An Exploration of the Time-varying Beta of the International Capital Asset Pricing Model: The Case of the Japanese and the Other Asia-Pacific Stock Markets

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Abstract

This study clarifies the state of dynamic evolution of the international CAPM betas for Asia Pacific (excluding Japan) and Japanese stock returns: first, both for Asia Pacific and Japanese stock markets, the time-invariant international CAPM beta values are not high. Second, over the period from July 2, 1990 to May 30, 2016, for Asia Pacific stock markets, the time-varying international CAPM betas gradually increase; while for the Japanese market, the time-varying international CAPM betas gradually decrease. We also find that the international time-varying CAPM betas for Japan are recently lower than those for Asia Pacific markets, thus, in the global equity investments, Japanese equities are more useful to obtain the diversification effects than the other Asia Pacific equities.

Keywords: Asia Pacific stock markets, International CAPM, Japanese stock market, Time-varying beta

1. Introduction

In asset pricing models, the beta values supply highly significant information for understanding the relations and evolution of asset returns. In rapidly changing and integrating international financial markets, the time-varying betas in the international capital asset pricing model (CAPM) are much more important than the time-invariant betas or domestic betas (As for the international CAPM, see Solnik (1974) and Adler and Dumas (1983), for example.). Based on these viewpoint and background, we attempt to reveal the state of evolution of the time-varying betas of the international CAPM by focusing on the Asia Pacific stock portfolio excluding Japan and the Japanese stock portfolio for the period from July 2, 1990 to May 30, 2016. This is our objective of the paper.

Our quantitative examinations employing the full Baba-Engle-Kraft-Kroner (BEKK) model (Engle and Kroner, 1995) reveal the following interesting evidence. First, both for Asia Pacific and Japanese stock markets, the time-invariant international CAPM beta values are not so high. Second, for Asia Pacific stock markets, the time-varying international CAPM betas gradually increase, while for the Japanese market, those values gradually decrease during our analyzing period. Our evidence implies that because the Japanese time-varying international CAPM betas are recently rather low, in practical global equity investments, Japanese equities are more useful to obtain the diversification effects than the other Asia Pacific equities.

After this introduction, Section 2 reviews related research; Section 3 explains our data; and Section 4 describes our quantitative methods. Section 5 presents our results; Section 6 exhibits some discussions; and in Section 7, we conclude the paper.

2. Literature Review

This section concisely reviews the previous related studies. Ramchand and Susmel (1998) tested a conditional version of the international CAPM and they suggested that in particular, for North American markets, the time- and state-varying betas were clearly found. A research by Coën (2001) developed an interesting international CAPM, in which human capital were included. Further, Mo and Wu (2007) developed an international CAPM, under which each equity index return was decomposed into two orthogonal jump-diffusion components. They suggested these two components were a global component and a country-specific component. Arouri, Nguyen, and Pukthuanthong (2012) suggested a theoretical testable international CAPM for partially segmented markets. Employing six emerging stock market data and three mature stock market data, they found that the degree of equity market integration varied

through time. A recent study by Tsuji (2012) conducted asset pricing research as to the Japanese stock market; however, it did not use the international CAPM framework.

Furthermore, Baillie and Cho (2016) analyzed the variation in the euro-dollar rates from an international CAPM perspective. They found that the euro-dollar rates were largely influenced by the US and Eurozone stock markets. As above, there are indeed some interesting past studies of the international CAPM; however, it is pointed out that not many studies of this model exist in the past literature. Hence, we note that our present study focusing on international CAPMs in Asia Pacific stock markets shall add precious facts and knowledge to the existing body of literature.

3. Data and Variables

This section explains the data for our analyses. This study employs three daily international stock portfolio returns. First is (1) the global equity market return, which is denoted by WM; second is (2) the Asia Pacific (excluding Japan) stock portfolio return, which is denoted by AP; and third is (3) the Japanese stock portfolio return, which is denoted by JP. All daily time-series percentage return data in US dollars are supplied by Kenneth French. Our analyzing sample period is from July 2, 1990 to May 30, 2016, and all the state of return evolution is understood from Figure 1.

Table 1. The estimation results of OLS of the international CAPM for Asia Pacific and Japanese stock portfolios

Panel A. Results for Asia Pacific stock portfolio returns			Panel B. Results for Japanese stock portfolio returns		
	Const.	Beta for AP		Const.	Beta for JP
Coef.	0.0197*	0.6928***	Coef.	−0.0054	0.6194***
p-value	0.0554	0.0000	p-value	0.6751	0.0000
Adjusted R-squared value		0.3256	Adjusted R-squared value		0.1552

Notes: In this table, *** and * denote the statistical significance at the 1% and 10% levels. Moreover, Const. means the constant term and Coef. denotes the coefficient.

4. Models and Methodology

We next document our models and methodology for our investigations. We first estimate the following international CAPM (1) by the ordinary least squares (OLS) approach.

$$r_{i,t} - r_{f,t} = \mu_i + \beta_i(r_{W,t} - r_{f,t}) + \varepsilon_{i,t}. \tag{1}$$

In model (1), $r_{i,t}$ is a portfolio return (We use AP or JP.); $r_{W,t}$ means the global equity market return (We use WM.); and $r_{f,t}$ is the risk-free rate. We obtain the time-invariant betas for the international CAPM by regressing $r_{i,t}$ on $r_{W,t}$; and the time-invariant beta is expressed as follows:

$$\beta_i = \sigma_{i,W} / \sigma_W^2. \tag{2}$$

In the above equation (2), the right-hand side numerator means the time-invariant covariance as to a portfolio return (AP or JP) and the global equity market return (WM). Further, the right-hand side denominator means the time-invariant variance as to the global equity market return. In order to derive the time-varying betas, in this study, we employ the following full BEKK model with asymmetric terms (3):

$$\mathbf{H}(t) = \mathbf{CC}' + \mathbf{A}'\mathbf{u}(t-1)\mathbf{u}(t-1)'\mathbf{A} + \mathbf{B}'\mathbf{H}(t-1)\mathbf{B} + \mathbf{D}'\mathbf{v}(t-1)\mathbf{v}(t-1)'\mathbf{D}. \tag{3}$$

In the application of model (3), we use only constant terms as the explanatory variables in the return equations of WM and AP or WM and JP. Further, in equation (3), $\mathbf{H}$ is the time-varying variance and covariance matrix and $\mathbf{u}$ is the matrix of the return equation residuals. In addition, $\mathbf{A}$, $\mathbf{B}$, $\mathbf{C}$, and $\mathbf{D}$ are coefficient matrices and $\mathbf{v}(t-1) = \mathbf{u}(t-1) \circ I_{u<0}(\mathbf{u}(t-1))$, where $\circ$ denotes the Hadamard product.

$$\beta_{i,t} = \sigma_{i,W,t} / \sigma_{W,t}^2. \tag{4}$$

Using the estimated elements of matrix $\mathbf{H}$, as above, the time-varying beta (4) can be derived. In equation (4), the right-hand side numerator means the time-varying covariance as to the global equity market return (WM) and a portfolio return (AP or JP); and the right-hand side denominator means the time-varying variance as to the global equity market return (WM).

Panel A. Global equity market and Asia Pacific (excluding Japan) stock portfolio returns
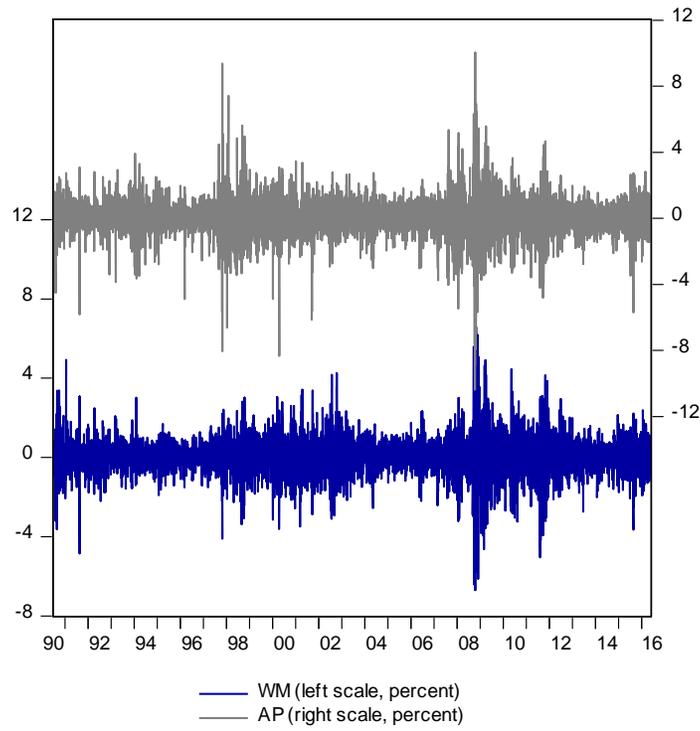
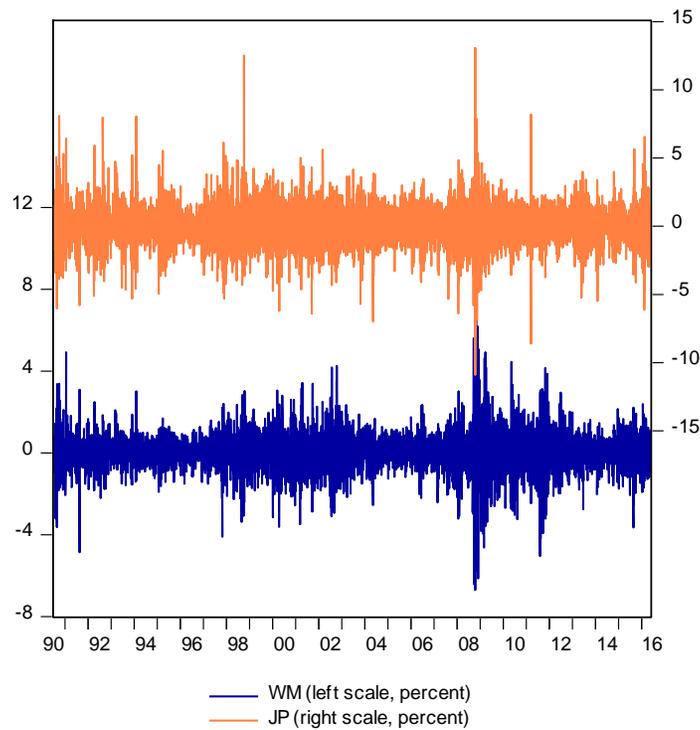Panel B. Global equity market and Japanese stock portfolio returns

Figure 1. Daily time-series return evolution of global, Asia Pacific, and Japanese stock markets: For the period from July 2, 1990 to May 30, 2016

Table 2. Estimation results of the full BEKK models for global, Asia Pacific, and Japanese stock portfolio returns: For the period from July 2, 1990 to May 30, 2016

Panel A. Results for global equity market and Asia Pacific (excluding Japan) stock portfolios

Return equations

Variables	Coef.	SE	*t*-stat.	*p*-value
Const. (WM)	0.0532***	0.0078	6.8481	0.0000
Const. (AP)	0.0647***	0.0097	6.6837	0.0000

BEKK specifications

Variables	Coef.	SE	*t*-stat.	*p*-value
C(1,1)	0.0861***	0.0072	12.0114	0.0000
C(2,1)	0.0649***	0.0158	4.1170	0.0000
C(2,2)	0.1525***	0.0121	12.6362	0.0000
A(1,1)	0.0940***	0.0208	4.5116	0.0000
A(1,2)	−0.2489***	0.0277	−8.9752	0.0000
A(2,1)	0.0613***	0.0096	6.3869	0.0000
A(2,2)	0.2742***	0.0169	16.1989	0.0000
B(1,1)	0.9709***	0.0045	216.9805	0.0000
B(1,2)	0.0303***	0.0085	3.5725	0.0004
B(2,1)	−0.0174***	0.0049	−3.5476	0.0004
B(2,2)	0.9050***	0.0097	94.6559	0.0000
D(1,1)	0.3223***	0.0175	18.4695	0.0000
D(1,2)	0.2166***	0.0335	6.4760	0.0000
D(2,1)	−0.0401**	0.0166	−2.4100	0.0160
D(2,2)	0.2282***	0.0299	7.6322	0.0000

Panel B. Results for global equity market and Japanese stock portfolios

Return equations

Variables	Coef.	SE	*t*-stat.	*p*-value
Const. (WM)	0.0438***	0.0067	6.4997	0.0000
Const. (JP)	0.0025	0.0132	0.1869	0.8517

BEKK specifications

Variables	Coef.	SE	*t*-stat.	*p*-value
C(1,1)	0.1056***	0.0070	14.9898	0.0000
C(2,1)	0.2057***	0.0182	11.3186	0.0000
C(2,2)	0.1056***	0.0112	9.4293	0.0000
A(1,1)	0.1341***	0.0183	7.3419	0.0000
A(1,2)	−0.1840***	0.0197	−9.3563	0.0000

A(2,1)	0.0064	0.0107	0.5961	0.5511
A(2,2)	0.2179***	0.0165	13.1924	0.0000
B(1,1)	0.9675***	0.0026	373.0438	0.0000
B(1,2)	0.0038	0.0051	0.7586	0.4481
B(2,1)	−0.0115***	0.0028	−4.1449	0.0000
B(2,2)	0.9399***	0.0050	186.2933	0.0000
D(1,1)	0.2798***	0.0175	15.9791	0.0000
D(1,2)	0.1387***	0.0292	4.7562	0.0000
D(2,1)	0.0076	0.0104	0.7279	0.4667
D(2,2)	0.2567***	0.0181	14.1481	0.0000

Notes: This table exhibits the maximum likelihood estimation results of the full BEKK models with asymmetric terms. The estimations are conducted for the sample period from July 2, 1990 to May 30, 2016. In this table, *** and ** indicate the statistical significance of the parameter estimates at the 1% and 5% levels, respectively. In addition, in this table, Const. means the constant term, Coef. denotes the coefficient, SE means the standard error value, and *t*-stat. means the *t*-statistic value. Furthermore, the element of matrix **CC′**'s *i*-th row and *j*-th column is denoted by C(*i*,*j*); the element of matrix **A**'s *i*-th row and *j*-th column is denoted by A(*i*,*j*); the element of matrix **B**'s *i*-th row and *j*-th column is denoted by B(*i*,*j*); and the element of matrix **D**'s *i*-th row and *j*-th column is denoted by D(*i*,*j*), respectively. The matrices **C**, **A**, **B**, and **D** are all those in equation (3).

5. Results of Analyses

5.1 Results of the OLS

First, Table 1 displays our OLS estimation results of the international CAPM for AP and JP. Table 1 suggests that our two OLS regressions statistically significantly derive the time-invariant international CAPM beta values for AP and JP at the 1% significance level. Specifically, for AP, the time-invariant international CAPM beta value is 0.6928 and the value for JP is 0.6194. Thus, we understand that the sensitivities of Asia Pacific (excluding Japan) and Japanese stock portfolio returns to the dynamic evolution of the global equity market are not so high on average.

5.2 Results of the Full BEKK and the Time-varying International CAPM Betas

Next, estimation results of our full BEKK models with asymmetry are exhibited in Table 2. It is noted that in Table 2, the element of matrix **CC′**'s *i*-th row and *j*-th column is denoted by C(*i*,*j*); the element of matrix **A**'s *i*-th row and *j*-th column is denoted by A(*i*,*j*); the element of matrix **B**'s *i*-th row and *j*-th column is denoted by B(*i*,*j*); and the element of matrix **D**'s *i*-th row and *j*-th column is denoted by D(*i*,*j*), respectively. These four matrices are those in equation (3). In Table 2, Panel A displays the estimation results for WM and AP; and Panel B shows the results for WM and JP. Both panel results in Table 2 suggest that our full BEKK models with asymmetric terms are well estimated by the maximum likelihood method.

Moreover, Figure 2 shows the beta value evolution of our two international CAPMs. Panel A of Figure 2 exhibits the time-varying beta values of AP; and Panel B of this figure displays the time-varying beta values of JP. Both series are obtained from equation (4) and these two series are shown for the period from July 2, 1990 to May 30, 2016. From the dynamic evolution seen in Panel A of Figure 2, we firstly understand that (1) for Asia Pacific stock markets, the time-varying international CAPM betas gradually increase although the values are clearly lower than 0.8 on average.

On the other hand, Panel B of Figure 2 suggests that (2) for the Japanese stock market, the time-varying international CAPM betas gradually decrease over our sample period. Similarly with the beta values of Asia Pacific stock markets, the time-varying betas for the Japanese stock market are low; in particular, after the Lehman Brothers collapse in 2008, they are around 0.5. The implication of the above results is that from the viewpoint of international equity investments, Japanese equities are more useful to obtain the diversification effects than the other Asia Pacific equities. It is again emphasized that the international CAPM betas for Japan are recently clearly lower than those for Asia Pacific equity markets as seen in Figure 2.

Panel A. Time-varying international CAPM betas of Asia Pacific (excluding Japan) stock portfolio returns
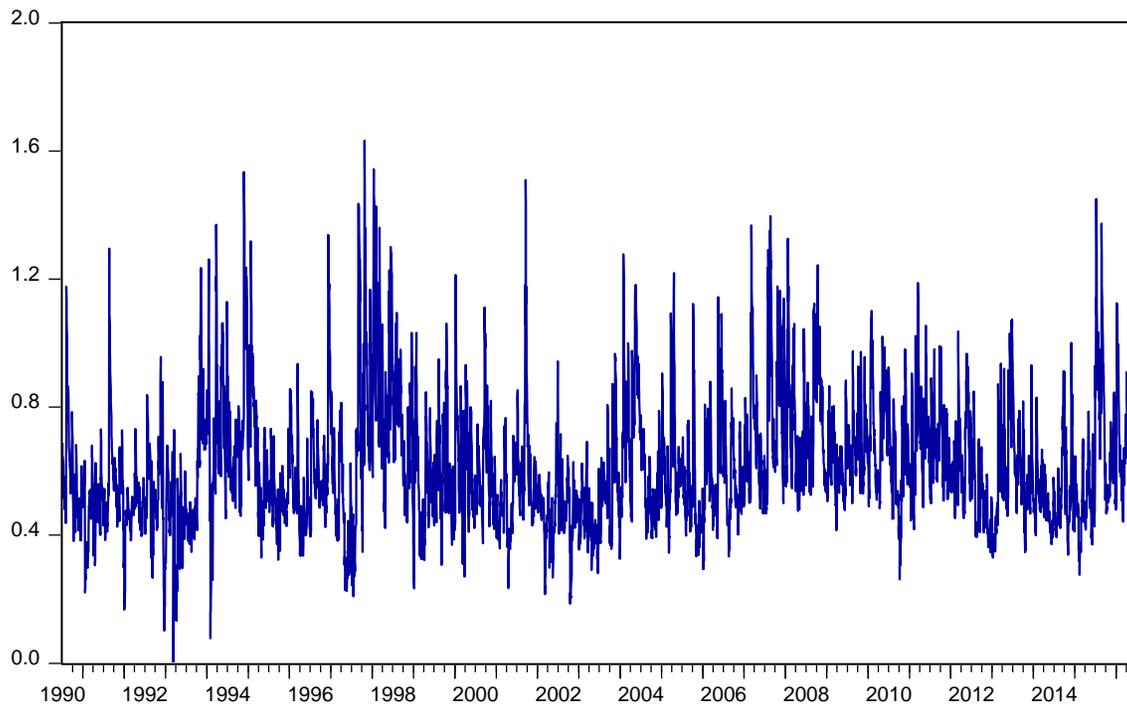
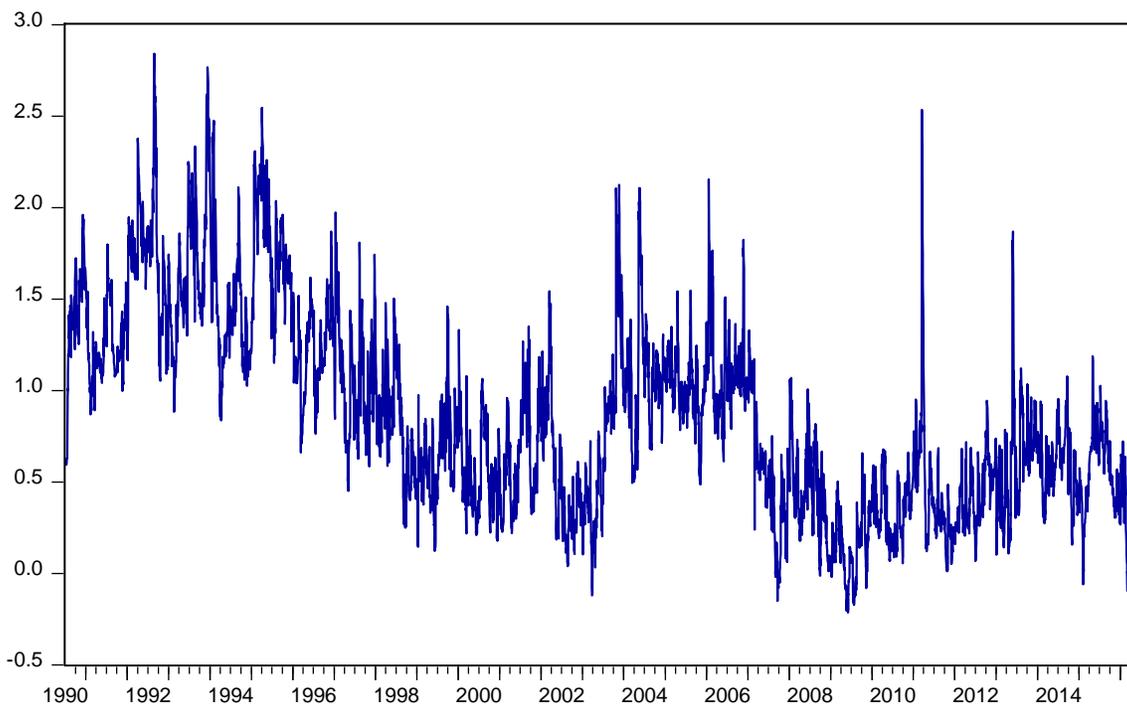Panel B. Time-varying international CAPM betas of Japanese stock portfolio returns

Figure 2. Dynamic evolution of the time-varying betas of Asia Pacific and Japanese stock portfolio returns: For the period from July 2, 1990 to May 30, 2016

6. Discussion

This section provides some discussions regarding our findings derived above. First, as we already pointed out, there is not enough quantitative research in the existing literature of the international CAPM; and in particular, little research of the international CAPM focusing on Japanese and Asia Pacific stock markets exists. Thus, we emphasize that our current study derived and supplied very precious evidence on the international CAPM as to Japanese and Asia Pacific stock markets.

We also note that our quantitative investigations of time-varying betas of the international CAPM clarified that, for the Japanese stock market and Asia Pacific stock markets, the levels and the state of evolution of the time-varying international CAPM betas were rather different. As we focused on the Japanese and Asia Pacific (excluding Japan) stock portfolios, our study has a natural limitation that it does not supply the results as to all international cases around the world; however, it is emphasized that the evidence from our study empirically and quantitatively offered a useful example and a valuable opportunity for considering international equity investments in practice.

In this sense, our findings from our study are meaningful and shall add important knowledge to existing and future academic research and business practice. In a rapidly changing and integrating global financial markets, quantitative research focusing on the international CAPM as our current study should be important and significant in the fields of finance, financial accounting, economics, and business.

7. Conclusions

This paper quantitatively examined the dynamic evolution of the international CAPM betas for Asia Pacific (excluding Japan) and Japanese stock portfolios. The analyzing period of this study was from July 2, 1990 to May 30, 2016. Our empirical examinations employing the full BEKK model with asymmetry derived the following interesting evidence. First, we clarified that (1) for Asia Pacific stock markets, the time-invariant international CAPM beta value was around 0.7; and the time-invariant international CAPM beta value for the Japanese stock market was around 0.6. We thus understand that the sensitivities of Asia Pacific and Japanese stock portfolio returns to the dynamic evolution of the global equity market were not so high on average.

Second, our investigations also revealed that (2) for Asia Pacific stock markets, the time-varying international CAPM betas gradually increased although the beta values were clearly lower than 0.8 even in the recent period. Furthermore, our empirical examinations also clarified that (3) for the Japanese stock market, the time-varying international CAPM betas gradually decreased over our analyzing period. In particular, the time-varying betas for the Japanese stock market were lower than roughly 0.5 after the Lehman Brothers collapse in 2008. We consider that the implication of the above evidence is that, recently, the Japanese equities become more useful to obtain the diversification effects than the other Asia Pacific equities.

As we summarized above, our applications of modern econometric models clarified the detailed state of the dynamic evolution as to the time-varying betas of the international CAPM for Asia Pacific and the Japanese stock portfolios. The evidence from our empirical work shall be helpful for deepen our understanding of the real-world evolution and relations of the international stock markets in a globalizing economy. Our findings shall be also useful for equity investments and portfolio management in practice from the international perspectives. Extending this kind of research is therefore one of our important future works.

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