**On the co-movements among Stock prices and exchange rates cointegration: a VAR/VECM approach**

**Abstract**

In this paper, based on the cointegration test, the causality test and the VECM model, we have shown that there is a two-way causality and a long-term relationship between the stock market and the exchange rate of each country. Our results lead to important implications from the point of view of investors and policy makers. They are highly relevant to the financial decisions of international investors on the management of their risks exposed to fluctuations in exchange rates and stock prices and on the benefits of potential diversification opportunities that may arise due to the decline in dependence between exchange rates and stock prices.

JEL classification : C1, C53, F37, G15

Keywords: Exchange rates, Stock Prices, VECM Model, Granger Causality.

## 1. Introduction

Over the last decade, an increasing number of works have emerged to model the relationship between exchange rates and stock prices. For example, **Nieh and Lee (2001)** examined the cointegration between stock prices and exchange rates for seven major countries during 1 October 1993 to 15 February 1996. They found that there is a long-term relationship between variables for all countries. **Ayuso and Blanco (2001)** examined if there is an increase in the integration of financial markets, and if so, to what degree this integration has occurred. They have extended their study to an international level by including the following stock markets: New York, London, Paris, Madrid, Frankfurt, Milan and Tokyo. Their study covers the period from 1990 to 1999. The authors use two methodologies: the use of standard measures of comovements, and the use of two alternative measures of market integration, methods based on **Chen and Knez (1995)** approach. Financial globalization has increased the funds flow into international financial markets, which has increased the interdependence between exchange rates and stock price returns (**Dark et al 1999**). **Granger, Huang and Yang (2000)** used daily data to analyze the cointegration between exchange rates and stock prices over the Asian financial crisis (1997). They show that there is a strong cointegration between exchange rates and stock prices in most Asian countries (Hong Kong, Taiwan, Malaysia, Singapore, Thailand, etc.). **Yang, Kolari and Min (2003)** analyzed the effect of the Asian financial crisis of 1997-1998 on the Japanese stock markets, ten other Asian countries and the americain exchange market in long and short terms. Also, they performed a comparative analysis of the degree of integration of the series before, during and after the crisis. As a result, they concluded that integration between these markets existed before and during the crisis and intensified after this crisis. Additionally, they found a strong influence of the US market on the Asian markets throughout the study period and Japan, Taiwan and the Philippines appeared to be isolated. **Phylaktis and Ravazzolo (2005)** studied the cointegration between stock prices and exchange rates for five countries (Thailand, Malaysia, Philippines, Hong Kong and Malaysia). They found a cointegration and bidirectional causality between stock prices and exchange rates. **Diamandis and Drakos (2011**) examined the long-term relationship and short-term dynamics between exchange rates and stock prices as well as the impact of exogenous shocks on four countries (Argentina, Brazil, Chile and Mexico) using a multiple cointegration techniques and Granger causality test. They showed a non significant long-term relationship between stock prices and exchange rates for each country. However, after having integrated the American stock market, they found that these variables will positively correlated: the American stock pricefacilitates the transmission between these countries. Statistically, **Chen-Yin Kuo (2016)** proved that the VECM is the best model than the other three traditional forecasting models (VAR, OLS and GLS) over a long period of forecast. They also find that this model produces smaller errors and behaves much better than the VAR model, which suggests that the VEC model is more accurate than the VAR model in the longest forecast horizon.

**2. Empirical Methodology**

If the variables are non-stationary and they haven’t any cointegration relationship, we will estimate the VAR model estimated as follows:

(1)

Where, are the estimated coefficients. First of all, we must identify the number of lags of the VAR (p) model above. The criteria for selecting include the probability test ratio (LR), Akaike information criteria (AIC) or Schwarz (SC). Once the VAR model is established, we would analyze the causal relationship between series (**Sims 1972**). From the previous equations, we consider the mean squared error (MSE) of:

(2)

If means that x do not causes y by the Granger causality test.

A VAR model with an explanatory variable of is represented by the following model:

(3)

To test if xt caused by , H0: β1 = β2 = … = βk = 0.

The value of the F-test equals to : (4) If our variables are non-stationary and there is a cointegration relationship, we should add an error correction term in the VAR model and having a vector error correction (VEC) model.

The VEC model with two variables can be written as follows:

(5)

(6)

Where, is the error correction term, and it is the residual error of and .

If is statistically significant by the F-test, there is a short-term Granger relation of to. If β1 is statistically significant, there is a long-term Granger relationship from Y to X.

**3. Empirical results**

In this section, we exposed the cointegration of stock prices and exchange rates. First of all, we present the data. Secondly, we present the results of unit root, cointegration and Granger causality tests. Finally, we model the volatility before presenting our conclusion.

We use a daily market index and exchange rates data of five developing countries and two emerging countries: Canada, Japan, Denmark, Hong Kong, Singapore, Mexico and Brazil from 1/1/2000 to 31/12/ 2015. The sample consists of 87,600 observations. All data come from the Board of Governors of the Federal Reserve System and the following links (https://www.federalreserve.gov/) and (<https://www.yahoo.finance.fr>). The Skewness coefficients are negative for all series of returns indicating an asymmetric distribution tail on the left. The results of the Jarque-Bera test indicate the rejection of the normality assumption for all series suggesting a non-linear behavior. The Ljung-Box test for correlating series of 10 off sets allowed us to reject the null hypothesis of autocorrelation (see **table1**).

**Table1**. Descriptive statistics

|  |
| --- |
| **Variables Mean S.D Skewness Kurtosis J.B Q2(10)** |
| **PANEL A**   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | **R (BRL/USD)** | 0.0134 | 0.8598 | -0.0889\*\*\* | 17.9220\*\*\* | 54227.51\*\*\* | 3050.04\*\* | | **R (CAD/USD)** | -0.0007 | 0.4816 | -0.0663\*\*\* | 12.8099\*\*\* | 23437.58\*\*\* | 760.647\* | | **R (SGD/USD)** | -0.0027 | 0.2767 | -0.1220\*\*\* | 11.2526\*\*\* | 16598.48\*\*\* | 414.958\*\* | | **R (JPY/USD)** | 0.0027 | 0.5323 | -0.3533\*\*\* | 10.3700\*\*\* | 13347.87\*\*\* | 162.484\*\*\* | | **R (MXN/USD)** | 0.0101 | 0.5309 | -0.8288\*\*\* | 24.4807\*\*\* | 113025.7\*\*\* | 2900.00\*\*\* | | **R (HKD/USD)** | -5.1363e-005 | 0.0253 | -1.7546\*\*\* | 45.6287\*\*\* | 445489.6\*\*\* | 723.071\*\*\* | | **R (DKK/USD)** | -0.0012 | 0.5438 | -0.2153\*\*\* | 10.4219\*\*\* | 13458.46\*\*\* | 416.170\*\* |   **PANEL B**   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | **R (BOVESPA)** | 0.0159 | 1.5047 | -0.0611\*\*\* | 9.8335\*\*\* | 11374.36\*\*\* | 1576.64\*\* | | **R (TSX)** | 0.0075 | 0.9556 | -0.7631\*\*\* | 17.4570\*\*\* | 51434.14\*\*\* | 170.784\*\* | | **R (STI)** | 0.0025 | 0.9747 | -0.4003\*\*\* | 13.0116\*\*\* | 24563.06\*\*\* | 1410.69\* | | **R (NIKKEI225)** | 8.96E-05 | 1.2669 | -0.4820\*\*\* | 13.6162\*\*\* | 27669.88\*\*\* | 2444.19\*\* | | **R (IPC)** | 0.0307 | 1.1173 | -0.0740\*\*\* | 11.5084\*\*\* | 17633.08\*\*\* | 1079.40\*\* | | **R (HSI)** | 0.0043 | 1.2651 | -0.0866\*\*\* | 16.0561\*\*\* | 41515.27\*\*\* | 1892.45\*\*\* | | **R (OMXC20)** | 0.0235 | 1.0854 | -0.2613\*\*\* | 11.9096\*\*\* | 19396.17\*\*\* | 2072.85\*\*\* | |

**Notes:** \*\*\*, \*\* and \* denote statistical significance at 1%, 5% and 10%, respectively.

We check the correlations between each pair of exchange rates and stock prices within four months, eight months, one year, two years, respectively (see **Appendix 1**). Thus, the correlation analysis identifies the level of correlation at different scales and the transmission of volatility between stock pricereturns and exchange rate returns. Therefore, we find that the correlation fluctuations are downward between each pair of stocks and exchange rates for all countries, especially after 2007. Moreover, we detect decreases in the correlations between each pair of stocks and exchange rates for all countries since 2010.

**Table 2** indicates that all the exchange rates returns are stationary in order of integration equal to 0 and the exchange rates in level are stationary. In order of integration equal to 1 with the exception of MXN / USD rate which is integrated in order two (see **Panel A**) and Panel B shows that all the stock prices series are stationary in level in order of integration equal to 1 and stationary in first difference in order of integration equal to 0.

**Table2.** ADF unit root test results

|  |
| --- |
| **Variables ADF test Probability Critical Value (5%) I (d)** |
| **PANEL A**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **BRL/USD**  **R (BRL/USD)** | -75.97064 | 0.0001 | -3.410573 | I(1) | | -76.41278 | 0.0001 | -3.410573 | I(0) | | **CAD/USD** | -77.11061 | 0.0001 | -3.410573 | I(1) | | **R (CAD/USD)** | -77.25916 | 0.0001 | -3.410573 | I(0) | | **SGD/USD** | -78.46198 | 0.0001 | -3.410573 | I(1) | | **R (SGD/USD)** | -78.44433 | 0.0001 | -3.410573 | I(0) | | **JPY/USD** | -78.03436 | 0.0001 | -3.410573 | I(1) | | **R (JPY/USD)** | -77.96752 | 0.0001 | -3.410573 | I(0) | | **MXN/USD** | -24.52884 | 0.0000 | -3.410577 | I(2) | | **R (MXN/USD)** | -75.98413 | 0.0001 | -3.410573 | I(0) | | **HKD/USD** | -57.22170 | 0.0000 | -3.410573 | I(1) | | **R (HKD/USD)** | -57.22249 | 0.0000 | -3.410573 | I(0) | | **DKK/USD** | -78.47106 | 0.0001 | -3.410573 | I(1) | | **R (DKK/USD)** | -77.48348 | 0.0001 | -3.410573 | I(0) |   **PANEL B**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **BOVESPA** | -78.69462 | 0.0001 | -3.410573 | I(1) | | **R (BOVESPA)** | -76.40613 | 0.0001 | -3.410573 | I(0) | | **TSX** | -74.18284 | 0.0001 | -3.410574 | I(1) | | **R (TSX)** | -74.81707 | 0.0001 | -3.410574 | I(0) | | **STI** | -75.63863 | 0.0001 | -3.410573 | I(1) | | **R (STI)** | -75.17447 | 0.0001 | -3.410573 | I(0) | | **(NIKKEI225)** | -79.16906 | 0.0001 | -3.410573 | I(1) | | **R (NIKKEI225)** | -79.08102 | 0.0001 | -3.410573 | I(0) | | **IPC** | -72.39650 | 0.0000 | -3.410573 | I(1) | | **R (IPC)** | -70.97170 | 0.0000 | -3.410573 | I(0) | | **HSI** | -78.91835 | 0.0001 | -3.410573 | I(1) | | **R (HSI)** | -78.98292 | 0.0001 | -3.410573 | I(0) | | **OMXC20** | -76.20924 | 0.0001 | -3.410573 | I(1) | | **R (OMXC20)** | -74.10668 | 0.0001 | -3.410573 | I(0) | |

Then, we focus on the bivariate cointegration methodology proposed by **Engle and Granger (1987)**. This methodology study the dynamic aspects between variables. Technically, if the estimated residuals are cointegrated: it is a long-term relationship and the estimate is based on VEC model and if the residuals are not cointegrated: it is a short-term relationship and the estimate is based on VAR model. **Table 3** indicates that there is a significant cointegration for the entire sample (at 1%, 5%, and 10% levels) which means that there is a long-term relationship between stock prices and exchange rates in each country. Also, we note that DKK / OMXC20, HKD /HSI, SGD / STI causality is significant at 1%, the causality of MXN/ IPC and HKD/ HSI is significant at 10% and BRL/Bovespa and CAD/ TSX causality is significant at 5%.

**Table 3.** Cointegration and causality results: exchange rates vs prices

|  |
| --- |
| **Series Cointegration Causality** |
| **Returns ADF test C.value 5% Prob Decision F-Statistic Prob** |
| |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | **BRL/Bovespa** | -77.0652 | -3.41057 | 0.0001 | yes |  | 2.62168 | 0.0993 | | **CAD/TSX** | -77.80145 | -3.410574 | 0.0001 | yes |  | 2.81078 | 0.0937 | | **SGD/STI** | -79.56212 | -3.410573 | 0.0001 | yes |  | 13.3949 | 0.0003 | | **JPY/ NIKKEI** | -80.37257 | -3.410573 | 0.0001 | yes |  | 15.445 | 0.0035 | | **MXN/IPC** | -79.90004 | -3.410573 | 0.0001 | yes |  | 1.36512 | 0.0427 | | **HKD/HSI** | -57.5504 | -3.410573 | 0.0000 | yes |  | 4.12458 | 0.0423 | | **DKK/OMEX** | -77.52351 | -3.410573 | 0.0001 | yes |  | 6.42702 | 0.0135 | |

**Table 4** shows that there is a significant cointegration relationship for all variables and that there is a bidirectional causality between each couple of series. These results show the long-term dynamic relationship justified by the VECM model.

**Table 4**. Cointegration and causality results: stock priceprices vs exchange rates

|  |
| --- |
| **Series Cointegration Causality** |
| **Returns ADF test C.value 5% Prob Decision F-Statistic Prob** |
| |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | | **Bovespa/BRL** | | -77.06200 | -3.410573 | 0.0001 | yes |  | 418.175 | 0.0590 | |  | **TSX/CAD** | -75.37400 | -3.410574 | 0.0001 | yes |  | 232.119 | 0.0151 | | **STI/SGD** | | -76.24450 | -3.410573 | 0.0001 | yes |  | 1.86394 | 0.0722 | | **NIKKEI/JPY** | | -81.52416 | -3.410573 | 0.0001 | yes |  | 0.86803 | 0.0515 | |  | **IPC/MXN** | -70.97157 | -3.410573 | 0.0000 | yes |  | 158.329 | 0.0364 | |  | **HSI/HKD** | -79.44633 | -3.410573 | 0.0001 | yes |  | 9.00585 | 0.0027 | |  | **OMXC20/DKK** | -74.14490 | -3.410573 | 0.0001 | yes |  | 0.00055 | 0.0814 | |

If it exist a cointegration relationship between two variables, we estimate the VECM model and its cointegration parameter and if there isen’t t any cointegration relationship we estimate the VAR model. In **table 5**, the coefficients are significant and all the absolute values of t-student are higher than 1.96 with the exception of Denmark (0.32). Thus, we conclude that there is a long-term dynamic between the stock prices and the exchange rates.

**Table 5.** VAR/VECM results: exchange rate vs stock prices

|  |
| --- |
| **Series VECM VAR** |
| **Coint Eq t-student Coint Eq t-student** |
| |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | **BRL/Bovespa** | -393,3996 | [-1,0830] |  | - | - | | **CAD/TSX** | -382.3891 | [-1.65600] |  | - | - | | **SGD/STI** | -312.2629 | [-4.12126] |  | - | - | | **JPY/ NIKKEI225** | 43.58178 | [11.9255] |  | - | - | | **MXN/IPC** | -134.6353 | [-2.58035] |  | - | - | | **HKD/HSI** | -2804.128 | [-1.82607] |  | - | - | | **DKK/OMEXC20** | -0.548877 | [-0.32102] |  | - | - | |

In **table 6**, the coefficients are statistical significant, all the absolute values of t-student are higher than 1.96 and we can conclude the long-term dynamics between the series.

**Table 6.** VAR/ VECM Results: Stock Prices vs. Foreign Exchange Rates

|  |
| --- |
| **Series VECM VAR** |
| **Coint Eq t-student Coint Eq t-student** |
| |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | **Bovespa/BRL** | -7.52E-06 | [-16.2989] |  | - | - | | **TSX/CAD** | -1.07E-05 | [-14.5998] |  | - | - | | **STI/SGD** | -2.14E-06 | [-2.90369] |  | - | - | | **NIKKKIE225/JPY** | -4.59E-05 | [-3.95517] |  | - | - | | **IPC/MXN** | -4.78E-05 | [-13.4960] |  | - | - | | **HSI/HKD** | -3.77E-07 | [-3.34945] |  | - | - | | **OMXC20/DKK** | 4.84E-05 | [7.48298] |  | - | - | |

The Granger causality test showed a direct or indirect causal link between the variables. This result supposes that there would be a dynamic interaction between series and each market could react to a shock on another market. The question now is what would be the magnitude of the shock reactions? and how long a market will take to cushion the effect of a random shock ? The study of IRF will provide answers. The impulse response is the output that is obtained when the input is a pulse, that is to say a sudden and brief variation of the signal. Indeed, when a pulse is the input of a linear system, the output is in general no longer a pulse, but a signal having an exact duration. **Figure 1** presents respectively the impulse response function of the exchange rate to a positive shock on the stock price for a period ranging from 0 to 10 months and the impulse response function of the stock price to a positive exchange rate shock. Therefore, we notice that the two markets react following a positive shock on one of them which confirms the results of the Granger causality test.







**Figure1.** Impulse response functions

However, we confirm the study of impulse response functions by decomposing variance of the forecast errors. It is a technique that measure the share of the variance of the forecast error of returns of a market, which is explained by the innovations of another market. Thus, for each of our stock price index, we performed this test by considering a horizon of 10 periods. The decomposing variance tables (see **Appendix 2**) report the results of exchange rate forecast errors following a random shock on its conditional volatility for a 10-months horizon. We find that, as the forecast period increases, the exchange rate innovations decrease suggesting that the foreign exchange market is a very volatile market. These results following a random shock show the share of conditional volatility fluctuations of the stock price index at the exchange rates. This result explains a strong interdependence between these two markets.

**4. Conclusion**

We obtain a result of significant stationaries for all stock market returns and exchange rate returns. Using the cointegration test, we can detect that there is a long-term linear combination of stock prices and exchange rates and that there is a bidirectional causal relationship between these two prices. The inspection of these reported results clearly shows that the managed float regime and the managed float exchange regime exhibit a very significant causality than the independent float regime and regardless of the independent floating exchange rate regimes. Floating directed, floating administered, both markets may react positively or negatively. Thus the results of Branson and Frankel (1983) and Nieh and Lee (2001) do not confirm our study.

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**APPENDIX 1**

**Figure 2:** Rolling correlation at 4 months **Figure 3:** Rolling correlation at 8 months

 

**Figure 4:** Rolling correlation at 12 months **Figure 5:** Rolling correlation at 24 months



**APPENDIX 2**

**Table 7:** Variance decomposing results: BRL / USD vs Bovespa

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  | | **BRL/USD** |  | |  |  |  | | | **BOVESPA** | |  |  |  |  |
|  |  |  |  |  | **SE** | **BRL/USD** | |  | **BOVESPA** | |  | **SE** | **BRL/USD** | | | **BOVESPA** | |  |  |  |
|  |  |  | **time** |  |  |  | |  |  | |  |  |  | | |  | |  |  |  |
|  |  |  | **1** |  | 0.8761 | | 100.00 |  | 0.0000 | |  | 1.7004 | | 3.4877 | | 96.5122 | |  |  |  |
|  |  |  | **2** |  | 0.9867 | | 81.6615 |  | | 18.3384 |  | 1.8172 | | | 9.0604 | | 90.9396 |  |  |  |
|  |  |  | **3** |  | 1.1183 | | 71.3154 |  | | 28.6845 |  | 2.0610 | | | 18.8665 | | 81.1334 |  |  |  |
|  |  |  | **4** |  | 1.2101 | | 67.2839 |  | | 32.7160 |  | 2.2266 | | | 21.3086 | | 78.6913 |  |  |  |
|  |  |  | **5** |  | 1.3060 | | 63.6822 |  | | 36.3177 |  | 2.4022 | | | 24.1145 | | 75.8855 |  |  |  |
|  |  |  | **6** |  | 1.3913 | | 60.8831 |  | | 39.1168 |  | 2.5550 | | | 26.0609 | | 73.9391 |  |  |  |
|  |  |  | **7** |  | 1.4733 | | 58.7377 |  | | 41.2622 |  | 2.7039 | | | 27.6678 | | 72.3321 |  |  |  |
|  |  |  | **8** |  | 1.5502 | | 57.0092 |  | | 42.9907 |  | 2.8431 | | | 28.9183 | | 71.0816 |  |  |  |
|  |  |  | **9** |  | 1.6238 | | 55.5822 |  | | 44.4177 |  | 2.9766 | | | 29.9723 | | 70.0276 |  |  |  |
|  |  |  | **10** |  | 1.6941 | | 54.3874 |  | | 45.6126 |  | 3.1039 | | | 30.8487 | | 69.1512 |  |  |  |

**Table 8:** Variance Decomposing results: CAD / USD vs TSX

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  | **CAD/USD** |  |  |  |  | **TSX** |  |  |  |  |
|  |  |  |  |  | **SE** | **CAD/USD** |  | **TSX** |  | **SE** | **CAD/USD** | **TSX** |  |  |  |
|  |  |  | **time** |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | **1** |  | 0.5079 | 100.0000 |  | 0.0000 |  | 1.0736 | 4.0888 | 95.9111 |  |  |  |
|  |  |  | **2** |  | 0.5604 | 86.35782 |  | 13.6421 |  | 1.1557 | 11.1758 | 88.8246 |  |  |  |
|  |  |  | **3** |  | 0.6449 | 76.53734 |  | 23.4626 |  | 1.2979 | 21.1886 | 78.8113 |  |  |  |
|  |  |  | **4** |  | 0.6989 | 72.55230 |  | 27.4477 |  | 1.3992 | 24.6490 | 75.3509 |  |  |  |
|  |  |  | **5** |  | 0.7571 | 69.27611 |  | 30.7238 |  | 1.5059 | 28.0639 | 71.9360 |  |  |  |
|  |  |  | **6** |  | 0.8078 | 66.78871 |  | 33.2112 |  | 1.5996 | 30.4685 | 69.5314 |  |  |  |
|  |  |  | **7** |  | 0.8570 | 64.86351 |  | 35.1364 |  | 1.6907 | 32.4666 | 67.5333 |  |  |  |
|  |  |  | **8** |  | 0.9028 | 63.32316 |  | 36.6768 |  | 1.7760 | 34.0416 | 65.9584 |  |  |  |
|  |  |  | **9** |  | 0.9468 | 62.06086 |  | 37.9391 |  | 1.8579 | 35.3651 | 64.6348 |  |  |  |
|  |  |  | **10** |  | 0.9886 | 61.0070 |  | 38.9929 |  | 1.9361 | 36.4713 | 63.5286 |  |  |  |

**Tableau 9:** Variance decomposing results: SGD / USD vs STI

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  | **SGD/USD** | |  |  |  |  | **STI** |  |  |  |  |
|  |  |  |  |  | **SE** | **SGDUSD** | |  | **STI** |  | **SE** | **SGD/USD** | **STI** |  |  |  |
|  |  |  | **time** |  |  |  | |  |  |  |  |  |  |  |  |  |
|  |  |  | **1** |  | 0.2964 | 100.0000 |  | | 0.0000 |  | 1.1486 | 12.8856 | 87.1143 |  |  |  |
|  |  |  | **2** |  | 0.3099 | 94.0367 |  | | 5.9632 |  | 1.2746 | 19.2054 | 80.7946 |  |  |  |
|  |  |  | **3** |  | 0.3376 | 84.6485 |  | | 15.3514 |  | 1.5205 | 25.9064 | 74.0935 |  |  |  |
|  |  |  | **4** |  | 0.3558 | 80.4135 |  | | 19.5864 |  | 1.6695 | 28.5035 | 71.4964 |  |  |  |
|  |  |  | **5** |  | 0.3766 | 76.1889 |  | | 23.8110 |  | 1.8339 | 30.5991 | 69.4009 |  |  |  |
|  |  |  | **6** |  | 0.3946 | 73.0566 |  | | 26.9433 |  | 1.9717 | 32.0101 | 67.9898 |  |  |  |
|  |  |  | **7** |  | 0.4126 | 70.3138 |  | | 29.6861 |  | 2.1066 | 33.1139 | 66.8860 |  |  |  |
|  |  |  | **8** |  | 0.4294 | 68.0567 |  | | 31.9432 |  | 2.2304 | 33.9633 | 66.0366 |  |  |  |
|  |  |  | **9** |  | 0.4458 | 66.0987 |  | | 33.9012 |  | 2.3491 | 34.6513 | 65.3486 |  |  |  |
|  |  |  | **10** |  | 0.4615 | 64.4148 |  | | 35.5851 |  | 2.4614 | 35.2143 | 64.7856 |  |  |  |

**Tableau 10:** Variance decomposing results: JPY / USD vs NIKKEI225

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  | **JPY/USD** | | |  |  | |  | |  | **NIKKEI225** |  |  |  |  |  |
|  |  |  |  |  | **SE** | **JPY/USD** | | |  | **NIKKEI225** | |  | **SE** | | **NIKKEI225** | **JPY/USD** |  |  |  |  |
|  |  |  | **time** |  |  |  | | |  |  | |  |  | |  |  |  |  |  |  |
|  |  |  | **1** |  | 1.3500 | 0.0000 |  | | 0.0000 | |  | | 0.6259 | | 12.9597 | 87.0402 |  |  |  |  |
|  |  |  | **2** |  | 1.4847 | 86.3428 |  | | 13.657 | |  | | 0.6786 | | 17.7658 | 82.2341 |  |  |  |  |
|  |  |  | **3** |  | 1.6632 | 71.4403 |  | | 21.559 | |  | | 0.7969 | | 26.5001 | 73.4998 |  |  |  |  |
|  |  |  | **4** |  | 1.7942 | 73.6290 | | |  | 26.370 | |  | 0.8676 | | 29.0067 | 70.9932 |  |  |  |  |
|  |  |  | **5** |  | 1.9297 | 69.8510 | |  | 30.149 | | |  | 0.9467 | | 31.7759 | 68.2240 |  |  |  |  |
|  |  |  | **6** |  | 2.0502 | 67.0058 | |  | 32.994 | | |  | 1.0134 | | 33.4135 | 66.5864 |  |  |  |  |
|  |  |  | **7** |  | 2.1667 | 64.7373 | |  | 35.262 | | |  | 1.0788 | | 34.8291 | 65.1708 |  |  |  |  |
|  |  |  | **8** |  | 2.2760 | 62.8991 | | |  | 37.100 | |  | 1.1391 | | 35.8849 | 64.1150 |  |  |  |  |
|  |  |  | **9** |  | 2.3809 | 61.3765 | | |  | 38.6234 | |  | 1.1970 | | 36.7695 | 65.2304 |  |  |  |  |
|  |  |  | **10** |  | 2.48108 | 60.0950 | | |  | 39.9050 | |  | 1.2520 | | 37.4902 | 62.5097 |  |  |  |  |

**Tableau 11**: Variance decomposing results: MXN / USD vs IPC

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  | **MXN/USD** |  | |  |  | |  | **IPC** |  |  |  |  |
|  |  |  |  |  | **SE** | **MXN** |  | | **IPC** |  | | **SE** | **MXN** | **IPC** |  |  |  |
|  |  |  | **time** |  |  |  |  | |  |  | |  |  |  |  |  |  |
|  |  |  | **1** |  | 0.06627 | 100.0000 |  | 0.0000 | | |  | 0.1144 | 6.7816 | 93.2183 |  |  |  |
|  |  |  | **2** |  | 0.09454 | 88.7117 |  | 13.2882 | | |  | 0.1172 | 16.8009 | 83.1001 |  |  |  |
|  |  |  | **3** |  | 0.11639 | 88.2586 |  | 21.7413 | | |  | 1.2177 | 14.1918 | 81.1542 |  |  |  |
|  |  |  | **4** |  | 1.13474 | 78.0358 |  | 30.9641 | | |  | 1.5173 | 20.8921 | 75.2001 |  |  |  |
|  |  |  | **5** |  | 1.15088 | 67.9035 |  | 32.0964 | | |  | 1.6181 | 23.7559 | 67.8284 |  |  |  |
|  |  |  | **6** |  | 2.16544 | 65.8158 |  | 2.1841 | | |  | 1.7107 | 28.0004 | 66.5551 |  |  |  |
|  |  |  | **7** |  | 2.17883 | 65.7533 |  | 36.2466 | | |  | 1.8101 | 32.5997 | 65.4587 |  |  |  |
|  |  |  | **8** |  | 2.19128 | 64.7066 |  | 37.2933 | | |  | 1.8179 | 34.8999 | 63.7701 |  |  |  |
|  |  |  | **9** |  | 2.20296 | 64.6704 |  | 39.3295 | | |  | 1.8832 | 36.5207 | 62.7881 |  |  |  |
|  |  |  | **10** |  | 2.21402 | 62.6414 |  | 39.8585 | | |  | 1.9678 | 37.9012 | 61.8997 |  |  |  |

**Tableau 12:** Variance decomposing results: HKD / USD vs HSI

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  | **HKD/USD** |  |  |  |  | **HSI** |  |  |  |  |
|  |  |  |  |  | **SE** | **HKD/USD** |  | **HSI** |  | **SE** | **HKD/USD** | **HSI** |  |  |  |
|  |  |  | **time** |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | **1** |  | 0.0263 | 100.0000 |  | 0.0000 |  | 1.5106 | 5.0859 | 94.9140 |  |  |  |
|  |  |  | **2** |  | 0.0273 | 93.8306 |  | 6.1693 |  | 1.6575 | 19.0045 | 90.9954 |  |  |  |
|  |  |  | **3** |  | 0.0290 | 84.7925 |  | 15.207 |  | 1.9834 | 23.7747 | 86.2251 |  |  |  |
|  |  |  | **4** |  | 0.0302 | 80.1778 |  | 19.8221 |  | 2.1692 | 35.4545 | 84.5454 |  |  |  |
|  |  |  | **5** |  | 0.0315 | 75.5473 |  | 24.4526 |  | 2.1692 | 36.8404 | 83.1595 |  |  |  |
|  |  |  | **6** |  | 0.0327 | 71.8671 |  | 28.1328 |  | 2.3832 | 37.7774 | 82.2225 |  |  |  |
|  |  |  | **7** |  | 0.0339 | 68.5479 |  | 31.4520 |  | 2.7327 | 38.5158 | 81.4841 |  |  |  |
|  |  |  | **8** |  | 0.0350 | 65.7191 |  | 34.2808 |  | 2.8914 | 39.0835 | 80.9164 |  |  |  |
|  |  |  | **9** |  | 0.0361 | 63.1992 |  | 36.8007 |  | 3.0443 | 39.5447 | 80.4552 |  |  |  |
|  |  |  | **10** |  | 0.0372 | 60.9777 |  | 39.0222 |  | 3.1887 | 39.9226 | 80.0774 |  |  |  |

**Table 13**: Variance decomposing results: DKK / USD vs OMXC20

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  | **DKK/USD** |  |  |  |  | **OMEXC20** |  |  |  |  |
|  |  |  |  |  | **SE** | **DKK/USD** |  | **OMXC20** |  | **SE** | **DKK/USD** | **OMXC20** |  |  |  |
|  |  |  | **time** |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  | **1** |  | 0.5851 | 100.0000 |  | 0.0000 |  | 1.2419 | 1.8352 | 98.1647 |  |  |  |
|  |  |  | **2** |  | 0.6121 | 94.8536 |  | 5.1463 |  | 1.3566 | 7.7346 | 92.2653 |  |  |  |
|  |  |  | **3** |  | 0.6783 | 84.3191 |  | 15.6808 |  | 1.5618 | 16.7059 | 83.2941 |  |  |  |
|  |  |  | **4** |  | 0.7185 | 79.5855 |  | 20.4144 |  | 1.6953 | 20.3801 | 79.6198 |  |  |  |
|  |  |  | **5** |  | 0.7654 | 75.0730 |  | 24.9269 |  | 1.8406 | 23.5683 | 76.4316 |  |  |  |
|  |  |  | **6** |  | 0.8054 | 71.7967 |  | 28.2039 |  | 1.9651 | 25.7333 | 74.2666 |  |  |  |
|  |  |  | **7** |  | 0.8454 | 68.9799 |  | 31.0200 |  | 2.0869 | 27.5023 | 72.4976 |  |  |  |
|  |  |  | **8** |  | 0.8827 | 66.6891 |  | 33.3108 |  | 2.1998 | 28.8795 | 71.1205 |  |  |  |
|  |  |  | **9** |  | 0.9189 | 64.7279 |  | 35.2721 |  | 2.3081 | 30.0195 | 69.9804 |  |  |  |
|  |  |  | **10** |  | 0.9536 | 63.0566 |  | 36.9433 |  | 2.4111 | 30.9625 | 69.0374 |  |  |  |