UNIVERSITY OF MACEDONIA

The relationship between stock prices and the FX market

Bachelor Thesis

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August, 2021

Abstract

This study examines the relationship between the foreign exchange market and the stock market in a group of advanced countries, Canada and Japan and a part of emerging countries Brazil and India over the period of 2002-2017. The whole research was carried out by applying the methods of unit root tests for stationarity, cointegration tests for the long run relationship between the two markets, the Granger causality test in order to explain the relationship in the short run period, Impulse Response Function which analyzes the response of the variables to shocks and Variance Decomposition analysis. The results demonstrate that there is long run relationship between the two markets only for Brazil. On the other hand, the Granger causality test shows that the exchange rate causes the stock prices in the case of the advanced countries, Canada and Japan. In India there are indications of bidirectional relationship between the two markets and in Brazil the stock market has a strong impact on the FX market in the short run period.

Keywords: Granger causality; exchange rates; stock prices; cointegration; IRF; Variance Decomposition

Acknowledgements

I would like to express my sincere gratitude and appreciation to my supervisor professor Panagiotidis Theodore, for his patience and guidance through each stage of the process. His continuous support, advice and immense knowledge in this field, have made this an inspiring experience for me.

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1. Introduction

Discussions regarding the relationship between stock market and foreign exchange rate have dominated in recent decades. Forecasts and econometric methodologies play a profound role in the analysis of the financial sector. However, the economy consists of a great deal of mechanisms which are determined by successive movements, as a consequence, it is extremely difficult to detect the direction of influences between the two markets. More and more investors strive to understand the factors that influence both of the markets in order to optimally manage their portfolios and the risk of their investments, this could be an interesting pursuit for the investment community and the further economic sector. The literature indicates that both advanced and emerging economies come under the microscope of many researches.

The extended research of Meese and Rogoff (1983) pointed out that structural models cannot surpass a random walk of forecasting. Moreover, they illustrated that the fluctuations are a combination of monetary policies, changes of oil prices and other parameters of modeling failures. Also, the exchange rate disconnected puzzle is included on their findings according to which, it is extremely difficult for financial institutions to create a model that can accurately predict the exchange rates movements. The theoretical framework of asset markets (e.g., Dornbusch and Fisher 1980) nominates that both trade balance and current account of countries, contribute to the configuration of exchange rates, so there is a positive linkage between stock prices and exchange rates. As far as models of portfolio balance are concerned, (Branson 1983) there is opposite relation from stock prices to exchange rates due to the fact that if stock market prices rise, the interest rate of country's currency will also rise. Consequently, the exchange rate will reduce.

Schwert (1981) suggests that the daily stock prices reflect the changes of the monthly CPI inflation from 1953 to 1978 but there is a weak relation. The sequence of these parameters raises questions about the exact explanation of the causal relation between SP and exchange rates so, the economists have to take into account a variety of economic chain reactions. For instance, Humpe and Macmillan (2009) investigated the Japanese economy and concluded that industrial production causes positively the SP and money supply causes with negative way the stock indices in the long run period. They highlighted the negative relation between macroeconomic variables, the industrial production was guided by consumer index and IR. According to them and Krugman et al. (1998), one possible way to explain this situation is to bear in mind the Keynesian liquidity trap which took place on the previous decades. The research of Naka et al. (1998) explored the effects of macroeconomic variables in domestic stock market in India. They concluded that SP was affected by industrial production at a huge amount and the inflation influenced the prices with a negative direction. However, they observed that the Indian economy was prone to socialist policies during the investigated period.

The framework of this research however, pertains to foreign exchange rates and stock prices, in order to identify the existence and the kind of the causal relationship between the two markets. According to the literature, most researchers utilize unit root tests, cointegration tests in order to study the long run relationship between the variables, the standard Granger causality test by means of Vector Auto – Regression or Vector Error Correction Models, and a huge package of alternative causality tests. Moreover there is a group of investigators who targets to explain the volatility and the linkage of stock prices and exchange rates via GARCH family models according to Kanas (2000), G.M. Caporale et al. (2014).

It is significant to refer that the academic community has extensively explored the causal relationship between stock prices and the FX market for plenty of countries throughout the years, however there are mixed results. For instance, Bhattacharya and Mukhergee (2003) investigated the economic sector of India for the decade of 1990 and they employed causality tests by Toda and Yamamoto (1995) method for stock market and a variety of financial variables, including the foreign exchange rate. The results indicated that the changes in the SP and the macroeconomic variables are not related in any obvious way. At this point, what is interesting to note is the Efficient Market Hypothesis by Fama (1970) which points out that the macroeconomic variables cannot be used as investment guidance. Furthermore, Granger et al. (2000) represented that during the Asian flu, the FX market led the SP in some Asian countries but the Philippines followed the portfolio approach, especially FX market was guided by SP with negative correlation. Ajayi et al. (1998) utilized both daily and weekly data for both advanced and emerging countries but the results were mixed in every case and Abdalla and Murinde (1997) showed that there is unidirectional causality from FX market to SP in three emerging economies. More recently, Nieh and Lee (2001) described that there is no relation between the two variables in the long run period for G7 countries but they detected short run relationships at maximum a day in some of them.

To put it briefly, we come to the conclusion that there is no theoretical or empirical model which can provide solid results, for this reason we are going to study with empirical way the results for a number of countries. The aim of this study is to analyze the relationship between stock prices and foreign exchange market both in advanced and emerging economies. Therefore it is organized by five Sectors. In particular, Section 2 contains an expanded literature review throughout the years, Section 3 discusses the framework of the methodology and the data description, Section 4 represents the empirical results of our survey which consist of unit root tests, cointegration tests for the long run relationship, Granger causality test for the short run relationship, Impulse Response Function (IRF) and Variance Decomposition analysis. Lastly, the Section 5 summarizes the findings of this research. Notice that our empirical results are conducted by means of the econometric programs R and Gretl.

2. Literature Review

More and more researchers strive to discover the causal relationship between stock markets and foreign exchange rates throughout the years. Despite the many empirical and theoretical studies, the previous relationship has nevertheless, become a controversial issue. According to the literature it is obvious that the results are not so clear. Many studies have been conducted with a wide range of methodologies however, many researches over the past three decades indicated that the results of the causal relationship between two markets are mixed. A great proportion of investigators examined the long run relationship between the two markets by cointegration tests as well as the short run relationship by means of the classical Granger causality test and Impulse Response Function. According to Bahamani-Oskooee and Sohrabian (1992), there are significant indications that the two financial variables do not cause each other in the short run period. In addition, the cointegration analysis indicated that the two markets cannot be related in the long run period for the American economy. Similar results are obtained according to Nieh and Lee (2001) who applied Johansen and Engle Granger tests and they came to the conclusion that there is no linkage for the countries which are included in the G-7 for the long run period nonetheless, some of them reflect significant indications of short run relationships but they last a maximum of one day. Additionally, Bhattacharya and Mukherjee (2003) examined the long run relationship by Toda and Yamamoto (1995) version of causality test and they concluded that there were no traces of causality relationship in both Indian markets. A study for Mexico according to Kutty (2010), indicated that the exchange rate was guided by stock prices in the short run period but there were no significant results for the long run period.

A group of investigations consists of the ARCH family methods so as to explain the volatility between the two markets. Particularly, Kanas (2000) pointed out that there is correlation from stock indices to exchange rates in the US, Japan, Canada and in the EU countries: UK and France. In addition, Katechos (2011) ends up that the relation between the stock returns and exchange rates depends on the conditions of yield of currencies. Walid et al. (2011) utilized two Markov switching-EGARCH models and they came to the conclusion that the exchange market affects with asymmetrically way the volatility of stock market both in calmness and tumultuous times in Hong Kong, Singapore, Malaysia and Mexico. Moreover, Andreou et al. (2013) used a VAR-GARCH model and the relationship between the two markets was characterized by bidirectional slipovers.

A huge variety of studies and methodologies indicates interesting results about the relationship between two markets. Abdalla and Murinde (1997) investigated a part of emerging economies and their results indicated that the FX market leads the SP in India, Korea and Pakistan while the FX market was under the influence of the SP in case of Philippines. What is more, Ajayi et al. (1998) investigated two groups of economies, advanced and emerging over the period 1985-1991. They concluded that in advanced economies, the exchange market responds to stock indices changes, however on the other group of markets the results are not so clear and the investigators have to bear in mind the development stage and the current economic conditions of each country. Granger, et al. (2000) separated their time series into three time horizons and they turn out that the movements on the FX market affects the stock market in South Korea over the period of Asian flu, at the same time, a great number of countries reflect bidirectional relations. Phylaktis and Ravazzolo (2005) found that six Pacific countries can use the US stock market as a barometer for their domestic markets in the 80s and 90s.

The following table incorporates extensive results and methods based on the literature.

Table 1: Overview of the literature

	Title of the paper/study	***(Authors names and year of publication)***	***Keywords***	***Data (Sources)***	***Conclusions***
1	Dynamic relationship between stock prices and exchange rates for G-7 countries	(Chien-Chung Nieh, Cheng-Few Lee, 2001)	Stock price, Exchange rate, Cointegration, VECM	The data consists of both stock market indices and foreign exchange rates (from IMM) for the G7 countries. All of them use the Dow Jones World Index and the US the IND. The exchange	In conclusion, the authors revealed (via VECM and VAR models) that there is no significant long-run linkage between two variables. In contrast, there is short-run significance, for about a day, in some particular countries.

				rate is calculated as foreign currency/US dollar and there are 618 daily obs. from 10:1993 to 2:1996 from Dow Jones, Inc.	They end up that there is a wide range of reasons like economic stage, policies, capital controls, expectations that influence each country with a different way, so investigators have to take into consideration all of these parameters. However, the data from the US reflects that the two markets are not correlated.
2	A bivariate causality between stock prices and exchange rates: evidence from recent Asian flu	(Clive W.J. Granger, Bwo-Nung Huang, Chin-Wei Yang, 2000)	Asian Flu, Bivariate Causality between Stock Prices and Exchange Rates	The investigators used exchange rates and stock prices from Hong Kong, Indonesia, Japan, South Korea, Malaysia, Philippines, Singapore Thailand and Taiwan. They are on a daily basis from 01:1986 to 06:1998 (3247 obs.) and they are collected from Datastream, also they are separated in three periods: Firstly, from 01:1986 to 11:1987 which reflects the pre-crash period, Secondly, from 12:1987 to 05:1997 which represents the after crash period, Thirdly, from 06:1997 to 06:1998 which reflects the peak of the Asia Flu.	The purpose of this paper was to analyze the relation between two markets over the years of the Asian flu. Cointegration tests indicated the long run relationship, the Granger causality test indicated the relationship in the short run period and the IRF analyzed the forecasting periods. Movements on the exchange rates can play an important role in the predictability of stock markets in S. Korea. In Philippines we have the opposite results (but with negative direction), while Indonesia and Japan reflect no pattern, the relationships in the rest of the countries reflect feedback directions. However, there are many economic parameters that can affect the volatility of these markets throughout the years. For instance, in the 90s the portfolio approach was significant due to withdrawal of capital controls. Finally, the Asia flu made the researchers to overhaul the function of financial markets.
3	Stock prices and the effective exchange rate of the dollar	(Mohsen Bahamani-Oskooee and Ahmad Sohrabian, 1992)		In this study, there are monthly data from 07:1973-12:1988 for the American economy. The S&P 500 index came from S&P Security Price Index Record and the exchange rate were provided by the International Financial Statistics of the IMF,	In this paper, Granger causality test constitutes an important role in order to study the causal relation. The researchers come to the conclusion that both stock market index and exchange rate can affect each other in the short run period. On the other side, there are not the appropriate indications to

				they were the most significant clues for particular analysis.	prove the accurate relation in the long run period.
4	On the relationship between stock returns and exchange rates: tests of granger causality	(Richard A. Ajayi, Joseph Friedman, Seyed M. Mehdian, 1998)		In this paper, the investigators used daily and weekly frequency of market indices and exchange rates (04:1985-08:1991) for Canada, Germany, France, Italy, Japan, UK, USA and Taiwan, Korea, Philippines, Malaysia, Singapore, Hong Kong, Indonesia, Thailand (12:1987-09:1991). They were provided by Citibase Data Services and Data Resource International.	To sum up, they observed that there are not the same results for both advanced and emerging economies via classical Granger causality test. For instance, the exchange rates respond to SP changes in advanced economies (including Indonesia, Philippines and Taiwan) while in the other group of countries the results are not so clear. Authors end up that the structure of the financial markets among countries plays the most significant role and these kind parameters have to be taken into account.
5	The Study of Causal Relationship between Stock Market Indices and Macroeconomic Variables in Cote d'Ivoire: Evidence from Error-Correction Models and Granger Causality Test	(Drama Bedi Guy Herve, Bouphanuvong Chanmalai, Yao Shen, 2011)	Stock prices market, Macroeconomic variables, VAR models, Granger-causality, IRF, FEVD	The data which took part in this investigation was BRVM10 from domestic stock market and a group of macroeconomic variables: industrial production and consumer price indices, domestic interest rate, real exchange rate and money supply from January 1999 to April 2007 with quarterly frequency from the IMF.	The results identified that only CPI and IR determine a part of the movements of stock prices in Cote d'Ivoire. The IRF, Forecast Error Variance Decomposition and Granger-causality test via VAR models indicated that the Stock market cannot absorb the developments of the economy. However, cointegration tests indicated that there is relationship in the long run period. In general, macroeconomic variables are not able of predicting the future movements of the stock indices. Moreover, monetary policies have to be focused on the industrial production because it can play a vital role in the linkage with the domestic stock market.
6	Causal relationship between stock market and exchange rate, foreign exchange	(Basabi Bhattacharya, Jaydeep Mukherjee, 2003)	Macroeconomic Aggregates, Stock Price Index, Granger Causality and Efficient Market	The macroeconomic variables that took part in this research were: foreign exchange reserves, REER and the value of trade balance (on a monthly basis from 1990 to 2001). Stock prices are represented by	The authors came to the conclusion (by using Toda and Yamamoto (1995) version in order to describe Granger Causality) that the stock market cannot be used as a compass in order to describe the changes in the three financial variables. However,

	reserves and value of trade balance: A case study for India		Hypothesis	the Bombay Stock Exchange Sensitive Index. All of them, were obtained from Handbook of Statistics on Indian Economy (2001)	the financial sector was under control of the banking sector for a long period, this fact influenced the foreign exchange. Also, the stock market in India is in stage of development and this could be investigated in future researches.
7	Stock market volatility and exchange rates in emerging countries: A Markov-state switching approach	(Chkili Walid, Aloui Chaker, Omar Masood, John Fry, 2011)	Markov regime switching, Stock market volatility, Exchange rate changes, Time varying transition probabilities	In this article the exchange rates and the stock indices are the main part the data. They are on weekly basis for Hong Kong, Mexico, Singapore, Malaysia. (12:1994 – 03:2009). The stock indices were gained from the ECONSTATS database and the Exchange rates from the PACIFIC database.	In this research, there is a Markov Switching-EGARCH model to analyze the behavior between FX and stock market. In summary, they observed that there were strong fluctuations throughout the periods due to regimes. However, the FX market affect the volatility of SP with an asymmetrically way.
8	The Relationship between Stock Prices and Exchange Rates Evidence from Turkey	(Oguzhan Aydemir, Erdal Demirhan, 2009)	Stock Prices, Exchange Rate, Toda-Yamamoto, Turkey	The investigators utilized the exchange rates and a wide range of different stock indices which represent the stock market. The data were from 02:2001 to 01:2008 on a daily basis and they are gained from the Central Bank of the Republic of Turkey.	This paper shows that the results are mixed, in particular, the relationship of the two researched markets are characterized by bidirectional way. They used VAR models, the Granger causality test for the short run period and Toda and Yamamoto (1995) method for the long run period. To sum up there are both negative and positive movements from stock indices to the FX market, the direction of the causality is positive only in case of technology indices. However, there is negative relationship from the FX market to all indices.
9	The relationship between exchange rates and stock prices: the case of Mexico	(Gopalan Kutty, 2010)	Exchange rates, cointegration, stock prices	The author decided to use Mexico's equity index, in particular, Bolsa from Dow Jones News/Retrieval and he used the domestic currency/US dollar as his exchange rate (by IMM). The frequency is on a weekly basis and there are 849 obs. from	In this article, the author employed the Engle and Granger method to study the relationship in the long run period, so he concluded that there are no indications of cointegration between the two markets in the long run period, however the Granger causality test provided that exchange rates were led by stock indices

				Jan 1989 to Dec 2006	in the short run period in Mexico.
10	On the linkages between stock prices and exchange rates: Evidence from the banking crisis of 2007–2010	(Guglielmo Maria Caporale, John Hunter, Faek Menla Ali, 2014)	Causality-in-variance, Cointegration, Exchange rates, Stock prices	The authors collect their data on a weekly basis in order to avoid econometrical problems like noise and anomalies. Exchange rates and stock market indices from Canada, the euro area, Japan, Switzerland, the UK, and the US were analyzed from 08:2003 to 12:2011 (441 obs.). Thomson DataStream provided the particular data.	In this paper, the investigators separated their data in pre-crisis and after crisis period, and they choose a GARCH model to explain the volatility dynamics between FX and SP. In the short-run period, the stock markets causes the exchange rates both in the USA and in the UK, there are opposite results for Canada and feed-back results for the rest of the countries over the period of economic crisis. In contrast, causality variance tests indicated that SP causes the FX market only in case of USA at the height of the crisis. Generally, every country reflects a different kind of economic climate. Expectations, inflows and outflows of capital, have to be taken into account. Investors were not capable of improving the efficiency of their portfolios due to there was not the appropriate reflection of economic sector.
11	Exchange rate and stock price interactions in emerging financial markets: evidence on India, Korea, Pakistan and the Philippines	(Issam S. A. Abdalla, Victor Murinde, 1997)		The data concern a group of emerging economies, India, Korea, Pakistan and Philippines. The authors analyzed the IFC stock price index in case of stock market, and the exchange rate from Jan 1985 to Jul 1994 on a monthly basis. The data are obtained from Datastream.	The researchers utilized the Granger causality test with BVAR and ECM models for each country and they came to the conclusion that SP was led by exchange rate in India, Korea and Pakistan. However in Philippines there is the opposite causality relation between the two markets, particularly exchange rates were guided by the stock market.
12	Dynamic linkages between exchange rates and stock prices: Evidence	(Ming-Shiun Pan, Robert Chi-Wing Fok , Y. Angela Liu, 2007)	Dynamic linkages between exchange rates and stock prices, East Asian markets	In this paper, the data are on a daily frequency, for stock market indices and exchange rates for East Asian economies, Hong Kong, Japan, Korea, Malaysia, Singapore, Taiwan, and	In summary, the authors utilized VAR analysis, approached by Sims (1980) and they concluded that the SP were driven by the FX market in case of Hong Kong, Japan, Malaysia, and Thailand (before the onset of the crisis).

	from East Asian markets			Thailand over the period 01:1988 – 10:1998. AREMOS database provided the particular data.	While the stock markets do not cause the FX markets for any country over the period of the economic crisis, on the other side, in these particular countries (with the sole exception of Malaysia) there is causality from the FX market to stock markets.
13	On the relationship between exchange rates and equity returns: A new approach	(Georgios Katechos, 2011)	Foreign exchange, Exchange rates, Stock returns, Interest parity, Risk premia	In this paper there are weekly data (they were gained from Thomson Reuters Datastream) from 01:1999 to 08:2010. The main composites of this study were a great number of combinations of exchange rates for US, Asian and European countries and the FTSE world Index which represents the stock indices.	According to this study, the currencies with higher value are linked with a positive relation with global stock market returns. On the other side, there is negative relation between those that reflect lower rates and stock markets. The author used GARCH [1,1] errors and ML-GARCH[1,1], too.
14	Stock and foreign exchange market linkages in emerging economies	(Elena Andreou, Maria Matsi, Andreas Savvides, 2013)	Volatility spillovers, MGARCH, Emerging economies	In this study there are weekly data for stock markets and exchange rates for India, Korea, Malaysia, Pakistan, Philippines, Thailand, Argentina, Brazil, Chile, Colombia, Mexico and Venezuela which came from the Emerging Markets Database (EMDB) for January 1989 to August 2008.	This research was conducted by means of a vector autoregressive model with Generalized Autoregressive Conditional Heteroskedasticity (VAR-GARCH). The results provide us that the variance of the two markets, stock and exchange, was characterized by bidirectional causality for all counties (except for Colombia) also, the financial crisis that broke out in Asia, had a huge contribution in the volatility between this particular markets.
15	Stock prices and exchange rate dynamics	(Kate Phylaktis, Fabiola Ravazzolo, 2005)	Stock market, Foreign exchange markets, Capital market integration, Asian financial crisis, Pacific Basin capital markets	The data concern Malaysia, Thailand (Jan 1980 to Dec 1980), Philippines (May 1986 to Dec 1998), Singapore (Jan 1990 to Dec 1998), Hong Kong (Jan 1981 to Dec 1998). In particular, stock indices, exchange rates/US dollar, and consumer price indices are on monthly basis and they came from IFS	The authors deduced that there is no long-run equilibrium in some particular countries, however the US stock market can be used as a barometer which can guide the domestic markets. The restrictions in FX markets did not play a significant determinant between the two markets, and the Country Funds gave the opportunity to investors to develop their investment skills

				database which is based on Datastream.	widely. Finally, according to constancy tests the Thailand received negative impacts over the period of Asian crisis. The authors applied cointegration tests, VECM and VAR models and multivariate Granger-causality
16	Volatility Spillovers Between Stock Returns and Exchange Rate Changes: International Evidence	(Angelos Kanas, 2000)		The author utilized data for US, Japan, Canada, the UK, France and Germany. He used the stock indices for every country and the exchange rate on a daily basis from 01:1986 – 02:1998 (3173 obs.). All of them were collected from the Bank of England, Datastream.	In summary, there was relation from stock prices to exchange rates for five countries (except Germany) while there were no indications for the opposite relation for every country. The cointegration test (Bierens 1997a, 1997b) and EGARCH (Nelson 1991) model indicated that there was negative correlation of coefficient between the two markets.
17	The exchange-Rate risk Exposure of Asset Returns	(Edward H. Chow, Wayne Y. Lee, Michael E. Solt, 1997)		For this investigation, the authors used the real exchange rates and indices on a monthly basis for 03:1977 - 12:1989, for British, Canada, France, Germany, Italy and Japan. The sources were the International Financial Monetary Fund (IMF), Federal Reserve Bulletin and the Citicorp Economic Database.	In conclusion, monthly data indicated that there are no indications of relationship between the two markets. On the other side the authors repeated the research by using data on a long run time horizon and they ended up that there were signs of correlation between the exchange rate and the stock returns.
18	Causal relationship between stock prices and exchange rates	(Paul Alagidede, Theodore Panagiotidis, Xu Zhang, 2011)	Granger causality, stock prices, exchange rates, Hiemstra Jones test, non-parametric causality	The authors utilized the exchange rates for Australia, Canada, Japan, Switzerland, UK from the Bank of England and the stock prices consist of the Dow Jones Country Titans index and Dow Jones Composite Average in case of UK, over the period 1992-2005.	On the whole, the authors detected no long relationship between the two markets nevertheless, they applied a range of causality tests, Granger test, Hiemstra Jones test, to study the short run relationship. They pointed out that the exchange rate causes the stock prices in case of UK, Canada, and Switzerland. Stock indices cause FX market in Switzerland and there is non-linear causality in Japan.

3. Methodology and Data

This chapter deals with the main methodology of this particular research. We utilized a combination of the methodology parts of Granger et al. (2000) and Alagidede et al. (2011) in order to analyze the relationship between the exchange rates and the stock prices in a group of advanced and emerging economies. At first glance, this study consists of a range of unit root tests which indicate the stationarity of our time series. Secondly, it is necessary to examine the long run relationship between the stock market and the FX market by means of cointegration techniques. Moreover, the Granger causality test plays a vital role so as to explain the short run relationship of our financial variables. Last but not least, the Impulse Response Function depicts the response of the variables to random shocks as well as their absorption period and the Variance Decomposition helps us to understand the impact of the variables changes.

3.1. Unit root tests

First of all, it is extremely significant to refer that the variables which take part in a regression have to be characterized by stationarity. Nelson and Plosser (1982) conducted a detailed survey to analyze the phenomenon of stationarity for a package of macroeconomic variables by means of ARMA models and the persistence of time series on the levels of first differences. The most common stationary test is the Dickey Fuller (DF) test, however there is a huge amount of tests. We are going to employ the Augment Dickey Filler test, the Phillips - Perron test and the KPSS test. We can outline that time series with no pattern can be characterized as white noise and it is just a random variation. Regarding the definition of white noise (weakly stationarity) we have the following: $E(Y_t)=\mu$, constant mean, $Var(Y_t)=E(Y_t-\mu)^2=\sigma^2$,constant variance and $\gamma_{t-r} = \begin{cases} \sigma^2 \\ 0 \end{cases} if\ t = r.$

3.1.1. Augment Dickey Fuller test (1981) and Phillips Perron test (1988)

According to the literature, it is evident that the first step is to employ unit root tests in order to study the stationarity of the time series. There are many tests that take part in this kind of researches, the Augment Dickey Fuller test is one of the main method to analyze the series. The

ADF test is the same test as the Dickey Fuller test but it targets to correct the autocorrelation of the residuals, according to the following models:

Without constant and without trend:

$$\Delta Y_t = \psi Y_{t-1} + \sum_{i=1}^{p} \alpha_1 \Delta Y_{t-1} + e_t \qquad (1)$$

Without trend:

$$\Delta Y_t = \mu + \psi Y_{t-1} + \sum_{i=1}^{p} \alpha_1 \Delta Y_{t-1} + e_t \qquad (2)$$

With trend:

$$\Delta Y_t = \mu + \lambda_t + \psi Y_{t-1} + \sum_{i=1}^{p} \alpha_1 \Delta Y_{t-1} + e_t \qquad (3)$$

Where μ represents a constant, λ is time trend, e_t is white noise, p indicates the lag length in order to face the autocorrelation of the residuals. For t-statistic we have the following equation: $t = \frac{\hat{\psi}}{se(\hat{\psi})}$. In this research the Akaike's information criterion (AIC) is used for the optimal lag length.

The Augment Dickey Fuller test is based on the null (H_0) and alternative (H_1) hypothesis:

H_0: $\psi = 0$, there is unit root, the time series are not stationary I(1)
H_1: $\psi < 0$, there is not unit root, the time series are stationary I(0)

At this point we reject the null hypothesis if the t-statistic is less than the critical value.

As we can take into consideration, in the Augment Dickey Fuller test there are extra additional terms in order to face the autocorrelation of the residuals. This particular test is non-parametric and follows the same asymptotic theory as the DF test, so there is the same structure on hypotheses. Phillips – Perron (Peter Phillips and Pierre Perron) test follows the same hypotheses as the Augment dickey Fuller test, the null hypothesis (H_0) means that there is unit root, as a result the series are not stationary I(1), the alternative hypothesis (H_1) means that there is not unit root test and the time series are stationary I(0).

3.1.2. Kwiatkowski – Phillips – Schmidt – Shin test (1992)

Last but not least, the KPSS test is a unit root test which is based on the Lagrange multiplier test and proposed by Denis Kwiatkowski, Peter Phillips, Peter Schmidt and Yongcheol Shin (1992). However, this particular test is based on the following hypothesizes:

Null hypothesis the data are stationary I(0) (t-statistic KPSS > critical value), the alternative the data are not stationary I(1) (t-statistic KPSS < critical value).

$$KPSS = \frac{1}{T^2}\sum_{t=1}^{T} S_{t^2}/S^2L \quad (4)$$

Where:

$$S^2 = \frac{1}{T}\sum_{t=1}^{T} e_t^2 + \frac{2}{T}\sum_{s=1}^{L} \left(1 - \frac{s}{L+1}\right) + \sum_{t=s+1}^{T} e_t e_{t-s} \quad (5)$$

And $S_t = \sum_{s=1}^{t} e_i$

At this point note that *1-s / (L+1) = w(s,L)* is the Bartlett window that ensure the positivity of S^2.

3.1.3. Zivot and Andrew test (1992)

As we can see, the previous tests, do not take into account some shocks that influence the financial variables, such as shocks, economic crises, flues etc. Perron and Vogelsang (1992) and Zivot and Andrew (1992) strived to explain the economic breakdowns by means of dummies into Equation (6). As it is perceived, the structural breaks can be explained by the following form:

$$\Delta y_t = \mu + \lambda_t + \psi y_{t-1} + \gamma DU_t(\lambda) + \sum_{i=1}^{p} \alpha_1 \Delta Y_{t-1} + e_t \quad (6)$$

Where $\lambda = T_B/T$ is the location of the break.

3.2. Cointegration tests

The next step is to apply cointegration tests in order to ensure the long run relation between the stock prices and the exchange rates of each country. The equilibrium relationship between two markets can be recognized by many methods, according to literature the most common are Engle – Granger (1987) two step methods, Johansen test (1995), Gregory and Hansen test (1996), Saikkonen and Lutkepohl test (2000a,b,c). Before we carry out cointegration test, we have to provide that the time series are not stationary I(1).

3.2.1. Engle-Granger two step method (1987)

In case of Engle and Granger (1987) test, we will use the Ordinary Least Squares (OLS) method according to the following regression:

$$SP_t = \alpha_1 + \beta_1 EX_t + u_{1t} \qquad (7)$$

$$EX_t = \alpha_2 + \beta_2 SP_t + u_{2t} \qquad (8)$$

Furthermore, we have to estimate the following regression where $\hat{u}_t$represents the residuals of the previous regressions:

$$\Delta\hat{u}_t = \mu + \lambda_t + \psi\hat{u}_{t-1} + \alpha_1 \Delta\hat{u}_{t-1} + error \qquad (9)$$

Which is based on the null hypothesis H_0: ψ=0, the residuals are not stationary $\hat{u}_t$~ I(1) so, there is no cointegrationand the alternative hypothesis H_1: ψ<0, the residuals are stationary $\hat{u}_t$~ I(0) and there is cointegration. In the last case, we have to take into account that there is a long run relationship between the two markets and it is necessary to test the causality relation by means of a Vector Error Correlation Model (VECM).

In order to decide the lag length of the model we are going to use the Information criteria which indicate the number of lags. The most common are the Akaike's criterion *AIC* (1973), Schwartz's Bayesian criterion *SBIC*(1978) and Hannan-Quin criterion *HQIC*(1979).

$$AIC = \ln(\hat{\sigma})^{\,2} + \frac{2k}{T} \qquad (10)$$

$$SBIC = \ln(\hat{\sigma})^{\ 2} + \frac{k}{T} LnT \qquad (11)$$

$$HQIC = \ln(\hat{\sigma})^{\ 2} + \frac{2k}{T} \ln(\ln(T)) \qquad (12)$$

Where$\hat{\sigma}$is the variance of residuals, k=p+q+1, T indicates the size of sample, k is the number of coefficients and q= Moving-Average process, MA(q) and p=Autoregressive model, AR(p). As we can observe LnT is the difference between AIC and SBIC criterion. The LnT is replaced by 2, in order to optimize our model we tend to choose the criterion which minimizes the price.

3.2.2. Johansen test (1995)

What is more, while the variables contain a unit root I (1), we employ Johansen test in order to establish the existence of long run relation between the two markets. Firstly, we have to bear in mind the indications of the Information criteria so as to choose the appropriate lag length. A VAR model can be written as:

$$Y_t = \sum_{j=1}^{p} A_j Y_{t-j} + u_t \qquad (13)$$

However, at this point, Johansen (1995) built a p-dimensional VECM model according to the following relation:

$$\Delta y_t = \Pi Y_{t-1} + \sum_{j=1}^{p-1} \Gamma_j \Delta y_{t-j} + u_t \qquad (14)$$

With $\Pi = \sum_{i=1}^{\rho} A_i - I$ and $\Gamma_j = -\sum_{j=i+1}^{\rho} A_j - I$, i = 1,2,..,r

The form of trace test-statistic is the following:

$$LR(r_0) = -T \sum_{j=ro+1}^{K} \log(1 - \lambda_j) \qquad (15)$$

Where the eigenvalues are represented by λ_j.

The null and the alternative hypotheses will indicate us whether there is cointegration relation or not. The null hypothesis is based on whether the number of cointegrating vectors is less than or equal to r, the alternative means that there are at most r cointegrating vectors. We can accept the null hypothesis if the statistic is smaller than critical value so, the variables do not have a long term relationship.

3.3. Vector Autoregressive Model, Vector Error Correction Model and Granger Causality test

The main part of this study is to figure out the relationship between the stock prices and foreign exchange rates. Plenty of investigators use the classical Granger causality (1969) to explain the causal relation between the two variables in the relative literature. In case that there is no cointegration we use the following framework of a vector autoregressive model:

$$\Delta SP_t = \alpha_1 + \sum_{j=1}^{m} \beta_{1j}\, \Delta SP_{t-j} + \sum_{j=1}^{m} \delta_{1j}\, \Delta EX_{t-j} + e_{1t} \qquad (16)$$

$$\Delta EX_t = \alpha_2 + \sum_{j=1}^{m} \beta_{2j}\, \Delta SP_{t-j} + \sum_{j=1}^{m} \delta_{2j}\, \Delta EX_{t-j} + e_{2t} \qquad (17)$$

where we symbolize the stock prices as SP and the exchange rates as EX, Δ is the difference operator because of the series have to be stationary and e_{it}, where $i=1,2$ is the white noise with zero mean, $E(e_t) = 0$ and constant variance $E(e^2_t) = \sigma^2$, α_i is a constant, m is the lag length. We follow two hypotheses to test the Granger causality, particularly, the null hypothesis (H_0) means that $\delta_{1j} = 0$ and the alternative (H_1) is at least one of δ_{1j} is not zero and means that EX does not cause SP. We apply the same hypothesis for δ_{2j}, too.

Conversely, in case of cointegration, we have to add the error correction term in the previous VAR models (16), (17), creating a Vector Error Correction Model.

$$\Delta SP_t = \alpha_1 + \varphi_1(SP_{t-1} - \xi EX_{t-1}) + \sum_{j=1}^{m} \beta_{1j} \Delta SP_{t-j} + \sum_{j=1}^{m} \delta_{1j} \Delta EX_{t-j} + e_{1t} \quad (18)$$

$$\Delta EX_t = \alpha_2 + \varphi_2(SP_{t-1} - \xi EX_{t-1}) + \sum_{j=1}^{m} \beta_{2j} \Delta SP_{t-j} + \sum_{j=1}^{m} \delta_{2j} \Delta EX_{t-j} + e_{2t} \quad (19)$$

Where φ_1 and φ_2 represent the long run disequilibrium between $SP_{t-1} - \xi EX_{t-1}$

The Granger Causality test provide us the direction of the movements between the SP and EX, from exchange rates to stock prices (EX→SP), from stock prices to exchange rates (SP→EX), bidirectional relation between the two markets (EX↔SP), and independent relationship between them. This particular test is based on the F distribution according to *Wald (1940)*:

$$F = \frac{\frac{SSR_R - SSR_U}{k}}{\frac{SSR_U}{n-2k-1}} \qquad (20)$$

Where SSR_R and SSR_U are the residuals sum of squares for restricted and unrestricted model, k is the number of restrictions and n is the size of sample

If the F value is less than the F statistic, then we accept the null hypothesis (H_0) and the EX does not cause the SP for the first model (similar effects for the second model), but if the F is greater than the F statistic, we reject the null hypothesis and the EX cause the SP according to the first model.

3.4. Data

To conduct this research we utilized data for both the foreign exchange market and the stock market. In other words, the exchange rates and the stock prices were the main components for this investigation for a number of countries. Particularly, we utilized monthly data for two advanced economies: Canada, Japan and two emerging economies: India and Brazil for the period 01:2002 – 12:2017. The spot exchange rates are obtained from the Federal Reverse economic Data database of the Federal Reserve Bank of St. Louis and they are expressed as a domestic currency per U.S. dollar. The stock indices are obtained from Yahoo Finance in case of Canada and Japan and from the domestic stock markets of Brazil and India. It is extremely significant to refer that the most researchers, at first step, converted their data into natural logarithms. The main idea of this particular research is based on the structure of Granger et al. (2000). The following table (*Table 2*) represents some details of our data.

Table 2: Data details

Country	*Exchange Rate*	*Stock Index*	*Currency*
<u>*Advanced Markets*</u>			
Canada	CAD/US	S&P/TSX Composite index	Canadian Dollar
Japan	JPY/US	Nikkei 225	Yen
<u>*Emerging Markets*</u>			
Brazil	BRL/US	BOVESPA index	Brazilian Real
India	INR/US	BSE Sensex	Indian Rupee

The next tables, (*Table 3* and *Table 4*) represent the descriptive statistics of both exchange rates and stock prices.

Table 3: Descriptive statistics for exchange rates

	Descriptive statistics			
	CAD/US	JPY/US	BRL/US	INR/US
Obs.	192	192	192	192
Mean	0.16011	4.6463	0.86453	3.92840
Median	0.14427	4.6814	0.82226	3.87670
Maximum	0.46982	4.8952	1.40010	4.22300
Std. Dev.	0.13671	0.1409	0.25310	0.16203
Skewness	0.4611	(0.6921)	0.2351	0.4928
Kurtosis	(0.7161)	(0.5419)	(1.0801)	(1.1341)

Table 4: Descriptive statistics for stock prices

	Descriptive statistics			
	S&P/TSX Composite index	Nikkei 225	BOVESPA index	BSE Sensex
Obs.	192	192	192	192
Mean	9.3561	9.4522	10.629	9.5037
Median	9.4261	9.3825	10.851	9.7503
Maximum	9.6933	10.033	11.244	10.436
Std. Dev.	0.2478	0.0304	0.5474	0.6847
Skewness	(0.9202)	0.1201	(1.2800)	(0.8349)
Kurtosis	(0.1809)	(1.2866)	0.54010	(0.4141)

As mentioned above, the macroeconomic variables have to be converted into natural logarithms in order to be capable of analyzing. The following figures (*Figure 1, Figure 2, Figure 3, and Figure 4*) disclose the pairs of time series for every country throughout the years. As we can see, both exchange rates and stock prices are not characterized as stationary on the levels and they follow a random walk, the literature showed that this fact was to be expected.

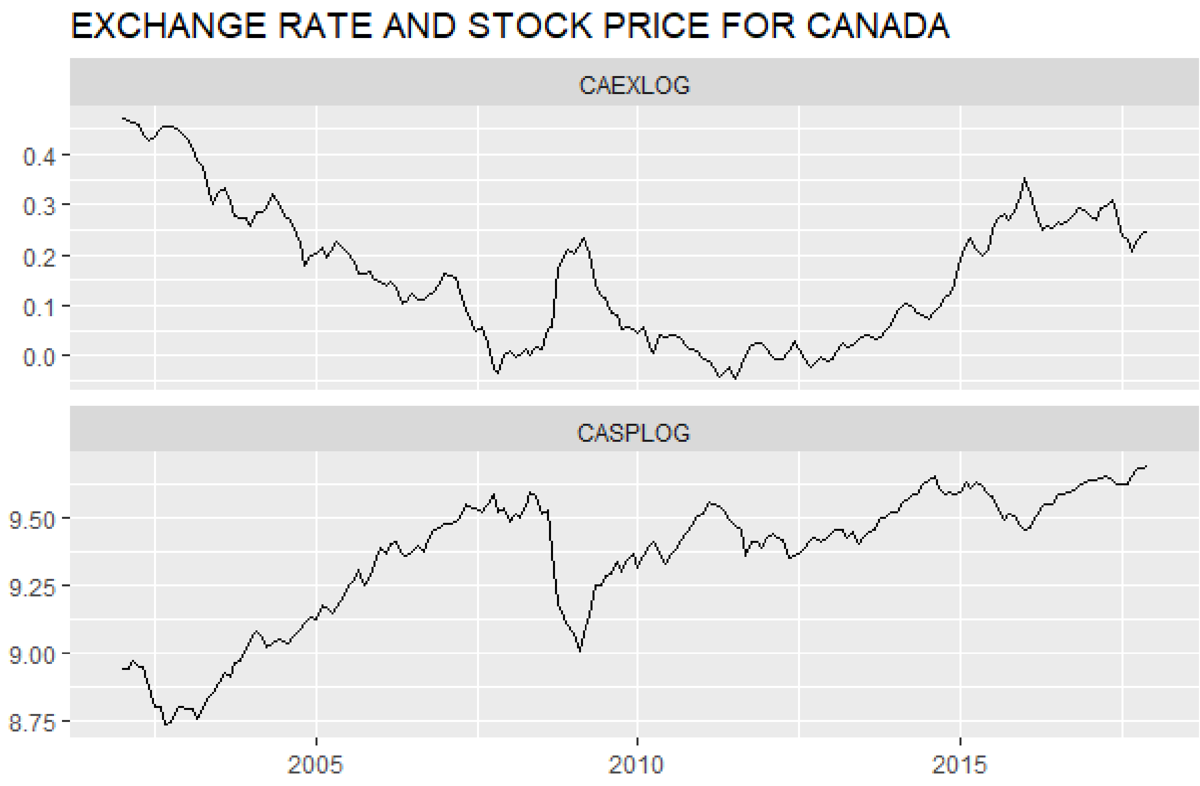


Figure 1: Exchange rate and stock price for Canada

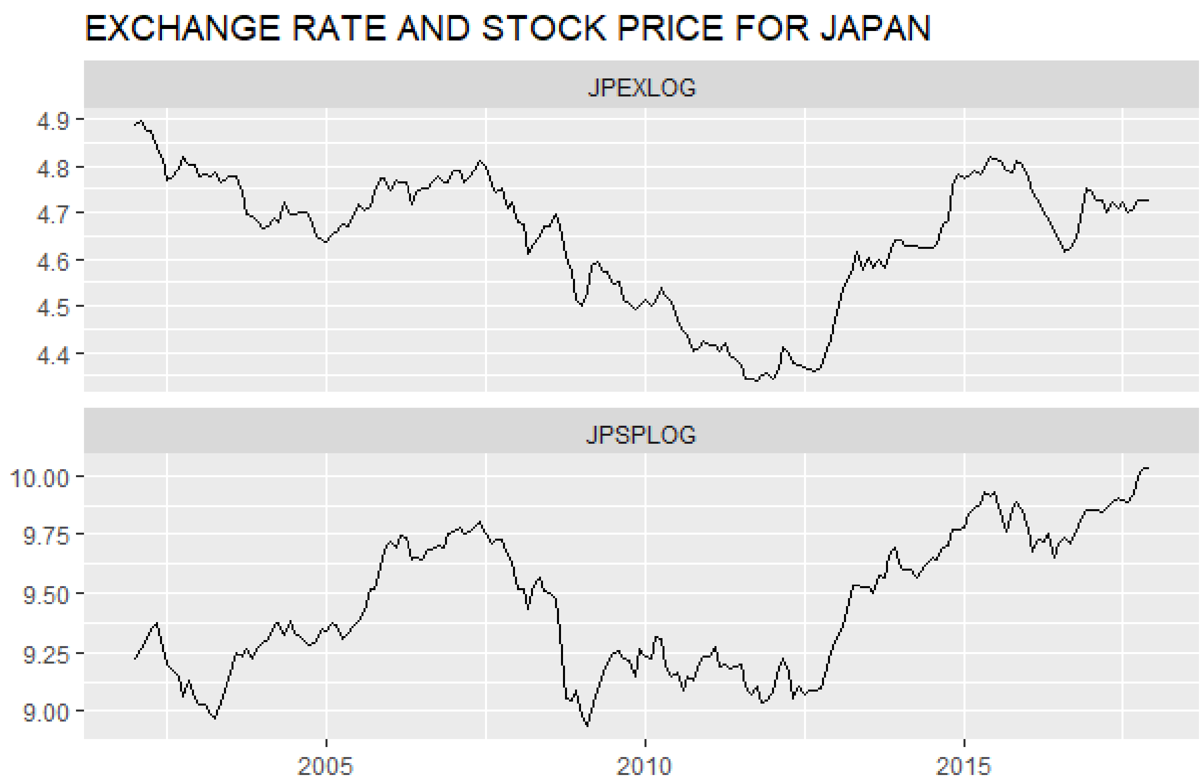


Figure 2: Exchange rate and Stock price for Japan

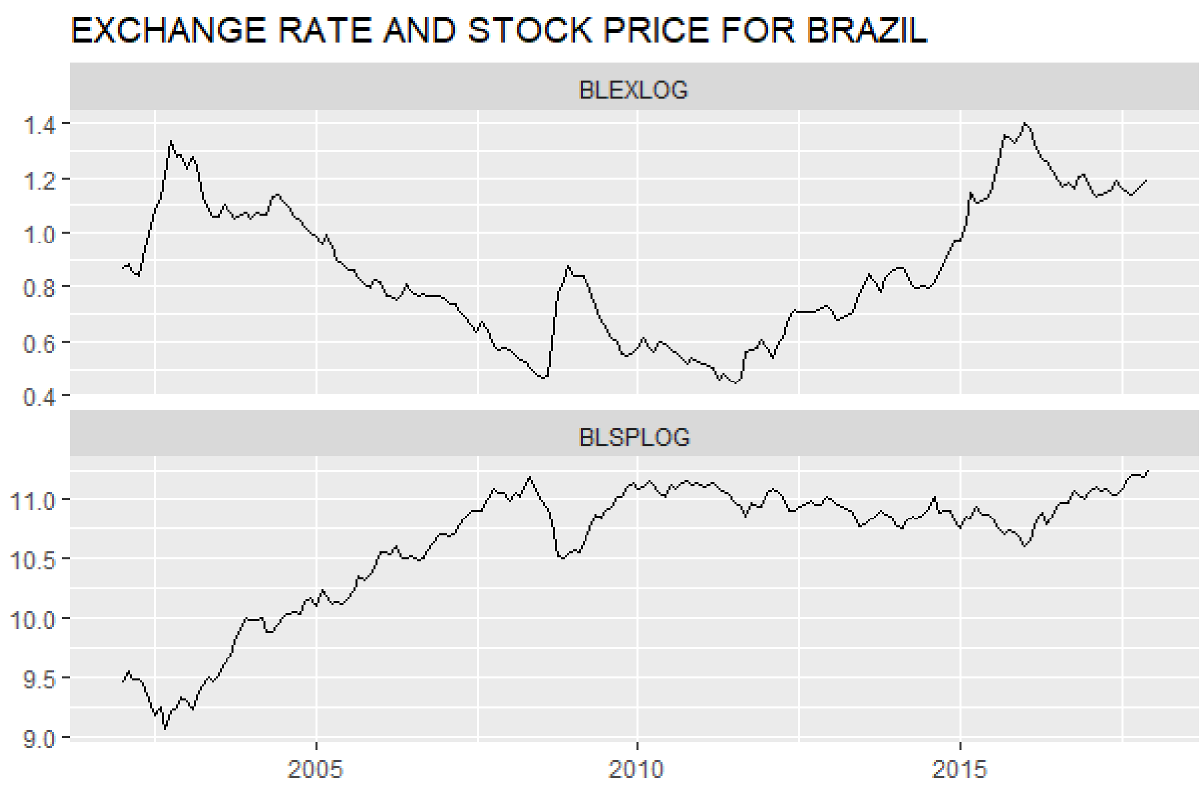


Figure 3: Exchange rate and Stock price for Brazil

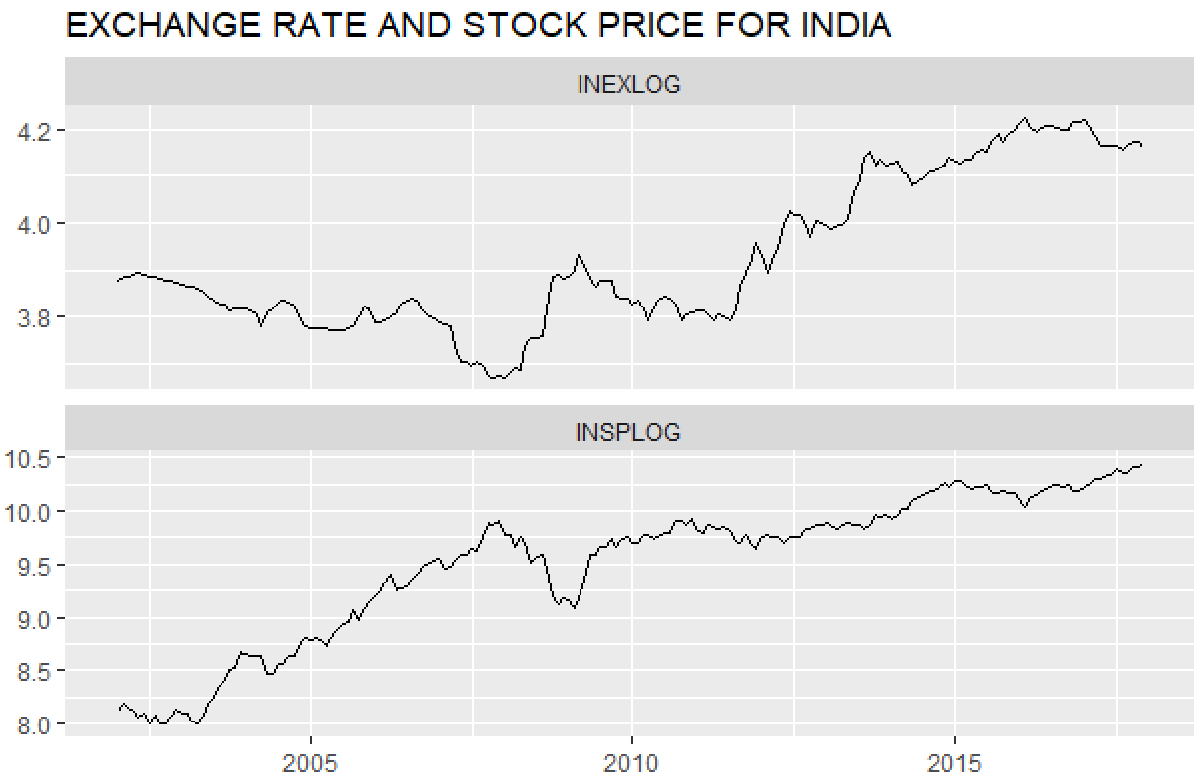


Figure 4: Exchange rate and Stock price for India

4. Preface of empirical results

In this particular context, we present and analyze the empirical results which were exported based on the methodology sector. Firstly, we apply a range of unit root tests in order to examine the stationarity on the financial variables. The main target of this research, is to detect the relationship between exchange rates and stock prices however, before applying causality tests for the short run period, we will utilize a number of cointegration tests to analyze the results in the long run period. After all, it is interesting to illustrate the results of the Impulse Response Function and the Variance Decomposition which depict the response of variables to random shocks and the period until their absorption.

In the beginning, it is important to highlight that the frequency of the data is on a monthly basis with a view to avoid size anomalies and noise problems. Kamstra et al. (2000) argue that the stock prices subject to a huge variety of size effects which can relate to psychological behaviors and there are day and week effects that incorporate temporary information and anomalies. As we can see Guglielmo et al. (2014) avoided daily frequency of data to eschew econometric problems, compared to Granger et al. (2000) which utilized daily frequency on their data and highlighted that there were effects.

4.1. Unit root tests: Augment Dickey Fuller test and Phillips –Perron test

Initially, it is necessary to test the variables for stationarity. Kwiatkowski et al. (1992) indicated that the unit root test is one of the main steps in order to detect stationarity in economic time series. Augment Dickey Fuller and Phillips – Perron (1988) tests are based on the same null and alternative hypothesis, in contrast with KPSS test. The results of unit root tests, both with and without trend, are included in the following table (*Table 5*).

Table 5: Augment Dickey Fuller and Phillips Perron tests

		(ADF) trend	(ADF) No trend	(PP) trend	(PP) No trend
Exchange rates		*t-statistic*	*t-statistic*	*t-statistic*	*t-statistic*
CAD/US	Level	(1.88537)	(2.31697)	(1.70313)	(2.23185)
JPY/US	Level	(1.76350)	(2.01834)	(1.54531)	(1.89418)
BRL/US	Level	(1.42627)	(1.35331)	(1.25526)	(1.18636)
INR/US	Level	(2.54424)	(0.70360)	(2.08089)	(0.38135)
CAD/US	D1	(9.85094)*	(9.64490)*	(9.73158)*	(9.55560)*
JPY/US	D1	(7.45513)*	(7.35872)*	(11.0199)*	(10.9137)*
BRL/US	D1	(6.08587)*	(6.30484)*	(9.05400)*	(9.03564)*
INR/US	D1	(4.93715)*	(4.85617)*	(9.54439)*	(9.51282)*
Stock Indices					
S&P/TSX Comp.	Level	(2.59736)	(1.56973)	(2.34836)	(1.50545)
Nikkei 225	Level	(1.59293)	(1.00061)	(1.59919)	(1.06735)
BOVESPA	Level	(1.67934)	(1.65776)	(1.79919)	(1.85305)
BSE Sensex	Level	(1.95463)	(1.55349)	(2.09743)	(1.53594)
S&P/TSX Comp.	D1	(7.48349)*	(7.50314)*	(11.0156)*	(11.0397)*
Nikkei 225	D1	(11.5888)*	(11.5760)*	(11.6530)*	(11.6486)*
BOVESPA	D1	(12.6261)*	(12.6235)*	(12.2102)*	(12.2106)*
BSE Sensex	D1	(12.1367)*	(12.1367)*	(12.7016)*	(12.7042)*

Notes: Without trend: 1% -> -3.43, 5% -> -2.86 and with trend 1% -> -3.96, 5% -> -3.41. D1 represents the differences of natural logarithms $\Delta SP = \ln(SP) - \ln(SP_{t-1})$, $\Delta EX = \ln(EX) - \ln(EX_{t-1})$.

According to literature, in the most papers the authors failed to reject the null hypothesis, so their time series had unit root. We end up that we cannot reject the null hypothesis, too. Obviously both exchange rates and stock indices are not stationary on the levels, this problem could be solved by creating the first differences of them as Nelson and Polsser (1982) indicated on their research. In this way, we ensure that the variables are stationary, as we can reject the null hypothesis (H_0) while t-statistic is higher than critical value and there is no unit root on them.

4.2. Kwiatkowski-Phillips-Schmidt-Shin test (KPSS)

Furthermore, we can use the KPSS test to check for stationarity, however it is interesting to refer that the hypotheses of this test are not the same as ADF test. Null hypothesis (H_0) means that the variables are stationary I (0) and alternative hypothesis (H_1) indicates that the time series are not stationary I (1). The *Table 6* indicates the results of the KPSS unit root test.

Table 6: Kwiatkowski-Phillips-Schmidt-Shin test

Variables	Difference	KPSS (trend)	KPSS (without trend)
Exchange rates		*statistic*	*statistic*
CAD/US	Level	0.81750	1.10337
JPY/US	Level	0.63354	0.94553
BRL/US	Level	0.83665	0.86416
INR/US	Level	0.73992	2.93849
CAD/US	D1	0.03845	0.43552
JPY/US	D1	0.07039	0.27460
BRL/US	D1	0.07672	0.17356
INR/US	D1	0.08111	0.22447
Stock indices			
S&P/TSX Comp.	Level	0.37135	2.63948
Nikkei 225	Level	0.44375	1.18028
BOVESPA	Level	0.79990	2.52955
BSE Sensex	Level	0.60052	3.36074
S&P/TSX Comp.	D1	0.04310	0.05120
Nikkei 225	D1	0.07720	0.12039
BOVESPA	D1	0.06699	0.18317
BSE Sensex	D1	0.04279	0.12209

Note: Critical value for 1% is 0.739 and for 5% is 0.463.

At first glance, the majority of economic time series are not stationary I (1) and for this reason we prefer to convert our time series into logarithmic first differences. Kutty (2010) argues that the most investigators avoid analyzing time series on their original measurements. Apart from this, Abdalla and Murinde (1997) which investigated a group of Asian emerging economies from 1985 to 1994, contend that there is no stationary on the levels, too.

4.3. Zivot and Andrew unit root test

An alternative approach would involve modifying the initial model by means of a structural break. Consequently, an interested test is that of Zivot and Andrew, which can study the stationarity of the variables including structural breaks. This fact gives us the chance to notice how much the breaks can affect the stationarity. The next table (*Table 7*) shows the t-statistics of this particular test and the dates on which the structural breaks have occurred. Furthermore, the *Figure 5* and *Figure 6* depict the structural breaks that are statistical significant based on Zivot and Andrew test. Both of them are related to the period of crisis of 2007-2009. The *Figure 5* shows the stock prices of Canada and the *Figure 6* depicts the Indian stock market as well as their significant structural breaks.

Table 7: Zivot and Andrew results

Zivot and Andrew test				
	Canada	Japan	Brazil	India
Exchange rates	-3.261	-3.7923	-4.4726	-3.2806
Str. Break	*8M2010*	*8M2008*	*3M2009*	*7M2011*
Stock indices	-6.2842	-4.3594	-4.1037	-5.1480
Str. Break	*5M2008*	*5M2008*	*9M2006*	*4M2008*

Note: The critical values are -5.57, -5.08 and -4.82 at 1 %, 5 % and 10% levels of significance.

As mentioned above, the structural breaks are significant only in case of stock market of Canada and India. This is clearly an impact of the financial crisis which took place on 2008.

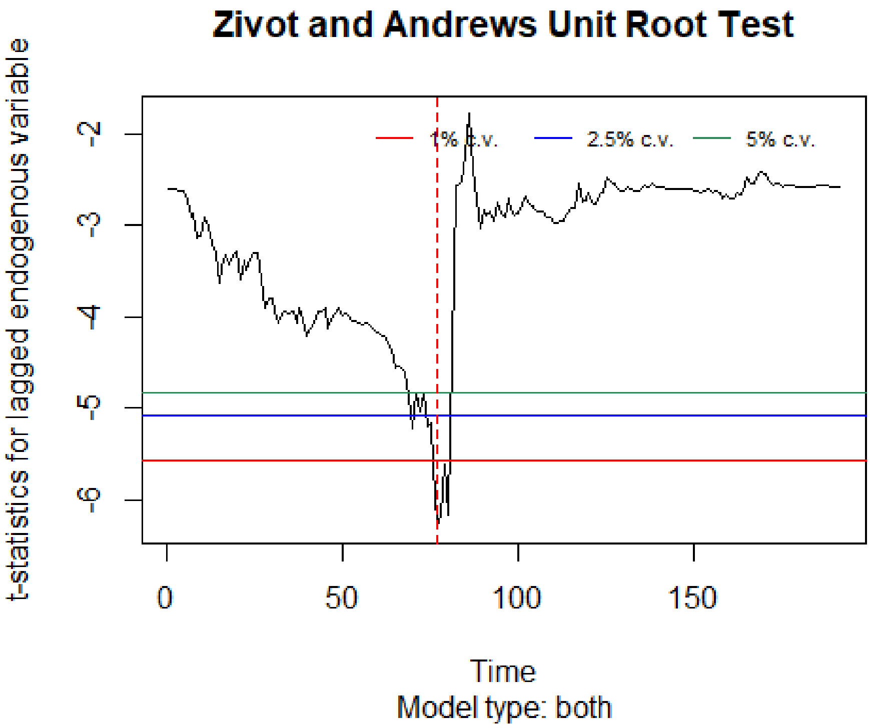


Figure 5: Structural breaks in Canada

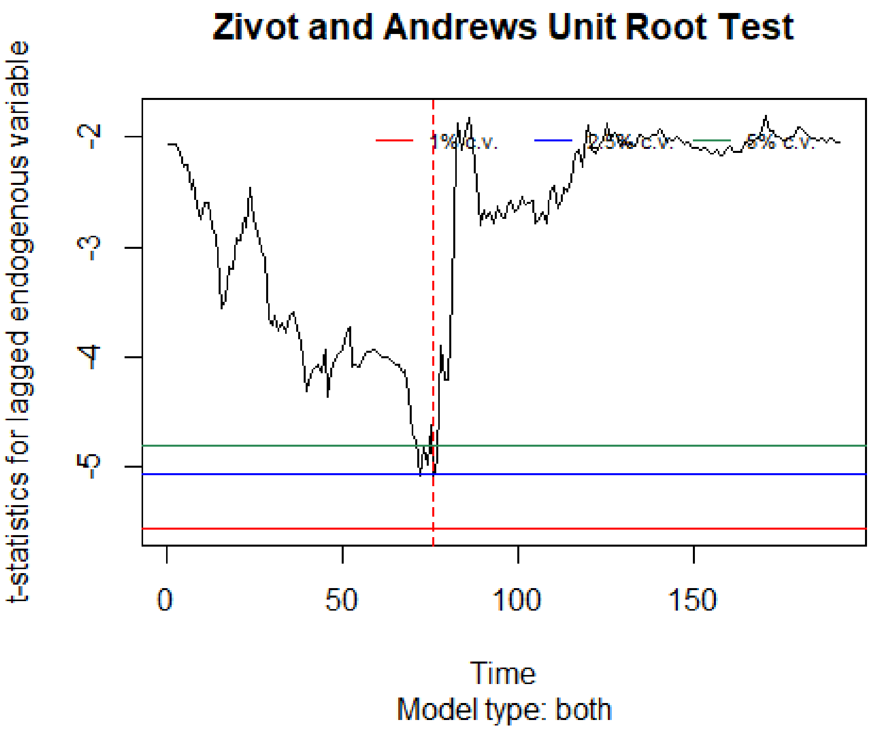


Figure 6: Structural breaks in India

At this point it is important to make a reference to the global financial crisis of 2007-09. It is undeniable that the collapse of Lehman Brothers in 2008 shocked the entire financial sector. As we can see the most of structural breaks, significant or not, concern this particular period of crisis. Within the literature, Horvath and Poldauf (2012) employed GARCH models for a great number of countries, including Brazil, Canada and Japan, so as to study the kind of correlation among stock markets during the period of crisis. They concluded that stock markets in Brazil, UK and Canada have strong indications of correlation with the stock market of US. What is more, Luchtenberg et al. (2015) examined whether contagion interact among countries during crises periods. In case of 2008 crisis, the United States received worldwide shocks as a whole, without distinguishing whether they came from different countries and they ended up that after the 2008 crisis, the contagion (because of shocks) has spread not only to emerging economies but also to economically strong countries to a great extend.

4.4. Cointegration tests

The complete analysis has two components, the relationship between the FX and SP market, both in the long and in the short run period. Before we study whether there is causality relationship between the SP and FX in the short run period, first of all, we must consider the long run relation between the two financial variables by means of cointegration tests. There are many cointegration tests that can provide relevant results, some of them are the Engle – Granger (1987) two step method and the Johansen test (1995). However, the previous tests do not reflect the impact of structural breaks. At this point of the research, we are among two paths of methodology techniques, the cointegration test indicates the suitable direction. Specifically, if there is no cointegration in the pairs of the variables of each country, we are going to use the standard Granger causality test through a VAR model, on the other hand, if there is equilibrium relationship we have to utilize the approach of causality test which is provided by a VECM model. Cointegration tests are going to indicate us whether the two markets can cause each other in the long run period. Consequently, if we demonstrate the long run relationship between SP_t and FX_t, we can explore the short run relationship by means of VECM or VAR model.

Before proceeding to the main analysis, we have to select the appropriate lag length of VAR models. Because of the fact that our data are on a monthly basis we select as maximum lag length 24, however the following tables (*Table 8, Table 9, Table 10 and Table 11*) represent only 8 lags for the sake of simplification. At first glance, the tables indicate the appropriate number of lags based on the information criteria. Highlight that we will rely on the indications of the BIC criterion in order to adopt the appropriate lag length. However, in some cases we must overcome autocorrelation problems, so it is necessary to increase the number of lags. In particular we realized that in case of India we have to utilize 6 lags and 2 lags for the other countries.

Table 8: Information criteria in Canada

Lags	*LogL*	*p(LR)*	*AIC*	*BIC*	*HQC*
1	746.12289	-	8.810987	-8.69942	-8.76571
2	773.41864	0.00000	**-9.08832**	**-8.90237**	**-9.01285**
3	776.52764	0.18345	-9.077710	-8.817380	-8.97206
4	778.83341	0.32952	-9.05754	-8.722830	-8.9217
5	780.44890	0.51994	-9.02915	-8.62006	-8.86313
6	785.74444	0.03157	-9.04458	-8.56111	-8.84836
7	789.87829	0.08225	-9.04617	-8.48832	-8.81977
8	793.32180	0.14198	-9.03955	-8.40731	-8.78296

Table 9: Information criteria in Japan

Lags	*LogL*	*p(LR)*	*AIC*	*BIC*	*HQC*
1	664.0536	-	-7.83397	**-7.7224**	-7.78869
2	672.2687	0.00249	-7.88415	-7.698200	**-7.80868**
3	676.843	0.05749	**-7.89099**	-7.63066	-7.78533
4	677.9384	0.70073	-7.85641	-7.5217	-7.72057
5	678.5076	0.88811	-7.81557	-7.40648	-7.64954
6	679.9348	0.58248	-7.78494	-7.30147	-7.58872
7	682.3166	0.31243	-7.76567	-7.20782	-7.53927
8	683.0712	0.82502	-7.72704	-7.09481	-7.47045

Table 10: Information criteria in Brazil

Lags	*LogL*	*p(LR)*	*AIC*	*BIC*	*HQC*
1	573.3344	-	-6.75398	-6.64241	-6.7087
2	593.7288	0.0000	-6.94915	**-6.7632**	**-6.87369**
3	598.0872	0.06858	**-6.95342**	-6.69309	-6.84777
4	599.4353	0.6099	-6.92185	-6.58714	-6.78601
5	599.5313	0.99567	-6.87537	-6.46628	-6.70934
6	602.3038	0.2358	-6.86076	-6.37729	-6.66454
7	605.5882	0.16051	-6.85224	-6.29439	-6.62584
8	607.2724	0.49815	-6.82467	-6.19244	-6.56808

Table 11: Information criteria in India

Lags	*LogL*	*p(LR)*	*AIC*	*BIC*	*HQC*
1	675.46056	-	-7.96977	-7.8582	-7.92449
2	689.24927	0.00002	-8.0863	**-7.90035**	**-8.01083**
3	691.0101	0.47459	-8.05964	-7.79931	-7.95399
4	692.15145	0.68392	-8.02561	-7.6909	-7.88977
5	698.78872	0.01001	-8.05701	-7.64792	-7.89098
6	708.25482	0.00081	-8.12208	-7.63861	-7.92587
7	715.71712	0.00486	**-8.163299**	-7.60545	-7.9369
8	716.05798	0.95356	-8.11974	-7.48751	-7.86315

4.4.1. Engle-Granger two step method

Since we have ensured the same order of integration in the previous stationarity tests, (see *Table 4* and *Table 5*) we can apply cointegration tests. The Engle and Granger test is one of them. After selecting the appropriate lag length via VAR models, we apply the particular test. As mentioned in the methodology sector, this particular approach is based on the stationarity of residuals. In other words, we will use the residuals of the OLS method so as to test whether they are stationary I(0) or not. According to indications, if we reject the null hypothesis (H_0) the residuals are characterized as stationary and there is cointegration. With this in mind, the Granger causality test has to be based on an error correction model (VECM).

The following table (*Table 12*) indicates the cointegration relation by means of Engle Granger test. The residuals are not stationary I(1), therefore we cannot reject the null hypothesis of no cointegration. Note that the critical values are the same as those of Augment Dickey Fuller test. On the side, the p-values are higher than 10% in all cases.

Table 12: Engle and Granger test

Engle - Granger Results				
	ADF (no trend)		ADF (with trend)	
Country	*t-statistic*	*p-value*	*t-statistic*	*p-value*
Canada	-1.2948	0.8327	-1.8865	0.8162
Japan	-2.3284	0.3638	-2.6953	0.4136
Brazil	-0.9716	0.9066	-2.1789	0.6900
India	-1.9966	0.5298	-2.4631	0.5401

4.4.2. Johansen test

After having a study of cointegration by means of Engle and Granger approach, further we apply the Johansen test (1995) for cointegration. We apply a detailed analysis of cointegration via Johansen version for all pairs of financial variables of countries. We accept the null hypothesis (H_0), if the price of critical value is larger than trace statistic, so there is no cointegration, on the other side, the null hypothesis is rejected if critical value is smaller than trace statistic. It is extremely significant to refer that the VAR model have to be well specified, for this reason it is necessary to ensure that there are not autocorrelation problems. At first stage, as mentioned in the previous paragraphs the lag length is determined by the Information criteria. The results in the following table (*Table 13*) are in contrast with the Engle and Granger test.

Table 13: Johansen test

	Canada EX/SP		Japan EX/SP		Brazil EX/SP		India EX/SP	
H_0:rank<=	*Statistic*	*p-value*	*Statistic*	*p-value*	*Statistic*	*p-value*	*Statistic*	*p-value*
0	8.3404	0.2181	9.1119	0.1635	13.069	0.0365	18.8830	0.0031
1	1.3315	0.2892	0.49323	0.5508	1.6006	0.2414	6.3939	0.0135

As we can see, the p-values indicate that we cannot reject the null hypothesis of no cointegration in Canada, Japan, and India at 5% significant level, this fact explains that there is no long run relationship between the two markets. Contrariwise, we reject the null hypothesis in Brazil, as a consequence we must apply a Vector Error Correction Model to study the Granger Causality for the short run period.

Granger et al. (2000) refer that there was no cointegration relation between their data from Asian countries during the period when the Asian flu broke out, probably on the grounds that the time series were on daily frequency and there were noise effects. Alagidede et al. (2011) conducted that they found no cointegration on their time series, too. In contrast, Abdalla and Murinde (1997) concluded that they detected cointegration in India and Philippines, thus they used a second model (ECM) for the cointegrated variables. Based on the methodology section, the variable pairs that are long run related have to be examined for short run relationship through VECM approach.

4.5. Granger Causality test

The long run relationship is only a part of the story, the main purpose of this particular research is to explore the relation between stock price and foreign exchange rate both in the long run and in the short run period. Based on the literature, investigators decide to test the causality relation in different ways according to the data structure. In the continue, as we have already described in the methodology part, we will frame a Vector Auto-Regression Model which gives us the opportunity to test the causality by means of Granger causality test. What is interesting to note is that we have to utilize VECM to test the causality in case of cointegrated variables. Researchers tend to utilize a combination of causality tests with the purpose of ensuring the validity of the results, for instance, Alagidede et al. (2011) examined the causality by using the standard Granger causality test for no cointegrated variables and Hiemstra-Jones test in order to study for non-linear causality.

Table 14: Granger Causality test

Null Hypothesis	F - Statistic	p-value
Canada		
Stock price--/→Exchange Rate	1.6352	0.1530
Exchange Rate --/→Stock price	4.0463	0.0017***
Japan		
Stock price --/→ Exchange Rate	0.59913	0.5504
Exchange Rate --/→Stock price	4.4438	0.0130**
India		
Stock price--/→Exchange Rate	2.6002	0.0269**
Exchange Rate --/→Stock price	4.6616	0.0005***
Brazil		
Stock price--/→Exchange Rate	4.7623	0.0002***
Exchange Rate --/→Stock price	1.8457	0.7288

Note: --/→ means does not Granger Cause, * = 1% significance, ** = 5% significance, *** = 10% significance.

The previous table (*Table 14*), indicates whether we can reject the null hypothesis or not. In other words, the p-value and the F-statistic give us the opportunity to understand the causal relation between foreign exchange market and stock market for every country. Note that according to Information Criterion *BIC* and VAR models, we utilized 5 lags for Canada and India and 2 for Japan and Brazil. Therefore, we observe that in Canada there is a causal relationship from FX market to stock prices at all significance levels (*p-value= 0.0017*). Alagidede et al. (2011) realized that the stock indices are caused by the FX market in most of the investigated countries. It is worth mentioning that our time horizon includes the global economic crisis of 2007-2009, based on the literature this fact has a significant impact on the final interpretation. In case of Japan we observe a similar kind of causal relationship between the two markets.

On the other hand, in terms of emerging economies, we end up that in India there is a bidirectional relationship between SP and exchange rates, stock prices cause the FX market at 1% and 5% significance levels and there is a causal relationship from exchange rate to stock market at all significance levels (*p-value = 0.0005*). The particular results are in contrast with those of Bhattacharya and Mukherjee (2003) which pointed out that there is no significant causal relationship between the two financial variables over the decade of 90s. They clarified that the stock market is not able of predicting the movements on others markets, including the FX market. In addition, they pointed out that the Indian economy was on development stage. This fact reflects that if the particular economy comes to a stable phase, it would be feasible the existence of causal relation between markets in future researches. In Brazil, we observe that the stock prices cause the exchange rate while there are no indications of causal relationship from exchange rate to SP.

Ajayi et al. (1998) identified that they discovered causal relation from SP to FX mainly in advanced economies but there are various results between of them, due to the fact that the emerging markets are not capable of reflecting the fluctuations in the economic sector, such as investing activities, and they fall victims of manipulation because of their limited possibilities. What is more, Chkili et al. (2014) focused on a group of countries with different regimes, via MS-VAR model, the results from Brazil showed that SP causes the exchange rates over the time horizons with high volatility levels. As well as, they emphasized that this kind of relation can be used as a barometer for investors and those who take part in monetary policies but they should be aware of the current economic shocks due to the high volatility.

At this point, it is worth mentioning the contribution of the efficient market hypothesis (EMH) by Fama (1970). It is indisputable that there are mixed results according to the literature, in some cases there is causal relation between the two markets but in some others there are not so clear results for both long run and short run period. Fama (1981) indicates that changes in an efficient stock market are not led by macroeconomic rules, by extension investors cannot interpret with absolute clarity the changes in macroeconomic variables so as to focus on increasing profits.

The indications of economic growth are often related with assets prices and they do not reflect the actual economic sector.

4.5.1. Impulse Response Function

Much attention has been drawn to Impulse Response Function (IRF). Resaran et al. (1998) mention in their analysis that IRF provide us the time horizon of the effects which are caused by a shock, however there are three reasons which play a vital role in the analysis of response function. Firstly, we have to know the type of the shocks, next it is important to know the past situation (before shocks t-1) and last but not least, the expected shocks for future period (t+1) are a significant parameter. This research contains a group of graphs via Impulse Response Function in order to explain the consequences of shocks in both exchange rates and stock indices.

We must take into account that the indications of the Impulse Response Function must agree with the results of causality tests. For example, according to Granger et al. (2000) in case the EX is affected by SP changes, the IRF analysis indicated that the response of SP to a shock of EX is not significant, this was something they noticed in the case of Philippines and Hong Kong. In the following paragraphs we represent the results of Impulse Response Function in case of each country. Nevertheless, we will focus on the figures which indicate significant response to shocks.

The following two figures represent the impulse response function in case of Canada and Japan. The Granger Causality test in the previous sector indicated that only the FX market causes the stock prices in advanced countries. On the one hand, they show the response of stock market to an exchange rate shock. By means of R, we selected a maximum period of 20. The Impulse Response Function gives us the opportunity to analyze the influence of random shocks. In Canada, (*Figure 7*) we observe that a shock from the FX market is absorbed approximately after the 14^{th} period. Firstly, the stock market has an upward course up to zero, next it follows a downward trend and after the 7^{th} period the stock market is up to zero. On the other hand, we realized that the stock prices do not cause the exchange rates. What is more, in Japan (*Figure 8*) there is the same kind of influence, in particular the FX market causes the stock market. At first glance, the graph (*Figure 8*) illustrates that the stock prices follow a downward trend after an exchange rate shock and the shock is absorbed approximately to 7^{th} period.

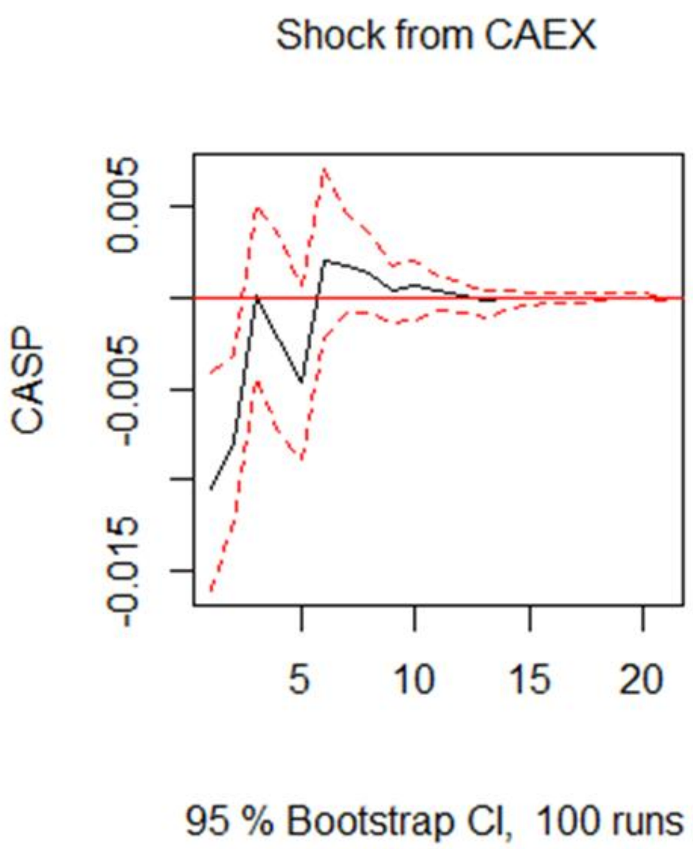


Figure 7: A shock from the FX market in Canada

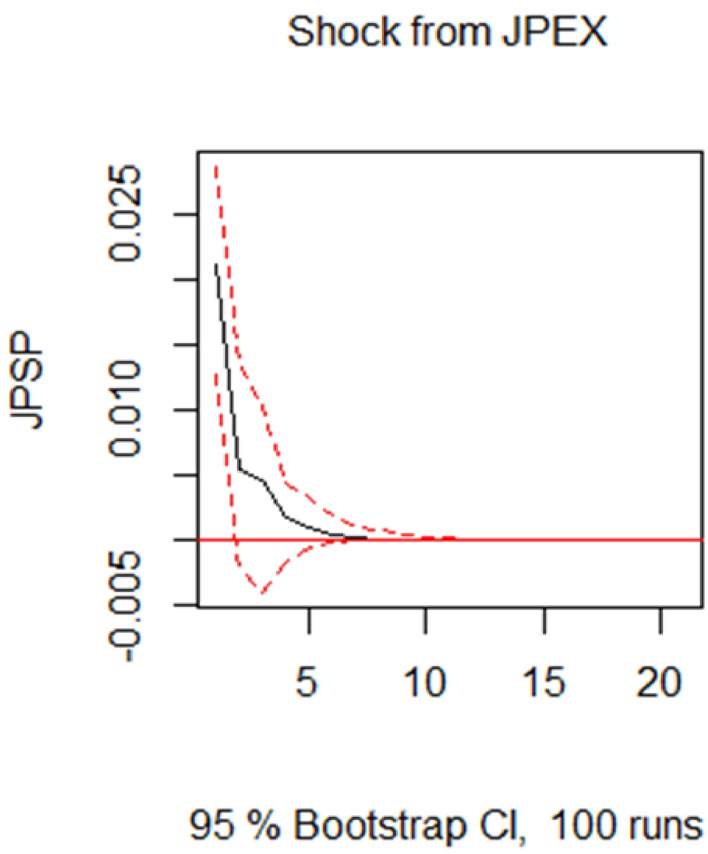


Figure 8: A shock from the FX market in Japan

Moreover, we present the same analysis for both India and Brazil. The Granger causality test indicated that there is bidirectional causal relationship in case of India. However the causality is stronger from the FX market to stock prices. The next figures (*Figure 9, Figure 10*) illustrate the particular shocks. With a quick glance we observe that there are plenty of ups and downs in both markets. It is interesting to refer that both of shocks are absorbed after the 15th period. In other words, the stock market follows an upward trend until the 5th period and falls until the 6th period. After that, it rises and reaches to 10th period, where there are not significant fluctuations. When the exchange rate receives a shock from the stock market, there are both upward and downward trends. First, the FX is negatively affected and in the 5th period we observe a strong downward trend however, approximately in the 7th period the FX market fluctuates around zero.

In Brazil we utilized a Vector Error Correlation Model to analyze the short run relationship. As we can see in the *Figure 11*, a shock from stock market has a negative impact on the exchange rate.

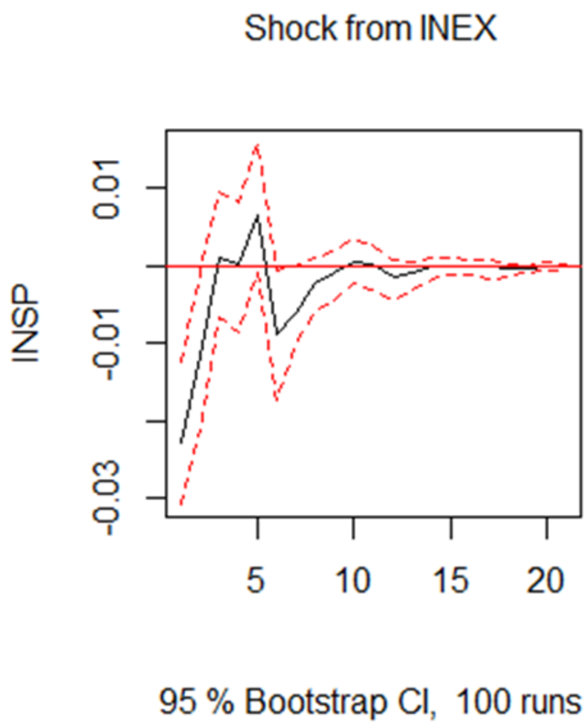


Figure 9: A shock from the FX market in India

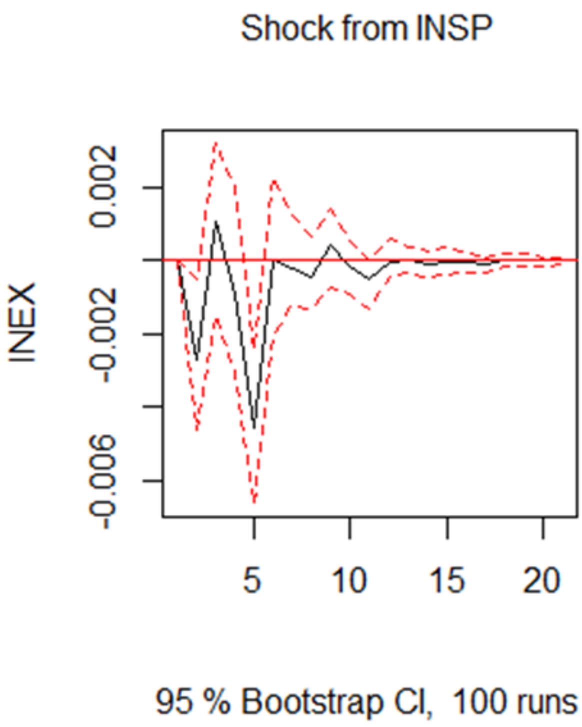


Figure 10: A shock from the stock market in India

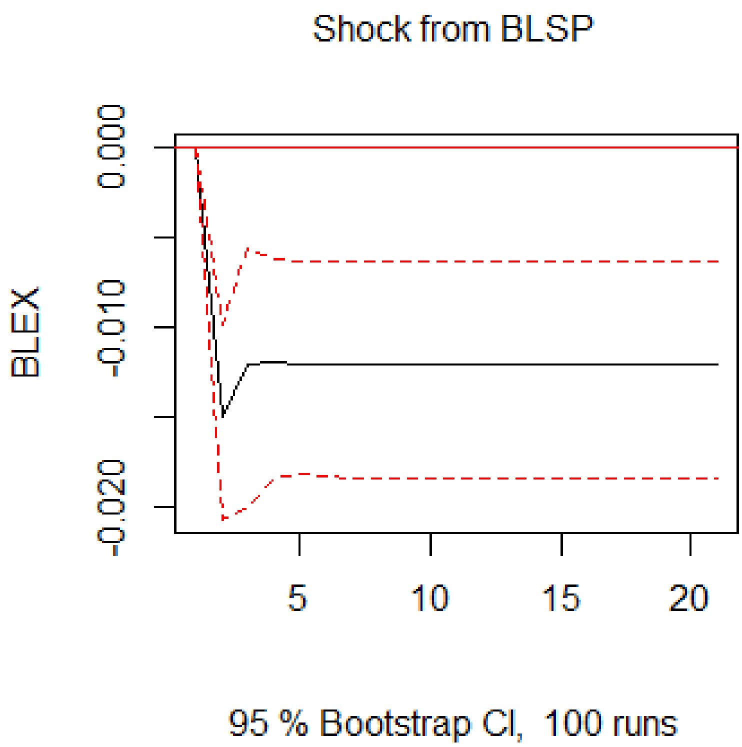
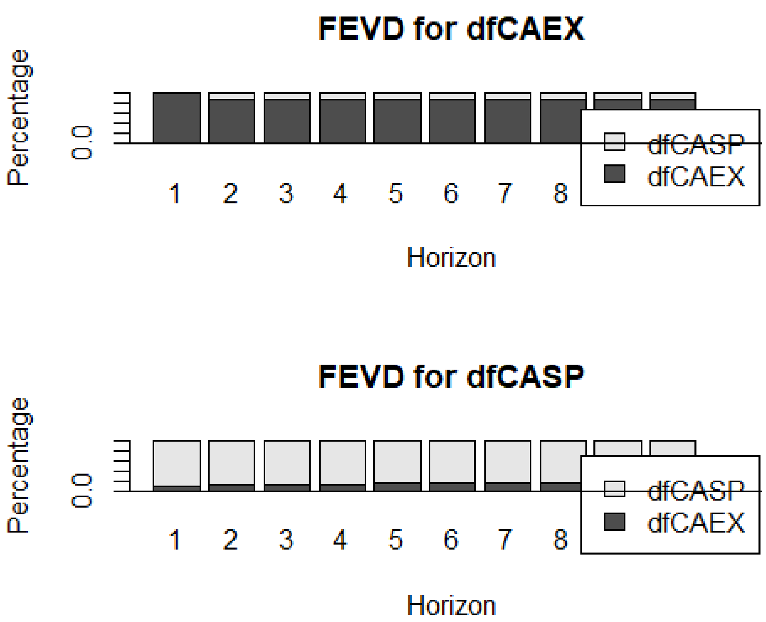


Figure 11: A shock from the stock market in Brazil

4.5.2. Variance Decomposition

The next graphs illustrate the Variance decomposition analysis. In general, through this analysis we can see to what extent the changes of a specific variable are caused due to changes of the same and to what extent to other variables. The first two graphs (*Figure 12*, *13*) concern the results for Canada and Japan. In this part of the analysis, we observe that in the case of Canada the main part of changes in the FX market are influenced by themselves, after the second period we notice a slight influence from the stock market. The same results are applied in the case of changes in the stock market with the difference that the exchange rate changes have little effect from the stock prices changes from the first period. On the other side, in Japan, the exchange rate changes are affected to an extremely small degree by the stock market while the changes in the stock market have traces of little influence from the FX market from the first period.

In India, (*Figure 14*) the exchange rate changes are affected by themselves to the greatest extend per cent but the changes in the stock market are influenced from the changes in the FX market to some extend from the first period. In case of Brazil, (*Figure 15*) it is obvious that the changes in stock indices are affected by the foreign exchange rate changes to a great extend.



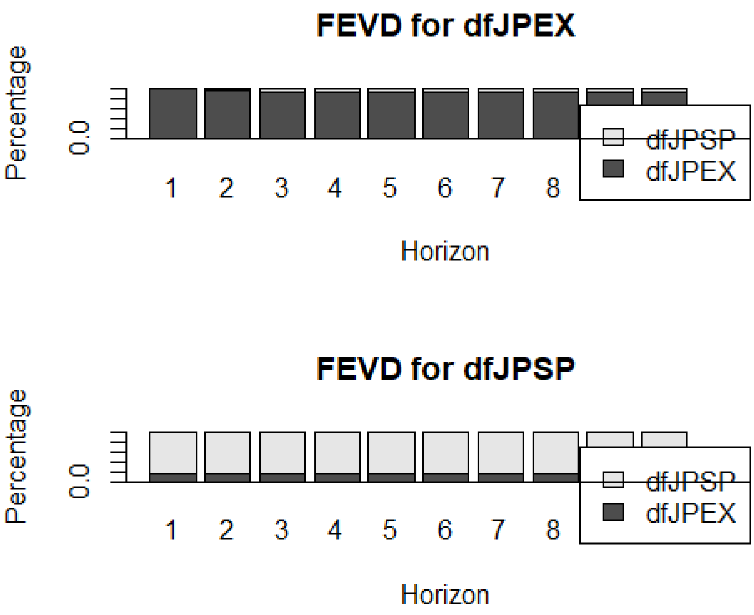
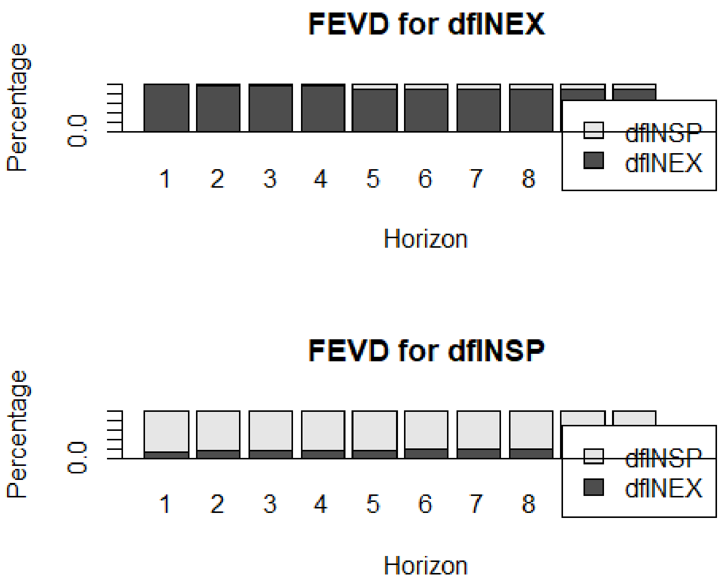


Figure 12: Variance Decomposition for Canada

Figure 13: Variance Decomposition for Japan



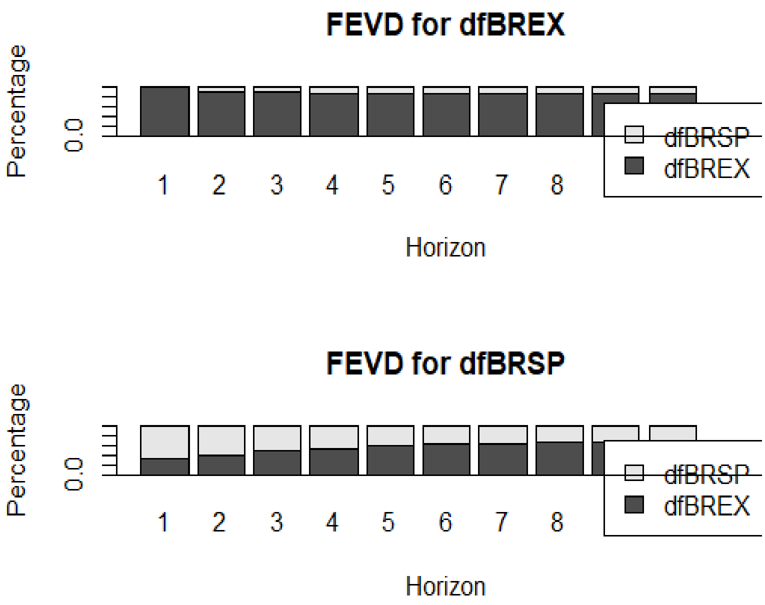


Figure 14: Variance Decomposition for India

Figure 15: Variance Decomposition for Brazil

5. Conclusion

In summary, having considered the results of the literature, we conclude that previous studies have provided a wide range of different results. This fact can be turned into a strong motivation for surveying and clarifying the relationship between the stock and exchange markets in countries with different levels of economic growth. As a matter of fact, the most studies are based on empirical researches, hence the investigators need to have comprehensive and detailed knowledge of the factors that can affect the respective markets. In this research, we studied two advanced and two emerging economies. Firstly, we employed stationarity tests. After that, cointegration tests played a profound role in order to explain the long run relationship between stock indices and exchange rates, Granger causality test indicated the short run relationship and the Impulse Response Function showed the response of variables to shocks.

In particular, according to Engle and Granger test we detected that our variables are not cointegrated, these results are in contrast with Johansen test indications, which explained that there is long run relationship only for Brazil. We cannot ignore that previous studies pointed out that emerging economies are mutable and this can be a factor that can explain the long run relationship. However, the Granger Causality test provided us significant results for the short run relationship. To put it more specifically, in case of advanced economies, Canada and Japan, we conclude that there is causal relation from the FX market to stock market but the stock prices do not cause the FX market in any of these countries. In India we observe a bidirectional relationship between the two markets, according to the literature we realize that the emerging countries are more vulnerable, as a result they accept strong waves of influence from the whole economic sector. In the other emerging economy, Brazil, we observed a strong relationship from the stock prices to exchange rate. We followed the similar methodology framework as Granger et al. (2000), however, they concluded that the results were mixed, they detected no cointegration on their time series but as regarded the short run period, the Philippines was under the portfolio approach. Additionally, the FX market leads the SP market in South Korea and there are feedback relations on the other Asian countries.

It is undeniable that the economy of each country is based on different foundations thereat, the economists strive to get as close as possible to the factors that can affect the interior of sectors of the economy. We can focus on the fact that every country must be studied individually taking into consideration the current development stage. It would be interesting for future investigators to study a variety with different countries and methodology techniques.

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7. Appendix

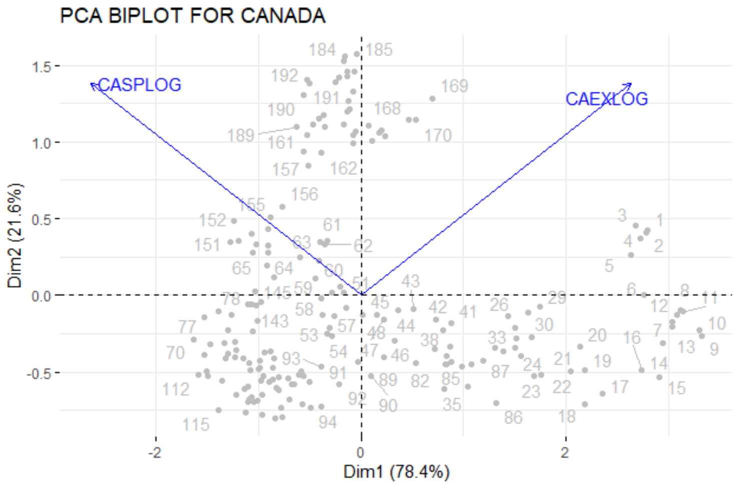

Figure 16: Principal Component Analysis in Canada

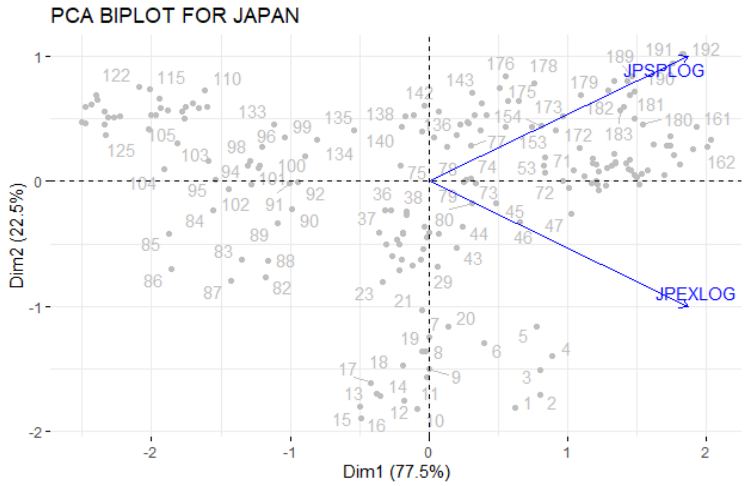

Figure 17: Principal Component Analysis in Japan

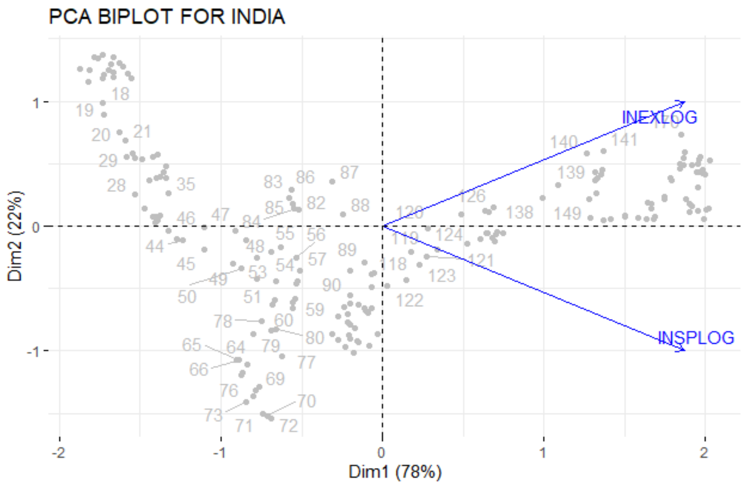

Figure 18: Principal Component Analysis in India

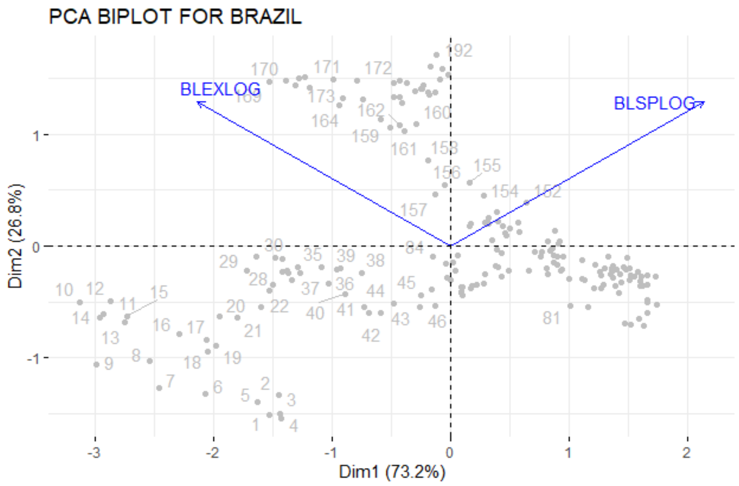

Figure 19: Principal Component Analysis in Brazil