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The nonlinear relationships between stock indexes and exchange rates

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ABSTRACT

The Lagrange multiplier (LM) principle is used to study the causality in variance and the relationships between the stock indexes and exchange rates of Brazil, Russia, India, and China (BRIC). Weekly closing prices from February 2002 to December 2013 are used for the analysis. The full study period is divided into two sub-periods after the Chow breakpoint test and Quandt–Andrews unknown breakpoint test. The causality is from exchange rate to stock in the first sub-period and no causality relationship between stock index and exchange rate in the second sub-period for Brazil. The causality is from stock index to exchange rate in both the first sub-period and the second sub-period for Russia. The causality is from exchange rate to stock index in both the first sub-period and the second sub-period for India. There is no causality relationship between stock index and exchange rate in the first sub-period, and from exchange rate to stock index in the second sub-period for China. The study results support the argument that volatility can be transmitted between stock index and exchange rate even when the returns of these two variables are either statistically uncorrelated or exhibit no causality in means.

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1. Introduction

The Lagrange multiplier (LM) principle is used in this paper to study the causality in variance and the relationships between the stock indexes and exchange rates in Brazil, Russia, India, and China. These four countries are termed “BRIC” by Goldman Sachs.

According to the traditional theory, the international trade is affected by the exchange rate changes. Changes of exchange rate against other currencies will affect a country’s international competitive advantage, real income, and output (Dornbusch and Fischer, 1980). The domestic stock market plays an important role in influencing the capital inflow or outflow. The stock market can be influenced by the exchange rate movement, or vice versa. For example, a decrease in the stock market index causes reduction of investors’ wealth, leads to a lower demand for money with lower interest rates, and discourages capital inflows. Such chain reactions cause currency depreciation. Therefore, innovation in the stock market affects the aggregate demand through wealth and liquidity effects and influences money demand (Gavin, 1989).

Many literatures study the relationships between stock index and exchange rate. However, most of the researches study the causality in mean and have different conclusions about the relationships between stock index and exchange rate. The causality is found to be from the exchange rate to stock market in India, South Korea, and Pakistan, but not in the Philippines by Abdalla and Murinde (1997). However, Ajayi et al. (1998) find that the causality between stock index and exchange rate is not found in Hong Kong, Singapore, Thailand, and Malaysia. There is bilateral causality between stock index and exchange rate in Taiwan. And the causality is from stock index to exchange rate in Indonesia and the Philippines. Hatemi-J and Irandoust (2002) use the monthly data from 1993 to 1998 with the Granger causality model and find the causality is from stock index to exchange rate in Sweden. Using the 1992–2002 data, Mishra (2004) shows there is no causality relationship between stock index and exchange rate in India. The stock index and exchange rate do not have causality relationship in the long run is also found by Ozair (2006). The stock indexes and exchange rates are found to be positively related in Brazil, Argentina, Chile, and Mexico by Diamandis and Drakos (2011) who use VECM model to study the monthly data from January 1980 to

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Table 1
Summary statistics of variables.

Variables	B-S	R-S	I-S	C-S	B-ER	R-ER	I-ER	C-ER
Mean	43,475.63	1228.920	12,216.88	2,279.341	2.232980	29.26017	47.24635	7.323695
Median	49,648.48	1378.985	13,892.28	2,156.668	2.128750	29.37900	45.99815	7.182900
Maximum	72,766.93	2478.870	21,004.96	5,903.264	3.874000	36.25700	66.59490	8.280000
Minimum	8,715.870	288.0100	2,875.530	1,013.637	1.552900	23.21600	39.12000	6.067800
Std. Dev.	19,407.69	572.0475	5918.181	955.5294	0.519073	2.522869	4.994874	0.811286
Skewness	−0.347396	−0.058834	−0.270321	1.318006	0.931753	−0.397773	1.256713	−0.043004
Kurtosis	1.724386	1.833740	1.546479	4.978874	3.175757	2.740531	4.847214	1.367988
Jarque–Bera	52.044***	33.892***	59.323***	267.991***	86.420***	17.272***	239.994***	65.881***

*The significant level at 10%.
**The significant level at 5%.
*** The significant level at 1%.

February 2009. However, negative relationships between the stock index and exchange rate are found in Malaysia, Singapore, South Korea, the Philippines, Taiwan, and Thailand by Tsai (2012), and in Indonesia, South Korea, and Thailand by Kubo (2012). The causality relationship is from exchange rate to stock index in Brazil and Russia, and no relationship between exchange rate and stock index in China by Tudor and Popescu-Dutaa (2012) who use VAR model to study the monthly data from January 1997 to March 2012.

Previous researches have shown inconsistent empirical results. Causalities between stock index and exchange rate are found in some studies. However, some researches do not find causality relationship between stock index and exchange rate. To provide further understanding, this paper attempts to offer an explanation for the different empirical results of the relationship between stock index and exchange rate. Data from Brazil, Russia, India, and China are used in this study. This paper has the following major contributions. This paper uses weekly data. Most of the literatures use monthly data and study the causality in mean. However, volatility can be transmitted between stock index and exchange rate even when the returns of these two variables are either statistically uncorrelated or exhibit no causality in means. This paper studies the causality in variance and the relationships between the stock indexes and exchange rates. The causality in variance test is used to study the conditional volatility dependence between stock index and exchange rate.

This paper is organized as follows. Section 2 presents the data used in the paper. Section 3 briefly describes the research methodology. Section 4 shows the analytical results. Section 5 concludes the paper.

2. Data profile

A number of studies have examined the relationship between the stock indexes and exchange rates. Most of literatures focus on monthly data. However, stock index and exchange rate are very volatile. Instead of monthly data, weekly data are more appropriate to represent actual financial phenomenon. Weekly closing prices of stock indexes and exchange rates in Brazil, Russia, India, and China are used in this paper. The data are taken from Taiwan Economic Journal (TEJ), cnYES.com, and Bombay Stock Exchange. The sample period is from February 2002 to December 2013. The variables used in this paper are the BOVESPA index for Brazil (B-S), RTS index for Russia (R-S), Bombay Sensitive 30 index for India (I-S), SSE Composite index for China (C-S), Brazil BRL exchange rate (B-ER), Russian RUB exchange rate (R-ER), India INR exchange rate (I-ER), and China CNY exchange rate (C-ER).

Table 1 reports the result of descriptive statistics of all variables in this study, including the means, standard deviations, maximum, minimum, skewness, kurtosis, and Jarque–Bera values. Among the four stock indexes, Russia's R-S has the smallest standard deviation, and Brazil's B-S has the largest standard deviation. Among the four exchange rates, Brazil's B-ER has the smallest standard deviation, and India's I-ER has the largest standard deviation. Regarding skewness statistics, China's C-S, Brazil's B-ER, and India's I-ER are left-tailed. The Jarque–Bera test shows that all variables reject the null hypothesis of normal distribution at $p < 0.01$.

3. Model for the empirical test

Different from the traditional Granger causality test that focuses on the mean changes, the causality in variance test is used to examine the conditional volatility dependence between two variables (Li et al., 2008). Causality in variance test can be used to study the general pattern in volatility transmission. Volatility could be transmitted between markets where returns are either statistically uncorrelated or exhibit no causality in means. Knowledge of the timing and direction of volatility transmission facilitates the assumption of hedge positions in response to foreign information shocks. The causality in variance information can be used to enhance the volatility forecasting in the international markets for academics, practitioners, traders, and asset managers.

The Hafner and Herwartz (2006) Lagrange multiplier (LM) principle is used to test the causality in variance. The relationships between stock indexes and exchange rates of BRIC countries are studied in this paper.

Assuming that $\{\varepsilon_t\}$ is fixed and $\{\varepsilon_t|F_{t-1}\}$=0, the following null hypothesis (H_0) will be tested given $i, j = 1, 2, \ldots, n,\ i \neq j$:

$$H_0 : \mathrm{Var}(\varepsilon_{it}|F^{(j)}_{t-1}) = \mathrm{Var}(\varepsilon_{it}|F_{t-1}) \quad (1)$$

where $F^{(j)}_t = F_t \backslash \sigma(\varepsilon_{jt}, \tau \le t)$. To examine H_0, consider the following model:

$$\varepsilon_{it} = \xi_{it}\sqrt{\sigma^2_{it} q_t}, \quad q_t = 1 + m'_{jt}\pi, \quad m_{jt} = \left(\varepsilon^2_{jt-1}, \sigma^2_{jt-1}\right)' \quad (2)$$

where $\sigma^2_{it} = \kappa_i + a_i\varepsilon^2_{i,t-1} + b_i\sigma^2_{i,t-1}$. In Eq. (2), a sufficient condition for Eq. (1) is $\pi = 0$, such that the H_0 and H_1 of the LM test are $H_0 : \pi = 0$, $H_1 : \pi \neq 0$.

A LM statistic can be derived from the univariate GARCH processes. The score of the Gaussian log-likelihood function of ε_{it} is given by $y_{it}(\xi^2_{it} - 1)/2$, where $y_{it} = \sigma^{-2}_{it}(\partial\sigma^2_{it}/\partial\theta_i)$, $\theta_i = (\kappa_i, a_i, b_i)'$. The following test statistics is proposed:

$$\lambda_{LM} = \frac{1}{4T}\left(\sum_{t=1}^{T}(\xi^2_{it} - 1)N'_{jt}\right) V(\theta_i)^{-1} \left(\sum_{t=1}^{T}(\xi^2_{it} - 1)N_{jt}\right) \xrightarrow{d} \chi^2(2) \quad (3)$$

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