

Econometric Analysis of Stock Price Co-movement in the Economic Integration of East Asia

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Abstract

This paper studies the economic integration of East Asian economies among one another and with the US using co-movement of stock market prices. Both time-varying correlations and regressions are employed. We have traced the increased integration from 1980 to 2011 among the NIEs of Korea, Hong Kong, Taiwan and Singapore, the increase in integration of China since the Shanghai stock market opened in 1990 and the effect of the recent great economic recession of the US on its economic influence on the East Asian economies.

JCL Classification, C22, G12

Key words: economic integration, time-varying regressions, East Asia, China, US, Japan, stock prices.

1. Introduction

The purpose of this paper is to study the economic integration of East Asian economies by observing the co-movements of weekly returns of stocks traded in their markets. Using time varying correlation and regression we trace the co-movement for a pair of markets in the three decades from 1980 to 2011. Three sets of economies are studied. The first is the newly industrial economies NIEs in East Asia, including Korea, Hong Kong, Taiwan and Singapore. The second consists of the three large economies of Japan, the US and China. Thirdly we consider the relations between the second set and the first set.

The inter-relationships between US, Japan and other Asian-Pacific equity markets have been widely recognized. Early studies show that, in the 1970s and 1980s, the US stock market influences most of the Asian-Pacific stock markets and that the Japanese market seems to have less significant impacts. Related empirical evidences can be found in Liu and Pan (1990) and Cheung and Mak (1992).

While in the 1990s, such pattern changed. Masih and Masih (1999) find Asian markets are affected more from each other, rather than from the developed markets. Ghosh, Sandi and Johnson (1999) find that Indonesia, Philippines, and Singapore are closely linked with Japan; while Hong Kong, India, Korea, and Malayasia are more linked with US. Ng (2000) finds significant regional shocks from Japan to Asian – Pacific stock markets, besides global shocks from US; Johnsen and Soenem (2002) find Asian Markets are highly correlated with Japan in the 1990s. Miyakoshi (2003) finds volatility of the Asian markets is influenced more by the Japanese market. Meanwhile, there exist significant adverse influences from the Asian markets on Japan. Huang, Yang and Hu (2000) show that, compared to Japan, US has stronger impact on Shanghai, Shenzhen and Hong Kong stock markets.

Based on the previous studies, we can expect that the equity market inter-relationships vary over time. Especially, due to the recent financial crises, there may exist structural changes in the international co-movements of equity markets. For example, Yang, Kolari and Min (2002) find

cointegration relationships among countries change over time, often strengthened around the period of financial crises.

In this paper, we study the process of economic integration of East Asian economies in the past three decades using the co-movements of their stock prices. To trace co-movements, we use two measures, time-varying correlation by rolling window estimation and time-varying coefficients in regressions between markets. While correlation is a symmetric indicator on interrelationship, time-varying coefficients can measure asymmetric impacts from one market to another and vice versa. The time-varying coefficients method, traced back to Chow (1984), can be used to show how the interrelationship of these equity markets evolve over time. In particular, compared to multivariate GARCH or stochastic volatility models, our method is not only valid in the presence of conditional heteroskedasticity frequently existing in stock returns, but also suitable when unconditional variance-covariance changes in a long span of time, three decades in our case. While multivariate GARCH models and stochastic volatility models tend to capture high frequency changes in volatility and covolatility, our method can better reveal the underlying smooth structural changes in the long run.

The rest of this paper is organized as follows. In section 2 we first describe the data and present time-varying correlations for the three sets of countries. In section 3, we present models of regression with time-varying parameters to study the co-movement between the rates of return for stocks traded in different stock markets. Section 4 discusses the results of time-varying coefficients with the three sets of economies to depict the changing co-movements of East Asian economies among themselves and with US market. Section 5 concludes.

2 Data

The data in this study consist of the weekly close price of stock market indices in Korea, Hong Kong, Taiwan, Singapore, Japan, United States and Mainland China. The indices include Korea Composite Stock Price Index (KOSPI), Hang Seng index for Hong Kong, TSEC weighted index for Taiwan, Straits Times Index (STI) for Singapore, NIKKEI 225 index for Japan, NYSE Composite Index for US and Shanghai Composite Index for China. All these indices cover the

sample period of January 1980 to July 2011, except for China. The Shanghai Composite Index data start from January 1992, one year after the Shanghai Stock Exchange was established in December 1990. All data can be retrieved from Datastream.

Since price indices are non-stationary, the co-movements between markets are difficult to be assessed with traditional econometric models. We transform the data into stationary process by calculating weekly returns from the price indices as the log difference in price:

$$r_t = \ln(P_t) - \ln(P_{t-1}).$$

With the return data, we can compute the variance of each market, and covariance or correlation between any pair of two markets. To reflect the change over time, we use a rolling window of 52 weeks, i.e about one year, of current and past returns to compute the variance and correlation at each point in time.

We first examine the economic integration among the NIEs. The results are graphically given in Figure 1. We present the results in the lower triangular part of a matrix, where the name of each market is denoted on the top and to the left of the figure. The diagonal boxes plot variances of the corresponding economies along time, and the off-diagonal boxes plot correlations between two economies.

[Figure 1 about here.]

From Figure 1 we observe heteroskedasticity evident in the variances. There are various spikes in the variances across markets, and some of them coincide with each other during financial crisis, such as the Asian financial crisis in late 1990s, and the recent global financial crisis. For Taiwan, the most unusual spike in volatility happened in late 1980s and 1990, echoing the price surge of 10 times within a year and a sudden crash at the end. In terms of pattern and timing, the Taiwan stock surge in late 1980s and crash in 1990 were in tandem with Japan that can be seen later in Figure 2 from the variance of Japan, but only with amplified scale and sharper fall, which dwarfs the magnitude of turmoil from later crisis. The dynamics of variances reveals that there

are co-movements in volatility between markets. To assess the extent of co-movement, we next look at correlations adjusted for the scales of variances.

The off diagonal boxes plot correlation between each pair of economies. Beginning with Korea from the first column, the increasing trends of the correlation with the three other economies are apparent, together with fluctuations that may reflect historical events too detailed to be studied in this paper. Hong Kong's increasing integration with Taiwan and Singapore, and Taiwan's increasing integration with Singapore are also seen in Figure 1.

To summarize the degree of integration among Japan, US and China, we present a path of the generalized variance and correlations of the rates of return for these three countries in Figure 2.

[Figure 2 about here.]

From the diagonal boxes of variances, the most common spike among the three markets is during the recent financial crisis. Japan's 1990 stock market crash can be easily identified. China experienced extremely high volatility in the first few years after the stock market was established in 1990. As market and investors became more mature, the volatility soon became tenable starting from late 1990s.

The off diagonal boxes of correlation shows that, for China, there was no increase in integration with Japan, but an increasing trend with the US becomes visible when China joined the WTO in 2002 and the trend was interrupted by the US financial crisis in 2008, only to resume in 2010. For Japan, an economy already highly integrated with the US economy in terms of trade and investment by 1980s, we do not find any increase in integration and the correlation fluctuates around zero, as Figure 2 reveals.

We next consider the integration of Japan, the US and China with the NIEs as shown in Figure 3.

[Figure 2 about here.]

For Japan, Figure 3 shows an increasing trend with Hong Kong since about 1993, with Korea, Taiwan and Singapore since the late 1990s. The increasing trends reflect the integration of these three economies and Japan in East Asia. These four economies did not get more integrated with the US economies as shown in the charts for the US in Figure 3. From 1990 China's integration with the NIEs did not increase. Although one may imagine that the correlation tends to increase in the last decade, as there are two peaks with persistent period of positive correlations. And the last peak is associated with the recent financial crisis. However, the tendency, if there is any, becomes vague due to the recent downturn since 2009.

To summarize, simple rolling estimation of correlations between the seven economies reveal a trend of increasing integration within East Asian economies, in particular within the NIEs, and between the NIEs and Japan. However, except for China which exhibits an increasing degree of integration with the US market, none other East Asian economies show higher integration with the US during the last three decades.

To investigate this issue further, we will employ time-varying regressions in the next section which can distinguish asymmetric impacts between markets.

3. Model of time-varying coefficient regressions for co-movement between stock returns

As revealed by the statistics of correlation between pairs of stock returns in Figure 1 to 3, there have been significant structural changes in the co-movement of returns among East Asian economies and with the US. To study the evolvement of the co-movements, we specify in this section two types of time-varying coefficient regressions. The first type is a bilateral regression between rate of return in one economy and return of one of its economic partners. The rate of return is the dependent variable in one regression and an explanatory variable in another regression, to reflect possible asymmetric effects between these two markets. The second type is multivariate regression with rate of return in one economy as the dependent variable and returns of multiple partners as explanatory variables. This is to check the robustness of the regression coefficients of the economic partners in the univariate case, conditional on the presence of other economic partners. In each specification, the time-varying coefficient of the current foreign

market return is modeled as a random walk process. The random walk model is appropriate to model long run movement with possible structural changes, while an autoregression coefficient of less than unity would imply a stationary process with the parameter converging to a constant.

3.1 Model specifications of time-varying coefficient regressions for co-movement between stock returns

Model I: Univariate regressions for bilateral co-movement

In this section we first specify the univariate time-varying coefficient regression for returns in two markets. In a bivariate distribution there are two regressions. We first regress the rate of return in domestic market on the return in a foreign market.

$$r_t^d = \alpha + \beta_t r_t^f + \epsilon_t \quad \epsilon_t \sim N(0, \sigma_\epsilon^2) \quad (1)$$

To reflect possible mutual and asymmetric effects from domestic market on foreign markets, we run the regressions also in the opposite directions.

$$r_t^f = \alpha + \beta_t r_t^d + \epsilon_t \quad \epsilon_t \sim N(0, \sigma_\epsilon^2) \quad (2)$$

In each specification, the time-varying coefficient of the current foreign market return is modeled as a random walk process.

$$\beta_t = \beta_{t-1} + u_t, \quad u_t \sim N(0, \sigma_u^2) \quad (3)$$

Model II: Multivariate regression

To check the robustness of the regression coefficient from the univariate regression with the domestic return as the dependent variable, we run multivariate regression with more than one stock returns from partner economies.

$$r_t^d = \alpha + \beta_{1t} r_{1t}^f + \dots + \beta_{nt} r_{nt}^f + \epsilon_t \quad \epsilon_t \sim N(0, \sigma_\epsilon^2) \quad (4)$$

Each of the time-varying coefficients is still modeled as random walk.

3.2 Estimation strategy of time-varying coefficient regression

These time-varying coefficient models fit naturally into the state-space framework. The states here are the time-varying parameters. Given the constant intercept coefficients, the time-varying latent states can be estimated by a Kalman filter. For the estimation of the constant coefficients and the latent states together, we use Bayesian inference with a Gibbs sampler. The prior distribution of α is normal, which produces posterior normal distributions. The prior distributions of parameters such as $\sigma_{\alpha}^2, \sigma_{\beta}^2$ are inverse Gamma, which produces posterior inverse Gamma distributions. These parameters can be taken as random draws directly. The Kalman filter step for the latent states is embedded in the Gibbs sampler, and we use the algorithm of DeJong and Shephard (1995) to draw from the posterior distribution of time-varying parameters. The hyperparameters of prior distribution for time-varying latent states are set at relatively large values, which allow the time-varying coefficients to change substantively over time.

4 Results

By using time-varying regressions we can observe the dependence of the returns of one economy on other economies.

4.1 Results from univariate regressions

Consider first the dependence of each of the four NIE on another NIE as shown in Figure 4. In each row, the label on the left indicates dependent variable, and the labels on top indicate the explanatory variables in a univariate regression. The solid lines are the estimated time-varying coefficients, and the dashed lines are the 95% confidence intervals for the estimates

[Figure 4 about here.]

The first row shows Korea's dependence on all other three NIEs had an increasing trend since about 1990. Hong Kong's dependence on Korea and Taiwan showed a shift in level since the mid or late 1990s but no evident increasing trend or shift in its dependence on Singapore, although its dependence on Singapore has been significantly positive most of the time. Since the mid 1990s, Taiwan has shown increasing dependence with the other three NIEs. Singapore's dependence on

Korea and Taiwan increased since the mid 1990s (the latter being small), but was hardly detected with Hong Kong, as Hong Kong's dependence on Singapore showed little increase also. In general there was an increase in dependence of each economy of the NIEs on another around the millennium.

Among Japan, the US and China, the time varying regressions are exhibited in Figure 5.

[Figure 5 about here.]

For Japan we found the dependence has not increased on the US; neither has the US dependence on Japan. But the US coefficient on Japan (in the first row and second column) has been relatively significant for some periods in the 1980s, while Japan's coefficient on the US is never significant. This result echoes the previous findings in Figure 2 that the correlation between the two markets is around zero with no positive trend within the sample period. As we have pointed out, although the economic integration of Japan and the US was already established by 1980s in terms of trade and foreign investment, there is little co-movement between stock market returns of the two economies. Japan's dependence on China increased since the mid 1990s. This is consistent with findings reported above. Again US dependence on China increased after 2000. China's increasing dependence on the US since the late 1990s was evident in Figure 5 while its dependence on Japan smoothly increased since the late 1990s, confirming previous findings.

Next, we investigate the dependence between the NIEs and the three big economies of Japan, the US and China. We first examine the impact of the three economies of Japan, the US and China on the NIEs with results reported in Figure 6. Then we report the impact of the NIEs on the three big economies in Figure 7.

Figure 6 displays the coefficients in the time-varying regressions of the four NIEs as dependent variables on Japan, the US and China

[Figure 6 about here.]

Japan became more influential on Korea since the late 1990s, but not more with Hong Kong and Singapore, while its effects on Taiwan resumed since the late 1990s after some decline since the late 1980s. The US influence on Hong Kong and Singapore did not show an increasing trend, and was not significant, while its influence on Korea had a dip in the late 1990s and early 2000s and its influence on Taiwan had a dip in the late 1980s and early 1990s, reflecting the event and aftermath of Taiwan's stock market crash accompanying that of Japan in the period. The decline in the US influences on Korea, Hong Kong and Taiwan in the late 1990s was possibly the result of the Asian Financial Crisis during that period. The influence of China on most NIEs, except for Korea, increased during the Asian Financial Crisis in late 1990s. China's effects then tended to stay significantly positive after 2000, and recently experienced a hump in 2008 possibly reflecting the common shock of the global financial crisis.

Figure 7 displays the coefficients in the time-varying regressions of Japan, the US and China as dependent variables on the four NIEs

[Figure 7 about here.]

The first row shows the influences of the NIEs on Japan. It is evident that starting from 2000, there are increasing trends in all four coefficients. This is more in line with the increasing time-varying correlations in Figure 3, although Japan's influences on NIEs from Figure 6 do not show a uniform increasing trend. In contrast, the coefficients in the second row do not display an increasing trend, nor are they significant for the US. For China, an increasing trend is seen after 2000. Consistent with Figure 6, there are humps in 2008 reflecting the co-movement responding to the common shock of the financial crisis.

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To summarize, when asymmetric bilateral impacts are considered with time-varying coefficients, we observe that:

- 1) The increasing trend in dependence is a mutual phenomenon among the four NIEs. The NIEs also experience increasing dependence with Japan and China to some extent. But no interdependence is found between NIEs and the US.

- 2) Although Japan and the US have been economically integrated in trade and foreign investment, there is no significant co-movement between the two stock markets, let alone increasing dependence.
- 3) China stands out as the only East Asian economy that has been experiencing an increasing dependence both with other East Asian economies and the US.

4.2 Robustness check with multivariate regressions

To check the robustness of our univariate results, we run multivariate regressions in this section to see whether the previous results hold for one market as explanatory variable, conditional on the presence of other markets. Especially we wish to find out whether the significant coefficient turns insignificant conditional on information from other markets. In general, our results hold in terms of the trend and significance, but the magnitude of coefficients may be reduced as a consequence. We take Taiwan in the NIEs as an example to test how the coefficients of Japan, China and the US behave in a multivariate regression.

We run the regression for equation (4) with Japan, the US and China for the overlapping sample from January 1992 to July 2011. The three series of coefficients are shown in Figure 8.

[Figure 8 about here.]

The coefficients estimated for all three markets on Taiwan are consistent with the results of univariate regressions shown in Figure 6 for the overlapping sample period from January 1992 to July 2011. The coefficients of US and Japan on Taiwan are just like a stretched version of the same images in the third rows of Figure 6. The coefficient of China on Taiwan is qualitatively similar, but smoother and with a reduced scale during the recent financial crisis. This reflects the joint influences of the US and Japan on Taiwan's stock returns with the same sign.

As an individual case among the Asian Tigers, Taiwan's multivariate regression with all three economies of Japan, the US and China actually reflects the general status of economic integration in East Asia. Within the region, Japan and China have higher impacts than the US.

While Japan has a significant role on the Asian markets, China has become more and more important in the past decade.

5. Conclusions

The results of this paper have clearly demonstrated the usefulness of time-varying correlations and regressions for studying the degrees of economic integration among economies as reflected in the co-movements of stock market returns. The same methodology can be applied to other topics than economic integration where other variables than rates of return to stocks may be more relevant.

On the subject of economic integration of East Asia, among the NIEs, among Japan, US and China and among the above two groups of economies, we have found econometric evidence to show the degrees of integration that are consistent with the recent economic histories of these economies. While it is not surprising to find increasing dependence within East Asian stock markets, it is interesting to find a not-so-close relationship between Japan and US stock markets in contrast to their economic integration in trade and investment, as well as China's unique increasing linkage with the US stock market. For future work, it would be of interest to construct econometric models using the time-varying coefficients or correlations as variables to be explained.

Acknowledgements

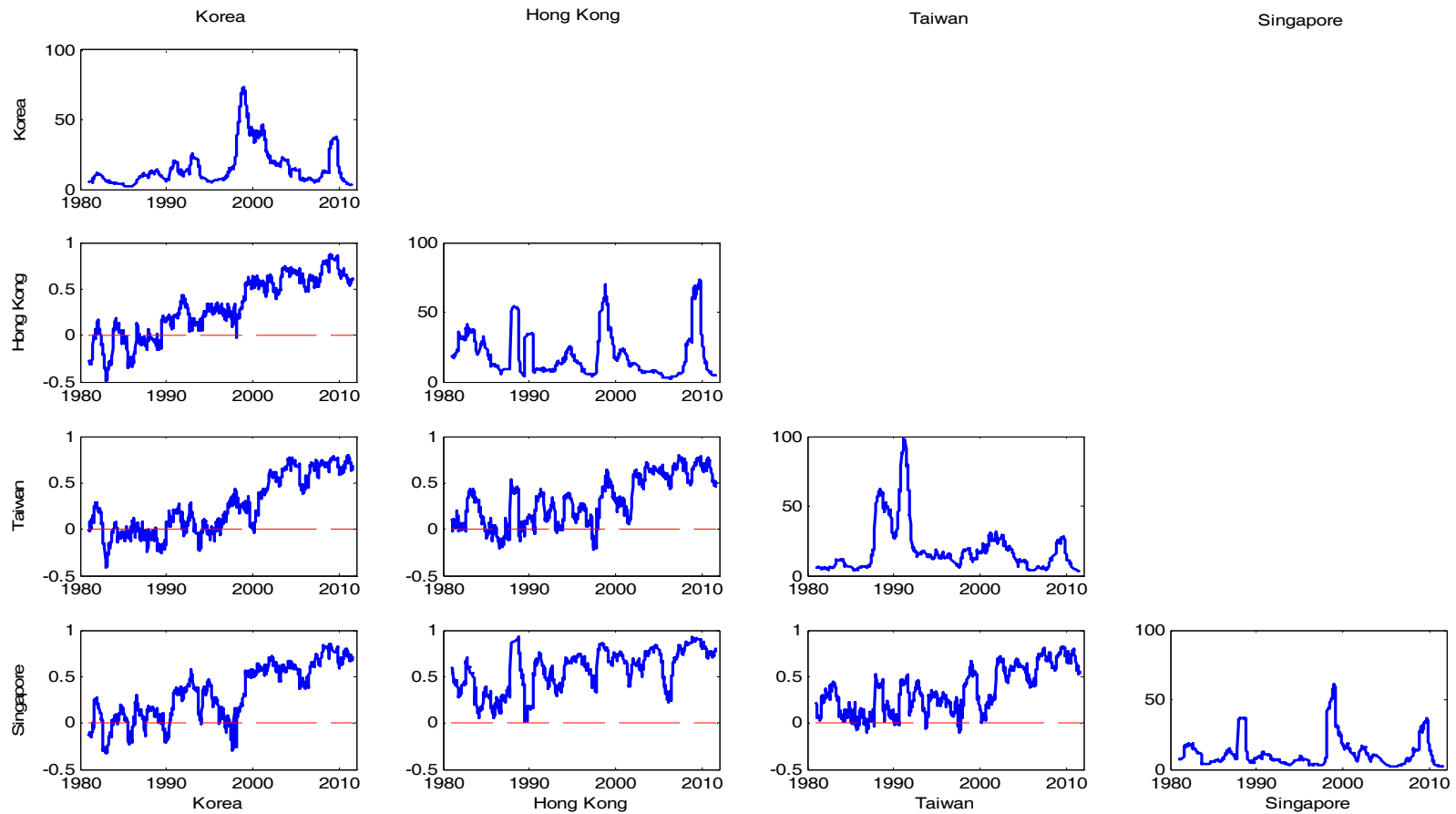
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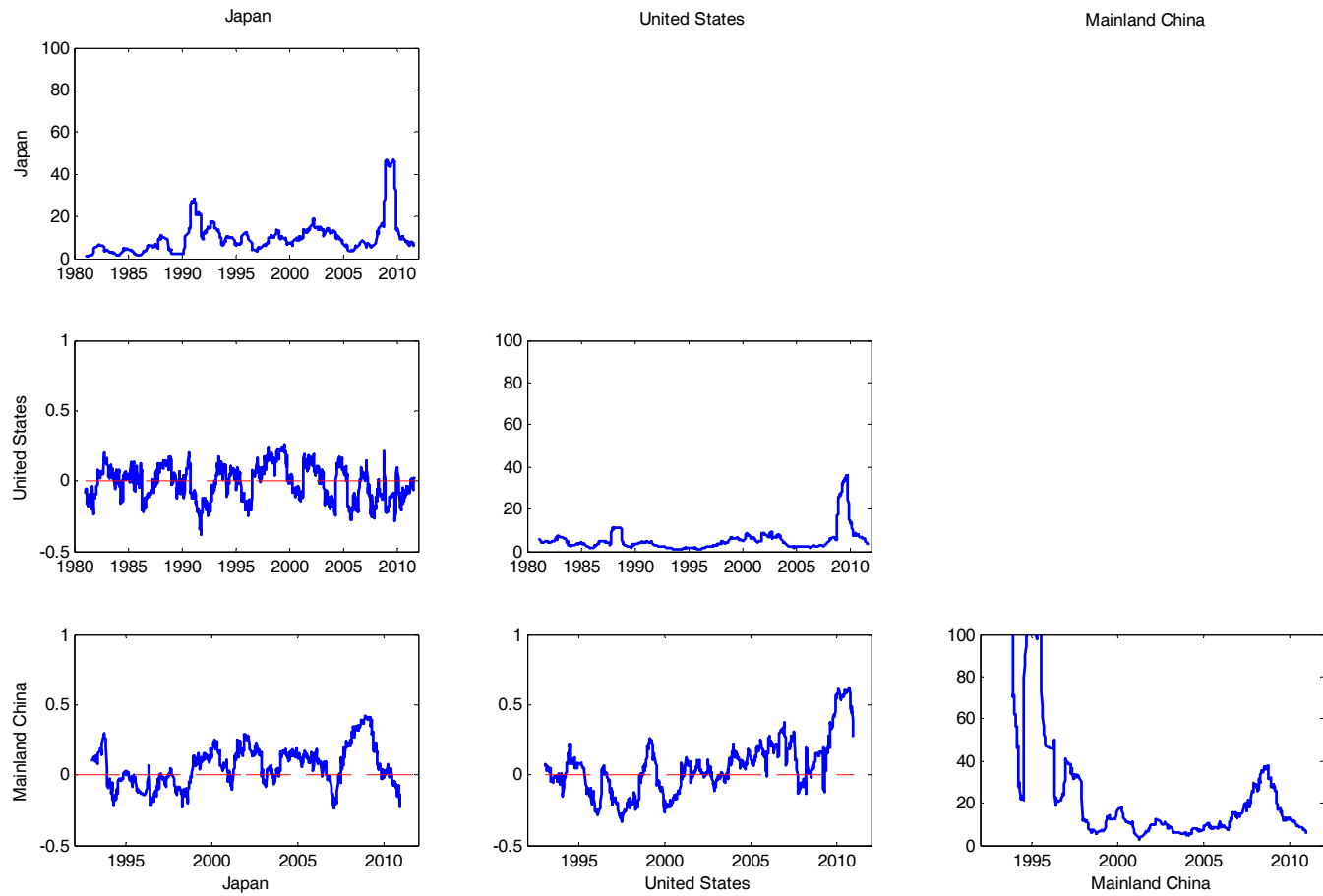
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Figure 1. Rolling Window Correlation for Newly Industrial Economics (NIEs)



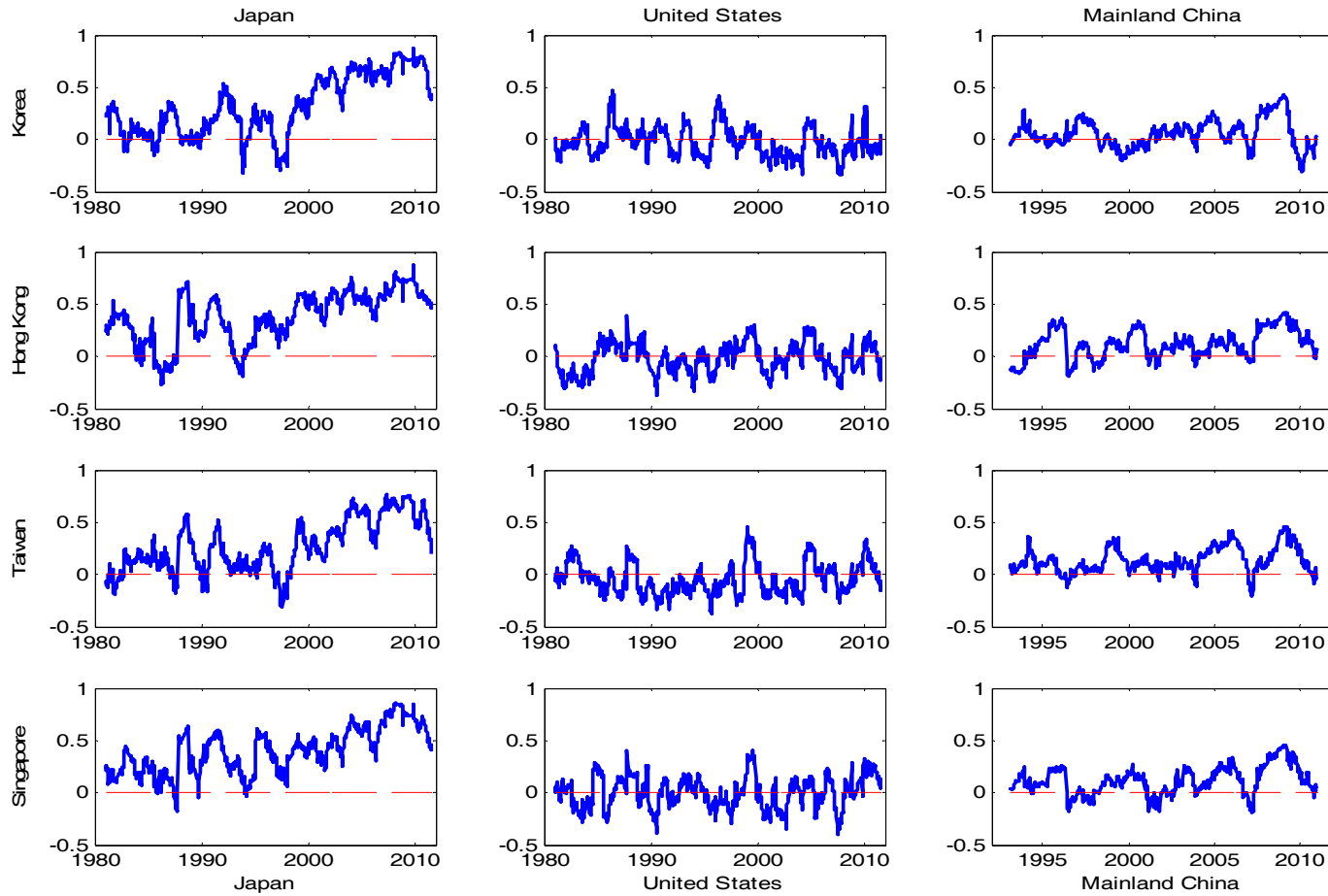
Note: The diagonal boxes plot variances of the corresponding economies along time, and the off-diagonal boxes plot correlations between two economies along time. The variances and correlations at each point are estimated using a rolling window of 52 periods, i.e. around one year.

Figure 2. Rolling Window Correlation for US, Japan and Mainland China



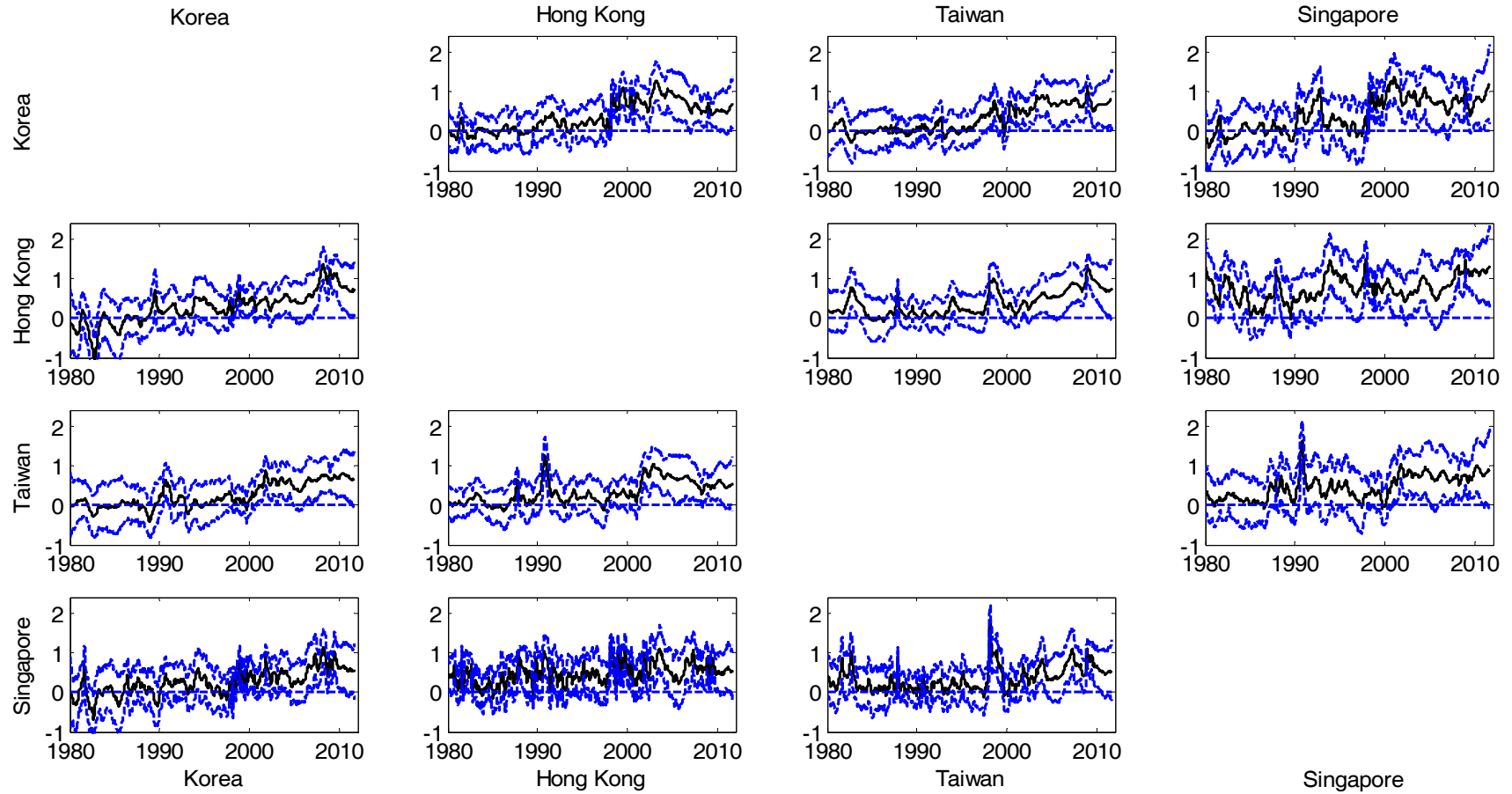
Note: The diagonal boxes plot variances of the corresponding economies along time, and the off-diagonal boxes plot correlations between two economies along time. The variances and correlations at each point are estimated using a rolling window of 52 periods, i.e. around one year.

Figure 3. Rolling Window Correlations between NIEs and US, Japan and Mainland China



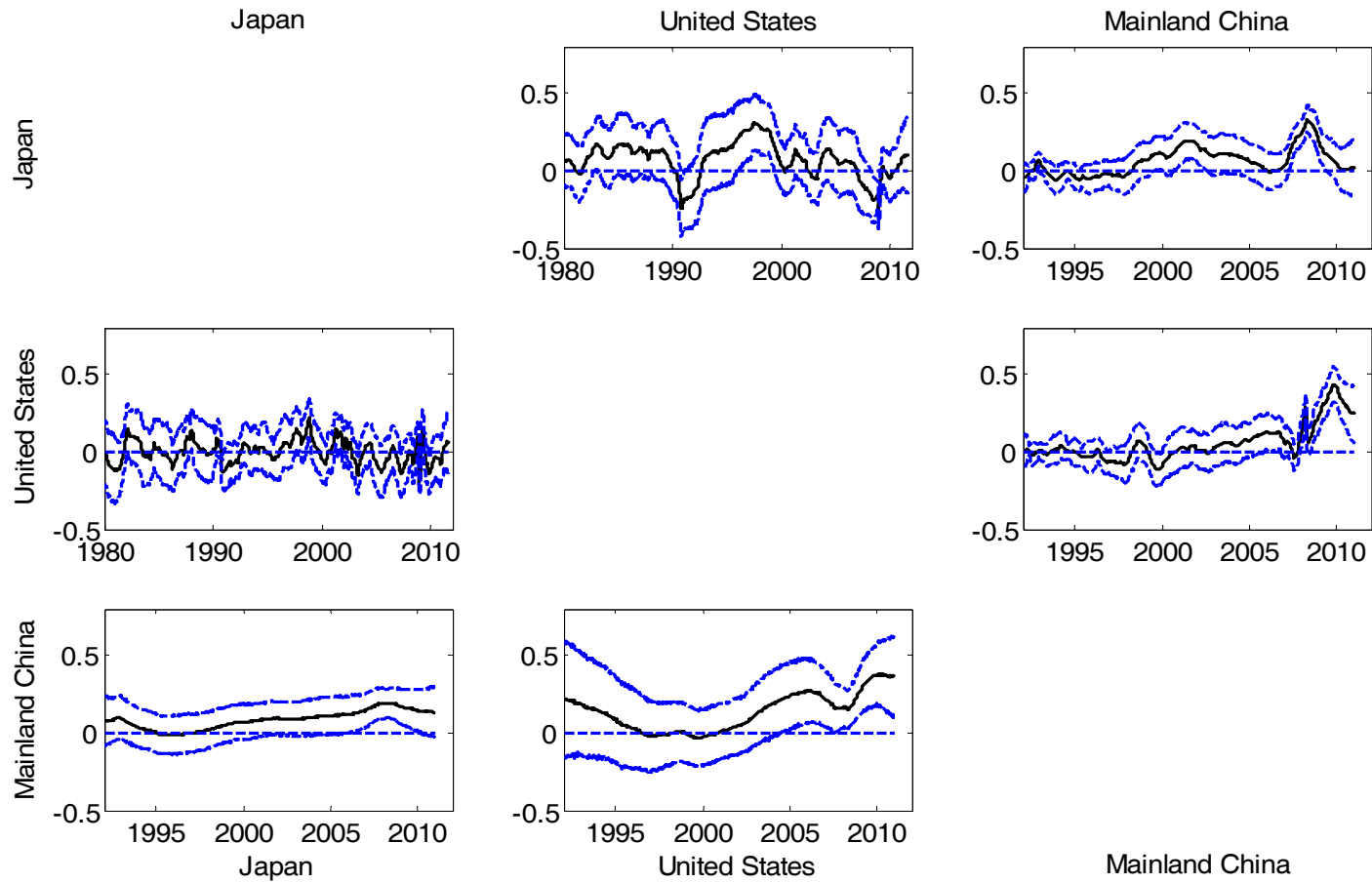
Note: Each box plots correlations between two economies along time. The correlations at each point are estimated using a rolling window of 52 periods, i.e. around one year.

Figure 4. Time-varying Coefficients of Bilateral Regressions for NIEs



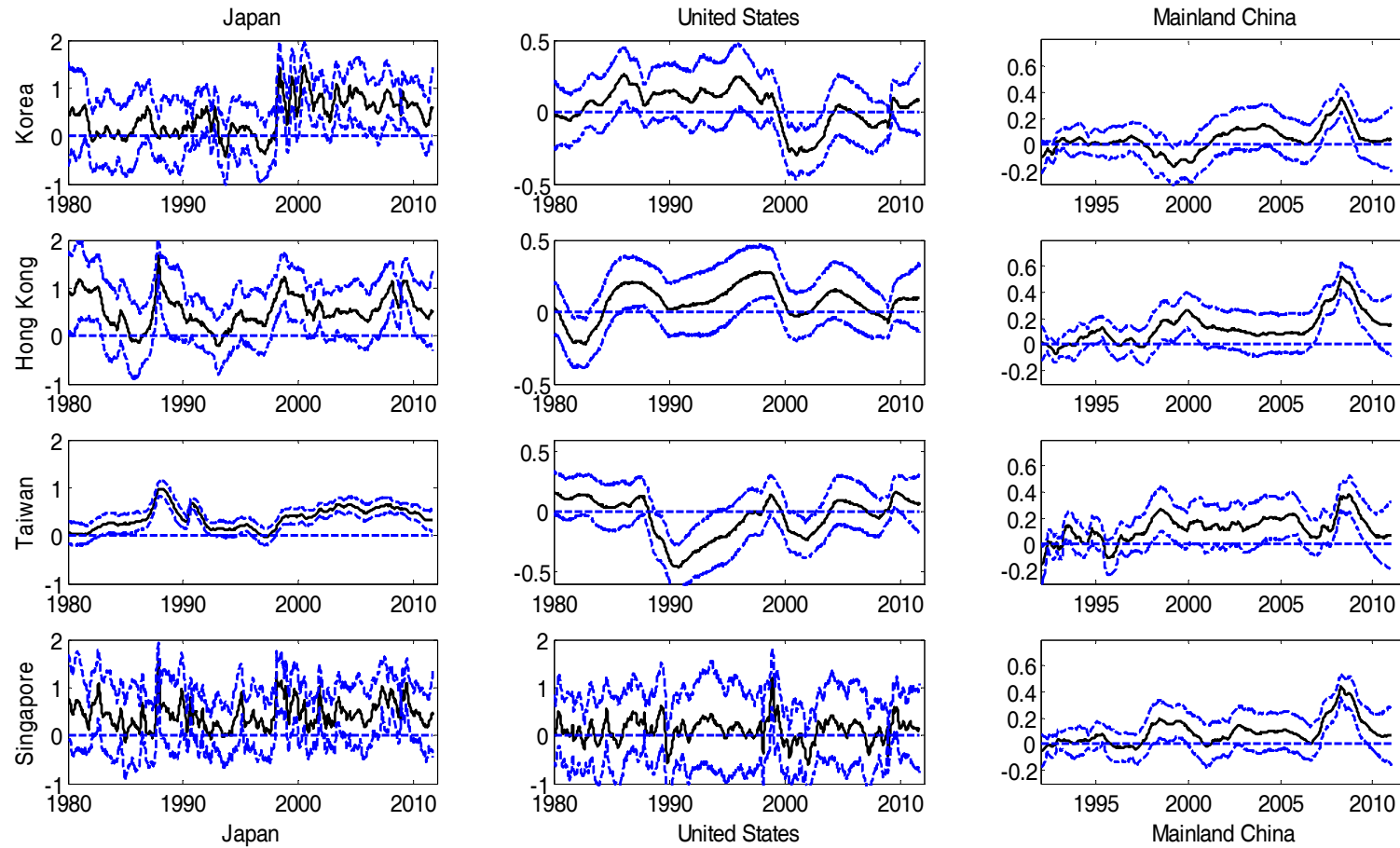
Note: This figure plots the time-varying coefficients of the bilateral regressions for pairs of NIEs. In each row, the label on the left indicates dependent variable, and the labels on top indicate the explanatory variables in a univariate regression. The solid lines are the estimated time-varying coefficients, and the dash lines are the 95% confidence intervals for the estimates.

Figure 5. Time-varying Coefficients of Bilateral Regressions for Japan, US and Mainland China



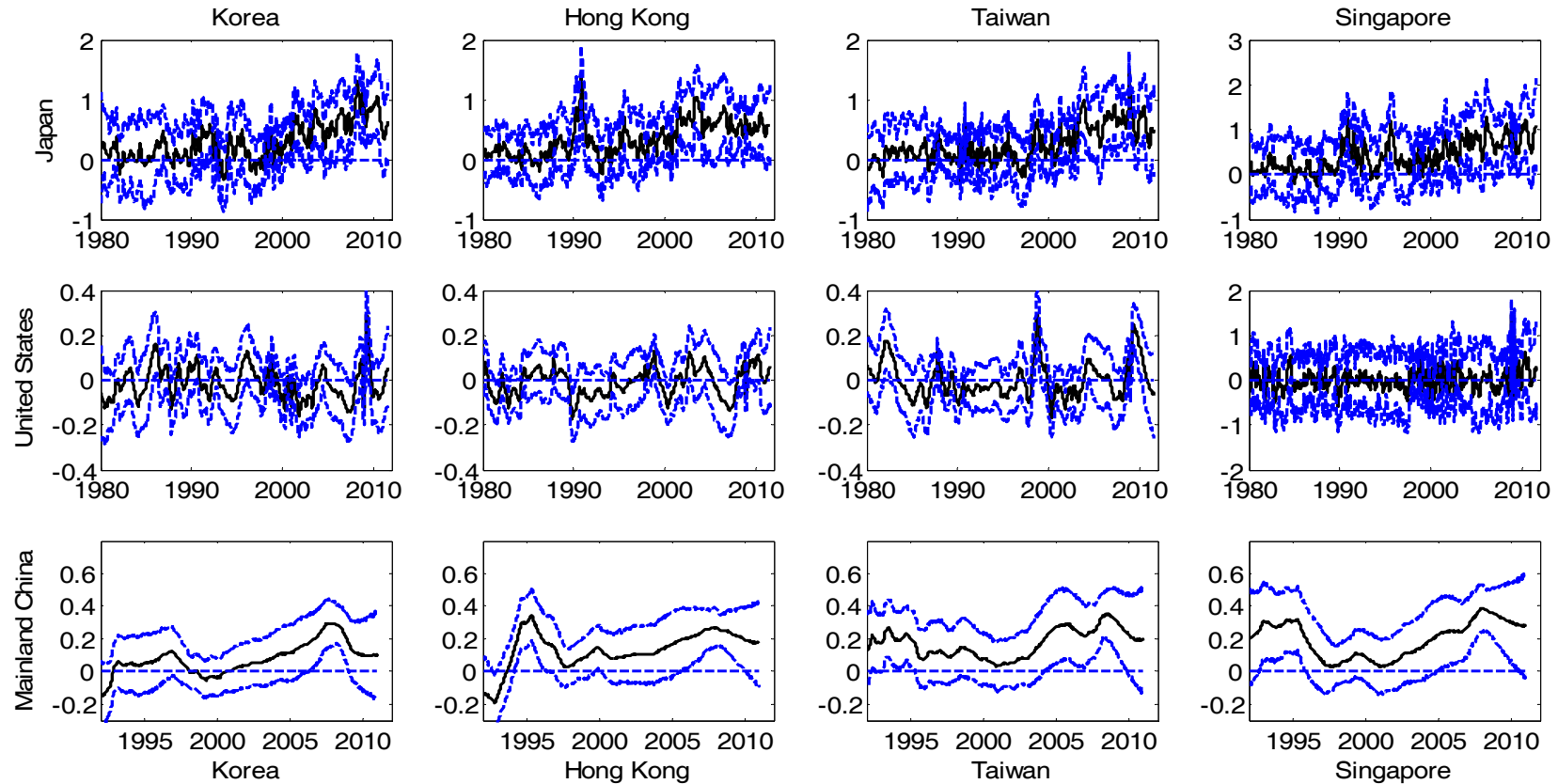
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Figure 6. Time-varying Coefficients of Bilateral Regressions between NIEs and US, Japan and Mainland China



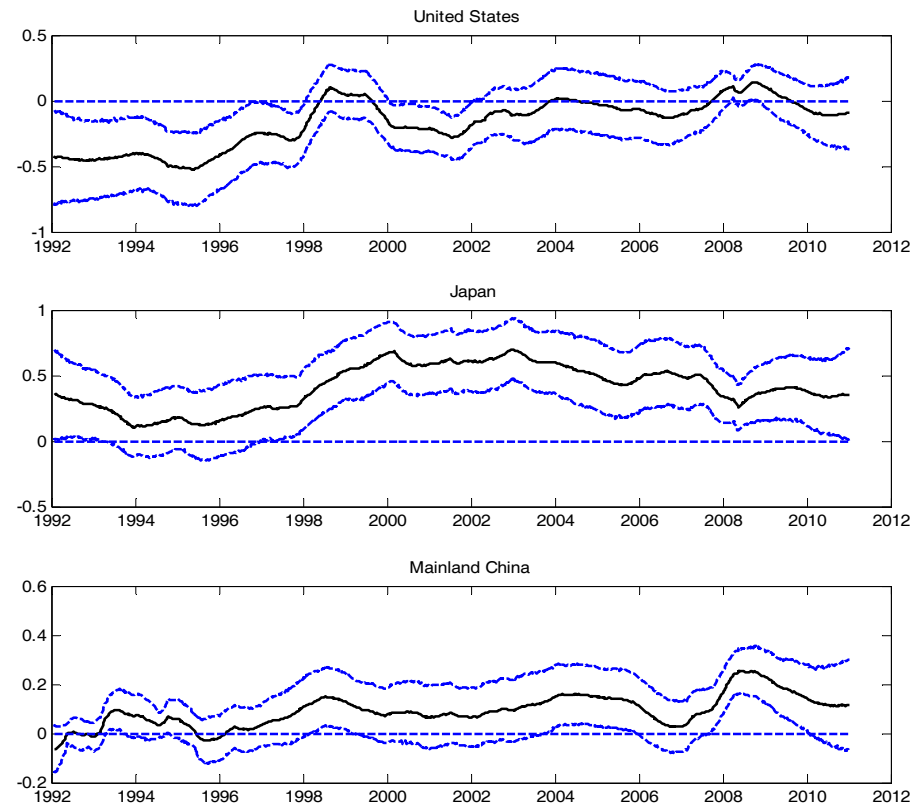
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Figure 7. Time-varying Coefficients of Bilateral Regressions between US, Japan and Mainland China and NIEs



Note: This figure plots the time-varying coefficients of the bilateral regressions for pairs of NIEs. In each row, the label on the left indicates dependent variable, and the labels on top indicate the explanatory variables in a univariate regression. The solid lines are the estimated time-varying coefficients, and the dash lines are the 95% confidence intervals for the estimates.

Figure 8. Time-varying coefficient on Taiwan with the US, Japan and China as explanatory variables in a multivariate regression



Note: This figure plots the time-varying coefficients of the regression with Taiwan stock return as the dependent variable, and stock returns of the US, Japan and Mainland China as explanatory variables in one multivariate regression. The solid lines are the estimated time-varying coefficients, and the dash lines are the 95% confidence intervals for the estimates.