Business Cycle Synchronization and Vertical Trade Integration
A Case Study of the Eurozone and East Asia

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Abstract

Business cycle synchronization is an important condition for a currency union to be successful. Frankel and Rose (1998) showed empirically that increased trade would have a positive impact on business cycle correlation while acknowledging the theoretical ambiguity on the relationship. Based on their finding, they claimed that the Eurozone's optimal currency criteria (OCA) can be satisfied *ex-post*. In this paper, we first investigate whether the Eurozone exhibits more synchronized business cycles since the adoption of the euro. Then, we attempt to link the business cycle synchronization with trade integration. Our new contribution is that we examine the role intra-industry trade (IIT), and vertical IIT (V-IIT), in business cycle synchronization using the data of two sets of countries, Eurozone and East Asia that have been going through distinctively different kinds of economic integration.

Our main findings are as follows. First, our empirical results suggest that the business cycle correlation increased over time, in both the Eurozone and East Asia, but synchronization has been progressing much faster in East Asia. Also, with respect to trade, intra-regional trade intensity in various measures has risen in East Asia but fallen in the Eurozone in recent years, perhaps due to the rise of China as an important trade partner for Europe. Second, unlike Frankel and Rose (1998), we find that the impact of increased trade intensity on business cycle correlation is ambiguous. This could be due to the fact that trade among countries with different factor endowment – *e.g*. countries within East Asia, among the Eurozone's old and new member states – may dampen the business cycle correlation via increased specialization in different industries that receive different shocks. Instead, IIT, in particular V-IIT, unambiguously increased business cycle correlation in both regions. Vertical IIT increased substantially over the last few decades in East Asia but not in the Eurozone, which is consistent with the rapid increase in business cycle correlation in East Asia.

Keywords: Business cycle synchronization; global integration; intra-industry trade; currency union;

JEL Classification Code: F15, F41, F42, F44

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The views expressed here are solely the ones of authors' and do not reflect the views of De Nederlandsche Bank. We thank Jakob De Haan, Dr. Hubert Gabrisch, Prof. Andrew Rose, Prof. Jean Imbs, Robert Vermeulen, Jon Frost, Pierre Lafourcade, Peter van Els and Jeroen Hessel for useful inputs. In addition, Martin Admiraal and Rene Bierdrager for their excellent help with data. All remaining errors are ours.

I. Introduction

Is the Eurozone an optimal currency area (OCA), or can it become one?[1] This question has been a highly debated topic in the midst of the recent crisis in Europe. One of the main criteria for OCA is business cycle synchronization: since a currency union requires a "one-size-fits-all" monetary policy, cyclical shocks need to be symmetric across countries and the member countries should exhibit similar business cycles[2] for the smooth management of a currency union.[3] Bayoumi and Eichengreen (1992) claim that the business cycle correlation in Europe is not high enough for a successful monetary union. On the other hand, Frankel and Rose (1998) argue that OCA can fulfill *ex-post*, as: (i) a currency union will substantially increase trade among member countries; and (ii) increased trade will increase business cycle correlation. However, there are two problems with their approach. First, the euro's impact on intra-euro trade has found to be rather modest (Micco, et al., 2003; Bun and Klaassen, 2006). Second, increased trade can affect business cycle co-movement in either way. If higher trade integration leads to more specialization in certain industries, which are subject to different kinds of shocks, it can dampen business cycle correlation (Krugman, 1993). On the other hand, if patterns of specialization occur *within* an industry – *e.g*. trading similar goods and/or products - fragmentation would amplify the business cycle correlation between countries.

In this paper, we first investigate whether the Eurozone exhibits more synchronized business cycles since the adoption of euro. Then, we look for links between the business cycle synchronization and different types of specific trade patterns: intra industry trade (IIT) and vertical intra-industry trade (V-IIT). Intra-industry trade is simultaneous exports and imports of goods classified in the same sector, and vertical intra-industry trade is IIT at different stages of processing (e.g. product segmentation, supply chains, etc.). Since V-IIT is largely a result of product segmentation, countries that are connected with V-IIT is likely to experience common shocks, thus higher business cycle synchronization.

The East Asian integration via V-IIT has proceeded much faster than that in the Eurozone over the last few decades. This unprecedented trade integration over the last few decades occurred largely via the development of the world's biggest global supply chain. The two regions – East Asia and the Eurozone – are undergoing economic integration in quite different manners: thus, comparing these two may shed some light on what is the important determinant of business cycle correlation. While Frankel and Rose (1998) examine the linkage between business cycles and trade intensity, they do not differentiate which type of trade (Intra vs. Inter, etc.) is likely to intensify business cycle synchronization, for which we are trying to fill the gap.

In order to understand specific channels on how trade integration affects business cycles, we

[1] Optimal Currency Area (OCA) represents a group of conditions for countries to successfully form and sustain a currency union. The OCA literature dates back to Mundell (1961) and Kenen (1969).
[2] It is needless to say that the business cycle synchronization has to be supported by "structural" synchronization, such as competitiveness and intra-euro current account balances.
[3] Krugman (2012) asserts that "asymmetric shock" is one of the main reasons of the "nightmare" of the Eurozone.

conduct the analysis on two regional groups – the Eurozone and East Asia.[4] We chose East Asia because among several economic blocs around the globe, it has exhibited one of the most rapid increases in inter-regional integration and subsequent business cycle correlation in the last few decades (Moneta and Ruffer, 2006) despite the lack of institutional framework, let alone common currency, such as that in the Eurozone.

Our empirical findings suggest that business cycle correlation increased in both the Eurozone and East Asia over time, but the speed of increase is faster in East Asia where there is a significant jump in correlation since the 1997 Asian Crisis. The impact of bilateral trade intensity on business cycles is significant, in general, but it can be ambiguous, contrary to the conclusion in Frankel and Rose (1998). On the other hand, IIT and V-IIV unambiguously increase business cycle correlation. Moreover, specific channels that indicate that trade affects business cycles seems to differ in the two regions. In East Asia, the role of IIT, in particular V-IIT, in driving business cycle correlation is quite significant compared to the Eurozone where there is only modest impact of V-IIT on output correlation. One explanation is that differences in factor endowments and supply chain segmentation in East Asia contributes to a large portion of V-IIT in total trade, which generates similar business cycles in the region. In addition, we find that the adoption of the euro positively and significantly contributes to business cycle correlation in the Eurozone, perhaps via a financial integration channel, not necessarily a trade channel. While some studies (Jansen and Stokman, 2014; Baldwin, *et al;* Micco*, et al.*) find significant and positive effect of the euro on trade and FDI, many studies find that the euro's impact on trade is small (e.g. Bun and Klaassen, 2007), especially compared what Rose (2000) predicted---a currency union would triple bilateral trade[5]. However, as the recent financial crisis in the Eurozone forcefully demonstrates, financial integration is much less straightforward and involves much higher risk especially in the downturn due to the fact that financial market is incomplete compared to the goods market.

This paper is organized as follows. In section 2, we survey the literature. Section 3 presents stylized facts about both regions' business cycle synchronization as well as trade integration. In section 4, we conduct a formal empirical analysis to assess which type of trade integration amplifies or dampens business cycle correlation. Section 5 concludes the paper with policy implications for the Eurozone.

II. Related Literature

Regarding the business cycle fluctuations and patterns of correlation among the euro area countries prior to 2008, De Haan *et al*. (2008) provide a comprehensive summary of empirical literature. According to their study, empirical evidence on business cycle correlation in the Eurozone

[4] In this paper, we do not explicitly take financial integration into account, as it is clear that Asian's financial markets are much less integrated than the ones in the Eurozone (Jung, 2013).
[5] Frankel (2008) gives detailed explanation on this.

is highly sensitive to the methodology and indicators employed. Some studies (*i.e*. Artis and Zhang, 1997 and 1999) find a high level of business cycle correlation in the euro area. On the other hand, Inklaar and De Haan (2001) show that European business cycles vis-à-vis Germany exhibit large fluctuations, independent of exchange rate regime of the Eurozone members. Giannone *et al*. (2009) find that business cycle linkages between the Eurozone periphery countries and the rest of the euro area are relatively weak. They also find that there is no significant change in both business cycle fluctuations and patterns of cross-country correlations after the inception of the euro. Overall, the majority seem to support an increasing trend in business cycle correlation in the Eurozone over-time, although if that is due to a currency union remains an issue.

For Asian countries, Imbs (2011) finds that an upward-shift of business cycle synchronization occurred in East Asia in the late 1990s, in particular since the 1997 Asian crisis. He points out the uniqueness of the upwards shift of developing East Asia's business cycle correlation; it substantially increased after the 1997 Asian crisis, whereas 2008Q3 saw a similar upward shift of business cycles in the developed world but not so much in East Asia. Kim and Kim (2013) provide empirical evidence of a significant increase in cross-country output correlation in East Asian and ASEAN countries since the 1990s. Hirata *et al*. (2013) provides a comprehensive survey of empirical studies on the synchronization of business cycles in different regions including Asia.

The theoretical relationship between trade integration and business cycle synchronization remains ambiguous. Heckscher-Ohlin's prediction is that trade would occur between two countries with different factor endowments, leading to specialization based on comparative advantages and low cross-country business cycle correlation. On the other hand, Krugman (1979) predicts that trade can occur within industries due to economies of scale and consumers' preference for variety, which would lead to IIT. Such trade *can* increase the business cycle correlation. At the same time, Krugman (1991) implied that the economies of scale can also leads to regional concentration of production, so it can have an opposite impact (dampening) on business cycle correlation. However, he did not specifically consider vertical fragmentation of trade.

however, if product specialization Kose and Yi (2001) hypothesize that an increasing product or vertical fragmentation of "back-and-forth" trade can lead to high business cycle correlation. On the empirical front, Frankel and Rose (1998) show that, based on the data of 10 industrial countries, increased trade leads to increased business cycle correlation. Baxter and Kouparitsas (2005) find that the relationship between business cycle co-movements and bilateral trade has a robust relationship, but the relationship with currency union is not robust.

More recent studies find that the pattern of trade is equally important as the volume or bilateral trade intensity in determining business cycle correlations[6]. Calderon *et al*. (2007) show that

[6] Inklaar *et al* (2008) find that, for OECD countries, trade intensity affects business cycle synchronization, but the effect is smaller than previously reported, and convergence in polices have equally important impact.

differences in the pattern of specialization generate a negative relationship between bilateral trade intensity and business cycle correlation, whereas IIT positively affects business cycle correlation. Bursten *et al*. (2008) find that countries with production sharing show a high cross-country correlation of output. Traistaru (2004) finds that sectoral specialization is negatively associated with business cycle synchronization. Several papers study the empirical relationship between trade and business cycles using the data of Asia including Shin and Wang (2003), Rana (2008) and Cortinhas (2007). They all conclude that an increase in IIT increases business cycle correlation in ASEAN and other Asian countries.

III. Stylized Facts of Trade and Business Cycle Correlation in the Eurozone and East Asia

i. Business Cycle Correlation

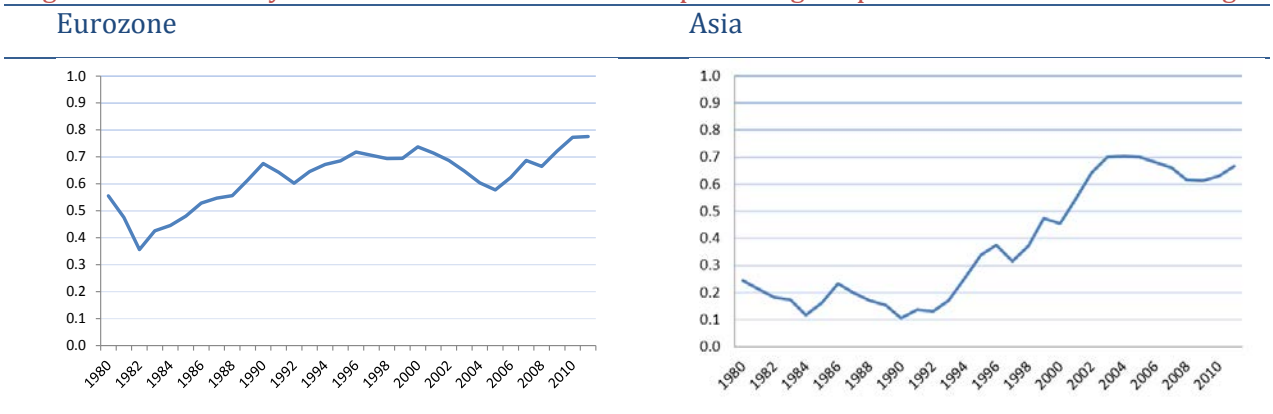
This section discusses the patterns of business cycle synchronization in East Asia and the Eurozone using data that covers the period between 1970 and 2011.[7],For the output series we use real GDP (base year=2005) in local currencies. In order to calculate the average degree of business cycle correlation for a country, we first calculate a simple pairwise correlation of a country's cycle component using HP-filtered[8] growth with the rest of countries in the region with a rolling window length of 10 years (40 observations). Then, we take the average of these pairwise correlations for each country (ρ_i. Finally we take the average business cycle correlation for a region by taking a simple average of ρ_i for all member countries as follows (Figure 1):

$$\rho_i = \frac{1}{n-1}\sum_{k=1}^{n-1}\rho_{i,k}, \qquad \rho^{REGION} = \frac{1}{n}\sum_{i=1}^{n}\rho_i \qquad [1]$$

(*REGION*=Asia or Eurozone)

where *i* represents country, *k* is the index for the rest of countries in the region, and n is the number of countries in the region.

Figure 1. Business Cycle Correlation in Asia and Europe Average of pairwise correlation in the region



Source: Authors' calculation based on OECD database. The year denotes the end of the moving window. Based on annual GDP data, cycle measured by HP filtered series.

[7] The data source is OECD (for Eurozone and Japan) and Oxford Economics (for the rest of the East Asian countries).
[8] See Mink et al. (2012) for the sensitivity of business cycle co-movement measured by different methods (we discuss further later in the text).

Figure 1 shows the average of pairwise correlation in the region ρ^{REGION}. We can confirm the findings in Imbs (2011) that there is a significant increase in business cycle correlation in Asia, and in particular since the Asian crisis in 1997. Currently, the level of synchronization in Asia (0.68) is approaching that of the Eurozone(0.77). In the Eurozone, the increase in business cycle correlation is rather modest and occurred mostly during 1980s, not in 1990s. Since the global financial crisis in 2008, business cycle correlation in Asia slightly decreased while it increased in the Eurozone, which also confirms the findings in Imbs (2011).

Next, in order to formally measure business cycle correlation, we use three measures, using quarterly data between 1990Q1 and 2012Q4. We use quarterly data, but due to a data restriction, we now use (i) year-on-year (y-o-y) GDP growth rates; (ii) output series filtered by HP filter[9]; and (iii) output series filtered by Baxter-King (1999) band pass filter. Table 1 summarizes the average of bilateral business cycle correlations in each region and how they evolved over time. For the sake of comparison, we present business cycle correlation for two sub-periods, with an obvious break-point at 1999, when the euro was adopted as a single currency in the region: 1990Q1-1997Q4 and 1999Q1 and 2007Q4 for the Eurozone and 1988Q1-1996Q4 and 1999Q1 and 2007Q4 for East Asia. For the East Asian country sample, we avoid the time when there was a currency crisis (1997-1998). For both regions, the post-Lehman shock period is excluded as contagion may increase co-movements via factors that are irrelevant to underlying economic fundamentals. Business cycle analysis including the crisis periods would require further investigation. Mink and De Haan (2013) argue that it is difficult to differentiate co-movements derived from contagion and common shocks.

Table 1: Business Cycle Correlations in East Asia and Eurozone

		Eurozone		East Asia	
		1990Q1-1998Q4	1999Q1-2007Q4	1988Q1-1996Q4	1999Q1-2007Q4
YoY Growth	AVG	**0.52**	**0.51**	**-0.02**	**0.42**
	STDev	*0.23*	*0.37*	*0.29*	*0.27*
Cycle (Hpfilter)	AVG	**0.62**	**0.73**	**0.07**	**0.38**
	STDev	*0.21*	*0.19*	*0.35*	*0.34*
Cycle (BK filter)	AVG	**0.52**	**0.68**	**0.27**	**0.60**
	STDev	*0.42*	*0.35*	*0.40*	*0.21*
	Sample size	55 pairs		45 pairs	

Source: Authors' calculations.

There are several observations worth noting. For East Asia, there are substantial increases in business cycle correlation in all three measures (net increase of between 0.31 and 0.44). In comparison, Eurozone's business cycles do increase, but by much smaller amount (net increase of -

[9] Note that some papers (i.e. Harvey and Jaeger, 1993) argue that HP filtered series can generate spurious correlation.

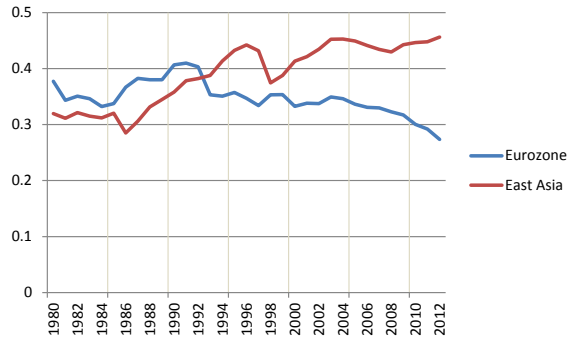
0.01 – 0.16). A higher cross-country correlation in the Eurozone in the second half is perhaps due to various policy initiatives that progressed Eurozone integration (Stage II of EMU), including the implementation of the Growth and Stability Pact in 1997 and the creation of European Central Bank (ECB) in 1998, which had led to similar economic policies among member countries (Inklaar, *et al.* 2008). For East Asia, China's joining WTO in December 2001 and the subsequent increase in regional trade perhaps played an important role in increasing cross-country output correlation. Another explanation can be Japan's increasing outwards FDI.[10] More importantly, as we will see in the next section, Asia's business cycle correlation is largely driven by supply chain segmentation or supply-chain trade integration, especially in machinery and transportation equipment sectors. The disaggregated production process has resulted in faster growth of intra-regional and intra-industry trade (Panagiotopoulos, 2012), which positively contributed to cross-country output correlation.

ii. Regional Trade Intensity

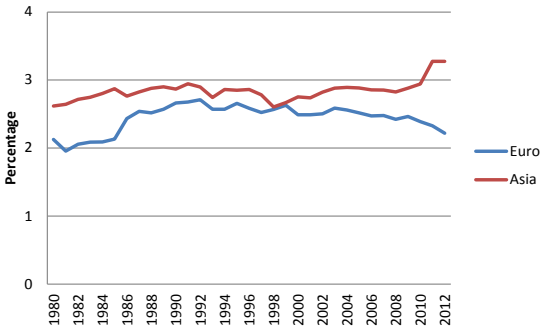
Figure 2 presents several indicators of regional trade intensity. Panel (a) is based on regional trade data (intra-regional trade divided by total trade), while panels (b) and (c) are based on bilateral pairs' trade volume in the region (as ratios of total trade or total GDP). In all three measures, the Eurozone's intra-regional trade has been falling whereas East Asia's regional trade intensity is has been increasing, especially from the late 90s. There are several potential explanations but the most plausible explanation is the rise of China as a major economic power in the region. For East Asian countries, trade with China substantially increased over time, which increases regional trade volume compared to global level. Many European economies are now increasingly trading with China, which partially explains lower intra-regional trade share.

Figure 2. Trade intensity of Eurozone and East Asia

(a) Ratio of exports to the other countries in the region divided by total trade (regional average)

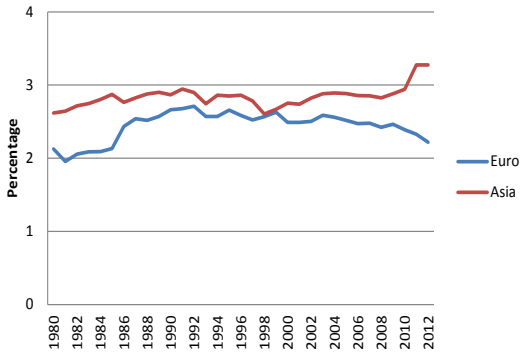


(b) Bilateral pairs' trade volume divided by total trade (regional average)



[10] Between 1991 and 1997, Japan's outward FDI increased by almost 50% (Source: IMF-IFS)

(c) Bilateral pairs' trade volume divided by GDP (regional average)



Author's calculation based on data from IMF-DOT, OECD-ITCS

iii. Vertical intra-industry trade

This section provides a detailed investigation of trade flows in the Eurozone and East Asia. Specifically, we examine the extent of IIT and V-IIT. To measure IIT, we use the modified Grubel-Lloyd (GL) index[11]. The original form of GL index of a country is expressed as:

$$GL = 1 - \left[\frac{\sum_g |X_g - M_g|}{\sum_g (X_g - M_g)}\right] \qquad [2]$$

where g is industry, and X and M are export and import volumes of a country. The index is very intuitive in the sense that if a pair of countries imports or exports goods and service only within the same industry, the GL index will be 1. However, as with many indicators, this indicator has some drawbacks. The basic *GL* index assumes balanced trade. Since many of our sample countries exhibit trade imbalances, we modify the Grubel-Lloyd index to account for trade imbalances (Gabrisch and Segnana, 2002), keeping the same intuition as [2][12]: .

$$GL^{adjusted} = \frac{\sum_{i=1}^{n}(X_i - M_i) - \sum_{i=1}^{n}|X_i - M_i|}{\sum_{i=1}^{n}(X_i - M_i) - \left|\sum_{i=1}^{n} X_i - \sum_{i=1}^{n} M_i\right|} \qquad [3]$$

Where subscript i stands for industry (total number of industries is n) , X and M are export and import volumes of each individual country in industry i. We apply [3] for bilateral trade of country i in another country in the same region (*e.g.* Taiwan and Korea, Germany and France, *etc.*). This index is sensitive to the disaggregation method of industries. We choose the SITC (rev.2) 4-digit level because the 4-digit level is known to best represent industries (Gabrisch and Segnana, 2002). We use the SITC 3-8 chapters to focus on manufacturing sectors.

Next, we construct the V-IIT index. Vertical IIT is defined as intra-industry trade that is differentiated by its quality. Vertical IIT is largely driven by supply-chain segmentation, which also explains strong correlation between V-IIT and foreign direct investment (FDI). One such example is

[11] Grubel and Lloyd (1971)
[12] The need of adjustment comes when the ratio of net trade to gross trade ratio is characterized by opposite trade imbalances for the sub-groups. See Anderson (2003) for detailed discussions and various measures to address this problem.

as follows: car components are shipped from Japan to China, where they are assembled into finished products and then exported back to Japan. Therefore, trade involved supply-chain segmentation and can be classified as V-IIT. Since we lack the price data of traded goods, we use the following criteria based on unit value of export and import to determine if certain industry's IIT measure can be considered as vertical or horizontal, following Greenway, et al. (2007) and many others:

$$IIT_H \ when \ 1-\alpha < \left(RUV = \frac{UVX_i}{UVM_i}\right) < 1+\alpha \qquad [4]$$

where subscript *i* stands for industry, *RUV* is relative unit value, *UVX* is unit value of exports, and *UVM* is unit value of imports. The unit value of trade is measured by quantity (US$) divided by weights (kilos) of trade in each industry. In other words, if condition [4] is satisfied, the bilateral trade is considered to be horizontal, and otherwise vertical. Greenway *et al*. (2007) suggested *α* to be 0.15 or 0.25, but following many recent studies (Gabrisch and Segnana, 2003; Yoshida *et al*., 2008), we choose to use 0.15. When the relative unit value falls within the range of 0.85 and 1.15 as shown in [4], the IIT measure for this industry is considered as horizontal IIT. If *RUV* falls outside of this range, it is classified as V-IIT.[13] Finally, in order to focus on the case that there is enough bilateral trade flow of each industry, we exclude (near-) one way trade that satisfies the following criteria:

$$\frac{Min(M_{ij},\ X_{ij})}{Max(M_{ij},\ X_{ij})} \leq 0.1 \qquad [5]$$

where *i* denotes industry and *j* denotes country. V-IIT is calculated as a ratio of IIT that can be classified as vertical trade.

Figure 3 displays how the IIT index (defined by modified GL index) as the ratio of IIT (x-axis) and VIIT (y-axis) evolved (for each country vs. rest of the countries in the region, and their average (in red dots)) in East Asia and the Eurozone – taking four data points in time 1980, 1990, 2000, 2010. Several observations are worth mentioning. First, there is a large increase in the IIT in both Eurozone and East Asia between 1980 and 2010. Second, V-IIT increased in East Asia (from 0.77 to 0.82) but almost unchanged in the Eurozone at around 0.75, now lower than East Asia. Third, we hardly observe any changes in IIT measures before and after the introduction of euro (comparing the data between 2000 and 2010). Most increases in IIT measure in Europe happened before the euro introduction, but not after.

[13] This is a widely used method in the literature, even though it is crude measure as prices of traded goods are not known.

Figure 3: The percentage of IIT and V-IIT trade in intra-regional trade

Source: Authors' calculation based on OECD-ITCS database. For calculation, please refer to the main text (pp.8-9)

V. Empirical Results

i. Key results

In this section, we examine the relationship between three types of trade integration (trade intensity, intra-industry trade, vertical integration) and business cycle correlations. We build on Frankel and Rose (1998), which used the following regression to investigate how trade intensity affects the cross-country output correlation:

$$\rho_{i,j,t} = \alpha + \beta \boldsymbol{Trade}(w)_{i,j,t} + \varepsilon_{i,j,t} \qquad [6]$$

where $\rho_{i,j}$ denotes output correlation between countries *i* and *j* at time *t* and *Trade*(*w*) - where *w* refers to different trade intensity concept - is the measure for trade intensity between the two countries, *i* and *j* at time *t*. In Frankel and Rose (1998), trade intensity is defined as (i) bilateral trade volume divided by total trade volume of two countries; and (ii) bilateral trade volume divided by nominal GDP of two countries[14]. We follow the first definition of trade intensity in this regression and use the second definition as a robustness check later. In addition to the baseline model [5], we extend this model by adding IIT (defined in equation [3]) and V-IIT (defined in [4]), which is defined as a cross-term of ratio of V-IIT and Grubel-Lloyd index[15]:

$$\rho_{i,j,t} = \alpha_1 + \beta_1 IIT_{i,j,t} + u_{i,j,t} \qquad [7]$$

$$\rho_{i,j,t} = \alpha_2 + \beta_2 VIIT_{i,j,t} + e_{i,j,t} \qquad [8]$$

where ρ represent business cycle correlations, and IIT represents the percentage share of intra-industry trade in total bilateral trade, and V-IIT is the percentage share of V-IIT in IIT.

We use three sub-periods for the analysis. In this analysis, we use quarterly data, and due to a data limitation, we use different time periods: 1980Q1 to 1989Q4, 1990Q1 to 1999Q4, and 2000Q1 to 2007Q4. We exclude the data after 2007Q4 to avoid the period of the global financial crisis for the reason we discussed earlier. Further, in earlier analysis, we excluded the period of Asian Financial Crisis, but here, for the sake of comparison, we use the same set of periods for both East Asia and Europe. First, we run these regressions separately for two regions of our interest, Eurozone and East Asia. Then, we pool the two regions in a single regression with dummy variables - regional dummy and euro dummy. The Euro dummy is to distinguish the two periods (before and after) that the Eurozone countries adopted the euro as their home currency (2001 for Greece, and 1999 for rest of the Eurozone economies). We focus on "core" Eurozone countries, and exclud countries that joined the euro later – e.g. Cyprus, Estonia, etc., for the data availability issue and also to focus on key Eurozone economies. For trade intensity data, we use the data of 1985, 1995, and 2005 for the three sub-period regressions. That is, business cycle correlation in the period of 1980Q1-1989Q4 is

[14] Inklaar *et al.* (2007) use in the regression gravity variables (instrumental variables for trade used by Frankel and Rose, 19998) and other factors that can potentially influence business cycle correlation. In this paper, we focus on the role of vertical trade integration in business cycle correlation, as hypothesized by Kose and Yi (2001). We plan to consider additional instrumental variables in the regression for sensitivity study later.

[15] Due to multicollinearity, we did not include IIT and VIIT in the same equation.

regressed on trade variables (trade intensity, IIT, and V-IIT) from 1985, period of 1990Q1-1999Q4 on 1995 trade data, and so on. In this way, we can circumvent reverse causality to some extent: *e.g*. country pairs with similar business cycle may be more likely to trade each other, and country pairs that adopt the euro may experience trade increase and business cycle correlation simultaneously. To extract cyclical components from the output series, we use the Baxter-King filter as the baseline exercise instead of HP filtering, as business cycles extracted by using HP filter tend to cause spurious correlation (Harvey and Jager, *cit*). In Annex I, we present the correlation of different measure of business cycles. We also report correlation among explanatory variables.

Table 2 presents the baseline results. Note that all panel regressions are run with country fixed effects. The trade intensity variable used in this table is bilateral pair's trade volume as ratio of total trade of the two countries. EMU is a dummy variable that is set to one when countries adopt the euro as their home currency (after 2001 for Greece, and 1999 for other countries in Eurozone). Aside from that, the Eurozone Dummy is included in the pooled regression to control for the regional effect. There are three notable findings. First, bilateral trade intensity variable is significant when included by itself for Europe (Estimation 5) and pooled sample (Estimation 9). This is consistent with Frankel and Rose (1998), who showed that trade intensity among *industrial* countries increases business cycle correlation. However, for East Asia, the coefficient on trade intensity has the expected sign but is not significant. This is perhaps due to the fact that East Asian countries in our sample have a wide range of GDP per capita (see Annex I), so a non-negligible part of regional trade is driven by different factor endowments, which increases specialization in different industries. This in turn can dampen the positive impact of trade intensity on business cycle synchronization.

Second, when we include the IIT measure, in addition to the bilateral trade intensity variable, the coefficient on IIT becomes positive and statistically significant in all three types of regressions (Estimations 2, 6, and 10). For East Asia, when the IIT is included, the coefficient on trade intensity becomes negative and insignificant, while it is still positive and significant in the case of Europe. When we include the V-IIT measure instead of IIT, together with trade intensity measure and without, V-IIT is statistically significant for both regions and pooled regression (except for the case when included with trade intensity in Europe). In East Asia, the impact of V-IIT seems to be particularly strong. This indicates that for East Asia, IIT that exploits differences in factor endowment and product segmentation (V-IIT) significantly increases business cycle correlation.

Third, the EMU dummy significantly and positively affect business cycle synchronization in both regressions (specification 5-12) - regression with European data only and pooled regression with Eurozone dummy. This indicates that the introduction of a single currency has had a significant and positive impact on the correlation of Eurozone's business cycles. One potential explanation for this is financial integration. While euro's impact on trade integration is found to be quite limited in the literature (*i.e*. Micco *et al*., 2003, and Maurice and Klaassen, 2007), the common currency's positive

impact on financial integration is quite strong.[16] For example, Kalemli-Ozcan *et al*. (2009) find that the degree of financial integration, measured as bilateral bank holdings and transactions, increased by 40% more amongst Eurozone member countries than countries that had opted-out[17]. However, we have to be careful in interpreting the impact of financial integration on business cycle, as theoretical and empirical support for financial integration's positive impact on business-cycle synchronization is mixed: while Imbs (2004, 2006) and Kose *et al*. (2003) find a positive correlation, Backus, Kehoe, and Kydland (1992) and Baxter and Crucini (1995) assert the opposite. A country when hit by a positive productivity shock experiences an increase in the marginal productivity of capital, and therefore, receives capital on net, leading to negative output correlation.

Table 2: Baseline Results by Region (Business cycles extracted by the Baxter-King filter)

	East Asia				Eurozone				Pooled			
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
Trade Intensity	2.113	-1.100	-1.231		2.059***	1.542**	1.693**		2.073***	0.970	1.082	
	[1.492]	[-.4915]	[-.5496]		(3.067)	(2.227)	(2.467)		[3.354]	[1.334]	[1.493]	
Grubel Lloyd Index (IIT)		0.825***				0.367*				0.544***		
		[3.198]				(1.903)				[3.664]		
Vertical IIT			0.911***	0.893***			0.306	0.417**			0.534***	0.603***
			[3.164]	[3.427]			(1.539)	(2.294)			[3.454]	[4.217]
EMU					0.430***	0.414***	0.415***	0.406***	0.430***	0.405***	0.403***	0.397***
					(6.398)	(6.063)	(6.07)	(5.86)	[6.39]	[5.903]	[5.817]	[5.675]
Eurozone									-0.152	-0.250	-0.248	0.332
									[-.8062]	[-1.098]	[-1.071]	[.917]
# of observations	82	72	72	78	145	145	145	154	227	217	217	232
R-squared	0.33	0.44	0.44	0.28	0.42	0.42	0.42	0.38	0.50	0.49	0.49	0.43

Correlation of cycles extracted using Baxter-King Filter
Note: Panel regression, with country fixed effect
In blakets is T-statistics
Constant and country-specific effect is not reported
***, **, * denotes statistical significance of 1, 5 and 10%, repsectively.
EMU: Eurozone after the adoption of the euro (2001 for Greece, 1999 for the rest of Eurozone countries)

ii. Robustness checks

In this section, we conduct several robustness checks. First, we use business cycles extracted by other measures - HP filter and y-o-y growth. Second, we use different definitions for trade intensity - bilateral trade volume divided by total GDP of the two countries. Third, we extend our sample into 2012, when business cycle correlation significantly increases in the Eurozone.

Different filtering method

[16] Micco et al. (2003) found the adoption of euro increased regional trade about 6%.
[17] For comprehensive literature survey, see Lane (2008).

Table 3(a) and 3(b) present results with business cycles extracted by different filters. Using HP filtered data does not significantly change baseline results from the Baxter-King filter. The fit of the model is good in all three models with R-square being around 0.4. One exception is that V-IIT is no longer significant in the Eurozone data while it is still significant in the pooled regression. When we use y-o-y growth rates for cycles, most results are similar to the baseline case except that the effects of IIT and V-IIT become insignificant even in the pooled regression: this could be explained by the weakness of using growth rates as a business cycle measure in Asia; because of the high trend growth in Asia compared to Europe, growth may not be a good measure to compare two regions' business cycles.

In summary, choosing different filtering methods does not make a significant difference in our main message – for Asia, V-IIT has been a strong driving factor of business cycle correlation, while it does not in the Eurozone. The relative similarity of factor endowment in the Eurozone gives less scope for economic integration via product segmentation: i.e. V-IIT.

Table 3 (a): Using Business Cycles extracted by HP filter

	East Asia				Eurozone				Pooled Sample			
Trade Intensity	1.737	-0.422	-0.539		1.506***	1.378***	1.397***		1.567***	0.886	0.921	
	[1.253]	[-.2199]	[-.2815]		[3.155]	[2.697]	[2.767]		[3.116]	[1.555]	[1.622]	
Grubel Lloyd Index		0.791***				0.0912				0.366***		
[IIT]		[3.936]				[.6532]				[3.011]		
											0.391***	0.439***
Vertical IIT			0.869***	0.848***			0.0912	0.177			[2.808]	[3.372]
			[3.862]	[4.166]			[.592]	[1.204]				
EMU					0.432***	0.428***	0.428***	0.420***	0.432***	0.415***	0.413***	0.408***
					[7.942]	[7.817]	[7.754]	[7.54]	[7.948]	[7.491]	[7.431]	[7.277]
Eurozone									-0.113	-0.239	-0.231	0.349
									[-.6444]	[-1.379]	[-1.326]	[1.313]
# of observations	82	72	72	78	145	145	145	154	227	217	217	232
R-squared	0.29	0.47	0.47	0.48	0.49	0.49	0.49	0.49	0.43	0.47	0.46	0.48

Note: Panel regression, with country fixed effect
In blakets is T-statistics
Constant and country-specific effect is not reported
***, **, * denotes statistical significance of 1, 5 and 10%, repsectively.
EMU: Eurozone after the adoption of the euro [2001 for Greece, 1999 for the rest of Eurozone countries]

Table 3 (b): Using Business Cycles defined as y-o-y growth

	East Asia				Eurozone				Pooled Sample			
Trade Intensity	1.779	-0.542	-0.673		1.775***	2.003***	1.987***		1.776***	1.330**	1.345**	
	[1.524]	[-.3404]	[-.4261]		[3.722]	[3.956]	[3.95]		[3.816]	[2.49]	[2.528]	
Grubel Lloyd Index [IIT]		0.742***				-0.161				0.193		
		[4.38]				[-1.343]				[1.593]		
Vertical IIT			0.827***	0.785***			-0.177	-0.0830			0.209	0.256*
			[4.403]	[4.637]			[-1.332]	[-.6225]			[1.48]	[1.928]
EMU					0.176***	0.184***	0.185***	0.176***	0.176***	0.167***	0.166***	0.160***
					[5.25]	[5.422]	[5.403]	[5.042]	[5.236]	[4.877]	[4.832]	[4.592]
Eurozone									-0.189	-0.0172	-0.0122	0.133
									[-.8955]	[-.1181]	[-.0837]	[.5383]
# of observations	82	72	72	78	145	145	145	154	227	217	217	232
R-squared	0.38	0.54	0.55	0.54	0.42	0.42	0.42	0.38	0.43	0.42	0.42	0.42

Note: Panel regression, with country fixed effect
In blakets is T-statistics
Constant and country-specific effect is not reported
***, **, * denotes statistical significance of 1, 5 and 10%, repsectively.
EMU: Eurozone after the adoption of the euro [2001 for Greece, 1999 for the rest of Eurozone countries]

Trade intensity defined as bilateral trade volume as a ratio of GDP

Next, we use different definition of trade intensity – trade per GDP, defined as bilateral trade volume divided by the sum of two countries' GDP. Again, the baseline regression results hold, except that the Eurozone dummy yields negative and significant result, while coefficients on EMU dummy are significantly positive as in the previous regression. Using different correlation measures (cycles extracted by HP filter and y-o-y growth), which are not reported in the paper, actually show that the negative and significant effects of Eurozone dummy disappears (*i.e.* it becomes insignificant).

Table 4: Results with Trade per GDP (Cycles extracted by Baxter-King Filter)

	East Asia				Europe				Pooled			
Trade per GDP	5.008***	1.957	1.912		6.526*	4.298	4.986		5.270***	2.620**	2.813*	
	[3.525]	[1.418]	[1.381]		[1.89]	[1.302]	[1.482]		[4.017]	[2.095]	[1.913]	
Grubel Lloyd Index [IIT]		0.716***				0.363*				0.508***		
		[2.774]				[1.819]				[3.385]		
Vertical IIT			0.786***	0.893***			0.297	0.417**			0.493***	0.603***
			[2.745]	[3.427]			[1.448]	[2.294]			[3.07]	[3.943]
EMU					0.417***	0.404***	0.405***	0.406***	0.418***	0.400***	0.398***	0.397***
					[6.215]	[5.954]	[5.938]	[5.86]	[6.189]	[5.857]	[5.011]	[4.964]
Eurozone									-0.260	-0.251	-0.246**	-0.371***
									[-1.342]	[-1.113]	[-1.993]	[-3.169]
# of obs	82	72	72	78	145	145	145	154	227	217	217	232
R-square	0.37	0.45	0.45	0.46	0.32	0.52	0.52	0.38	0.47	0.50	0.49	0.49

Including the data up to 2012

Our data in three sub-periods cover the years up to 1990, 2000, and 2007. We intentionally exclude the data after 2007 because the global financial crisis and subsequent European sovereign debt crisis would cause contagion effects and may change the dynamics of business cycle correlation. While it is beyond the scope of this paper to completely distinguish between common shocks and contagion, we repeat the regressions after including the data up to 2012. For the third sub-period regression, we derive business cycle correlation between 2002Q1 to 2012Q4 and regress the correlation on the trade intensity data of 2007.

Table 5 shows the results. Again, our basic story holds, except that for Eurozone IIT and V-IIT measures become more significant even in the regression with Europe only. Including the data up to 2012 increases the business cycle correlation in Europe: for the period 2002Q1-2012Q4, average cross-country correlation in Europe is 0.84 (BK filter), 0.74 (HP filter), and 0.75 (y-o-y growth rates). We can explain the increase in correlation by contagion, which significantly increases correlation among European countries after global financial and debt crisis, especially in the lack of adjustment mechanism in Europe through exchange rate and monetary policy (Bayoumi and Eichengreen, 1996). Changes in cyclical correlation alter the effects of trade intensity in the regression. However, this conjecture warrants further investigation.

Table 5: Results including year 2012 (Cycle extracted using Baxter-King Filter)

	East Asia				Europe				Pooled			
Trade per GDP	1.061*	-0.141	-0.124		0.362	-0.153	-0.0344		0.696	-0.154	-0.0822	
	[1.947]	[-.2236]	[-.1946]		[.4924]	[-.2069]	[-.047]		[1.515]	[-.311]	[-.1673]	
Grubel Lloyd Index [IIT]		0.545***				0.470**				0.505***		
		[3.456]				[2.334]				[3.943]		
Vertical IIT			0.582***	0.617***			0.441**	0.478**			0.508***	0.544***
			[3.426]	[3.702]			[2.017]	[2.331]			[3.719]	[4.167]
EMU					0.449***	0.422***	0.424***	0.422***	0.449***	0.420***	0.420***	0.418***
					[6.355]	[6.007]	[5.986]	[5.991]	[6.394]	[6.039]	[5.991]	[5.961]
Eurozone									-0.276**	0.579***	0.597***	-0.642**
									[-2.297]	[3.656]	[3.764]	[-2.078]
# of obs	138	128	128	136	200	200	200	209	338	328	328	345
R-square	0.51	0.51	0.41	0.49	0.48	0.50	0.49	0.49	0.49	0.51	0.50	0.50

VI. Conclusion

We find that, somewhat different from Frankel and Rose (1998), trade's impact on business cycle correlation can be ambiguous especially for a country pair with a large difference in GDP per capita (or simply put, factor endowments). However, intra-industry trade (IIT) and particularly vertical intra-industry trade (V-IIT) unambiguously increases the business cycle correlation. This is an

intuitively reasonable observation given that V-IIT largely represents product segmentation. Product segmentation places trading partners in a supply channel, allowing countries to face similar shocks and eventually generate similar business cycles. The importance of V-IIT in explaining cyclical co-movements seems to be larger for East Asia, which is the world's largest supply chain.

Another interesting finding is that the adoption of the euro has a significant and positive impact on the correlation of business cycles even in the presence of trade channel. One potential explanation is the financial channel where the euro promoted financial market integration (ECB, 2013), which may have positively contributed to business cycle correlation. Of course, the conjecture that financial integration has led to higher business cycle synchronization needs further investigation. We plan to study this dimension in the near future.

Finally, we find that the degree of business cycle correlation in East Asia is almost at the same level as the Eurozone's (before the global financial crisis), which could potentially indicate that the region can leap a net benefit from a currency zone, although not necessarily a common currency.

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Annex I: Real GDP per Capita

Real GDP Per capita (2005 PPP based US$)			
Ireland	40,951	Singapore	47,873
Netherlands	37,278	Hong Kong	33,638
Germany	34,833	Japan	31,867
Austria	34,288	Taiwan	29,963
Finland	32,603	Korea	29,272
France	30,000	Malaysia	10,837
Belgium	29,786	Thailand	8,200
Italy	29,051	China	8,189
Greece	22,314	Indonesia	4,217
Portugal	20,946	Philippines	3,487
AVG	31,205		20,754
STDEV	6,226		15,520

Source: Pen World Tables (version 8.0)

Annex II: Correlations among variables

Correlation of different "cycles"

	BK filter	HP filter	YoY Growth
BK filter	1.00		
HP filter	0.77	1.00	
YoY Growth	0.67	0.67	1.00

Correlation among explanatory variables

	Trade Intensity (1)	Trade Intensity (2)	IIT (GL index)	VIIT	Euro	EMU
Trade Intensity (1)	1.00					
Trade Intensity (2)	0.39	1.00				
IIT (GL index)	0.28	0.39	1.00			
VIIT	0.27	0.38	0.99	1.00		
Euro	-0.29	0.02	-0.03	-0.04	1.00	
EMU	-0.15	0.01	0.07	0.08	0.66	1.00