

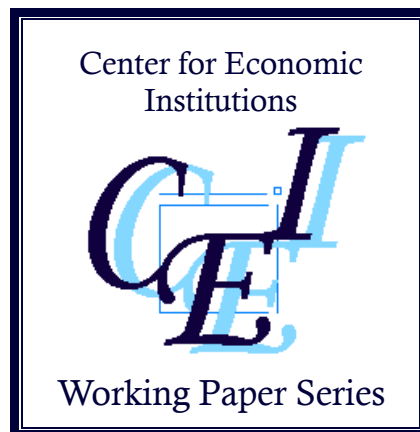
**Center for Economic Institutions**  
**Working Paper Series**

No. 2011-9

**“China in the World Economy: Dynamic  
Correlation Analysis of Business Cycles”**

**Jarko Fidrmuc<sup>I</sup>, Iikka Korhonen<sup>II</sup>  
and Ivana Bátorová<sup>III</sup>**

**December 2011**



Institute of Economic Research  
Hitotsubashi University  
2-1 Naka, Kunitachi, Tokyo, 186-8603 JAPAN  
<http://cei.ier.hit-u.ac.jp/English/index.html>  
Tel:+81-42-580-8405/Fax:+81-42-580-8333

# China in the World Economy: Dynamic Correlation Analysis of Business Cycles<sup>\*</sup>

Jarko Fidrmuc<sup>I</sup>

Iikka Korhonen<sup>II</sup>

Ivana Bátorová<sup>III</sup>

December 2011

## Abstract

We analyze globalization and business cycles in China and selected OECD countries using dynamic correlation analysis. We show that dynamic correlations of business cycles of OECD countries and China are negative at business-cycle frequencies and positive for short-run developments. Furthermore, trade and financial flows of OECD countries and China reduce the degree of business cycle synchronization within the OECD area, especially at business-cycle frequencies. Thus, different degrees of participation in globalization can explain the differences between the business cycles of OECD countries.

**Keywords:** Globalization, business cycles, synchronization, trade, FDI, dynamic correlation.

**JEL Classification:** E32, F15, F41.

---

\* We appreciate the research assistance by Yin Xia. We benefited also from comments by Volker Nitsch, Helge Berger, Gerhard Illing, Tomasz Kozluk, Michael Funke, Juraj Zeman, Pavol Brunovský, Eiji Ogawa and seminar participants at Hitotsubashi University in Tokyo. Further thanks also go to Tuuli Koivu, Aaron Mehrotra, Ayhanan Kose and conference participants at the Allied Social Science Meeting in San Francisco in January 2009, the CESifo Economic Studies Conference on Measuring Economic Integration in Munich in 2011, and two anonymous referees.

<sup>I</sup> Zeppelin University Friedrichshafen; CESifo Munich, Germany; Mendel University Brno, Czech Republic. e-mail: jarko.fidrmuc@zeppelin-university.de.

<sup>II</sup> Institute for Economies in Transition, Bank of Finland. Postal address: PO Box 160, 00101 Helsinki, Finland. Email: iikka.korhonen@bof.fi.

<sup>III</sup> Comenius University, Faculty of Mathematics, Physics and Informatics, Department of Applied Mathematics and Statistics, Bratislava, Slovakia. Email: ivana.batorova@gmail.com.

# **China in the World Economy: Dynamic Correlation Analysis of Business Cycles**

December 2011

## **Abstract**

We analyze globalization and business cycles in China and selected OECD countries using dynamic correlation analysis. We show that dynamic correlations of business cycles of OECD countries and China are negative at business-cycle frequencies and positive for short-run developments. Furthermore, trade and financial flows of OECD countries and China reduce the degree of business cycle synchronization within the OECD area, especially at business-cycle frequencies. Thus, different degrees of participation in globalization can explain the differences between the business cycles of OECD countries.

**Keywords:** Globalization, business cycles, synchronization, trade, FDI, dynamic correlation.

**JEL Classification:** E32, F15, F41.

## **1. Introduction**

Few events in the world economy can match the emergence of China in recent decades. Predominantly agrarian before 1980, China today boasts an extensive modern industrial economy with booming urban regions. The country's rapid trade growth is supported by large inflows of foreign direct investment (Eichengreen and Tong, 2007). Not surprisingly, growth in the world's most populous country has changed the distribution of economic activities across the world. Between 1990 and 2006, the share of Chinese GDP in the world economy, valued at purchasing-power-adjusted prices, increased from 3.6 percent to 11.5 percent (Borin et al., 2011).

The international distribution of economic activities has important implications for business cycles. Emerging countries, particularly China, contribute significantly to global growth. Thus, global economic prospects may be less dependent than earlier on the performance of large developed economies such as the US and Germany. This situation may make countries in a particular region less vulnerable to demand shocks (IMF, 2007).

The literature on business cycle synchronization stresses the importance of foreign trade and capital flows. Thus, the emergence of China as a large trading nation and a target for international investment may have significant effects on the business cycles of its partner countries.

Even as China has opened up to the world economy, recent business cycle trends suggest differences among countries in their intensity of trade and financial relations with China. This seems especially important in the case of European countries. We observe a joint EU cycle up to the 1980s (Artis and Zhang, 1997; Fatas, 1997), which essentially vanishes in the 1990s (Artis, 2003). Moreover, the intensity of trade and

financial links with China differs among individual EU countries. For example, the UK, Germany, Finland, and the Netherlands have extensive links with China, while many other EU countries have quite modest economic ties.

Foreign trade and foreign direct investment (FDI) are generally seen as important drivers of business cycles. However, their effects on correlations across international business cycles are ambiguous. Frankel and Rose (1998) find a robust positive relationship between trade intensity and correlation of business cycles between OECD countries. This is reflected in high shares of intra-industry trade between these countries. Yet China's specific position in the international division of labor has resulted in increased vertical specialization (see Dean et al., 2008 and 2009). Krugman (1993), for example, argues that this should cause business cycle divergence between countries. Moreover, FDI can be either a substitute or a complement for exports between a pair of countries.

In addition to the rich literature on trade between China and the developed countries (Bussière et al., 2008, and Bussière and Mehl, 2008), there is a genre (e.g. de Grauwe and Zhang, 2006) that looks at the determinants of business cycles in Southeast Asia. Few papers deal specifically with synchronization of business cycles in developed countries and China, a gap in the literature that this paper aims to help fill.

Two major findings in our study stand out. First, the business cycle in China is quite different from OECD countries (with the exception of Korea). Second, trade and financial flows with China have reduced the degree of business cycle synchronization between OECD countries. This stands in sharp contrast to the positive relationship between trade and business cycles, which is extensively documented in the earlier

literature (and confirmed here for OECD countries). To our knowledge, this result is new to the literature.

The paper is structured as follows. The following section discusses the determinants of international business cycles. Section 3 introduces the concept of dynamic correlation and discusses the stylized facts of business cycles in selected developed countries and China. Section 4 describes the business cycle of China and Section 5 investigates the impact of China on the degree of business cycles synchronization between OECD countries. The last section concludes with suggestions for future research.

## **2. Determinants of international business cycles**

Economic development is determined by domestic factors (e.g. aggregate demand shocks and economic policies) and international factors (e.g. external demand and international prices of traded goods), as well as their interaction. In open economies, international factors play an important role, often driving the formulation of domestic policies so as to insulate the economy from adverse external economic shocks. Frankel and Rose (1998) argue that trade, and more generally economic integration among countries, results in increased synchronization of individual business cycles. They contend that trade links provide a channel for transmission of shocks across countries. In this vein, Kenen (2000) employs a Keynesian model to show that the correlation between two countries' output changes increases with the intensity of trade links. Kose and Yi (2006) subsequently analyze this issue using an international real business cycle model. Although their model suggests a positive relation between trade and output movements, only modest qualitative effects are obtained.

The hypothesis of a positive relationship between trade and business cycles is not universally accepted. Krugman (1993), for example, argues that countries should be expected to specialize increasingly as they become more integrated. Thus, the importance of asymmetric or sector-specific shocks should increase with the degree of economic integration – a pattern perhaps more appropriate here for explaining Chinese business cycles.

The role of trade links has been studied extensively in the empirical literature. Despite theoretical ambiguities, the authors generally find that countries that trade more extensively with each other exhibit a higher degree of output comovement (e.g. Frankel and Rose, 1998; Otto et al., 2001; Baxter and Kouparitsas, 2005). However, it is not trade relations per se that induce business cycle synchronization. Indeed, the Frankel-Rose hypothesis underscores the fact that bilateral trade is mainly intra-industry trade (although this indicator does not directly enter their analysis). Instead, they argue that specialization increases the exposure to sector-specific shocks transmitted via intra-industry trade. Fontagné (1999) discusses the relation between intra-industry trade and symmetry of shocks in a monetary union. Fidrmuc (2004) demonstrates that intra-industry trade is a better indicator of business cycle symmetry than simple trade intensity.

Given China's tendency to specialize vertically (Dean et al., 2008 and 2009), this channel may not be highly relevant for the Chinese business cycle. Instead, the specialization forces discussed by Krugman (1993) appear to dominate and to drive the differences in the business cycles of China and its various trading partners.

Financial integration between countries could also play an important role in synchronization of business cycles, but again the impact of financial integration on

business cycles is ambiguous. On the one hand, the impacts of financial markets are similar to those of trade links. Thus, business cycles in one country are likely to affect investment decisions and asset prices in other countries via financial flows. Conversely, FDI enables countries to specialize (Kalemli-Ozcan et al., 2001, Imbs, 2004, de Haan et al., 2008b, and Aruoba et al., 2010) such that a high degree of financial integration may reduce the degree of comovement. Here, empirical analysis seems to indicate a less robust impact of financial integration on business cycle synchronization (Artis et al., 2008).

The literature on business cycle correlation has focused mainly on developed economies. Among the studies that look at business cycle correlation in Eastern Asia, we cite the most relevant papers. Sato and Zhang (2006) find common business cycles for the East Asian region. Shin and Sohn (2006) show that trade integration (and to a much lesser extent, financial integration) enhances comovement of output in East Asia.<sup>1</sup> Kumakura (2005) reports that the share of electronic products in foreign trade increases business cycle correlation for the countries around the Pacific. Shin and Wang (2004) observe that trade is a significant determinant of business cycle correlation for East Asian countries. Rana (2007) extends the work of Shin and Wang by confirming that it is especially intra-industry trade which matters for business cycle correlation also in the case of East Asia, also when the period of Asian crisis is taken into account. Baldacci et al. (2011) show that emerging countries' bond spreads are affected by trade linkages between countries.

---

<sup>1</sup> Kočenda and Hanousek (1998) document a high degree of convergence and integration of the East Asian capital markets.



Few if any papers directly examine the correlation of business cycles between China versus other emerging Asian economies and OECD countries. Kose et al. (2008) compares business cycles of industrial countries and emerging economies, showing that there is convergence within both groups, but divergence (decoupling) between the groups of industrial and emerging economies. The decoupling of business cycles between China and developed economies has been confirmed also by Akin and Kose (2008) and Kose et al. (2008), while Fidrmuc and Korhonen (2010) and Kim et al. (2011) show that correlation of business cycles between Asian economies and developed countries increased after the financial crisis of 2008. He and Liao (2011) use a structural factor model to assess business cycle correlation between emerging Asian economies, including China, and the G7 countries. They find that role of global factors increased between 1995 and 2008, but Asian countries as a group have remained somewhat disconnected from the G7 business cycle. Moreover, for China the global factors mattered less than for Asian countries on the average, while the regional factor was more important.

### **3. Spectral analysis and dynamic correlation**

While analysis in the time dimension is a standard tool of business cycle analysis, the application of spectral analysis may offer new and more robust insights. Business cycles analysis is usually sensitive to the choice of detrending techniques (Canova, 1998). Statistical filters, especially the Hodrick-Prescott filter, may generate artificial cycles (Harvey and Jaerger, 1993). Moreover, the Hodrick-Prescott filter suffers from end-point bias. The band-pass filter, which is recommended in the more recent literature, results in a loss of observations at the beginning and end of a time series. By contrast,

first differences of equal quality are available for the whole sample, but they include all frequencies. For relatively short samples, as is often case for emerging economies, static correlation may be artificially high if comovements of cycles of different frequencies coincide in the sample. Such countries may also display periods of high and low business cycle synchronization (decoupling and recoupling), which are commonly observed among countries (Fidrmuc and Korhonen, 2010).

Spectral analysis may provide a way around the several caveats attached to standard business cycle analysis. Spectral techniques enable decomposition of aggregate fluctuations into a sum of cycles of different frequencies. This provides detailed information on the underlying cyclical structure of an economic series while obviating both end-point bias and loss of observations. Information on short-run and long-run cycles can also be made available for economic analysis.

The first application of spectral analysis in macroeconomics occurred in the 1960s. Granger (1966) paved the way for the use of spectral analysis in economics. Currently, spectral analysis is represents a promising stream of business cycle analysis (de Haan et al., 2008a), although applications are still rare. A'Hearn and Woitek (2001) discuss historical business cycles by means of spectral analysis. Hughes-Hallett and Richter (2009 and 2011) present spectral analyses of business cycles of Chinese regions and European emerging countries.

The spectrum can be estimated by parametric or non-parametric methods. Non-parametric methods assume that the spectra for similar frequencies are also similar. Therefore, a spectrum can be estimated as a weighted average of the value of a sample periodogram,  $S(\lambda)$ , for frequencies  $\lambda_i$  and  $\lambda_j$ , where the weights depend on the distance between  $\lambda_i$  and  $\lambda_j$ . Thus, the non-parametric spectrum estimator can be written as

$$\hat{S}^{NP}(\lambda_j) = \sum_{m=-h}^h \kappa(\lambda_{j+m}, \lambda_j) \hat{S}(\lambda_{j+m}), \quad \text{where } \lambda_j = \frac{2\pi j}{T}, \quad (1)$$

where  $\kappa$  denotes the kernel function (e.g. Bartlett kernel) that attributes weights to included frequencies, and  $h$  is a smoothing parameter (bandwidth).

Alternatively, the spectrum can be estimated parametrically as

$$\hat{S}^p(\lambda) = \frac{\sigma^2}{2\pi} \frac{1}{\left(1 - \sum_{j=1}^p \phi_j e^{-i\lambda j}\right) \left(1 - \sum_{j=1}^p \phi_j e^{i\lambda j}\right)}, \quad (2)$$

where the  $\phi_j$  are parameters of an AR( $p$ ) process specified for autocorrelations of the variable  $y_t$ .

The most commonly used metric for comovement between time series is classical correlation, which however does not enable the separation of idiosyncratic components from common comovements. It is also basically a static analysis and so is unable to capture the dynamics of comovement. Spectral methods can also be used to analyze business cycle synchronization between countries, in the manner of correlation analysis. Granger (1969) first introduced cross-spectral techniques to economics by describing pairs of time series in frequency domain via decomposition of their covariance into frequency components. In this vein, we apply dynamic correlations<sup>2</sup> as proposed by Croux et al. (2001). For two variables  $y_i$  and  $y_j$  with spectral density functions  $S_i$  and  $S_j$  and co-spectrum  $C_{ij}$  defined for the frequency  $\lambda$  over the interval  $-\pi \leq \lambda \leq \pi$ , the dynamic correlation,  $\rho_{ij}$ , is

---

<sup>2</sup> Messina et al. (2009) discuss dynamic correlation in a discussion of wage developments over the business cycle. Haan et al. (2008) discuss alternative measures of synchronisation of business cycles.

$$\rho_{ij}(\lambda) = \frac{C_{ij}(\lambda)}{\sqrt{S_i(\lambda)S_j(\lambda)}}. \quad (3)$$

The dynamic correlation lies between -1 and 1. Moreover, it is interesting to analyze the average dynamic correlations over a given interval of frequencies. If we define an interval as  $\Lambda = [\lambda_1, \lambda_2)$ , the dynamic correlation within the frequency band  $\Lambda$  is then defined as

$$\rho_{ij}(\Lambda) = \frac{\int_{\Lambda} C_{ij}(\lambda) d\lambda}{\sqrt{\int_{\Lambda} S_i(\lambda) d\lambda \int_{\Lambda} S_j(\lambda) d\lambda}} \quad (4)$$

In particular, if  $\lambda_1 = 0$  and  $\lambda_2 = \pi$ ,  $\rho_{xy}(\Lambda)$  is reduced to the static correlation between  $y_i$  and  $y_j$ , i.e.  $\text{corr}(y_i, y_j)$ . The dynamic correlation within the frequency band, defined in (4), can be used e.g. to measure the comovement of business cycles of two countries, since we can select the frequency band of interest (business cycle frequencies, or short-run and long-run frequencies) and evaluate the dynamic correlation within this frequency band. Croux et al. (2001) estimate the spectra and cross-spectra of analyzed time series by non-parametric methods.

#### 4. Stylized facts of the business cycle in China and selected countries

We use quarterly data on gross domestic production (GDP) from IMF International Financial Statistics. For developed countries, the time series start in the 1970s or 1980s. Where seasonal adjustment is required, we perform the US Census Bureau's X12 ARIMA procedure for the entire available period. All variables are taken in logarithms and first differences.

For China, we use national quarterly GDP data in current prices deflated by the CPI. We adjusted the time series using the same procedure as for other countries. In China's case, the time series start from 1992. This restricts our analysis to the period between 1992 and 2007. Finally, we do not use more recent data so as to avoid the effects of the financial crisis in 2008.

All time series were tested for unit roots by the Dickey-Fuller GLS test, as proposed by Elliott et al. (1996), which improves the power of the ADF test by detrending (see Table A.1). The test clearly rejects the null of unit root in outputs of all the included countries. Similarly, the Kwiatkowski et al. (1992) tests fail to reject the null of stationarity for all countries. Panel versions of both tests (according to Im et al., 2003, and Hadri, 2000) confirm these results.

Figure 1 presents estimated spectra for the Bartlett kernel and the parametric estimator of autoregressive processes AR(1) and AR(2). We see that all three methods yield largely similar spectra, although parametric estimators assuming an AR(1) process, which was recommended by the information criteria (Schwarz information criterion), result in relatively smooth spectra. The differences are especially large for the small and emerging economies. This confirms that the parametric spectrum estimator can be sensitive to the order of underlying autoregressive processes. Despite these differences, we see that the long-run frequencies dominate the spectra of large OECD countries. By contrast, the spectra for small open economies, including newly industrialized countries such as China, put more weight on the relatively short-run frequencies.

Figure 2 presents dynamic correlations of business cycles in China versus selected developed economies over the period studied. As in most cited studies, we distinguish among three components of the aggregate correlation. First, the long-run movements

(over 8 years) correspond to the low frequency band, below  $\pi/16$ . Second, the traditional business cycles (with periods between 1.5 and 8 years) belong to the medium part of the figure (shaded area) between  $\pi/16$  and  $\pi/3$ . Finally, the short-run movements are defined by frequencies over  $\pi/3$ . Although it is usual to neglect these developments in the literature, we look at them here as the short-run dependences of economic development, which may be important in the case of China.

We see that business cycles in China and selected economies vary significantly over the frequencies. Only a handful of countries show relatively high positive correlations with the long-run cycles of China. These countries include the non-European OECD countries (US, Korea, Australia, Japan). To a lesser degree, we also see small positive correlations of among the long-run developments in Denmark, Italy, Norway, and perhaps the UK. In general, the non-European OECD countries trade more intensively with China than with the remaining countries in our sample, which may help explain the extent of business cycle correlation. For European countries, however, this explanation is less credible.

We find a more homogeneous picture for the traditional business cycle frequencies (between  $\pi/16 \approx 0.2$  and  $\pi/3 \approx 1$ ). In general, negative correlations of business cycles between China and OECD countries dominate. Generally speaking, only Korea and Denmark show positive correlation over the whole interval of business cycle frequencies. The positive correlation between business cycles in China and Korea confirms the earlier findings of Shin and Sohn (2006) and Sato and Zhang (2006), while the result for Denmark seems to be a statistical anomaly. As before, the non-European OECD countries show positive correlation at the lower range of the interval (close to

eight years). Only France, Spain, Turkey and Israel show positive correlation at business cycle frequencies close to 1.5 years.

Finally, we see large differences in short-run frequencies. In general, the dynamic correlations tend to increase at the right end of the spectrum (see Figure 2). This would correspond to strong business linkages between suppliers from China and final producers in developed countries. Among the European countries, short-term correlation appears to be high for Finland and Sweden. Short-run correlations are also high also for the US and Korea, but only marginally positive for Japan. All these countries can be characterized as having highly intensive relationships with China over a longer period.

Figure 3 compares average dynamic correlations at business-cycle and short-run frequencies via the static correlations for the sample. We see that negative correlation dominates for nearly all countries, especially at business-cycle frequencies. Only Korea, Denmark, Spain and Italy show positive correlation of business cycles with China. At the same time, several countries show low negative or even positive dynamic correlation at short-run frequencies. This is especially the case for Korea, Finland, Sweden, and the US. As a result, the application of dynamic correlations strengthens the evidence of decoupling of Chinese business cycles from those of the other countries.

## **5. Exposure to a globalization shock and business cycles of OECD countries**

The stylized facts of the previous sections show that business cycles in China and in the OECD countries are decoupled. Furthermore, the intensity of economic links with China differs quite a lot between the OECD countries (Bussière et al., 2008). This can influence the business cycles of the individual OECD countries. The synchronization

between OECD countries may decline as a result of differing exposures to ‘globalization’ or ‘China’ shock. Alternatively, differing specialization patterns during the globalization period may also lead to increasing dissimilarities between business cycles in the OECD countries, despite similar exposure to trade and financial integration with China and other emerging markets.

Therefore, we focus our analysis on the business-cycle correlations between the OECD countries (excluding Korea and Mexico, due to data unavailability). We start with estimation of the traditional OCA endogeneity equation, following Frankel and Rose (1998), for individual frequencies,

$$\rho_{ij}(\lambda) = \gamma_1(\lambda) + \gamma_2(\lambda)b_{ij} + v_i \quad (5)$$

where  $\rho$  is the bilateral dynamic correlation at frequency  $\lambda$  and  $b_{ij}$  denotes the bilateral trade-to-GDP ratio for countries  $i$  and  $j$ . We compute average trade intensity over the period 1993–2003, which reflects the data availability for all countries. Because estimating (5) by OLS may be inappropriate (see Imbs, 2004), we use two stage OLS.<sup>3</sup> This reflects the possibility that bilateral trade flows are influenced by exchange rate policies. Therefore, trade intensities have to be instrumented by exogenous determinants of bilateral trade and financial flows. Such instruments are provided by the so-called ‘gravity model’ (Anderson and van Wincoop, 2003), including the log of GDP and GDP per capita, log of distance between trading partners, and dummies for geographic adjacency, common language, and whether the country was among the 15 earlier member states of EU or NAFTA.

---

<sup>3</sup> OLS results are available from the authors upon request.



Usually, equations similar to (5) are estimated for static correlation between OECD countries, which is represents the starting point of our analysis. The results are presented in the first column of Table 1. Similarly, other authors sometimes use the band-pass filter (BPF), which is also presented in the third column in Table 1, Bloc A. In addition, Table 1 presents results for all intervals of dynamic correlations (ADC) for selected frequency intervals. As expected, we see that the trade coefficients estimated for the average dynamic correlations over all frequencies are nearly equal to the results for the static correlation. The same is true for the average of dynamic correlations over business-cycle frequencies, while the results for the band-pass filter are much higher. We also see that the trade coefficient is insignificant for the average dynamic correlation over the short-run frequencies. This means that trade mainly impacts the business-cycle and long-run frequencies. This is an interesting extension of the Frankel and Rose (1998) result.

The detailed results for the individual frequencies are reported in block A of Figure 4. We see that the positive relationship between business cycle similarities and degree of trade integration is fully confirmed for the business-cycle frequencies as well as for the long-run frequencies in OECD countries. Again, the relationship is positive, but no longer significant for nearly all short-run frequencies.

In the next step, we extend equation (5) to

$$\rho_{ij}(\lambda) = \gamma_1(\lambda) + \gamma_2(\lambda)b_{ij} + \delta(\lambda)x_i + \delta(\lambda)x_j + \omega_i \quad (6)$$

where  $x$  is a measure of economic and financial integration with China, which enters for both countries  $i$  and  $j$ . In particular, we examine the ratios of bilateral trade and FDI stocks and flows (between 2001 and 2005) recorded between OECD countries  $i$  and China to the GDPs of the OECD countries studied. This shows the importance of

economic and financial links from the perspective of the OECD countries. We restrict the coefficients for economic and financial integration with China,  $\delta$ , to be the same for both countries, as the differences are caused by different ordering of the countries in the data matrix. This reflects also that we use only half of all the possible combinations of  $n$  countries, because the indicators are the same (except for possible errors in trade and FDI statistics) for the country pair  $i$  and  $j$  and for the pair  $j$  and  $i$ .

The previous results for bilateral trade intensities of OECD countries remain unchanged (see Table 1, blocks B to D) if we include data for trade and financial links of OECD countries with China. Furthermore, we see that the adjusted coefficients of determination improve as well. Actually, trade flows between OECD countries explain only 4 percent of the variance of our measure of similarity of comovements at the business-cycle frequencies. The inclusion of trade intensity with China explains an additional 15 percent of the variance in business cycle similarities for the average of dynamic correlations for business-cycle frequencies. The share of explained variance is even higher for static correlations, correlations using the band-pass filter and average dynamic correlations for the long-run frequencies.

In contrast to trade integration between OECD countries, Table 1 and Figure 4 show that  $x$  has a negative sign and is highly significant, especially at the longer-term business-cycle frequencies. This pattern is the same for all indicators of economic and financial links between OECD countries and China. This confirms our hypothesis that high intensity of trade and financial links with China has a negative effect on a country's synchronization with business cycles of other OECD countries. For the short-run frequencies, the estimated coefficients are insignificant, and in a few cases they have positive signs.

In all estimations, the effects of bilateral OECD trade intensity remains positive and significant for business-cycle frequencies (especially those at the right-hand spectrum). However, the coefficients are slightly smaller in all estimations where trade with China is included. This finding is also seen in the individual frequencies in Figure 4.

## **6. Conclusions**

One of the most significant economic events in recent decades was the emergence of China as an important trading nation. During this gradual process, China has gained in economic importance and has increasingly influenced economic developments around the world. While China has undoubtedly become an important factor in the growth of the global economy, we were specifically interested here in the extent of China's influence on business cycles in developed OECD countries.

We show that the interdependence between business cycles in China and in developed economies is generally modest. However, many countries show a relatively high correlation for some short-run frequencies. Many transnational companies use China as a significant part of their production chain (see Dean et al., 2008 and 2009), and this is especially true for the other Asian countries. In turn, most countries show a negative correlation with China for the traditional business cycles (cycle periods between 1.5 and 8 years). This confirms the decoupling of business cycles between industrial countries and emerging economies discussed recently in the literature (Kose et al., 2008).

Overall, our results confirm the special position of China in the world economy, although the countries having already intensive trading relationships with China (e.g. Korea, Japan and the US) also have more similar cycles with China over all frequencies.

Despite the increased trade links between the countries, the Chinese business cycle remains in general rather different from the rest of the world.

Finally, we show that countries engaged intensively in trade with and investment in China tend to have a lesser degree of synchronization of business cycles with the other OECD countries. At the same time, trade and financial integration between the OECD countries increase the similarity of business cycles in the OECD countries. Both effects are less important for the short-run comovements. Although these findings are somewhat subject to data problems, our results confirm the business-cycle dissynchronization effects of trade specialization between China and OECD countries, as described by Krugman (1993), while synchronization effects prevail between the OECD countries (Frankel and Rose, 1998).

## References

- A'Hearn, B. and U. Woitek, (2001), "More international evidence on the historical properties of business cycles", *Journal of Monetary Economics* 47, 321-346.
- Akin, C., and M. A. Kose, (2008), "Changing Nature of North-South Linkages: Stylized facts and explanations", *Journal of Asian Economics* 19, pp. 1–28.
- Anderson J.E., and E. van Wincoop (2003), "Gravity with gravitas: A solution to the border puzzle", *American Economic Review* 93, pp. 170-192.
- Aruoba, S. B., Diebold, F. X., Kose, M. A. and M. E. Terrones, (2010), "Globalization, the Business Cycle, and Macroeconomic Monitoring." Working Paper 16264, NBER.
- Artis, M. J. (2003), "Is there a European Business Cycle?", Working Paper 1053, CESifo, Munich, [http:// www.cesifo.de/DocCIDL/1053.pdf](http://www.cesifo.de/DocCIDL/1053.pdf).

- Artis, M. J., J. Fidrmuc and J. Scharler (2008), “The transmission of business cycles: implications for EMU enlargement”, *Economics of Transition* 16, pp. 559-582.
- Artis, M. J. and W. Zhang (1997), “International business cycles and the ERM: Is there a European business cycle?”, *International Journal of Finance and Economics*, Vol. 2, pp. 1099-1158.
- Baldacci, E., Dell’Erba, S. and T. Poghosyan (2011), “Spatial spillovers in emerging market spreads”, Working Paper 11/221, International Monetary Fund, Washington.
- Baxter, M. and M. A. Kouparitsas (2005), “Determinants of business cycle comovement: a robust analysis”, *Journal of Monetary Economics* 52, pp. 113-57.
- Borin, A., Cristadoro, R., Golinelli, R. and G. Parigi (2011), “Forecasting world output: The rising importance of emerging Asian economies”, 6<sup>th</sup> Colloquium on Modern Tools for Business Cycle Analysis, Eurostat, [http://epp.eurostat.ec.europa.eu/portal/page/portal/euroindicators\\_conferences/6th\\_colloquium/program\\_papers](http://epp.eurostat.ec.europa.eu/portal/page/portal/euroindicators_conferences/6th_colloquium/program_papers).
- Bussière, M., J. Fidrmuc and B. Schnatz (2008), “EU enlargement and trade integration: Lessons from a gravity model”, *Review of Development Economics* 12, pp. 501-515.
- Bussière, M. and A. Mehl (2008), “China's and India's roles in global trade and finance: twin titans for the new millennium”, Occasional Paper No. 80, ECB, Frankfurt.
- Canova, F. (1998), “De-trending and business cycle facts”, *Journal of monetary Economic* 41, pp. 533–540.
- Croux, C., M. Forni and L. Reichlin (2001), “A measure of comovement for economic variables: Theory and empirics”, *Review of Economics and Statistics* 83, pp. 232-241.
- De Grauwe, P. and Z. Zhang (2006), “Introduction: Monetary and economic integration in the East Asian region”, *World Economy* 29, pp. 1643-1647.

- de Haan, J., Inklaar, R. And Jong-A-Pin, R. (2008a), “Will Business Cycles In The Euro Area Converge? A Critical Survey of Empirical Research”, *Journal of Economic Surveys* 22, pp. 234-273.
- de Haan, J., Inklaar, R. and R. Jong-A-Pin (2008b), “Trade and business cycle synchronisation in OECD countries – A re-examination”, *European Economic Review* 52, pp. 646-666.
- Dean, J., K. C. Fung, and Z. Wang (2008), “How vertically specialized is Chinese trade?”, Bank of Finland Institute for Economies in Transition Discussion Paper 31/2009, Bank of Finland, Helsinki.
- Dean, J., Lovely, M. E., and M. Jesse (2009), “Decomposing China-Japan-U.S. trade: Vertical specialization, ownership, and organizational form”, *Journal of Asian Economics* 20, pp. 596-610.
- Eichengreen, B. and H. Tong (2007), Is China’s FDI coming at the expense of other countries. *Journal of the Japanese and International Economies* 21, 153-172.
- Elliott, G., Rothenberg, T. J. and J. H. Stock (1996), “Efficient tests for an autoregressive unit root”, *Econometrica* 64, pp. 813–836.
- Fatás, A. (1997), “EMU: Countries or regions?”, *European Economic Review* 41, pp. 753-60.
- Fidrmuc, J. (2004), “The endogeneity of the optimum currency area criteria, intra-industry trade, and EMU enlargement”, *Contemporary Economic Policy* 22, pp. 1-12.
- Fidrmuc, J. and I. Korhonen (2010), “The impact of the global financial crisis on business cycles in the emerging economies in Asia”, *Journal of Asian Economics* 21, pp. 293-303.

- Frankel, J. A. and A. K. Rose (1998), "The endogeneity of the optimum currency area criteria", *Economic Journal* 108, pp. 1009-25.
- Fontagné, L. (1999), "Endogenous symmetry of shocks in a monetary union", *Open Economies Review* 10, pp. 263-87.
- Granger, C. W. J. (1966), "The typical spectral shape of an economic variable", *Econometrica* 34, pp. 150-161.
- Granger, C. W. J. (1969), "Investigating casual relations by econometric models and cross-spectral methods", *Econometrica* 37, pp. 424-438.
- Hadri, K. (2000), "Testing for stationarity in heterogenous panel data", *Econometrics Journal* 3, pp. 148-161.
- Harvey, A.C. and Jaeger, A. (1993), "De-trending, Stylized Facts and the Business Cycle", *Journal of Applied Econometrics* 8, pp. 231-47.
- He, D. and Liao, W. (2011), "Asian business cycle synchronisation", Working Paper 06/2011, Hong Kong Institute for Monetary Research.
- Hughes Hallett, A. and C. Richter, (2009), "Economics in the backyard: How much convergence is there between China and her special regions?" *World Economy* 32, pp. 819-861.
- Hughes Hallett, A. and C. Richter, (2011), "Is there clustering among the Eurozone economies? Evidence from how the EU's New Member States are converging", *Journal of Policy Reform* 14, pp. 127-150.
- Im, K. S., Pesaran, M. H. and Y. Shin, (2003), "Testing for Unit Root in Heterogenous Panels", *Journal of Econometrics* 115, pp. 53-74.
- Imbs, J. (2004), "Trade, finance, specialization, and synchronization", *Review of Economics and Statistics* 86, pp. 723-34.

- IMF (2007), "The changing dynamics of the global business cycle", *World Economic Outlook*, Chapter 5, October 2007, IMF, Washington, D.C.
- Kalemli-Ozcan, S., B. E. Sørensen and O. Yosha (2001), "Economic integration, industrial specialization, and the asymmetry of macroeconomic fluctuations", *Journal of International Economics* 55, pp. 107-37.
- Kenen, P. B. (2000), *Currency areas, policy domains, and the institutionalization of fixed exchange rates*, Discussion Paper No. 467, London School of Economics, Centre for Economic Performance, London, <http://cep.lse.ac.uk/pubs/download/dp0467.pdf>.
- Kim, S, Lee, J.-W. and C.-Y. Park (2011), "Emerging Asia: Decoupling or Recoupling", *World Economy* 34, 23-53.
- Kočenda, E. and J. Hanousek (1998), "Integration of Emerging Equity Markets: Major Asian Players", *Korean Economic Review* 14, pp. 99-114.
- Kose, M. A. and K.-M. Yi (2006), "Can the standard international business cycle model explain the relation between trade and comovement?", *Journal of International Economics* 68, pp. 267-295.
- Kose, M. A., C. Otrok and E. Prasad (2008), "Global Business Cycles: Convergence or Decoupling?", Working Paper No. 14292, National Bureau of Economic Research, Cambridge, <http://www.nber.org/papers/w14292>.
- Krugman, P. R. (1993), "Lessons of Massachusetts for EMU", in: Torres, F. and F. Giavazzi, eds., *Adjustment and Growth in the European Monetary Union*, Cambridge University Press and CEPR, Cambridge, pp. 241-261.
- Kumakura, M. (2005), "Trade and Business Cycle Correlations in Asia-Pacific", Discussion Paper No. 44, Institute of Developing Economies.



- Kwiatkowski, D., Phillips, P. C. B., Schmidt, P. and Y. Shin (1992), "Testing the Null Hypothesis of Stationarity against the Alternative of a Unit Root: How Sure Are We That Economic Time Series Have a Unit Root?", *Journal of Econometrics* 54, pp. 159-178.
- Messina, J., Strozzi, C., and J. Turunen (2009), "Real Wages over the Business Cycle: OECD Evidence from the Time and Frequency Domains", *Journal of Economic Dynamics and Control* 33, pp. 1183-1200.
- Otto, G., G. Voss and L. Willard (2001), Understanding OECD output correlations, Research Paper No. 2001-05, Reserve Bank of Australia, Sydney, <http://www.rba.gov.au/rdp/RDP2001-05.pdf>.
- Rana, P.B. (2007), "Trade intensity and business cycle synchronization: The case of East Asia", Working Paper Series on Regional Economic Integration No. 10, Asian Development Bank.
- Sato, K. and Z. Zhang (2006), "Real output co-movements in East Asia: Any evidence for a monetary union?", *World Economy* 29, pp. 1671-1689.
- Shin, K. and Y. Wang (2004), "Trade integration and business cycle co-movements: the case of Korea with other Asian countries", *Japan and the World Economy* 16, pp. 213-230.
- Shin, K. and C.-H. Sohn (2006), "Trade and financial integration in East Asia: Effects on co-movements", *World Economy* 29, pp. 1649-1669.

**Table 1: Estimation Results for Static Correlation, Band-Pass Filter, and Average Dynamic Correlation over Selected Frequency Intervals**

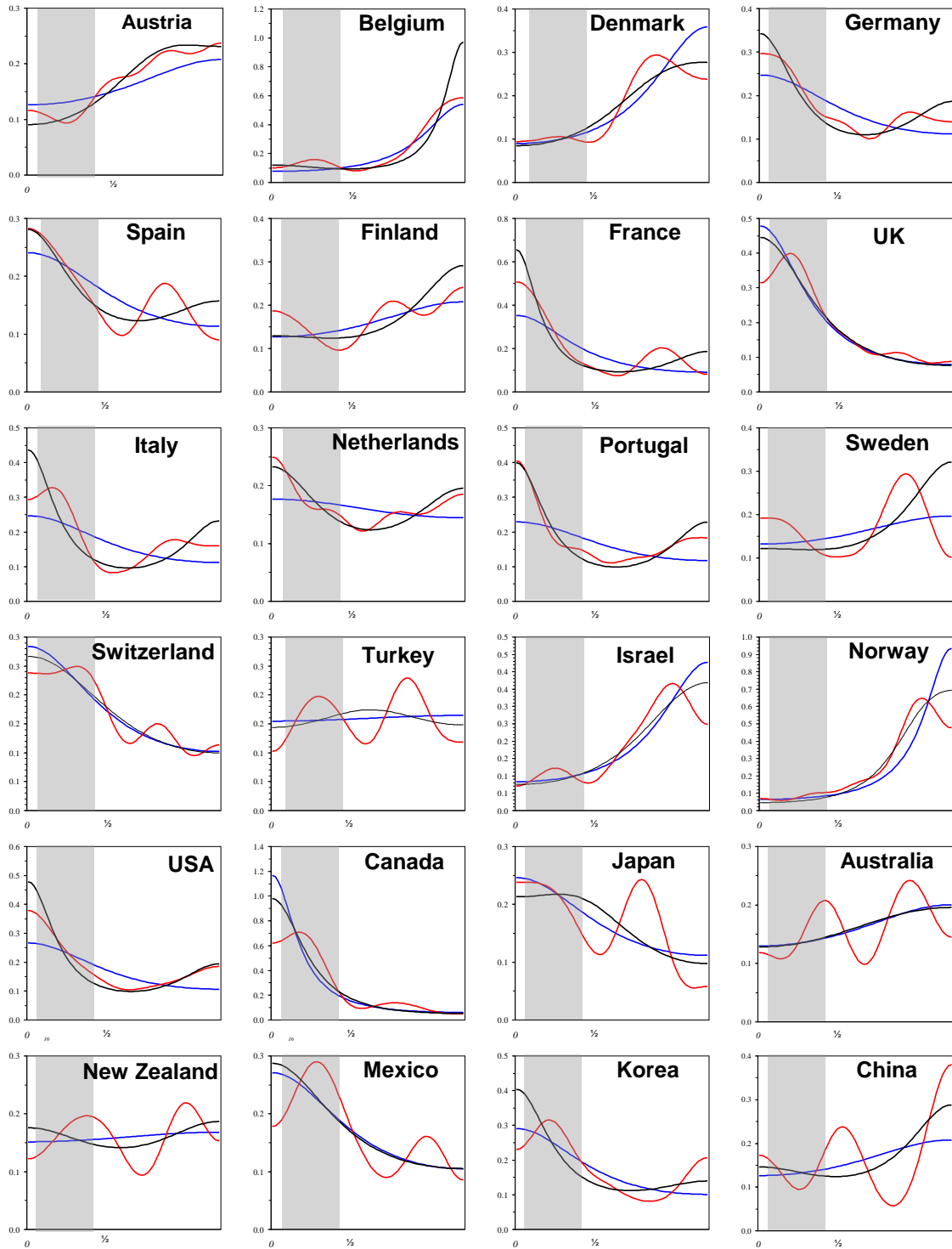
	Static Correlation	Average Dynamic Correlation	Static Correlation for BPF	ADC: Bus. Cycle Frequencies	ADC: Short-Run Frequencies	ADC: Long-Run Frequencies
<b>A: Basic Equation (Only OECD Bilateral Data)</b>						
OECD Trade	0.709 *** (0.188)	0.613 *** (0.187)	1.264 *** (0.370)	0.684 *** (0.244)	0.311 (0.205)	1.602 *** (0.304)
Intercept	0.136 *** (0.017)	0.130 *** (0.017)	0.304 *** (0.034)	0.226 *** (0.022)	0.058 *** (0.019)	0.295 *** (0.028)
<i>N</i>	171	171	171	171	171	171
Adjusted R <sup>2</sup>	0.087	0.059	0.004	0.037	0.023	0.049
<b>B: Augmented Equation 1 (incl. OECD Countries' Trade with China)</b>						
OECD Trade	0.669 *** (0.175)	0.581 *** (0.179)	1.149 *** (0.311)	0.629 *** (0.226)	0.307 (0.206)	1.498 *** (0.244)
Trade with China	-1.135 *** (0.221)	-0.893 *** (0.225)	-3.274 *** (0.392)	-1.568 *** (0.284)	-0.130 (0.259)	-2.944 *** (0.307)
Intercept	0.336 *** (0.042)	0.288 *** (0.043)	0.881 *** (0.075)	0.502 *** (0.054)	0.081 (0.049)	0.814 *** (0.059)
<i>N</i>	171	171	171	171	171	171
Adjusted R <sup>2</sup>	0.208	0.135	0.297	0.181	0.019	0.388

**Table 1, Continued**

<b>C: Augmented Equation 2 (incl. OECD Countries' FDI Stock in China)</b>						
	<b>Static</b>	<b>Average</b>	<b>Static</b>	<b>ADC:</b>	<b>ADC:</b>	<b>ADC:</b>
	<b>Correlation</b>	<b>Dynamic</b>	<b>Correlation</b>	<b>Bus. Cycle</b>	<b>Short-Run</b>	<b>Long-Run</b>
		<b>Correlation</b>	<b>for BPF</b>	<b>Frequencies</b>	<b>Frequencies</b>	<b>Frequencies</b>
OECD Trade	0.930 ***	0.773 ***	1.932 ***	1.075 ***	0.324	2.070 ***
	(0.195)	(0.192)	(0.407)	(0.259)	(0.215)	(0.317)
FDI Stocks in China	-0.134 ***	-0.147 ***	-0.122	-0.144 ***	-0.110 ***	-0.278 ***
	(0.037)	(0.037)	(0.078)	(0.049)	(0.041)	(0.060)
Intercept	0.161 ***	0.163 ***	0.298 ***	0.244 ***	0.089 ***	0.346 ***
	(0.021)	(0.020)	(0.043)	(0.028)	(0.023)	(0.034)
<i>N</i>	171	171	171	171	171	171
Adjusted R <sup>2</sup>	0.134	0.126	-0.060	0.047	0.059	0.090
<b>D: Augmented Equation 3 (incl. OECD Countries' FDI Flows to China)</b>						
OECD Trade	0.843 ***	0.680 ***	1.730 ***	0.836 ***	0.280	1.936 ***
	(0.176)	(0.172)	(0.357)	(0.211)	(0.208)	(0.264)
FDI Flows to China	-3.045 ***	-3.151 ***	-5.793 ***	-4.962 ***	-1.730 ***	-6.465 ***
	(0.468)	(0.458)	(0.951)	(0.563)	(0.554)	(0.703)
Intercept	0.269 ***	0.273 ***	0.545 ***	0.447 ***	0.141 ***	0.575 ***
	(0.027)	(0.026)	(0.054)	(0.032)	(0.031)	(0.040)
<i>N</i>	171	171	171	171	171	171
Adjusted R <sup>2</sup>	0.262	0.259	0.143	0.333	0.070	0.334

Note: BPF (band pass filter), ADC (avg dynamic correlation) over selected frequencies. Standard errors in parentheses. Business cycle frequencies are the average of dynamic correlations for frequencies  $\pi/16$  to  $\pi/3$ . Short-run frequencies are the frequencies over  $\pi/3$  (cycle period less than 1.5 yrs). Estimations are performed for 171 country pairs for OECD countries. Dynamic correlations were estimated using quarterly data between 1992 and 2007. \*\*\*, \*\*, and \* denote significance at 1, 5, and 10 percent level, respectively.

**Figure 1: Estimated Spectra for Selected Countries**

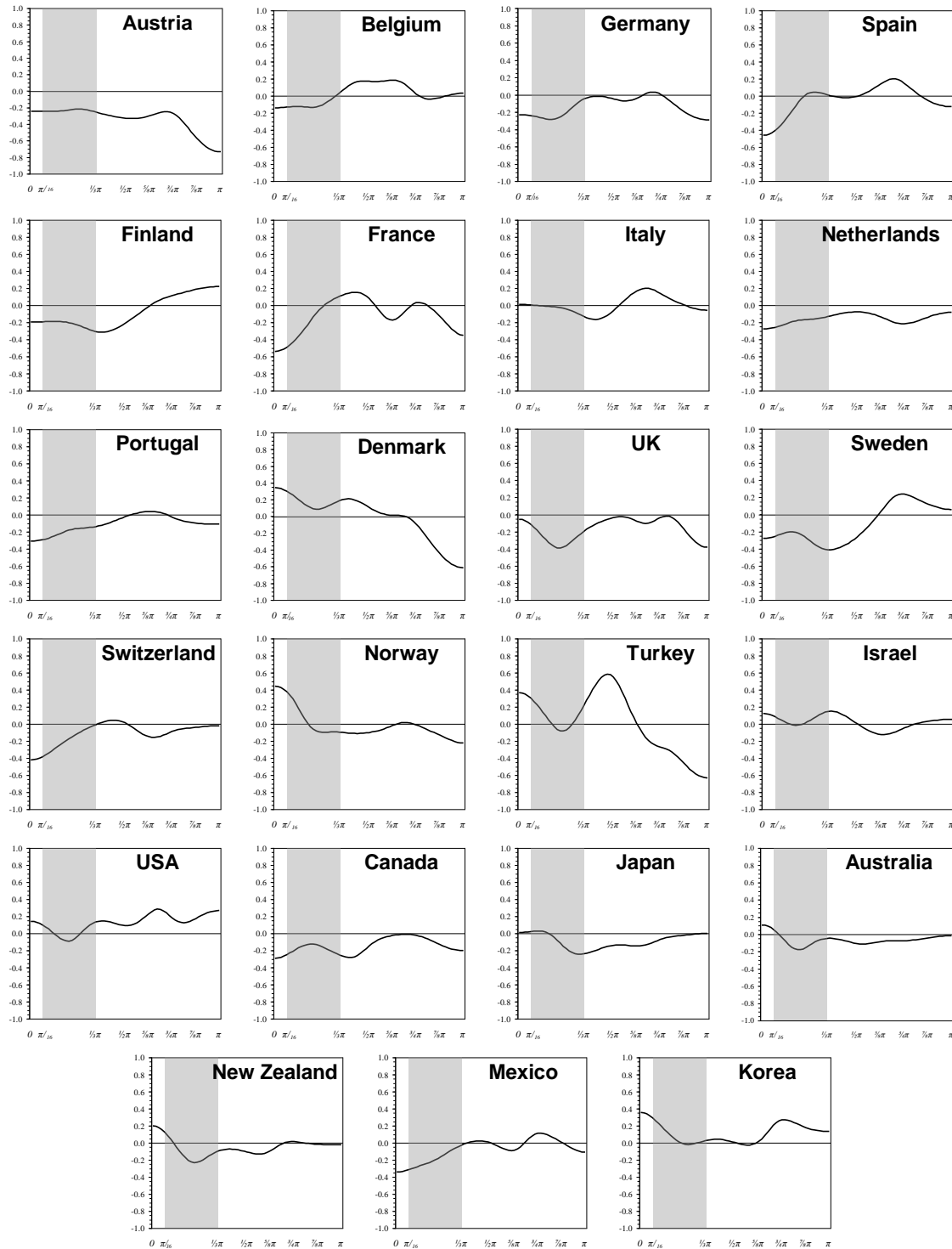


— Non-parametric spectrum — Parametric spectrum for AR(1) — Parametric spectrum for AR(2)

Note: Shaded areas denote business-cycle frequencies ( $\pi/16$  to  $\pi/3$ ). Dynamic correlations estimated using quarterly data between 1992 and 2007.

Source: Own estimations.

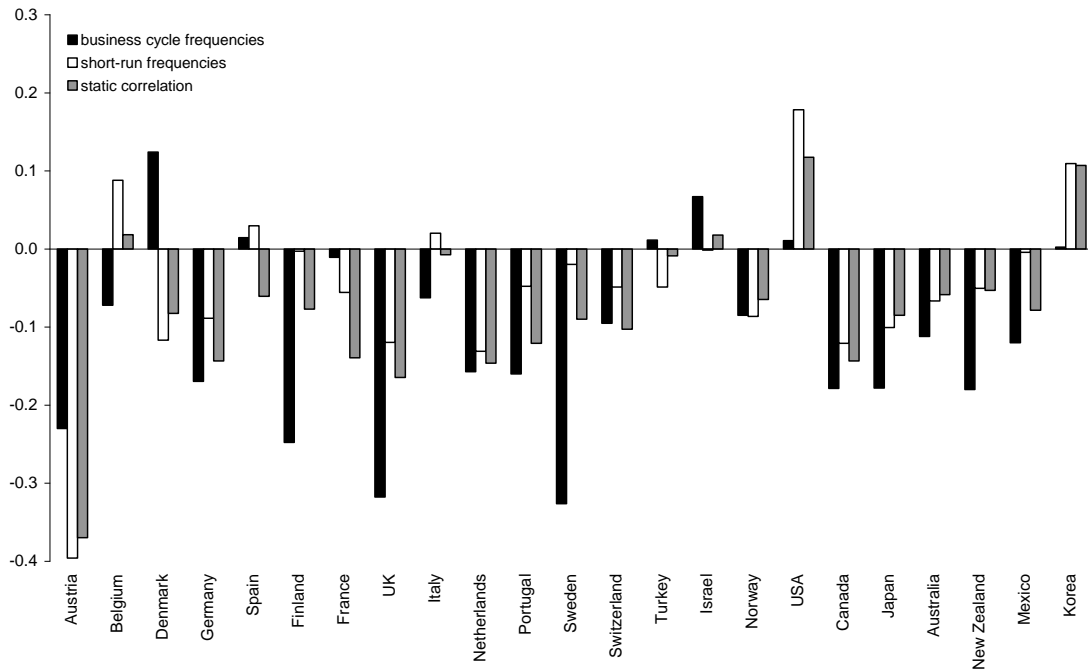
**Figure 2: Dynamic Correlations between China and Selected Countries**



Note: Shaded area denotes business-cycle frequencies ( $\pi/16$  to  $\pi/3$ ). Dynamic correlations estimated using quarterly data between 1992 and 2007.

Source: Own estimations.

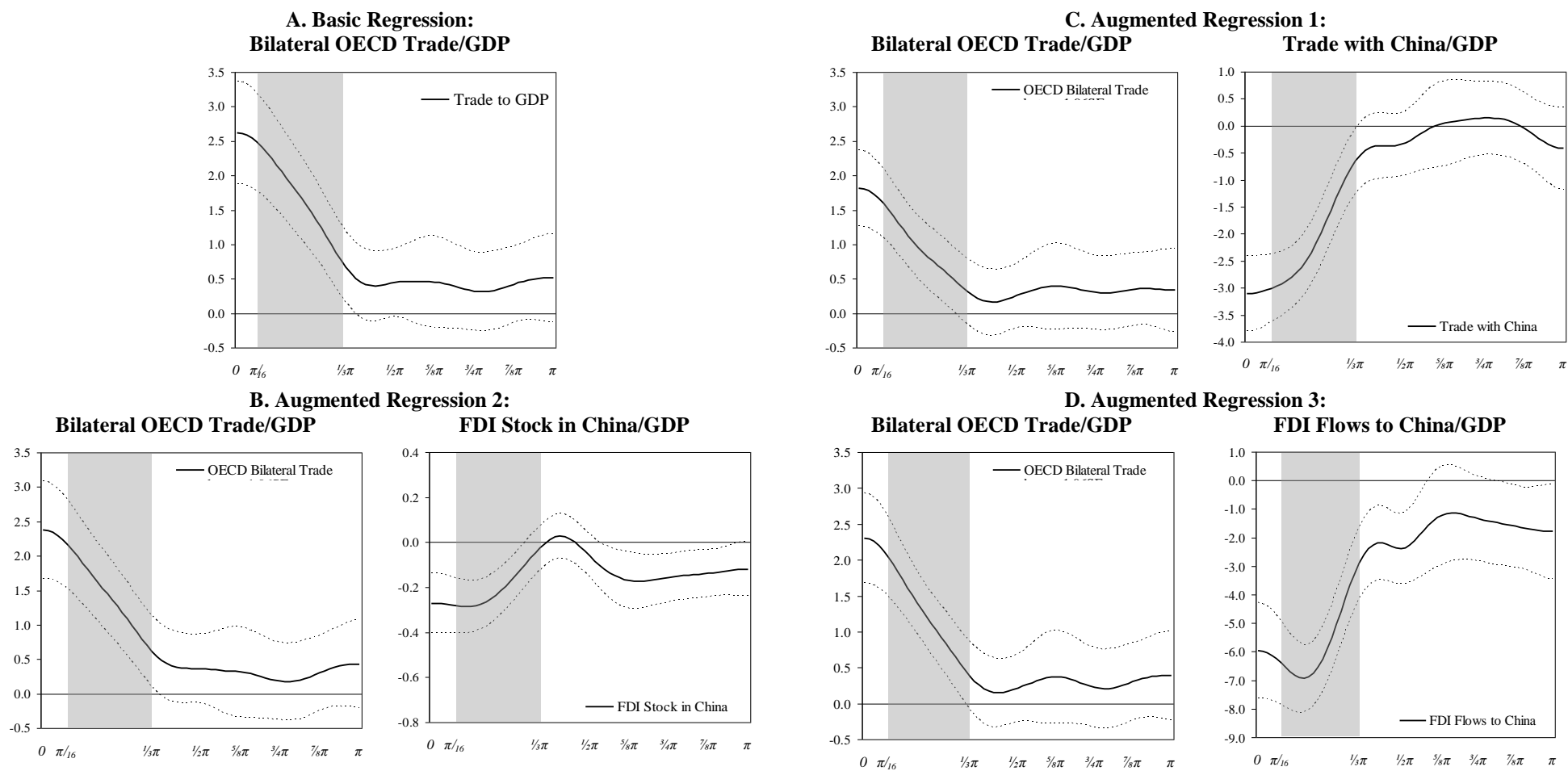
**Figure 3: Average Dynamic Correlations in China and Selected Countries**



Note: Business-cycle frequencies are the average of dynamic correlations for frequencies  $\pi/16$  to  $\pi/3$ . Short-run frequencies are the frequencies over  $\pi/3$  (cycle period less than 1.5 yrs). Dynamic correlations estimated using quarterly data between 1992 and 2007.

Source: Own estimations.

**Figure 4: Regression Results by Frequencies, Determinants of Business Cycle of OECD Countries**



Note: Each block of the table corresponds to a regression set, which includes the bilateral OECD trade and a proxy for countries' links to China (except the basic regression). Confidence bands are for 1.96 standard errors. Business-cycle frequencies are in shaded area ( $\pi/16$  to  $\pi/3$ ). Estimations are performed for 171 country pairs for OECD countries. Dynamic correlations estimated using quarterly data between 1992 and 2007. For better comparison, explanatory variables are rescaled to yield coefficients of the same magnitude.

**Table A.1: Selected Unit Root Tests**

	DF GLS		Lags	KPSS
Australia	-8.016	***	0	0.413
Austria	-9.894	***	0	0.121
Belgium	-3.317	**	1	0.101
Canada	-3.409	**	0	0.116
China	-5.392	***	0	0.216
Denmark	-4.995	***	1	0.091
Finland	-3.999	***	1	0.195
France	-5.353	***	0	0.201
Germany	-4.897	***	0	0.117
Israel	-3.356	**	2	0.045
Italy	-5.544	***	0	0.082
Japan	-6.375	***	0	0.251
Korea	-5.977	***	0	0.084
Mexico	-5.662	***	0	0.075
Netherlands	-6.845	***	0	0.169
Norway	-13.733	***	0	0.149
New Zealand	-7.712	***	0	0.108
Portugal	-5.271	***	0	0.210
Spain	-5.393	***	0	0.303
Sweden	-4.001	***	1	0.241
Switzerland	-6.072	***	0	0.248
Turkey	-7.451	***	0	0.145
United Kingdom	-3.399	**	0	0.107
USA	-3.597	**	1	0.150
Panel	-35.745 <sup>IPS</sup>	***	0 to 1	-0.273 <sup>PKPSS</sup>

Note: DF GLS – Dickey-Fuller GLS test (incl. trend) of Elliott et al. (1996), KPSS - Kwiatkowski et al. (1992) test, IPS – Im, Pesaran and Shin (2003) test (no trend), PKPSS – Panel version of KPSS tests according to Hadri (2000). Lag structure determined according to Schwarz information criterion. \*\*\*, \*\*, and \* denote significance at 1, 5, and 10 percent level, respectively.