies time-invariant individual effects. The autoregressive parameters α_{1j} and regression slope coefficients β_{1j} are allowed to vary across entities. $Y_{i,t}$, and $X_{i,t}$ are interchanged in equation (13) to test for causality.

Like Granger (1969), the procedure to determine the existence of causality is to test for significant effects of past values of X on the present values of Y. Therefore, the null hypothesis is defined as;

$$H_0: \gamma_{i1} = \ldots = \gamma_{ik} = 0 \ \ \forall_i = 1, \ldots, N$$

This corresponds to the absence of causality for all individuals in the panel. The test assumes that there can be causality for some entities but not necessary for all. The alternative hypothesis is thus defined as;

$$H_1: \gamma_{i1} = \ldots = \gamma_{ik} = 0 \ \ \forall_i = 1, \ldots, N_1$$

$$\gamma_{i1} \neq 0 \, or \ldots or \, \gamma_{ik} \neq 0 \ \ \forall_i = N_1 + 1, \ldots, N$$

Where $N_1 \in [0, N-1]$ is unknown. If $N_1 = 0$, there is causality for all entities included in the panel. N_1 is strictly lower than N, otherwise, there is no causality for all entities, and H_1 reduces to H_0.

Against this background, DH proposes the following three-step procedure to obtain the average Wald statistic; (a) estimate the regression equation enclosed in (12) for all countries; (b) perform F-tests of the K linear hypotheses $\gamma_{i1} = \ldots = \gamma_{ik} = 0$ to retrieve W and (c) finally compute the average of individual-country Wald statistics. The average Wald statistic $\overline{W}$ is;

$$\overline{W} = \frac{1}{N} \sum_{I=1}^{N} Wi \tag{14}$$

Where Wi is the standard adjusted Wald test statistic for individual country i observed during T periods. It is to be noted that the test is designed to detect causality at the panel level, and rejecting H_0 does not imply the absence of causality for some individuals. Under the assumption that Wi is identically and normally distributed, it can be shown that the standardized statistic $\overline{Z}$ when $T \to \infty$ first and then $N \to \infty$, that is T > N panel, follows a standard normal distribution;

$$\overline{Z} = \sqrt{\frac{N}{2K}} \cdot \left(\overline{W} - K \right) \to N(0,1) \tag{15}$$

Also for a fixed T dimension with T > 5 + 3K and $N \to \infty$, that is N > T panel, the approximated standardized statistic $\widetilde{Z}$ follows a standard normal distribution;

$$\widetilde{Z} = \sqrt{\frac{N}{2K} \cdot \frac{T - 3K - 5}{T - 2K - 3}} \cdot \left[\frac{T - 3K - 3}{T - 3K - 1} . \overline{W} - K \right] \to N(0,1) \tag{16}$$

The testing procedure of the null hypothesis in (13) is finally based on $\overline{Z}$ and $\widetilde{Z}$. If these are larger than the corresponding critical values, then one should reject the null hypothesis and conclude that there is Granger Causality among variables under consideration.

3.4 Static panel models

To check the robustness of the results and to gauge the effects of excessive volatility/fluctuations in the exchange rate on the economic growth of BRICS economies, we also employed static panel models. However, we omitted the specifics of these models for sake of conciseness. Last but not least, the appropriate model selection was based on specification tests (Wald test and Hausman test).

3.5 Data sources

The study is based on secondary data. The data required for empirical analysis was extracted from the World Bank's database of World Development Indicators and the International Financial System (IFS) database of the International Monetary Fund. The data was collected for the period 1995–2017 for five BRICS emerging economies. Note that during this period,

these economies appeared to have developed strategies and policies to promote bilateral trade flows, foreign investments and integration through a reduction in tariff and non-tariff barriers.

4. Results and discussion

4.1 Results of PURT

The results of PURT are reported in Table 1 and Table 2. As demonstrated by these tables, the results from LCC and IPS tests confirm that LEXP, LGDP, LTOP and LK are stationary at the first difference, while CVOL and LL are level stationary. This suggests that our variables of interest are mutually integrated and hence none of them is of the order I(2). So panel ARDL appears to be the most suitable technique for estimation in the present study.

4.2 Impact of conditional exchange volatility on economic growth

In Tables 3 and 4, we present the estimated relationship between economic growth and conditional exchange rate volatility by both MG and PMG estimators of panel ARDL. Due to the varied results from two estimators, selecting the appropriate and preferred model using

Series	Method	Statistic	Prob	Cross-sections	Obs
LEXP[a]	Levin, Lin and Chu	−1.06	0.14	5	110
D[b] (LEXP)***	Levin, Lin and Chu	−6.49	0.00	5	105
LGDP	Levin, Lin and Chu	0.08	0.53	5	108
D(LGDP)***	Levin, Lin and Chu	−5.21	0.00	5	105
LTOP	Levin, Lin and Chu	−1.47	0.70	5	109
D(LTOP)***	Levin, Lin and Chu	−6.39	0.00	5	104
LK	Levin, Lin and Chu	−0.84	0.200	5	105
D(LK)***	Levin, Lin and Chu	−4.22	0.00	5	105
CVOL***	Levin, Lin and Chu	−3.74	0.00	5	110
LAB***	Levin, Lin and Chu	−8.50	0.00	5	108

Note(s): The null hypothesis of LLC assumes a common unit root process. *** represents a 1% level of significance
Lag selection is automatic based on SIC
[a]L is the prefix of every variable, except CVOL, signifies log transformation
[b]D signifies first difference
Source(s): Authors' own creation

Table 1.
Results of LLC test

Series	Method	Statistic	Prob	Cross-sections	Obs
LEXP	IPS	1.39	0.91	5	110
D(LEXP)***	IPS	−5.01	0.00	5	105
LGDP	IPS	2.42	0.99	5	108
D(LGDP)***	IPS	−3.58	0.00	5	105
LTOP	IPS	−0.55	0.28	5	109
D(LTOP)***	IPS	−6.39	0.00	5	104
LK	IPS	1.08	0.86	5	105
D(LK)***	IPS	−3.51	0.00	5	105
CVOL***	IPS	−3.74	0.00	5	110
LL***	IPS	−4.45	0.00	5	108

Note(s): The null hypothesis of IPS assumes an individual unit root process ***represents 1%, level of significance
Source(s): Authors' own creation

Table 2.
Results of IPS test

Dependent variable; economic Growth[a]						
Regressor	Coef	Std. Err	Z	P >|z|	95% conf. Interval	
Long-run Estimates						
CVOL	20.70526	14.01171	1.48	0.139	−6.757196	48.16771
LEXP	0.0115633	0.7931771	0.01	0.988	−1.543035	1.566162
LTOP	−0.9926503	0.1129526	−8.79	0.000***	−1.214033	−0.7712673
LK	0.7604215	0.5018207	1.52	0.130	−0.223129	1.743972
LL	10.06706	10.46888	0.96	0.336	−10.45158	30.58569
Short-run Estimates						
ECT	−0.5139735	0.2190481	−2.35	0.019**	−0.9432999	−0.0846471
D (CVOL)	−1.853771	3.72353	−0.50	0.619	−9.151756	5.444213
D(LEXP)	0.140037	0.0942691	1.49	0.137	−0.044727	0.3248011
D(LTOP)	−0.0399044	0.1274869	−0.31	0.754	−0.2897742	0.2099653
D(LK)	0.1947911	0.120858	1.61	0.107	−0.0420862	0.4316684
D(LL)	−0.8549804	0.9724885	−0.88	0.379	−2.761023	1.051062
Cons	16.64466	10.43827	1.59	0.111	−3.813963	37.10329

Note(s): *** and ** represent 1% and 5% level of significance respectively
[a]MG and PMG models were estimated by using the command xtpmg in Stata
Source(s): Authors' own creation

Table 3.
Mean group estimates

Dependent variable; economic growth						
Regressor	Coef	Std. Err	Z	P >|z|	95% conf. Interval	
Long-run Estimates						
CVOL	−1.864261	0.8668703	−2.15	0.032**	−3.563296	−0.1652263
LEXP	0.6684767	0.0456043	14.66	0.000***	0.579094	0.7578594
LTOP	−1.038281	0.0911234	−11.39	0.000***	−1.21688	−0.8596827
LK	0.2516368	0.0438494	5.74	0.000***	0.1656936	0.3375801
LL	0.3368628	0.1366531	2.47	0.014**	0.0690276	0.604698
Short-run Estimates						
ECT	−0.3453199	0.1716848	−2.01	0.044**	−0.681816	−0.0088238
D (CVOL)	1.101618	2.338924	0.47	0.638	−3.48259	5.685825
D(LEXP)	0.2382725	0.1270983	1.87	0.061*	−0.0108357	0.4873806
D(LTOP)	−0.1578084	0.1826239	−0.86	0.388	−0.5157446	0.2001279
D(LK)	0.3371744	0.1082955	3.11	0.002***	0.1249191	0.5494296
D(LL)	−1.027499	0.4715185	−2.18	0.029**	−1.951658	−0.10334
Cons	0.4641944	0.2439621	1.90	0.057*	−0.0139625	0.9423513

Note(s): ***, ** and * represent 1%, 5% and 10% level of significance respectively
Source(s): Authors' own creation

Table 4.
Pooled Mean group estimates

the Hausman test is necessary. The Hausman test with an h-statistic value of 2.68 and a *p*-value of 0.7489 (which is greater than a 5% level of significance) indicates slope homogeneity, and PMG model is appropriate (see Table 5). The direction of our analytical efforts, therefore, focuses on PMG estimators.

Test summary	Chi-sq. Statistic	Chi-sq. d.f	Prob
Cross-section random	2.68	5	0.7489

Source(s): Authors' own creation

Table 5.
Hausman test Results

The PMG long-run estimators show that conditional exchange rate volatility (COVL) has a negative and significant impact on the economic growth of BRICS economies at a 5% critical value. The results meet the a priori expectation that conditional exchange rate volatility would be detrimental to the economic growth of BRICS economies (Rapetti, 2020; Morina *et al*., 2020). The possible reason for this result might be that these economies are financially liberalized, and the given country group is characterized by the absence of a common currency (countries that share a common currency are less likely to experience high volatility in their bilateral exchange rates). The negative effect of exchange rate volatility on growth may be explained by its uncertainty and instability (Dixit and Pindyck, 1994; Barguellil *et al*., 2018). These findings, however, contradict those of Abdinur and Elmas (2022), Khan (2021) and Touitou *et al*. (2019) who found a positive relationship between economic growth and exchange rate. Further, as financial development increases, economies are better able to hedge against potential swings in the exchange rate, which lessens the adverse effects of volatility (Aghion *et al*., 2009; Perazzi and Romero, 2022). Similarly, trade openness tends to have a negative and significant impact on panel countries' economic growth (Durham, 2004; Nguyen *et al*., 2023). This may be because developing countries like BRICS face difficulties in competing with developed countries in international markets and hence fail to reap the benefits of international trade (Asghar *et al*., 2015).

Moreover, the negative impact of trade openness on the economic growth of panel countries might be attributed to their exports of low-quality products (Haussmann *et al*., 2007) and lowering as well as volatile exchange rates (Jafari Samimi *et al*., 2012). However, other control variables seem to have a significant and positive impact on the economic growth of BRICS economies. The results suggest that exports tend to have a favorable impact on the economic growth of panel countries (Usman, 2023; Sunde *et al*., 2023; Kong *et al*., 2021); therefore, to achieve a higher and sustainable growth path, moving ahead with exports is more feasible in BRICS economies. This is true, particularly for economies that lack resources to bring more advanced technology to private homes (Tiwari and Mutascu, 2011). Labour force and gross capital formation carry a positive sign and are also statistically significant. This signifies that an increase in labour force and gross capital formation leads to a rise in economic growth (Kormendi and Meguire, 1985; Mankiw *et al*., 1992; Barro and Sala-i- Martin, 1995; Podrecca and Carmeci, 2001; Rahman and Alam, 2021; Topcu *et al*., 2020; Islam and Biswas, 2023). In a nutshell, Paudel (2020) makes the case that economic growth is a long-term phenomenon that results from the interaction of many production elements, such as labour force, capital and technology; therefore, to accelerate economic growth, rising nations such as the BRICS should focus on improving investment and labour employment scenarios (Kinyanjui *et al*., 2022).

The short-run results from the PMG model show that only exports and gross capital formation tend to have a positive and significant impact on the given panel countries' economic growth, while exchange rate volatility and trade openness show an insignificant impact (Bahmani-Oskooee and Ratha, 2004). The insignificant impact of exchange rate volatility and trade openness in the short-run signifies that their negative effect on economic growth is not immediate for given countries. Therefore, it can be argued that although exchange rates have an impact on the economy over the long term, their short-term effects on economic growth may be limited or unclear because of a variety of factors such as market inefficiencies, adjustment lags and the intricacy of the dynamics of international trade (De Grauwe and Rovira, 2012). Surprisingly, the labour force shows a negative and significant impact on growth in the short run. In the short run, lack of employability and resultant frictional and structural unemployment affects the labour force's productivity. This subsequently impacts countries' potential for economic growth.

Regarding the speed of adjustment, the coefficient of error correction term (ECT) is within 0 and 1 range, negative and statistically significant. This is an indication that the model converges towards equilibrium. The speed of adjustment is about 35% in the given case.

4.3 Results of Dumitrescu and Hurlin panel causality test

The DH panel causality test results are presented in Table 6 [4]. The results reveal that exchange rate volatility, exports, labour force and gross capital formation homogeneously cause economic growth, but economic growth does not homogenously cause exchange rate volatility, exports, labour force and gross capital formation. These results suggest that there is a homogenous unidirectional causality running from CVOL, LEXP, LL, LK to GDP. Trade openness does not homogenously causes economic growth, but economic growth homogeneously causes trade openness.

4.4 Results of static panel models

The results of the pooled OLS model, fixed effects model and random effects model are presented in Table 7. The F-test is commonly used to pick between the pooled OLS model and the fixed effects model, as previously indicated. The F-test, also known as the Wald test, gives a value of (25.02), which is statistically significant at a 1% significance level, indicating that the fixed effects model outperforms the pooled regression model (Table 7). Because the pooled OLS model does not appear to be adequate in this case, we will concentrate our analytical efforts on fixed effect and random effect estimators. However, Hausman test is used to pick

Null hypothesis	W-stat	Zabar-Stat	Prob
CVOL does not homogeneously cause LGDP	8.54	9.59	0.00***
LGDP does not homogeneously cause CVOL	1.53	0.53	0.59
LEXP does not homogeneously cause LGDP	8.30	9.27	0.00***
LGDP does not homogeneously cause LEXP	1.42	0.39	0.69
LL does not homogeneously cause LGDP	7.99	8.88	0.00***
LGDP does not homogeneously cause LL	1.77	0.84	0.39
LK does not homogeneously cause LGDP	2.76	2.12	0.03***
LGDP does not homogeneously cause LK	1.77	0.84	0.39
LTOP does not homogeneously cause LGDP	6.85	7.411	1.E−13
LGDP does not homogeneously cause LTOP	2.94	2.35	0.01**

Note(s): *** and ** represent 1% and 5% level of significance respectively
Source(s): Authors' own creation

Table 6.
Results of Panel causality test

Dependent variable: LGDP Variable	Coefficient	Std. Error	*t*-Statistic	Prob
CVOL	−0.028	0.0091	−3.088	0.002***
LEXP	0.420	0.029	14.14	0.00***
LTO	−0.591	0.038	−15.39	0.00***
LGFC	0.495	0.026	18.45	0.00***
LLF	0.282	0.064	4.378	0.00***
DUM	0.048	0.022	2.17	0.031**
C	0.592	1.067	0.554	0.58

Wald/F test = 25.02 (0.000)***, Hausman test = 82.08 (0.000)***

Note(s): Based on the specification tests, Fixed Effects Model was considered as an appropriate model for estimation. In fact, choice between Pooled OLS model and Fixed effects model was based on F (Wald test statistic and the choice between Fixed Effects Model and Random Effects Model was based on the outcome of the Hausman test. For brevity, only the results of FEM has been reported
*** and ** represent 1% and 5% level of significance respectively
Source(s): Authors' own creation

Table 7.
Results of selected fixed effects Model

between FEM and REM. The null hypothesis - the random-effects is more appropriate - is rejected because the *p*-value of the Hausman test is statistically significant at a 1% significance level (the Hausman test statistic is provided in Table 7). As a result, FEM estimators are at the forefront of our analytical efforts.

On the whole, the results of the FEM are consistent with the PMG model. Like PMG model, the FEM model also shows that exports, labour force and gross capital formation positively affect economic growth in BRICS countries while conditional exchange rate volatility and trade openness show a negative effect on their growth. The coefficient for our dummy variable is positive and statistically significant. This implies that economic growth in BRICS economies, on an average, increases by about 0.048% if the exchange rate volatility lies within its band value. In other words, exchange rate volatility positively and significantly affects the economic growth in the BRICS countries when it fluctuates in the 0–1.54 range. Therefore, whenever the exchange rate volatility exceeds the 0–1.54 range, the economic growth of BRICS is lowered by about 5%.

5. Conclusion

This study empirically examined the relationship between exchange rate volatility and economic growth for five emerging economies of BRICS. The static and dynamic panel models were employed as estimation methods. The results showed that conditional exchange rate volatility and trade openness hurt the BRICS countries' economic growth in the long run. However, in the short run, conditional exchange rate volatility and trade openness do not significantly impact the growth in these countries. Therefore, the adverse effects of exchange rate volatility and trade openness on economic growth seem to be limited to the long run. Notwithstanding this, yet we found that exports and the amount of capital both in the short-run and long-run have a significant contributory impact in promoting the economic growth of the five emerging BRICS economies. The results of the causality test reconciled with that of ARDL wherein unidirectional causality from exchange rate volatility, exports, labour force and gross capital formation to GDP was found. Further, there is a dichotomy among the researchers as for as the impact of exchange rate volatility on economic growth is concerned. Some researchers claim that exchange rate volatility reduces growth, and several shreds of empirical evidence claim that lower exchange rate volatility is linked with an increase in economic growth, at least in the short run. However, the permissible range within which exchange rate volatility can positively impact economic growth still remains unanswered. The present study contributed to this aspect and found that whenever the exchange rate volatility exceeds the 0–1.54 range, the economic growth of BRICS is reduced, on average, by 5%.

The findings of the study has important policy implications. First, for sustainable economic growth prospects of these economies, we recommend the formulation and implementation of complemented fiscal, monetary and exchange rate policies either through the creation of a common currency area or through the coordinated efforts to mitigate exchange rate and trade risks, especially in the long-run. Second, BRICS countries can boost internal demand through targeted fiscal stimulus or infrastructure development, lowering their reliance on external demand caused by exchange rate fluctuations. Third, the findings revealed that exports have a beneficial impact on the economic growth of the BRICS countries. Relying on a small number of export items or markets can render BRICS economies more vulnerable to exchange rate changes. As a result, trade diversification and export promotion can lessen sensitivity to currency movements and broaden economic resilience. Fourth, to offset the impact of excessive exchange rate changes, BRICS countries can set up currency hedging systems, implement temporary capital controls during periods of extreme volatility or create currency swap agreements with other nations or regions. Finally,

investment and labour policies that are coherent and well-coordinated can support market stabilisation, promote investment and increase worker productivity and job prospects.

Notes

1. Based on IMF classification (2016) in which many variants of floating exchange rate system are included in flexible exchange rate system (for further clarifications see Annual Report on Exchange rate Arrangements and Exchange Restrictions, 2016).
2. We employed the dummy variable technique to achieve this objective.
3. GARCH graphs of sample countries is given in the appendix.
4. The optimal lag length used for this test based on AIC.

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Further reading

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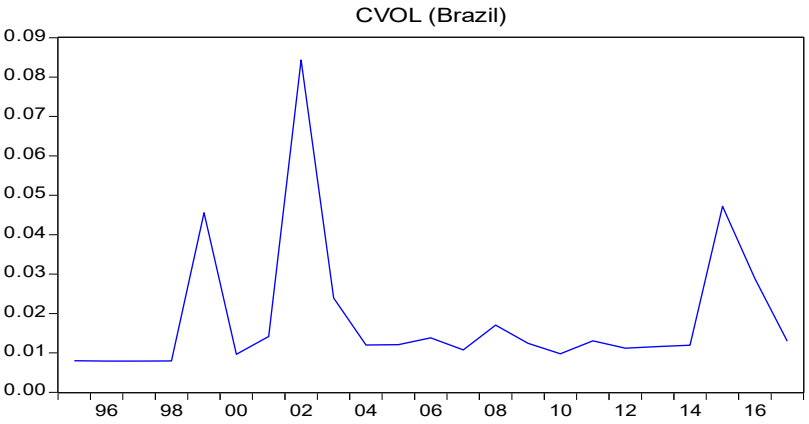
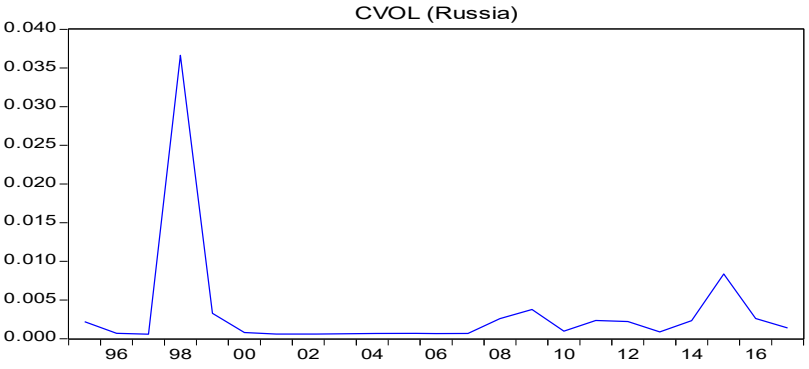
Appendix



Source(s): Authors' own creation

Figure A1. GARCH Graph of Brazil



Source(s): Authors' own creation

Figure A2. GARCH Graph of Russia

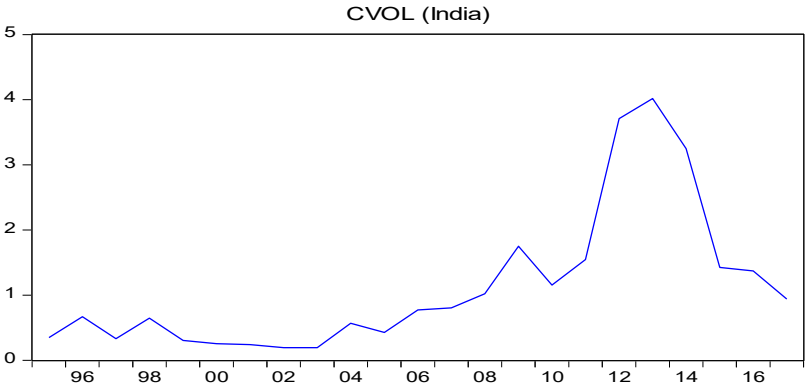


Figure A3.
GARCH Graph of India

Source(s): Authors' own creation

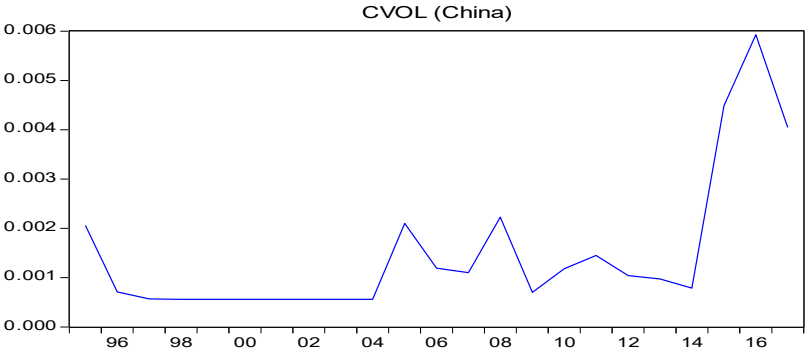


Figure A4.
GARCH Graph of China

Source(s): Authors' own creation

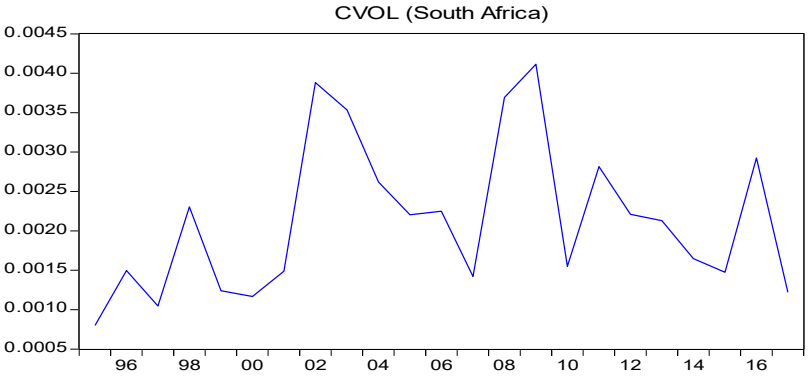
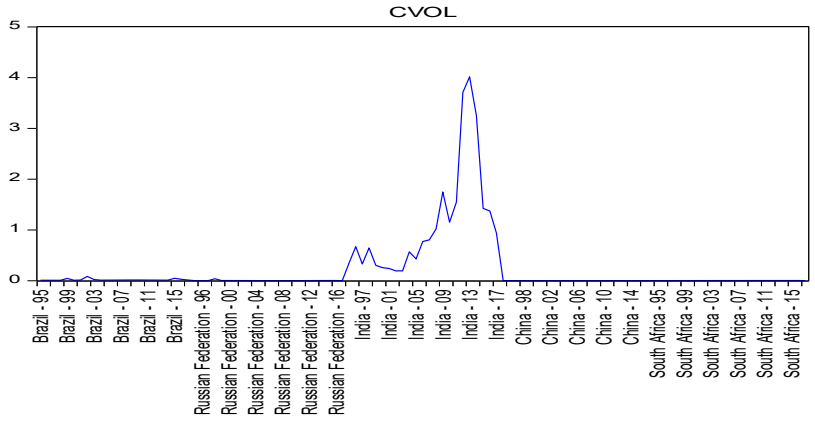


Figure A5.
GARCH Graph of South Africa

Source(s): Authors' own creation



Source(s): Authors' own creation

Figure A6.
GARCH Graph of BRICS

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