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Trade and Business Cycle Correlations in Asia-Pacific

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Abstract

Recent empirical studies challenge the traditional theory of optimum currency areas by arguing that a monetary union enhances trade and business cycle co-movements among its member countries sufficiently as to obviate the need for national monetary policy. This paper examines the empirical relationship between trade and business cycle correlations among thirteen Asia-Pacific countries, paying particular attention to the structural characteristics of their economies and other issues not explored fully in the literature. According to our result, although trade is relevant to the business cycles of individual countries, the main determinant of their international correlations is not the geographical structure of their trade but what they produce and export -- more specifically the extent to which their output and exports are concentrated on electronic products.

Keywords: business cycles, optimum currency area, trade, electronics

JEL classification: F15, F33, F40

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1. Introduction

The Asian financial crisis in 1997 and the European monetary unification in 1999 have spurred debates about monetary and exchange rate arrangements in East Asia. Although an EU-style monetary union is generally regarded as unrealistic in contemporary East Asia, a number of observers now call for a regional exchange rate regime, arguing that such an arrangement would help prevent competitive devaluations and contagious currency crises (Williamson 2005). There is also a perception that stable exchange rates would accelerate the ongoing integration of the regional economies by promoting trade and foreign direct investment (Kawai 2005).

While the theory of optimum currency areas (OCA) warns against a monetary union among countries with idiosyncratic business cycles, recent empirical studies challenge this conventional wisdom. Frankel and Rose (1998), among others, argue that the formation of a monetary union boosts trade among member countries and reduces their business cycle incongruity. If such effects are sufficiently strong, the traditional OCA criteria may prove to be overly stringent, as like-minded countries may be able to turn themselves into an OCA on their own initiative, if not in the short run but over a sufficiently long period of time.

This paper examines the relationship between trade and business cycle correlations among 13 Asia-Pacific economies. While we maintain the basic empirical framework of Frankel and Rose (1998), we pay close attention to the structural characteristics of East Asian economies, including their heavy dependence on a limited range of products, growing trade in intermediate products, and their sensitivity to cross-border capital movement. Although our result confirms the role of trade as a channel through which individual countries are linked to the international economy, the primary determinant of the business cycle correlations among our sample countries is not the geographical structure of their trade but what they produce and export. More specifically, income correlations are notably high among countries specializing in the electronics industry, reflecting the highly volatile nature of this industry.

This paper is organized as follows. The next section surveys a sample of the existing studies on trade and business cycle synchronization and highlights a few issues that are potentially important but not explored in these studies. Sections 3 and 4 develop our empirical framework and present our estimation results. Section 5 summarizes the findings of the paper and discusses their implications for exchange rate arrangements in East Asia. Appendix A provides an additional analysis of recent business cycles in the Asia-Pacific economies while Appendix B explains the source and construction of our data set.

2. Previous studies

According to the standard OCA theory, the net benefit of monetary union is a positive function of the magnitude of trade and the degree of business-cycle synchronization among member countries, since trade presumably increases the opportunities for reaping efficiency gains whereas synchronized business cycles reduce the need for national monetary policy. Therefore, if we plot the extent of trade among a group of countries against the correlations of their incomes as in Figure 1, the set of points at which the cost and benefit of monetary union just cancel each other out should take the form of a downward-sloping curve. Countries located to the right of this line will benefit from forming a currency union while countries located to its left should maintain national currencies.

This standard analysis has been challenged recently. A number of recent empirical studies have found that a monetary union has strong trade-promotion effects, suggesting that countries whose *ex ante* relationship is at point *A* in Panel (b) will not remain there after the introduction of a common currency (Rose 2000; Rose and Stanley 2005). However, where exactly their relationship will settle down is not straightforward and depends on *why* trade expands. If, for example, currency union enhances trade by forcing member countries to specialize in a limited set of industries and to exchange different types of goods, their business cycles may become more idiosyncratic, particularly when sectoral shocks constitute an important factor behind national business cycles (Krugman 1993). If, on the other hand, a common currency promotes intra- as well as inter-industry trade by helping firms penetrate into the markets of other countries, trade expansion may strengthen international transmission of national economic shocks and make their business cycles more synchronized. If this second effect dominates the first one, monetary unification will nudge member countries toward an OCA first by boosting trade and then by reducing their business cycle asymmetries.

Whether the foregoing effect takes place in reality is, of course, an open question. One difficulty in assessing this issue empirically is the paucity of real-world episodes of monetary unification, particularly in recent history that is relevant to contemporary policy making. Frankel and Rose (1998, hereafter F&R) approached this problem by estimating the following cross-sectional regression model:

$$\rho(i,j) = \alpha + \beta T(i,j) + \sum_k \gamma_k Z_k(i,j) + \varepsilon(i,j) \tag{1}$$

where $\rho(i,j)$ refers to the business cycle correlation between countries *i* and *j*, $T(i,j)$ represents trade intensity between these two countries, and $Z_k(i,j)$, $k=1,2,\ldots$ are other relevant variables. The coefficient of interest in this equation is β; if this coefficient takes on a large positive value, there is at least indirect evidence that trade helps synchronize national business cycles. F&R estimated eq. (1) for 21 OECD countries using the instrumental variable method and indeed found positive and statistically significant values for β under a variety of specifications.

Although a few authors have subsequently applied the preceding framework to East Asian countries, their results are not as clear-cut as in F&R's original work. For example, Crosby (2003) investigated the relationship between bilateral trade and business cycle co-movements for 13 Asia-Pacific countries. His result identified no discernible relationship between the two but instead found that the structural and technological similarity between two countries, measured by the share of manufacturing in domestic value added and the stock of IT products, was related positively with their income correlations. Meanwhile, Choe (2001) does find that bilateral trade strengthens business cycle confluence for a group of 10 East Asian countries. According to his result, however, this effect is not uniform across countries but particularly salient for the members of the Association of Southeast Asian Nations (ASEAN). Shin and Wang (2004) have tested the possibility that intra- and inter-industry trade causes different effects on income correlations by including an index of intra-industry trade intensity as an explanatory variable. In their estimation, while the bilateral trade variable is significant when it is included on its own, the estimated value of its coefficient drops substantially when the intra-industry trade index is also included.

While the preceding studies shed some light on the relationship between trade and business cycles in East Asia, it is not clear how we can provide a unified explanation for their finings. To motivate what we do in the following sections, we raise here three issues that may complicate F&R's empirical model but have so far received little attention. In our view, these issues are particularly pertinent to the East Asian countries.

First, although most existing studies define $T(i,j)$ in terms of the intensity of *bilateral* trade between countries *i* and *j*,[1] defining this variable in this way makes it difficult to interpret the meaning of its coefficient. To see why, consider a situation in Figure 2(a), where countries *i* and *j* export not only to each other but also to a third country *k*. If the volume of the latter trade is substantially larger than the former trade, the main source of external demand shocks for countries *i* and *j* should be country *k*, in which case the coefficient on $T(i,j)$ may confound the effects of the bilateral trade and the exports to the third country. In this connection, one may recall that most East Asian countries still depend heavily on extra-regional markets (e.g. the United States), although trade among themselves is also increasing rapidly.

Second, although intra-regional trade has been growing in East Asia, a sizable part of this trade is accounted for not by final consumption goods but by parts and components of machinery.[2] In Figure 2(b), country *i* exports an intermediate good to country *j*, and country *j* exports a final good produced using this intermediate material to countries *i* and *k*. As the price of the final good should include the cost of imported materials, the gross trade value

[1] The exact specification of $T(i, j)$ varies from one study to another. For example, F&R compute this variable as either $[X(i, j) + X(j, i)] / [X(i) + X(j) + M(i) + M(j)]$ or $[X(i, j) + X(j, i)] / [Y(i) + Y(j)]$, where $X(i, j)$ denotes country *i*'s exports to country *j*, $X(i)$ and $M(i)$ are the total exports and imports of country *i*, and $Y(i)$ is its GDP. Crosby specifies $T(i, j)$ as $\max\{[X(i, j) + X(j, i)] / Y(i), [X(i, j) + X(j, i)] / Y(j)\}$.

[2] In 2003, intermediate machinery accounted for 27.9 percent of the total merchandise exports of ten developing East Asian countries. Between 1992 and 2003, the share of intra-regional trade in their aggregate exports has risen from 38.1 to 52.5 percent for intermediate goods but has fallen from 44.6 to 35.2 percent for finished products (Athukorala and Yamashita 2005).

between countries i and j now suffers from double counting. Moreover, as country k consumes part of the final output, the export performance of country i may be sensitive to country k's business cycle even if there is no direct trade between these two countries. These examples raise questions concerning the meaning of β in eq. (1).

The third and more technical issue is the merit of estimating eq. (1) with the instrumental variable (IV) method. F&R argue that the IV method is warranted because of endogeneity between $T(i, j)$ and the dependent variable. In their view, countries tend to target their currencies to those of their most important trading partners and, in doing so, implicitly coordinate their monetary policies to those of the latter countries. To the extent that exchange rate stability promotes trade and that coordinated monetary policies enhance income correlations, they argue, β reflects not only the genuine effect of $T(i, j)$ on $\rho(i, j)$ but also the simultaneous effect of monetary policy on these two variables (F&R 1998, pp.1018). A few subsequent studies also make use of the IV method.

There is, however, doubt about the preceding argument.[3] As noted by Gruben et al. (2003), if $T(i, j)$ and $\rho(i, j)$ are endogenous for the reason suggested by R&R, OLS should bias the estimate of β upward. In F&R's estimation, however, most OLS estimates of β are substantially smaller than the corresponding IV estimates, sometimes by the factor of two to three.[4] IV can overestimate β if there is an omitted variable in eq. (1) and if this omitted variable is correlated with the instruments for $T(i, j)$. F&R and most other studies

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[3] Beside what is discussed below, the foregoing argument is slightly puzzling as it presumes that monetary policy coordination between two or more countries *always* strengthens their business cycle correlations. If these countries are exposed to very different economic shocks, it seems more likely that adopting a single monetary policy amplifies the asymmetry of their business cycles. As the implicit dollar pegs of East Asian countries before 1997 were widely recognized as an important cause of the subsequent regional crisis, this point is particularly pertinent in our present context.

[4] The result of OLS estimation is provided in a discussion paper version of F&R (1998). Although OLS biases β downward when there are measurement errors in $T(i, j)$, the reported discrepancies between the OLS and IV estimates look too large to be explained for this reason alone. Moreover, if explanatory variables are suspected to involve serious measurement errors, one should first attempt to improve their accuracy before resorting to the IV method. This is one reason why we develop rather elaborate trade variables in Section 3.

are guided by the standard "gravity" model of international trade and instrument $T(i, j)$ with such variables as the distance between the two countries and their geographical adjacency. It is conceivable, however, that these variables are also correlated with other factors that are relevant to international income correlations.

For East Asian countries, one plausible candidate of such factors is international capital movement. While there is still debate about the fundamental cause of the Asian financial crisis, it is plain that massive capital flights in 1997-98 triggered this event and helped invite the subsequent region-wide recession. Similarly, pre-crisis economic booms in many East Asian countries are likely to have been assisted by acceleration in capital inflows, while many observers point to the recent surge of capital flows into China as an important factor behind the country's property- and stock-market booms. To the extent that foreign investors "lump" geographically proximate countries when assessing their economic prospects, international capital flows may be correlated spatially and hence also with the standard gravity-equation variables.

3. Estimation strategy

This section sets forth our empirical framework. While we retain F&R's basic model, we construct each variable carefully so as to address the issues discussed in Section 2. Our sample is the following 13 countries in the greater Asia-Pacific Region: Australia, China, India, Indonesia, Japan, Korea, Malaysia, New Zealand, the Philippines, Singapore, Taiwan, Thailand and the United States. Our sample is the same as that of Crosby (2002), except that we drop Hong Kong and add India to our list. Hong Kong is excluded partly because of statistical problems associated with entrepôt trade but also because its economy is increasingly dominated by the service sector.[5] We include India because this country is an increasingly important trading partner for other countries and also to increase variations in the size and structural characteristics of our sample countries. With 13 countries, we have 13

[5] Eq. (1) implicitly assumes that merchandise trade is the main channel through which economic shocks spread across countries. Hong Kong's exports are, however, increasingly dominated by services and entrepôt trade for China and other countries.

$\times 12 \div 2 = 78$ country combinations.

For estimation of eq. (1) to be meaningful, we need to ensure that the dependent variable reflects bilateral business cycle synchronizations accurately. Although it is desirable for this purpose to compute $\rho(i, j)$ using as many business-cycle episodes as possible, most East Asian economies have undergone substantial structural changes during the past few decades, suggesting that too old data are be very relevant to their contemporary relationships. As quarterly GDP data of some countries became available only in the 1990s, we compute our measures of $\rho(i, j)$ using annual real GDP data for 1984-2003.[6] Appendix A provides an additional analysis using more recent quarterly GDP data to check the robustness of what we will see in this and the next section.

Most existing studies first filter the log real GDP series of countries *i* and *j* using either first-differencing or the Hodrick-Prescott (HP) filter and then compute $\rho(i, j)$ in terms of their correlation coefficient. Since the HP filter is sensitive to a break in a series, however, correlations of HP-filtered series become unnaturally high among countries that were affected severely by the Asian crisis.[7] In what follows, therefore, we develop our measures of $\rho(i, j)$ in terms of first differenced series. Let $y_t(i)$ denote the natural logarithm of country *i*'s real GDP in year *t* and let $\Delta y_t(i)$ be $y_t(i) - y_{t-1}(i)$. Our first measure of bilateral business cycle co-movements is simply:

$$\rho_1(i, j) \equiv corr\left(\Delta y_t(i), \Delta y_t(j)\right) \tag{2}$$

where $corr(x_t, y_t)$ denotes the correlation coefficient for $\{x_t\}$ and $\{y_t\}$.

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[6] While F&R also use an index of real industrial output and the unemployment rate, the former is not available for some of our sample countries and the latter is evidently unsuited as a measure of business cycles for countries like China.

[7] This problem is aggravated by the fact that the coefficient of correlation is sensitive to an outlier in the sample. While some authors use other measures of bilateral co-movements, these measures are generally unsuited here because of our relatively few data points. Pootrakul et al. (2003) assess the co-movements of the exports of East Asian countries using a "concordance" statistic developed by McDermott and Scott (2000) and find that the export cycles of most regional countries are more synchronized when measured by this statistic.

The foregoing index may understate the linkage between the two countries if one country's business cycle affects the other's with a substantial time lag. To allow for this possibility, we also consider the following measure:

$$\rho_2(i,j) \equiv 2/3 \times \left\{ \rho_1(i,j) + 1/2 \times \max\left[corr\left(\Delta y_t(i), \Delta y_{t-1}(j)\right), corr\left(\Delta y_{t-1}(i), \Delta y_t(j)\right) \right] \right\} \quad (3)$$

The correlation coefficients on the right hand side (RHS) of eqs. (2) and (3) are computed excluding data for 1998 to alleviate the effect of the Asian crisis.[8] For the lagged correlation coefficients in eq. (3) we make use of data for 1983 and 2004 as well.[9]

Table 1 presents the values of our two co-movement indicators for our 78 country pairs (the lower-left part lists $\rho_1(i,j)$ while $\rho_2(i,j)$ is shown in the upper-right). In this table, the business cycles of four Southeast Asian countries (Indonesia, Malaysia, Singapore and Thailand) appear to be correlated tightly, and the values for the Malaysia-Singapore pair are particularly large. We also observe relatively close co-movements among three English-speaking industrial countries (Australia, New Zealand and the United States) and three Northeast Asian countries (Japan, Korea and Taiwan).

Our next task is to develop a measure of $T(i,j)$. We would like the coefficient of this variable, β, to reflect accurately the effect of trade on the income co-movements between countries i and j. We judge standard bilateral trade intensity indices as too simplistic for this purpose and develop our own indicators. Let us first consider good k that is produced in industry l. Let $X_k^l(i,m)$ denote the value of the exports of this good from country i to country m. We classify all goods k = 1, 2, … into two distinct sets – one composed entirely of finished products and the other composed of raw materials and intermediate goods – and write the former set as A. Using these notations, we adjust each $X_k^l(i,m)$, k = 1, 2, … as follows:

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[8] Further excluding data for 1997 and/or 1999 does not materially change what we will find below.

[9] As both $\rho_1(i, j)$ and $\rho_2(i, j)$ lie between [-1, 1], we apply the Fisher transformation to their values when estimating eq. (1) to avoid unnecessary statistical complications.

$$\tilde{X}_k(i,m) \equiv \begin{cases} \delta^l(i) X_k^l(i,m) & \text{if } k \in A \\ \sum_{j \neq i} \theta^l(j,m) X_k^l(i,j) & \text{if } k \notin A \end{cases} \tag{4}$$

$$\delta^l(i) \equiv \frac{O^l(i) - \sum_{j \neq i} \sum_{k \notin A} X_k^l(j,i)}{O^l(i)}, \qquad \theta^l(i,m) \equiv \frac{X^l(j,m)}{O^l(j)}, \tag{5}$$

where $O^i(l)$ denotes the total output of industry *l* in country *i*.

The meaning of eq. (4) is as follows. If *k* is a final product, producing this good may require imported materials and intermediate products that do not contribute to country *i*'s income. The first line in eq. (4) strips this part from the gross export value. If *k* is a raw material or intermediate good, the final good produced in country *j* using this material may not be consumed at home but instead be exported to other countries. The second line in eq. (4) adjusts the export destinations of the intermediate good *k* to the countries where the consumption of the finished product takes place.[10] In practice, the distinction between final and intermediate products is not always clear, and there are cases in which intermediate materials cross national borders more than once. However, the preceding adjustment should take us some way toward addressing the kind of problems discussed in Section 2. See Appendix B for details about the actual adjustment procedure.

We next aggregate $\tilde{X}_k(i,m)$ for all *k* = 1, 2, … and compute $\tilde{X}(i,m) \equiv \sum_k \tilde{X}_k(i,m)$. This value (roughly) corresponds to the part of country *i*'s domestic value added that depends either directly or indirectly on the demand from country *m*. Using this value, we now define $T(i,j)$ as follows:

$$T(i,j) \equiv \sum_m \min\left[\frac{\tilde{X}(i,m)}{Y(i)}, \frac{\tilde{X}(j,m)}{Y(j)}\right], \tag{6}$$

where $Y(i)$ denotes country *i*'s nominal GDP and *m* = 1, 2, .. include *i* and *j*. In our definition, $T(i,j)$ measures the extent to which the tradables sectors of the two countries rely on the demand coming from the same set of countries.

[10] In eq. (5), $\theta^l(j,j)$ corresponds to the domestic shipment ratio of industry *l* in country *j*. If the final good is consumed entirely at home, we have $\theta^l(i,j)=1$ and $\tilde{X}_k(i,j) = X_k^l(i,j)$.

In eq. (6), $\tilde{X}(i,i)$ represents the (adjusted) aggregate value of the tradable goods that are produced and consumed in country *i*. Provided that the following inequality relations hold,[11]

$$\frac{\tilde{X}(i,i)}{Y(i)} \geq \frac{\tilde{X}(j,i)}{Y(j)}, \qquad \frac{\tilde{X}(i,j)}{Y(i)} \leq \frac{\tilde{X}(j,j)}{Y(j)} \tag{7}$$

we can divide the RHS of eq. (7) into the following two components:

$$\begin{aligned} T(i,j) &\equiv \left(\frac{\tilde{X}(i,j)}{Y(i)} + \frac{\tilde{X}(j,i)}{Y(j)} \right) + \sum\nolimits_{m \neq i,j} \min \left[\frac{\tilde{X}(i,m)}{Y(i)}, \frac{\tilde{X}(j,m)}{Y(j)} \right] \\ &\equiv T_1(i,j) + T_2(i,j). \end{aligned} \tag{8}$$

In eq. (9), $T_1(i,j)$ reflects the intensity of bilateral trade between countries *i* and *j* whereas $T_2(i,j)$ indicates the extent to which the two countries depend on common third-country markets. Most existing studies implicitly assume that the second part is not relevant to the income correlation between countries *i* and *j*. We can test the validity of this assumption by including $T_1(i,j)$ and $T_2(i,j)$ as independent explanatory variables in eq. (1).

Figure 3 plots the computed values of $T(i,j)$, $T_1(i,j)$ and $T_2(i,j)$ for our 78 country pairs in two scatter diagrams. As can be seen in the left panel, there are a number of cases in which $T_2(i,j)$ is substantially larger than $T_1(i,j)$, a tendency particularly salient for relatively small countries in Southeast Asia. We also note that the values of $T(i,j)$ and $T_2(i,j)$ for the Malaysia-Singapore pair are very large and close to being an outlier among our 78 samples. As the business cycles of these two countries are also correlated very tightly in terms of our indicators, this pair may become a leverage point when estimating eq. (1). We thus add in all subsequent regressions a dummy variable that takes the value of 1 when (*i, j*) = (Malaysia, Singapore) and 0 otherwise.

According to Gruben et al. (2002) and Shin and Wang (2004), intra-industry trade has stronger effects on bilateral business cycle co-movements than does inter-industry trade. Clark and van Wincoop (2001) and Imbs (2004) also report that the bilateral trade variable

[11] These relations do hold for all of our 78 country pairs.

often ceases to be significant in a model like (1) once the two countries' industrial structures are taken into account explicitly. To investigate whether these findings hold for our samples, we let $\tilde{X}_k(i) \equiv \sum_{m \neq i} \tilde{X}_k(i,m)$ and define the following value:

$$\omega(i,j) \equiv \sum_k \min\left[\frac{\tilde{X}_k(i)}{\sum_k \tilde{X}_k(i)}, \frac{\tilde{X}_k(j)}{\sum_k \tilde{X}_k(j)}\right] \tag{9}$$

This value can be regarded as a similarity index of the commodity structures of the two countries' exports. We can then consider the following specifications:

$$\rho(i,j) = \alpha + \beta_1 \omega(i,j) T(i,j) + \beta_2 (1 - \omega(i,j)) T(i,j) + \ldots + \varepsilon(i,j) \tag{10}$$

$$\rho(i,j) = \alpha + \beta T(i,j) + \gamma \omega(i,j) + \ldots + \varepsilon(i,j) \tag{11}$$

If it is found that $\beta_1 \neq \beta_2$, one might believe that the composition of export goods affects the way in which trade influences the business cycle. If we also find $\beta = 0$ and $\gamma \neq 0$, however, what matters primarily for the income correlation between two countries is not the geographical structure of their trade but the extent to which their exports are composed of similar goods.

Our last task is to decide how to control for the effect of international capital flows. To the extent that capital movements can plausibly influence the dependent variable, we judge it best to recognize this possibility explicitly and to develop an independent explanatory variable that captures the dynamics of capital flows in countries *i* and *j*. To this end, we first define $ci_t(i)$ as the ratio of country *i*'s net private capital inflow in year *t* to its nominal GDP in the preceding year.[12] We then compute the correlation between $\{ci_t(i)\}_t$ and $\{ci_t(j)\}_t$ for 1984-2003:[13]

$$\nu(i,j) \equiv corr(ci_t(i), ci_t(j)) \tag{12}$$

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[12] We use the previous year's GDP to alleviate potential simultaneity between capital flows and domestic income.

[13] To maintain consistency with the dependent variable, this variable is also computed excluding data for 1998.

We note, however, that this variable is likely to be endogenous to the dependent variable.[14] Other factors that might affect the dependent variable are examined at the end of the next section.

4. Estimation results

Table 2 shows the result of our first set of regressions. As these results were obtained with OLS, the coefficients on $v(i,j)$ are likely to be biased upward (see below). Although the estimated coefficients on most variables are of the expected sign, not all of them are statistically significant. In particular, our general trade variable, $T(i,j)$, is only marginally significant when the dependent variable is $\rho_1(i,j)$ and not significant when it is $\rho_2(i,j)$. Similarly, in the specifications that include $T_1(i,j)$ and $T_2(i,j)$, only the first variably is (weakly) significant. On the other hand, when $T(i,j)$ is split into $\omega(i,j)T(i,j)$ and $(1-\omega(i,j))T(i,j)$, the coefficient of the former variable is highly significant and has the expected sign whereas that of the latter is insignificant and negative. This observation corroborates the result of the previous studies that the commodity composition of exports matters for international income co-movements. The last equation further divides $\omega(i,j)T(i,j)$ into $\omega(i,j)T_1(i,j)$ and $\omega(i,j)T_2(i,j)$; interestingly, the second variable is now also significant at or close to the 10 percent level.

We next consider IV estimation to deal with potential endogeneity between $v(i,j)$ and the error term. As it is not clear what serves as a good instrument for $v(i,j)$, we first make a conjecture concerning factors that affect international capital flows and regress $v(i,j)$ on a set of candidate variables. First and as we noted earlier, there are reasons to expect that international portfolio investment is correlated spatially. In addition, the flow of foreign direct investment -- an important part of cross-border capital flows – is often correlated with trade flows (Wei and Frankel 1997; Lipsey and Ramstetter 2001), suggesting

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14 The standard Granger causality test suggests causality from $\Delta y_t(i)$ to $ci_t(t)$ in a few countries and the opposite causality in some other countries, although these results tend to be sensitive to the choice of lag length and the treatment of data during the Asian crisis.

that standard gravity variables are correlated not only with bilateral trade intensity but also with our correlation index of capital flows.[15] Most existing studies instrument their trade variables with some or all of the following variables: (a) *the distance between countries i and j*; (b) *a dummy variable indicating the two countries' geographical adjacency*; and (c) *a dummy variable which indicates whether or not the two countries share a common language*. As our sample includes very large countries with multiple centers of economic activity, we measure (a) not in terms of the distance between the capital cities of countries i and j but by taking a weighted average of the distances between several most populous cities in the two countries. In addition, only four of our 78 country combinations have a common border, and these include the Malaysian-Singapore pair.[16] We thus replace (b) with (b)′ *the square of (a)*; doing so also allows for a nonlinear relationship between the distance and $v(i,j)$. See Appendix B for the sources of these variables.

In addition, the standard economic theory predicts that capital tends to flow from labor-scarce, high-wage countries to labor-abundant, low-wage countries. This suggests the possibility that $v(i,j)$ is related negatively with (d) *the gap in per capita income between countries i and j*. In addition, our sample includes countries that maintain regulations on international capital movement. As long as these regulations are effective, the dynamics of the balance of the capital account in such countries may be less correlated with those of other countries with similar economic characteristics. As capital controls tend to be tighter in low income countries such as China and India, (e) *a variable representing the minimum of the per capita incomes of countries i and j* may also be associated negatively with $v(i,j)$.

Table 3 shows a sample of the results of regressing $v(i,j)$ on (a), (b)′, (c), (d), (e) and the other explanatory variables in our original regression model. Although we

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[15] While F&R instruments $T(i,j)$, our trade variables reflect not only bilateral trade intensity but also the dependence of countries i and j on common third markets and the commodity structures of their exports. Therefore, the kind of causalities assumed by F&R is less likely to be an issue here. Although Imbs (2004, pp.731) states that "nonsynchronized countries tend to trade more", we are puzzled as to why this should be the case.

[16] In some other cases (e.g. China and India), border areas are far removed from the centers of economic activity in the two countries and often mired with ethnic strife and/or territorial disputes.

experimented with a number of other specifications, the language variable turned out to be insignificant in all cases. As the other four exogenous variables generally remained significant and had the expected sign, we instrument $v(i,j)$ below with these four variables and the other explanatory variables included in each equation.

Table 4 provides the result of the IV estimation. Although $v(i,j)$ is now insignificant at conventional confidence levels, we keep reservations about this result since the correlations between $v(i,j)$ and its instruments are not very tight.[17] The results are otherwise similar to what we saw in Table 2, except that the relative significance of $\omega(i,j)T_1(i,j)$ and $\omega(i,j)T_2(i,j)$ is now reversed in favor of the latter variable.

The preceding results suggest that, other thing being equal, the business cycles of two countries become more synchronized when there is a more overlap in the commodity structures of their exports. Does this relationship hold for all goods and industries, or is this a feature unique to a particular good or industry? To investigate this question, we define the following variable

$$\omega^l(i,j) \equiv \sum_{k\in l} \min\left[\frac{\tilde{X}_k(i)}{\sum_h \tilde{X}_h(i)}, \frac{\tilde{X}_k(j)}{\sum_h \tilde{X}_h(j)}\right] \tag{13}$$

where, as before, l denotes a specific industry. We decompose $\omega(i,j)$ into $\omega^l(i,j)$ and $\omega(i,j)-\omega^l(i,j)$ and estimate our model using $\omega^l(i,j)T(i,j)$ and $\left(\omega(i,j)-\omega^l(i,j)\right)T(i,j)$ as independent explanatory variables. Among the countries for which Table 1 indicated relatively tight income co-movements, Australia, New Zealand and the United States depend (relatively) heavily on the exports of agricultural goods and processed food products, whereas the exports of most East Asian countries contains substantial amounts of electronic goods (Kumakura 2005). We thus consider two cases of l = 1 = agricultural, food and beverages industries and l = 2 = electronics industry.

The result is shown in Table 5. In equations that include $\omega^1(i,j)T(i,j)$ and $\left(\omega(i,j)-\omega^1(i,j)\right)T(i,j)$, the former variable is not significant and has the negative sign,

[17] While we performed the Hausman test of contemporaneous correlation between the regressors and the error term, the hypothesis of no correlation was not rejected in any of these specifications.

whereas the latter is positive and (close to being) significant at the 10 percent level.[18] On the other hand, when $\omega(i,j)T(i,j)$ is divided into $\omega^2(i,j)T(i,j)$ and $\left(\omega(i,j)-\omega^2(i,j)\right)T(i,j)$, the former is highly significant in all cases while the latter is insignificant. This result suggests that the effect of export product similarity is not general but specific to the electronics industry. Interestingly, when $\omega^2(i,j)T(i,j)$ is further decomposed into $\omega^2(i,j)T_1(i,j)$ and $\omega^2(i,j)T_2(i,j)$, only the latter remains significant at the conventional confidence levels.[19] While the reason for this result is not clear, it might reflect the fact that, while many developing Asian countries exchange a substantial amount of intermediate electronic products, most of finished goods go to other countries such as the United States (see further discussion at the end of this section).

As noted in Section 3, some of the existing studies report that the systematic relationship between bilateral trade and income co-movements disappears once the difference in the two countries' industrial structures is controlled for. For our sample countries, industry shocks seem to be particularly pertinent to the electronics sector. Although one way of controlling for such effects is to include $\omega^2(i,j)$ as an independent variable, it is not difficult to devise a variable that captures more directly the importance of the electronics sector in each pair of countries. For example, if we let $s(i)$ denote the share of the electronics industry in country *i*'s GDP and define the following variable

$$s(i,j) \equiv \min\left[s(i), s(j)\right] \tag{14}$$

this variable serves as a domestic-output analogue of $\omega^2(i,j)$.[20]

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[18] Grimes (2005) explores the possibility that the business cycles of Australasia are driven by shocks in the mining sector. Adding this sector to $l = 1$ does not materially change our estimation result.

[19] Although the point estimates of the coefficient on $\omega^2(i,j)T_1(i,j)$ are much larger than those for $\omega^2(i,j)T_2(i,j)$, the mean and the standard deviation of the first variable are 0.006 and 0.009 whereas those for the second variable are 0.019 and 0.027. Thus marginal changes in these variables should have roughly the same effect on the dependent variable.

[20] Clark and van Wincoop (2001) and Imbs (2003) employ the following more general similarity index of industrial structure:

$$s(i,j) \equiv \sum_l \min[s^l(i), s^l(j)]$$

Table 6 presents the result of estimations that include either $\omega^2(i, j)$ or $s(i, j)$ as an independent explanatory variable. These variables are generally not significant when $T(i, j)$ is also present, apparently because these variables are correlated to each other fairly strongly.[21] However, $s(i, j)$ is highly significant when the trade variable is dropped, and the point estimate of its coefficient is not very sensitive to the inclusion of $T(i, j)$. Moreover, comparison of Tables 2, 4 and 6 reveals that models that include only $s(i, j)$ outperform systematically models with $T(i, j)$ or $T_1(i, j)$ and $T_2(i, j)$ but no industry variables. As far as our sample countries are concerned, therefore, trade seems to synchronize national business cycles not by passing around fluctuations in the aggregate demand but primarily by transmitting shocks specific to the electronics sector.

We note, however, that the overall explanatory power of our regression models is fairly modest even in Table 6, suggesting that there are other factors affecting international business cycle correlations. Although our trade variables refer only to merchandise trade, our sample includes countries in which services constitute a sizable proportion of aggregate trade. In a few countries (e.g. the Philippines), net income flows and remittances from overseas workers also constitute a sizable part of national foreign exchange earnings. We thus compute for each country the difference between the current account balance and the balance of merchandise trade in each year and divide this value by its nominal GDP in the previous year. Letting $si_t(i)$ denote this value, we then define the following variable:

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where $s^l(i)$ denotes the share of the value added of industry l in country i's GDP and l = 1, 2, … refers to each industry in the domestic manufacturing sector. If we designate l = 1 = electronics industry and rewrite the RHS of this equation as

$$s(i, j) \equiv \min[s^1(i), s^1(j)] + \sum_{l \neq 1} \min[s^l(i), s^l(j)] \equiv s^1(i, j) + [s(i, j) - s^1(i, j)],$$

the last two terms correspond to $\omega^2(i, j)$ and $[\omega(i, j) - \omega^2(i, j)]$ in the previous estimation. When both of these terms are included as independent explanatory variables, the coefficient of the first term generally remains positive and statistically significant whereas the second term is insignificant.

[21] This evidently reflects growing international production sharing in the electronics sector. $\omega^2(i, j)$ and $s(i, j)$ are also correlated with $T_1(i, j)$ and $T_2(i, j)$.

$$\lambda(i,j) \equiv corr\left(\Delta si_t(i), \Delta si_t(j)\right). \tag{15}$$

As this variable can be seen as an index of the synchronicity of the service and income receipts between countries *i* and *j*, we repeat our previous regressions by adding this variable to the list of regressors. The result is shown in Table 7.[22] While the coefficient on $\lambda(i,j)$ has the expected sign, it is estimated imprecisely and statistically insignificant in all cases. Meanwhile the coefficients of $\omega^2(i,j)$ and $s(i,j)$ remain similar to Table 6. This observation lends further support to our previous finding that the electronics industry plays a very special role in business cycle synchronicity in the Asia-Pacific region.

Why, then, are income correlations stronger among countries that depend on the electronics industry? Is this because the demand for electronic products is more volatile than that for other types of goods? Or does it reflect supply-side factors, such as rapid technological progress in this industry? While a full analysis of this question is beyond the scope of this paper, available evidence suggests that both demand and supply factors are important. To shed light on this point, let us first look at Table 8, which shows: [A] the share of each Asia-Pacific country in the global consumption of electronic goods; [B] the share of the electronics industry in each country's GDP; [C] the ratio of net electronics exports to GDP; and [D] the correlation of each country's business cycle with cyclical fluctuations in the world electronics market, measured in terms of the correlation coefficient for each country's real GDP growth rate and the growth rate of the total sales value of electronic products in the world (both nominal and real). In [A], we find that the United States is by far the largest market for electronic goods, with Japan being the distant second. As one can see in [C], the United States is also a net importer of electronic goods, and its net imports dominate those of other countries in value terms (not shown here). This fact is reflected in [D], where we find a close synchronicity between cyclical fluctuations in the global shipments of electronic goods and the US business cycle. Meanwhile, we observe in [B] and [C] that the shares of the electronics sector in domestic production and exports are much

[22] Although we present only the results of OLS estimation, those based on the IV method were similar.

higher in smaller East Asian countries, particularly in Malaysia and Singapore.[23] Notice further in [D] that the business cycles of several East Asian countries are also correlated closely with the growth rate of global electronics shipments, although, as we saw in Table 1, their correlations with the US business cycles are generally modest.

This last observation suggests that trade in electronic goods is not merely a channel through which the US business cycle is passed onto East Asian countries but also entails its own dynamics. Figure 4 shows the time series of the annual growth rates of world GDP, US GDP and the nominal US dollar value of the world exports (= imports) of intermediate electronics products. The last series is broken down into the changes in sales price and volume to illustrate their relative importance.[24] What stands out from this figure is that while the cyclical fluctuations in the world electronic market are correlated fairly closely with the world and US business cycles, the former is by far more volatile than the latter. In addition, although the volume of trade in electronics has increased every year except for 2001-2002, the price has been more volatile and exhibits a clearer pattern of cyclicality. The price dynamics in Figure 4 is related closely to fluctuations in the prices of semiconductor devices, a segment of the world electronics industry particularly prone to investment-driven boom-and-bust cycles (Kumakura 2005). East Asian countries whose business cycles are correlated closely with cyclical fluctuations in the world electronics market, such as Korea, Malaysia, Singapore and Taiwan, all depend heavily on semiconductor devices and related products. These observations suggest that supply shocks, and particularly those relating to relatively "upstream" segments of the industry, also play an important role in the dynamics of the international electronics market.

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[23] In our previous estimations, although the Malaysia-Singapore dummy was highly significant in equations that include only trade variables, it often ceased to be so when $\omega^2(i, j)$ or $s(i, j)$ was added to the regressors. This observation suggests that the conspicuously high income correlation between these two countries was not necessarily due to inexplicable special factors but reflects their heavy dependence on the electronics industry.

[24] In many East Asian countries, a large part of trade in electronics is accounted for by parts and components, whose price tends to be substantially more variable than finished products. The price movement is imputed by the difference between the growth rates of value and volume and not adjusted for quality changes.

What we have seen in this section gives us a clue as to what is responsible for the findings of the previous studies. For example, Crosby (2003) measures the structural difference and technological gap between two countries by the differences in the share of manufacturing in GDP and the numbers of PCs and mobile phones per thousand persons, and reports that these variables help explain international income correlations. In our (and Crosby's) sample, however, the difference in the share of manufacturing in GDP between two countries is correlated strongly with the gap in their per capita incomes, which is, as we saw previously, also related positively with the bilateral correlations of net capital inflows. Moreover, IT goods are used more widely in countries where the electronics sector constitutes a leading industry. Thus these indicators of the structural and technological differences between two countries are likely to be correlated with the extent to which their economies are exposed to fluctuations in the world electronics market. Similarly, a dummy variable for ASEAN membership is found to be highly significant in Choe's (2001) estimation, and the author attributes this finding to long-standing industrial and political cooperation among member countries.[25] In our sample, however, when the ASEAN dummy is included with $\omega^2(i, j)$ or $s(i, j)$ and the Malaysia-Singapore dummy, the first variable is in fact never significant, and even the Malaysia-Singapore dummy often ceases to be significant. Therefore, what Choe interprets as the special effect of ASEAN membership seems to reflect the facts that this group includes relatively small countries whose economies are sensitive to the vicissitude of the world electronics market. Lastly, Shin and Wang (2004) find that an index of intra-industry trade is correlated strongly with the regressand and conclude that the business cycles of two countries become more synchronous only when intra-industry trade increases between these countries. As similar results are reported for countries outside the Asia-Pacific region (e.g. Fidrmuc 2001 and Gruben et al. 2002), trade may indeed primarily transmit industry shocks rather than

[25] Although the ASEAN Preferential Trading Arrangement (PTA) and Enhanced Preferential Trading Arrangement (EPTA) may have promoted trade among its member countries, such effects should appear in the trade variables and do not explain why the membership dummy becomes significant.

general demand shocks.[26] For our sample countries, however, the standard intra-industry trade index is highly correlated with $\omega^2(i,j)$ and $s(i,j)$, since a substantial part of intra-industry trade among East Asian countries occurs in the electronics sector. When estimated on our data, models that include only the intra-industry trade variable never outperform those which include only $\omega^2(i,j)$ or $s(i,j)$, and this remains the same even if the trade variables are also included.[27]

5. Conclusions

This paper re-examined the relationship between trade and business cycle co-movements in the Asia-Pacific region. While some recent studies argue that the business cycles of countries entering a currency union become sufficiently synchronous as to render the traditional OCA criteria all but irrelevant, what we have seen in this paper suggests that this is not necessarily the case. As far as our sample countries are concerned, although trade does appear to constitute important glue linking national economies, the key determinant of the correlation between two countries' business cycles is the extent to which their economies are exposed to the international market for electronic goods. While the dynamics of the world electronics market is in part driven by the economic condition of major consumer countries (e.g. the United States), supply-side factors, such as rapid technical progress and investment cycles in this industry, also seem to play an important role. In East

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[26] Even when two countries engage only in inter-industry trade, their business cycles can be correlated positively if industry shocks are unimportant and each country's import demand is very sensitive to changes in its domestic income.

[27] Shin and Wang test the effect of fiscal and monetary policy coordination by adding variables representing the correlations of the budget deficit/GDP ratio and the M2 growth rate between two countries. In their study, the first variable is never significant while the second one is highly significant in OLS regressions but insignificant in panel regressions, apparently reflecting endogeneity between money supply and the business cycle. If we re-compute our dependent variables by adjusting each country's GDP for its net fiscal position and repeat the previous regressions, most qualitative results remain the same although some variables are estimated less precisely.

Asia, therefore, the geographical structure of trade is a relatively poor predictor of international income co-movements, and what is more important is what each country exports.

It is not clear, however, whether this state of affairs remains the same in the future. First, evidence suggests that the main growth engine of the world electronics market is shifting from volatile corporate IT investment to relatively stable household consumption, thanks in part to the availability of an increasingly wide range of consumer electronics and related services (Linden et al. 2003; Monetary Authority of Singapore 2005). As the electronics industry becomes more mature and inter-connected with other industries, it may become less prone to major market convolutions of the kind that battered a number of East Asian economies in 2000/2001 (see Appendix A). In recent years, furthermore, the manufacturing sectors of the East Asian countries have been undergoing major restructuring, in part because of China's emergence as a major regional assembly platform but also due to the other countries' efforts to diversify their products and make their economies more resilient to external shocks (Ernst 2004). As the world electronics market becomes less volatile and the production and exports of the East Asian countries become less concentrated on electronic goods, trade might become more important as a channel through which aggregate demand shocks are transmitted across the regional economies.

Lastly, we note that trade and industry factors were able to explain a relatively modest part of income co-movements in the Asia-Pacific region, leaving a major part of their cross-country variations unaccounted for. Moreover, although monetary union might indeed help promote trade in East Asia, the fact that many of the regional economies are already quite open and export substantial proportions of their output raises questions concerning the extent to which further trade helps synchronize their business cycles. Similarly, the fact that business cycles are not in close synchronicity even among smaller and geographically proximate Southeast Asian countries a suggests that their economies are also exposed to substantial idiosyncratic shocks and that judicious use of macroeconomic policy can take them a long – if not the full -- way toward neutralizing undesirable external shocks. Therefore, East Asia's policy-makers are well advised to think carefully before venturing onto an ambitious regional exchange rate arrangement.

Appendix A. Recent business cycles in Asia-Pacific

In the preceding sections, we measured business cycle correlations among the Asia-Pacific economies using annual GDP data for 1984-2003. This low-frequency dataset, however, may miss important information concerning the dynamics of individual economies and their causal relationships. In addition, given substantial structural changes that many Asian economies have undergone during the recent past, there are concerns about the relevance of data on earlier years to their contemporary relationship. As quarterly GDP data became available in most countries by the early 1990s, this Appendix focuses on 1992 onward and provides an additional analysis of their income co-movements.[28]

As in the preceding sections, we start by defining a measure of bilateral business cycle synchronization. Let $\Delta y_t(i)$ denote the first difference of the seasonally-adjusted quarterly series of country *i*'s log real GDP. This Appendix considers the following index of bilateral real income co-movements:

$$\begin{aligned}\rho(i,j) \equiv 1/6 \times corr\left[\Delta y_{t-2}(i), \Delta y_t(j)\right] + 1/3 \times corr\left[\Delta y_{t-1}(i), \Delta y_t(j)\right] \\ + 1/2 \times corr\left[\Delta y_t(i), \Delta y_t(j)\right].\end{aligned} \tag{16}$$

In contrast to the previous indicators, this index is not symmetric between countries *i* and *j* – i.e. $\rho(i,j) \neq \rho(j,i)$. If, for example, the business cycle of country *i* affects that of country *j* through trade or some other channels while the opposite effect is weak or absent, we should have $\rho(i,j) > \rho(j,i)$.

In Section 4, we measured the cyclical condition of the world electronics market by the real growth rate of the global consumption of electronic products and found that this variable was correlated strongly with the business cycles of some East Asian countries. As this variable is available only at the annual frequency, this Appendix instead considers the growth rates of (a) the new orders for electronic goods in the United States and (b) the global sales of semiconductor devices, both deflated with the most relevant PPI indices for

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[28] We exclude India in this Appendix due to lack of data.

the United States.[29] We compute the dynamic relationships of these two variables with the GDP cycle of each country using the same formula in eq. (16).

The two panels in Table A show the result of our calculation. The correlation indices in Panel [a] were calculated for 1992Q3-2004Q4, excluding data for 1997Q3-1999Q2 to alleviate the effect of the Asian crisis.[30] As we can see, the relative strength of bilateral income co-movements in this panel differs slightly from what we saw in Table 1. Most notably, the correlations among Australia, New Zealand and the United States are much weaker than in Table 1, suggesting that our previous observation was not robust. Second, among the four Southeast Asian countries for which our previous measures indicated strong co-movements, only Malaysia and Singapore exhibit an unambiguously tight relationship. In addition, the business cycles of these two countries look correlated with those of a few Northeast Asian countries, particularly Taiwan. As the income cycles of these countries are all correlated strongly with our two indicators of the cyclical state of the world electronics market, it now seems certain that the latter is an important determinant of the former.

Panel [B] presents our bilateral correlation indices computed with the data for 1999Q3-2004Q4. Here six countries -- Japan, Malaysia, Singapore, Taiwan and the United States – stand out as a high correlation group, and the income cycles of all these countries are related tightly with our electronics indicators. This observation is not very surprising since the world electronics market has experienced a substantial gyration during this period – first expanding rapidly and then going into a tailspin along with the formation and burst of the US IT bubble (see also Figure 4). Among the five high-correlation countries, $\rho(i,j) > \rho(j,i)$ always holds for i = the United States and j = the other countries, and the same is generally true when we replace i with our electronics indicators. We also observe $\rho(i,j) < \rho(k,j)$ for i = the United States, k = the electronics cycle and j = the other four countries. Therefore, whilst the US business cycle did seem to influence those of many East Asian economies during this period, a substantial part of this effect seems to have been

[29] These two variables are used widely as, respectively, leading and coincident indicators of the cyclical condition of the international electronics market (Ping et al 2004).

[30] As in Section 3, we also used data for 1992Q1-Q2 and 2005Q1-Q2 when computing the lagged correlation coefficients in eq. (16).

mediated by the dynamics of the world electronics market, and the latter also appears to have exerted its own impact.

In the lower panel, we also observe $\rho(i, j) < \rho(j,i)$ for i = Japan and j = the other four countries in the high-correlation group. While it may be unwise to read too much into this observation, it clearly tells us that the strong income correlations between Japan and the other countries during this period were not the result of the Japanese business cycle influencing the other countries. A more plausible explanation is that the Japanese economy has become more susceptive to external events in recent years because of its weak domestic demand and increased dependence on external demand. As Japan is a major producer of electronic goods and also depends increasingly on the import demand from its neighbors, a major slump in the world electronics market may now doubly hit the Japanese economy, first by depressing the export earnings of its leading industry and then by a more broad-based reduction in the import demand from other Asian countries whose incomes are also sensitive to the condition of the international electronics market.

Appendix B. Data source and variable compilation

Trade and industry indices

Statistics on bilateral trade were gathered from the UN comtrade database, Statistics Canada World Trade Database (WTD) and other national sources. Industry data were obtained from the UNIDO INDSTAT database, the OECD STAN database and national sources. As comtrade and WTD are known to have difficulties that are important for our purposes (concerning, for example, the treatment of re-exports and unreported data), adjustment was made to the original data when judged necessary and practicable using data obtained from other sources. These sources include the World Bank Trade and Production Database, the NBER-UN World Trade Dataset, and the Analytical Database of International Trade complied by the Centre d'Etudes Prospective et d'Informations Interanationales (CEPII).

To conduct the adjustment in eqs. (4)-(5), we first need to classify all traded goods into the sets of final products and other goods and into broad industrial categories. This has been accomplished by recompiling the original SITC-based data according to the UN Classification by Broad Economic Categories (BEC) and then by aggregating the obtained data into five broad industries. These industries are: (1) Food and beverages; (2) Fuels and lubricants; (3) Transport equipment; (4) Other machinery; and (5) Other consumer goods. While there are concerns about potential over-aggregation, BEC does not permit finer industrial classification.

We included in the set of export-destination countries m = 1, 2, .. all 13 countries in our sample and the following five countries: Canada, Germany, France, Mexico and the United Kingdom. These countries import (a) 7.5 percent or more of the total exports of at least one of the 13 sample countries and/or (b) 2.5 percent or more of the total exports of at least three of these 13 countries.

Indices for business cycle correlations

Annual real GDP data are from IMF's World Economic Outlook; the quarterly data were gathered from the IMF International Financial Statistics (IFS) and national sources.

Index of capital movement correlations

The net capital inflow in each year was measured as the difference between the overall balance of the private sector and the balance of the current account. Data on these variables come from IFS and the CEIC Asia Database.

Indices of the world electronics cycle

Data on the global sales of electronic goods and semiconductor devices are obtained from the Reeds Electronics Yearbook of World Electronics Data and the US Semiconductor Industry Association. Data on the new orders for electronics in the United States, as well as relevant PPI indices, come from the US Bureau of Census.

Geography variables

Constructed from the CEPII distance measure dataset. Details of this dataset are available in Clair et al. (2004).

Per capita income indices

Constructed with data obtained from the World Bank World Development Indicators.

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Table 1. Bilateral business cycle co-movements (based on annual data)

	AUS	CHN	IND	IDN	JPN	KOR	MYS	NZL	PHL	SGP	TAP	THA	USA
Australia		0.425	0.566	-0.102	0.319	0.153	0.001	0.542	0.088	0.210	0.259	0.116	0.609
China	0.350		0.031	0.101	-0.078	0.043	-0.003	0.397	-0.395	0.052	0.310	-0.024	0.450
India	0.593	-0.148		0.176	0.308	0.048	0.277	0.357	0.417	0.255	0.048	0.330	0.301
Indonesia	-0.117	0.096	0.133		0.220	0.145	0.564	-0.089	0.226	0.489	0.275	0.581	-0.097
Japan	0.250	-0.129	0.273	0.256		0.454	0.093	-0.203	-0.032	0.221	0.482	0.525	0.281
Korea	0.104	0.003	0.071	0.125	0.429		0.199	0.032	-0.016	0.340	0.575	0.415	0.159
Malaysia	0.047	0.006	0.298	0.651	0.123	0.204		-0.032	0.447	0.727	0.245	0.531	0.041
New Zealand	0.566	0.412	0.224	-0.034	-0.401	0.075	0.030		0.111	0.105	0.090	-0.099	0.354
Philippines	-0.025	-0.521	0.475	0.173	-0.064	0.071	0.370	0.042		0.399	-0.110	0.203	-0.215
Singapore	0.244	0.070	0.263	0.529	0.196	0.432	0.876	0.224	0.368		0.458	0.485	0.194
Taiwan	0.186	0.313	-0.010	0.349	0.399	0.658	0.298	0.169	-0.050	0.535		0.388	0.425
Thailand	0.126	-0.040	0.374	0.532	0.522	0.478	0.487	-0.100	0.214	0.480	0.375		-0.114
United States	0.738	0.411	0.381	-0.080	0.181	0.130	0.082	0.460	-0.255	0.270	0.463	-0.108	

(Notes) Computed excluding 1998. Values in the lower-left part show ρ1(i, j); values in the upper right are ρ2(i, j). Shade indicates values over 0.5.

Table 2. OLS estimation

	Dependent variable: ρ_1					Dependent variable: ρ_2				
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
T	0.575*					0.351				
	(0.339)					(0.285)				
T_1		0.990*					0.882*			
		(0.541)					(0.470)			
T_2		0.521					0.282			
		(0.375)					(0.323)			
ωT			2.130**	1.458**				2.039***	1.146**	
			(0.810)	(0.575)				(0.712)	(0.497)	
$(1 - \omega) T$			-1.123					-1.492*		
			(0.924)					(0.784)		
ωT_1					2.254**					2.230**
					(1.030)					(0.948)
ωT_2					1.325**					0.964
					(0.677)					(0.603)
ν	0.156**	0.171**	0.153**	0.155**	0.165**	0.208***	0.226***	0.204***	0.206***	0.220***
	(0.065)	(0.073)	(0.066)	(0.064)	(0.068)	(0.058)	(0.065)	(0.058)	(0.056)	(0.060)
MYS-SGP	0.329**	0.293**	0.313**	0.238*	0.210*	0.255**	0.209*	0.237*	0.138	0.110
	(0.148)	(0.142)	(0.145)	(0.133)	(0.125)	(0.129)	(0.123)	(0.125)	(0.118)	(0.112)
SER	0.239	0.240	0.234	0.235	0.236	0.211	0.211	0.203	0.207	0.208
R^2 (adj.)	0.136	0.128	0.174	0.167	0.158	0.168	0.164	0.228	0.200	0.195

(Notes) Values in parentheses are White heteroskedasticity-consistent standard errors. (*), (**) and (***) indicate significance at, respectively, 10, 5 and 1 percent levels. SER stands for the standard error of regression. The intercept is not reported. MYS-SGP is a dummy variable for the Malaysia-Singapore pair.

Table 3. Regressions of the capital movement variable

Explanatory variable	Dependent variable: ν (1)	(2)	(3)	(4)	(5)
Distance	-2.167**	-2.038**	-2.074***	-2.748***	-2.840**
	(0.997)	(0.967)	(0.918)	(0.885)	(1.263)
Distance^2	0.124**	0.117*	0.152***	0.153***	0.159**
	(0.062)	(0.060)	(0.056)	(0.055)	(0.077)
Language	-0.090				
	(0.088)				
Income per capita (minimum)	-0.102**	-0.104**	-0.091**	-0.086*	-0.086*
	(0.045)	(0.044)	(0.045)	(0.045)	(0.046)
Income per capita (difference)	-0.111**	-0.114**	-0.119***	-0.128***	-0.122***
	(0.044)	(0.044)	(0.044)	(0.045)	(0.045)
T			-1.074**	-0.929**	-0.886
			(0.469)	(0.471)	(0.046)
ω				-0.362	-0.378
				(0.416)	(0.438)
MYS-SGP					-0.073
					(0.416)
SER	0.367	0.367	0.362	0.362	0.364
R^2 (adj.)	0.146	0.148	0.171	0.170	0.158

(Note) See Table 2.

Table 4. IV estimation

	Dependent variable: ρ_1 (1)	(2)	(3)	(4)	(5)	Dependent variable: ρ_2 (1)	(2)	(3)	(4)	(5)
T	0.575					0.351				
	(0.354)					(0.312)				
T_1		1.365*					1.171			
		(0.796)					(0.784)			
T_2		0.472					0.243			
		(0.372)					(0.323)			
ωT			2.146***	1.463**				2.057***	1.151**	
			(0.768)	(0.566)				(0.674)	(0.499)	
$(1 - \omega) T$			-1.140					-1.510*		
			(0.958)					(0.845)		
ωT_1					2.326					2.181
					(1.559)					(1.552)
ωT_2					1.312**					0.973*
					(0.622)					(0.539)
ν (IV)	0.170	0.282	0.098	0.108	0.176	0.222	0.312*	0.143	0.156	0.213
	(0.173)	(0.188)	(0.178)	(0.168)	(0.181)	(0.153)	(0.169)	(0.160)	(0.148)	(0.161)
MYS-SGP	0.322	0.213	0.339*	0.260	0.203	0.248	0.147	0.267	0.161	0.105
	(0.197)	(0.211)	(0.201)	(0.177)	(0.194)	(0.182)	(0.201)	(0.187)	(0.163)	(0.182)
SER	0.245	0.245	0.241	0.242	0.243	0.223	0.223	0.218	0.221	0.222
R^2 (adj.)	0.091	0.093	0.121	0.115	0.109	0.069	0.070	0.115	0.088	0.082

(Notes) See Table 2.

Table 5. Estimation with disaggregated trade variables

	Dependent variable: ρ_1						Dependent variable: ρ_2					
	(1)	(2)	(3)	(4)	(5)	(6)	(1)	(2)	(3)	(4)	(5)	(6)
ω_1 T	-2.481			-3.629			-4.175			-5.407		
	(12.588)			(12.172)			(12.148)			(11.438)		
ω_2 T		2.546**			2.599**			2.706**			2.762**	
		(1.176)			(1.217)			(1.062)			(1.144)	
$(\omega - \omega_1)$ T	0.613*			0.627			0.407			0.422		
	(0.359)			(0.390)			(0.308)			(0.353)		
$(\omega - \omega_2)$ T		-0.235			-0.257			-0.617			-0.640	
		(0.678)			(0.689)			(0.566)			(0.601)	
ω_2 T_1			3.276			4.421			3.606			4.189
			(2.528)			(3.569)			(2.291)			(3.428)
ω_2 T_2			2.045**			1.931**			1.552*			1.494*
			(0.953)			(0.910)			(0.877)			(0.846)
ν	0.161**	0.167**	0.171**				0.214***	0.220***	0.225***			
	(0.071)	(0.066)	(0.069)				(0.063)	(0.058)	(0.060)			
ν (IV)				0.202	0.192	0.244				0.259	0.247	0.262
				(0.185)	(0.175)	(0.192)				(0.164)	(0.156)	(0.171)
MYS-SGP	0.317**	0.230*	0.194	0.293	0.215	0.126	0.237*	0.136	0.066	0.211	0.121	0.031
	(0.152)	(0.131)	(0.128)	(0.213)	(0.195)	(0.233)	(0.132)	(0.116)	(0.117)	(0.197)	(0.184)	(0.221)
SER	0.240	0.237	0.237	0.246	0.244	0.243	0.212	0.207	0.208	0.224	0.221	0.222
R^2 (adj.)	0.126	0.148	0.148	0.083	0.099	0.105	0.160	0.199	0.190	0.062	0.091	0.082

(Note) See Table 2.

Table 6. Estimation with electronics variables

	Dependent variable: ρ_1								Dependent variable: ρ_2							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
T	0.390		0.235		0.371		0.210		0.035		-0.041		0.018		-0.065	
	(0.430)		(0.414)		(0.438)		(0.407)		(0.379)		(0.358)		(0.401)		(0.358)	
ω_2	0.198	0.378*			0.218	0.399			0.340	0.356*			0.358	0.365		
	(0.290)	(0.232)			(0.301)	(0.246)			(0.278)	(0.210)			(0.295)	(0.230)		
s			3.538	4.253**			3.803	4.536**			4.075*	3.952**			4.328**	4.059**
			(2.342)	(1.896)			(2.330)	(2.036)			(2.140)	(1.683)			(2.024)	(1.801)
ν	0.161**	0.165**	0.179***	0.183***					0.215***	0.215***	0.233***	0.233***				
	(0.065)	(0.066)	(0.066)	(0.065)					(0.058)	(0.058)	(0.058)	(0.057)				
ν (IV)					0.199	0.233	0.213	0.235					0.249	0.246	0.266*	0.252
					(0.169)	(0.178)	(0.165)	(0.173)					(0.151)	(0.159)	(0.148)	(0.159)
MYS-SGP	0.372**	0.511***	0.283*	0.349***	0.358*	0.473***	0.264	0.309*	0.328**	0.340***	0.202	0.191*	0.315*	0.323***	0.184	0.176
	(0.165)	(0.057)	(0.149)	(0.111)	(0.199)	(0.119)	(0.203)	(0.170)	(0.144)	(0.054)	(0.131)	(0.100)	(0.185)	(0.109)	(0.188)	(0.154)
SER	0.240	0.239	0.237	0.236	0.246	0.245	0.244	0.243	0.211	0.209	0.207	0.206	0.223	0.222	0.221	0.221
R^2 (adj.)	0.128	0.133	0.148	0.157	0.086	0.095	0.097	0.107	0.171	0.182	0.196	0.207	0.071	0.081	0.084	0.092

(Note) See Table 2.

Table 7. Estimation with a variable for net service exports and income receipts

	Dependent variable: ρ_1								Dependent variable: ρ_2							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
T	0.596*				0.413		0.255		0.373				0.058		-0.019	
	(0.341)				(0.433)		(0.414)		(0.289)				(0.381)		(0.359)	
ω_2					0.195	0.383							0.337	0.363*		
					(0.291)	(0.233)							(0.279)	(0.213)		
ω_2 T		2.620**	2.300***							2.787**	1.932**					
		(1.206)	(0.809)							(1.096)	(0.732)					
$(\omega - \omega_2)$ T		-0.228								-0.609						
		(0.680)								(0.566)						
ω_2 T_1				3.161								3.483				
				(2.568)								(2.306)				
ω_2 T_2				2.157**								1.673*				
				(0.983)								(0.918)				
s							3.585	4.345**							4.126*	4.069**
							(2.354)	(1.923)							(2.148)	(1.716)
ν	0.153**	0.163**	0.160**	0.166**	0.157**	0.162**	0.175**	0.180***	0.204***	0.216***	0.210***	0.219***	0.211***	0.212***	0.229***	0.229***
	(0.067)	(0.068)	(0.067)	(0.071)	(0.066)	(0.068)	(0.068)	(0.067)	(0.059)	(0.059)	(0.058)	(0.062)	(0.059)	(0.059)	(0.059)	(0.058)
λ	0.039	0.050	0.050	0.048	0.037	0.026	0.045	0.039	0.041	0.055	0.057	0.052	0.039	0.037	0.049	0.050
	(0.094)	(0.098)	(0.098)	(0.099)	(0.096)	(0.096)	(0.096)	(0.096)	(0.084)	(0.088)	(0.087)	(0.087)	(0.086)	(0.085)	(0.086)	(0.086)
MYS-SGP	0.320**	0.216	0.205	0.185	0.362**	0.510***	0.272*	0.344***	0.245*	0.121	0.091	0.057	0.318**	0.339***	0.190	0.185*
	(0.148)	(0.133)	(0.126)	(0.131)	(0.165)	(0.057)	(0.150)	(0.112)	(0.130)	(0.121)	(0.118)	(0.121)	(0.146)	(0.054)	(0.133)	(0.101)
SER	0.240	0.239	0.237	0.239	0.241	0.241	0.239	0.237	0.212	0.209	0.208	0.209	0.212	0.210	0.208	0.207
R^2 (adj.)	0.126	0.139	0.150	0.138	0.118	0.122	0.139	0.147	0.159	0.192	0.191	0.182	0.161	0.173	0.188	0.199

(Note) See Table 2.

Table 8. Relationship between national economies and the world electronics market

	AUS	CHN	IND	IDN	JPN	KOR	MYS	NZL	PHL	SGP	TAP	THA	USA
[A] Share in world electronics consumption:													
1985-2003 (average)	0.012	0.032	0.007	0.004	0.147	0.018	0.005	0.002	0.002	0.010	0.008	0.005	0.372
1985-1994 (average)	0.011	0.016	0.007	0.003	0.157	0.014	0.004	0.002	0.001	0.008	0.007	0.004	0.376
1990-2003 (average)	0.012	0.040	0.007	0.004	0.144	0.020	0.005	0.002	0.003	0.012	0.008	0.006	0.355
[B] Value added of the electronics industry in GDP:													
1984-2001 (average)	0.009	0.037	0.015	0.011	0.042	0.052	0.072	0.008	0.014	0.099	0.057	0.023	0.021
1984-1993 (average)	0.009	0.027	0.016	0.006	0.048	0.044	0.052	0.008	0.010	0.097	0.051	0.014	0.022
1991-2001 (average)	0.008	0.043	0.014	0.015	0.038	0.056	0.085	0.008	0.017	0.102	0.062	0.028	0.019
[C] Ratio of net exports of electronics to GDP:													
1985-2002 (average)	-0.019	-0.004	-0.005	0.006	0.019	0.039	0.087	-0.024	0.043	0.215	0.084	0.015	-0.005
1985-1994 (average)	-0.017	-0.012	-0.004	-0.009	0.022	0.031	0.037	-0.024	-0.009	0.139	0.057	-0.003	-0.003
1991-2002 (average)	-0.020	-0.002	-0.005	0.011	0.017	0.041	0.103	-0.024	0.055	0.231	0.090	0.020	-0.005
[D] Correlation between the annual growth rates of country real GDP and:													
World electronics sales (nominal)	0.232	0.118	0.395	0.169	0.358	0.757	0.306	0.212	0.264	0.497	0.747	0.396	0.474
World electronics sales (real)	0.256	0.196	0.298	0.061	0.159	0.552	0.463	0.197	0.148	0.616	0.563	0.120	0.602

(Notes) [A] is computed for final products only. In [B], the electronics industry refers to ISIC (rev.2) 3825 and 383. Net electronics exports in [C] are for SITC (rev.2) 75, 76 and 77. In [D], the growth rate of world electronics sales (real) is calculated as the difference between the growth rate of nominal world electronics sales and the global inflation rate, both measured in terms of US dollars. [D] is computed for 1984-2003 excluding 1998.

(Source) Author's calculation with data from Reeds Electronics Research, UN Comtrade, UNIDO INDSTAT, IMF WEO and national statistics.

Table A. Bilateral business cycle co-movements (based on quarterly data)

[A] 1992:Q3−2004:Q4 (country i in row; country j in column)

i ↓ j →	AUS	CHN	IDN	JPN	KOR	MYS	NZL	PHL	SGP	TWN	THA	USA	*Elec (a)*	*Elec (b)*
Australia		0.189	-0.130	0.084	0.236	0.214	0.153	0.118	0.255	0.313	-0.055	0.178	*0.085*	*0.186*
China	0.003		0.106	0.070	0.014	0.244	0.118	-0.142	0.148	0.105	0.063	-0.012	*0.147*	*0.185*
Indonesia	-0.035	0.168		0.171	-0.033	0.073	0.078	-0.062	0.063	0.053	0.013	0.056	*0.106*	*0.037*
Japan	-0.081	0.088	-0.029		-0.081	0.198	-0.144	0.232	0.092	0.077	-0.174	0.143	*0.205*	*0.050*
Korea	0.139	0.050	0.122	0.100		0.300	0.166	0.109	0.307	0.339	0.166	0.113	*0.084*	*0.383*
Malaysia	0.013	0.135	0.076	0.244	0.279		0.060	0.011	0.421	0.433	0.139	0.199	*0.319*	*0.428*
New Zealand	0.143	0.123	0.172	-0.110	0.174	0.096		0.045	0.123	0.169	0.246	0.048	*0.005*	*0.133*
Philippines	0.144	-0.047	-0.111	0.101	0.031	-0.044	0.036		-0.068	0.030	-0.072	0.064	*0.048*	*-0.163*
Singapore	0.103	0.156	0.101	0.218	0.302	0.346	0.144	0.012		0.398	0.100	0.254	*0.241*	*0.405*
Taiwan	0.147	0.176	0.165	0.284	0.365	0.421	0.162	0.068	0.510		0.140	0.307	*0.319*	*0.470*
Thailand	-0.043	0.078	0.287	-0.006	0.218	0.075	0.292	-0.055	0.027	0.171		0.094	*0.097*	*0.159*
United States	0.191	0.049	0.055	0.283	0.196	0.253	0.039	0.141	0.280	0.380	0.013		*0.379*	*0.272*
Electronics (a)	*0.087*	*0.148*	*0.040*	*0.319*	*0.109*	*0.331*	*-0.085*	*0.032*	*0.369*	*0.336*	*0.033*	*0.420*		*0.398*
Electronics (b)	*0.026*	*0.161*	*0.099*	*0.273*	*0.310*	*0.447*	*0.054*	*-0.109*	*0.511*	*0.402*	*0.156*	*0.236*	*0.374*	

[B] 1999:Q3−2004:Q4 (country i in row; country j in column)

i ↓ j →	AUS	CHN	IDN	JPN	KOR	MYS	NZL	PHL	SGP	TWN	THA	USA	*Elec (a)*	*Elec (b)*
Australia		0.066	-0.198	0.030	0.297	0.240	0.170	0.140	0.220	0.376	0.085	0.160	*0.108*	*0.260*
China	-0.057		0.103	0.181	-0.028	0.074	0.087	0.046	0.060	-0.004	0.107	0.150	*0.153*	*0.093*
Indonesia	-0.252	0.055		0.223	-0.161	0.072	-0.037	-0.063	0.030	-0.061	-0.070	0.017	*-0.004*	*-0.002*
Japan	-0.155	0.163	0.114		-0.048	0.276	0.039	0.303	0.215	0.111	-0.021	0.194	*0.270*	*0.215*
Korea	0.153	0.046	-0.004	0.191		0.412	0.112	0.098	0.368	0.311	0.065	0.121	*0.052*	*0.433*
Malaysia	0.040	0.072	0.159	0.535	0.362		0.077	0.162	0.524	0.483	0.155	0.389	*0.363*	*0.624*
New Zealand	0.122	0.069	-0.019	-0.007	0.136	0.185		0.194	0.076	0.148	0.262	0.003	*-0.038*	*0.076*
Philippines	0.104	0.018	-0.195	0.049	-0.004	0.001	0.119		-0.046	0.016	-0.062	-0.043	*0.123*	*-0.099*
Singapore	-0.065	0.240	0.213	0.471	0.283	0.434	0.043	-0.002		0.384	0.092	0.299	*0.261*	*0.458*
Taiwan	0.146	0.199	0.129	0.424	0.322	0.506	0.096	0.085	0.553		0.125	0.331	*0.297*	*0.523*
Thailand	0.023	0.189	0.067	0.179	0.188	0.360	0.249	-0.040	0.237	0.221		0.327	*0.278*	*0.374*
United States	0.156	0.155	0.074	0.404	0.216	0.474	0.031	0.112	0.430	0.415	0.123		*0.460*	*0.478*
Electronics (a)	*0.014*	*0.199*	*0.044*	*0.446*	*0.081*	*0.358*	*-0.136*	*0.054*	*0.395*	*0.322*	*0.133*	*0.512*		*0.444*
Electronics (b)	*-0.025*	*0.104*	*0.203*	*0.566*	*0.331*	*0.609*	*-0.040*	*-0.045*	*0.547*	*0.454*	*0.230*	*0.462*	*0.413*	

(Notes) Electronics (a) and (b) refer to the real growth rates of USA electronics new orders and global semiconductor shipments. The first series is deflated with the USA PPI for manufacturing durables; the latter is deflated with the USA PPI for manufacturing durables (intermediate only). Shade indicates values over 0.4.

(Source) Author's calculation with data from IMF IFS, CEIC databases and USA SIA.

Figure 1. Endogeneity of OCA criteria?

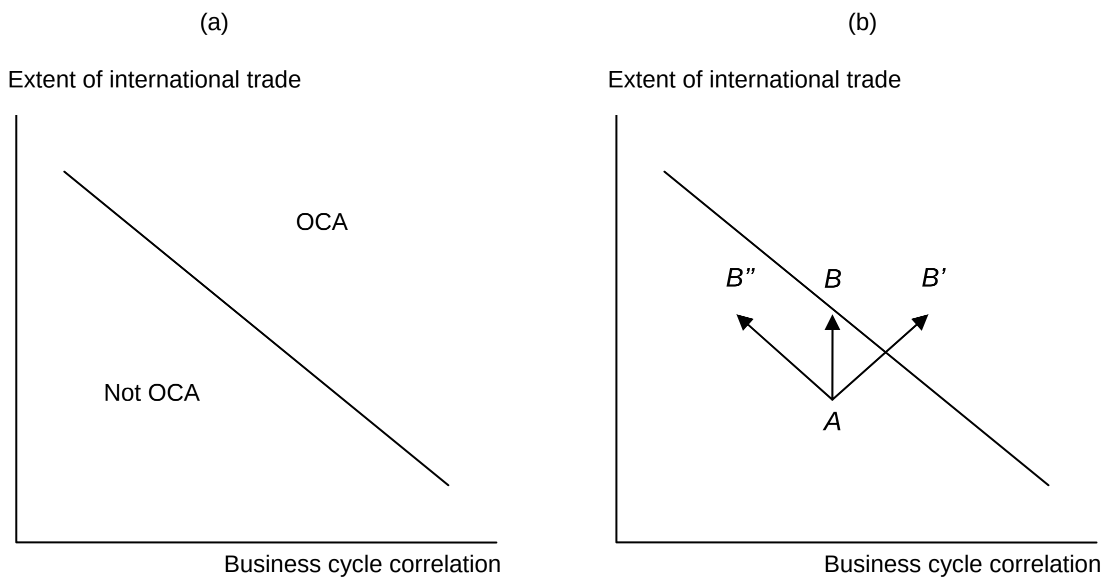


Figure 2. Multilateral trade and international production sharing

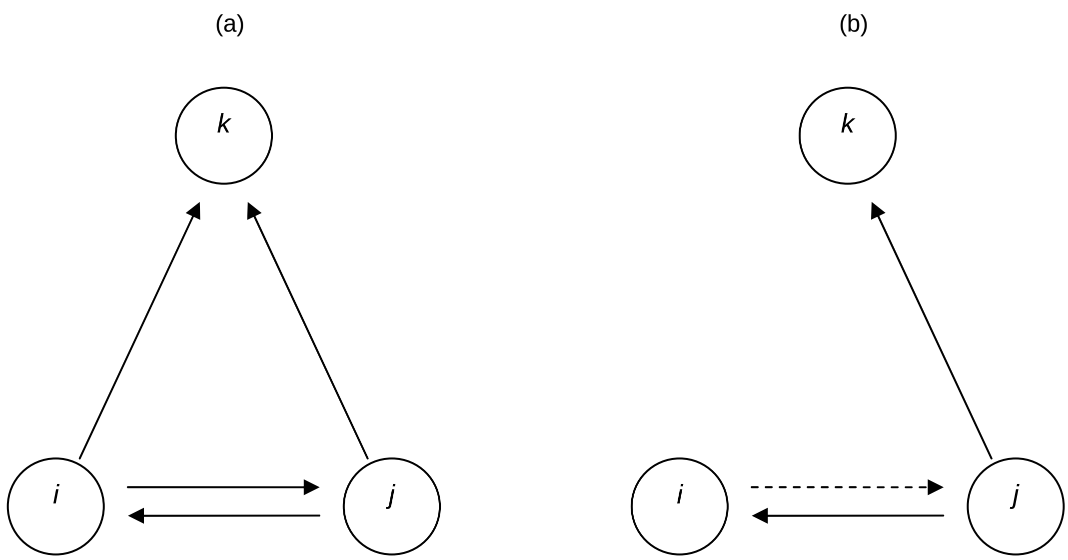
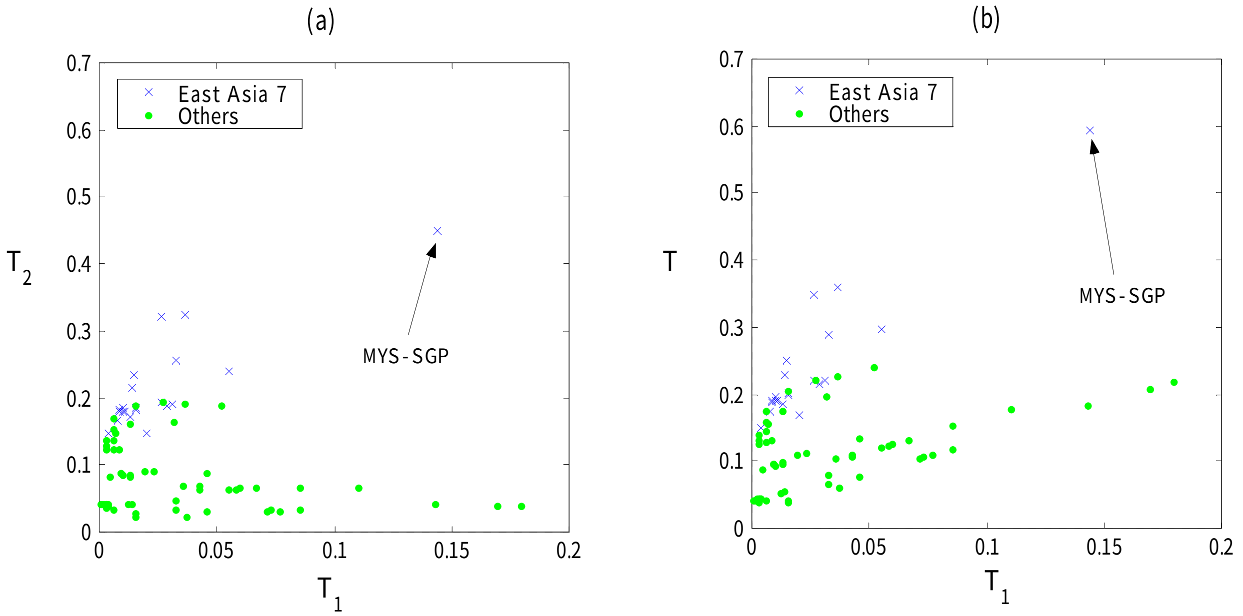


Figure 3. Scatter plots of trade variables



(Note) East Asia 7 refers to combinations among Indonesia, Korea, Malaysia, Philippines, Singapore, Taiwan and Thailand.

Figure 4. Cyclicality of the world electronics market and the global business cycle

(Notes) All series are measured in terms of growth rate over previous year. Price and volume changes in world electronics trade are computed with data for 29 major exporting countries and refer only to intermeidate products.
(Source) Author's calculation with data from UN Comtrade, IMF WEO and other national statistics.