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A Bivariate Causality Between Brazilian Stock Prices and Foreign Exchange Rates: Evidence from Global Financial Crisis, 2007

Ghulam Ali, Sayyed Mahdi Ziaei and Melati Binti Ahmad Anwar

Faculty of Management and Human Resource Development,
Universiti Teknologi Malaysia, Johor Bahru, Malaysia

Abstract: In this study the impact of global crisis over intertwining between exchange rates and stock prices is examined in Brazil. Average nominal exchange with US Dollar and Bovespa stock exchange index on weekly basis covering the period from 5th May, 2003 to 6th September, 2011is used for analysis. Furthermore, data was divided into three sub-periods i.e., pre-crisis, crisis period and post-crisis period. Results of unit-root test revealed that data of both markets were found to non-stationery and integrated at order one. The Johansen cointegration test is applied to investigate the comovement of exchange rates and stock price during three sub-periods. The results show that no proof of cointegration is found during pre-crisis period but only single cointegration is found during and post crisis period. Thereafter, Granger causality test is applied which postulates that bilateral causality is found between exchange rates and stock prices in the pre-crisis period. It can be suggested with the help of results that both series are affected to each other in the short-run. During crisis and post-crisis periods suggested that stock prices are significantly Granger cause to exchange rates.

Key words: Brazil · Exchange rates · Stock prices · Stationarity · Cointegration · Causality

INTRODUCTION

Stock market and exchange rates are considered key indicators for the development of a country. It is theoretically believed that the movement of this couple of indicators is depending on each other. Presently, there is no consensus postulated about the relationship of these variables in financial literature. There are two groups of theorists that explain the movement of these variables. One group of theorists believes that movement of stock prices affects movement of the exchange rates and second group beliefs are opposing this point of view.

First theory was introduced by [1] and further supported by [2] which is known as Goods Market Approach. They believe that this process is initiated by a change in price of foreign exchange. They argue that when devaluation occurs in a currency that will cause the local currency to be cheaper in the international market and resultantly the local products of that country will also become cheaper. Therefore, if this country is export-dominate, then the demand for country products increases that leads to increase the profitability of firms in the result of higher exports and this process leads a positive change in the stock prices. In case of rise in exchange rates will react adversely. Hence, we can say that stock prices changes due to a change in exchange rate.

Portfolio Balance theory is established by [3] and introduced a model named as stock-oriented model. The rationale of this theory is that investors portfolio of investment are affected by the demand and supply forces of the market. The theory states that rising trend in the stock prices attracts the foreign investors for investment that leads to increase the demand for foreign exchange that push the exchange rates to become high. In the case of bearish trend in the stock market looses the attraction of international investors and they are completed to make an exit from the market through selling their portfolios. Resultantly, the demand for local currency will decrease and prices of local currency will decrease in the international foreign market. Therefore, according to this theory the relationship of the stock prices and exchange rate is found to be positive.

Corresponding Author: Ghulam Ali, Faculty of Management and Human Resource Development, Universiti Teknologi Malaysia, Johor Bahru, Malaysia.

Both theories present opposite views about the relationship of stock price and exchange rates. However, there is second way to look into this phenomenon of this relationship with empirical research. We indent to investigate this relationship in the Newly Industrialized Counties of the world with help of historical data. The focus of current research is the economy of Brazil which is included in the list of Newly Industrialized countries of the world. Our objective is to investigate that which theory has played the role in the development of Brazil.

Literature Review: As we observed that theoretical consensus is still solvable. In the same way, many empirical studies are conducted by different researcher using historical data of different economies. The mixed results are reported through empirical studies. As referred by [4] that stock prices are associated has three factors: firm-related factors, economic factors and market-oriented factors. This era of research is related with economic factors and it is started in seventies and probably the first study is conducted by [5]. They investigate the relationship of stock prices and exchange rates using the data of six countries and reports that relationship between such variables is not found. After thatAggarwal [6] examines the relationship of changes in dollar and stock prices using US markets monthly data covering the period from 1974 to 1978. He applies regression model for estimation and results reveal that association between these variables is found to be positive and further reports that interaction between such variable is proved to be stronger in short-term rather in long-term. A study is also established by [2] to explore the influence of group of factors including exchange rate on the stock prices. He used monthly data of nine developed markets such as Japan, Germany, Switzerland, Belgium, U.S. Canada and Netherlands and results suggest that depreciation in the countries reports positive relationship which is not statistically significant. It is further explained that inflationary trend is found to be adverse. Soenen and Hennigar [7] use monthly data to examine the relationship of effective exchange rates with stock prices from 1980 to 1986 by discovering negative and strong relationship between these variables.

Moreover, Bahmani-Oskooee and Sohrabian [8] apply cointegration and Granger causality tests to investigate the long-term comovement as well as the direction of relationship between stock prices and exchange rates. To measure these relationships, the data of S&P 500 index and effective exchange rates is used at monthly basis covering period from 1973-1988. In the short-run, a bidirectional causality relationship is found between the variable but it is reported that the long-term relation does not exist between the variables. Furthermore, a Portfolio Balance Model is applied by [9] to reveal that what factors determine the exchange rates. He uses bonds rates, money market rates and stock prices as the determinants and explains that stock prices is used as addition determinant in the model and impact of this determinant is found stronger comparing with bond rates and interest rates.

The Granger causality test is employed by [10] to investigate the relationship of exchange rate and price level changes while the changes occur in these variables using the data from Turkey. The data is found to be very sensitive regarding to lag selection; anyhow, he used different method for selection of lag-length. The data suggested that stock prices cause the affect over the foreign exchange and similarity in results is found in all different methods of lags. But there is no proof that exchange rates cause an affect over the price level changes. Another study is conducted by [11] conclude that abnormal stock returns get a very little effect of current changes in dollar while abnormal returns of stock prices are affected negatively by the lagged of the changes in dollar.

The majority of researchers focus the Asian emerging economies such as Abdalla and Murinde [12] reveal only unidirectional causality that moves from exchange rates to stock price using the data of Korea, India and Pakistan. As Ajayi, Friedman and Mehdian [13] uses the daily data of developed and emerging countries and investigates the causal relationship of exchange rate and stock market changes. The results postulate that evidence of unidirectional causality from stock prices to exchange rates is found in the developed countries, whereas, data of developing countries is not supportive to investigate causal relation between stock prices and currency rates. However, the results of six developed economies are supportive to prove the integration between stock markets and currency markets but mix results are found for emerging economies. Granger, Huang and Yang [14] uses Bivariate Granger causality test on the group of Asian economies and concludes mix results about causality between stock prices and exchange rates. But most of the markets favor the portfolio approach.

As noted by Nath and Samanta [15] that a new opportunity of research is created for researchers to examine the dynamic relationship between stock prices and exchange rates during Asian Financial crisis 1997.

Daily data of Indian stock market index and exchange rate is used from Mar 1993 to Nov 1995 and the results do not reveal any relationship between both markets during this period. Primarily, researchers used regression analysis to examine the impact of exchange rate over the stock prices. Later on cointegration tests are used by the researchers through applying VAR methodology. A study is conducted by [16] using cointegration test and Granger Causality tests to explore the interrelation between stock prices and exchange rates. The data of Asia pacific countries is used for the period of approximately of nine years and conclude that stock markets and exchange rates are interacting positively in the real terms and the US equity market has intermediary role to maintain this relation.

Pan, Fok and Liu [17] use the daily data of East Asian economies from 1988-1998 to explore dynamic reactions of stock prices and exchange rates and the mix results are found regarding to causality. However, a causal relation is looking to move from exchange rate towards stock prices during the crisis period but Malaysia is not shown this relation. Pavlova and Rigobon [18] suggest that relationship of stock market and exchange rate are not constant but it is based on supply and demand forces. They argue that the effect of demand force is double as compared to supply force while determining the behavior of exchange rates and asset prices.

Zhao [19] uses vector autoregression model to investigate relationship of stock prices and foreign exchange rates in China. He reports that he cannot find the relation of stock prices and exchange rates. Singh [20] examine the interrelationship of Bombay Stock Exchange (BSE) with three variable including exchange rates. He reports that exchange rate does not cause any change in the Indian stock markets. It is reported by Jiranyakul [21] by applying cointegration test that Thai stock exchange is not in equilibrium with exchange rates on the long-term basis. By running non-causality test, he finds that a positive bidirectional causality between stock prices with nominal effective exchange rates. Katechos [22] investigate the relationship of stock returns with exchange rate by using data of important global market and dividing currencies into three categories. He reveals that currencies holding low interest rates are negatively related with global equity returns while the currencies holding high interest rates are positively related with global equity returns.

A recent study by [23] finds time-varying relation between FTSE eTX all share index and FTSE Eurotop 300 by using high frequency data. This study is conducted by using data of different sectors indices of Indian stock exchange and exchange rates. Results reveal that exchange rate concurrently interacts to all sectors indices [24]. An investigation conducted by [25] cannot find cointegration between Shanghai stock prices and exchange rate of Chinese Yuan with dollar. During the period of global crisis, no causality is found between both series. However, unidirectional causal impact is found from exchange rates to stock price in the post crisis period. Result reported by Wu *et al*., [26] revealed a stable and strong and long-term association between exchange rate and stock prices using data from Philippines. Similar results are reported by [27] in case of Turkish markets. Data of ten countries including Brazil that are trading with America was examined by [28] postulated that cointegration between exchange and stock prices are not found during and after the period of financial crisis. In order to causality, the study showed the mixed results.

Most of the recent studies were conduct only considering the data of an individual country. Considering this tendency, the author is instigated to conduct an individual study on Brazil that is very close to America in respect of trade and also one of newly industrial country of the global economy. Additionally, the second motivation of study is that relationship of exchange rate and stock prices is not be found to be stable by a battery of previous studies mentioned in the literature. Hence, the author realizes that the relation of both series be re-examined on regular basis if any major change happens in the world business cycle. The current study is attempting to examine causal relation between exchange rates and stock prices in Brazil by dividing data into three periods' i.e. pre-crisis, crisis and post crisis period. Results of the study are specifically useful for government policy makers as well as portfolio investors and international traders.

Data and Methodology: The weekly data for exchange rates and stock prices is collected from ECONSTAT database. The nominal exchange rates in the terms of US Dollar and stock index of Bovespa stock is used for analysis. Cointegration and causality tests are applied to examine the dynamic and causal relationship between exchange rates and stock prices. First of all, the stationarity of the data is confirmed through applying Augmented Dickey Fuller Test (ADF) and Philips Perron Test (PP) unit roots whether the test series are integrated at the same order e.g., level or first difference. If series are found to be stationary at the same level, the co-integration test developed by [29] and [30] is applied to measure the long-run movement between exchange rate and stock prices. According to VAR methodology,

The VAR methodology is used for Co-integration test which is explained as under:

$$\Delta Y_t = \lambda + \sum_{i=1}^{K} A_K Y_{t-1} + e \quad (1)$$

Here Y_i is co-integrating vector of I(1) variables, λ is a vector of constants and ε_1 is a vector of white noise residuals [31]. According to Johansen method, two test statistics are applied for cointegration: first is maximum eigenvalue test and second is trace statistics. The equations for these tests are presented in the following:

$$\lambda_{max}(r, r+1) = -T ln(1-\hat{\lambda}_{r+1})$$
$$\lambda_{trace}(r) = -T + \sum_{i=r+1}^{g} ln(1-\hat{\lambda}_i) \quad (2)$$

According to likelihood ratio statistics, first statistics is maximum eigenvalue statistics which states that null hypothesis of a r cointegration vectors are accurately in opposition to r + 1 alternative vectors. Second statistics is trace statistics which estimates that alternate hypothesis against at most r cointegrating vectors hypothesis. Critical value of maximum eigenvalue statistics and trace statistics are reported in paper written by [30].

Here, r means N cointegrating vectors in the null hypothesis and $\hat{\lambda}$ is the calculated value for *i*th ordered eigenvalue the π matrix. Initially, $\hat{\lambda}_i$ is bigger but more bigger with negative sign will be $\ln(1-\hat{\lambda}_i)$ and therefore, more bigger will be considered test statistic. Each eigenvalue is linked with different cointegrating vector which is the eigenvectors. A significant cointegrating vector is one having significant value other than zero. λ_{trace} is a combined test in which null hypothesis has many number of cointegrating vectors and those are less than or equal to r. Alternatively, these numbers are more than r. conversely, λ_{max} carries out individual tests for each eigenvalue and its null hypothesis is the number of cointegrating vectors is r and alternative of r + 1.

Granger [32] established causality test to measure the effect of one variable over the other. In this study, there are two variables, i.e., exchange rates denoted by E and stock prices denoted by S. The variable S Granger causes variable E if lag of variable S significantly influence the value of variable E and vice versa. This test can be presented in the following two regression equations:

$$s_t = \gamma_0 + \sum_{i=1}^{n} a_i E_{t-i} + \sum_{i=1}^{n} \beta_j S_{t-j} + \mu_{1t} \quad (3)$$

$$E_t = \gamma_1 + \sum_{i=1}^{m} \lambda_i E_{t-i} + \sum_{i=1}^{m} \delta_j S_{t-j} + \mu_{2t} \quad (4)$$

Here, S_t and E_i denotes stock price and exchange rates and t shows the time period. White noise errors which are mutually uncorrelated is presented u_{1t} and u_{2t}. Equation 3 demonstrates that the current value of S is explained by own lag as well as by the lag of E. In the same way, Equation 4 shows that the current value of E is explained by own lag as well as by the lag of S. The results through the analysis of above two equations are derived in three ways, *viz,* bilateral, unilateral or independent.

- Bilateral or feedback causality is found if coefficients of S and E are found different from zero and statistically significant in both regression equations.
- When the estimated coefficients of lag E as a group are statistically different from zero i.e., $\sum_{i=1}^{m} \delta_i \neq 0$ in Equation 3 and estimated coefficients of lag S as a group are not found different from zero i.e., $\sum_{i=1}^{m} \delta_i \neq 0$, it shows unilateral causality which means that only E is causing S $\sum_{i=1}^{n} a_i$.
- When the estimated coefficients of lag S as a group are not statistically different from zero i.e., $\sum_{i=1}^{n} a_i \neq 0$ in Equation 3 and estimated coefficients of lag S as a group are found different from zero i.e., $\sum_{i=1}^{m} \delta_i \neq 0$, it indentifies unilateral causality which means that only S is causing E.
- The series are said to be independent if the sets of both S and E coefficients are not found statistically significant.

Empirical Results: As suggested by [33], we examine the stationarity of both series under observation by using ADF and PP unit root tests at level and first difference. Table 1 presents the results of these tests. While looking

Table 1: Results of ADF and PP stationarity test

Sub-periods	ADF		PP	
Name of Series	Level	1st Difference	Level	1st Difference
Pre-crisis Period				
Forex	-0.003813	-10.76287*	0.005518	-12.67711*
Stock	-0.931639	-16.36565*	-0.909103	-16.31518*
During Crisis Period				
Forex	-0.313428	-8.369022*	NA	-7.018226*
Stock	-0.491153	-9.986801*	NA	-9.97215*
Post-crisis period				
Forex	-1.947878	-8.346207*	-1.921117	-8.369022*
Stock	-1.692513	-9.149089*	-1.718406	-9.163779*

*Significant at 1% critical value

Table 2: The results of the Johansen cointegration tests between stock prices and exchange rates

		λ Trace		λ Max	
Sub-periods	Null Hypothesis	Trace statistic	1% CV	Max-eigen statistic	1% CV
Pre-crisis period	None	6.36877	15.49	6.355421	14.6
	At most 1	3.841466	3.84	0.013349	3.84
Crisis Period	None	17.56872*	15.49	16.3473*	14.6
	At most 1	1.221388	3.84	1.221388	3.84
Post-crisis period	None	14.1812	15.49	9.442146	14.26
	At most 1	4.739053*	3.84	4.739053*	3.84

Note: Lag length of VAR is 6 during crisis period and post crisis and the lag length for pre-crisis periods is 2.

Table 3: Pairwise Granger Causality Tests

Sub-periods	Null Hypothesis	F-Statistic	P-Value
Pre-crisis period	Stock→Forex	15.2776	0.00000
	Forex→Stock	3.86506	0.02270
During Crisis period	Stock→Forex	6.47406	0.00270
	Forex→Stock	1.10611	0.33680
Post-crisis period	Stock→Forex	17.42680	0.00000
	Forex→Stock	1.60511	0.20800

into the results, we accept the null hypothesis. It means that series are not stationary at the level and having unit root. By applying unit root test at 1st difference, it is revealed that series have no unit root and these are integrated at I (1).

We applied Johansen cointegration test to investigate the cointegration relation between exchange rates and stock prices by dividing the data in three sub-periods i.e., before, after and during the global financial crisis. The result shown in Table-2 reveals that evidence of cointegration in both trace test and maximum Eigenvalue test was not found before the crisis period but during as well as after crisis periods one cointegration is found in the estimation.

To determine the direction of causality between the exchange rate and stock prices, the Granger causality test was used. The results of causality are shown in Table-3. It can be clearly derived from the results that two ways causality is found in the pre-crisis period which proves that both markets were not independent but they are affecting each other. We can say that both economic activities as well as capital flow movements were actively working in Brazil before the crisis periods. But during and after the crisis periods, only unidirectional causality is found which reveals that capital funds movement is only affecting the exchange rates.

Table 3 shows F-statistics with P-value which explains bivariate casual relationship of exchange rates and stock prices. The pre-crisis period proves bivariate causality between exchange rates and stock prices but the crisis period and post-crisis period shows that only stock prices affect the exchange rates. This result supports stock-oriented model which means that movement of stock market influence the exchange market.

Implications, Limitations and Future Directions: Results of the study can be used by monetary and fiscal policy makers at the government level alternatively the portfolio managers and investors in country like Brazil. International investors and trading are also can utilize these results while designing their investment and trading policies respectively. The study of a relationship between the both markets would be helpful to implement basic counteractive measures to escape from any future expected financial crisis.

Contemporaneously, private sector with some low degree of government assistance is leading to frame development strategies in Brazil. Therefore, this study is specially initialized for Brazil that is endeavoring to evade from global economic imbalance. For future research, this study will be extended to examine the relationship of both variables in a comparative way among Brazil, Russia, India and China (BRIC) countries. Recently, scant attention is given by researchers to study these variables in comparative way in BRIC countries because these countries are at a similar level of economic development and interaction of trade relation is going to increase in these countries. According to experts, the economy power of world developed economic is in progress to switching towards developing economies.

CONCLUSION

In this study the impact of global crisis over intertwining between exchange rates and stock prices is examined in Brazil. Average nominal exchange with US Dollar and Bovespa stock exchange index on weekly basis covering the period from 5th May, 2003 to 6th September, 2011 is used for analysis. Furthermore, data was divided into three sub-periods i.e., pre-crisis, crisis period and post-crisis period. Results of unit-root test revealed that data of both markets were found to non-stationery and integrated at order one. The Johansen cointegration test is applied to investigate the co-movement of exchange rates and stock price during three sub-periods. The results show that no proof of cointegration is found during pre-crisis period but only single cointegration is found during and post crisis period. Thereafter, Granger causality test is applied which postulates that bilateral causality is found between exchange rates and stock prices in the pre-crisis period. It can be suggested with the help of results that both series are affected to each other in the short-run. During crisis and post-crisis periods suggested that stock prices are significantly Granger cause to exchange rates. To some extent, results of the study are supportive to Goods Market Approach that believes that stock prices are influenced in response of fluctuation in forex market.

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