The Volatility Spillover Effect between the US and Emerging Economies' Stock Markets

Ying Yu[1, *], Ronghua Yi[1,2]

[1]*Economics and Management School, China Jiliang University, China*
[2]*College of Modern Science and Technology, China Jiliang University, China*
**corresponding author*

Keywords: emerging economies, spillover effect, market linkage.

Abstract: A growing number of foreign companies from emerging economies are listed in the US, so a BEKK multi-GARCH model is used to analyze the linkage and spillover effect between the US and emerging economies stock market. The results show that the US market has one-way mean spillover effects on emerging economies. There is a two-way volatility spillover effect between the South African market and the US market. There is a one-way volatility spillover effect in the Korean, the Indian and the Chilean markets and the US market. And there is no volatility spillover in the Chinese mainland, the Brazilian and the Mexican markets and the US market.

1. Introduction

Since the 1990s, many foreign companies listed in the major exchanges in the world that have traded up to 4,700, not only from developed markets, but many emerging economies have begun to open up their stock markets (Karolyi, 2006)[1]. This has greatly facilitated cross-market linkages between emerging and developed markets, and has raised concerns among academics about the linkage between emerging markets and between emerging and developed markets. Beirne et al. (2010)[2] studying the effects of market volatility in 41 countries reveals that emerging markets are affected by global and regional markets, and that volatility spillover effects in emerging markets in Europe are even more pronounced. Kim et al. (2015)[3] examine the spillover effects of the recent financial crisis on financial markets in five emerging Asian countries and find that the financial markets of the sample countries were briefly highly correlated with US markets. Zhou et al. (2012)[4] use the GMM method to find that during the subprime crisis, the US market had volatility spillovers into other markets, while the instability of the other markets stimulated the US market. Zheng and Zuo (2013)[5] using the Markov Switching causality model study found that market volatility spillovers in the US, the UK, Germany, Japan and Hong Kong were two-way and particularly significant during the Asian financial and subprime crises.

Since the 1990s, an increasing number of foreign companies have been listed in the US, resulting in increased linkage between the US market and the home markets of these foreign companies, as well as the increasing contribution of foreign companies to the US market. Therefore, this paper takes

NYSE as the research object to explore the linkage and volatility spillover effects between emerging economies and the US stock market.

2. The Empirical Model

When investigating dynamic correlation and volatility spillovers between emerging economies and the US stock market, Perry (2012)[6] states that the strongest evidence of volatility spillover comes from the estimation of the BEKK model. In this paper, the BEKK is selected to test the dynamic spillover effect between emerging economies and the US stock market.

2.1. VARMA-GARCH (1,1) Model

Mean equation:

$$r_{it} = m_{i0} + \sum_{j=1}^{2} m_{ij} r_{jt-1} + \varepsilon_{it}, \varepsilon_{it} | I_{it-1} \sim N(0, h_{it}), i = 1,2 \tag{1}$$

$$\varepsilon_{it} = v_{it} h_{it}^{1/2}, v_{it} \sim N(0,1) \tag{2}$$

$$h_{it} = c_{ii} + \sum_{j=1}^{2} \alpha_{ij} \varepsilon_{jt-1}^{2} + \sum_{j=1}^{2} \beta_{ij} h_{jt-1} \tag{3}$$

where r_{it} is the return for the time series, and ε_{it} is a random error term with conditional variance h_{it}. The market information available at time *t-1* is denoted as I_{it-1}. Equation (3) specifies a GARCH(1,1) process with VARMA terms (Ling and McAleer, 2003)[7].

2.2. BEKK-GARCH (1,1) Model

The BEKK-MGARCH model was proposed by Engle and Kroner (1995)[8] in the following form:

$$H_t = CC' + A\varepsilon_{t-1}\varepsilon_{t-1}'A' + BH_{t-1}B' \tag{4}$$

where H_t is the conditional variance-covariance matrix of the residual vector ε_t under the information set I_{t-1}, C is the 2*2 step under the triangle matrix, A is the two-dimensional ARCH term coefficient matrix, B is the two-dimensional GARCH term coefficient matrix, and ε_{t-1} is the 2*1 matrix composed of residual terms. The specific form is as follows:

$$H_t = \begin{bmatrix} h_{11,t} & h_{12,t} \\ h_{21,t} & h_{22,t} \end{bmatrix}, \quad \varepsilon_{t-1} = \left[\varepsilon_{1,t-1}, \varepsilon_{2,t-1}\right]'$$

$$A = \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix}, \quad B = \begin{bmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{bmatrix}, \quad C = \begin{bmatrix} c_{11} & 0 \\ c_{21} & c_{22} \end{bmatrix}$$

For ease of observation, the elements in the conditional variance-covariance matrix H_t are expanded as follows:

$$\begin{aligned} h_{11,t} &= c_{11}^2 + \left(\beta_{11}^2 h_{11,t-1} + 2\beta_{11}\beta_{12} h_{12,t-1} + \beta_{12}^2 h_{22,t-1}\right) \\ &+ \left(\alpha_{11}^2 \varepsilon_{1,t-1}^2 + 2\alpha_{11}\alpha_{12}\varepsilon_{1,t-1}\varepsilon_{2,t-1} + \alpha_{12}^2 \varepsilon_{2,t-1}^2\right) \end{aligned} \tag{5}$$

$$\begin{aligned} h_{22,t} &= c_{22}^2 + \left(\beta_{22}^2 h_{22,t-1} + 2\beta_{21}\beta_{22} h_{12,t-1} + \beta_{21}^2 h_{11,t-1}\right) \\ &+ \left(\alpha_{21}^2 \varepsilon_{1,t-1}^2 + 2\alpha_{21}\alpha_{22}\varepsilon_{1,t-1}\varepsilon_{2,t-1} + \alpha_{22}^2 \varepsilon_{2,t-1}^2\right) \end{aligned} \tag{6}$$

$$h_{12,t} = c_{11}c_{21} + \left[\beta_{11}\beta_{12}h_{11,t-1} + \left(\beta_{12}\beta_{21} + \beta_{11}\beta_{22}\right)h_{12,t-1} + \beta_{21}\beta_{22}h_{22,t-1}\right] + \left[\alpha_{11}\alpha_{12}\varepsilon_{1,t-1}^{2} + \left(\alpha_{12}\alpha_{21} + \alpha_{11}\alpha_{22}\right)\varepsilon_{1,t-1}\varepsilon_{2,t-1} + \alpha_{21}\alpha_{22}\varepsilon_{2,t-1}^{2}\right] \quad (7)$$

By equations (5) and (6), the main diagonal α_{ii} and β_{ii} (i=1,2) in matrices *A* and *B* respectively reflect the ARCH effect and GARCH effect of the volatility of the return itself, that is, the aggregation and persistence of the volatility. The non-main diagonal elements α_{ij} and β_{ij} (i, j=1, 2, $i \neq j$), respectively, reflect the return *j* to return *i* of the ARCH-type and GARCH-type volatility spillover effect.

3. Empirical Results and Discussion

We select the daily closing index series of market indices in 7 emerging economies, namely, the Mumbai SENSEX30 Index in India (SEN), the Korea Composite Index (HZ), the Shanghai Index in Chinese mainland (SZ), the South African FTSE Index (NF), the São Paulo IBOVESPA Index in Brazil (IBO), the IPSA Chile 40 Index (IPSA), and the Mexico MXX Index (MXX). We use the Dow Jones Industrial Average (DJIA) to represent the US market.

3.1. Summary Statistics for Market Returns

Table 1: Summary statistics for the market returns in 7 emerging economies and the US market.

	DJIA	SZ	HZ	SEN	NF	IBO	IPSA	MXX
Mean	0.031	0.025	0.014	0.044	0.048	0.038	0.040	0.055
Std. dev	1.056	2.024	1.755	1.527	1.500	2.081	1.138	1.488
Skewness	-0.170	1.032	-0.330	-0.581	-0.212	0.272	0.171	0.007
Kurtosis	8.446	22.540	6.615	11.686	235.728	13.218	17.306	7.126
Student's t	2.451	0.934	0.615	1.890	2.203	1.302	2.711	2.853
Jarque-Bera	21,023.2	122,932.7	10,235.6	24,429.1	10,944,563.4	36,269.2	73,692.1	12,613.3
Probability	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ADF test	-63.23***	-52.190***	-53.172***	-46.249***	-51.958***	-50.786***	-50.625***	-53.965***
KPSS test	0.104	0.031	0.109	0.060	0.036	0.043	0.062	0.062

*Note: ***, **, * represent a significance level of 1%, 5%, and 10%, respectively here and in the table below.*

Table 1 shows that each rate of return is positive, and the Student's t statistic indicates that its mean value is significantly not zero. Each series shows nonzero skewness and higher kurtosis (both higher than 3), and the return series have significant peak states for the characteristics of the JB statistics, indicating that the returns do not have a normal distribution. The ADF and KPSS tests show that each time series is stable.

3.2. BEKK Results

Table 2: BEKK parameter estimates.

	SZ	HZ	SEN	NF	IBO	IPSA	MXX
Mean							
m_{10}	0.064*** (5.925)	0.071*** (7.206)	0.068*** (4.973)	0.074*** (7.346)	0.057*** (4.548)	0.066*** (6.048)	0.061*** (6.291)
m_{11}	-0.026 (-1.485)	-0.029** (-2.397)	-0.072*** (-4.870)	-0.051*** (-3.590)	-0.044*** (-3.073)	-0.034** (-2.360)	-0.020 (-1.365)
m_{12}	-0.002 (-0.426)	0.012 (1.634)	0.013 (1.312)	0.029 (1.569)	0.011 (1.489)	0.008 (0.640)	0.012 (1.385)
m_{20}	0.219 (1.468)	0.022 (1.407)	0.066*** (3.649)	0.075*** (3.375)	0.088*** (3.676)	0.054*** (5.738)	0.073*** (5.911)
m_{21}	0.118*** (8.442)	0.418*** (26.732)	0.249*** (11.586)	0.325*** (16.874)	0.043 (1.382)	0.058*** (4.562)	0.038** (1.991)
m_{22}	0.002 (0.140)	-0.027** (-2.413)	0.019 (1.072)	-0.055*** (-3.880)	-0.0001 (-0.009)	0.186*** (10.947)	0.073*** (4.462)
Variance							
c_{11}	0.119*** (6.943)	0.132*** (9.012)	-0.129*** (-7.404)	0.154*** (4.766)	0.125*** (8.199)	0.112*** (8.600)	0.116*** (6.899)
c_{21}	0.021 (1.144)	0.044*** (3.067)	-0.059* (-1.931)	0.032 (0.114)	0.185*** (5.778)	0.039 (1.224)	0.078*** (4.509)
c_{22}	-0.097** (-2.194)	0.061*** (2.793)	0.043 (1.032)	0.170*** (2.905)	0.180*** (6.065)	0.261*** (4.210)	0.080*** (5.978)
α_{11}	0.278*** (9.546)	0.306*** (12.032)	0.313*** (10.275)	0.358*** (12.351)	0.288*** (9.114)	0.272*** (12.229)	0.279*** (11.356)
α_{12}	-0.002 (-0.099)	0.067** (2.300)	0.093*** (2.614)	0.321*** (4.361)	-0.007 (-0.097)	-0.002 (-0.096)	0.023 (0.741)
α_{21}	0.002 (0.433)	0.005 (0.158)	0.008 (0.339)	0.002 (0.255)	0.017 (1.608)	0.023* (1.736)	0.006 (0.686)
α_{22}	0.252*** (5.817)	0.210*** (6.640)	0.163*** (3.138)	0.146*** (3.383)	0.272*** (9.774)	0.452*** (7.468)	0.250*** (9.997)
β_{11}	0.955*** (101.455)	0.946*** (118.519)	0.943*** (94.052)	0.877*** (115.613)	0.952*** (95.182)	0.957*** (116.827)	0.953*** (110.403)
β_{12}	-0.001 (-0.099)	-0.019** (-2.447)	-0.026*** (-2.962)	-0.243*** (-3.391)	0.0003 (0.017)	0.017 (1.622)	-0.010 (-1.130)
β_{21}	-0.001 (-0.617)	-0.002 (-0.328)	-0.003 (-0.415)	0.097*** (3.225)	-0.006 (-1.454)	-0.005 (-0.679)	-0.0002 (-0.085)
β_{22}	0.970*** (84.290)	0.977*** (140.481)	0.985*** (89.314)	0.989*** (134.636)	0.954*** (92.555)	0.862*** (20.943)	0.968*** (143.260)
Log L	-18634.1	-16778.8	-12635.4	-13832.7	-15709.6	-15396.6	-16257.9
AIC	6.478	6.045	5.954	5.861	6.325	5.223	5.455
SIC	6.498	6.065	5.980	5.884	6.347	5.242	5.455
Diagnostic test							
Q_1 (20)r	24.523 (0.220)	22.634 (0.306)	18.563 (0.550)	14.868 (0.784)	19.284 (0.503)	20.475 (0.429)	21.628 (0.361)

$Q_2(20)r$	35.293 (0.019)	25.026 (0.200)	21.656 (0.359)	37.316 (0.011)	29.164 (0.085)	29.032 (0.087)	35.225 (0.019)
$Q_1(20)r^2$	26.095 (0.163)	28.901 (0.090)	28.458 (0.099)	32.679 (0.037)	26.897 (0.138)	30.531 (0.062)	23.083 (0.285)
$Q_2(20)r^2$	9.497 (0.976)	18.328 (0.566)	8.483 (0.988)	6.745 (0.997)	35.251 (0.019)	2.742 (1.000)	48.275 (3.89e-004)

Note: 1. The T values in parentheses and the P values in parentheses are from the diagnostic tests. 2. In this study, "1" represents the NYSE, and "2" represents the home market of companies from emerging economies.

According to the mean equation, the hysteresis phase of the DJIA, NF and HZ has a significant negative effect on the current period when it is lagged by one period. There is a significant positive effect on the current period in the IPSA and MXX. There is no lag in the SZ and IBO, which have a significant effect on the current period. This result indicates that there is either positive or negative statistical significance of the mean spillover effects of the DJIA, NF, HZ, IPSA, and MXX, and the volatility depends on their own past volatility. Each model shows that the estimation coefficient of m_{21} (except for the IBO) is positive and significant, which indicates that the DJIA has significant positive mean spillover effects on the SZ, HZ, SEN, NF, IPSA and MXX. The results show that the US market has spillover effects on these emerging markets, and thus volatility in the US market will have an impact on these emerging markets.

In the BEKK model, there are several significant volatility spillovers. Both the HZ and SEN have positive significant short-term volatility spillover persistence and negatively significant long-term volatility spillovers in the DJIA. The NF has positive and significant short-term volatility spillovers in the DJIA. There is a two-way long-term volatility spillover between the NF and the DJIA. The DJIA has positive volatility in the IPSA.

The above analysis shows that, in addition to the Brazilian market, the US market has significant mean spillover effects on the Chinese mainland, Korean, Indian, South African, Chilean and Mexican markets. The Korean market, the Indian market and the South African market have volatility spillover continuity in the US market, and the US market has volatility spillover continuity in the South African market and the Chilean market. In short, the US market has one-way mean spillover effect on emerging economies. However, there is a two-way volatility spillover effect between the South African and the US market. There is a one-way volatility spillover effect between the Korean, Indian and the Chilean markets and the US market. There is no volatility spillover between the Chinese mainland, Brazilian and Mexican markets and the US market.

4. Conclusions and discussion

Through an empirical analysis of the sample of listed companies in the US over the past 25 years, we find that the US market has one-way mean spillover effect on emerging economies. However, there is a two-way volatility spillover effect between the South African and the US market. There is a one-way volatility spillover effect between the Korean, Indian and the Chilean markets and the US market. There is no volatility spillover between the Chinese mainland, Brazilian and Mexican markets and the US market.

In short, the listing of companies from emerging economies in the US has contributed to increasing the US market. We find that there is a two-way or one-way volatility spillover effect between emerging economies and the US market. There are also several emerging economies that do not have direct volatility spills with the US market, and the explanation for the reasons is a follow-up issue that needs to be studied. In the next study, we will also consider the issue of "quality contagion" and the extent of spillover between emerging economies and the US market.

Acknowledgements

This paper is funded by the National Natural Science Foundation of the State “Research on the effect and risk of international board of the stock market” (71871205) and “Theoretical and empirical research on reverse cross-listing and voluntary delisting of the stocks listed in overseas markets” (71473235) and the Zhejiang Provincial Key Research Base of Management Science and Engineering.

References

[1] Karolyi, G.A. (2006). The World of Cross-Listings and Cross-Listings of the World: Challenging Conventional Wisdom. Review of Finance, 10:99-152.

[2] Beirne, J., Caporale, G.M., Schulze-Ghattas, M. and Spagnolo, N. (2010). Global and Regional Spillovers in Emerging Stock Markets: a Multivariate GARCH-in-Mean Analysis. Emerg. Mark. Rev. 11 (3), 250–260.

[3] Kim, B.H., Kim, H. and Lee, B.S. (2015). Spillover Effects of the US Financial Crisis on Financial Markets in Emerging Asian Countries. International Review of Economics & Finance, 39, 192-210.

[4] Zhou, X.Y., Zhang W.J. and Zhang, J. (2012). Volatility Spillovers between the Chinese and World Equity Markets. Pacific-Basin Finance Journal, 20(2), 247-270.

[5] Zheng, T., Zuo, H. (2013). Reexamining the Time-varying Volatility Spillover Effects: A Markov Switching Causality Approach. N. Am. J. Econ. Financ. 26, 643–662.

[6] Perry, S. (2012). Correlations and Volatility Spillovers between Oil Prices and the Stock Prices of Clean Energy and Technology Companies. Energy Economics, 34(1), 248-255.

[7] Ling, S. and McAleer, M. (2003). Asymptotic Theory for a Vector ARMA-GARCH Model. Econometric Theory, 19(2), 280-310.

[8] Engle, R. and Kroner, K.F. (1995). Multivariate Simultaneous Generalized ARCH. Econometric Theory, 11(1), 122-150.