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Working Paper Series No. 2007/14

Determinants of Business Cycle Synchronization in East Asia: An Extreme Bound Analysis

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October 2007

Abstract

We investigate the determinants of business cycle synchronization in East Asia by testing the robustness of the potential candidates, using the technique of Extreme Bound Analysis in an OLS regression framework with Newey-West correction for heteroskedasticity and autocorrelation. We find that trade openness and intra-industry trade are major channels of business cycle synchronization. Although the similarity of monetary policies is statistically correlated with degree synchronization, we are unsure whether the former causes the latter or vise versa. The findings are probably good news to the proponents of the prospective currency union. If the trend of increasing openness and bilateral intra-industry trade continues in East Asia, it is expected that the costs of forming a currency union would diminish as business cycles become more synchronized.

Keywords: Business Cycle Synchronization, East Asia, Extreme Bound Analysis, Currency Union

1. Introduction:

As trade and financial integration has been thriving in East Asia, the desire of forming a currency union has emerged in the region. In academia and policy circle, discussion on the prospective formation of a common currency has been put forward. From the perspective of the Optimum Currency Area (OCA), an important criterion for a currency area to work is the degree of business cycles synchronization across countries. Though it is probable that East Asia is not yet sufficiently synchronized for a currency union to be realized (see, for example, Chow and Kim (2003), Sato *et al* (2003)), an understanding of the driving forces behind business cycle synchronization in this area is necessary. A number of potential factors have been attributed to driving business cycle co-movements in the literature. Since theory is indeterminate upon which factors are behind synchronization, identifying the determinants of synchronization is thus an empirical matter.

This paper is an attempt to empirically investigate the determinants of business cycle synchronization in East Asia. We focus on a number of potential variables which are common in the literature and of which data are within our reach. Specifically, we verify the relationship between business cycle synchronization and the extent of bilateral trade, bilateral intra-industry trade, trade openness, similarity of export, capital account openness, and fiscal and monetary policy coordination. We also take a gravity dummy into consideration. Our dataset is comprised of ten East Asia countries: China, Hong Kong, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Taiwan and Thailand, covering the period from 1970 to 2000.

A problem with the popular approach is that determinants might not be robust across specifications. A variable appears significant in one specification might turn out insignificant in another. Thus, the results found might be dependent on the choice of independent variables, which often varies across studies. To ascertain the robustness of the determinants across various specifications, we follow Baxter and Kouparitsas (2004) and Bower and Guillemineau (2006) to adopt an OLS-based Extreme Bound Analysis (EBA) as suggested by Leamer (1983) and developed by Levine and Renelt (1992) and Sala-i-Martin (1997). In Leamer's view, a variable is "robust" if and only if its statistical significance is not conditional on information set, that is, on whether other variables are added to (or excluded from) the regression equation. A robust variable must first be significant in a bivariate regression and remains significant upon the inclusion of various combinations of additional variables. The EBA sets up conditions which ensure the robustness of a determinant. As regressions on cross-section data are often subject to sampling uncertainty and sampling error correlations, we estimate the equation using OLS regression with Newey-West correction for heteroskedasticity and autocorrelation. We employ different detrending methods and treatment of the gravity dummy variable to examine the sensitivity of our findings.

Our results show that trade openness and intra-industry trade are the major determinants of synchronization in East Asia. We also find the similarity of monetary policies to be robust in the regressions though we are unsure whether it causes business cycle synchronization or vice versa. Other candidates appear unlikely to affect synchronization.

The remainder of the paper is organized as follows. Section 2 briefly describes our definition of variables and estimation methodology. Section 3 discusses EBA results, the robustness of the determinants and implications. The final section is, as usual, conclusion.

2. Definition of Variables and Econometric Methodology:

2.1 Definition of Variables:

There are several variables deemed to influence business cycle synchronization. The foremost candidates are no doubt bilateral trade variables. Since trade is an important linkage among economies, it is believed to be a channel for technological spill-over and shock transmission. However, theory is not unambiguous on which directions bilateral trade drives synchronization. On one hand, comparative advantage trade theories of Ricardian-type imply that increased trade spurs production specialization and thus deflects business cycles. On the other hand, a wide range of theoretical models, from multi-sector international models with intermediate goods trade to one-sector versions with either technology or monetary shocks, show that increased bilateral trade often results in highly correlated business cycles. What is behind this ambiguity might be whether bilateral trade is mainly intra-industry or inter-industry. The former is believed to make business cycles converged while the latter would drive business cycles apart. Which is more likely to occur in reality is an empirical question. Frankel & Rose (1998) find from a pool of twenty industrialized countries that closer trade links would result in more correlated business cycles. Gruben *et al* (2003) divide trade into intra-industry trade and inter-industry trade and find that the former is more capable of explaining synchronization.

Not only bilateral trade but the extent of total trade, which is often referred to as "trade openness", may also matters. Open countries are exposed more to technological transmission and to external shocks and hence might be more synchronized. The similarity of economic structure is also considered as a potential determinant. Countries with similar economic structure are exposed to similar sector-specific shocks and therefore, may have similar business cycles. Previous empirical evidences are, however, conflicting. Imbs (2004) finds the similarity of industrial structure is correlated with business cycle correlation while Baxter and Kouparitsas (2004) show that this relationship is fragile.

Following the wave of financial liberalization and globalization, financial capital movement is increasingly a channel for cross-country shock transmission. Kose *et al* (2003) and Imbs (2004) find that financial integration magnifies international spill-over of macroeconomic fluctuations and thereby increase synchronization. Coordinated policies might also be the causes of synchronization. If two countries adopt similar policies, say, monetary and fiscal policies, they are likely to experience similar business cycles. Finally, gravity variables such as distance, language and population might, as well, influence the degree of synchronization between countries.

In this paper, we examine the relationship between business cycle synchronization and variables of bilateral trade, bilateral intra-industry trade, trade openness, similarity of economic structure, capital account openness, fiscal and monetary policy coordination. We also consider introducing a gravity dummy variable to the regression equation. The variables used in this paper are defined as follow:

2.1.1 Business Cycle Synchronization:

In the literature, it is common to use the simple contemporaneous bilateral correlation coefficient of the cyclical components of GDP of two countries as a measure of their business cycle synchronization.

$$corr_{ij} = corr(y_i, y_j) = \frac{\text{cov}(y_i, y_j)}{\sqrt{\text{var}(y_i).\,\text{var}(y_j)}}$$

However, since correlation coefficient is bounded in the [-1;1] interval, the error term in a regression model with those correlation coefficients as dependent variable is unlikely to be normally distributed. This makes the inference on estimated results biased. To remedy, we follow Inklaar *et al* (2005) to apply the Fisher's ztransformation on the correlation coefficients to ensure the transformed values are normally distributed (David, 1949).

$$syn_{ij} = corr_{trans,ij} = \frac{1}{2}\ln(\frac{1+corr_{ij}}{1-corr_{ij}})$$

where $corr_{ij}$ is the pair-wise correlation coefficient of the cyclical components of GDP of country i and country j.

To obtain the cyclical components of GDP, two popular detrending methods are employed. First, we detrend the GDP series using Hodrik – Prescott (1980) high pass filter (HP method) with dampening parameter of 100. Later, we detrend the series by taking log and first-differencing the log of GDP data (FD method). The aim is to ensure that our findings is robust regardless which detrending method is used.

2.1.2 Bilateral Trade:

Bilateral trade intensity can be captured through two alternative measures. The first one is bilateral trade scaled by combined GDP of the two countries (Trade1):

$$Trade1_{i,j} = \frac{1}{T}\sum_t \frac{X_{ij,t} + M_{ij,t}}{Y_{i,t} + Y_{j,t}}$$

The second measure is the bilateral trade to total trade ratio (Trade2):

$$Trade2_{i,j} = \frac{1}{T}\sum_t \frac{X_{ij,t} + M_{ij,t}}{X_{i,t} + M_{i,t} + X_{j,t} + M_{j,t}}$$

where $X_{ij,t}$ is export from country i to country j (import to country j from country i) at time t, $M_{ij,t}$ is import to country i from country j (export from country j to country i) at time t; $Y_{i,t}$ and $Y_{j,t}$ are GDP of country i and country j respectively.

2.1.3 Intra – Industry Trade:

As argued above, the effect of bilateral trade on business cycle synchronization might be unclear since we do not know whether intra-industry or inter-industry trade is dominant. To examine the role of intra-industry trade, we construct a measure of intra-industry trade *à la* Grubel and Lloyd (1975):

$$IIT_{ij} = \frac{1}{T}\sum_t \left(1 - \frac{\sum_k |X_{ij,k,t} - M_{ij,k,t}|}{\sum_k (X_{ij,k,t} + M_{ij,k,t})}\right)$$

where $X_{ij,k,t}$ is the nominal export of product k from country i to country j at time t and $M_{ij,k,t}$ is the nominal import of product k from country j to country i. As we do not have trade data detailed to each product, we rely on data of trade structure broken down into ten first-digit sub-industries of the United Nation's Standard International Trade Classification (SITC), revision 2: 0 - Food and live animals; 1 - Beverages and tobacco; 2 - Crude materials, inedible, except fuels; 3 - Mineral fuels, lubricants and related materials; 4 - Animal and vegetable oils, fats and waxes; 5 - Chemicals and related products, n.e.s.; 6 - Manufactured goods classified chiefly by material; 7 - Machinery and transport equipment; 8 - Miscellaneous manufactured articles; 9 - Commodities and transactions not classified elsewhere in the SITC.

2.1.4 Openness:

The "openness" of a country is often measured by the ratio of total trade to GDP. To measure "bilateral" openness, we construct two alternative indicators: combined total trade to combined GDP ratio (Open1) and averaged total trade to GDP ratio (Open2) as follows:

$$Open1_{ij} = \frac{1}{T}\sum_t \frac{(X_{i,t} + M_{i,t} + X_{j,t} + M_{j,t})}{Y_{i,t} + Y_{j,t}}$$

$$Open2_{ij} = \frac{1}{T}\sum_t \frac{1}{2}\left(\frac{(X_{i,t} + M_{i,t})}{Y_{i,t}} + \frac{(X_{j,t} + M_{j,t})}{Y_{j,t}}\right)$$

where $X_{i,t}$, $M_{i,t}$ and $X_{j,t}$, $M_{i,t}$ are total export and total import of country i and country j; $Y_{i,t}$ and $Y_{j,t}$ are GDP of country i and country j, respectively.

2.1.5 Similarity of Export:

As discussed above, the similarity of economic structure can influence the synchronization of business cycles. Since data on the economic structures of East Asian countries are not available, we use their export structures as proxies. Countries with similar export structures would be affected similarly by external shocks to their exports, hitting their export revenues and their export sectors. We measure the similarity of export structures between country i and country j by the period average of the sum of the absolute differences of sectoral export shares:

$$E\,\text{xp}\,sim = \frac{1}{T}\sum_{t}\sum_{n=1}^{N} | S_{i,n} - S_{j,n} |$$

where $S_{i,n}$ and $S_{j,n}$ denote export share of sector *n* in country i and country j respectively. Similar to the construction of intra-industry trade index, export is divided into ten sectors corresponding to the ten first-digit sub-sectors of the United Nation's Standard International Trade Classification (SITC), revision 2.

2.1.6 Capital Account Openness:

To measure capital account openness, it is common to use the IMF's binary indicators of exchange restrictions published in its Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER). Chinn and Ito (2002) propose a new measure of de-jure capital account openness, constructed as the first standardized principal component of the inverse of the IMF binary indicators. The incorporation of various IMF indicators allows the new measure to capture the intensity of capital controls as well as their evolution. In this paper, we measure bilateral capital account openness as the period average of the sum of the Chinn and Ito's indicators (Chinn and Ito, 2002):

$$Kaopen_{ij} = \frac{1}{T}\sum_{t}(Kaopen_{i,t} + Kaopen_{j,t})$$

where $Kaopen_{i,t}$ and $Kaopen_{j,t}$ are the Chin and Ito's measures of capital account openness of country i and country j, respectively.

2.1.7 Fiscal Policy:

Fiscal policy is a macroeconomic instrument whereby governments can manipulate to alter business cycles. Conventionally, fiscal policy similarity between two countries is measured by the correlation coefficient of budget deficit to GDP ratios. However, as budget deficit is generally determined by the state of business cycle, the inclusion of this variable on the right side of the regression equation often results in simultaneity problem. We, therefore, employ another measure of fiscal policy similarity, the period mean of the absolute differences in the government spending to GDP ratios.

$$FIS_{ij} = \frac{1}{T}\sum_{t} \left| \frac{Govspending_{i,t}}{GDP_{i,t}} - \frac{Govspending_{j,t}}{GDP_{j,t}} \right|$$

where $Govspending_{i,t}$ and $Govspending_{j,t}$ are the general government final consumption expenditure in country i and country j respectively.

2.1.8 Monetary Policy:

Similar to fiscal policy, monetary policy is a major instrument whereby governments can affect business cycle. If two countries follow similar monetary policies, it is probable that they have similar business cycles. However, we should be cautious of the causal direction. Similar monetary policies might also be the result of similar business cycles since monetary authorities might react in the same manner to shocks. We measure bilateral monetary policy similarity using the correlation coefficient of money supply (M2) growth rates.

$$M2_{ij} = corr(M2_i, M2_j)$$

where $M2_i$ and $M2_j$ are M2 money supply growth rates in country i and country j respectively.

2.1.9 Exchange Rate Stability:

Another indicator of monetary policy coordination is the stability of bilateral exchange rate. We measure nominal bilateral exchange rate stability using its standard deviation scaled by mean:

$$NER\_ER = \frac{std(NER_{ij})}{mean(NER_{ij})}$$

where NER_{ij} is the nominal bilateral exchange rate between the currencies of country i and country j. The bilateral exchange rates are computed via cross rates against US dollar.

2.1.10 Gravity Dummy:

It is well-known in the literature that gravity variables, such as adjacency, distance, common language, population and land can explain economic growth, bilateral trade and thus business cycle synchronization. In this paper, we construct a gravity dummy based on the distinction between the Northeast and Southeast Asian countries. These groups are different not only in geographical distances but also in language and culture. The dummy takes the value of unity for the pairs of countries which are in the same regions and of zero otherwise.

2.2 Econometric Methodology

To identify the determinants of business cycle synchronization, a simple regression model of the following form can be used:

$$Y = \beta X + \gamma D + u$$

where Y is a measure of business cycle synchronization, X is a vector of candidate variables that might influence synchronization, D is a vector of control variables and u is the error term. It is, however, observed that estimated coefficients from this type of equation are often unstable and much conditional on the choice of information set. A variable appears as significant in one specification might turn out to be insignificant in another. Hence, estimation results are not reliable and might be tailored with the specific specification selected. To obtain "true" determinants of business cycle co-movements, we follow Baxter and Kouparitsas (2004) and Bower and Guillemineau (2006) to employ an OLS-based Extreme Bound Analysis (EBA) as suggested by Leamer (1983) and developed by Levine and Renelt (1992) and Sala-i-Martin (1997). The aim of the procedure is to ascertain the robustness of the determinants across various specifications.

In Leamer' view, a variable is "robust" if and only if its statistical significance is not conditional on the choice of information set, that is, on whether other variables are added to (or excluded from) the regression equation. A robust variable must first be significant in the bivariate regression and remains significant upon the inclusion of various combinations of additional variables. The EBA regression framework takes the form:

$$Y = \beta_i I + \beta_m M + \beta_z Z + u$$

where Y is a measure of business cycle synchronization; M is a candidate determinant which we want to test for its robustness and Z is a vector of control variables, which might also be potential determinants. We would like to examine the sensitivity of β_m upon various alterations of Z. The I-variables are the "always included" exogenous variables. Following Levine and Zervos (1993), the EBA procedure proceeds as follows:

i) For each M-variable, we first run a baseline bivariate regression without any Z variables.

ii) Add from one to three of the Z-variables in every possible combination into the equation

iii) Compute the "extreme bounds" of β_m from the estimated β_m. The upper extreme bound is the maximum estimate of β_m plus two times its standard error (UEB= $\beta_m^{max} + 2\sigma(\beta_m^{max})$) and the lower extreme bound is the minimum estimate of β_m minus two times its standard error (LEB= $\beta_m^{min} - 2\sigma(\beta_m^{min})$).

An M-variable is considered a robust determinant if all estimated β_m are statistically significant and the extreme bounds are of the same sign.

The above EBA procedure is, however, rather restrictive. A variable might fail this test of robustness due even to a single outlier in a single regression. As a result, few and in many cases, no variables appear robust through the test. For example, using EBA test, Levine and Renelt (1992) show that no variables are robust determinants of economic growth. Sala-i-Martin (1997) suggests a more relaxed variant of the EBA test which makes use of the entire distribution of the estimated β_m. He argues that if at least 95 percent of the density function for β_m lies on either side of zero, it is probably safe to conclude that β_m is robust. His CDF(0) statistics measures the larger area under the density function in either side of zero and is computed as CDF(0) or 1-CDF(0), where CDF is the cumulative distribution function of β_m. CDF(0) statistics, thus, would lie in the [0.5;1] interval. Details of the construction of the CDF for both normal and non-normal distributions are given in Sala-i-Martin (1997). In this paper, we conduct both original EBA test and Sala-i-Martin (1997) variant with weighted normal CDF[1]. A variable is regarded as robust if it passes the original EBA test or if its CDF(0) is not

[1] CDF(0) statistics are identical whether we use weighted or unweighted, normal or non-normal CDF functions.

lower than 95 percent and estimated β_m are significant in at least 90 percent of regressions.

We treat the gravity dummy in three alternative scenarios. First, we do not include the gravity dummy in the equation since it might be collinear with the bilateral trade variables. Second, we use the gravity dummy as an I-variable to control for the part of business cycle co-movement that is strictly exogenous to the country pairs. Lastly, we treat the gravity dummy as an M-variable and a Z-variable. For other variables, each would successively be an M-variable and one to three variables from the rest are added as Z-variables, provided that Trade1 and Trade2 or Open1 and Open2 do not coexist in any regressions.

The equation is estimated by ordinary least square. As cross-section regressions are often subject to sampling uncertainty and sampling error correlations, we apply a Newey-West correction for heteroskedasticity and autocorrelation in the residuals.

3. Results:

We employ the above methodology on a dataset including ten East Asian countries and territories: China (Mainland), Hong Kong (China), Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Taiwan province of China and Thailand. The full sample covers the period from 1970 to 2000. To examine whether the determinants of synchronization have changed over time, we break the sample into three sub-periods: 1970-1979, 1980-1989 and 1990-2000. Data are obtained and processed from various sources as described in the Appendix.

The Figure below illustrates the evolution of business cycle synchronization in East Asia over time. The average correlation coefficient of business cycles has increased from 0.34 in the seventies to 4.12 in the eighties and 0.64 in the nineties. Many country pairs have experienced dramatic change in their degree of synchronization. For instance, business cycle correlation coefficient between Japan and Singapore was nearly zero in the seventies but rose to 5.4 in the nineties. The trend is hardly surprising given the process of regional integration and globalization and the emergence of East Asian economies. Table 1 reports bilateral business cycle correlation coefficients for the sample from 1970 to 2000. Highly correlated business cycles are observed in the group of Korea and the Southeast Asian countries. The presence of Korea in the group is perhaps due partially to the regional financial crisis, in which Korea and the Southeast Asian were the worst victims. China's business cycle is poorly correlated with those of others.

Figure: Business Cycle Correlation over Time

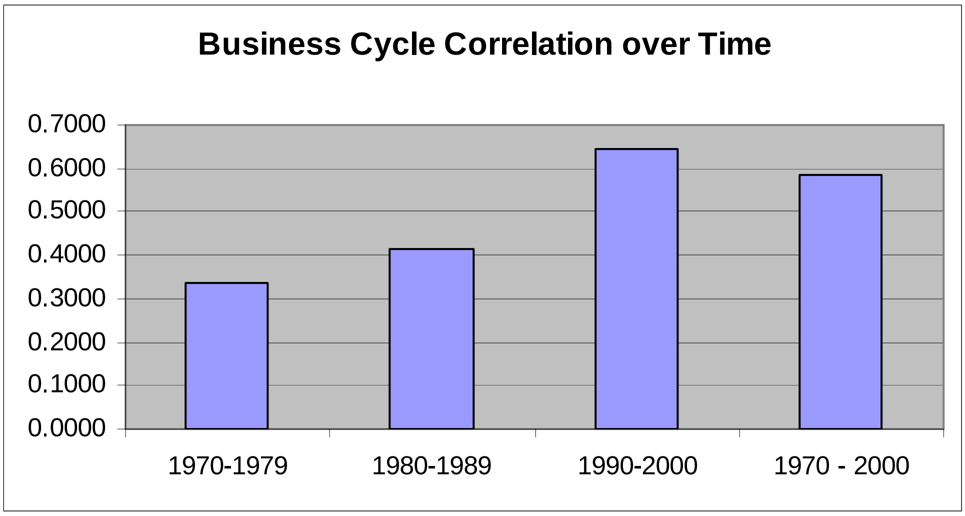

Table 1: Bilateral Business Cycle Correlation Matrix (1970 – 2000)

	Japan	Korea	China	Hong Kong	Taiwan	Singapore	Malaysia	Thailand	Indonesia	Philippines
Japan	1.00									
Korea	0.69	1.00								
China	-0.37	0.08	1.00							
Hong Kong	0.32	0.55	0.15	1.00						
Taiwan	0.71	0.72	-0.39	0.53	1.00					
Singapore	0.41	**0.81**	0.36	**0.83**	0.49	1.00				
Malaysia	0.41	**0.87**	0.32	0.72	0.51	**0.95**	1.00			
Thailand	0.66	**0.92**	0.08	0.71	0.67	**0.90**	**0.89**	1.00		
Indonesia	0.48	**0.91**	0.17	0.67	0.60	**0.88**	**0.94**	**0.90**	1.00	
Philippines	0.40	**0.81**	0.29	0.73	0.59	**0.84**	**0.87**	**0.83**	**0.90**	1.00

* Bold figures indicate highly correlation coefficients.

What have determined the evolution of business cycle synchronization in East Asia? In what follows, we present EBA analysis for the case in which the cyclical components of GDP are extracted by Hodrik – Prescott method and in which the gravity dummy is not included.[2]. Discrepancies found in other scenarios are noted at the end of this section. The results of EBA tests are presented in Table 2 for full sample and Table 3 to Table 5 for the sub-periods. In each table, we report baseline, maximum and minimum estimated β_m and associated standard errors; upper and lower extreme bounds; the percentage of regressions in which estimated β_m are significant at five percent level; and weighted Sala-i-Martin's CDF(0) statistics. The EBA results are summarized in Table 6. In total, we have run 1022 regressions for each M - variable.

3.1 Bilateral trade:

We consider two measures of total bilateral trade successively. From previous studies, we expect positive coefficients for these variables, that is, greater bilateral trade leads to more synchronized business cycles. EBA results on these variables are, however, contrary to our expectation. Coefficients on Trade1 are positive in some regressions but negative in others while those on Trade2 are always negative. Neither is found significant in baseline bivariate regression. Trade1 is significant in merely 24 percent of regressions while Trade2 is insignificant in all regressions. Neither pass the original EBA test nor the CDF(0) test.

Results for the sub-periods are similar except that CDF(0) for Trade2 is larger than 0.95 in period of 1970-1979. Yet, since Trade2 is always insignificant, we can not put it as robust.

3.2 Bilateral Intra-Industry Trade

[2]Results for other scenarios are available upon request.

For bilateral intra-industry trade variable (IIT), we also expect its coefficient to be positive since intra – industry trade is believed to promote synchronization. However, the EBA result in Table 2 shows that intra-industry trade is not a robust determinant of business cycle synchronization. The extreme bounds are of different signs and CDF(0) is less than 95 percent. The variable appears to be significant in only nine percent of regressions and the estimated coefficients are sometime negative.

However, IIT appears robust when we consider two sub-periods: 1970-1979 and 1980-1989. In these periods, the estimated coefficients on IIT are positive and always significant in all regressions. The extreme bounds are all positive and CDF(0) is unity. It is surprising that while IIT seems to have been increasing in the region, its role in driving synchronization has diminished in recent years.

3.3 Trade openness:

Trade openness is measured by two variables: combined total trade to combined GDP ratio (Open1) and average total trade to GDP (Open2). We expect positive coefficients on these variables since open economies are likely to expose to similar external shocks and technological transmission and hence have similar business cycles. EBA tests confirm this expectation. All estimated β_m on both variables are positive. For the variable Open1, estimated coefficients are positive and significant in all regressions. The extreme bounds are of the same sign. For the variable Open2, β_m is significant in the baseline regression but remains significant in only 55 percent of regressions although CDF(0) test shows that 98 percent of regressions would give positive β_m. The extreme bounds are, however, of different signs.

Regarding the sub-periods, Open1 passes the original EBA test in period 1990-2000. In the 1980-1989, the extreme bounds are of different signs but CDF(0) approximates unity and estimated coefficients are significant in 91 percent of regressions. Therefore, we still consider Open1 as robust in this period. In the period of 1970-1979, despite that the CDF(0) is close to unity (0.99), Open1 is significant in merely 74 percent of regressions and thus cannot be considered robust. Open2 is fragile in all periods although CDF(0) statistics are, at times, over 95 percent.

In general, we conclude that openness to trade is a robust determinant of business cycle synchronization. An increase in the degree of trade openness would result in subsequent increase in the degree of business cycle synchronization in East Asia.

3.4 Similarity of Export:

Since export similarity is measured by the period average of the sum of the absolute differences of sectoral export shares, we expect estimated coefficients of this variable are negative. That is, we expect greater similarity of export structures leads to stronger business cycle synchronization. EBA results in Table 2 show that the estimated coefficients are of mixed signs, insignificant in the baseline regression and merely significant in eight percent of regressions. The upper extreme bound is positive but the lower extreme bound is negative. CDF(0) is just 0.87. Similar results are found when we consider the sub-periods. Obviously, the similarity of export structure is unlikely to be a robust determinant of synchronization in East Asia.

3.5 Capital Account Openness:

Capital account openness is measured by Chinn and Ito's indices. Countries with more open capital account would expose more to global financial shocks and thus are likely to have similar business cycles. We, therefore, expect positive coefficients on this variable. Result in Table 2 shows that capital openness is a fragile determinant of synchronization. Estimated coefficients are small and not always positive as expected. The extreme bounds are of different signs. In no regressions we find capital openness to be significant. CDF(0) statistics is low (just around 0.73). Similar results are found for the sub-periods as shown in Table 3 to Table 5.

3.6 Similarity in Fiscal Policies:

We measure the similarity in fiscal stance by the mean of the absolute differences in government spending to GDP ratios. We expect the estimated coefficients to be negative, that is, larger difference in government spending ratios leads to less synchronized business cycles. In Table 2, we see that the estimated coefficients have the correct sign in all regressions. However, in no regression the coefficients appear significant. The extreme bounds are of different signs. Although CDF(0) is larger than 95 percent, we cannot claim this variable robust. In the sub-periods, we find mixed signs for the estimated coefficients in two periods, 1970-1979 and 1980-1989, in which CDF(0) statistics are very low (around 0.6). For the period 1990-2000, the estimated coefficients have correct sign but insignificant in all regressions. We conclude that the similarity of fiscal polices is not a major force to drive business cycle synchronization.

3.7 Similarity in Monetary Policies:

We use the correlation coefficient between money supply (M2) growth rates to measure the similarity in monetary policies. We expect countries with similar monetary policies to experience similar business cycles. If so, the estimated coefficients on this variable must be positive. Table 2 indicates that the estimated coefficients have correct sign. They are positive, large and significant in all regressions. The extreme bounds are both positive and the CDF(0) approximates unity. The variable is found robust as well in the sub-periods 1970-1979 and 1980-1989 as shown in Table 3 and Table 4. Only in recent period of 1990-2000, the similarity of monetary policies appears fragile. The estimated coefficients are of wrong sign and insignificant in all regressions. The upper bound is positive while the lower bound is negative. Although CDF(0) is high (0.98), we can not claim this variable robust in this period. Though the similarity of monetary policies is robust statistically, it might be the consequence, rather than cause, of business cycle synchronization.

3.8 Bilateral Exchange Rate Stability:

Another measure of monetary policy coordination is the stability of bilateral exchange rate. As we measure exchange rate stability by its standard deviation, we expect this variable to have a negative coefficient since more stable (less volatile) exchange rate probably induces greater synchronization. The result in Table 2 shows that, the estimated coefficients are of mixed signs and insignificant at five percent level in all regressions. The variable fails the original EBA test as the extreme bounds are of different signs. The CDF(0) statistics is extremely low (0.51). Similar result is found for the period of 1990-2000. For the sub-periods 1970-1979 and 1980-1989, the estimated coefficients on this variable are all negative as expected but insignificant in all regressions. Bilateral exchange rate stability is, thus, not a robust determinant of synchronization.

Regarding the treatment of the gravity dummy, we found no difference whether the gravity dummy is included, either as an I-variable or as a Z-variable, using HP as the detrending method of GDP. The robustness of the variables is unchanged. As an M-variable, the gravity dummy appears fragile in explaining business cycle synchronization.

The results are almost similar when we use the first-differencing method to generate the cyclical components of aggregate output. When the gravity dummy is not included, we find that in the sub-period of 1980 – 1989, Trade1 is a robust determinant while IIT and Open1 are not robust. When the gravity dummy enters as an I-variable, capital account openness (Kaopen) becomes robust in the full sample. No variables are robust in the period of 1970 – 1979 and Open2 is robust in the period of 1990 – 2000. When the gravity dummy is used as a Z-variable, IIT becomes non-robust in the period of 1980 – 1989. If the gravity dummy serves as an M-variable, it appears robust only in the period of 1980 – 1989.

In summary, trade openness and intra-industry trade turn out to be robust determinants of business cycle synchronization in East Asia. Although we find the similarity of monetary policies is statistically correlated with the degree of synchronization, it is unclear to us whether the former leads to the latter or vice versa. Bilateral trade and capital account openness seems to be robust determinants at times, when first-differencing is used as the detrending method.

The finding that trade openness, rather than bilateral trade, is the major channel of synchronization imply that global shocks, rather than regional shocks, are more influential in shaping business cycles in East Asia. Our results confirm that intra-industry trade is an important channel behind synchronization although its role has become less clear recently. Our results are not conflicting with those of Shin & Wang (2003), which indicate that intra-industry trade is the major channel leads to close business cycle coherence.

Our findings have important implications for the preparation of the prospective currency union in East Asia. In the past decades, trade openness and intra-industry trade have increased rapidly in most countries in the region, as clear from Table 7. As globalization and regional integration is accelerating and irresistible, one might expect the trend would continue and as a result, East Asia would become increasingly synchronized.

4. Conclusion:

In this paper, we attempt to identify the determinants of business cycle synchronization in East Asia by applying an OLS-based Extreme Bound Analysis to a dataset of ten East Asian countries over the period from 1970 to 2000. The method is designed to test the robustness of the determinants across various specifications. We find that trade openness and intra-industry trade are major channels of business cycle synchronization in East Asia. We also find the similarity of monetary policies is statistically correlated with degree synchronization though we are unsure of the causal direction. Other candidates such as bilateral trade and capital account openness are unlikely to be driving forces of output co-movement.

Our findings are probably good news to proponents of an East Asian currency area. Although East Asia is not yet sufficiently synchronized, the regional increasing openness and integration might provide momentum to business cycle convergence, making a currency union plausible.

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Table 2: Extreme Bound Analysis of the determinants of business cycle synchronization (1970-2000)

M-var		β_m	Std Error	Extreme Bounds	Percentage of Significance	Sala-i-Martin CDF(0)	Robustness
Trade1	Baseline	6.211	3.640		23.62	0.8387	Fragile
	Max	9.145	3.355	15.855			
	Min	-1.658	4.924	-11.505			
Trade2	Baseline	-4.278	6.711		0	0.8135	Fragile
	Max	-2.493	6.035	9.577			
	Min	-6.447	4.830	-16.106			
IIT	Baseline	1.164	0.703		8.90	0.8771	Fragile
	Max	1.704	0.601	2.906			
	Min	-0.564	0.647	-1.858			
Open1	Baseline	0.627	0.182		100	0.9999	**Robust**
	Max	0.798	0.224	1.245			
	Min	0.602	0.195	0.211			
Open2	Baseline	0.373	0.181		55.12	0.9790	Fragile
	Max	0.519	0.167	0.853			
	Min	0.185	0.139	-0.093			
Expsim	Baseline	0.199	0.234		7.90	0.8668	Fragile
	Max	0.635	0.296	1.227			
	Min	-0.226	0.241	-0.708			
Kaopen	Baseline	0.059	0.057		0	0.7307	Fragile
	Max	0.119	0.068	0.255			
	Min	-0.078	0.053	-0.184			
Fis	Baseline	-0.060	0.040		0	0.9720	Fragile
	Max	-0.049	0.042	0.036			
	Min	-0.113	0.040	-0.194			
M2	Baseline	0.695	0.211		100	0.9999	**Robust**
	Max	0.931	0.227	1.384			
	Min	0.578	0.174	0.230			
Ner_sd	Baseline	-0.052	0.191		0	0.5053	Fragile
	Max	0.206	0.170	0.546			
	Min	-0.273	0.265	-0.802			

Table 3: Extreme Bound Analysis of the determinants of business cycle synchronization (1970-1979)

M-var		β_m	Std Error	Extreme Bounds	Percentage of Significance	Sala-i-Martin CDF(0)	Robustness
Trade1	Baseline	2.896	3.050		0	0.8692	Fragile
	Max	3.031	3.088	9.208			
	Min	-12.370	4.848	-22.067			
Trade2	Baseline	-5.930	5.911		0	0.9715	Fragile
	Max	-5.930	5.911	5.893			
	Min	-11.031	5.346	-21.722			
IIT	Baseline	2.080	0.450		100	1.0000	**Robust**
	Max	2.324	0.506	3.336			
	Min	1.382	0.483	0.417			
Open1	Baseline	0.696	0.216		74.42	0.9946	Fragile
	Max	0.911	0.229	1.370			
	Min	0.309	0.285	-0.261			
Open2	Baseline	0.228	0.213		0	0.6245	Fragile
	Max	0.289	0.214	0.716			
	Min	-0.271	0.207	-0.685			
Expsim	Baseline	0.119	0.242		0	0.6872	Fragile
	Max	0.261	0.276	0.813			
	Min	-0.075	0.209	-0.494			
Kaopen	Baseline	0.087	0.075		0	0.7237	Fragile
	Max	0.121	0.077	0.274			
	Min	-0.049	0.061	-0.171			
Fis	Baseline	0.038	0.038		0	0.6304	Fragile
	Max	0.044	0.039	0.122			
	Min	-0.014	0.027	-0.067			
M2	Baseline	0.459	0.138		100	0.9993	**Robust**
	Max	0.460	0.111	0.683			
	Min	0.396	0.116	0.165			
Ner_sd	Baseline	-1.414	1.020		0	0.8614	Fragile
	Max	-0.474	0.905	1.335			
	Min	-1.675	1.102	-3.879			

Table 4: Extreme Bound Analysis of the determinants of business cycle synchronization (1980-1989)

M-var		β_m	Std Error	Extreme Bounds	Percentage of Significance	Sala-i-Martin CDF(0)	Robustness
Trade1	Baseline	9.758	4.097		9.30	0.7338	Fragile
	Max	9.788	3.813	17.414			
	Min	-4.389	4.171	-12.731			
Trade2	Baseline	-5.126	8.470		0	0.9119	Fragile
	Max	-5.126	8.470	11.813			
	Min	-8.942	5.165	-19.271			
IIT	Baseline	3.003	0.633		100	0.9999	**Robust**
	Max	3.078	0.671	4.420			
	Min	1.808	0.588	0.632			
Open1	Baseline	0.990	0.282		90.7	0.9986	**Robust**
	Max	1.154	0.312	1.778			
	Min	0.247	0.201	-0.155			
Open2	Baseline	0.458	0.229		12.79	0.9045	Fragile
	Max	0.538	0.236	1.009			
	Min	-0.060	0.190	-0.440			
Expsim	Baseline	-0.201	0.319		0	0.6024	Fragile
	Max	0.130	0.251	0.632			
	Min	-0.464	0.345	-1.154			
Kaopen	Baseline	0.040	0.071		0	0.5091	Fragile
	Max	0.091	0.083	0.257			
	Min	-0.051	0.049	-0.149			
Fis	Baseline	0.014	0.048		0	0.6127	Fragile
	Max	0.024	0.050	0.124			
	Min	-0.052	0.049	-0.150			
M2	Baseline	1.092	0.243		100	1.0000	**Robust**
	Max	1.093	0.261	1.615			
	Min	0.766	0.286	0.194			
Ner_sd	Baseline	-1.795	0.560		0	0.9800	Fragile
	Max	-0.391	0.442	0.493			
	Min	-1.855	0.584	-3.023			

Table 5: Extreme Bound Analysis of the determinants of business cycle synchronization (1990-2000)

M-var		β_m	Std Error	Extreme Bounds	Percentage of Significance	Sala-i-Martin CDF(0)	Robustness
Trade1	Baseline	3.379	3.480		0	0.5893	Fragile
	Max	3.504	3.503	10.509			
	Min	-3.685	2.900	-9.484			
Trade2	Baseline	-4.827	4.347		0	0.9312	Fragile
	Max	-3.120	4.240	5.361			
	Min	-7.304	3.233	-13.770			
IIT	Baseline	1.038	0.552		11	0.9147	Fragile
	Max	1.294	0.710	2.713			
	Min	0.038	0.467	-0.896			
Open1	Baseline	0.493	0.148		100	0.9986	**Robust**
	Max	0.640	0.223	**1.087**			
	Min	0.342	0.153	**0.035**			
Open2	Baseline	0.348	0.171		42.520	0.9669	Fragile
	Max	0.447	0.194	0.835			
	Min	0.094	0.218	-0.342			
Expsim	Baseline	-0.056	0.265		0	0.6258	Fragile
	Max	0.216	0.291	0.798			
	Min	-0.646	0.449	-1.544			
Kaopen	Baseline	0.040	0.060		2.37	0.7920	Fragile
	Max	0.107	0.051	0.210			
	Min	-0.016	0.074	-0.164			
Fis	Baseline	-0.073	0.033		0	0.9603	Fragile
	Max	-0.031	0.034	0.036			
	Min	-0.108	0.039	-0.186			
M2	Baseline	-0.378	0.174		0	0.9858	Fragile
	Max	-0.326	0.196	0.066			
	Min	-0.432	0.146	-0.724			
Ner_sd	Baseline	0.059	0.239		0	0.7843	Fragile
	Max	0.755	0.436	1.628			
	Min	-0.134	0.316	-0.766			

Table 6: Summary of the EBA results

Variable	**1970-1979**	**1980-1989**	**1990-2000**	**1970-2000**
Bilateral Trade (Trade1)	Fragile	Fragile	Fragile	Fragile
Bilateral Trade (Trade2)	Fragile*	Fragile	Fragile	Fragile
Intra-Industry Trade	**Robust**	**Robust**	Fragile	Fragile
Trade Openness (Open1)	Fragile*	**Robust**	**Robust**	**Robust**
Trade Openness (Open2)	Fragile	Fragile	Fragile*	Fragile*
Export Similarity (Expsim)	Fragile	Fragile	Fragile	Fragile
Capital Account Openness (Kaopen)	Fragile	Fragile	Fragile	Fragile
Similarity of Fiscal Policy (Fis)	Fragile	Fragile	Fragile*	Fragile*
Similarity of Monetary Policy (M2)	**Robust**	**Robust**	Fragile*	**Robust**
Bilateral Exchange Rate Stability (Ner_sd)	Fragile	Fragile*	Fragile	Fragile

(* Fragile but CDF(0) is larger than 95 percent)

Table 7: Openness to Trade and Average Intra – Industry Trade in East Asia

	Openness to Trade			**Intra – Industry Trade**		
	1970-1979	1980-1989	1990-2000	1970-1979	1980-1989	1990-2000
Japan	0.1987	0.2089	0.1670	0.2141	0.2377	0.3885
Korea	0.4980	0.5806	0.5665	0.2104	0.3000	0.4641
China	0.0689	0.2379	0.5057	0.0686	0.2305	0.4693
Hong Kong	1.2957	1.4988	1.6366	0.3217	0.3734	0.3758
Taiwan	1.0873	0.8215	0.8179	0.2050	0.3220	0.5001
Singapore	2.2595	2.9405	2.5988	0.2478	0.3833	0.5535
Malaysia	0.8195	1.0197	1.7347	0.2317	0.3082	0.5239
Thailand	0.3735	0.4871	0.7857	0.1654	0.3060	0.5302
Indonesia	0.3601	0.3995	0.5296	0.1045	0.3173	0.3987
Philippines	0.3976	0.4091	0.7212	0.1907	0.3229	0.5021

Appendix: Data sources

Data	Sources
GDP data of East Asian countries except Taiwan	World Development Indicator 2006
GDP data of Taiwan	IMF World Economic Outlook Database, April 1999 and April 2007
Data on total trade, bilateral trade, bilateral trade structure and export structure of East Asian countries	NBER World Trade Flows Database 1962 – 2000
Capital Account Openness	Chinn and Ito (2002) Kaopen indices
General government final consumption expenditure of East Asian countries except Taiwan	World Development Indicator 2006
General government final consumption expenditure of Taiwan	Statistical Yearbook of the Republic of China 1995, 2005
Money supply (M2) growth of East Asian countries except Taiwan	World Development Indicator 2006, ADB Key Indicators of Developing Asian and Pacific Countries 1999, Volume 30
Money supply (M2) growth of Taiwan	Taiwan Statistical Databook 2006
Nominal exchange rates of East Asian countries except Taiwan	World Development Indicator 2006
Nominal exchange rate of Taiwan	Taiwan Statistical Databook 2006