A study on the relationship of nominal exchange rates and stock prices: the case of Brazil

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Abstract

This work studied the relationship between stock prices and exchange rates (US dollar per unit of Brazilian real) in Brazil, both in the short- and long-run, with daily data from 2001 to 2018. While there was evidence of a positive relationship between the two variables in the short-run, a cointegration test found no statistical significance supporting such relation over the long-term. Further, a linear Granger causality was employed and provided evidence for the presence of bidirectional causality between the variables, hence supporting both exchange rates as the lead variable (traditional approach) and stock prices as the lead variable (portfolio balance approach).

Contents

1 Introduction

The nominal exchange rate is an indicator of the economic situation of a country, with its effect pertaining mostly to the balance of trade (BOT) (Dornbusch & Fischer, 1980). A currency depreciation leads to cheaper exports and more expensive imports, and it, therefore, has a positive impact on the BOT. Conversely, this variation in domestic money can negatively impact companies and individuals that rely substantially on imports. For currency appreciation, the opposite effects hold. As a result of these factors and multiple other drivers, exchange rates can have ambiguous effects on a country's economy, with this analysis focusing on its relationship and effect on a stock price index. The case where stock prices lead exchange rates is idem evaluated.

This paper will study the case of Brazil, where a floating exchange rate was adopted in January 1999 as an economic measure of the "Real Plan", after a period in which the Brazilian currency was pegged to the dollar to control the over 3000 yearly inflation rate. As Tabak (2006) notes, this was followed by a rapid depreciation of real and a strong increase of overall home stock value, contrasting with the stock devaluation evidence from Asian countries under the effect of the 1997-1998 Asian crisis.

In Brazil, the average performance of the 60 traded domestic stocks at the Sao Paulo Stock Exchange is measured by the BOVESPA index. This benchmark represents an important indicator for the state of the Brazilian economy, the motivation for its use in this paper. Further, the nominal exchange rate employed is displayed in units of US dollar per one Brazilian real. Effectively, the objective of this work is to investigate the following:

"Is there a significant relationship, in correlation terms, between the BOVESPA index and the US dollar/real exchange rate in the period of 2001 to 2018? Further, does causation exist between the variables?

The paper is not limited to bivariate analysis. Overall, it may complement other works that focus purely on econometric analysis rather than including control variables. Tabak (2006) studies the relationship between BOVESPA and nominal exchange rates in this manner. To a certain extent, Lin (2012) investigates the case of Asian countries controlling for interest rates and foreign reserves, but this is certainly not enough to resolve all prospective omitted variable bias. Furthermore, to bolster the external validity of the work, a brief sub-period review, through graphs and use of dummy variables, is considered to check for seasonal effects related to the two main variables.

In addition to the above-mentioned, the Augmented Dickey-Fuller test and the Engel-Granger Two-Step procedure are conducted to assess whether the two series are stationary and/or cointegrated, sighting the possible necessity of first-difference integration and the possible presence of a long-run relationship between the stock index and the exchange rate. Other tests are conducted for heteroskedasticity and autocorrelation evaluation. To choose the optimal regression model, the procedure of minimizing the Akaike Information Criteria (AIC) is employed. Further, a study on the causal relationship between the variables is assessed through a Granger causality test.

In the scientific sphere, this paper is the first to encompass such a large time framework as will be shown in the Data and Methodology sections, posing opportunities for new results that may contribute to research enhancement. The same applies to the incorporation of multiple control variables.

Alternatively, it can be viewed as a policy-relevant review, an additional instrument to build government measures that might deliver short- and long-term benefits to the population. On a microeconomic, investors can benefit from extra input to construct profitable portfolios while companies might be able to construct more efficient hedging strategies.

The rest of this research is organized as follows. Section 2 comprises a literature review, presenting evidence from several regions and results found. Section 3 is resumed to the Data. Section explains the Methodology adopted. Section 5 presents the results. Section 6 concludes and suggests points for future research.

2 Literature Review

Because the exchange rate is the most important economic factor after inflation and interest rates, multiple studies have previously evaluated the relationship between stock prices (or indexes) and exchange rates. These concentrated on different directions of impact, namely whether exchange rates drive stock prices, whether it is the opposite that holds, a combination of both (bi-causality), or evidence that no significant relationship exists. Additionally, distinctions with regards to regionality are important, meaning different results can be seen depending on the country for instance, therefore these will be briefly presented here.

2.1 Exchange rates driving stock prices as focus

Aggarwal (1981) found that the profitability of multinational companies is related to the exchange rate, hence their stock price is affected by a variation of this financial rate. Bartov and Bodnar (1994) concluded that only lags of the exchange rates, not the contemporaneous values, drives firms current stock returns.

Pan, Fok, and Liu (2007) investigated the case in eight Asian countries and derived that exchange rates significantly influence stock prices, except for Malaysia, from 1988 to 1996. They also studied the Asian crisis period, comprising 1997 and 1998, but no significant relationship was attained.

Ajayi and Mougoue (1996) evidenced that a currency devaluation leads stock prices to decrease in value both in the short- and long-run, using data from Japan, France, Germany, Italy, Japan, Canada, the Netherlands, the UK, and the USA. This is also ratified by Dimitrova (2005), who employed a multivariate model with results indicating that an exchange rate depreciation depresses the stock market on average.

Sui and Sun (2016) used the Chow test to find structural breaks in data from the BRICS countries (Brazil, Russia, India, China, and South Africa), aiming to investigate if sudden changes in the exchange rate would impact the stock prices and vice-versa. They found that spillover effects on the exchange rate produce a negative and significant impact on stock values, but the opposite does not hold. For China, this was only true for the period comprising the 2008-2009 crisis.

Wu (2000) studied the case of Singapore employing a vector error correction model (VECM), an econometric method where the lag of estimated residuals from the bivariate regression model is included as a control variable. It seeks to estimate the degree by which the stationary interest variables are cointegrated in the long run. The author evidenced that an appreciation of the Singaporean currency versus the US dollar and the Malaysian ringgit is associated with a stock market upward movement in the long term, while a depreciation against the Japanese yen and the Indonesian rupiah is responsible for equal effect during the most of 1990s. Versus the US dollar, the exchange rate has a reversal impact during the 1997-1998 crisis and the posterior recovery period of 1999-2000.

Mgammal (2012) reviewed the relationship between exchange rate and stock prices for two gulf countries, the Kingdom Saudi Arabia (KSA) and United Arab Emirate (UAE), using monthly data from January 2008 to December 2009 and applying linear regression jointly with the Pearson correlation method, which evaluates how strong is the relationship between two specified variables. It was found that a UAE's currency appreciation was associated with a negative impact on the stock market index in the short run. Concerning KSA, the driving effect of the exchange rate was positive, but the statistics for the short run were not significant.

Dahir, Mahat, Razak, and Bany-Ariffin (2017) applied the recently developed wavelet analysis to evaluate the relationship of the exchange rate and stock returns in the BRICS countries. The method used 64-128 days subperiods in the separated periods of 2008, 2010-2012, and 2012-2015. It was found that the exchange rate has a positive impact on stock returns for Brazil and Russia over the medium and long-run and a negative one in India; meanwhile, bidirectional causality is evidenced in South Africa and no significant relationship is observed in China.

Adjasi, Biekpe, and Osei (2011) used vector autoregressive models and vector error correction models to investigate how the relationship between exchange rate and stock prices is presented in 7 African countries. In Tunisia, it is found that cointegration is significant from a Likelihood ratio (LR) test, and therefore there exists a long-run relationship, where a currency depreciation is associated with bear markets. Additionally, sudden changes in the exchange rate, through an impulse response analysis, elicit a stock price increase in Ghana, Kenya, Mauritius, and Nigeria as opposed to a decrease occurring in Egypt and South Africa.

Harjito and McGowan (2007) applied Johansen cointegration and Granger causality tests on 1993-2002 data from Indonesia, the Philippines, Singapore, and Thailand. A significant long-run relationship existed between exchange rates and stock prices for the four countries, but no strong conclusive short-run association could be stated even though the result sign indicated the exchange rate as the lead variable.

Alagidede, Panagiotidis, and Zhang (2011) examined data from January 1992 to December 2005 referring to the UK, Canada, Switzerland, Japan, and Australia. No long-run relationship was found for exchange rates and stock prices, but causality from the former to the latter was observed for Canada, Switzerland, and the UK, in a robust analysis that employed three types of Granger causality tests. Non-linear causality was considered through the application of the Hiemstra-Jones method, resulting in stock prices and exchange rates being the lead variable in Japan and Switzerland, respectively.

2.2 Stock prices driving exchange rates as focus

There is also extensive literature supporting the portfolio-balance approach, where the stock prices are the drivers for exchange rate changes.

Richard, Simpson, and Evans (2007) explored the Australian context with daily data over a three-and-a-half-year period, using a VAR model with consideration for stationarity, heteroskedasticity, and other relevant analysis. The authors evidenced that an increase in overall Australian stock prices was followed by a strong appreciation of its currency. It held not only for the short-run but also for the long-run with a cointegration test.

Caporale, Hunter, and Ali (2014) focused on the period comprising the bank crisis of 2007-2010, applying impulse response analysis and UEDCC-AGARCH bivariate models to understand the volatility transmission structure. The regions researched were the US, the UK, Canada, Switzerland, Japan, and the euro area. In the US and the UK, stock returns changes granger caused exchange rate variation; meanwhile, Japan and the European Economic area experienced bidirectional causality. Canada's evidence supported exchange rates granger causing stock prices.

Granger, Huang, and Yang (2000) used data from the Asian flu period and apply unit root jointly with cointegration tests for stationarity and long-run relationship purposes, respectively. Their paper suggests that stock prices lead exchange rates in the Philippines, with an increase in the former being associated with a decrease in the latter. For South Korea, exchange rates lead stock prices. Further, feedback relations (bidirectional causality) are verified for Hong Kong, Malaysia, Singapore, Thailand, and Taiwan, while no significant causality is obtained for Japan.

Tasagkanos and Siriopoulos (2013) used a structural nonparametric cointegration regression method, where ordinary least-squares assumptions are not needed and advantages such as robustness to outliers or measurement errors are important. Data should be larger, and the authors met this using daily data from 2008 to 2012. The analysis involved USA and EU exchange rates, resulting in stock prices being the lead variable in the long-run for the European Economic Area and in the short-run for the US, respectively.

Hatemi-J and Irandoust (2002) studied the case of Sweden using a non-granger causality procedure and a VAR model. The result supported the portfolio balance approach, where stock prices drive exchange rates. A bull stock price moment was associated with an appreciation of the Swedish krona.

2.3 Bidirectional causality as focus

Bahmani-Oskooee and Sohrabian (1992) reviewed the relationship between the S&P 500 and US dollar effective exchange rate for the period from 1973 to 1988, evidencing bidirectional causality between the two variables in the short-run. The cointegration test showed no long-run relationship.

Smyth and Nanda (2003) investigated the relationship between the two variables for Bangladesh, Pakistan, India, and Sri Lanka using daily data from 1995 to 2001. Both Engel-Granger and Johansen cointegration tests were applied, and a significant long-run association between exchange rates and stock prices could be stated.

Aydemir and Demirhan (2009) studied the context for Turkey distinguishing the association of exchange rates with 5 stock price indices, namely national 100, services, financials, industrials, and technology. For all of them, they found significant bidirectional causality.

2.4 No relationship

Rahman and Uddin (2009) examined data for Bangladesh, India, and Pakistan, reviewing the relationship between each country's exchange rate versus the US dollar and the respective stock price index, namely Karachi Stock Exchange All Share Price Index, Bombay Stock Exchange Index, and Dhaka Stock Exchange General Index. Johansen's procedure and Granger causality tests respectively showed no long-run relationship and no causality between the two variables.

Solnik (1987) studied the context for Canada, France, Germany, Japan, Netherlands, Switzerland, U.K., and U.S.A. No significant relationship was found.

3 Data

3.1 Value of the BOVESPA Index and nominal exchange rate

The data comprises 4461 observations, with a period from 2nd January 2001 to 28th December 2018, and is extracted from the website Investing.com. It comprises the daily closing prices for the benchmark index of the most important Brazilian stocks and the nominal exchange rate for real, namely the number of dollars necessary to buy 1 unit of the Brazilian currency.

Figure 1 in appendix represents the average yearly performance of the BOVESPA in the 18 years comprising this research. It is observable the presence of exogenous shocks around the year 2010, which coincides with the delayed effects of the 2009 economic crisis. At that year, Brazil experienced a real GDP loss of 0.13 percent and the Sao Paulo Stock Exchange followed along with a slight devaluation. There seems to be a plateau in the valuation of BOVESPA until 2016, after a more pronounced loss in the two preceding years. It reflects the political turmoil in the South American country as an outcome of the impeachment of President Dilma Rousseff, a process completed on 31st August 2016, when the vice-president Michel Temer was proclaimed as the substitute.

Figure 2 in appendix presents a plot of the average exchange rate (units of dollar per real) for the same period. There seems to be a small devaluation of real against the dollar in 2009, definitely partially because of the 2009 economic crisis, followed by appreciations possibly because of Brazil's resistance to the disastrous results of the great recession, hence attracting investors and a considerable inflow of US dollars. From 2014 to 2015, we see a high devaluation of the Brazilian currency. The corruption accusations and the impeachment chaos itself were relevant drivers for this.

3.2 Interest Rates and foreign exchange reserves

I include other variables to conduct tests in a multivariate model. Because one of this work's aim is analyzing short-run fluctuations in both the exchange rate and stock index, I disregard models monthly and yearly models. This paper uses the 1-year spot interest rate, called Selic, and the foreign exchange reserves (in millions of USD), both reported daily. Inflation, industrial output, and GDP growth rate are not reported day by day and hence are excluded.

We get the data for both control variables from the website of the Central Bank from Brazil.

4 Methodology

4.1 Augmented Dickey-Fuller test for Stationarity

To test if the time series for stock index and exchange rate are stationary or not, the Augmented Dickey-Fuller (1981) test for unit roots is employed. For robustness, an intercept and a trend are used. The ADF model is given as follows:

$$Y_t - Y_{t-1} = \alpha + \beta t + \delta Y_{t-1} + \epsilon_t \tag{1}$$

The null hypothesis is δ=0 and it indicates that there is a unit root, meaning the specific series is non-stationary, which In other words indicates that the series does not simultaneously have constant mean, constant variance and constant autocovariance for each given lag. If the null is not rejected, a integration of order N is applied in such a way that the output series becomes stationary.

4.2 Breusch-Pagan test for Heteroskedasticity

To minimize a downward bias related to the value of t-statistics and an upward bias in the standard errors in tests for significance of coefficient estimators and, as a consequence, a higher probability to accept the null of no effect, it is relevant to test the data regarding possible heteroskedasticity. The following regressions are conducted:

$$Y_t = \alpha + \beta X_t + \epsilon_t \tag{2}$$

$$(\epsilon_t)^2 = \mu + \delta X_t \tag{3}$$

A regression of the squared residuals from equation (I) is conducted in the model (II) with X_t as an independent variable. The aim is to detect whether variance changes over time depending on the value of the regressor at that specific moment. If the coefficient estimator for X_t in (II) is significant, heteroskedasticity is present, and therefore it is necessary to use heteroskedastic-robust standard errors in model (I).

4.3 Durbin Watson test for Autocorrelation

To detect the presence of residual autocorrelation, the Durbin Watson test is conducted. The following equations describe its intuition:

$$Y_t = \alpha + \beta X_t + \epsilon_t \quad (4)$$

$$\epsilon_t = \mu + \delta \epsilon_{t-1} \quad (5)$$

The process entails estimating the residuals from the regression of Y_t on X_t and regressing its residuals on the first lag, then testing the significance of coefficient estimator δ. It is conducted through a two-sided test with the null hypothesis of no autocorrelation.

4.4 Engle-Granger Two-Step procedure for Cointegration

Besides analyzing the short-term relationship between the variables of interest, it is fundamental to understand their association over the long-term. For this verification, a requirement is that the variables or their transformations (like first-difference) are stationary. Afterward, the Engle-Granger Two-Step procedure (1987) can be applied to measure the degree of cointegration or long-run association between regressand and regressor. It entails analyzing the stationarity of the residuals from the bivariate regression. The following equations summarizes the method:

$$Y_t = \alpha + \beta X_t + \epsilon_t \quad (6)$$

$$\Delta\epsilon_t = \delta \Delta\epsilon_{t-1} \quad (7)$$

The process resembles the Augmented Dickey-Fuller (1981) test, but this time applied to the estimated residuals without both drift (constant) and trend factor time. The intuition is that the stationarity of the residuals would mean they converge to a specific mean value as time passes. For significance, critical values are modified in comparison with ADF ones.

If cointegration is present, it is relevant to use the lag of the residual as a control variable in multivariate regression, the so-called Vector Error Correction Model (VECM).

4.5 Lag selection and multivariate vector autoregression (VAR) model

The model's lag length selection for dependent and independent variables aims to minimize residual autocorrelation. In this paper, the method of minimizing the Akaike Information Criteria (AIC). Furthermore, white standard errors are applied in case the bivariate model presents heteroskedasticity, checked through the Breusch-Pagan test. If autocorrelation is also detected through the Durbin Watson procedure, Newey-West standard errors are employed. This is relevant for robustness against these two possible issues and guarantees better efficiency for the studied models as any standard error bias is minimized.

To reduce the omitted variable bias in the measurement of the effect of the exchange rate on the stock index value, control variables are used in a multivariate vector autoregression model. Listed dummies are set for days of the week; periods before, during, and after the impeachment of President Dilma Rousseff; January and December effects; and Great Recession of 2009. Two continuous daily variables are used as regressors, namely daily interest rates (taxa Selic) and foreign exchange reserves. Other possible drivers, such as inflation and industrial output, are not considered because daily data is not available for these variables. The same procedure is repeated for the effect of stock index value on the exchange rate.

4.6 Linear Granger Causality test

Granger causality (1969) tests differ from the t-tests used for coefficient estimator significance and the F-tests conducted to analyze the joint significance of several regressors. Specifically, stating that X granger-causes Y means that lags 1 to N of X are jointly significant predictors of the current value of Y. The value of N is subject to several debates. Among others described at Thornton & Batten (1985), this paper prioritizes residual autocorrelation, adopting the minimization of AIC to select the granger model lag length. The prospective models look as follows:

$$Y_t = \sum_{i=1}^{N} \beta_{t-i} X_{t-i} \quad (8)$$

Four cases are possible outcomes of a Granger causality analysis. If X granger-causes Y or vice-versa, unidirectional causality is present. In case X granger-causes Y and Y granger-causes X, bidirectional causality is present. Finally, the absence of Granger causality in both directions implies that X and Y are independent.

5 Empirical Results

5.1 Econometric tests

Table 1 (see appendix) presents the results for the Augmented Dickey-Fuller unit root test, which tests if the variables are stationarity.

The evidence elicits that both stock index price and nominal exchange rate are not stationary, hence a model with the pure variables would yield a spurious regression. This makes necessary two variable transformations, which can be defined by the following equations:

(I) Ratio Stock Index Return = (Stock Index Price – 1st lag Stock Index Price)/1st lag Stock Index Price

(II) Ratio Nominal Exchange Rate Variation = (Nominal Exchange Rate – 1st lag Nominal Exchange Rate)/1st lag Nominal Exchange Rate

The two new variables are stationary at the 1 percent significance level, as shown by the p-values in brackets in Table 1.

The Breusch-Pagan test verifies the possible presence of heteroskedasticity. Table 2 presents the results.

Considering the two possible specifications, when BOVESPA is the dependent variable and when the exchange rate assumes this position, it is verified that the null hypothesis of homoscedasticity is rejected at the 1 percent significance level for both cases. Because of this, it is fundamental to change the standard errors of the next session's regressions to account for their upward bias.

The next investigation analyzes if residuals are autocorrelated, which is tested by a two-sided Durbin Watson test with the null hypothesis of no autocorrelation. In this paper, for the 10 percent two-sided significance level, H0 is not rejected if the Durbin Watson d-statistic is larger than 1.898. If the value lies between 1.894 and 1.898, the test is inconclusive. For values lower than 1.894, there is statistical evidence for rejecting the null hypothesis of no autocorrelation, implying autocorrelation among regression errors.

Table 3 summarizes the results and shows the regressions present significant autocorrelation at the 10 percent level.

Because heteroskedasticity and autocorrelation are present in both regressions, it is fundamental to use Newey-West standard errors in the multivariate VAR model of the next session as they are robust to both issues.

Further, it is important to study whether the variables of interest have a significant relationship in the long-run. For this purpose, the Engle-Granger two-step procedure is applied. Table 4 shows the output.

The cases reported have a non-significant test statistic when compared to the relevant critical values, named after MacKinnon (1991). It implies that there is not enough statistical evidence supporting the presence of cointegration between the variables BOVESPA and the exchange rate.

5.2 Multivariate VAR model and Granger Causality tests

To investigate the relationship between exchange rates and stock prices, it is relevant to minimize residual autocorrelation when selecting the lag length of the variables of interest, namely the ratio exchange rate variation and the ratio stock index return. It is done by minimizing the Akaike Information Criteria (AIC).

Additionally, as suggested in the previous section, Newey-West standard errors should be used.

For the case in which the lead variable is the ratio exchange rate variation, the optimal lag length consists of 1 lag for both dependent and independent variables (percentual stock index return). An ARDL (1,1) model defines it.

Further, to reduce possible omitted variable bias (OVB), several control variables are used. Further information on those can be obtained in section 3.2.5. Panel A (see appendix) reports the multivariate model.

As observed, the effect of ratio exchange rate variation on stock index return is significant at the 1 percent level, evidencing that every 1 percent appreciation of the real yields an additional 0.8032 percent return on the BOVESPA Index. Regarding the first lag of the independent variable, the effect is statistically significant at 5 percent and has a magnitude of around a ninth of the current value.

Moreover, it is of relevance to mention the statistical significance, both at the 10 percent level, of the dummies for Monday and Friday (Wednesday was used as the default day). It is in line with previous research on the Monday effect, which translates into low or negative average stock returns from Friday to Monday. Explanations for such phenomenon, defined as a calendar anomaly, relate to increased asymmetric information between informed and uninformed investors as the market is closed (Foster & Viswanathan, 1990) and to the release of bad news by companies as the market closes on Friday.

Surprisingly, variables relating to other calendar anomalies, such as the January effect, or dummies associated with political or economic distress, namely Impeachment and Great Recession periods, do not have a significant impact on the stock index return. Along with them, none of the daily continuous control regressors, the interest rate, and the foreign exchange reserves, have a significant effect on the dependent variable.

Finally, the Granger causality test is conducted for the bivariate ARDL (1,1) model with the ratio exchange rate variation as the lead variable. The lags of the test are selected by minimizing Akaike Information Criteria (AIC), with an outcome of 3 lags for both independent and dependent variables.

The test statistic was 15.695, following an X2 distribution. The reported p-value is 0.001, indicating that ratio exchange rate variation granger-causes ratio stock index returns at the 1 percent level.

To extend the analysis, it is fundamental to study the case where stock index return is the lead variable. A similar procedure for the lag length selection is applied and the outcome is an ARDL (2,2) model. Additionally, Newey-West standard errors and the same control variables are used. Panel B illustrates this multivariate VAR model.

From panel B, it can be stated that lags 1 and 2 of ratio stock index return have a statistically significant positive effect on the ratio exchange rate variation at the 10 percent level, but with a small magnitude of 0.0262 and 0.0248 percent, respectively. The most relevant impact stands for the current value of ratio stock index return, significant at the 1 percent level and for which every additional 1 percent return appreciates the real by 0.3247 percent.

Other significant variables include lags 1 and 2 of the dependent variable, both at the 1 percent level. It indicates how the current exchange rate is partially determined by ex-ante expectations, in a process like the one which happens with inflation.

Finally, there is a significant effect, at the 10 percent level, of the dummy for the period comprising the impeachment of President Dilma Rousseff. It is justifiable as the political turmoil caused a foreign capital outflow, especially of dollars, but this occurred mostly before the actual start of the process on 7th October 2015, possibly due to event-date uncertainty and investor sentiment. Hence, the period itself had a positive effect on the exchange rate, with the real slightly appreciating on average. Another result, which occurs perhaps due to country attributes, is the significant effect of the dummy Friday, at the 1 percent level, on the dependent variable.

For additional evaluation, the Granger causality test is used in this model. The lag length is the same as the one from panel A's model, namely 3 lags for both dependent and independent variables. The test-statistic was 6.2562, with a reported p-value of 0.10, indicating that ratio stock index returns granger-causes ratio exchange rate variation at the 10 percent level.

6 Conclusion

This paper investigated the relationship and causation that can exist between exchange rates and stock prices in Brazil, using daily data from 2001 to 2018. To accomplish this aim, several econometric tests and Newey-West standard errors were used to guarantee that any data analysis bias with regards to stationarity, heteroskedasticity, and autocorrelation would be minimized.

Further, a multivariate vector autoregression model was built to investigate the short-run relationship between ratio exchange rate variation and ratio stock index returns, the two stationary-transformed variables. To study the long-run relationship of the variables of interest, the Engle-Granger two-step procedure was applied. Lastly, causality is assessed by way of a Granger causality test, in both directions of effect, namely the possibility of exchange rates granger-causing stock prices and vice-versa.

The results indicate a significant positive relationship between ratio exchange rate variation and ratio stock index returns, meaning that additional returns imply an appreciation of the real versus US dollar and an appreciation of the real imply an increase in the BOVESPA returns. Moreover, no long-run relationship between stock index value and the exchange rate was verified. Finally, the Granger causality tests provide statistical significance of unidirectional causality from ratio exchange rate variation to ratio stock returns at the 1 percent level. The other direction, from ratio stock returns to ratio exchange rate variation, is also significant, but at the 10 percent level. In conclusion, there is evidence for the presence of bidirectional causality at least at the 10 percent level. In the framework of this research, the focus was to obtain an overall picture of how stock prices and exchange rates relates in Brazil, on average. Importantly, several biases were minimized through data size, transformations, tests, and control variables, giving robustness to this work, and letting it be applied in policy, investing, and science enhancement.

Some possible improvements must be considered in any application of the afore-mentioned results, standing as suggestions for future research. For instance, a study considering monthly data would be relevant because it would allow the inclusion of relevant macroeconomic control variables, such as inflation, industrial output, and GDP growth. Additionally, a sub-period analysis, like the wavelet method and the Chow tests, would minimize any seasonal effects on the model coefficientt period. Lastly, other causality tests, such as the non-linear Granger causality one, can be applied as checks for robustness and support or not the presence of bidirectional causality in Brazil.

References

Ajayi, R. A., & Mougouė, M. (1996a). ON THE DYNAMIC RELATION BETWEEN STOCK PRICES AND EXCHANGE RATES. Journal of Financial Research, 19(2), 193–207.

Adjasi, C. K.D., & B.N. Biekpe, B.N. (2005). Stock Market Returns and Exchange Rate Dynamics in Selected African Countries: A bivariate analysis, The African Finance Journal, July, Cape Town, South Africa.

Alagidede, P., Panagiotidis, T., & Zhang, X. (2011). Causal relationship between stock prices and exchange rates. The Journal of International Trade & Economic Development, 20(1), 67–86.

Aydemir, O., Demirhan, E., (2009). The relationship between stock prices and exchange rates: evidence from Turkey. International Research Journal of Finance and Economics, 23, 207–215.

Bahmani, O. M. & Sohrabian, A. (1992). Stock Prices and the effective exchange rate of the dollar. Applied Economics, 24, 459-464.

Bovespa Historical Rates (BVSP) - Investing.com. Investing.com. (2020). Retrieved 7 July 2020, from https://www.investing.com/indices/bovespa-historical-data.

Breusch, T. S., & Pagan, A. R. (1979). A Simple Test for Heteroscedasticity and Random Coefficient Variation. Econometrica, 47(5), 1287.

BRL USD Historical Data - Investing.com. Investing.com. (2020). Retrieved 7 July 2020, from https://www.investing.com/currencies/brl-usd-historical-data.

Caporale, G. M., Hunter, J., & Menla Ali, F. (2014). On the linkages between stock prices and exchange rates: Evidence from the banking crisis of 2007-2010. International Review of Financial Analysis, 33, 87-103.

Dados diários. Bcb.gov.br. (2020). Retrieved 7 July 2020, from https://www.bcb.gov.br/htms/SELIC/SELICdiarios.asp?frame=1.

Dickey D.A., & Fuller W.A. (1981). Likelihood ratio statistics for autoregressive time series with a unit root. Econometrica, 49, 1057–1072.

Dimitrova, D. (2005). "The Relationship between Exchange Rates and Stock Prices: Studied in a Multivariate Model". Issues in Political Economy, 14, 1–25.

Dornbusch, R., & Fischer, S. (1980). Exchange rates and the current account. American Economic Review, 70, 960–971.

Engle, R., & Granger, C. (1987). Co-Integration and Error Correction: Representation, Estimation, and Testing. Econometrica, 55(2), 251-276.

Foster, F. D., & Viswanathan, S. (1990). A Theory of the Interday Variations in Volume, Variance, and Trading Costs in Securities Markets. Review of Financial Studies, 3(4), 593–624.

Granger, C. (1969). Investigating Causal Relations by Econometric Models and Cross-spectral Methods. Econometrica, 37(3), 424-438.

Granger, C. W. J., Huangb, B.-N., & Yang, C.-W. (2000). A bivariate causality between stock prices and exchange rates: evidence from recent Asianflu. The Quarterly Review of Economics and Finance, 40(3), 337–354.

Harjito, D.A. and McGowan, C.B. Jr (2011), “Stock price and exchange rate causality: the case of four ASEAN countries”, Southwestern Economic Review, Vol. 34 No. 1, pp. 103-114.

Hatemi-J, A., & Irandoust, M. (2002). On the Causality Between Exchange Rates and Stock Prices: A Note. Bulletin of Economic Research, 54(2), 197–203.

Lin, C.-H. (2012). The comovement between exchange rates and stock prices in the Asian emerging markets. International Review of Economics & Finance, 22(1), 161–172.

MacKinnon, J.G. (1991), ‘Critical values for cointegration tests’, in R.F. Engle and C. W. J.Granger (eds), Long-run Economic Relationships: Readings in Cointegration, Oxford University Press, Oxford, 267-276.

Mgammal, M. H. (2012). The Effect of Inflation, Interest Rates and Exchange Rateson Stock Prices Comparative Study Among Two Gcc Countries. International Journal of Finance and Accounting, 1(6), 179 to 189.

Mohamed Dahir, A., Mahat, F., Ab Razak, N. H., & Bany-Ariffin, A. N. (2018). Revisiting the dynamic relationship between exchange rates and stock prices in BRICS countries: A wavelet analysis. Borsa Istanbul Review, 18(2), 101-113.

Rahman, Md. L. and Uddin, J. (2009), “Dynamic relationship between stock prices and exchange rates: evidence from three South Asian countries”, International Business Research, Vol. 2 No. 2, pp. 167-174.

Richards, N.D., Simpson, J. and Evans, J. (2009), “The interaction between exchange rates and stock prices: an Australian context”, International Journal of Economics and Finance, Vol. 1 No. 1, pp. 3-23.

Smyth, R., & Nandha, M. (2003). Bivariate causality between exchange rates and stock prices in South Asia. Applied Economics Letters, 10(11), 699–704.

Sui, L., & Sun, L. (2016). Spillover effects between exchange rates and stock prices: Evidence from BRICS around the recent global financial crisis. Research in International Business and Finance, 36, 459-471.

TABAK, B. M. (2006). THE DYNAMIC RELATIONSHIP BETWEEN STOCK PRICES AND EXCHANGE RATES: EVIDENCE FOR BRAZIL. International Journal of Theoretical and Applied Finance, 09(08), 1377–1396.

Thornton, D., & Batten, D. (1985). Lag-Length Selection and Tests of Granger Causality Between Money and Income. Journal of Money, Credit and Banking, 17(2), 164-178.

Time Series Management System. www3.bcb.gov.br. (2020). Retrieved 7 July 2020, from https://www3.bcb.gov.br/sgspub/consultarvalores/consultarValoresSeries.do?method=consultarSeriesseries=13621.

Tsagkanos, A., & Siriopoulos, C. (2013). A long-run relationship between stock price index and exchange rate: A structural nonparametric cointegrating regression approach. Journal of International Financial Markets, Institutions and Money, 25, 106-118.

Wu, Y. (2000). Stock prices and exchange rates in a VEC model—The case of Singapore in the 1990s. Journal of Economics and Finance, 24, 260274.

Appendix

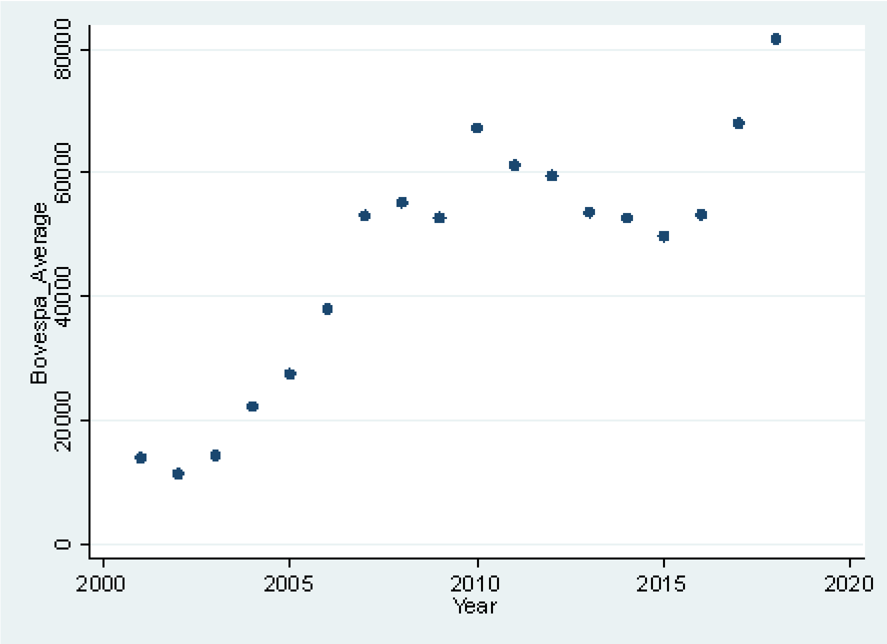

Figure 1: Average BOVESPA Price vs Time (in years)

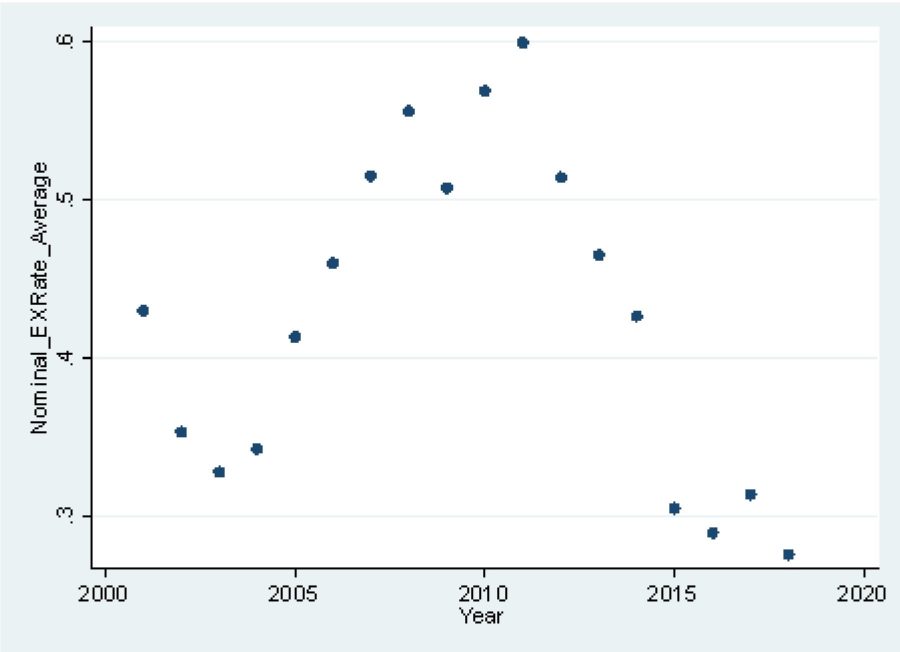

Figure 2: Time series for average yearly nominal exchange rate

Table 1

Variable	Test statistic
Stock Index Price (BOVESPA)	-2.220 (p=0.4786)
Nominal Exchange Rate (USD/REAL)	-1.242 (p=0.9016)
Ratio Stock Index Return	-66.968*(p=0.0000)
Ratio Nominal Exchange Rate Variation	-70.203*(p=0.0000)

*Significant at the 1% level.

Table 2

Dependent Variable	Independent Variable	F-statistic
BOVESPA	Exchange Rate	1603.12* (p=0.0000)
Exchange Rate	BOVESPA	2750.08* (p=0.0000)

*Significant at the 1% level.

Table 3

Dependent Variable	Independent Variable	Durbin Watson d-statistic
BOVESPA	Exchange Rate	0.0013*
Exchange Rate	BOVESPA	0.0016*

*Significant at the 10% level.

Table 4

Dependent Variable	Independent Variable	Test statistic
BOVESPA	Exchange Rate	-0.548
Exchange Rate	BOVESPA	-0.788

*Significant at the 10% level.

Panel A

Ratio Stock Index Return	Coefficient Estimator	NW Standard Error
Lag 1 Ratio Stock Index Return	-0.0279	0.0224
Ratio Exchange Rate Variation	0.8032***	0.0388
Lag 1 Ratio Exchange Ratio Variation	0.0875**	0.0353
Monday	-0.0014*	0.0007
Tuesday	-0.0007	0.0007
Thursday	-0.0011	0.0007
Friday	-0.0013*	0.0007
December Effect	0.0002	0.0008
January Effect	-0.0008	0.0008
Selic Daily Interest Rate	0.0026	0.0078
Foreign Exchange Reserves	0.0000	2.790×10^{-6}
Impeachment Period	-0.0003	0.0011
After Impeachment Period	0.0007	0.0006
Great Recession Period	-0.0006	0.0013
Constant	0.0014	0.0016

*,**,and *** indicate statistical significance at the 10, 5, and 1 percent level, respectively.

Panel B

Ratio Exchange Rate Variation	Coefficient Estimator	NW Standard Error
Lag 1 Ratio Exchange Rate Variation	-0.0829***	0.0282
Lag 2 Ratio Exchange Rate Variation	-0.0798***	0.0278
Ratio Stock Index Return	0.3247***	0.0124
Lag 1 Ratio Stock Index Return	0.0262*	0.0157
Lag 2 Ratio Stock Index Return	0.0248*	0.0139
Monday	0.0000	0.0005
Tuesday	0.0004	0.0004
Thursday	0.0004	0.0005
Friday	0.0012***	0.0004
December Effect	0.0003	0.0005
January Effect	0.0006	0.0005
Selic Daily Interest Rate	-0.0024	0.0056
Foreign Exchange Reserves	0.0000	1.860×10^{-6}
Impeachment Period	0.0013*	0.0008
After Impeachment Period	-0.0001	0.0004
Great Recession Period	0.0002	0.0007
Constant	-0.0001	0.0011

*,**,and *** indicate statistical significance at the 10, 5, and 1 percent level, respectively.