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The Causality Relationship Among Global Competitiveness, GDP Per Capita, and Exchange Rate Volatility in BRICS+ Countries, 2012–2024

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ABSTRACT
This study examines the long-run relationship and short-run causality among global competitiveness, proxied by the Global Innovation Index (GII), GDP per capita (PPP), and real effective exchange rate volatility (REER_VOL) in nine BRICS+ countries over the period 2012–2024. The study is motivated by mixed empirical evidence on the linkages between innovation, economic growth, and exchange rate stability in developing economies. Using annual panel data, the analysis applies the Panel Autoregressive Distributed Lag (Panel ARDL) approach with Pooled Mean Group (PMG) and Mean Group (MG) estimators, complemented by the Dumitrescu-Hurlin panel Granger causality test to identify short-run predictive directions. Data processing was carried out in EViews and cross-checked in Stata for robustness. The results show only one significant long-run relationship, namely a negative effect of GDP per capita on exchange rate volatility. The Error Correction Terms are negative and significant in all three equations, confirming adjustment toward long-run equilibrium even though most individual long-run coefficients are not significant. The Dumitrescu-Hurlin test finds no evidence of short-run Granger causality in any of the six tested directions. These findings indicate that exchange rate stability in BRICS+ countries is shaped more by fundamental income levels than by short-run dynamics among the three variables. Policymakers are encouraged to prioritize long-run economic capacity building to support currency stability, while future research should extend the observation period and incorporate moderating or mediating variables.
Keywords: *BRICS+; Exchange rate volatility; GDP per capita; Global competitiveness; Panel ARDL*

INTRODUCTION

The shift in the global economic order toward a more multipolar configuration is marked by the growing role of developing-country coalitions that promote South-South cooperation. BRICS, originally comprising Brazil, Russia, India, China, and South Africa, was introduced by O'Neill (2001) as a group of developing countries with strong growth prospects. Since 1 January 2024, the group has expanded into BRICS+ with the addition of Egypt, Ethiopia, Iran, Saudi Arabia, and the United Arab Emirates, followed by Indonesia's accession as a full member in January 2025 (Jütten, 2024). This expansion has enlarged the bloc's collective economic weight and reinforced its agenda for a more inclusive global governance architecture (Junior, 2025), including through the New Development Bank's expanded financing, which had approved a cumulative USD 34.8 billion for 105 projects by the end of 2023 (New Development Bank, 2023).

As the largest developing economy in Southeast Asia, Indonesia is closely linked to global economic dynamics through international trade and global demand (World Bank Group, 2023). Full BRICS+ membership opens opportunities to strengthen trade and investment partnerships, access development financing, and diversify transaction instruments, while also placing Indonesia within a policy forum relevant to the agenda of productivity and macro stability (Strangio, 2025). Against this backdrop,

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this study focuses on three interrelated macroeconomic variables, namely global competitiveness, GDP per capita, and exchange rate volatility. Competitiveness affects a country's productivity, which in turn drives GDP per capita, while exchange rate volatility affects relative prices, the cost of capital, and external sector performance, as sharp appreciation or depreciation can disrupt export competitiveness.

Global competitiveness in this study is proxied by the Global Innovation Index (GII), published annually by the World Intellectual Property Organization together with Cornell University and INSEAD through 80 innovation input and output indicators (Cornell University et al., 2020). The GII trend for 2012–2024 across the nine BRICS+ countries shows considerable variation. China recorded the most consistent improvement, the United Arab Emirates maintained a comparatively high score throughout the period, while South Africa and Egypt experienced a gradual decline. This variation confirms that innovation capacity is a key determinant of a country's productivity and economic competitiveness.

GDP per capita reflects the average economic output per capita and is therefore commonly used as a welfare indicator (World Bank Group, 2025). This study uses GDP per capita based on Purchasing Power Parity to ensure consistent cross-country comparison. The data show that the United Arab Emirates and Saudi Arabia occupy the highest income levels, while India, South Africa, Egypt, and Indonesia occupy the lower-middle range, confirming that BRICS+ is not a homogeneous group but rather reflects considerable disparities in economic structure, innovation capacity, and fiscal capability (Gong et al., 2024).

The third variable, exchange rate volatility, is measured through the Real Effective Exchange Rate (REER) sourced from the Bank for International Settlements (2023) because it provides a long-run series with time-varying trade weights. Developing countries, including BRICS+ members, tend to be more vulnerable to exchange rate volatility owing to their dependence on commodity exports and international capital flows (International Monetary Fund. Research Dept., 2023). Russia recorded the sharpest volatility spike in 2022, while Egypt experienced a substantial volatility increase in 2016 and 2024. This phenomenon is equally relevant for Indonesia, given that the International Monetary Fund (IMF) Article IV Consultation 2023 report noted significant external pressure on the Rupiah throughout 2022–2023 driven by US dollar appreciation and falling commodity prices (International Monetary Fund, 2023b), a finding corroborated by Pratiwik et al. (2023), who showed that Rupiah volatility is strongly influenced by global interest rates and domestic fundamentals.
Compared with the advanced-economy G7 group, BRICS+ as a whole still lags behind in both innovation capacity and income levels. World Intellectual Property Organization (2025) reports that the United States and the United Kingdom consistently rank among the top five in global innovation, while the average G7 GDP per capita in 2024 reached USD 57,316 PPP, far exceeding the BRICS+ average (The Global Economy, 2024). In terms of exchange rate behavior, G7 economies such as the United States exhibit a comparatively stable REER, underpinned by strong monetary policy credibility and deep financial markets (Federal Reserve Bank of St. Louis, 2026).

Although the relationship among global competitiveness, GDP per capita, and exchange rate volatility has been widely studied, most prior research remains limited to partial two-variable analysis and has not examined the causal relationship among all three variables simultaneously within a single empirical framework. Unlike studies that treat only one variable as the dependent variable, this study estimates each variable as the dependent variable in turn, given that the relationships among the three variables are unlikely to be strictly unidirectional. Studies using the GII as a competitiveness proxy also rarely link it simultaneously to GDP per capita and exchange rate volatility, while prior BRICS studies generally do not cover the far more heterogeneous BRICS+ configuration following its 2024–2025 expansion.

Based on this gap, the present study aims to analyze the long-run and short-run causal relationships among global competitiveness, GDP per capita, and exchange rate volatility across nine BRICS+ countries over the period 2012–2024. Specifically, it examines whether a causal relationship exists between global competitiveness and GDP per capita, between global competitiveness and exchange rate volatility, and between GDP per capita and exchange rate volatility, and it further tests the short-run and long-run effects among the three variables. The findings are expected to enrich the empirical literature on BRICS+ economic dynamics while providing an analytical foundation for Indonesia to maximize its role as a BRICS+ member in strengthening innovation, improving welfare, and safeguarding macroeconomic stability.

LITERATURE REVIEW

This section outlines the conceptual and theoretical foundations of the three research variables, namely global competitiveness, GDP per capita, and exchange rate volatility, followed by a summary of prior studies and the development of the research hypotheses.

Global Competitiveness

Global competitiveness refers to the set of institutions, policies, and factors that determine a country's level of economic productivity (World Economic Forum, 2019). Ginevičius et al. (2023) argue that competitiveness is a complex phenomenon reflecting a country's ability to leverage economic, social, and institutional resources to compete in international markets. This study proxies global competitiveness through the Global Innovation Index (GII), compiled by WIPO together with Cornell University and INSEAD across 80 innovation input and output indicators, organized into two sub-indices, namely the Innovation Input Sub-Index, covering institutions, human capital and research, infrastructure, market sophistication, and business sophistication, and the Innovation Output Sub-Index, covering knowledge and technology outputs and creative outputs (Cornell University et al., 2020).

The theoretical foundation for global competitiveness in this study draws on three frameworks. First, Porter's (1990) Diamond Model of National Competitiveness explains a nation's competitive advantage through four interacting determinants, namely factor conditions, domestic demand conditions, related and supporting industries, and firm strategy, structure, and rivalry. Second, Krugman's (1994) productivity theory asserts that a nation's long-run standard of living is determined almost entirely by domestic productivity, in line with Romer's (1990) view that innovation is the principal engine of productivity growth. Third, the National Innovation Systems framework of Lundvall (1992) and Nelson (1993) explain that innovation capacity is the outcome of complex institutional interaction among universities, research institutions, firms, and government, so that innovation-based competitiveness develops gradually and differs across countries according to their national innovation system characteristics.

GDP per Capita

GDP per capita reflects the average income or output generated per individual in a country, calculated by dividing the total monetary value of goods and services produced by the population size (International Monetary Fund, 2026). Mankiw (2018) identifies physical capital accumulation, human capital, technological progress, and economic institutions and political stability as determinants of cross-country variation in GDP per capita. This study uses the World Bank's GDP per capita, PPP (constant 2021 international dollars) indicator, transformed into its natural logarithm (LNGDPPC) to stabilize variance and facilitate interpretation (Wooldridge, 2020).

Three growth theories underpin this variable. Romer's (1990) endogenous growth theory treats innovation and knowledge accumulation as endogenous variables generated through research and development investment, with non-rival and partly non-excludable knowledge producing spillovers that sustain long-run growth. Lucas's (1988) human capital accumulation theory emphasizes that investment in education and training generates positive externalities for aggregate productivity, so that GDP per capita tends to move steadily and remains relatively insulated from short-run shocks. Solow's (1956) neoclassical growth theory explains that GDP per capita is determined by capital accumulation, labor force growth, and technological progress, implying conditional convergence among countries with similar structural characteristics. Together, these frameworks suggest that GDP per capita in BRICS+ countries is driven more by domestic structural dynamics than by external variables such as global competitiveness or exchange rate volatility alone.

Exchange Rate Volatility

Exchange rate volatility measures the degree of fluctuation or instability of the exchange rate over a given period, with higher volatility reflecting greater uncertainty and risk in international trade and cross-border investment (International Monetary Fund, 2004). This study uses the Real Effective Exchange Rate (REER) as the volatility indicator because it more accurately captures international price competitiveness than the nominal exchange rate, as it accounts for trade weights and relative inflation among trading partners (Bank for International Settlements, 2023). Kayani et al. (2023) found that REER volatility has an asymmetric effect on international trade flows, exerting a stronger drag on developing Asian economies.

Five theoretical approaches inform this variable. Dornbusch's (1976) overshooting theory explains that the difference in adjustment speed between fast-adjusting asset markets and sticky goods markets causes the exchange rate to overshoot before gradually returning to its long-run equilibrium. The hysteresis theory of Baldwin and Krugman (1989) shows that large exchange rate shocks can leave permanent effects on trade structure due to the sunk costs faced by exporting firms. Aghion et al. (2009) provide empirical evidence that real exchange rate volatility depresses productivity growth, particularly in countries with shallow financial markets. The Purchasing Power Parity theory of Cassel (1918), further developed by Frenkel (1976), explains that the long-run exchange rate mirrors the ratio of price levels between countries, while short-run deviations arise from price rigidity. The Balassa-Samuelson effect (Balassa, 1964; Samuelson, 1964) explains that countries whose tradable-sector productivity grows faster tend to experience a gradual and predictable REER appreciation rather than sudden volatility spikes.

Prior Studies

Table 1 summarizes a number of prior studies examining the linkages among global competitiveness, GDP per capita, and exchange rate volatility, particularly in developing countries and the BRICS+ region.

Table 1. Summary of Prior Studies

Author(s)	Method	Key Findings
Jamel et al. (2021)	Panel analysis of BRICS and Sub-Saharan Africa, 1995–2018	Trade openness and GDP per capita strengthen trade openness and reinforce cross-regional economic ties.
Kordalska & Olczyk (2016)	Conceptual and literature review	Global competitiveness and economic growth exhibit a mutually reinforcing (two-way) relationship.
Elian et al. (2025)	Panel cointegration and causality, BRICS 1981–2019	Economic growth positively affects FDI, while exchange rate volatility has a negative but insignificant long-run effect.

Bhat et al. (2024)	Dynamic panel and Dumitrescu-Hurlin causality	Conditional exchange rate volatility significantly reduces economic growth in emerging economies.
Jabi (2025)	VECM and panel data, BRICS	GDP raises REER but reduces trade competitiveness, whereas depreciation lowers REER.
Nach & Ncwadi (2024)	SVAR modeling, BRICS	REER, GDP, and inflation play an important role in monetary stability and economic integration in BRICS.
Bate et al. (2023)	Multistage cross-country analysis based on the GII	Income, education, and infrastructure significantly affect innovation performance, with country-specific bottlenecks.
Nasir & Zhang (2024)	Panel data across GII pillars	An innovation competitiveness gap persists across countries, with advanced economies remaining more dominant and stable.

Source: Compiled by the authors (2026)

Drawing on the theoretical framework above, the relationship among global competitiveness, GDP per capita, and exchange rate volatility is regarded as reciprocal rather than unidirectional. Innovation-based competitiveness is theoretically expected to raise productivity and GDP per capita through the endogenous growth mechanism, while higher GDP per capita reflects stronger economic fundamentals that dampen exchange rate volatility, consistent with Purchasing Power Parity theory and the Balassa-Samuelson effect. Conversely, high exchange rate volatility can suppress long-run innovation investment, as explained by Aghion et al. (2009), and generate hysteresis effects on export competitiveness, as explained by Baldwin and Krugman (1989).

Hypothesis Development

Based on the theoretical framework and prior studies outlined above, the research hypotheses are formulated as follows.

H1: GDP per capita has a long-run effect on global competitiveness in BRICS+ countries over 2012–2024.

H2: Exchange rate volatility has a long-run effect on global competitiveness in BRICS+ countries over 2012–2024.

H3: Global competitiveness has a long-run effect on GDP per capita in BRICS+ countries over 2012–2024.

H4: Exchange rate volatility has a long-run effect on GDP per capita in BRICS+ countries over 2012–2024.

H5: Global competitiveness has a long-run effect on exchange rate volatility in BRICS+ countries over 2012–2024.

H6: GDP per capita has a long-run effect on exchange rate volatility in BRICS+ countries over 2012–2024.

H7: There is short-run Granger causality among global competitiveness, GDP per capita, and exchange rate volatility in BRICS+ countries over 2012–2024.

METHODS

This study employs a quantitative approach using annual panel data from nine BRICS+ member countries, namely Indonesia, Brazil, Russia, India, China, South Africa, Saudi Arabia, the United Arab Emirates, and Egypt over the period 2012–2024, yielding 117 country-year observations in a balanced panel. Ethiopia and Iran were excluded owing to the lack of consistent data availability

throughout the observation period. The entire population was used as the research sample (Sahir, 2021).

Data were obtained from secondary sources, namely the Global Innovation Index score published by WIPO for global competitiveness, measured on a 0–100 index scale, GDP per capita (PPP, constant 2021 international dollars) from the World Development Indicators for GDP per capita, and monthly Real Effective Exchange Rate data from the Bank for International Settlements for exchange rate volatility. REER volatility was computed by first calculating the monthly REER return, then taking the standard deviation of the twelve-monthly returns within each calendar year, following Gujarati and Porter (2009). GDP per capita was transformed into its natural logarithm (LNGDPPC) to stabilize variance.

The data were analyzed using the Panel Autoregressive Distributed Lag (Panel ARDL) model with Pooled Mean Group (PMG) and Mean Group (MG) estimators developed by Pesaran, Shin, and Smith (1999), processed in EViews with Stata used for robustness checks. The choice of Panel ARDL is based on the unit root test results, which reveal a mixed order of integration, with global competitiveness and GDP per capita found to be I(1) while exchange rate volatility is I(0), so that neither the Vector Autoregressive nor the Vector Error Correction Model can be applied, as both require a uniform order of integration (Pesaran et al., 2001). The general Panel ARDL (p, q) model is specified as follows.

$$Y_{\mathrm{it}} = \alpha_{\mathrm{i}} + \Sigma\lambda_{\mathrm{ik}} Y_{\mathrm{i,\,t-k}} + \Sigma\delta'_{\mathrm{ik}} X_{\mathrm{i,\,t-k}} + \varepsilon_{\mathrm{it}} \quad (1)$$

where Y_{it} denotes the dependent variable for country i in period t, X_{it} denotes the vector of independent variables, α_{i} denotes the country-specific intercept, and p, q denotes the optimal lag length, which the AIC, SC, HQ, and FPE criteria consistently select as lag 1 in this study. This equation is reparameterized into the Error Correction Model form as follows.

$$\Delta Y_{\mathrm{it}} = \phi_{\mathrm{i}}[Y_{\mathrm{it-1}} - \theta'_{\mathrm{i}} X_{\mathrm{it}}] + \Sigma\lambda_{\mathrm{ik}} \Delta Y_{\mathrm{i,\,t-k}} + \Sigma\delta'_{\mathrm{ik}} \Delta X_{\mathrm{i,\,t-k}} + \mu_{\mathrm{i}} + \varepsilon_{\mathrm{it}} \quad (2)$$

where ϕ_{i} is the Error Correction Term coefficient, which must be negative and significant as a condition for cointegration, $[Y_{\mathrm{it-1}} - \theta'_{\mathrm{i}} X_{\mathrm{it}}]$ represents the deviation from long-run equilibrium, and λ_{ik} and δ'_{ik} denote the short-run coefficients. This study estimates three equations in turn so that the direction of the causal relationship can be analyzed comprehensively: global competitiveness (GII) as the dependent variable with GDP per capita (LNGDPPC) and exchange rate volatility (REER_VOL) as independent variables; GDP per capita as the dependent variable with GII and REER_VOL as independent variables; and exchange rate volatility as the dependent variable with GII and LNGDPPC as independent variables.

Prior to Panel ARDL estimation, this study conducted a Cross-Section Dependence test using the CD, CDw, CDw+, and CD* statistics (Pesaran, 2015, 2020, 2021; Fan & Liao, 2015; Juodis & Reese, 2022; Pesaran & Xie, 2021), followed by first-generation unit root tests, namely Levin-Lin-Chu (Levin et al., 2002) and Im-Pesaran-Shin (Im et al., 2003) in EViews, and the second-generation Cross-sectionally Augmented IPS test (Pesaran, 2007) in Stata as a robustness check accommodating cross-section dependence. The choice of estimator, PMG or MG, for each equation was determined through the Hausman test, whose null hypothesis states that PMG is the more efficient estimator. The existence of a long-run relationship was tested through the Bounds Test (Pesaran et al., 2001), which remains valid under a mixed order of integration of I(0) and I(1). Short-run causality was tested using the Dumitrescu and Hurlin (2012) approach, which accommodates heterogeneity in causality coefficients across panel members, with the Z-bar tilde statistic used as the reference for panels with a short time dimension. As a final diagnostic step, residual normality was tested using the Jarque-

Bera statistic in EViews as well as the Skewness-Kurtosis and Shapiro-Wilk tests in Stata for comparison.

RESULTS

This study uses panel data from nine BRICS+ countries over the period 2012–2024, yielding 117 observations. Testing in Stata confirms that the data form a perfectly balanced panel with no missing values, satisfying the basic assumption of PMG estimation (Pesaran et al., 1999).

Table 2. Descriptive Statistics of the Research Variables

Statistic	Global Competitiveness (GII)	GDP per Capita (LNGDPPC)	Exchange Rate Volatility (REER_VOL)
Mean	36.241	9.971	3.700
Median	35.590	9.760	2.406
Maximum	56.300	11.230	24.954
Minimum	22.700	8.610	0.571
Std. Dev.	7.369	0.736	3.608
Skewness	0.819	0.390	2.849
Kurtosis	3.587	2.010	14.140
Jarque-Bera (Prob.)	14.766 (0.001)	7.746 (0.021)	763.185 (0.000)
Observations	117	117	117

Source: EViews and Stata output, processed by the authors (2026)

As shown in Table 2, global competitiveness has a mean of 36.24 with a range from 22.70 to 56.30, reflecting substantial variation in innovation capacity across BRICS+ countries. GDP per capita, expressed in natural logarithm form, has skewness and kurtosis values relatively close to a normal distribution, whereas exchange rate volatility shows a kurtosis of 14.14, indicating the presence of extreme observations during episodes of heightened volatility in certain countries and years.

Table 3. Summary of Panel Unit Root Tests

Variable	LLC Level	IPS Level	LLC 1st Diff.	IPS 1st Diff.	CIPS Level	CIPS 1st Diff.	Decision
Global Competitiveness (GII)	0.166	0.869	0.101	0.010	-1.575	-2.552	I(1)
GDP per Capita (LNGDPPC)	0.025	0.971	0.000	0.000	-1.581	-2.127	I(1)
Exchange Rate Volatility (REER_VOL)	0.000	0.000	0.172	0.000	-3.299	-4.758	I(0)

Source: EViews and Stata output, processed by the authors (2026). LLC and IPS values are p-values; CIPS values are test statistics compared against the 5% critical value in (Pesaran, 2007).

Prior to the unit root tests, the Cross-Section Dependence test using the CD, CDw, CDw+, and CD* statistics confirmed cross-country dependence for all three variables, consistent with the interconnection among BRICS+ economies through global trade and financial markets, so that the second-generation CIPS test was used as a complement. As shown in Table 3, global competitiveness and GDP per capita are non-stationary at level but stationary at first difference, and are therefore classified as I(1), while exchange rate volatility is stationary at level and is therefore classified as I(0). This mixed order of integration justifies the use of Panel ARDL with the PMG/MG estimators as the

only valid methodological framework (Pesaran et al., 1999, 2001). Optimal lag selection based on the AIC, SC, HQ, and FPE criteria consistently selected lag 1, so all estimations use the Panel ARDL (1,1,1) specification.

The cross-section Bounds Test results show variation in cointegration across countries, with a significant long-run relationship confirmed for one cross-section in the global competitiveness equation, two cross-sections in the GDP per capita equation, and three cross-sections in the exchange rate volatility equation, while the remaining units show insignificant or inconclusive results. The Hausman test was then used to select the final estimator for each equation. For the global competitiveness equation, the Hausman statistic of 9.821 ($p = 0.020$) is significant at the 5% level, so the Mean Group (MG) estimator was selected. For the GDP per capita equation, the variance-covariance matrix was not positive definite, so following Pesaran et al. (1999) the Pooled Mean Group (PMG) estimator was retained. For the exchange rate volatility equation, the Hausman statistic of 1.940 ($p = 0.585$) is not significant, so the PMG estimator was selected.

Table 4. Panel ARDL Estimation Results for Global Competitiveness (MG Estimator)

Component	Coefficient	Std. Error	t-Statistic	Prob.
Long Run				
LNGDPPC	-95.058	68.549	-1.387	0.169
REER_VOL	1.661	1.289	1.289	0.200
Constant	991.794	667.885	1.485	0.141
Short Run				
ECT (COINTEQ)	-0.518	0.155	-3.331	0.001
D(LNGDPPC)	13.937	8.170	1.706	0.091
D(REER_VOL)	0.109	0.144	0.756	0.451

Source: EViews output, processed by the authors (2026)

Table 5. Panel ARDL Estimation Results for GDP per Capita (PMG Estimator)

Component	Coefficient	Std. Error	t-Statistic	Prob.
Long Run				
GII	0.008	0.019	0.443	0.659
REER_VOL	-0.133	0.106	-1.259	0.208
Constant	10.637	0.179	59.458	0.000
Short Run				
ECT (COINTEQ)	-0.276	0.138	-1.999	0.048
D(GII)	0.006	0.013	0.477	0.441
D(REER_VOL)	-0.001	0.004	-0.440	0.662

Source: EViews output, processed by the authors (2026)

Table 6. Panel ARDL Estimation Results for Exchange Rate Volatility (PMG Estimator)

Component	Coefficient	Std. Error	t-Statistic	Prob.
Long Run				
GII	0.018	0.021	0.864	0.389
LNGDPPC	-1.119	0.271	-4.130	0.000
Constant	13.375	2.640	5.066	0.000
Short Run				
ECT (COINTEQ)	-0.853	0.122	-6.990	0.000
D(GII)	-0.391	0.283	-1.381	0.179
D(LNGDPPC)	-11.491	19.540	-0.588	0.568

Source: EViews output, processed by the authors (2026)

The estimation results presented in Tables 4-6 are based on the Error Correction Model specified in Equation (2), which is the reparameterized form of the general Panel ARDL model in Equation (1). Table 4 reports the estimation results for the global competitiveness equation using the Mean Group estimator. The long-run model is $GII_{it} = 991.794 - 95.058\ LNGDPPC_{it} + 1.661\ REER\_VOL_{it}$, and the short-run error correction model is $\Delta GII_{it} = -0.518\ ECT_{i,t-1} + 13.937\ \Delta LNGDPPC_{i,t-k} + 0.109\ \Delta REER\_VOL_{i,t-k} + \mu_i + \varepsilon_{it}$. Neither GDP per capita nor exchange rate volatility has a significant long-run effect on global competitiveness, while the short-run Error Correction Model, as specified in Equation (2), yields an Error Correction Term (ECT) of -0.518, which is significant at the 1% level. The indicates that approximately 51.8 percent of the deviation of global competitiveness from its long-run equilibrium is corrected within one year.

Table 5 reports the estimation results for the GDP per capita equation using the PMG estimator. The long-run model is $LNGDPPC_{it} = 10.637 + 0.008\ GII_{it} - 0.133\ REER\_VOL_{it}$. Neither global competitiveness nor exchange rate volatility has a significant long-run effect on GDP per capita, while the ECT of -0.276 is significant at the 5% level, indicating an adjustment speed of 27.6 percent per year, slower than in the other two equations.

Table 6 reports the estimation results for the exchange rate volatility equation using the PMG estimator. The long-run model is $REER\_VOL_{it} = 13.375 + 0.018\ GII_{it} - 1.119\ LNGDPPC_{it}$. Unlike the previous two equations, GDP per capita has a negative and significant effect on exchange rate volatility at the 1% level, while global competitiveness remains insignificant. This finding is the only significant long-run relationship in the entire system of equations. The ECT of -0.853, significant at the 1% level, represents the fastest adjustment speed among the three equations, with approximately 85.3 percent of the deviation corrected within one year.

Table 7. Dumitrescu-Hurlin Panel Granger Causality Test Results

Direction of Causality (H0)	Z-bar tilde	p-value	Decision
GII does not Granger-cause LNGDPPC	0.140	0.889	Fail to reject H0
LNGDPPC does not Granger-cause GII	-0.700	0.484	Fail to reject H0
GII does not Granger-cause REER_VOL	-0.754	0.451	Fail to reject H0
REER_VOL does not Granger-cause GII	-0.790	0.430	Fail to reject H0
LNGDPPC does not Granger-cause REER_VOL	-0.477	0.633	Fail to reject H0
REER_VOL does not Granger-cause LNGDPPC	-1.015	0.310	Fail to reject H0

Source: Stata output, processed by the authors (2026). Identical results were obtained in EViews.

Table 7 shows that all six directions of the Dumitrescu-Hurlin causality test fail to reject the null hypothesis at the 5% significance level, with p-values ranging from 0.310 to 0.889. This finding indicates the absence of short-run Granger causality across every pair of research variables, including the direction from GDP per capita to exchange rate volatility, which is nonetheless significant in the long run.

Table 8. Residual Normality Test Results (Jarque-Bera)

Equation	Estimator	Jarque-Bera	Prob.	Decision
Global Competitiveness as dependent	MG	2.362	0.307	Normal
GDP per Capita as dependent	PMG	58.803	0.000	Not normal
Exchange Rate Volatility as dependent	PMG	1202.500	0.000	Not normal

Source: EViews output, processed by the authors (2026)

As shown in Table 8, the residuals of the global competitiveness equation are normally distributed, supporting the validity of statistical inference for all of its coefficients, including the ECT. In contrast, the residuals of the GDP per capita and exchange rate volatility equations deviate from normality, mainly due to extreme observations in REER volatility for Russia in 2022 and volatility spikes in Brazil (2015), India (2016), and Egypt (2024).

DISCUSSION

The Effect of GDP per Capita and Exchange Rate Volatility on Global Competitiveness

The Mean Group estimation shows that neither GDP per capita nor exchange rate volatility has a significant long-run effect on global competitiveness across the nine BRICS+ countries over 2012–2024. This finding indicates that rising income does not automatically translate into greater innovation capacity, as innovation-based competitiveness is determined more by the quality of institutions, human capital, infrastructure, and the effectiveness of the national innovation system than by income level alone (Bate et al., 2023). This result is consistent with Alnafrah (2021), who found that the efficiency of national innovation systems differs significantly across BRICS countries, making generalization difficult. The lack of a significant effect of exchange rate volatility on global competitiveness further indicates that research and development investment decisions are strategic and long-term in nature, and are therefore not responsive to short-run exchange rate fluctuations, a result that contrasts with Wen and Usman (2024), whose study of China involved a far more homogeneous economic structure than BRICS+.

This finding is consistent with Porter's (1990) Diamond Model and the National Innovation Systems framework of Lundvall (1992) and Nelson (1993), both of which emphasize that competitiveness is formed through the interaction of institutions, industry, and policy rather than through income level alone. The Error Correction Term of -0.518, significant at the 1% level, confirms that even though the individual long-run relationships are not significant, an adjustment mechanism toward equilibrium still operates at the level of the overall system of equations.

The Effect of Global Competitiveness and Exchange Rate Volatility on GDP per Capita

The Pooled Mean Group estimation shows that global competitiveness has no significant long-run effect on GDP per capita, indicating that rising innovation capacity does not automatically raise per capita income, because the contribution of innovation to economic growth strongly depends on the effectiveness of the national innovation system and a country's capacity to commercialize innovation outcomes (Vlasova & Saprykina, 2024). This result appears to diverge from Romer's (1990) theoretical prediction that innovation drives growth, but it aligns with the argument that applying endogenous growth theory to a heterogeneous group such as BRICS+ requires additional institutional conditions that are not yet fully met. Lucas's (1988) human capital accumulation theory is also relevant here, as Lucas emphasizes labor quality and education as drivers of productivity rather than innovation scores alone.

Exchange rate volatility likewise shows no significant effect on GDP per capita, consistent with Solow's (1956) view that physical capital accumulation and technological progress are the primary determinants of long-run growth, rather than short-run monetary fluctuations. The ECT of -0.276, significant at the 5% level, indicates a relatively slow adjustment speed, reflecting the fact that GDP per capita is shaped by numerous structural factors and therefore adjusts gradually.

The Effect of Global Competitiveness and GDP per Capita on Exchange Rate Volatility

The PMG estimation shows that GDP per capita has a negative and significant effect on exchange rate volatility, while global competitiveness remains insignificant. This finding is the only significant

long-run relationship in the entire system of equations and therefore constitutes the study's main result. The negative effect of GDP per capita indicates that higher-income countries possess stronger economic fundamentals and are consequently better able to absorb external pressure on their currencies, consistent with the International Monetary Fund (2023) External Sector Report, which notes that stronger economic fundamentals help cushion external pressure, particularly in developing economies. This result is also consistent with Frenkel's (1976) Purchasing Power Parity theory and the Balassa-Samuelson effect (Balassa, 1964; Samuelson, 1964), which explain that countries with higher productivity and income tend to experience more stable and predictable real exchange rate movements.

The insignificant effect of global competitiveness on exchange rate volatility can be explained through Dornbusch's (1976) overshooting theory, which asserts that short-run exchange rate movements are driven more by monetary policy and financial market expectations than by real factors such as innovation capacity. Aghion et al. (2009) further explain that the relationship between exchange rates and productivity strongly depends on a country's level of financial development, so that in several BRICS+ members whose financial markets are not yet fully developed, the transmission from innovation to exchange rate stability becomes indirect and statistically difficult to detect. The ECT of -0.853, significant at the 1% level, represents the fastest adjustment speed among the three equations, suggesting that exchange rate stability is the outcome of a long-run development process rather than short-run policy intervention.

Causality and Short-Run versus Long-Run Effects

The Dumitrescu-Hurlin causality test finds no significant causal relationship among global competitiveness, GDP per capita, and exchange rate volatility at the 5% level across all six tested directions. This result does not contradict the Panel ARDL findings, which show that all three Error Correction Terms are negative and significant, because the two tests measure different dimensions, namely short-run predictive ability in the Dumitrescu-Hurlin test and the adjustment mechanism toward long-run equilibrium in Panel ARDL (Dumitrescu & Hurlin, 2012; Pesaran et al., 1999). This finding differs from Thi and Do (2024), who found a bidirectional relationship between innovation and economic growth across 71 countries, but is consistent with Pradhan et al. (2023), who emphasize that the effect of innovation on economic growth in developing countries strongly depends on institutional quality and governance.

The absence of short-run causality can be explained through the hysteresis theory of Baldwin and Krugman (1989), which shows that the effects of exchange rate fluctuations on real variables such as growth and innovation are often persistent and only become apparent over longer horizons rather than instantaneously within annual periods. By integrating Panel ARDL and the Dumitrescu-Hurlin causality test within a single analytical framework, this study provides evidence that the dynamics among global competitiveness, economic growth, and exchange rate stability in BRICS+ are shaped more by a gradual process of economic development than by short-run responses.

CONCLUSIONS

This study examined the causal relationships among global competitiveness, GDP per capita, and exchange rate volatility in BRICS+ countries. The results indicate that only GDP per capita has a significant long-run effect on exchange rate volatility, with higher income levels associated with greater currency stability. No other long-run or short-run relationships are supported by the data, suggesting that exchange rate stability is driven mainly by strong economic fundamentals rather than innovation capacity or short-term dynamics. However, the findings should be interpreted cautiously due to several limitations, including the relatively short observation period (2012–2024), the limited

sample of nine BRICS+ countries, country heterogeneity, and the use of single indicators to represent each construct.

Despite these limitations, the study contributes to the literature by analyzing global competitiveness, GDP per capita, and exchange rate volatility as an integrated system and by combining Panel ARDL and Dumitrescu–Hurlin causality methods to distinguish long-run adjustment from short-run causality. The findings imply that policies aimed at exchange rate stability should prioritize sustained income growth and stronger economic fundamentals rather than relying solely on innovation-driven strategies. Future research should extend the study period, include more BRICS+ economies, apply alternative indicators, and consider factors such as institutional quality, governance effectiveness, and financial market depth to better understand the links among competitiveness, economic development, and exchange rate stability.

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USE OF ARTIFICIAL INTELLIGENCE (AI)
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CONFLICT OF INTEREST
The authors declare no conflicts of interest.

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