E C O N O M I C S B U L L E T I N

Does the US IT stock market dominate other IT stock markets: Evidence from multivariate GARCH model

Zhuo Qiao
Department of Economics, National University of Singapore

Venus Khim-Sen Liew
Labuan School of International Business and Finance, Universiti Malaysia Sabah

Wing-Keung Wong
Department of Economics, National University of Singapore

Abstract

Utilizing multivariate GARCH framework, this study finds that generally the US Information Technology (IT) market contributes a strong volatility rather than mean spillover effect to non-US IT markets, implying that the US IT market plays a dominant role in affecting the volatility of world IT markets. However, our further analysis of the dynamic path of correlation coefficients reveals that the strong relationship between US and non-US IT markets had weakened after the burst of the IT bubble.

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1. Introduction

The revolution in information technology (IT) in the past decade or so, coupling with the liberalization and globalization of goods and financial market, has greatly enhanced the inter-linkage between international financial markets especially the world stock markets. Much evidence has been documented in the recent literature regarding the association between correlation and volatility, the existence of an increasing trend in co-movements in international stock markets and the nature of transmission mechanism of mean and variance spillovers from one market to others (Karolyi, 1995; Hamori and Imamura, 2000; Caporale *et al*., 2002; Liao and Williams, 2004; Morana and Beltratti, 2006). Nonetheless, studies that focus on interdependence among industry-based stock markets are relatively rare. Among the few, Jorge and Iryna (2002) scrutinized the Telecommunications, Media and Technology (TMT) and non-TMT sectors, whereas Jeon and Jang (2004) focused the technology-based stocks only[1].

Following the spirit of these two recent studies, but focusing on the IT sector and using more recent econometric approach, the current research attempts to study the spillover effects among the IT-based stock markets. Specifically, the nature of spillover effects, if any, between US and the non-US IT markets is of special interest. This study is motivated by the observation that the business cycle of the recent US and the world economy is closely associated to the growth of IT sectors (Oliner and Sichel, 2000; Maich, 2003). Importantly, should spillovers exist, investors and portfolio managers have to closely monitor the movements in both markets and carefully devise their globally investment strategy accordingly. First, spillovers imply international diversification strategy should be adopted with active portfolio management. Second, discovering the causality direction of spillovers may provide useful insights in better understanding the long-run direction of a stock market based on others. Third, the transmission mechanism of mean or variance spillovers may produce better econometric models in describing the temporal behavior of international stock markets.

This study is confined the examination of the spillover effects between the information technology (IT) stock market in the United States and those in Japan, France, Canada, Finland, Sweden and Hong Kong. The multivariate representation of GARCH model initially formulated by Baba *et al*. (BEKK, 1990), or the so-called BEKK GARCH model, which has the advantage of allowing one to investigate the lead-lag relationships or informational spillover effects of two or more variables, both the first (causality in mean) and second order (causality in variance) specifications, is utilized in this study. This model has gained its popularity in financial market studies to test for the volatility

[1] Jorge and Iryna (2002) found, based on T-GARCH modelling, that the US market plays an important role in determining price dynamics in Asia-Pacific stock markets for both sectors, whereas Jeon and Jang (2004) discovered, from vector autoregression analysis, that only a unidirectional causation from the US high technology to the South Korean high technology markets.

transmission or spillover effects after the seminal work of Engle and Kroner (1995)[2]. Considering the usefulness of this model in the identification of informational spillover effects in financial markets, this study, therefore, adopts it to analyze international linkages between the information technology stocks.

2. Data and the Model

The weekly IT indices of the United States (US), Japan (JP), France (FR), Canada (CA), Finland (FIN), Sweden (SWE) and Hong Kong (HK) taken from *DataStream International* covering the period from January 1995 to December 2005 with the total number of observations to be 574 are employed in our study. The weekly Wednesday indices are utilized to alleviate the effects of noise characterizing daily data and to avoid the day-of-the-week effect (Lo and MacKinlay, 1988). In addition, to avoid exchange rate bias, all indices are expressed in US dollars. The weekly continuously compounded rate of return, r_t, on date *t* is defined as:

$$r_t = 100(\ln p_t - \ln p_{t-1}) \tag{1}$$

where p_t is the corresponding price index on date *t* for each of the IT stock price indices.

The descriptive statistics of the resulting weekly returns reveal that, the returns are typically left-skewed, platykurtic and non-normal[3]. More importantly, the Ljung-Box statistic suggests the existence of strong serial correlation in the squared levels of all the stock returns, thereby revealing the presence of time-varying volatility such as GARCH effects in these series. In the vein of Karolyi (1995) and Liao and Williams (2004), the following bivariate BEKK GARCH(1,1) framework is then adopted to model the dynamic linkages between the two IT markets in terms of both mean and volatility spillover effects (Baba *et al*., 1990; Engle and Kroner, 1995)[4]:

$$\begin{aligned} r_{1t} &= c_1 + \phi_{11} r_{1t-1} + \phi_{12} r_{2t-1} + \varepsilon_{1t} \\ r_{2t} &= c_2 + \phi_{21} r_{1t-1} + \phi_{22} r_{2t-1} + \varepsilon_{2t} \end{aligned} \tag{2}$$

where r_{1t} and r_{2t} denote the stock index returns on US and the individual non-U.S IT stock markets, respectively[5]. The vector of error terms, $\varepsilon_t = (\varepsilon_{1t}, \varepsilon_{2t})'$ conditional on the

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[2] Karolyi (1995), for instance, utilized this framework to model international transmissions of stock returns and volatility in the context of US and Canada, whereas Caporale *et al*. (2002) applied it to the East Asian markets to examine the causality relationship between stock prices and exchange rates volatility. More recently, Liao and Williams (2004) employed this framework to model stock market interdependence in groups of European Community.

[3] The results are available on request.

[4] This specification is usually sufficient to model volatility in financial time series (Baba *et al*., 1990).

[5] As the US IT industry is believed to hold a leading position in the world, this study only examines the linkages between the US IT market and the IT markets in the non-US countries, not among non-US countries.

past information set Ω_{t-1} is specified as:

$$\varepsilon_t \mid \Omega_{t-1} \sim N(0, \Sigma_t) \tag{3}$$

where $\Sigma_t = \begin{pmatrix} \sigma_t^{11} & \sigma_t^{12} \\ \sigma_t^{21} & \sigma_t^{22} \end{pmatrix} = A_0 A_0^{'} + A_1 (\varepsilon_{t-1} \varepsilon_{t-1}^{'}) A_1^{'} + B_1 \Sigma_{t-1} B_1^{'}$ is the symmetric and positive semi-definite variance-covariance matrix of ε_t, A_0 is a lower triangular matrix, and A_1 and B_1 are unrestricted square matrices. This framework enables us to examine the dynamics of Σ_t fully. Usefully, it allows for the interaction between the conditional variances and covariances, thereby allowing us to observe the contemporaneous information flows across market. The expansion of BEKK (1, 1) into individual dynamic equations generates the following variance and covariance equations:

$$\begin{aligned}
\sigma_t^{11} &= \left(A_0^{11}\right)^2 + \left[A_1^{11}\varepsilon_{1t-1} + A_1^{12}\varepsilon_{2t-1}\right]^2 + \left[\left(B_1^{11}\right)^2 \sigma_{t-1}^{11} + 2B_1^{12}B_1^{11}\sigma_{t-1}^{12} + \left(B_1^{12}\right)^2 \sigma_{t-1}^{22}\right], \\
\sigma_t^{22} &= \left(A_0^{21}\right)^2 + \left(A_0^{22}\right)^2 + \left[A_1^{21}\varepsilon_{1t-1} + A_1^{22}\varepsilon_{2t-1}\right]^2 + \left[\left(B_1^{21}\right)^2 \sigma_{t-1}^{11} + 2B_1^{21}B_1^{22}\sigma_{t-1}^{21} + \left(B_1^{22}\right)^2 \sigma_{t-1}^{22}\right], \\
\sigma_t^{12} &= A_0^{11}A_0^{21} + A_1^{11}A_1^{21}\varepsilon^2_{1t-1} + (A_1^{11}A_1^{22} + A_1^{12}A_1^{21})\varepsilon_{1t-1}\varepsilon_{2t-1} + A_1^{12}A_1^{22}\varepsilon^2_{2t-1} + B_1^{11}B_1^{21}\sigma_{t-1}^{11} + \\
&\quad \left(B_1^{12}B_1^{21} + B_1^{11}B_1^{22}\right)\sigma_{t-1}^{12} + B_1^{12}B_1^{22}\sigma_{t-1}^{22}.
\end{aligned} \tag{4}$$

This BEKK specification is a more general and flexible multivariate GARCH model as there is no restriction imposed on the coefficients but they contain all the ARCH and GARCH items in the equations; see Baba *et al*. (1990) for more details. Remarkably, in this framework, the dynamics of the conditional variance and covariance are modeled directly and the volatility spillover effects across return series indicated by the off-diagonal entries of coefficient matrices A_1 and B_1 can also be estimated. Particularly, the ϕ_{12} (ϕ_{21}) measures the mean spillover effects from the non-US (US) to the US (non-US); whereas A_1^{12} and B_1^{12} (A_1^{21} and B_1^{21}) measure the volatility spillover effects from the non-US (US) to the US (non-US) stock market.

3. Empirical Results

The estimated VAR(1)-BEKK GARCH(1,1) models is presented in Table 1. Among the estimates of mean equations, the highly-significant positive estimates of ϕ_{21} for US-HK and US-JP suggest that there are mean spillover effects from the US IT stock market to both Japan and Hong Kong IT stock markets. On the other hand, positive mean spillover effects from France, Canada and Sweden IT stock markets to the US IT stock market are revealed by the significantly positive estimates of ϕ_{12}. As for US and Finland, no mean spillover is detected in either direction. All-in-all, it can be concluded that US IT market does not play a dominant role in mean spillover effect as it contributes a mean spillover effect to only a few other IT markets but, on the other hand, some other IT markets also generate significant mean spillover effects to the US IT market.

Table 1
Estimates for VAR (1)-BEKK GARCH(1, 1) Model

Estimates	Markets					
	US-JP	US-FR	US-CA	US-FIN	US-SWE	US-HK
c_1	0.315（0.152)**	0.305(0.163)*	0.229(0.160)	0.322(0.191)*	0.297(0.167)*	0.379(0.180)**
c_2	0.084(0.166)	0.311(0.201)	0.215(0.237)	0.594(0.286)**	0.410(0.318)	0.269(0.258)
ϕ_{11}	-0.056(0.050)	-0.108(0.057)*	-0.145(0.055)***	-0.081(0.060)	-0.123(0.054)**	-0.055(0.053)
ϕ_{12}	-0.009(0.036)	0.095(0.042)**	0.071(0.032)**	0.053(0.037)	0.062(0.028)**	0.023(0.032)
ϕ_{21}	0.171(0.042)***	0.034(0.062)	-0.087(0.081)	0.003(0.076)	-0.119(0.095)	0.158(0.063)***
ϕ_{22}	-0.056(0.042)	0.011(0.058)	0.116(0.063)*	-0.069(0.057)	-0.021(0.068)	0.018(0.052)
A_0^{11}	0.238(0.286)	0.038(1.289)	0.199(0.275)	0.126(1.058)	0.385(0.269)	0.380(0.226)*
A_0^{21}	-0.430(0.509)	-0.6932(6.233)	-0.807(1.687)	1.447(12.402)	-0.758(0.668)	1.435(0.448)***
A_0^{22}	0.233(0.866)	0.6053(0.122)	0.009(154.815)	0.631(28.120)	0.009(52.541)	0.000(2.142)
A_1^{11}	0.287(0.045)***	0.207(0.055)***	0.249(0.046)***	0.268(0.049)***	0.237(0.047)***	0.117(0.049)**
A_1^{12}	0.030(0.031)	0.044(0.041)	0.006(0.037)	-0.018(0.035)	0.028(0.027)	0.073(0.023)***
A_1^{21}	-0.023(0.045)	-0.118(0.063)*	-0.026(0.070)	0.072(0.078)	-0.043(0.078)	-0.104(0.073)
A_1^{22}	0.196(0.032)***	0.376(0.044)***	0.311(0.057) ***	0.230(0.043)***	0.216(0.031)***	0.402(0.038)***
B_1^{11}	0.961(0.017)***	0.989(0.016)***	0.971(0.016)***	0.993(0.026)***	0.969(0.018)***	0.995(0.009)***
B_1^{12}	-0.016(0.012)	-0.023(0.016)	-0.003(0.013)	-0.027(0.022)	-0.008(0.008)	-0.037(0.008)***
B_1^{21}	0.033(0.015)**	0.065(0.022)***	0.040(0.027)	0.070(0.037)**	0.056(0.025)**	0.028(0.016)*
B_1^{22}	0.962(0.011)***	0.900(0.022)***	0.933(0.022)***	0.908(0.026)***	0.960(0.008)***	0.895(0.017)***

Note: The estimates are based on equations (2) to (4) in the text. The first-order A_1^{ij} and B_1^{ij} terms are the elements of the ARCH and GARCH coefficient matrices A_1 and B_1 in Equations (3) and (4). Numbers in parentheses are standard errors. ***, ** and * indicate significance at the 1, 5 and 10% level, respectively.

As for volatility spillover effect, it is found that the volatility in US IT market has been transmitted to all other IT markets, based on the significantly positive estimates of B_1^{21} (except Canada). Conversely, Hong Kong is the only country with significant positive estimates of A_1^{12} and B_1^{12}, implying that excluding Hong Kong, other IT markets have no significant influence on the volatility of US IT market[6].

To solicit further insights on the dynamic evolution path of correlation between the IT markets, the time-varying conditional correlation coefficients estimated from the VAR (1)-BEKK (1, 1) model for each pair of markets are depicted in Figure 1. This figure provides some interesting stylized facts: For the period 1999-2002, i.e. the period of the formation, spread and collapse of the IT bubble, the correlation between US and non-US IT markets is high and exhibits an upward trend, indicating the market relations are very close during the IT bubble which becomes a global event to affect each stock market significantly. However, after the burst of the IT bubble, the correlation path exhibits steep

[6] The diagnostic check of Ljung-Box test is applied to both the standardized residuals and the squared standardized residual series. Results show that all the fitted models are adequate and successful in capturing the dynamics in the first two moments of the index return series. The results are available upon request.

downward trend, suggesting that the relation between US and non-US IT market has weakened ever since.

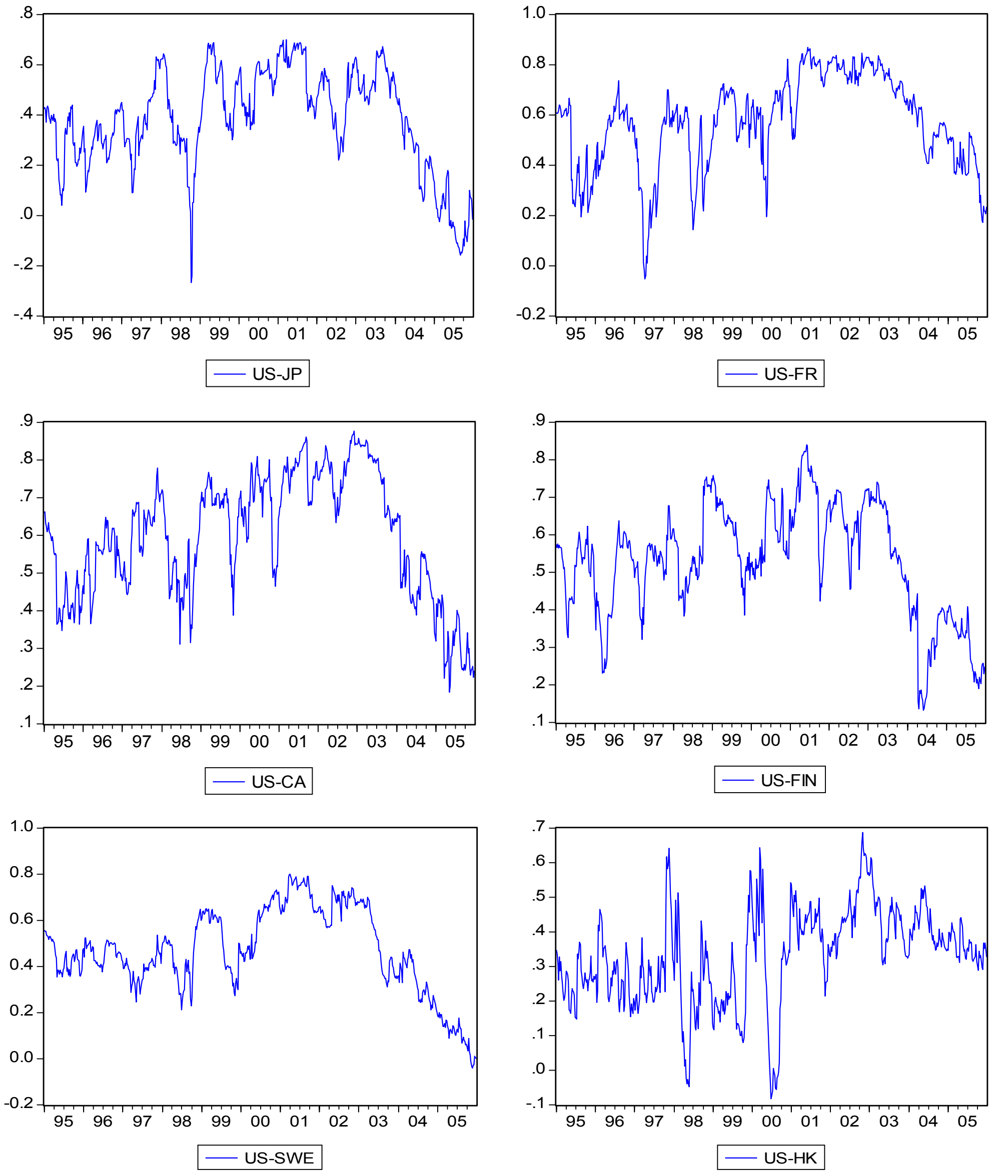

Figure 1 Contemporaneous correlations among the IT markets

4. Conclusions

Based on multivariate GARCH framework of Baba *et al*. (1990), this study finds that generally the US IT market contributes a strong volatility rather than mean spillover effect to non-US IT markets, implying that the US IT market plays a dominant role in affecting the volatility of world IT markets. However, our further analysis of the dynamic path of correlation coefficients reveals that the strong relationship between US and non-US IT markets had weakened after the burst of the IT bubble. From the policy perspective, it can be said that while mean stock return may, to some extent, be insightful, investors and portfolio managers can better understand the behaviour of those IT stocks outside the US by closely monitoring the volatility of the US IT stock return. Besides, investing in US and non-US IT stocks simultaneously should provide no diversification benefit.

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