Granger Causality of Interest Rate and Exchange Rate on Stock Volatility at Chicago Options Market

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Abstract

This paper investigates the Granger Causality test to determine the correlation between interest rates and exchange rates with the composite stock volatility measurement of different companies under the Chicago Board Options and Exchange. Using the daily sector data for all observed variables from the St. Louis Fed over the period of 2007-2012, as well as introducing the technique of autoregressive lag model, I have examined whether the current and the previous values of a particular volatility index, interest rate, and exchange rate could have significant Granger Causality effects to the return behavior of those other indices, interest rates, and exchange rates. A two-way Granger Causality test was performed within the R studio, and the estimated result makes it essential to understand how the stock volatility indices behave over the contemplated time, especially with the following changes in interest rate and exchange rate, thus forecasting one another. The result further indicates, in most cases, interest rates positively Granger cause the stock market volatility indices more than in comparison with the exchange rates within the time period, although both of them are identified as major determinants of stock price volatility.

Keywords: Stock Volatility Index; Granger Causality; Exchange rate; Interest rate
JEL category: JEL: C21, C22

Stock volatility means the relative rate at which the price of a security moves up and down. Volatility is found by calculating the annualized standard deviation of a daily change in price. If the price of a stock moves up and down rapidly over a short period of time, we say it has high volatility. On the other hand, if the price almost never changes, we say it has low volatility. In finance, volatility is a measure of the price variation of a financial instrument over time. How far and fast stock prices move can be measured by stock market volatility. Several indicators have been developed over the years, such as the S&P 500 Volatility Index (VIX), the NASDAQ Volatility Index (VXN), and the Russell 2000 Volatility Index (RVX), to track the status of broad market volatility and help investors decide when to buy or sell stocks. Stock prices rarely move in a straight line. Most of the time they move up and down, even sometimes trending higher and lower. Interest rate and foreign exchange rate risks are two significant economic and financial factors that affect the common stock value. The interest rate, which reflects the price of money, has an effect on other variables in money and capital markets. The interest rates indirectly affect the valuation of the stock prices, and stock volatility directly creates a shift between the money market and capital market instruments.

The "stock oriented" idea of the exchange rate was studied by Gul and Ekinci (2006). Gul and Ekinci states that advances in the stock market affect the exchange rate through the liquidity and wealth effects: a rise in the interest rate increases the opportunity cost of holding cash balances and, therefore, creates a negative impact on money demand. This reduction in money demand creates an excess supply of credit and stimulates a decrease in stock prices. A decrease in stock prices reduces the wealth of domestic investors, which lowers their demand for money further. Banks then react by lowering interest rates, which dampens capital inflows, lessening the demand for domestic currency, and therefore depreciating domestic currency. Hence, this will cause an impact on the country's exchange rate situation. In a separate study, Md-Yusuf and Rahman (2012) argued that foreign exchange rates are a major source of macroeconomic uncertainty that affects the stock volatility. Foreign exchange rates have become highly volatile since the abandonment of the fixed exchange rate system in 1973. The volatility has been considered a risk in the exchange rate, and the risk has certain implications on the economic growth of a country, as the company's competitiveness within the country is generally affected by the exchange rate changes through their impact on input and output price. When currency appreciates, the sales and profits of exporters will decline and stock prices will drop, due to the fact that exporters lose their international competitiveness. On the other hand, importers' competitiveness in domestic markets will increase, which would lead to the growth in profit and stock prices. These scenarios would be opposite in the case of currency depreciation. Exchange rate volatility influences the value of the stock, since the future cash flows of the firm will change and affect their investment plan on stock or bond. Previous findings reveal that exchange rates and stock prices demonstrate a high relationship when returns in asset markets are lower and volatility is higher.

This paper deals with the variables, which are the different companies' stock volatilities, the exchange rates, and the interest rates. The four stock volatilities from the set of companies' stock volatility are called CBOE Volatility Index® (VIX®), CBOE NASDAQ 100 Volatility Index, CBOE S&P 500 3-Month Volatility Index, CBOE Eurocurrency ETF Volatility Index. The daily data from the Chicago Board Options Exchange (CBOE)'s—the largest U.S. options exchange with annual trading volume—are collected for those stock price volatilities. In the case of exchange rates, I went through the rates of a few influential and controlling currencies that are most commonly connected with U.S. business and exchange. These are the U.S./Euro Foreign Exchange Rate, the Japan/U.S. Foreign Exchange Rate, and the U.S./U.K. Foreign Exchange Rate. The last two exchange rates that I took are Japan/U.S. Foreign Exchange Rate and U.S./U.K. Foreign Exchange Rate, and I want to examine a stimulating picture about how the Granger causes stock volatility index. For interest rates, I collected the daily rates of the 3-Month Certificate of Deposit: Secondary Market Rate, the 6-Month Certificate of Deposit: Secondary Market Rate, and the 3-Month Treasury Bill: Secondary Market Rate from the *St. Louis Fed* as a measure of effective rate. I am using only the daily data so that other comparative measurement of interest rates cannot be used predominantly.

Ex-ante Discussion

The performance of the stock market can reflect the overall performance of a country's economy. When the stock market is doing well, it may imply that the economy is experiencing high growth. It is proven that the Granger testing procedure requires one set up and tests two equations. The functional form of the model may be illustrated in the following form:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \beta_1 x_{t-1} + \beta_2 x_{t-2} + \varepsilon_t$$

$$x_t = \gamma_0 + \gamma_1 y_{t-1} + \gamma_2 y_{t-2} + \delta_1 x_{t-1} + \delta_2 x_{t-2} + \mu_t$$

The first equation is used to test the following null hypothesis. H_0: x_t does not cause $y_t (x_t \nRightarrow y_t)$.

Unrestricted regression: $y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \beta_1 x_{t-1} + \beta_2 x_{t-2} + \varepsilon_t$

Restricted regression: $y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \varepsilon_t$

From these regressions, we can calculate the joint *F-statistic*. If the *F-statistic* is high enough, then we can reject H_0 (the null hypothesis) and conclude that x_t causes $y_t (x_t \Rightarrow y_t)$. The second equation is used to test the null hypothesis. $H_0 : y_t$ does not cause $x_t (y_t \nRightarrow x_t)$

Unrestricted regression: $x_t = \gamma_0 + \gamma_1 y_{t-1} + \gamma_2 y_{t-2} + \delta_2 x_{t-2} + \mu_t$

Restricted regression: $x_t = \gamma_0 + \delta_1 x_{t-1} + \delta_2 x_{t-2} + \mu_t$

From these regressions, we may calculate a second *F-statistic*. If the *F-statistic* is high enough, then we can reject H_0 and conclude that y_t *does* cause $x_t (y_t \Rightarrow x_t)$.

In each equation, the current value of one variable (x_t or y_t) is a function of the other variable and its own value in previous time periods ('lagged' values). The thought process behind the Granger test is that, if previous values of y_t variable significantly influence current values of variable x_t, then one can say that y_t causes x_t. Recall that the purpose of this study is to find out whether the interest rates and the exchange rates Granger causes the volatility index and vice versa. If the interest rates or the exchange rates cause changes in the volatility index, then we could expect those changes in the stock volatility index to start Granger causes in the interest rate or exchange rate. The regression procedure was designed by including ten variables: four are volatility indices of different measurement, three for representative exchange rates, and three for interest rates. The data series that the model incorporates was from the Federal Reserve Bank of St. Louis, namely as FRED economic data. I have practiced the common data set ranging from December 2007 to December 2012. The volatility indices are based on the common stock prices of the top publicly traded American companies stock and bond. I used the VIX (the implied volatility index on stocks constructed using S&P 500 index options) as our measure of stock market volatility; and the VXNCLS, also known as the NASDAQ 100 (the implied volatility index on domestic and international non-financial securities), based on their market capitalizations, with certain rules capping the influence of the largest components; the EVZCLS, also known as the Euro VIX (the implied volatility index on the euro-dollar exchange rate), constructed using the options traded on the Currency Shares

Euro Trust ETF, as my measure for exchange rate volatility.[1] The CBOE Eurocurrency ETF Volatility Index (Ticker - EVZ) measures the market's expectation of 30-day volatility of the U.S./Euro Exchange Rate by applying the VIX methodology to options on the Currency Shares Euro Trust (Ticker - FXE).

Literature Review

A significant number of previous studies conducted in this area for a variety of countries using various techniques have produced varying results. Internationalization of stock markets, liberalized capital flows, and huge foreign investment in U.S. equity markets have led stock and foreign exchange markets to become increasingly interdependent and caused several financial and currency crises across the whole world, especially in U.S. during the fiscal year 2008-2009. Mishra et al. (2007) pointed out that different emerging markets around the globe have led academicians and practitioners to re-examine the nature of volatility spillovers between stock and foreign exchange markets that have seen large correlated movements resulting in market contamination. One related study conducted by Kutty (2010) examined the relationship between stock prices and exchange rates in Mexico. The stock index data for Kutty's study, obtained from the Dow Jones News/Retrieval, is provided by Dow Jones and consists of weekly closing of the *Bolsa*, Mexico's equity index, a market capitalization weighted index of the leading 35-40 stocks. The value of the Mexican Peso per U.S. dollar starting from the first week of January 1989 to the last week of December 2006 was obtained from the International Monetary Market. After eliminating some of the incompatible data, a total of 849 data points were generated. The Granger Causality test shows that stock prices lead exchange rates in the short run, and there is no long run relationship between these two variables. This finding substantiated the results of Bahmani-Oskooee and Sohrabian's (1992) conclusion, but contradicts the findings of other studies, which reported a long-term relationship between exchange rates and stock prices (Kutty, 2010; Bahmani-Oskooee & Sohrabian, 1992).

In a paper, Dimitrova (2005) studied if there was a link between the stock market and exchange rates that might explain fluctuations in either market. He made the case that, in the short run, an upward trend in the stock market may cause currency depreciation, whereas weak currency may cause a decline in the stock market. To test these assertions, he used a multivariate, open-economy, short run model that allowed for simultaneous equilibrium in the goods, money, foreign exchange, and stock markets in two countries. Specifically, this paper focused on the United States and the United Kingdom over the period of January 1990 through August 2004. It found support for the hypothesis that a depreciation of the currency may depress the stock market, and the stock market will react with a less than one percent decline to a one percent depreciation of the exchange rate. This also implies that an appreciating exchange rate boosts the stock market.

Earlier research by Neih and Lee (2001) examined the dynamic relationship between stock prices and exchange rates for the G7 countries using basic cointegration tests and Vector Error correction models from 1993 to 1996. This research did not account for dual causality between the variables and their findings suggest that there is no long run relationship between the stock prices and the exchange rates in G7 counties. Yet, it has been observed that exchange rates have been used to explain the behavior of stock prices on the assumption of corporate earnings tend to respond to fluctuations in exchange rates.

Muller and Verschoor (2006) examined how multinational firms in the U.S. are affected by exchange rate fluctuations. They believed that currency movements are a major source of macroeconomic instability, which affects a firm's value, a situation they refer to as exchange rate exposure. They outlined several theoretical reasons why the exchange rate and stock price interaction might be asymmetric. These include the asymmetric impact of hedging on cash flow, firms pricing to market-strategies, asymmetry due to hysteric behavior, investors' over-reaction and mispricing errors, and nonlinear currency risk exposure. They have demonstrated, moreover, that asymmetries are more pronounced towards large versus small currency fluctuations than over depreciation and appreciation cycles.

In a separate research project, the relationship between Nifty returns and Indian Rupee/U.S. Dollar Exchange Rates has been widely examined by Agrawal et al. (2010). They found that the correlation between Nifty returns and exchange rates were negative. Further investigation into the causal relationship between the two variables using the Granger Causality test highlighted a kind of unidirectional relationship between Nifty returns and exchange rates, running from the former toward the latter.

Muradoglu et al. (2000) investigated the causal relation between market returns and exchange rates, interest rates, inflation, and industrial production for 19 emerging markets from 1976 to 1997. Their findings supported that the relation between stock returns and macroeconomic variables was mainly linked to the size of the stock market. Kim (2003) used monthly data for the period between January 1974 and December 1998 in the United States. The findings supported that stock prices have a positive correlation with industrial production, but a negative relationship with the real exchange rate, interest rate, and inflation. Another paper written by Zafar, Urooj, and Durrani (2008) exhibited that relating short term interest rates with stock returns and market volatility established that nominal one month T-bill yield had a significantly positive relation with market variance, but negatively correlated with future stock returns. Another study by Çifter and Ozun (2007) applied the Granger Causality test to daily closing values of the Istanbul Stock Exchange 100 Index and compounded interest rates to examine cthe impact of changes in the interest rates on the stock returns. Their results proved interest rate as a Granger Causality of ISE 100 Index starting with nine days' time-scale effect and specified that effects of interest rates on stock return increased with higher time scales.

A similar but extensive study by Muktadir-al-Mukit (2012) on volatility of market index at the Dhaka Stock Exchange (DSE) observed that, both in the long run and in the short run, interest rates are ranked first in terms of the impact on the change of market index and also exchange rates have a positive shock where interest rates have a negative shock on the market index. By using the Johansen procedure of the cointegration test, Muktadir-al-Mukit suggested that, in the long run, exchange rates have a positive impact and interest rates have a negative impact on stock prices where the coefficients of all the explanatory variables are found statistically significant. The estimated error correction coefficient indicates that about 7.8 percent deviation of the DSE general index from its long run equilibrium level is corrected each period in the short run. The interest rate and the exchange rate have negative impacts on the stock market index in the long run as well as the short run, providing some useful insights into the effects on the stock market index of Malaysia, as shown in the research conducted by Thang (2009). In order to search for the long run and short run impacts, respectively, he used the standard econometrics time series model as the Johansen Juselius (JJ) Cointegration test, the Vector Error Correction Model (VECM), and the Granger Causality test. The author divulges that interest rates have a negative impact on the stock market index. When the interest rate is high, investors will move their money from the equity market to savings, fixed deposits, and bond markets. By contrast, when the interest rate is low, investors will shift their money into the stock market in order to gain higher profits.

Methodology

As previously stated, the methodology I use is the two-way Granger Causality, which is an indistinct but recognizable application of the joint *F-statistic*. Usually, time series variables are used for this type of test. If a time series is stationary, the test is performed using the level values of two (or more) sets of variables. On the other hand, if the variables are supposed to be non-stationary, then the test that will be used is the *Augmented Dickey-Fuller* test (the R command adf.test), testing for a unit root (when a series has a unit root it is non-stationary). The null hypothesis is that the series is non-stationary; if the *p-value* is low enough then we will reject the null hypothesis. On the other hand, if the *p-value* is higher than 5% then we must accept the null hypothesis for non-stationarity and will try for transforming the series. Typically, the first differences of any series will be stationary. The number of lags to be included is usually chosen using the *Akaike information criterion***.** Any particular lagged value of one of the variables is retained in the regression if it is significant according to a *t-test* and the other lagged values of the variable jointly add explanatory power to the model according to an *F-test*. The null hypothesis of no Granger Causality is retained, if and only if, no lagged values of an explanatory variable have been retained in the regression. In practice, it might be the case that neither variable Granger causes the other or that each of the two variables Granger causes the other.

Empirical Results and Findings

After running the standard statistical package R, installing all the relevant packages, and opening all the appropriate libraries such as install. Packages("fImport") and library(fImport) and writing down the relevant codes to include all of the observed variables and extracting the data set from St. Louis Fred by using the R command, I got the following basic statistical results. I have also transformed the data set into a stationary data after performing the unit root test. The R-command established all the pertinent results, which is recorded into the following Table 1 as the summary statistics. This table also shows the descriptive statistics of the chosen ten variables as a first part of my result. The optimal lag length attaching with the model can also be found from the appropriate R-command.

The preliminary analysis for all series demonstrates that interest rates volatilities are highly persistent (according to their standard deviation) but mean reverting. The two volatility indices with the shortest maturity, VXVCLS and EVZCLS, have the lowest level of implied volatility (μ= around

0.0038 & σ=around 1%), but there is a much higher volatility for the other two option indices, VXNCLS (μ = 25.93, σ=10.57%) and VIXCLS (μ = 24.67, σ=10.96 %). A sharp shift took place recently in volatility as the credit crisis unfolded. The mean and standard deviation of the two interest rates was found to be relatively close, but the mean and standard deviation for DTB3 was found to be moderately low. For DCD90, I got μ=0.863 and σ=1.15% and for DTB3 I found μ=0.362 and σ=0.64%. However, all the exchange rate indices have a similar average level and standard deviation compared to the VXVCLS, and EVZCLS. The average value of the Japan/U.S. Foreign Exchange Rate was found to be negative, possessing in addition a higher standard error then the other two exchange rates. Finally, I see that the behavior of the NASDAQ 100 and CBOE VIX Volatility Indices are quite different than expected, since they are based on some normalization scheme under CBOE.

Table 1: Descriptive statistics of daily rates of volatility indices, exchange rates, and interest rates over the period 2007 to 2012, n=1,384*

Variables (in first differences)	Description	Mean	Std. Dev.	Min.	Max.	Skewness	Kurtosis	Lag Length
VIXCLS	CBOE Volatility Index: VIX	24.6738	10.9636	11.30	80.86	1.95	4.47	33
VXNCLS	CBOE NASDAQ 100 Volatility Index	25.9366	10.5722	12.03	80.64	1.95	4.79	33
VXVCLS	CBOE S&P 500: 3-Month Volatility Index	0.0059	1.4855	-8.46	10.25	0.61	8.53	49
EVZCLS	CBOE Euro Currency ETF Volatility Index	0.0013	0.7414	-7.24	4.15	0.02	14.00	32
DTB3	3-Month Treasury Bill: Secondary Market Rate	0.3627	0.6421	0.00	3.29	2.49	5.48	29
DCD6M	6-Month Certificate of Deposit: Secondary Market Rate	1.0373	1.1594	0.25	5.38	1.68	1.77	1
DCD90	3-Month Certificate of Deposit: Secondary Market Rate	0.8637	1.1583	0.18	5.50	1.93	2.73	1
DEXUSEU	U.S./Euro Foreign Exchange Rate	0.0014	0.0103	-0.04	0.06	0.16	2.38	40
DEXJPUS	Japan/U.S. Foreign Exchange Rate	-0.0128	0.7032	-4.96	3.16	-0.38	5.40	32
DEXUSUK	U.S./U.K. Foreign Exchange Rate	0.0036	0.0120	-0.07	0.07	-0.33	4.49	11

**where n is the number of observations in the sample.*

The following table generates some stimulating results for Granger Causality. The null hypothesis for this test is that the H_0: variable A does not cause variable B (A ↛ B). The result from Table 2 shows that CBOE Volatility Index: VIX has a negative Granger causal relationship over the NASDAQ 100 Volatility Index, the Euro Currency ETF Volatility Index, the U.S./Euro Foreign Exchange Rate, the Japan/U.S. Foreign Exchange Rate, the U.S./U.K. Foreign Exchange Rate, the 3-Month Certificate of Deposit, and the 3-Month Treasury Bill. The VIX has no correlation with the S&P 500 3-Month Volatility Index and the 6-Month Certificate of Deposit. The CBOE NASDAQ 100 Volatility Index shows a positive Granger Causality with the CBOE Volatility Index, the S&P 500 3-Month Volatility Index, the Eurocurrency ETF Volatility Index, and the U.S./Euro and Japan/U.S. Foreign Exchange Rate, but has a negative causal relationship with the U.S./U.K. Foreign Exchange Rate, the 3-Month Certificate of Deposit, the 6-Month Certificate of Deposit, and the 3-Month Treasury Bill. The CBOE S&P 500 3-Month Volatility Index has a positive causal relationship with the CBOE Volatility Index, the NASDAQ 100 Volatility Index, the Euro Currency ETF Volatility Index, the U.S./Euro and the Japan/U.S. Foreign Exchange Rates, the 3-Month Certificate of Deposit, and the 3-month Treasury Bill. The CBOE Euro Currency ETF Volatility Index has no causal relationship with the NASDQ 100 and the S&P500 3-Month Volatility Index, and positive Granger correlation was found with the U.S./Euro and the Japan/U.S. Foreign Exchange Rates. In the case of the U.S./Euro Foreign Exchange Rate, there was some negative Granger correlation on interest rates, but I found zero Granger correlation with the CBOE Volatility Index. However, I have discovered that the Japan/U.S. Foreign Exchange Rate has a negative causal relationship to the CBOE Volatility Index, the S&P 500 3-Month Volatility Index, and the Euro Currency ETF Volatility Index, but a positive correlation with the NASDAQ 100 Volatility Index. The test results of positive or negative Granger Causality and the result of zero Granger Causality can be established from their respective lower and higher P-values. Accordingly, from Table 2 a reader can easily illuminate the test results which are statistically significant and which are not.

The U.S./U.K. Foreign Exchange Rate has shown no correlation with all the model interest rates and shows a negative Granger Causality with the S&P 500 and the Euro Currency ETF Volatility Index. The 3-Month Certificate of Deposit has positive Granger Causality with different stock volatility indices as well as other measures of interest rates, but it has a negative causal relationship with the Japan/U.S. Foreign Exchange Rate. The 6-Month Certificate of Deposit, however, does not show any significant Granger causes with other stock volatilities and foreign exchange rates. Nonetheless, it is evident that the 3-Month Treasury Bill shows substantial Granger Causality with all stock Volatilities and foreign exchange rates, and it shows strong correlation with the 3-Month Certificate of Deposit and the 6-Month Certificate of Deposit. These results are also found as statistically significant.

Table 2: The R packages generated Granger Causality results of the selected variables

Variable A	Variable B	P-value	Long Run Multiplier*	pvLRM**	Result
VIXCLS	VXNCLS	0.0067	-3.00E-05	0.06335	-1
VIXCLS	VXVCLS	0.89722	0	0.35384	0
VIXCLS	EVZCLS	0	-0.00072	0.00675	-1
VIXCLS	DEXUSEU	0	-0.00024	0.28607	-1
VIXCLS	DEXJPUS	0	-0.00011	0.36479	-1
VIXCLS	DEXUSUK	5.00E-05	2.00E-05	0.16787	1
VIXCLS	DCD90	0.00809	-0.00017	0.0036	-1
VIXCLS	DCD6M	0	0	0.00013	0
VIXCLS	DTB3	0.00763	-3.00E-05	0.00717	-1
VXNCLS	VIXCLS	0	0.00586	2.00E-05	1
VXNCLS	VXVCLS	0	0.00023	0.00036	1
VXNCLS	EVZCLS	0	0.00871	0.0551	1
VXNCLS	DEXUSEU	0	0.00652	0	1
VXNCLS	DEXJPUS	0	0.00405	0	1
VXNCLS	DEXUSUK	0	-0.00037	0.16567	-1
VXNCLS	DCD90	0	-0.00122	0.1757	-1
VXNCLS	DCD6M	0	- 4.00E-05	0.00013	-1
VXNCLS	DTB3	0	-0.00012	0.27698	-1
VXVCLS	VIXCLS	0	0.00371	0.06661	1
VXVCLS	VXNCLS	0	0.00083	0.02595	1
VXVCLS	EVZCLS	0	0.00925	0.13245	1
VXVCLS	DEXUSEU	0	0.00549	0.0974	1
VXVCLS	DEXJPUS	0	0.00461	0.13015	1
VXVCLS	DEXUSUK	0.00013	-0.00024	0.20606	-1

Variable A	Variable B	P-value	Long Run Multiplier*	pvLRM**	Result
VXVCLS	DCD90	0	0.00166	0.15264	1
VXVCLS	DCD6M	0	-2.00E-05	0.08667	-1
VXVCLS	DTB3	0	0.00023	0.01461	1
EVZCLS	VIXCLS	4.00E-05	-0.05957	0	-1
EVZCLS	VXCLS	0.17281	0.00019	0.23331	0
EVZCLS	VXVCLS	0.45722	-3.00E-05	0.45439	0
EVZCLS	DEXUSEU	0	0.03163	0.29925	1
EVZCLS	DEXJPUS	0	0.01434	0.1342	1
EVZCLS	DEXUSUK	0.00825	-0.00118	0.11272	-1
EVZCLS	DCD90	0.08417	-0.00135	0.40497	0
EVZCLS	DCD6M	2.00E-05	-8.00E-05	0.00428	-1
EVCLS	DTB3	0.14661	6.00E-05	0.42872	0
DEXUSEU	VIXCLS	0	-0.03179	0.16511	-1
DEXUSEU	VXNCLS	0.83464	0.00012	0.31221	0
DEXUSEU	VXVCLS	0.67699	-0.00013	0.16797	0
DEXUSEU	EVZCLS	7.00E-05	-0.05148	0.33132	-1
DEXUSEU	DEXJPUS	2.00E-05	0.01469	0.05869	1
DEXUSEU	DEXUSUK	0.00144	-0.00129	0.23447	-1
DEXUSEU	DCD90	0.01199	-0.00286	0.31492	-1
DEXUSEU	DCD6M	1.00E-05	-0.00016	0.01215	-1
DEXUSEU	DTB3	0.88385	3.00E-05	0.47837	0
DEXJPUS	V IXCLS	2.00E-05	-0.00939	0.2929	-1
DEXJPUS	VXNCLS	0	0.0016	2.00E-05	1
DEXJPUS	VXVCLS	0.00033	-0.00025	0.13107	-1
DEXJPUS	EVZCLS	0	-0.02287	0.3577	-1
DEXJPUS	DEXUSEU	0.00051	0.00702	0.42526	1
DEXJPUS	DEXUSUK	0.48138	-0.00143	0.30099	0
DEXJPUS	DCD90	0.0072	0.01382	1.00E-05	1
DEXJPUS	DCD6M	0.28574	-0.00012	0.2116	0
DEXJPUS	DTB3	0	0.00104	0.0649	1

Variable A	Variable B	P-value	Long Run Multiplier*	pvLRM**	Result
DEXUSUK	VIXCLS	0.18421	-0.25391	0.12265	0
DEXUSUK	VXNCLS	0.32476	-0.00653	0.26058	0
DEXUSUK	VXVCLS	0.01803	-0.0087	0.02496	–1
DEXUSUK	EVZCLS	0.03782	-0.8542	0	–1
DEXUSUK	DEXUSEU	0.03003	-0.58688	0.01182	–1
DEXUSUK	DEXJPUS	0.67391	-0.07866	0.41555	0
DEXUSUK	DCD90	0.95942	0.00483	0.47916	0
DEXUSUK	DCD6M	0.24114	0.00224	0.19137	0
DEXUSUK	DTB3	0.20026	-0.00881	0.0643	0
DCD90	VIXCLS	0.04011	0.00238	0.40799	1
DCD90	VXNCLS	0.00939	0.00039	0.40669	1
DCD90	VXVCLS	0.00161	0.00042	0.13576	1
DCD90	EVZCLS	0.01985	0.0215	0.27561	1
DCD90	DEXUSEU	0.00546	0.00306	0.44264	1
DCD90	DEXJPUS	0.00045	-0.05099	6.00E-05	-1
DCD90	DEXUSUK	0.20261	-0.00083	0.37669	0
DCD90	DCD6M	0.00505	3.00E-05	0.43286	1
DCD90	DTB3	0	0.00074	0.19541	1
DCD6M	VIXCLS	0.02154	0.71062	0.3193	1
DCD6M	VXNCLS	0.04641	-0.00235	0.4753	-1
DCD6M	VXVCLS	0.15068	0.01914	0.12978	0
DCD6M	EVZCLS	0.00658	1.98135	0.14032	1
DCD6M	DEXUSEU	0.00257	0.5228	0.32728	1
DCD6M	DEXJPUS	0.61268	-0.28078	0.27748	0
DCD6M	DEXUSUK	0.49257	-0.11948	0.26046	0
DCD6M	DCD90	0.54712	0.19865	0.32377	0
DCD6M	DTB3	0.00061	-0.01258	0.17711	-1
DTB3	VIXCLS	0	0.48349	0.14976	1
DTB3	VXNCLS	0	0.03787	0.02485	1
DTB3	VXVCLS	0	0.009	0.11309	1

Variable A	Variable B	P-value	Long Run Multiplier*	pvLRM**	Result
DTB3	EVZCLS	0	0.85332	0.001	1
DTB3	DEXUSEU	0	0.42337	0.14731	1
DTB3	DEXJPUS	0	0.10992	0.36672	1
DTB3	DEXUSUK	0.00061	-0.05356	0.01729	-1
DTB3	DCD90	0	0.11259	0.0037	1
DTB3	DCD6M	0	0.00026	0.40352	1

**Long Run Multiplier is used to find out the specific sign of the relationship*

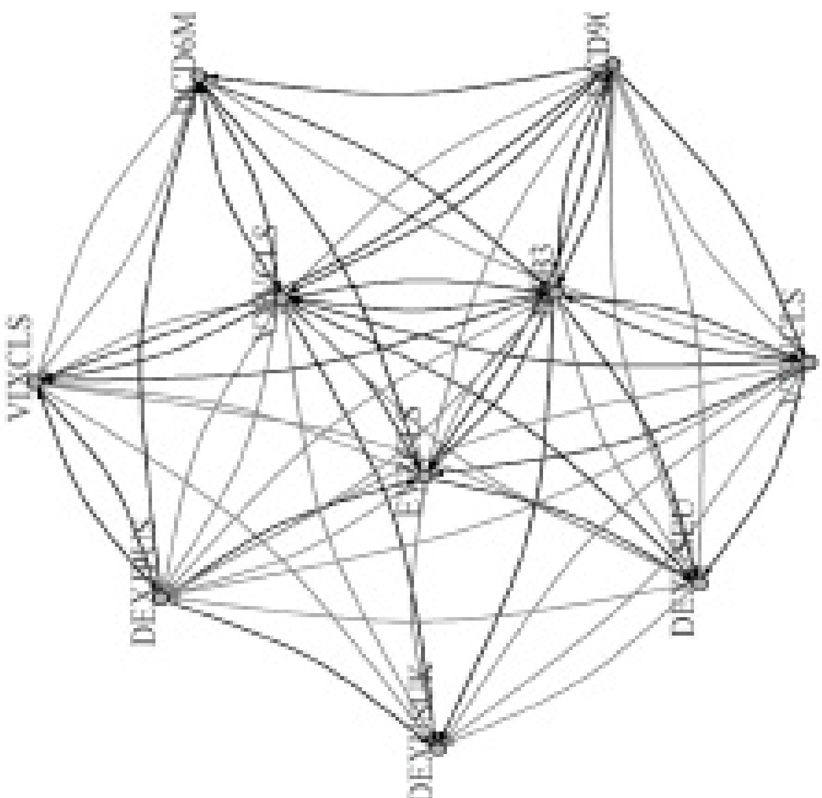
***pvLRM is the probability value when the null hypothesis of the Long Run Multiplier is not equal to zero*

Ex-post Discussion

The results of Table 2 produce a flow chart (Figure 1) through R command, which incorporates each of the variables with a node; each link exhibits a causal relationship. I can figure out some important depictions from the data. The light color node shows negative Granger Causality, and the black color node displays as positive Granger Causality. The 3-Month Certificate of Deposit (DCD90) positively Granger causes the CBOE Volatility Index® VIX® (VIXCLS), the S&P 500 3-Month Volatility Index (VXVCLS), and the NASDAQ 100 Volatility Index (VXNCLS). The 3-Month Treasury Bill (DTB3) also shows positive Granger Causality to VXVCLS, VXNCLS, VIXCLS, and the Euro Currency ETF Volatility Index (EVZCLS), and the opposite direction also produces the same positive effect. The DTB3 has a two-way positive Granger causes with VXNCLS. The DEXUSEU exchange rate also demonstrates two-way positive Granger Causality with DTB3. The 6-Month Certificate of Deposit (DCD6M) shows positive Granger Causality to the CBOE Volatility Index® (VIX®) and the Euro Currency ETF Volatility Index (EVZCLS). DCD6M does not Granger causes VXVCLS and vice versa. But, this DCD6M shows negative causality with VXNCLS and the DTB3 interest rate. The Japan/U.S. Foreign Exchange Rate (DEXJPUS) Granger causes VIXCLS, EVZCLS Index, but it shows negative causal relationship with VXVCLS and VXNCLS. However, the flow chart reveals that VXVCLS, EVZCLS, and VXNCLS Granger cause the U.S./Euro Foreign Exchange Rate (DEXUSEU). Yet the reverse is not true. The U.S./U.K. Foreign Exchange Rate (DEXUSUK) has a negative Granger Causality on

VXVCLS, VXNCLS, and EVZCLS. On the other hand, VXNCLS and VIXCLS have a negative Granger Causality on the DEXUSUK Foreign Exchange Rate. Therefore, I can say that interest rates have a clear causality effect on stock volatility and also upon the exchange rates volatility, but the exchange rates in response to most of the cases could distinguish positive causal effects on stock volatility. What I have found in this study is that in most cases, exchange rates have a negative causal relationship with stock volatility and could not establish Granger Causality both ways. The findings of this study therefore verify that interest rates have a clear-cut impact on stock volatilities and the exchange rates, although they did create some notable impact on stock volatilities, but it surely does create a substantial Granger Causality impact on the index volatilities and, in many studies, established proof in favor of this.

Figure 1: Flow



Shortcomings

This study has some shortcomings, because I have developed only a few interest rates and exchange rates, and I also could not focus more on the relative acceptabilty among a large number of appropriate exchange rates and interest rates, which may affect stock volatility more substantially. I did not use any structural model for this issue, but I think it will get much more relevance for any further research if all of those structural models regarding conintegration and error correction are introduced. I hope that the researchers in this area can come up with a better result of causality should they take into account different econometric models, such as vector error correction model (VECM) or Exponential Generalized Autoregressive Conditional heteroskedasticity model (EGARCH), and if they use other possible tests for unit root determination (with exception to the ADF test).

Conclusion

This research empirically examines the dynamics between the volatility of some stock returns and the movement of dollar exchange rates and interest rates in terms of the extent of interdependency and causality. Daily data from December 2007 to December 2012 for the vaious exchange rates and the major representative interest rates have been used in this paper to investigate the two-way causality in a Granger procedure between stock volatility and, among themselves, by using the probability value for the long run multiplier test within a set range of time periods. Considering the results, I examined the signs of how each of these variables affects the others within the time frame. The empirical findings from the causality tests therefore show strong statistical evidence by establishing a two-way causal relationship between the two variables (stock volatility and interest rate) which exists only to some extent and, in some cases, demonstrates no relationship among them. Hence, the Granger Causality test was applied to those two variables, which proved unidirectional causality running from interest rates to stock returns and also from exchange rates to stock returns, but in the opposite cases the bi-directional effect was not found to be true. Perhaps a different scenario between them may be gotten if the number of interest rates and exchange rates is no longer restricted.

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Endnotes

1. The superiority of the information content of implied volatility over historical volatility measure in various markets has been extensively documented (see among others, Blair, Poon and Taylor, 2001; Poon and Granger, 2003; Christensen and Prabbala, 1998; Jorion, 1995).