Macroeconomic Interdependence in East Asia

Nagayasu, Jun

1 April 2010

Macroeconomic Interdependence in East Asia

April 2010

Jun Nagayasu[1]
University of Tsukuba

Abstract:
This paper analyzes macroeconomic interdependence among 10 Asian economies. In this connection, we decompose their macroeconomic activities (real GDP) into common and country-specific components using the Bai-Ng method (2004). Our results suggest first that both components are nonstationary and have permanent effects on their overall economy. Second, we find the relative importance of common factors in all countries in terms of their contribution to variations in real GDP. But evidence is also obtained of country-specific effects becoming increasingly important in countries like China in recent years. Therefore, if, for example, China is expected to grow at a fast pace in future, our findings imply that creation of a regional monetary union of these 10 countries needs to be held back until the Chinese economy has become more dominant in the region.

JEL classification: F4
Keywords: Asian economic integration, factor models, common and factors
File name: Nagayasu_JWE.doc

[1] Corresponding author; University of Tsukuba, Graduate School of Systems and Information Engineering, 1-1-1 Tennodai, Tsukuba, Ibaraki 305-8573 JAPAN; Tel/Fax +81 29 853 5067; Email Nagayasu.jun.gn@u.tsukuba.ac.jp. This research was funded by a Grant-in-Aid for Scientific Research (B) No. 21330075. An earlier version was presented at the 3rd All China Economics International Conference (HK 2009) and the 3rd International Trade Workshop at the Research Center for International Economics (Beijing 2009). I would thank for comments Juyoung Cheong, S. R. Gangadharan, Hyun-Hoon Lee, Kui-Wai Li, Tatsuyoshi Miyakoshi and other conference participants. However, all remaining errors are mine.

1. Introduction

This paper focuses on regional economic interdependence. High interdependence is regarded as indicating that economies are highly integrated in the region, and this situation can be created by historical economic and political efforts. Economic and political cooperation has a long history in Asia. The Association of South-East Asian Nations (ASEAN), now consisting of 10 countries,[2] was established in 1967 to help achieve regional security, and socio-cultural and economic integration. Furthermore, the ASEAN Free Trade Area (FTA) agreement, which aimed to eliminate tariff and non-tariff barriers in the region, was signed in 1992 by six members (Brunei, Indonesia, Malaysia, Singapore, Thailand, and the Philippines) and later by the others. Such regional efforts seem to have paid off. Some Asian countries (e.g., Hong Kong (HK)) had achieved outstanding economic results for several decades and had been regarded as a world-class economic success story. However, history has shown that such success does not last forever. The 1997 Asian crisis which erupted in Thailand came as a surprise to many economists and policy-makers the world over. Its adverse effects spilled over to neighboring countries, and consequently many countries experienced a sharp economic downturn. Mitigating this contagious effect in Asian emerging markets called for further regional cooperation. As a result, a more comprehensive group of Asian countries, the ASEAN Plus Three Countries (China, Japan, and Korea), was formed in 1997 to discuss regional economic and financial stability issues. This dialog led to the establishment of the Chiang Mai Initiative, a short-term credit arrangement among these countries to remedy pressure from lack of foreign reserves.[3]

In order to examine economic interdependence, we shall decompose macroeconomic activities into common and country-specific factors, then investigate their importance, and analyze the transmission channel which will create international economic interdependence

[2]The ASEAN members are Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Singapore, Thailand, the Philippines, and Vietnam.
[3]See Bayoumi, Eichengree and Mauro (2000) and Chey (2009) for discussion of a possible Asian monetary union.

in the region. In order to do this we use the factor model proposed by Bai and Ng (2004) which does not require *a priori* assumptions about the stationarity of common and country-specific components. This is probably the first time for this approach to be used in this research field, and in this respect our research departs significantly from previous studies which focused largely on business cycles (i.e., economic growth) that are assumed to be stationary. Furthermore, when common factors are found to be nonstationary, we evaluate the long-run implications of economic trends in a cointegrated system. Our study also differs from most previous studies in its use of long(er) historical data including post-Asian crisis observations which enable us to conduct an analysis of common factor movements in recent years.

In short, we find evidence of more than one common factor and of both country-specific and common components being nonstationary, which, based on previous studies, implies that both components have made a permanent contribution to the overall economic activities in the past. Furthermore, while we confirm the sizable contribution of common factors in explaining GDP variations, the country-specific effect seems increasingly important in some countries like China since the Asian crisis. Finally, unlike some previous studies (see the next section) focusing on stationary business cycles, this paper reports a strong relationship between common factors and international trade, confirming trade as the transmission channel between countries.

2. Literature Review

Due to economic and political implications, a lot of research has been attempted in order to investigate economic integration, in particular, using data on business cycles across countries. For example, Selover (2004) studied interdependence between Korea and Japan, and found that Japanese business cycles have a moderate effect on Korean ones. Zhang, Sato and McAleer (2004) studied a group of 10 Asian countries plus the US, compared estimates from the European Economic Community (EEC), and concluded that underlying structural shocks are less symmetrical in Asia. Germany, a leading country in Europe, shows a similar and significant correlation pattern of demand shocks with other core

European countries. In contrast, Japan, a large economy in Asia, does not exhibit significant correlation with other Asian countries. Similarly, Moneta and Ruffer (2009) examined the output growth of 10 Asian countries from 1993 to 2005 using a dynamic common factor model, and reported a significant common factor shared by these countries except China and Japan. Their result for Japan is consistent with Rand and Tarp (2002) who find that the nature and characteristics of business cycles in developing countries differ from those in developed countries.

However, unlike the abovementioned studies which found that China (mainland) and Japan are not synchronized with the rest of Asia, Sato and Zhang (2006) documented that Japan is one of the most integrated countries in the region using the cointegration method. Out of 55 possible pairs of Asian countries, 10 pairs are found to be cointegrated with a positive cointegrating vector. Three pairs out of 10 are related with Japanese GDP (in levels), and interestingly China is strongly correlated only with HK. This somewhat different result may be attributable to the different focus of their research: whether data are in level or difference (i.e., business cycles).[4]

Research was also conducted to try to identify the transmission channel of business cycles, and has frequently focused on international trade.[5] For example, this confluence of business cycles seems to be driven by a strong trade (especially export) channel (Selover 1999, Moneta and Ruffer 2009), rather than by consumption or investment (Moneta and Ruffer 2009). Webber (2009) suggested that exports and investment are sources of common fluctuation in Asian business cycles. Furthermore, using data for over 100 countries on

---

[4] There are more comprehensive studies in terms of country coverage. Using annual data from 106 countries from 1960 to 2005, Kose, Otrok, and Prasad (2008) reported evidence of convergence in business cycles within industrial countries and within emerging markets, but not between industrial and emerging markets. Furthermore, they found the relative importance of country-specific factors in the post-1985 period by means of the variance decomposition method. In contrast, by decomposing business cycles into common and country-specific components using a Bayesian dynamic latent factor model, Kose, Otrok, and Whiteman (2008) confirmed the increasing importance of common factors in explaining variations in output, consumption and investment in the more recent period (1986:3-2003:4) compared with the Bretton Woods period (1960:1-1972:2).

[5] There are studies examining financial market integration in Asia. For example, Park and Shin (2009) documented weak evidence of financial integration in East Asia.

international trade, industrial structures, factor endowments, and currency union, among others, Baxter and Kouparitsas (2005) confirmed that international bilateral trade is the most important channel. However, some researchers argue against international trade as a transmission channel. For example, Crosby (2003) failed to find evidence to link between business cycles and a trade intensity variable in East Asia. Furthermore, Imbs (2004) underscored specialization patterns which directly reflect differences in GDP per capita using data from 24 (relatively prosperous) countries.

In addition to these studies based on macroeconomic data, there is lots of research on economic integration using the micro (firm)- level data (e.g., Ando 2006). They tend to show the high level of economic integration in East Asia from both the import and export sides. However, partly due to data availability, the research has been based almost exclusively on the tradable goods sector like the manufacturing industry. As a consequence, the non-tradable goods sector has not been covered in previous studies. Since our research utilizes macroeconomic data, the non-tradable goods sector is also taken into account.

3. Statistical Methods

In order to extract country-specific and common elements from the GDP, we use the statistical method (Bai and Ng 2004) which is known as the panel unit root test based on a factor model. Examination of the time-series properties of data such as stationarity has piqued the interest of many researchers over recent decades. Initially, statistical tests (i.e., the unit root test) were proposed in the univariate context and then were extended to analyze the stationarity in panel data (Lin and Levin 1992). They were developed with an assumption of no cross-sectional correlation in the data. But this is unlikely to hold in actual economic and financial data, and a violation of this assumption biases test statistics (O'Connel 1998). Thus Bai and Ng (2004) proposed a procedure for estimating cross-sectional correlation (i.e., communal elements (F_t in equation (1) in the panel data) using a factor model. This paper will utilize these elements as a proxy for common movements across countries. Below we will explain briefly the concept of their statistical approach.

For the data X_{it} ($i = 1,\ldots,N$ and $t = 1,\ldots,T$), the factor model with individual effects (c_i) can be expressed as:

$$X_{it} = c_i + \lambda_i' F_t + e_{it} \quad (1)$$

where F_t and e_{it} are common and country-specific elements respectively, and individuals (countries) and time are denoted as i and t. Since these elements are unobservable, an appropriate number of common factors (r) need to be determined by information criteria (e.g., Bai and Ng 2002). Given this information, both elements are estimated by a factor model, and we can carry on testing their stationarity. However, when e_{it} is nonstationary, the estimates of λ_i and e_{it} are no longer consistent, and therefore they proposed a differencing equation (1):

$$x_{it} = \lambda_i' f_t + z_{it} \quad (2)$$

where $x_{it} = \Delta X_{it}$, $f_t = \Delta F_t$, and $z_{it} = \Delta e_{it}$. Equation (2) suggests that f_t is common to all individuals, but λ_i makes a unique level of common factors $\lambda_i' f_t$ for each country. Thus, one can interpret λ_i as a parameter for capturing the influence of f_t over the countries to a different degree. They are a reasonable proxy for common factors because for example some countries are more affected by oil shocks than others, and the extent to which the country is affected by this shock can be measured by λ_i. We call $\lambda_i' f_t$ as well as $\lambda_i' F_t$ common factors in the subsequent study, and thus our concept of the common factor may be slightly different from other studies that assume constant common factors across countries. Finally, e_{it} and F_t can be recovered by $e_{it} = \sum_{s=2}^{t} z_{is}$ and $F_t = \sum_{s=2}^{t} f_s$ where $t = 2,\ldots,T$.

While our focus is more on common factors, we are also interested in country-specific components. Testing individually the stationarity of the country-specific component for country i is identical to the standard Augmented Dickey-Fuller (ADF) test based on equation (2).

$$\Delta\hat{e}_{it} = d_{i0}\hat{e}_{it-1} + d_{i1}\Delta\hat{e}_{it-1} + ... + d_{ip}\Delta\hat{e}_{it-p} + error \quad (3)$$

where estimates are denoted by $\wedge$. Based on this test for individual countries, we can calculate the statistic for evaluating the stationarity of a group of country-specific components by pooling p-values ($p_e(i)$) obtained from the individual ADF test.

$$P_e = \frac{-2\sum_{i=1}^{N} ln(\ p_e(i)) - 2N}{\sqrt{4N}} \rightarrow N(0,1) \quad (4)$$

This statistic is shown to be asymptotically normally distributed, and its large positive value becomes evidence against the null of no cointegration.

With respect to common factors, testing their stationarity is identical to the standard ADF in the presence of a single common factor. If we assume that changes in common factors contain the constant, the test is based on the following equation.

$$\Delta\hat{F}_t = c_0 + \delta_0\hat{F}_{t-1} + \delta_1\Delta\hat{F}_{t-1} + ... + \delta_p\hat{F}_{t-p} + error \quad (5)$$

In this case, the statistic is referred to as ADF_f, and the critical value equals -2.86 at the five percent significance level. In the presence of multiple common factors, one can use the multivariate cointegration method to check if there is a long-run relationship between the common factors. In this paper, we use the Johansen test which is probably the most popular multivariate cointegration method.

4. Data

We consider 10 Asian economies: China (mainland), Hong Kong (HK), Indonesia, Japan, Malaysia, Singapore, South Korea, Taiwan, Thailand, and the Philippines, five of which are ASEAN members. In addition, the US is included in our data set since it is an important trading partner of all these countries. Long historical data on the GDP for most Asian countries are not readily available, and therefore, we obtained quarterly real GDP data from Tilak Abeysinghe's homepage (http://www.fas.nus.edu.sg/ecs/esu/data.html) in order to evaluate common factor movements. We utilize all countries listed there and create a balanced panel data set spanning from 1975Q1 to 2007Q1 (base year = 1995).

These data are plotted in Figures 1 and 2, and their basic statistics are summarized in Table 1. Real GDP in Figure 1 shows that there is a significant economic slowdown in 1997 at the time of the Asian crisis but there are signs of a prompt economic recovery. A similar trend in real GDP growth can be observed in Figure 2. Table 1 summarizes the basic statistics of real GDP (both in levels and differences). According to this table, the Chinese economy (GDP in levels) is very volatile as her standard deviation is far higher than others, and by contrast Japan, the Philippines and US experienced very low volatility.

In addition, the correlation matrix is presented in Table 2. It shows that most pairs are positively correlated with each other regardless of the data being the level or growth of GDP. However, unlike other countries, the Chinese GDP growth is negatively correlated with other countries including Japan, Malaysia, South Korea, Taiwan, Thailand and the Philippines. This indicates that, as previous studies have suggested, the Chinese economy may be less integrated with the rest of Asia. We also note that all Asian countries except the Philippines are positively correlated (but insignificantly) with the US GDP growth.

With respect to trade data, three sources are used. Quarterly total import and export data are obtained from the IMF's International Finance Statistics (IFS). Their real values are calculated using the consumer price index (CPI) from the IFS. In addition, quarterly bilateral export and import data are obtained from the Direction of Trade (DOT) data set also from the IMF. But coverage is limited to China, HK, Indonesia, Japan, Malaysia, Singapore, South Korea, Thailand, and the Philippines, and thus in order to supplement them total import and export data for Taiwan are downloaded from the homepage of the Central Bank of the Republic of China (Taiwan).

5. Empirical Results

5.1. PANIC estimates

The results of decomposition of real GDP to common and country-specific factors are summarized in Table 3. Different groupings of countries are considered in order to check the robustness of our findings. Our benchmark model consists of 10 Asian countries ($N = 10$). The group of 9 ($N = 9$) drops China from our benchmark, and that of 11

($N = 11$) adds the US to the group of 10. First, we calculate the number of common factors (r) using information criteria, IC1, IC2, and IC3 (Bai and Ng 2002), and find that there is evidence of one and three common factors depending on the information criteria. A single common factor is supported by IC3, and three factors by IC1 and IC2. This result is generally robust to the composition of the panel of countries ($N = 9$, 10 or 11). As there is at least one common factor, it appears essential for these Asian countries to consider the economic conditions of their neighboring countries when forming economic stabilization policies. Our estimates of common ($\lambda_i' F_t$) and country-specific (e_{it}) factors for r = 3 and N = 10 are plotted in Figures 3 and 4 respectively. Figure 3 shows a sharp fall in the common factors around 1997, which suggests that the adverse effects of the Asian crisis were shared by these countries. Figure 4 shows that the country-specific effect is becoming increasingly important in China. Since these values are cumulative values of $\lambda_i' f_t$ and z_{it} respectively (see Section 3), there are only small differences in their initial values among countries.

We also check the stationarity of these factors ($\lambda_i' F_t$ and e_{it}), and the results are reported in Table 3. Our statistic (P_e) in equation (4) shows that a group of country-specific factors is nonstationary, and similarly each common factor is found to be nonstationary. Since multiple common factors are found in our data, it is of interest to examine the stationarity of the group of common factors. We test this by means of the Johansen multivariate cointegration test using different compositions of common factors (i.e., $r = 2,3$) and report evidence of non-cointegration in Table 4. The nonstationarity of both factors suggests that country-specific and common shocks are both permanent, and that both elements are important in determining their long-run economic performance. Therefore, this suggests that the nonstationarity of real GDP reported in previous studies (e.g., Sato and Zhang 2006) is attributable to the nonstationarity of both factors.[6]

5.2. The Relative Importance of Common and Country-Specific Factors

[6]It follows that country-specific and common factors are not cointegrated.

The relative importance of common factors is examined by calculating three ratios: 1) the ratio of the standard deviation of common factors to that of GDP, 2) the ratio of the standard deviation of country-specific factors to that of GDP, and 3) the ratio of country-specific factors to that of common factors. Where common factors are relatively important, the first ratio should approach one, and the second and the third ratios should be close to zero. On the other hand, if country-specific factors are dominant, the second ratio should approach one. While it is certainly a simplistic method, it helps us understand their relative importance. The subsequent analysis is based on three common factors ($r = 3$) which two out of three information criteria suggest.

Table 5 summarizes the results of these ratios with different assumptions about the composition of countries (N) in the panel.[7] First, there is no doubt that common factors are important in all countries, and they seem to dominate GDP variations particularly in Singapore and South Korea. Their first ratio is close to one, and the second and third ratios measuring the contribution of country-specific effects are nominal. The first ratio of HK and the Philippines is also close to one, but their second and third ratios are relatively larger than that of Singapore and South Korea. Indeed, the importance of the common factor is confirmed by the variance ratio test. Although there remain significant differences between e and X , the variance ratio test for ($\lambda F, X$) suggests that, except China whose first ratio is around 0.8, the variation of the common factor is statistically and consistently identical to that of the total GDP. This result seems to be generally robust to the composition of countries under investigation.

Given that these economies experienced a transition phase en route to industrialization, we also check if the relative importance of the factors has changed over time. Table 6 shows the p -values of the variance ratio tests for these ratios in two sub-sample periods when $r = 3$.[8] The breaking point of 1997Q2 is consistent with the economic disaster in Thailand,

[7]Our different assumptions are based on there being one, two or three common factors and a group of nine, ten or eleven countries, but such assumptions seem to barely alter the final results. For this reason, such results are not reported here.

[8]The results with $r = 1$ and 2 are not reported here due to space constraints. But the results with a

the first country hit by the Asian crisis. Generally, we can observe a similar pattern in these ratios to those from the full sample. However, there is evidence that country-specific effects become increasingly significant in the post-1997 period, particularly, in China and the Philippines. The null of the variance test for ($\lambda F, e$) cannot be rejected for these two countries in the pre-1997 period, but it can be rejected in the post-1997 period. The rapid economic growth in China in recent years and the lesser effects of the 1997 crisis on the Philippines (Figure 2) may be attributable to this result.

5.3. The Transmission Channel

While many other transmission channels can be considered (see Section 2), this sub-section focuses on international trade as a transmission channel of economic activities due to data availability, and looks at whether there is a positive and cointegrated relationship between common factors ($\lambda_i^{'} F_t$) and international trade in the panel data context. The presence of cointegration ensures that there is a linear combination between them and becomes evidence of a long-run relationship. We would expect that common factors and trade related data are positively correlated and also cointegrated since many Asian countries have adopted an open market policy and international trade has been regarded as an engine of economic development. But as discussed, some previous studies (e.g., Crosby 2003, Imbs 2004, Shin and Wang 2004) question the role of (simple) international trade as a transmission channel of business cycles, and argue that it is other characteristics of a country such as the intra-industry trade and industry structures which create interdependence in business cycles.

Here we use two types of trade data. One is the real value of total import and export data, and the other is trade concentration measures which are also created separately for imports and exports.[9]

---

different size of r will not alter our general conclusion.

[9]A similar definition of concentration ratios was used previously (e.g., Frankel and Rose 1998; Shin and Wang 2004), and these ratios are calculated for each country and time period.

$$\frac{Im\,p_{ijt}}{Im\,p_{it}} \text{ for imports and } \frac{Exp_{ijt}}{Exp_{it}} \text{ for exports}$$

where $Im\,p$ and Exp refer to imports and exports respectively. The subscripts (i and j) represent home country (i) and the rest of Asia (j), and t is time. Thus Exp_{ijt} / Exp_{it} shows the exports of country i to the rest of Asia divided by the total exports of country i, and $Im\,p_{ijt} / Im\,p_{it}$ indicates the proportion of imports to country i from Asia to the total imports to that country. Here, we use the benchmark model, and thus Asia is defined as the 10 Asian countries used in this study. Since high ratios indicate high concentrations of regional trade, one might expect that a high concentration ratio would be closely and positively associated with common factors.

Table 7 summarizes the trade data and shows that regional trade within ASEAN is high; the trade concentration measure of most ASEAN countries is around 50 percent. The non-ASEANs like Japan and Korea exhibited a slightly lower level of regional trade, but interestingly, mainland China shows a high concentration of international trade with other Asian countries.[10]

Table 8 reports the estimated relationship, based on $r = 3$ and $N = 10$, between the common factor and trade-related data.[11] We use several panel data estimation methods (OLS, Adjusted (Adj.) OLS, and Fully Modified (FM) OLS).[12] Generally, when total trade data is employed, a positive and significant relationship is obtained for both imports and exports, and there is cointegration between the trade value and common factors. However, when the trade concentration is considered, evidence to support their relationship with common factors (in levels) becomes very weak; there is no evidence of cointegration between them using the panel cointegration method (Kao 1999). There is a possibility that structural breaks may destroy the relationship, but our result is also confirmed by the

[10]This table also shows that the US is an important trade partner for all countries, especially for Japan, Korea and the Philippines.
[11]Previous studies (e.g., Wu, Chen and Lee 2001) often showed that export and import data are nonstationary.
[12]See Kao and Chiang (2000).

Westerlund test (2006) which takes account of multiple and unknown structural breaks in the panel data (see Appendix).[13]

These import and export elasticities seem stable over time. Figure 5 shows that estimates of imports and exports using the Asian related trade data by extending one observation by one observation from 1997Q2 to 2007Q1. The sensitivity of trades sharply dropped right after the eruption of the Asian crisis with the exception of the estimate of imports in 1997, and has become very stable since then. In addition, we can observe that the estimate of exports is always higher than that of imports, confirming the relative importance of exports in explaining the common factors.

Therefore, we conclude that trade is one important transmission channel for international economic interdependence, and the result implies that our common factors are also influenced by economic developments elsewhere such as the US and Europe. Furthermore, China which exhibits high trade concentration with other Asian countries (Tables 7) shows a low correlation with common factors (Tables 5 and 6). This implies the significance of her domestic market, and therefore although China trades a lot with other Asian countries, one may conclude that international trade is less important for her compared with other Asian economies.

In general, our results strongly support the role of international trade, and in particular, both imports and exports are found to be a driving force of common factor movements. This point was controversial in previous studies using business cycle data, but a statistically more sensible approach seems to yield our rather clear-cut result. Use of common factors which presumably contain more international elements than whole economic activities (i.e., business cycles) and consideration of their time-series properties appear to contribute to the stronger evidence in favor of this relationship.

6. Summary and Discussion

[13]In order to check this weak relationship between the concentration ratio and common factors, we also employ the growth (rather than the level) of the common factors. The results are not shown in the paper due to limited space, but the parameter sign remains generally unchanged although the linear relationship with the growth of the common factors is now found to be stationary.

We studied economic dependence in macroeconomic activity among East Asian countries. Monitoring their level of regional integration is important not only when considering further economic and financial integration but also when forming economic policy to stabilize their own economies. When a country is largely dependent on other members, a shock in one member country will directly and possibly quickly influence other countries.

Our results are as follows. Using real GDP data and decomposing macroeconomic activities into the common and idiosyncratic factors by means of the Bai-Ng method (2004), we find more than one common factor among Asian countries. Furthermore, common factors dominate variations in GDP in each country, confirming their open economic policy; in other words, international trade is a driving force of the common factors. In addition, while their size may be inconsequential, both common and country-specific factors have a permanent effect on macroeconomic activities (i.e, they are nonstationary), and country-specific factors are increasingly significant in recent years in particular in China and the Philippines. This may underline the significant presence of non-tradable sectors. Unlike the condition for international trade, monetary union requires homogeneous economic environments. Therefore, if for example China is expected to grow at a fast pace in future, our findings imply that creation of a regional monetary union of these 10 countries needs to be delayed until the Chinese economy has become more dominant in the region.

Finally, while our analysis is statistically solid, there are many issues that one could investigate in the future. For example, we focused on international trade as a transmission channel of common factors. However, there are many other channels through which stocks are transmitted across countries (See Section 2). This can be carried out when more data are disseminated for these countries. We believe that the understanding and identification of the exact nature of transmission mechanisms will help propose a more concrete approach for further economic integration.

References

Ando, M., 2006. Fragmentation and vertical intra-industry trade in East Asia. North American Journal of Economics and Finance 17, 257-281.

Bai, J., Ng, S., 2002. Determining the number of factors in approximate factor models. Econometrica 70(1), 191-221.

Bai, J., Ng, S., 2004. A Panic attack on unit roots and cointegration. Econometrica 72(4), 1127-1177.

Baxter, M., Kouparitsas, M. A., 2005. Determinants of business cycle movements: a robust analysis. Journal of Monetary Economics 52(1), 113-157.

Bayoumi, T., Eichengreen, B., Mauro, P., 2000. On regional monetary arrangements for ASEAN. Journal of the Japanese and International Economies 14, 121-148.

Chey, H-K., 2009. A political economic critique on the theory of optimum currency areas, and implications for East Asia, World Economy 32, 1685-1705.

Crosby, M., 2003. Business cycle correlation in Asia-Pacific. Economic Letters 80, 35-44.

Frankel, J. A., Rose, A. K., 1998. The endogeneity of the optimum currency area criteria. Economic Journal 108, 1009-1025.

Galesi, A., Sgherri, S., 2009. Regional financial spillovers across Europe: a global VAR analysis. IMF Working Paper WP/09/23.

Gregory, A. W., Hansen, B. E., 1996. Residual-based tests for cointegration in models with regime shifts. Journal of Econometrics 70, 99-126.

Imbs, J., 2004. Trade, finance, specialization and synchronization. Review of Economics and Statistics 86(3), 723-734.

Kao, C., 1999. Spurious regression and residual-based tests for cointegration in panel data. Journal of Econometrics 90, 1-44.

Kao, C., Chiang, M. H., 2000. On the estimation and inference of a cointegrated regression in panel data. Advances in Econometrics 15, 179-222.

Kose, M. A., Otrok, C., Whiteman, C. H., 2003. International business cycles: world, region, and country-specific factors. American Economic Review 93(4), 1216-1239.

Kose, M. A., Otrok, C., Prasad, E. S., 2008. Global business cycles: convergence or decoupling? NBER Working Paper No. 14292.

Kose, M. A., Otrok, C., Whiteman, C. H., 2008. Understanding the evolution of world business cycles. Journal of International Economics 75, 110-130.

Levin, A, Lin, C-F., 1992. Unit root tests in panel data: Asymptotic and finite-sample properties. Discussion Paper 92-23, University of California, San Diego.

Moneta, Fabio and Rasmus Ruffer, 2009, Business cycle synchronization in East Asia, Journal of Asian Economics 20, 1-12.

Park, Y. C., Shin, K., 2009. Economic integration and changes in the business cycle in East Asia: is the region decoupling from the rest of the world? Asian Economic Papers 8(1), 107-140.

Rand, J., Tarp, F., 2002. Business cycles in developing countries: are they different? World Development 30, 2071-2088.

Sato, K., Zhang, Z., 2006. Real output co-movements in East Asia: any evidence for a Monetary Union? World Economy, 1671-1689.

Selover, D. D., 1999. International interdependence and business cycle transmission in ASEAN. Journal of the Japanese and International Economies 13, 230-253.
Selover, D. D., 2004. International co-movements and business cycle transmission between Korea and Japan. Journal of the Japanese and International Economies 18, 57-83.
Shin, K., Wang, Y., 2003. Trade integration and business cycle synchronization in East Asia. Asian Economic Papers 2(3), 1-20.
Stockman, A., 1988. Sectoral and national aggregate disturbances to industrial output in seven European countries. Journal of Monetary Economics 21, 387-409.
Zhang, Z., Sato, K., McAleer, M., 2004. Is a monetary union feasible for Asia? Applied Economics 36, 1031-1043.
Weber, E., 2009. Common and uncommon sources of growth in Asia Pacific. Journal of the Japanese and International Economies 22, 20-36.
Westerlund, J., 2006. Testing for panel cointegration with multiple structural breaks. Oxford Bulletin of Economics and Statistics 68(1), 101-132.
Wu, L-L., Chen, S-L., Lee, H. Y.2001. Are current account deficits sustainable? Evidence from panel cointegration. Economics Letters 72, 219-224.

Appendix

The Westerlund LM test (2006) is for detecting cointegration with multiple and unknown structural breaks in the panel data based on the LM method. The notable features of this method include its ability to detect unknown multiple structural breaks which are considered under both the null and alternative hypotheses, and multiple structural breaks are allowed in the deterministic component. More precisely, his model evaluates the null hypothesis of cointegration: $H_0 : \varphi_i = 0$ for all $i = 1,\ldots,N$ against the alternative of no cointegration: $H_1 : \varphi_i \neq 0$ for $i = 1,\ldots,N_1$ and $\varphi_i = 0$ for $i = N_{1+1},\ldots,N$, using the following specification.

$$Ln(Common_{it}) = z_{it}\gamma_{it} + Ln(Trade_{it})\beta_i + e_{it}$$
$$e_{it} = r_{it} + u_{it}$$
$$r_{it} = r_{it-1} + \varphi_i u_{it}$$

where subscript t ($t = 1,\ldots,T$) represents time and i ($i = 1,\ldots,N$) prefectures. z is the vector of the deterministic term ($z = [1]'$) which varies between regimes, and the residual, u_{it}, is assumed to be stationary. Greek letters are parameters to be estimated.

This test essentially examines the time-series properties of the residual, e_{it}. When $\varphi_i = 0$ and $r_{i0} = 0$ which is a reasonable assumption in the presence of the fixed effects, $r_{it-1} = 0$ and thus $r_{it} = 0$. This suggests that $e_{it} = u_{it}$ and that there is cointegration in the panel data since is assumed to be stationary.

This LM test statistic requires first the identification of the number of regimes ($j = 1,...,M_i + 1$ and so M_i is the maximum number of structural breaks, where $i = 1,...,N$) and of break points ($T_i = (T_{i1},...,T_{iM_i})'$). These notations mean that $T_{i0} = 1$ and $T_{iM_i+1} = T$, and break points for each equation are determined by minimizing the sum of squared residuals.

This is estimated for each regime and since all combinations of j and T_i are considered, it is called a global minimizer. Given the value of for each j, the optimal number of structural breaks is determined using the Schwarz Bayesian information criterion.
Given the information about the size and location of the breaks, we can construct the LM test statistics.

where ω_{11i}^2 is the long-run variance of (e_{it}, v_{it}) where $v_{it} = x_{it} - x_{it-1}$, and $S_{it} = \sum_{k=T_{ij-1}+1}^{t} e_{ik}^*$ where e_{ik}^* is the efficient estimate of e_{it} which can be estimated by the Fully-Modified OLS. With some adjustment terms, Westerlund shows that this statistic follows the standard normal distribution, and its large value suggests rejection of the null.

Tables

Table 1. Basic Statistics of Real GDP (log)

Levels	Mean	Standard Deviation	Max	Min
China	4.1446	0.8519	5.5947	2.8382
HK	4.2714	0.5270	5.0802	3.1079
Indonesia	4.2415	0.4734	4.9659	3.3247
Japan	4.4364	0.2572	4.7808	3.8948
Malaysia	4.2199	0.5920	5.1580	3.1241
Singapore	4.2009	0.6440	5.2214	3.0604
S. Korea	4.1487	0.6277	5.0757	2.9977
Taiwan	4.2186	0.6344	5.1209	2.9403
Thailand	4.1148	0.5795	4.9471	3.0364
Philippines	4.5348	0.2702	5.1258	4.0057
USA	4.4885	0.2892	4.9693	3.9658
Differences				
China	0.0211	0.0135	0.0629	-0.0348
HK	0.0154	0.0222	0.1096	-0.0416
Indonesia	0.0128	0.0167	0.0569	-0.0969
Japan	0.0069	0.0116	0.0402	-0.0412
Malaysia	0.0159	0.0161	0.0550	-0.0665
Singapore	0.0169	0.0158	0.0553	-0.0281
S. Korea	0.0162	0.0225	0.0779	-0.0722
Taiwan	0.0170	0.0130	0.0639	-0.0194
Thailand	0.0149	0.0177	0.0574	-0.0499
Philippines	0.0088	0.0188	0.0678	-0.0690
USA	0.0078	0.0076	0.0386	-0.0204

Note: Full sample.

Table 2. Correlation Matrix (log GDP, Full Sample)

Levels	China	HK	Indonesia	Japan	Malaysia	Singapore	S Korea	Taiwan	Thailand	Philippines
China	1.0000									
HK	0.9792	1.0000								
Indonesia	0.9846	0.9939	1.0000							
Japan	0.9683	0.9928	0.9889	1.0000						
Malaysia	0.9931	0.9836	0.9929	0.9742	1.0000					
Singapore	0.9946	0.9880	0.9935	0.9801	0.9984	1.0000				
S. Korea	0.9928	0.9907	0.9932	0.9871	0.9930	0.9952	1.0000			
Taiwan	0.9902	0.9951	0.9941	0.9910	0.9919	0.9952	0.9974	1.0000		
Thailand	0.9834	0.9887	0.9959	0.9895	0.9905	0.9917	0.9949	0.9929	1.0000	
Philippines	0.9590	0.9379	0.9437	0.9107	0.9650	0.9601	0.9434	0.9437	0.9329	1.0000
USA	0.9963	0.9793	0.9798	0.9671	0.9899	0.9914	0.9905	0.9899	0.9778	0.9653
Differences										
China	1.0000									
HK	0.0541	1.0000								
Indonesia	0.0244	0.2615	1.0000							
Japan	-0.0180	0.0971	0.0841	1.0000						
Malaysia	-0.2179	0.1535	0.4674	0.1783	1.0000					
Singapore	0.0478	0.3216	0.2914	0.0233	0.4287	1.0000				
S. Korea	-0.0832	0.2408	0.1490	0.2645	0.3024	0.0755	1.0000			
Taiwan	-0.1246	0.2800	0.0778	0.0900	0.2236	0.3190	0.1608	1.0000		
Thailand	-0.0114	0.1221	0.4094	0.0645	0.3871	0.3003	0.2024	0.1131	1.0000	
Philippines	-0.1945	0.2383	0.0940	0.0201	0.1664	0.1340	0.0645	0.0860	0.0280	1.0000
USA	0.0017	0.0401	0.0332	0.0511	0.1502	0.1424	0.0920	0.2288	0.1429	-0.0576

Table 3. PANIC Test Results

Full Sample	Country-specific factor, P_e	Common factor, ADF_f	Information Criteria, IC1	IC2	IC3
$N =$ 10	-1.370	-2.184 , -1.074 , -0.768	3	3	1
$N =$ 9	-0.453	-2.311 , -1.304 , -1.275	3	3	1
$N =$ 11	-1.417	-2.203 , -0.875 , -0.712	3	3	2

Note: Full sample. The PANIC test and information criteria are based on Bai and Ng (2004) and Bai and Ng (2002) respectively. The statistic (P_e) for evaluating the stationarity of country-specific factors is normally distributed and thus its 5% critical value is 1.64. When there is only one common factor, the factor unit root test (ADF_f) has a 5% critical value of -2.86 (the constant only). A maximum of 4 common factors are considered when deciding the true number of common factors in the information criteria. $N = 10$ refers to all 10 Asian countries, and $N = 9$ to 9 when China is not included. $N = 11$ is the panel of 10 Asian countries and the US.

Table 4. Cointegration among Common Factors by Johansen Test

	$N = 10$ Trace statistics (p -value)	$N = 9$ Trace statistics (p -value)	$N = 11$ Trace statistics (p -value)
Factors 1, 2			
$r = 0$	9.077 (0.358)	7.473 (0.523)	9.768 (0.299)
$r = 1$	2.274 (0.131)	3.457 (0.063)	2.197 (0.138)
Factors 1, 2, 3			
$r = 0$	22.751 (0.259)	18.837 (0.505)	24.032 (0.199)
$r = 1$	8.178 (0.447)	9.376 (0.332)	8.156 (0.449)
$r = 2$	2.452 (0.117)	3.520 (0.061)	2.571 (0.109)

Note: Full sample. The r is the number of common factors, and N is that of countries. The lag length of four is used for this test.

Table 5. The Relative Importance of Common Factors (Full Sample)

$r = 3, N =$	10	9	11	10	9	11
	Std (λF)/*Std* (X)			Var ratio test (λF, X) (p-value)		
China	0.7786	–	0.7884	0.0030	–	0.0090
HK	1.0505	1.0377	1.0425	0.7671	0.5536	0.5198
Indonesia	1.1763	1.0854	1.1729	0.9742	0.2958	0.0556
Japan	0.9224	0.8823	0.9270	0.2258	0.2111	0.4859
Malaysia	1.0854	1.0419	1.0868	0.8485	0.5680	0.2959
Singapore	1.0240	0.9235	1.0280	0.6419	0.4248	0.6839
S.Korea	0.9458	1.0042	0.9446	0.3015	0.8775	0.5931
Taiwan	0.8959	0.8237	0.9045	0.1364	0.0416	0.3224
Thailand	1.1170	1.0243	1.1202	0.9122	0.7028	0.1657
Philippines	0.9638	1.0381	0.9470	0.3876	0.5835	0.6287
US	–	–	0.9064	–	–	0.3162
	Std (e)/*Std* (X)			Var ratio test (e, X) (p-value)		
China	0.2312	–	0.2209	0.0000	–	0.0000
HK	0.1159	0.0995	0.1109	0.0000	0.0000	0.0000
Indonesia	0.2111	0.1200	0.2096	0.0000	0.0000	0.0000
Japan	0.1615	0.1705	0.1615	0.0000	0.0000	0.0000
Malaysia	0.1241	0.0932	0.1253	0.0000	0.0000	0.0000
Singapore	0.0539	0.0846	0.0565	0.0000	0.0000	0.0000
S.Korea	0.0541	0.0296	0.0549	0.0000	0.0000	0.0000
Taiwan	0.1104	0.1734	0.1037	0.0000	0.0000	0.0000
Thailand	0.1583	0.0778	0.1636	0.0000	0.0000	0.0000
Philippines	0.2549	0.2710	0.2550	0.0000	0.0000	0.0000
US	–	–	0.1481	–	–	0.0000
	Std (e)/*Std* (λF)			Var ratio test (e, λF) (p-value)		
China	0.2969	–	0.2801	0.0000	–	0.0000
HK	0.1103	0.0959	0.1064	0.0000	0.0000	0.0000
Indonesia	0.1749	0.1106	0.1787	0.0000	0.0000	0.0000
Japan	0.1751	0.1933	0.1742	0.0000	0.0000	0.0000
Malaysia	0.1143	0.0895	0.1152	0.0000	0.0000	0.0000
Singapore	0.0526	0.0916	0.0550	0.0000	0.0000	0.0000
S.Korea	0.0572	0.0295	0.0581	0.0000	0.0000	0.0000
Taiwan	0.1232	0.2105	0.1147	0.0000	0.0000	0.0000
Thailand	0.1417	0.0759	0.1461	0.0000	0.0000	0.0000
Philippines	0.2645	0.2611	0.2693	0.0000	0.0000	0.0000
US	–	–	0.1634	–	–	0.0000

Note: Includes the constant term. "X" is real GDP. The variance (Var) ratio test.

Table 6. The Relative Importance of Common Factors
(Variance Ratio Test(*p*-value) with Different Sample Periods)

$r = 3, N = 10$	1970Q2-1997Q2			1997Q3－2007Q1		
	$(\lambda F, X)$	(e, X)	$(e, \lambda F)$	$(\lambda F, X)$	(e, X)	$(e, \lambda F)$
China	0.1310	0.0000	0.0000	0.0145	0.0000	0.0002
HK	0.7838	0.0000	0.0000	0.2443	0.0000	0.0000
Indonesia	0.3456	0.0000	0.0000	0.5813	0.0000	0.0000
Japan	0.0876	0.0000	0.0000	0.0950	0.0000	0.0000
Malaysia	0.1890	0.0000	0.0000	0.8057	0.0000	0.0000
Singapore	0.6355	0.0000	0.0000	0.4162	0.0000	0.0000
S.Korea	0.8665	0.0000	0.0000	0.5084	0.0000	0.0000
Taiwan	0.2429	0.0000	0.0000	0.1732	0.0000	0.0000
Thailand	0.7148	0.0000	0.0000	0.5749	0.0000	0.0000
Philippines	0.0816	0.0000	0.0000	0.0118	0.0000	0.0039
$r = 3, N = 9$						
HK	0.7743	0.0000	0.0000	0.3498	0.0000	0.0000
Indonesia	0.6783	0.0000	0.0000	0.8807	0.0000	0.0000
Japan	0.0439	0.0000	0.0000	0.2229	0.0000	0.0000
Malaysia	0.2666	0.0000	0.0000	0.8252	0.0000	0.0000
Singapore	0.7924	0.0000	0.0000	0.9957	0.0000	0.0000
S.Korea	0.7249	0.0000	0.0000	0.6814	0.0000	0.0000
Taiwan	0.0766	0.0000	0.0000	0.4985	0.0000	0.0000
Thailand	0.8269	0.0000	0.0000	0.8320	0.0000	0.0000
Philippines	0.5411	0.0000	0.0000	0.0270	0.0000	0.0012
$r = 3, N = 11$						
China	0.1514	0.0000	0.0000	0.0185	0.0000	0.0000
HK	0.7386	0.0000	0.0000	0.2564	0.0000	0.0000
Indonesia	0.3807	0.0000	0.0000	0.5637	0.0000	0.0000
Japan	0.0919	0.0000	0.0000	0.0853	0.0000	0.0000
Malaysia	0.1967	0.0000	0.0000	0.7696	0.0000	0.0000
Singapore	0.6344	0.0000	0.0000	0.3875	0.0000	0.0000
S.Korea	0.8525	0.0000	0.0000	0.5146	0.0000	0.0000
Taiwan	0.2687	0.0000	0.0000	0.1518	0.0000	0.0000
Thailand	0.7297	0.0000	0.0000	0.5383	0.0000	0.0000
Philippines	0.1130	0.0000	0.0000	0.0103	0.0000	0.0533
US	0.7145	0.0000	0.0000	0.0871	0.0000	0.0000

Note: See table 5.

Table 7. Trade Concentration (Average)

	Imports		Exports	
	Within Asia	With the US	Within Asia	With the US
China	0.428	0.115	0.505	0.145
HK	0.661	0.077	0.442	0.232
Indonesia	0.465	0.115	0.576	0.149
Japan	0.278	0.194	0.292	0.289
Malaysia	0.531	0.158	0.515	0.176
Singapore	0.485	0.149	0.458	0.171
S. Korea	0.378	0.195	0.353	0.238
Taiwan	--	--	--	--
Thailand	0.476	0.113	0.407	0.180
Philippines	0.433	0.202	0.403	0.307

Note: The data are from the IMF's Direction of Trade, and statistics are computed as trade to/from each partner country divided by the total trade of the home country. The sample period is 1981Q1 to 2007Q1.

Table 8. The Long-Run Relationship between Trade and Common Factors

	Total trade (*p*-value)		Trade within Asia (*p*-value)		Trade concentration (*p*-value)	
	Import	Export	Import	Export	Import	Export
OLS	0.539 (0.000)	0.470 (0.000)	0.396 (0.000)	0.378 (0.000)	0.018 (0.000)	0.012 (0.000)
Adj OLS	0.612 (0.000)	0.536 (0.000)	0.457 (0.000)	0.438 (0.000)	0.021 (0.000)	0.014 (0.000)
FMOLS	0.262 (0.000)	0.257 (0.000)	0.546 (0.000)	0.564 (0.000)	0.031 (0.000)	0.034 (0.000)
Panel cointegration test						
DF_{ρ}^{*}	-10.044 (0.000)	-9.707 (0.000)	-8.643 (0.000)	-4.641 (0.000)	-1.005 (0.157)	-0.514 (0.304)
DF_{t}^{*}	-2.559 (0.000)	-2.490 (0.000)	-2.476 (0.000)	-1.144 (0.126)	-1.070 (0.142)	-0.435 (0.435)
Panel cointegration test with breaks						
LM	--	--	--	--	118.400 (0.000)	5.200 (0.000)

Note: The panel cointegration test is based on Kao (1999) which examines the null of no cointegration, and the lag length of four is determined by the Akaike Information Criterion. The panel cointegration test with structural breaks is based on Westerlund (2006) which examines the null of cointegration with breaks, and breaks are considered in the constant and time trend. The maximum number of breaks is three. Figures in parentheses are p-values. Due to data availability, the analysis using total trade data is based on 10 Asian countries, while that for trade concentration is based on 9 countries (i.e., excluding Taiwan). The sample period is 1981Q1 to 2007Q1.

Figures

Figure 1. Standardized Real GDP of Asian Countries (in natural log)

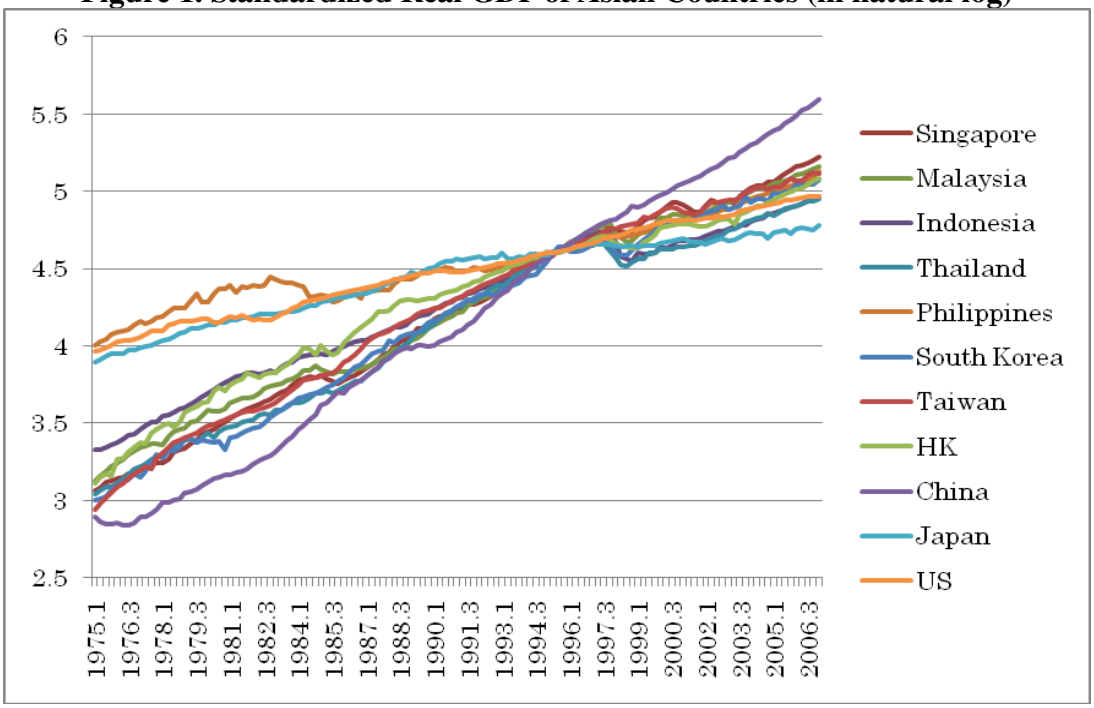


Figure 2. Real GDP Growth (log difference)

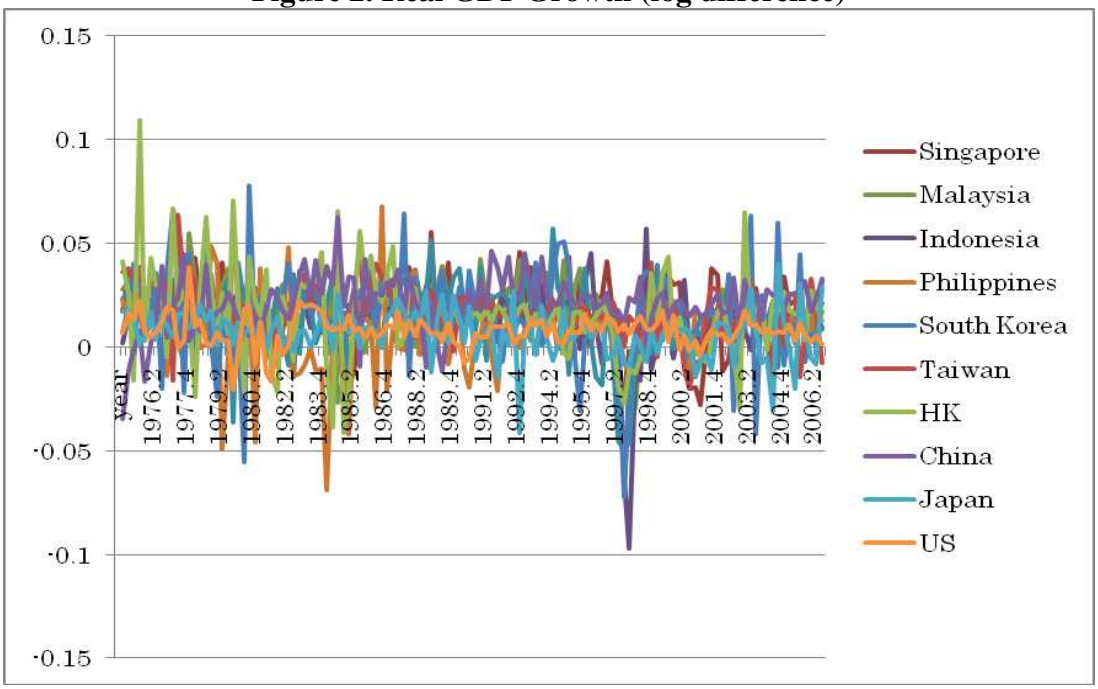
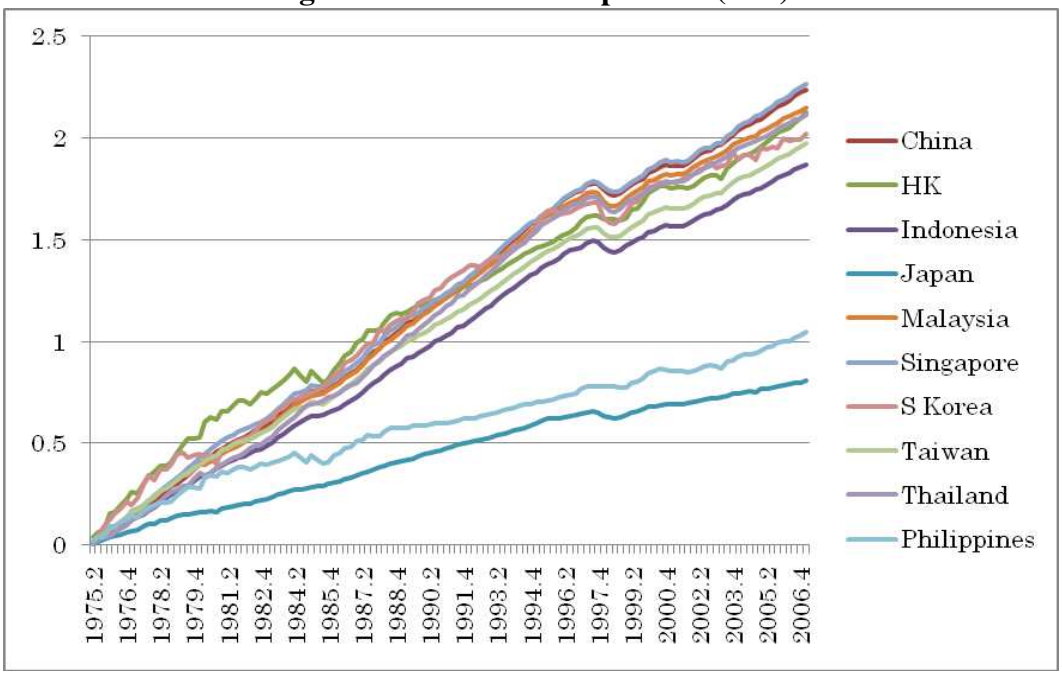
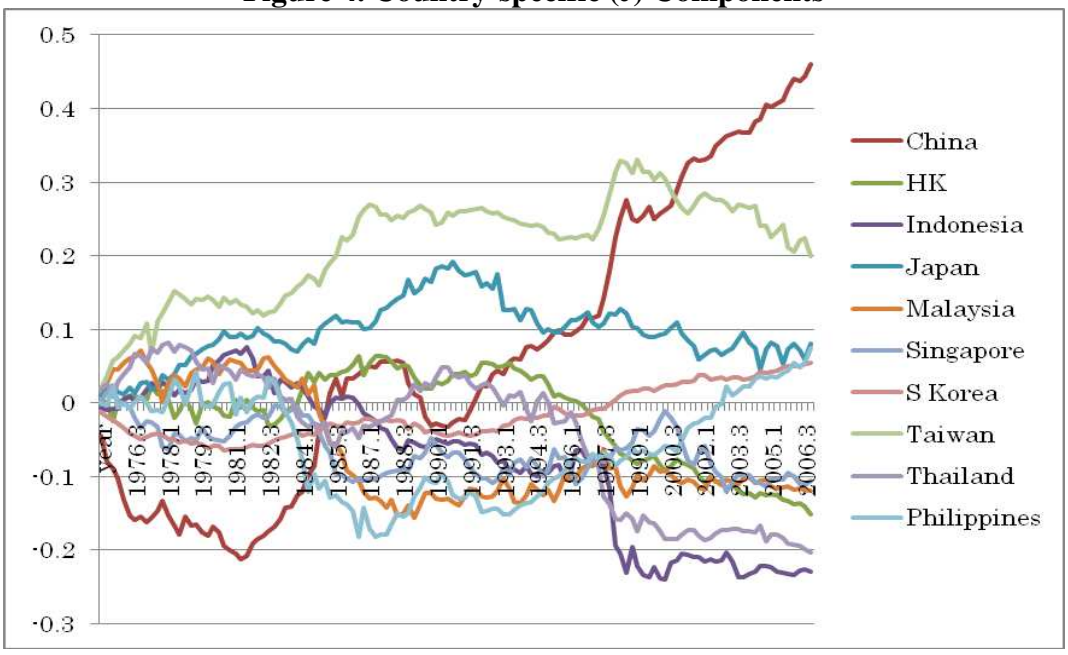


Figure 3. Common Components (λF)



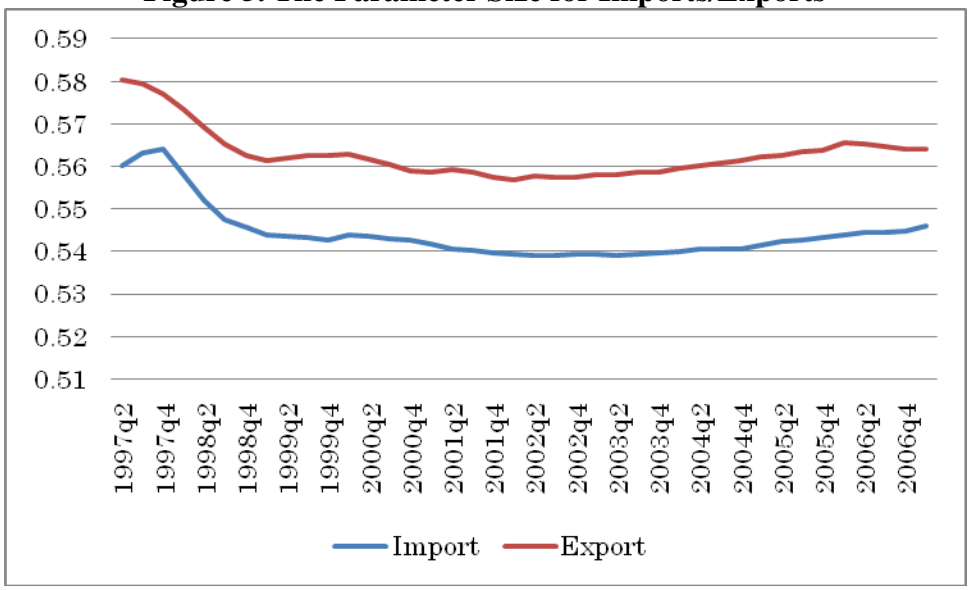
Note: See the main text (Section 3) about the definition and derivation of λF.

Figure 4. Country-specific (e) Components



Note: See the main text (Section 3) about the definition and derivation of e.

Figure 5. The Parameter Size for Imports/Exports



Note: The imports and exports represent the total amount of trade to and from Asian countries.