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Foreign Exchange Reserves and Economic Growth of Brazil: A Nonlinear Approach

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ABSTRACT

The research **aims** to look at the linear and nonlinear causal relationships between Brazil's accumulated international reserves and economic growth from 1989 Q1 through 2021 Q4. For empirical investigation, this study employed **econometric procedures** such as the Augmented Dickey Fuller and Zivot-Andrews unit root tests, the linear Granger causality test, Johansen's cointegration test, the BDS test, and the nonlinear Granger causality test proposed by Hiemstra and Jones. The study **concluded** that there is a bidirectional linear and non-linear causality between foreign exchange reserve and economic growth. This study fills the gap in the literature by exploring the nonlinear relationship between international reserves and economic growth, while earlier studies primarily explored linear relationships. Foreign trade policymakers can utilize the model developed here to formulate applicable policies about foreign exchange reserves. Based on the findings, the study proposes that Brazil can accrue foreign reserves if surplus assets are invested in alternate sources such as economic infrastructure projects and regional infrastructure development.

Keywords: economic growth; foreign exchange reserves; Brazil; causality; nonlinear relationship; COVID-19

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INTRODUCTION

International reserves have been increased dramatically during the previous decade [1]. According to international trade theory, there is a relationship between international trade and economic growth. Previous researches revealed the evidences of a positive relationship between international reserve and economic growth. However they have confirmed the linear relationship between international reserves and economic growth [2, 3].

The majority of previous research has been confined to the use of linear models. The COVID-19 pandemic, financial crises, economic structures, changes in the economic environment, and regime transitions, on the other hand, can all create structural changes in the pattern of international reserves. This opens up the possibility of a nonlinear relationship between international reserves and economic growth. *Figure* depicts the temporal patterns of international reserves for the Brazilian economy. Previous research did not consider nonlinearity [4], no study has been published that sheds light on the nonlinear relationship between international reserves and economic growth.

The current analysis addresses a gap in the literature by examining the linear and nonlinear relationship between international reserves growth in the context of the Brazilian economy. In international financial economics, the relationship between international reserves and economic growth is seen as a critical problem. Previous research has disregarded the nonlinear behaviour that structural breaks can cause. In this study, both linear and nonlinear Granger causality tests are used to investigate the relationship between Brazil's international reserves and economic growth. In summary, this analysis depicts the Brazilian economy's linear and nonlinear relationship between international reserves and economic growth.

We examine linear and nonlinear causal relationships between Brazil's accumulated international reserves and economic growth from 1989 Q1 through 2021 Q4. This research contributes to the literature in different ways by analysing the interrelationship between international reserve and

economic growth in Brazil for the first time. The preliminary plan of Brazilian government for floating band creates havoc in the country amidst the election. Brazil's Economy Ministry is studying a target for the country's substantial foreign exchange reserves as inflation remains the top concern of voters ahead of a presidential election. Foreign reserve sales by the central bank help to contain the dollar's rise against the Brazilian real, easing inflationary pressures. The existence of such a plan surprised top-level technicians at the Economy Ministry of Brazil, who said there was no agreement on a target for reserves. A central bank criticized the idea and said that this would directly interfere with the exchange rate policy that is entirely the responsibility of the central bank. Therefore, this is very important to investigate in detail, the relationship between international reserves and economic growth. The study showed that there is a bidirectional linear and non-linear causality between foreign exchange reserve and economic growth. Foreign trade policymakers can utilize the model developed here to formulate applicable policies about foreign exchange reserves. Based on the findings, the study proposes that Brazil can accrue foreign reserves if surplus assets are invested in alternate sources such as economic infrastructure projects and regional infrastructure development.

The remainder of the paper is organised as follows: after this introduction section, section 2 includes a review of relevant literature, and section 3 describes the data description and research technique for this study. Section 4 summarises empirical findings and discusses them. Section 5 brings the research to a conclusion.

LITERATURE REVIEW

Existing literature on international reserves are mainly focused on the linear relationship between foreign exchange reserves and economic growth [5, 6]. The studies on the presence of a non-linear relationship have not been found. M.M.S. Malloy [1] sought to quantify the relative importance of alternative explanations for international reserves accumulation, as well as to develop a linear model of precautionary demand for international reserves, viewing it as self-insurance against costly output contractions caused by sudden stops and capital flight. The empirical test added two sets of variables to prior econometric definitions of international reserves. The first set of factors dealt with mercantilist motives, such as lagging export growth and deviations from predicted purchasing power parity (PPP). Using dummy variables, the second set of variables attempted to capture precautionary adjustment in the aftermath of an unexpected sudden-stop crisis. The study revealed that when the economy is vulnerable to unexpected event there is a high demand for international reserves as a form of self-insurance to avoid the costly liquidation of long-term projects.

In the Russian context, this study [7] examined the finance growth nexus using four variate VAR model. The employed oil prices and exchange rates in the study. The period of study was from 1999 to 2014. The results suggested the causality from econ. Growth to money supply and bank lending, which was related to the decrease in the amount of intervention in forex markets.

Whereas, [8] studied the need for international reserves in China, a typically planned economy. By including monetary disequilibrium, the study constructed an error correction model (ECM) in linear form for the demand for money as well as the need for international reserves. The recursive regression technique was used in the study to examine the stability of the dynamic demand for international reserves. It was observed that China's dynamic foreign exchange reserves held a steady link with the average inclination to import, exchange rates, and variability in the balance of payments. Domestic monetary disequilibrium was found to have a considerable and steady link (with a two-period lag) with the dynamic process of international reserves holdings. In the short term, changes in income had a negative impact on reserve holdings, however in the long run; close proportionality was retained between international reserve holdings and domestic income level.

In similar research [9] utilised a linear model to examine the demand for international reserves in the Indian setting from 1983 to 2005, using quarterly data. The variables employed in the study included imports/GDP, broad money/GDP, exchange rate volatility, and interest rate differential. The findings revealed that all of these variables had an impact on India's reserve

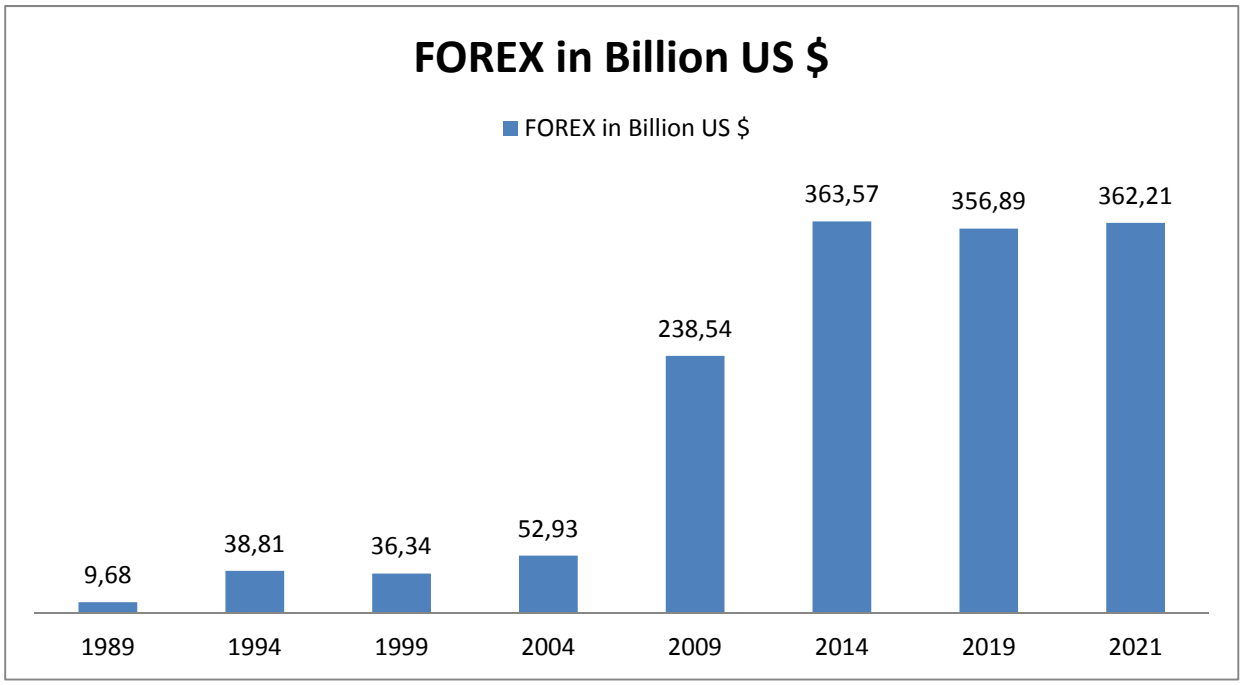

Fig. **Trends in International Reserves of Brazil Over Years**

Source: Prepared by the researchers based on data from World Development Indicators.

demand function. The researchers [10] examined Pakistan's reserves demand function from 1982Q1 to 2003Q2 using a cointegration approach and an error correction model. The analysis established a consistent long-term reserves demand in Pakistan. Pakistan's long-run reserves strategy seems to be influenced by international trade, balance-of-payments volatility, and the opportunity cost of retaining reserves.

C. Hiemstra and J.D. Jones [11] analyzed the impact of the accumulation of international reserves to economic growth in developing countries. The study used balanced panel data for China, Russia and Brazil and established the relationship between economic growth foreign exchange reserves by using method which includes the ONK with fixed individual effects. The results suggested that the rise in international reserves causes the economic growth, while causality has not been observed in the reversed direction. The study found that exchange rate depreciates which arises as a result of international reserves accumulation but it is not inflationary.

In twenty-four OECD nations [12] explored the probability of Granger causality between real exports and real GDP from 1960 to 1997. A panel data technique based on SUR systems and Wald tests with country-specific bootstrap critical values was used. The data collection included yearly measurements for 24 OECD nations. The study's goal was to look for Granger causality between real exports and real GDP in a bivariate framework. The research found a unidirectional causality from exports to GDP in Belgium, Denmark, Iceland, Ireland, Italy, New Zealand, Spain, and Sweden; unidirectional causality from GDP to exports in Austria, France, Greece, Japan, Mexico, Norway, and Portugal; bidirectional causality between exports and growth in Canada, Finland, and the Netherlands, and no evidence of causality between these variables in Australia, Korea, Luxembourg, Switzerland, the United Kingdom, and the United States.

However, several researchers [5, 13] examined both linear and non-linear relationships between variables. L. Konya [12] used data from 1975/2009 and 1980/2009 to analyse both linear and nonlinear correlations between exchange rate volatility and import flows in the United States and Malaysia. The linear relationship was assessed using the bound test technique, while the nonlinear relationship was tested using nonlinear causality proposed by Hiemstra and Jones. The empirical findings revealed that there is no co-integration between exchange rate volatility and imports in both Malaysia and the

United States. The link between exchange rates and import flows was nonlinear. In comparison to the linear connection, this study showed that a change in exchange rate volatility would have a bigger influence on import flows.

In the ASEAN-5 economies [5] examined the relationship between export and economic growth for a period from 1953 to 2008. The approach used in the study was both linear and nonlinear. The study used the nonparametric unit root test of Augmented Dickey-Fuller and Breitung, the Johansen cointegration test, the Hiemstra and Jones nonlinearity test, the Diks and Panchenko nonparametric test, and the BDS test. To determine the direction of causation between export growth and economic growth, a typical linear vector autoregressive model was utilized. The research found a linear and nonlinear association between export growth and economic growth in Malaysia, Thailand, Indonesia, and Singapore, but no linear or nonlinear relationship was observed in the Philippines.

DATA SOURCE AND METHODOLOGY

Data

The study makes use of quarterly data ranging from 1989Q1 through 2021Q4. The data is measured in billions of US dollars. The dependent variable in this study is international reserves minus gold. The concept of international reserves proposed by International Financial Statistics is used in this study. International reserves are made up of gold, the monetary authority›s foreign currency deposits, the IMF›s reserve position, and special drawing rights [14]. Furthermore, gold is omitted since it is little when compared to the other components of international reserves. Economic growth (Econ) is used as an independent variable which is measured in terms of real GDP. The data on real GDP and international reserve is collected from world development indicators of World Bank.

Linear Granger Causality Test

The bivariate Granger Causality test can be used to investigate a link between two variables. The test presumes that the present value of one variable is connected to previous values of that variable as well as another variable. The vector autoregression (VAR) model provided was employed in the study based on the Granger Causality test.

Following is the bivariate VAR model:

$$\Delta IR_t = \alpha_1 + \sum_{i=1}^{k} \beta_{1i} \Delta Econ_{t-i} + \sum_{j=1}^{k} \gamma_{1j} \Delta IR_{t-j} + \mu_t, \quad (1)$$

$$\Delta Econ_t = \alpha_2 + \sum_{i=1}^{k} \beta_{2i} \Delta IR_{t-i} + \sum_{j=1}^{k} \gamma_{2j} \Delta Econ_{t-j} + \mu_t', \quad (2)$$

where α_1 and α_2 are intercept terms, IR is international reserves, *Econ* is economic growth, β and γ are estimated coefficients, and *k* is the order of lag chosen using the Akaike Information Criteria. The null hypothesis for the aforementioned models is that *IR* does not Granger cause *Econ* in Eq. (1) and Econ does not Granger cause *IR* in Eq. (2). Furthermore, the Wald test was used to investigate the joint hypothesis of $\beta_{1i} = 0$ and $\gamma_{2j} = 0$. Furthermore, the Augmented Dickey-Fuller tests wasutilised in the study to determine whether or not the variables are stationary. The E. Zivot and D. W. Andrews unit root test is also used to determine endogenous structural breaks [6].

Hiemstra and Jones Nonlinear Granger's Causality Test

A nonlinear Granger causality test was proposed by C. Hiemstra and J.D. Jones [11]. It is founded on nonparametric estimators of temporal relationships within and between time series. When using a linear technique, such as the Granger causality test, there is an issue with identifying a nonlinear causal link [3, 14]. M. Kashif et al. [14] modified a version of the E. Baek and W. Brock [15] test, which varies from the linear causality test developed by C.W. Granger [16].

Let F ($Xt|l_{t-1}$) indicate the conditional probability distribution of X_t given the information set L_{t-1}, which consists of a l_x — length lag vector of X_t and a L_y — length lag vector of Y_t. *Y* is said to not Granger-cause *X* if the vector of previous *Y*-values is removed from the information set and the distribution of current *X*-values is unaffected. As a result, C. Hiemstra and J.D. Jones' [11] null hypothesis may be phrased as follows:

$$H_0 : F\left(X_t \setminus l_{t-1} = F(X_t \setminus l_{t-1} - Y_{t-ly}^{ly}\right), \quad (3)$$

where Y_{t-ly}^{ly} represents the $t - l_y$ — length lagged vector of Y and

$$Y_{t-ly}^{ly} = (Y_{t-ly}, Y_{t-ly+1}, \ldots\ldots, Y_{t-1}).$$

The null hypothesis given in equation (3) implies that for all $\epsilon > 0$

$$P\left(\| X_t^n - X_s^n \| < \epsilon \,|\, \| X_{t-lx}^{lx} - X_{s-lx}^{lx} \| < \epsilon, \| Y_{t-ly}^{ly} - Y_{s-ly}^{ly} \| < \epsilon\right) = \\ = P\left(\| X_t^n - X_s^n \| < \epsilon \,|\, \| X_{t-lx}^{lx} - X_{s-lx}^{lx} \| < \epsilon\right), \quad (4)$$

where $P(A|B)$ denotes the conditional probability of A provided B and $\|...\|$ represents thesupremum norm. Equation (4) states that in addition to the lagged Ly-length lagged vector of $Y_t$being ϵ-closed, the conditional probability that two arbitrary n — length lagged vectors of X_t are within distance ϵ, given that the lagged L_x — length lagged vector of X_t is ϵ-closed, will be the same. Moreover, C. Hiemstra and J.D. Jones [11] showed that T-statistics follow normal distribution under equation (3) which is:

$$T_{statistics} = \sqrt{q}\left[\frac{C_1\left(n+L_x, L_y, \epsilon\right)}{C_2\left(L_x, L_y, \epsilon\right)} - \frac{C_3\left(n+L_x, \epsilon\right)}{C_4\left(L_x, \epsilon\right)}\right] \sim Q\left(0, \sigma^2, n, L_x, L_y, \epsilon\right). \quad (5)$$

Here

$$C_1\left(n+L_x, L_y, \epsilon\right) = \\ = P\left(\| X_{t-lx}^{n+lx} - X_{s-lx}^{n+lx} \| < \epsilon, \| Y_{t-ly}^{ly} - Y_{s-ly}^{ly} \| < \epsilon\right),$$

$$C_2\left(L_x, L_y, \epsilon\right) = \\ = P\left(\| X_{t-lx}^{lx} - X_{s-lx}^{lx} \| < \epsilon, \| Y_{t-ly}^{ly} - Y_{s-ly}^{ly} \| < \epsilon\right),$$

$$C_3\left(n+L_x, \epsilon\right) = P(\| X_{t-lx}^{n+lx} - X_{s-lx}^{n+lx} \| < \epsilon),$$

$$C_4\left(L_x, \epsilon\right) = P\left(\| X_{t-lx}^{lx} - X_{s-lx}^{lx} \| < \epsilon\right).$$

RESULTS AND DISCUSSION

Descriptive Statistics

Since the data for the variables under investigation may be influenced by seasonal influences. As a result, the study employed the XII adjustment procedure created by the United States Bureau of the Census in 1965 to defer seasonal effects and acquire descriptive statistics. *Table 1* displays the relevant descriptive statistics for the variables under investigation. The average international reserves (IR) are 99.25 billion US dollars, with a standard deviation of 121.26, a maximum of 374.63 billion US dollars, and a minimum of 4.52 billion US dollars. The average economic growth is 245.78 billion US dollars, with a standard deviation of 183.89, a maximum of 662.83 billion US dollars, and a minimum of 51.08 billion US dollars.

Unit Root Tests

Before doing the Granger causality test, the study used the Augmented Dickey-Fuller (ADF) and Zivot-Andrews (ZA) unit root tests to examine the stationarity of the variables. The ZA unit root test is used in the study to allow for an endogenous structural break. The variables' ADF and ZA unit root test statistics are shown in *Table 2*. The outcomes of both exams are comparable. The ADF test t–statistics for IR variable at the level and first difference are –0.95 and –6.75, respectively, while the ZA test t–statistics are –3.89 with a structural break period of 1998Q3 and –4.95 with a structural break period of 2006Q3. In the same sequence, the ECON variables are –1.58, —5.37, and –3.48 with a structural break period of 2000Q2 and –5.36 with a structural break period of 2009Q2. The unit root null hypotheses for both variables cannot be rejected at the level, but they may be rejected at the first difference. This demonstrates that the variables are I (1), i.e., of order one integration. As a result, the Granger causality test is used in the study.

Bivariate Vector Autoregressive (VAR) Model

Based on the Granger causality test, the VAR is used, although Engle and Granger [17] proved that a VAR in first differences will not be specified adequately if the variables are co-integrated. A multivariate time series representation with an invertible moving average would no longer be available for the differenced system. As a result, before using the VAR model, it is necessary to determine if the non-stationary variables are co-integrated [18, 19].

If the variables are non-stationary but co-integrated, an error-correction model should be used instead of the VAR model. The study utilizes maximum likelihood rank tests [20, 21] to examine

Table 1

Descriptive Statistics

Descriptive Statistics	IR	Econ
Mean	99.251	245.78
Median	44.05	165.68
Maximum	374.63	662.83
Minimum	4.52	51.08
Std. Dev.	121.26	183.89
Observations	132	132

Source: Authors' calculation based on data analysis.

Table 2

Unit Root Tests Results

ADF test			ZA test			
Variables	Level	1st difference	Level	Break period	1st difference	Break period
LnIRt	−0.95	−6.75*	−3.89	1998Q3	−4.95**	2006Q3
LnEcont	−1.58	−5.37*	−3.48	2000Q2	−5.36**	2009Q2

Source: Authors' calculation based on data analysis; * and ** denotes rejection of null hypothesis at 1% and 5% significance level respectively.

the long-term equilibrium relationship between the variables. The test results reveal that there is no co-integration. Because the variables are not co-integrated, a vector autoregressive (VAR) model looks to be feasible. A bivariate VAR model was specified in equations 1 and 2 in section 3.2 of this study. The lag is chosen based on the Akaike information criterion, which is lag five.

Granger Causality Test

The vector autoregressive (VAR) model between international reserves and economic growth was conducted and Granger causality was tested. For this purpose, two Granger null hypotheses have been tested. First is that international reserves don't Granger cause economic growth (IR⇏ECON) and second is that economic growth doesn't Granger cause international reserves (ECON⇏IR). The results of theGranger causality test are provided in *Table 3*. It reveals that calculated F-values for null hypotheses IR⇏ECON and ECON⇏IR are 11.37 with a p-value of 0.05 and 19.47 with a p-value of0.00 respectively. Thus, the hypothesis IR⇏ECON can be rejected at a 5 per cent level whereas ECON⇏IR can be rejected at a 1 per cent level. Based on these findings, it is possible to conclude that there is a bidirectional causal link between Brazil›s international reserves and economic growth. These findings are consistent with earlier research [22]. In addition, if the relationship between these variables is nonlinear, using a linear model will result in estimate bias. As a result, the work addresses the issue of nonlinearity.

BDS Test

To address the issue of nonlinearity, the BDS test described by Brock et al. (1987) was used for the VAR model residuals. This test assists in the verification of the assumption of identically and independently distributed error terms (i.i.d.). If the i.i.d.

Table 3

Granger Causality Test Results

Null Hypothesis	F-Statistics	P-value
IR⇏ECON ECON⇏IR	11.37# 19.47*	(0.05) (0.00)

Source: Author's calculation.

Notes: 1. Lag selection based on AIC, optimum lag = 5.2. * and # denotes rejection of null hypothesis at 1% and 5% significance level respectively. 3. The null hypothesis IR⇏ECON means international reserves don't cause economic growth.

Table 4

BDS Test Results

Standard deviation	Dimension	LnEcont	P-value
0.5	2	6.08*	0.00
0.5	3	7.45*	0.00
0.5	4	8.39*	0.00

Source: Author's calculation.

Notes: * denotes rejection of null hypothesis at 1% significance level.

Table 5

Nonlinear Causality Test Results

H0: *IR ⇏ Econ*			H0: *Econ ⇏ IR*		
Lx = Ly	**CS**	**TS**	***Lx = Ly***	**CS**	**TS**
3	0.20	2.03*	4	−1.26	−11.86
4	0.38	3.97*	5	−1.22	−12.27
5	0.54	5.69*	6	−2.31	−21.49
6	0.97	10.11*	7	−9.29	−94.78
7	5.77	59.39*	8	11.85	124.01*

Source: Author's calculation.

Notes: 1. $L_x = L_y$ denotes the number of lags on the residuals series. 2. CS is the difference value between two conditional probabilities while TS is the standardized test statistics. 3. Calculated t-statistics (TS) are compared with the critical values presented in [21]. 4. * indicates rejection of null hypothesis at 1% significance level.

assumption is violated, it is possible to conclude that the variables have a nonlinear relationship. As a result, a nonlinear causality test, rather than a linear Granger causality test, would be more suitable. *Table 4* shows the BDS test findings for the Brazilian economic growth (ECON) series. The findings indicate that, regardless of the dimensions, the null hypothesis of i.i.d. can be rejected at a 1% level of significance. This implies that there is nonlinearity in the residuals and that applying a linear model would be incorrect. As a result, the study employs the nonlinear causality test.

Nonlinear Causality Test

The nonlinear causality test was used in the study, as recommended by Hiemstra and Jones [23]. *Table 5* shows the outcomes of this study. The results reveal that nonlinear Granger causality running from international reserves to economic growth exists at lag orders of 3, 4, 5, 6, and 7, but only at lag order 8 does the same running from economic growth to international reserves. As a result, a nonlinear causal link running in both directions can be recognised. As a result, it is possible to conclude that there is a bidirectional nonlinear causal link

between international reserves and Brazilian economic development.

CONCLUSION & IMPLICATIONS

This research looked at the impact of the international reserves on economic growth, with a focus on the Brazilian economy. In international financial economics, the link between foreign reserves and economic growth is seen as a critical problem. The current study looked at the link between international reserves and economic growth from both a linear and nonlinear perspective.

The majority of previous research has been confined to the use of linear models. The COVID-19 outbreak, financial crises, economic structures, changes in the economic environment, and regime transitions can create structural changes in the pattern of international reserves. This opens up the possibility of a nonlinear link between international reserves and economic development. Authors in this study attempt to fill the gap in the literature by exploring the nonlinear relationship between international reserves and economic growth, while earlier studies primarily explored linear relationships. Foreign trade policymakers can utilize the model developed here to formulate applicable policies about foreign exchange reserves. Based on the findings, the study proposes that Brazil can accrue foreign reserves if surplus assets are invested in alternate sources such as economic infrastructure projects and regional infrastructure development.

For analytical objectives, time series quarterly data from 1989Q1 to 2021Q4 were employed in the study. The dependent variable is international reserves minus gold (IR), whereas the independent variable is economic growth (Econ). To investigate the link between the two, the researchers used a bivariate vector autoregressive (VAR) model-based Granger causality method.

The Augmented Dickey-Fuller test was performed to determine the variables' stationarity. The Zivot-Andrews unit root test is also used to determine endogenous structural breaks. To circumvent the problem of limited power of identifying a causal link, the nonlinear causality test based on nonparametric estimators of temporal relationships inside and across time series was also applied.

The study used the X11 adjustment programme proposed by the U.S. Bureau of the Census 1965 in order to retard the seasonal factors. The Augmented Dickey-Fuller (ADF) and Zivot-Andrews (ZA) unit root tests suggested that both the variables are I (1), i.e., integrated of order one. The maximum likelihood rank test did not show any co-integration between the variables that's why the study employed a vector autoregressive (VAR) model at lag five. The results of the Granger causality test concluded that there is a bidirectional causal relationship between international reserves and economic growth for Brazil.

These tests indicated a nonlinear causal link that ran in both directions. In other words, the study discovered a bidirectional nonlinear causal link between international reserves and economic growth in Brazil.

Based on these findings, the study recommends that foreign exchange reserves management policies be written in such a way that a significant portion of these reserves are set aside for the purpose of investment because increased foreign exchange reserves can reduce consumption while increasing investment and economic growth.

REFERENCES

1. Malloy M. M. Factors influencing emerging market central banks' decision to intervene in foreign exchange markets. IMF Working Paper. 2013;(70). URL: https://www.imf.org/external/pubs/ft/wp/2013/wp1370.pdf
2. Hakim A. Estimating foreign exchange reserve adequacy. *International Research Journal of Business Studies*. 2013;6(1)63–72. DOI: 10.21632/irjbs.6.1.63–72
3. Nneka C.-A. External reserves: Causality effect of macroeconomic variables in Nigeria: 1980–2009. *Kuwait Chapter of the Arabian Journal of Business and Management Review*. 2012;12(1):14–27. (In Arab.)
4. Delatte A.-L., Fouquau J. The determinants of international reserves in the emerging countries: A nonlinear approach. *Applied Economics*. 2011;43(28):4179–4192. DOI: 0.1080/00036846.2010.489886

5. Lim S. Y., Ho C. M. Nonlinearity in ASEAN-5 export-led growth model: Empirical evidence from nonparametric approach. *Economic Modelling*. 2013;32:136–145. DOI: 10.1016/j.econmod.2013.01.044
6. Zivot E., Andrews D. W.K. Further evidence on the great crash, the oil-price shock, and the unit-root hypothesis. *Journal of Business & Economic Statistics*. 1992;10(3):251–270. DOI: 10.1080/07350015.1992.10509904
7. Ono S. Financial development and economic growth nexus in Russia. *Russian Journal of Economics*. 2017;3(3):321–332. DOI: 10.1016/j.ruje.2017.09.006
8. Ford J. L., Huang G. The demand for international reserves in China: An ECM model with domestic monetary disequilibrium. *Economica. New Series*. 1994;61(243):379–397. DOI: 10.2307/2554622
9. Prabheesh K. P., Malathy D., Madhumathi R. Demand for foreign exchange reserves in India: A co-integration approach. *South Asian Journal of Management*. 2007;14(2):36–46. URL: https://www.researchgate.net/publication/46446648_Demand_for_Foreign_Exchange_Reserves_in_India_A_Co-integration_Approach
10. Khan K., Ahmed E., Kazmi A. A. The demand for international reserves: A case study of Pakistan (with comments). *The Pakistan Development Review*. 2005;44(4):939–957. DOI: 10.30541/v44i4IIpp.939–957
11. Hiemstra C., Jones J. D. Testing for linear and nonlinear Granger causality in the stock price-volume relation. *The Journal of Finance*. 1994;49(5):1639–1664. DOI: 10.1111/j.1540–6261.1994.tb04776.x
12. Kónya L. Exports and growth: Granger causality analysis on OECD countries with a panel data approach. *Economic Modelling*. 2006;23(6):978–992. DOI: 10.1016/j.econmod.2006.04.008
13. Wong Y. S., Ho C. M., Dollery B. Impact of exchange rate volatility on import flows: The case of Malaysia and the United States. *Applied Financial Economics*. 2012;22(24):2027–2034. DOI: 10.1080/09603107.2012.697120
14. Kashif M., Sridharan P., Thiyagarajan S. Factors affecting international reserves with special reference to India. *Vision: The Journal of Business Perspective*. 2017;21(4):339–349. DOI: 10.1177/0972262917733
15. Baek E., Brock W. A general test for nonlinear Granger causality: Bivariate model. 1992. URL: https://users.ssc.wisc.edu/~wbrock/Baek%20Brock%20Granger.pdf
16. Granger C. W.J. Investigating causal relations by econometric models and cross-spectral methods. *Econometrica*. 1969;37(3):424–438. DOI: 10.2307/1912791
17. Engle R. F., Granger C. W.J. Co-integration and error correction: representation, estimation, and testing. *Econometrica*. 1987;55(2):251–276. DOI: 10.2307/1913236
18. Singhal N., Goyal S., Singhal T. Insurance-growth nexus: Empirical evidence from emerging Asian markets. *Transnational Corporations Review*. 2020;12(3):237–249. DOI: 10.1080/19186444.2020.1756170
19. Singhal N., Goyal S., Singhal T. The relationship between insurance and economic growth in Asian countries: A regional perspective. *Macroeconomics and Finance in Emerging Market Economies*. 2022;15(3):301–322. DOI: 10.1080/17520843.2021.1957599
20. Johansen S. Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. *Econometrica*. 1991;59(6):1551–1580. DOI: 10.2307/2938278
21. Johansen S., Juselius K. Maximum likelihood estimation and inference on cointegration — with applications to the demand for money. *Oxford Bulletin of Economics and Statistics*. 1990;52(2):169–210. DOI: 10.1111/j.1468–0084.1990.mp52002003.x
22. Fukuda S. I., Kon Y. Macroeconomic impacts of foreign exchange reserve accumulation: Theory and international evidence. ADBI Working Paper Series. 2010;(197). URL: https://www.adb.org/sites/default/files/publication/156052/adbi-wp197.pdf
23. Krušković B. D., Maričić T. Empirical analysis of the impact of foreign exchange reserves to economic growth in emerging economics. *Applied Economics and Finance*. 2015;2(1):102–109. DOI: 10.11114/aef.v2i1.653

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M. Kashif — defined the research problem, objectives of the study and developed the conceptual framework of the study.
N. Singhal — analyzed the literature, collected the data and conducted the analysis and she is the corresponding author.
S. Goyal — wrote the conclusions of the research and implication of the study. She also did revision of paper.
S. K. Singh — compiled the tables, interpreted the result, discussed the results.

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