15. VOLATILITY SPILLOVERS BETWEEN EQUITY AND BOND MARKETS: EVIDENCE FROM G7 AND BRICS[1]

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Abstract

This study implies the causality-in-variance test newly developed by Hafner and Herwartz (2006) to investigate the volatility spillovers between domestic equity and bond markets in the G7 and BRICS countries. The empirical result shows that there is ethier unidirectional or bidirectional spillover effect in every developed market and weak evidence for Russia in both directions. In details, there is bidirectional volatility spillovers between the equity and bond markets in France, Brazil and South Africa, and unidirectional spillovers from the bond to the equity in the US, UK and Germany at 1% level of significance. However, no rigorous conclusions could be drawn by the LM-GARCH model in the case of Japan, Italy, Canada, India and China. This has important implications for domestic cross-market portfolio allocation and risk management in both developed and emerging markets.

Keywords: volatility spillover, equity market, bond market, causality-in-varince, LM-GARCH

JEL Classification: C12, C32, G12, G15

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I. Introduction

Stocks and bonds are two basic asset classes that are crucial in asset allocation and risk management. Since the 1970s, the relationship between equity and bond markets has been attracting a great deal of interest from policy makers and scholars. The motivation is more than obvious. On the one hand, we intend to profit by forecasting the trend of the prices of equities according to that of the bonds, or in the reverse way; on the another hand, we need to evaluate whether there is volatility spillover between two markets or not, which can help the supervisory authorities stabilize the financial system upon impact of financial market risk.

Dean *et al*. (2010) noted several explanations that can be advanced for the existence of spillover effects in return and volatility within the equity and bond markets: (a) The asset substitution hypothesis regards equities and bonds as competing assets, so that it predicts negative correlation of the two assets; (b) The financial contagion hypothesis refers to the propagation of return shocks across markets as an over-reaction to news disclosures or noise; (c) News specificity hypothesis holds that the news conveyed by price changes in stock and bond differ in terms of the degree to which they provide information of a specific nature about the respective asset classes; (d) The news decomposition hypothesis breaks down news into two distinct components - news about future cash flows and news about discount rates, to which equity and bond prices react differently. Therefore, different kinds of news can bring about different kinds of spillover between the two markets; (e) The hypothesis of asymmetric price adjustment considers that the asymmetric transaction costs result in different rates of news impoundment into market prices and then the asymmetric price adjustment occurs.

Numerous studies (e.g. Campbell and Ammer, 1993; Kwan and Simon, 1996; Ilmanen, 2003; Baele, Bekaert and Inghelbrecht, 2010; Chui and Yang, 2012) have been advocating a connection between the returns and volatility of stock and bond markets since Merton (1974), who posited that the negative relation of the two assets during periods of higher volatility were based on their different levels of risk. These papers mainly focus attention on the statistical correlation between the returns and volatility of the two markets.

The spillovers in return and volatility, which take the lead-lag effect into account, are generally considered as causality-in-mean and causality-in-variance, respectively. Some researchers explore the causality-in-mean between different financial markets, e.g. equity markets of different counties or regions (Hiemstra and Jonathan, 1994; Huang *et al*., 2000; Bhar and Hamori, 2003), the equity market and the exchange market (Abdalla and Murinde, 1997) and international exchange markets (Engle and Lin, 1990). As for the causality-in-volatility, which is usually called volatility spillover, Lin *et al*. (1994) found that volatility spillover existed between the American and Japan stock markets. Baele (2005) investigated how the American stock market and the aggregate European stock market affected the European national stock markets.

In contrast, comparatively less attention has been paid to the spillover between the returns and volatility of equities and bonds. Steeley (2006) found that the past bond market volatility affected both equity and bond markets and fed back into short-term yield volatility in the UK. Fang (2006) examined the volatility transmission of stock and bond markets of the USA and Japan and found unidirectional volatility transmission from the stock market to the bond market in both domestic cross markets, but showed weak evidence for the spillover effects between international stock and bond markets. Fang (2007) investigated the transmission of market-wide volatility between the equity markets and bond markets of Japan, Germany, the U.K., and the U.S., finding that within the domestic cross markets, the volatility transmission was unidirectional from the stock market to the bond market. Dean *et al*. (2010) found only volatility spillover from bond market to stock market by taking the example of the stock and bond market of Australia from 1992 to 2006. Christiansen (2010) examined the volatility spillover from the US and aggregate European asset markets into European national asset markets, finding that the national bond volatilities were mainly influenced by bond effects and the national stock volatilities were mainly influenced by stock effects.

Since earlier analysis mainly concentrated on the equity-bond volatility spillover in developed financial markets (e.g., the US, Japan, the UK and other European counties), we prefer to explore the spillover in the emerging markets further in this paper, to be specific the BRICS, as well as the developed countries, among which we select the G7.

For testing causality in variance, two approaches have been followed in the literature. On the one hand, a two-step methodology was introduced by Cheung and Ng (1996) that concentrates on the cross correlation function (CCF) of squared univariate GARCH residual estimates. On another hand, the MVGARCH models rely on a dynamic specification, like BEKK-GARCH (Engle and Kroner, 1995; the acronym comes from synthesized work on multivariate models by Baba, Engle, Kraft and Kroner), the GO-GARCH (Alexander and Chibumba, 1997), and the DCC-GARCH (Engle and Sheppard, 2001). While the latter promises substantial gains in power, likelihood based tests within multivariate dynamic models typically suffer from a curse of dimensionality. In this study we adopt the model developed by Hafner and Herwartz (2006) - we call it LM-GARCH[6] - to assess the volatility spillover between the equity and bond markets of the G7 and BRICS countries.

Compared with the existing literature, our study has two main contributions, according to our knowledge: (a) We are among the few to explore the volatility spillover effects in the emerging markets, which play a more and more important role in the worldwide financial market, and compare the different effects between the two groups of countries; (b) We adopt the newly developed LM-GARCH to test the causality in variance, which can overcome the problems that MVGARCH model has been faced with, and provide a new tool for further study about the volatility spillover effect.

[6] *Up to now, the two-step-GARCH model by Hafner and Herwartz (2006) does not have a formal name. The reason we call it LM-GARCH is that the key of model is a LM test based on univirable GARCH, which we will explain in Section* α *of our paper.*

II. Methodology

The causality-in-variance test of Hafner and Herwartz (2006) based on the Lagrange multiplier (LM) principle overcomes the shortfalls of Cheung and Ng's method and is very practical for empirical illustrations. Furthermore, the Monte Carlo experiment carried out in Hafner and Herwartz (2006) indicates that the LM approach is more robust against leptokurtic innovations in small samples and the gain from carrying the LM test increases with the sample size, which further show that an inappropriate lead and lag order choice in the CCF test distorts its performance and, thereby, leads to the risk of selecting a wrong order of the CCF statistic. In what follows, we briefly explain the details of causality in the variance test.

In this LM-GARCH approach, the causality-in-variance test is a Lagrange Multiplier (LM) based on estimating univariate GARCH models. The null hypothesis of non-causality in variance between two return series is described as follows:

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

where: $\mathcal{F}_t^{(j)} = \mathcal{F}_t \setminus \sigma(\varepsilon_{j\tau}, \tau \leq t)$, and ε_{it} are the residuals of the GARCH model.

The following model is considered to test H_0 .

$$\varepsilon_{it} = \xi_{it}\sqrt{\sigma_{it}^2 g_t}, \qquad g_t = 1 + z_{jt}'\pi, \quad z_{jt} = \left(\varepsilon_{jt-1}^2, \sigma_{jt-1}^2\right)' \quad (2)$$

where conditional variance $\sigma_{it}^2 = \omega_i + \alpha_i\varepsilon_{i,t-1}^2 + \beta_i\sigma_{it-1}^2$, and ε_{it} indicates the standardized residuals of the GARCH model.

In Eq. (2), the sufficient condition for Eq. (1) is $\pi = 0$ which ensures that the null hypothesis of non-causality in variance H$_0$: $\pi = 0$ is tested against the alternative hypotheses H$_1$: $\pi \neq 0$. An LM statistic can be constructed by means of estimated univariate GARCWhere conditional variance $\omega_i + \alpha_i\sigma_{it}^2 = \varepsilon_{i,t-1}^2 + \beta_i\sigma_{it-1}^2$, anH processes. The score of the Gaussian log-likelihood function of ε_{it} is given by

$$x_{it}(\xi_{it}^2 - 1)/2$$

where:

$$x_{it} = \sigma_{it}^{-2}\left(\frac{\partial\sigma_{it}^2}{\partial\theta_i}\right), \theta_i = (\omega_i, \alpha_i, \beta_i)'$$

Hafner and Herwartz (2006) propose the following LM statistic to test the volatility transmission between two series:

$$\lambda_{LM} = \frac{1}{4T}\left(\sum_{t=1}^{T}(\xi_{it}^2 - 1)\, z_{jt}'\right)V(\theta_i)^{-1}\left(\sum_{t=1}^{T}(\xi_{it}^2 - 1)\, z_{jt}\right)\xrightarrow{d}\chi^2,$$

where:

$$V(\theta_i) = \frac{\kappa}{4T}\left(\sum_{t=1}^{T} z_{jt}z_{jt}' - \sum_{t=1}^{T} z_{jt}x_{it}'\left(\sum_{t=1}^{T} x_{it}x_{it}'\right)^{-1}\sum_{t=1}^{T} x_{it}z_{jt}'\right),$$

$$\kappa = \frac{1}{T}\sum_{t=1}^{T}(\xi_{it}^2 - 1)^2.$$

The asymptotic distribution of the test statistic λ_{LM} will depend on the number of misspecification indicators in z_{jt}. Since there are two misspecification indicators in λ_{LM}, the test has an asymptotic chi-square distribution with two degree of freedom.

III. Data and Variables

We use daily data of equity indices and bond indices of G7 (i.e., the US, the UK, Japan, France, Germany, Italy, Canada) and BRICS countries (i.e., Brazil, Russian Federation, India, China, South Africa). Considering the different history of development of the equity and bond market in different countries, the dataset for the G7 countries consist of daily data between Dec. 30, 1988 and Dec. 7, 2012 for the equity and bond indices: S&P 500 and US DS Gov. Index (US), FTSE 100 and UK DS Gov. Index (UK), CAC 40 and FR DS Gov. Index (France), DAX 30 and BD DS Gov. Index (Germany), TOPIX and JP DS Gov. Index (Japan), FTSE ITALY and Italy DS Gov. Index (Italy), S&P/TSX and Canada DS Gov. Index (Canada).

As for the BRICS countries, the equity and bond indices and their timespans are as follows: Brazil Bovespa Index and JPM EMBI+ Brazil Index (Brazil, Jan. 1, 1994 - Dec. 7, 2012), Russian Micex Index and Micex CBI Index (Russia, Jan. 01, 2003 - Dec. 7, 2012), India BSE Index and JPM ELMI+ India Index (India, Jan. 1, 1997 - Dec. 7, 2012); Shanghai SE Composite Index and FTSE Global Gov. CH Index (China, Oct. 13, 2004 - Dec. 7, 2012), FTSE/JSE All Share Index and SA DS Gov. Index (South Africa, Aug. 31, 2000 - Dec. 7, 2012).

The source of the raw data is Thomson Reuters DataStream and the econometric tests are completed in EViews 6.0.
Each data series is then converted into daily logarithmic returns, as follows:

$$Re_{i,t} = lnPe_{i,t} - lnPe_{i,t-1}, \qquad \text{for } t = 1, 2, \ldots, T; i = 1, 2, \ldots, 12$$
$$Rb_{i,t} = lnPb_{i,t} - lnPb_{i,t-1}, \qquad \text{for } t = 1, 2, \ldots, T; i = 1, 2, \ldots, 12$$

where:

$Re_{i,t}$ is the return for each equity index at time t for country i;

$Rb_{i,t}$ is the return for each bond index at time t for country i;

$Pe_{i,t}$ is the equity index at time t for country i;

$Pe_{i,t-1}$ is the equity index at time t-1 for country i;

$Pb_{i,t}$ is the bond index at time t for country i;

$Pb_{i,t-1}$ is the bond index at time t-1 for country i;

Table 1 presents the descriptive statistic and ADF P-value for the Re and Rb series. It shows that, as expected, the SD of the equity indices is higher than that of the bond indices in all countries. In terms of Re, Brazil is the highest, while Japan is the lowest. As for the mean of Rb, Brazil is the highest, while Russian Federation is the lowest.

Table 1

Descriptive Statistic and ADF P-value

Country		Mean	SD	Skewness	Kurtosis	JB	ADF-P
US	Re	2.61E-04	0.01141	-0.25909	12.03	21280.8	0.0001
	Rb	4.48E-05	0.00288	-0.18521	5.39	1525.0	0.0001
UK	Re	1.91E-04	0.01119	-0.12980	9.28	10287.0	0.0000
	Rb	5.08E-05	0.00346	0.08190	6.50	3193.4	0.0001
France	Re	1.33E-04	0.01393	-0.04105	7.83	6061.2	0.0000
	Rb	3.99E-05	0.00241	-0.16448	5.45	1586.9	0.0001
Germany	Re	2.77E-04	0.01449	-0.25685	9.13	9854.5	0.0001
	Rb	3.34E-05	0.00220	-0.34009	5.87	2267.9	0.0001
Japan	Re	-1.75E-04	0.01298	-0.13099	9.60	11345.7	0.0001
	Rb	1.79E-05	0.00171	-0.41118	7.64	5766.0	0.0001
Italy	Re	3.49E-05	0.01446	-0.09622	7.19	4567.9	0.0000
	Rb	4.79E-05	0.00285	0.64731	25.69	134336.6	0.0001
Canada	Re	2.05E-04	0.01006	-0.74683	14.37	34225.1	0.0000
	Rb	5.03E-05	0.00303	-0.23962	5.91	2266.3	0.0001
Brazil	Re	1.02E-03	0.02333	0.49862	14.29	26425.6	0.0001
	Rb	4.76E-04	0.01060	-0.96828	22.73	80914.2	0.0000
Russia	Re	5.82E-04	0.02297	-0.23746	19.21	28411.8	0.0001
	Rb	-3.03E-05	0.00195	-0.11888	40.55	152248.8	0.0000
India	Re	4.72E-04	0.01670	-0.25701	8.62	5522.2	0.0001
	Rb	2.43E-04	0.00443	-0.29970	14.05	21194.8	0.0001
China	Re	1.86E-04	0.01713	-0.31231	6.65	1216.7	0.0001
	Rb	3.40E-05	0.00197	0.19205	32.94	79439.3	0.0000
South Africa	Re	4.75E-04	0.01268	-0.10182	6.40	1546.3	0.0001
	Rb	6.99E-05	0.00420	-1.67978	55.45	368359.8	0.0000

IV. Empirical Findings

Before we construct the GARCH model, we need to test the ARCH (autoregressive conditional heteroskedasticity) effects of the equities and bonds series. We apply the ARCH-LM model (Engel, 1982) to test the ARCH effect which is shown in Table 2. We can see that the ARCH effect (lag =1) is significant in all the 24 time series.

Table 2

LM-Test for the ARCH Effects in the Residuals

Country		F-statistic	Prob. F	Obs* R-squared	Prob. Chi-Square
US	Re	287.06	0.0000	274.53	0.0000
	Rb	24.17	0.0000	24.08	0.0000
UK	Re	360.25	0.0000	340.70	0.0000
	Rb	243.74	0.0000	234.66	0.0000
France	Re	225.99	0.0000	218.16	0.0000
	Rb	110.38	0.0000	108.50	0.0000
Germany	Re	212.50	0.0000	205.57	0.0000
	Rb	67.71	0.0000	67.00	0.0000
Japan	Re	271.67	0.0000	260.42	0.0000

Country		F-statistic	Prob. F	Obs* R-squared	Prob. Chi-Square
	Rb	178.99	0.0000	174.06	0.0000
Italy	Re	214.80	0.0000	207.72	0.0000
	Rb	154.66	0.0000	150.97	0.0000
Canada	Re	588.31	0.0000	537.80	0.0000
	Rb	142.40	0.0000	139.27	0.0000
Brazil	Re	217.12	0.0000	208.06	0.0000
	Rb	424.48	0.0000	391.03	0.0000
Russia	Re	32.77	0.0000	32.39	0.0000
	Rb	131.24	0.0000	125.00	0.0000
India	Re	207.73	0.0000	197.93	0.0000
	Rb	89.71	0.0000	87.86	0.0000
China	Re	44.59	0.0000	43.71	0.0000
	Rb	1008.26	0.0000	684.35	0.0000
South Africa	Re	113.52	0.0000	109.70	0.0000
	Rb	45.90	0.0000	45.28	0.0000

To investigate volatility transmission between equity prices and bond prices, firstly we estimate the univariate GARCH (1, 1) processes. The estimations are shown in Table 3 and graphs of conditional variance (GARCH) of the return series estimated by GARCH (1, 1) are given in the Appendix.

Table 3

Estimations of the Univariate GARCH (1, 1) Model

		ω_i	p-value	α_i	p-value	β_i	p-value
US	Re	1.03E-06	0.0000	0.0656	0.0000	0.9259	0.0000
	Rb	6.90E-08	0.0000	0.0326	0.0000	0.9592	0.0000
UK	Re	1.28E-06	0.0000	0.0842	0.0000	0.9055	0.0000
	Rb	1.39E-07	0.0000	0.0430	0.0000	0.9454	0.0000
France	Re	3.02E-06	0.0000	0.0852	0.0000	0.8991	0.0000
	Rb	1.13E-07	0.0000	0.0622	0.0000	0.9180	0.0000
Germany	Re	3.96E-06	0.0000	0.1012	0.0000	0.8811	0.0000
	Rb	4.42E-08	0.0000	0.0531	0.0000	0.9385	0.0000
Japan	Re	3.21E-06	0.0000	0.1098	0.0000	0.8748	0.0000
	Rb	2.15E-08	0.0000	0.0736	0.0000	0.9220	0.0000
Italy	Re	2.37E-06	0.0000	0.0841	0.0000	0.9064	0.0000
	Rb	8.02E-09	0.0000	0.1071	0.0000	0.9037	0.0000
Canada	Re	6.95E-07	0.0000	0.0739	0.0000	0.9191	0.0000
	Rb	1.08E-07	0.0000	0.0511	0.0000	0.9377	0.0000
Brazil	Re	8.03E-06	0.0000	0.0988	0.0000	0.8850	0.0000
	Rb	3.56E-07	0.0000	0.1599	0.0000	0.8548	0.0000
Russia	Re	1.10E-05	0.0000	0.1055	0.0000	0.8697	0.0000
	Rb	3.51E-08	0.0000	0.3537	0.0000	0.7523	0.0000
India	Re	5.35E-06	0.0000	0.1174	0.0000	0.8685	0.0000
	Rb	4.92E-08	0.0000	0.0544	0.0000	0.9474	0.0000

		ω_i	p-value	α_i	p-value	β_i	p-value
China	Re	2.18E-06	0.0000	0.0468	0.0000	0.9461	0.0000
	Rb	1.12E-08	0.0000	0.0453	0.0000	0.9530	0.0000
South Africa	Re	2.45E-06	0.0000	0.0915	0.0000	0.8935	0.0000
	Rb	2.87E-07	0.0000	0.0863	0.0000	0.8957	0.0000

Note: variance equation: $\sigma_{it}^2 = \omega_i + \alpha_i \varepsilon_{i,t-1}^2 + \beta_i \sigma_{i,t-1}^2$. ω_i, α_i and β_i in the table are obtained from GARCH (1, 1).

Then, we check whether the stability conditions of the GARCH model hold, which impose the constraints $\omega_i > 0, \alpha_i \geq 0, \beta_i \geq 0$. All of the estimated GARCH models satisfy the stability condition. It shows that all the estimated coefficients are statistically meaningful at 1% level of significance. The positive coefficients in the GARCH equation show that the conditional variance process of the equity and bond returns are convergent. We observe that the GARCH parameter (β_i), which indicates long-run volatility, is much higher than the ARCH parameter (α_i), which indicates the short-run volatility in all data series. The result, therefore, clearly shows that the volatility processes of both equity and bond returns are dominated by the GARCH effect.

Following the stability check, the diagnostic test for the specification of the GARCH model is needed for considerate argument. We carry out the ARCH-LM test (Engel, 1982) for the remaining ARCH left in the standardized residuals and the result is presented in Table 4, from which one may see whether GARCH (1, 1) is a proper model for all the series, except for the bond returns of Japan, Italy, Canada, India and China. As a consequence, the volatility spillover effects between the equity and bond markets in these five countries may not be well studied by the LM-GARCH (1, 1) model[7].

Table 4

Test for the Remaining ARCH Left in the Standardized Residuals

Country		F-statistic	Prob. F	Obs* R-squared	Prob. Chi-Square
US	Re	1.34	0.2472	1.34	0.2471
	Rb	0.52	0.4700	0.52	0.4700
UK	Re	1.28	0.2585	1.28	0.2584
	Rb	1.18	0.2766	1.18	0.2766
France	Re	2.61	0.1063	2.61	0.1062
	Rb	0.14	0.7041	0.14	0.7040
Germany	Re	0.33	0.5678	0.33	0.5678
	Rb	1.79	0.1804	1.80	0.1803
Japan	Re	0.28	0.5965	0.28	0.5964
	Rb	12.29	0.0005	12.27	0.0005
Italy	Re	0.00	0.9897	0.00	0.9897
	Rb	8.76	0.0031	8.75	0.0031
Canada	Re	0.00	0.9483	0.00	0.9483
	Rb	11.83	0.0006	11.81	0.0006

[7] *We further find out that not only GARCH (1, 1), but also GARCH (1, 2), GARCH (2, 1) and GARCH (2, 2), are not applicable to the bond series of the five countries for the restrictions of stability conditions or diagnostic test.*

Country		F-statistic	Prob. F	Obs* R-squared	Prob. Chi-Square
Brazil	Re	0.07	0.7973	0.07	0.7973
	Rb	0.64	0.4224	0.64	0.4223
Russia	Re	2.33	0.1274	2.32	0.1273
	Rb	0.02	0.8869	0.02	0.8868
India	Re	1.60	0.2060	1.60	0.2060
	Rb	10.53	0.0012	10.51	0.0012
China	Re	0.01	0.9245	0.01	0.9244
	Rb	15.02	0.0001	14.93	0.0001
South Africa	Re	2.51	0.1136	2.51	0.1135
	Rb	1.18	0.2776	1.18	0.2775

After determining the volatility processes of the return series, we now start to examine the volatility spillover effect between equities and bonds. To this end, the causality in variance test by LM-GARCH is carried out and the results are illustrated in Table 5.

Table 5 indicates bidirectional volatility spillover between the equity and bond markets in France, Brazil and South Africa, unidirectional spillover from the bond to the equity in the US, the UK, and Germany at 1% level of significance, while in the case of Russian Federation there is not enough evidence of spillover of either direction.

Table 5

Result for Test of Causality-in-Variance

	Equity Price $\nRightarrow$ Bond Price		Bond Price $\nRightarrow$ Equity Price	
	λ_{LM}	p-value	λ_{LM}	p-value
US	8.33	0.0155	17.16	0.0002
UK	8.34	0.0154	17.28	0.0002
France	15.27	0.0005	18.28	0.0001
Germany	8.55	0.0139	13.71	0.0011
Brazil	19.95	0.0000	64.61	0.0000
Russia	5.35	0.0690	6.64	0.0361
South Africa	28.35	0.0000	13.63	0.0011

V. Conclusions

In this study, a theoretical model newly developed by Hafner and Herwartz (2006) is used to examine the volatility spillover between the equity and the bond markets in the G7 and BRICS counties.The findings of this paper can be concluded as follows.

V.1 Idiosyncratic volatility spillover effect in individual countries

The empirical result indicates bidirectional volatility spillover between the equity and bond markets in France, Brazil and South Africa, unidirectional spillover from the bond to the equity in the US, the UK and Germany at the significance of 1%, while in the case of Russian Federation, there is little evidence of spillover in ethier direction. Also, no rigorous conclusions could be drawn by the LM-GARCH model in the case of Japan, Italy, Canada, India and China. The result suggests that the equity-bond volatility spillover effect may appear idiosyncratic in different countries.

Ⅴ.2 Comparisions between developed and emerging markets

From the empirical result, one may see that there is ethier unidirectional or bidirectional equity - bond volatility spillover effect in all the developed markets. In contrast, in the emerging countries, the Russian Federation shows weak evidence for the existence of the spillover effect in both directions. According to the theories described in Part Ⅰ – Introduction, the spillover effect can be regarded as the consequence of information transimission among different markets. That is to say, spillover effect provides evidence of efficiency of cross market information transmission and the integration of financial markets, which should be improved in the Russian Federation.

Taking the subprime crisis and sovereign debt crisis into account, our emperical result has significant, meaningful and practical implication. This paper may contribute to better domestic cross-markets portfolio and risk management for investors and policy makers in both developed and emerging markets.

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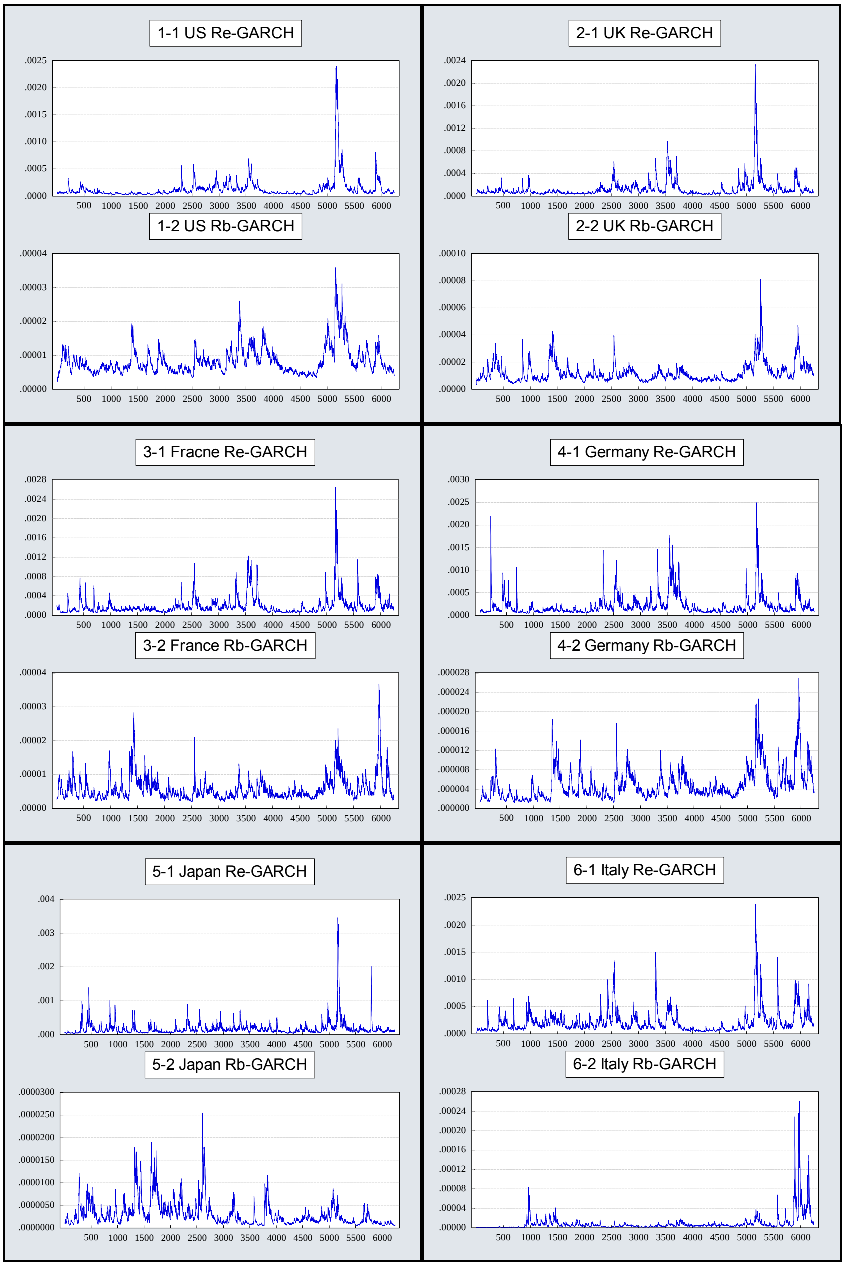
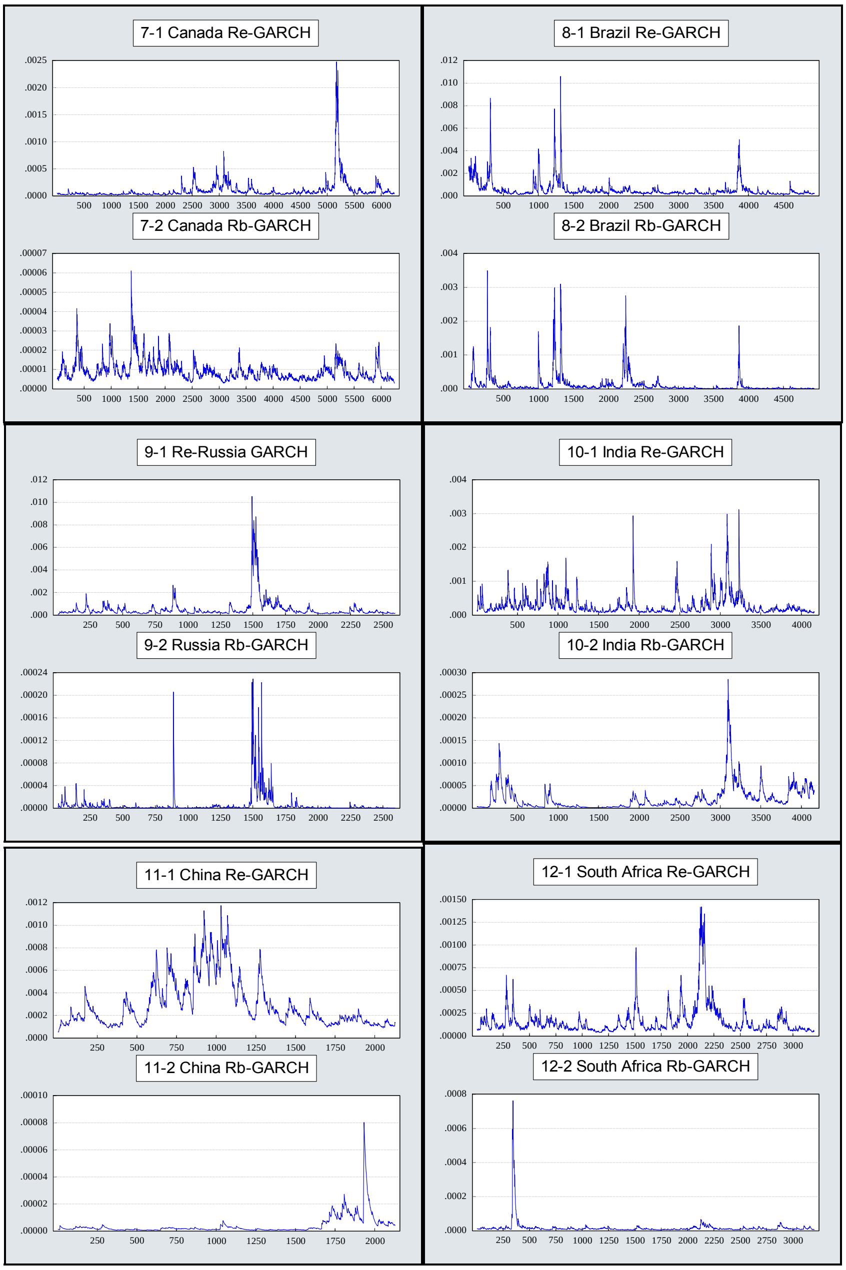
Appendix

Conditional Variance of Returns by GARCH (1, 1)




7-1 Canada Re-GARCH
8-1 Brazil Re-GARCH
7-2 Canada Rb-GARCH
8-2 Brazil Rb-GARCH
9-1 Re-Russia GARCH
10-1 India Re-GARCH
9-2 Russia Rb-GARCH
10-2 India Rb-GARCH
11-1 China Re-GARCH
12-1 South Africa Re-GARCH
11-2 China Rb-GARCH
12-2 South Africa Rb-GARCH