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China in the world economy: dynamic correlation analysis of business cycles

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Jarko Fidrmuc, Iikka Korhonen and
Ivana Bátorová

China in the world economy: Dynamic correlation analysis of business cycles

Bank of Finland, BOFIT
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Helsinki 2008

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All opinions expressed are those of the authors and do not necessarily reflect the views of the Bank of Finland.

Jarko Fidrmuc, Iikka Korhonen and Ivana Bátorová

China in the world economy: Dynamic correlation analysis of business cycles

Tiivistelmä

Tässä keskustelualoitteessa analysoidaan dynaamisen korrelaation avulla Kiinan ja OECD-maiden suhdannevaihteluita vuosina 1992–2006. Lähes kaikkien OECD-maiden lyhyen aikavälin suhdannevaihtelun korrelaatio Kiinan kanssa on positiivinen. Tämä johtunee kansalliset rajat ylittävien yritysten tuotantoketjujen yleistymisestä. Dynaaminen korrelaatio on kuitenkin yleensä negatiivinen, kun suhdannekierron frekvenssi on perinteinen. Niillä mailla, jotka käyvät enemmän kauppaa Kiinan kanssa, on yleensä hieman suurempi suhdannevaihtelujen korrelaatio Kiinan kanssa. Vaikka Kiinan kanssa käytävä kauppa lisääkin suhdannevaihteluiden korrelaatiota OECD-maiden tapauksessa vain hieman, se vähentää suhdannevaihteluiden korrelaatiota OECD-maiden välillä

Asiasanat**:** Suhdannevaihtelut, synkronisaatio, kauppa, suorat sijoitukset, dynaaminen korrelaatio.

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

Jarko Fidrmuc† Iikka Korhonen‡ Ivana Bátorová§

March 2008

Abstract

We analyze the business cycles in China and in selected OECD countries between 1992 and 2006 using dynamic correlations. Nearly all OECD countries show positive correlations of the very short-run developments which may correspond to intensive supplier linkages. However, dynamic correlations at the business cycle frequencies are negative. Countries facing a comparably longer history of intensive trading links tend to show slightly higher correlations of business cycles with China. Even though trade and financial flows do not really increase correlations of business cycles between China and OECD countries, they lower the degree of business cycle synchronization within the OECD area.

JEL Classification: E32, F15, F41.

Keywords: Business cycles, synchronization, trade, FDI, dynamic correlation.

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1 Introduction

Few events in the world economy 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 high trade growth is supported by large foreign direct investment (FDI) flows (Eichengreen and Tong, 2005). Not surprisingly, growth in the world's most populous country has changed the distribution of economic activities across the world. Between 1980 and 2006, the share of Chinese GDP in the world economy valued at market exchange rates increased from 1.7% to 5.5% (this share is even higher if purchasing-power-adjusted prices are used).

The international redistribution of economic activities holds important implications for business cycles. Emerging countries, and particularly China, contribute significantly to global growth. Thus, global economic prospects are 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 a significant impact 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) that essentially vanishes in the 1990s (Artis, 2003). Moreover, the intensity of the trading and financial links with China has diverged 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 with China.

Foreign trade and foreign direct investment (FDI) are generally seen as important factors of business cycles. However, their effects on correlation of 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 should result in increased specialization. Krugman (1993), for example, argues that this should cause business cycle divergence between countries. Moreover, FDI can be either a substitute or a complement to exports between a pair of countries.

In addition to the rich literature on trade between China and the devel-

oped countries (Bussière et al., 2008), there are also a range of authors (e.g. de Grauwe and Zhang, 2006) dealing with the determinants of the business cycles in Southeast Asia. Few papers deal specifically with the synchronization of business cycles in developed countries and China, so this paper aims to help fill this gap in the literature.

Three 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 flows between OECD countries and China have so far had rather limited effects on the comovements in China and OECD countries, although they have increased the comovement at the short-run frequencies. This stands in sharp contradiction to the positive relationship between trade and business cycle similarities between OECD countries extensively documented in the earlier literature (and confirmed here for OECD countries). Finally, trade and financial flows with China have lowered the degree of business cycle synchronization between OECD countries. To our knowledge, this result is novel 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 on business cycles in selected developed countries and China. Section 4 analyzes the determinants of dynamic correlation of business cycles in China and in developed countries, while Section 5 investigates the impact of China on the degree of business cycles synchronization between OECD countries. The last section concludes with suggestions on directions for future research.

2 Determinants of business cycle synchronization

Economic development is determined by domestic factors (e.g. aggregate demand shocks and budgetary policy) and international factors (e.g. external demand and international prices for traded goods), as well as their interaction. In open economies, international factors play an important role, often driving the formulation of domestic policies designed 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 trade links provide a channel for transmission of shocks across countries. In line with approach, Kenen (2000) shows in a Keynesian model that the correlation between two countries' output changes increases with the intensity of

trade links. Kose and Yi (2006) subsequently analyze this issue in an international real business cycle model. Although their model suggests a positive relation between trade and output comovement, only small qualitative effects are obtained.

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

The role of trade links has been studied extensively in the empirical literature. Despite the theoretical ambiguities, authors generally find that countries trading more intensively exhibit a higher degree of output comovement (e.g. Frankel and Rose, 1998; Otto et al., 2001; Baxter and Kouparitsas, 2005). It is not trade relations per se, however, that induce business cycle synchronization. Indeed, Frankel and Rose's 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 the symmetry of shocks in a monetary union. Fidrmuc (2004) demonstrates that intra-industry trade is a better indicator for business cycle symmetry than simple trade intensity.

Given China's tendency to specialize vertically, this channel may not be particularly relevant for the Chinese business cycle. Instead, the specialization forces discussed by Krugman (1993) appear to dominate and drive the differences in 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, financial markets work similarly to 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 allows countries to specialize (Kalemli-Ozcan et al., 2001; Hoffmann, 2003; Imbs, 2004) such that a high degree of financial integration may reduce the extent of cofluctuations. Empirical analysis here seems to indicate a less robust impact of financial integration on business cycle synchronization (Artis et al., 2008).

In any case, the literature on business cycle correlation is concentrated on developed economies. Among the studies that look at business cycle correlation in Eastern Asia, we note the most relevant papers. Sato and Zhang (2006) find common business cycles for the East Asian region. Shin and Sohn

(2006) show trade integration (and financial integration to a considerably lesser extent) enhances comovements of output in East Asia.[1] Kumakura (2005) reports that the share of electronic products in foreign trade increases business cycle correlation for the countries around the Pacific. Finally, Shin and Wang (2004) observe that trade is a significant determinant of business cycle correlation for East Asian countries. Few, if any, papers directly examine the correlation of business cycles between China and other emerging Asian economies and those of the OECD countries.

3 Correlation and dynamic correlation analysis

The literature shows that correlation analysis is the basic approach applied in the study of degrees of synchronization between economic variables.

The most common measure of comovement between time series is *classical correlation*, which is also commonly used in business cycle correlation. Unfortunately, classical correlation does not allow for a separation of idiosyncratic components and common comovements. It is also basically a static analysis, so it fails to capture dynamics in comovement. For our purposes here, we prefer the alternative measure of synchronization of business cycles, *dynamic correlation*, as proposed by Croux et al. (2001).

Let x and y be zero-mean real stochastic processes. Let $S_x(\lambda)$ and $S_y(\lambda)$ be the spectral density functions of x and y and $C_{xy}(\lambda)$ be the co-spectrum, $-\pi \leq \lambda \leq \pi$. So the dynamic correlation equals

$$\rho_{xy}(\lambda) = \frac{C_{xy}(\lambda)}{\sqrt{S_x(\lambda)S_y\lambda}}. \tag{1}$$

The dynamic correlation lies between -1 and 1.

If two stochastic processes x and y are obtained by summing the waves of x_t and y_t within a given frequency interval, the dynamic correlation can be defined on frequency band. Set $\Lambda = [\lambda_1, \lambda_2)$, where $0 \leq \lambda_1 \leq \lambda_2 \leq \pi$. So the dynamic correlation within the frequency band Λ is defined as

$$\rho_{xy}(\Lambda) = \frac{\int_\Lambda C_{xy}(\lambda)d\lambda}{\sqrt{\int_\Lambda S_x(\lambda)d\lambda \int_\Lambda S_y(\lambda)d\lambda}}. \tag{2}$$

Particularly, if $\lambda_1 = 0$ and $\lambda_2 = \pi$, the $\rho_{xy}(\Lambda)$ is reduced to the static correlation between x_t and y_t, $\text{corr}(x_t, y_t)$.

[1] Kočenda and Hanousek (1998) document a high degree of convergence and integration of the East Asian capital markets.

The dynamic correlation within the frequency band, defined in (2), can be used, for example, to measure the comovement of seasonal components of two economic time series as we can select the frequency band of interest and evaluate the dynamic correlation within this frequency band.

4 Stylized facts for the business cycle in China and selected countries

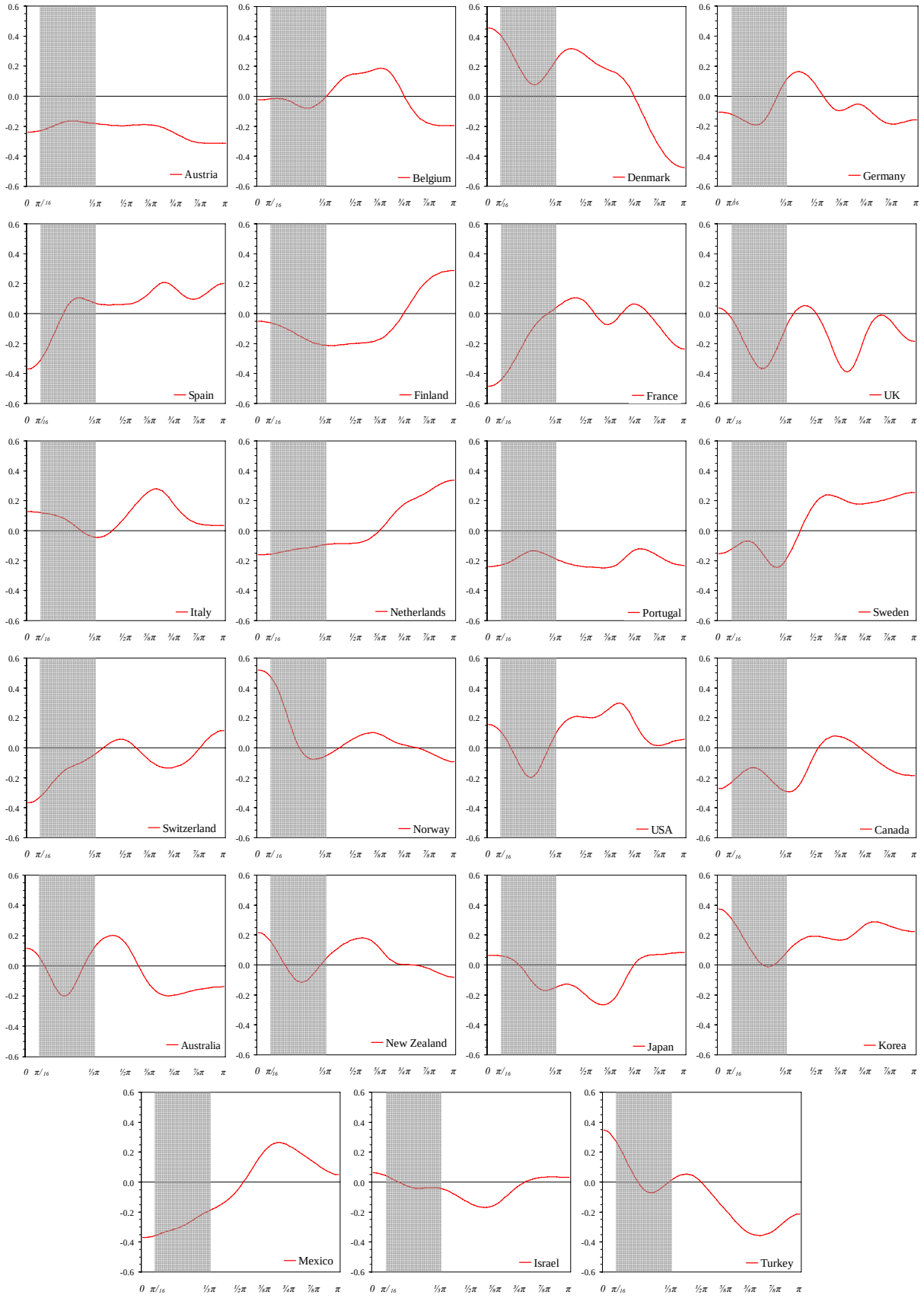
We use quarterly GDP data taken from IMF International Financial Statistics. For developed countries, the time series start in the 1970s or 1980s. Where seasonal adjustment is required, we perform the US Census Bureau's X12 ARIMA procedure for the entire available period.

For China, we use national quarterly data in current prices deflated by the CPI. It is important to note here that these time series have undergone major revision recently. So far, only annual data are available according to the new methodology.[2] 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 2006.

Figure 1 presents dynamic correlations of business cycles in China and selected developed economies between 1992 and 2006. 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 (i.e. cycles with a period between 1.5 and 8 years) belong to the medium part of the figure (marked as a shadow 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 literature, we look at them here as the short-run dependences of economic development could potentially be important in China's case.

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

[2] The impact of the revision on correlations should be moderate as long as the dynamic properties of the time series remain the same.



Note: Business cycle frequencies are marked by the shadow area.

Figure 1: Dynamic Correlations between China and Selected Countries, 1992-2006

this explanation is less credible.

We find a more homogenous 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 in China and OECD countries dominate. Basically, only Korea, Denmark, and Spain show a positive correlation over the whole interval of business cycle frequencies. This confirms the earlier findings of Shin and Sohn (2006) and Sato and Zhang (2006). As before, the non-European OECD countries show a positive correlation at the lower range of the interval (close to eight years). Only Italy and Spain show positive correlation at 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 1). 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, the Netherlands, 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 2 compares average dynamic correlations at the business cycle and the short-run frequencies with the static correlations for the sample. We can see that the negative correlations dominate for nearly all countries especially for the business cycle frequencies. Only Korea, Denmark, Spain and Italy show a positive correlation of business cycles with China. At the same time, several countries show low negative or even positive dynamic correlations for the short-run frequencies. This is especially strong for Korea, Finland, Netherlands, Sweden, and the USA.

5 Factors explaining the pattern of dynamic correlations

We now briefly assess some potential determinants of business cycle correlation between China and other countries. We check whether the extent of foreign trade between a particular country and China influences the degree of business cycle correlation. If the country has extensive trade ties with China, the intuitive expectation is that the business cycles would have a higher probability of moving together. Of course, at different frequencies e.g. different economic policies may cause divergence between the business cycles.

Furthermore, FDI inflows to China from the analyzed OECD countries

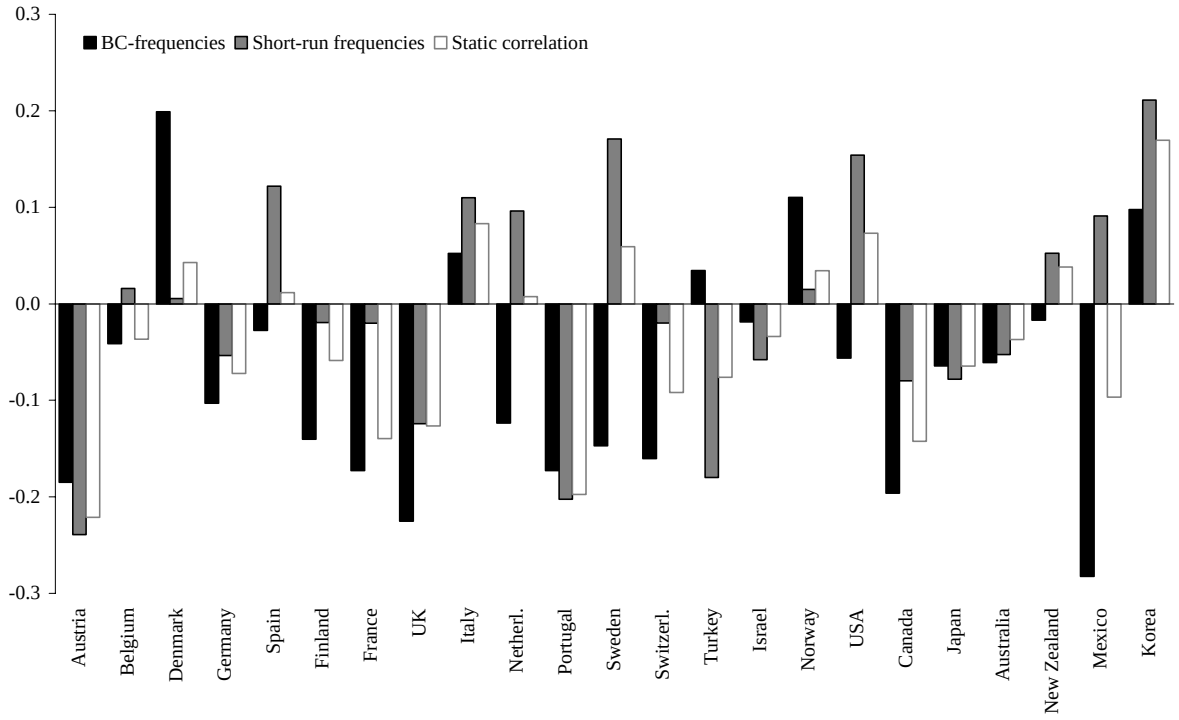


Figure 2: Aggregate Correlations of Business Cycles in China and Selected Countries, 1992-2006

may also affect business cycle correlations. The larger the stock of FDI sent to China (as percentage of the sending country's GDP), the more extensive the economic ties. Given China's status in many multinational companies' production networks, a large FDI stock is likely to signify extensive economic integration.

We use foreign trade data from the IMF's Direction of Trade statistics to calculate the average share of China in both exports and imports of the OECD countries between 1995-2006. This period captures the rapid growth of China's foreign trade. For the FDI stock, we use the annual flow data for host countries of FDI to China between 1997 and 2005 from the various issues of China Statistical Yearbooks. We add up these annual flows and treat the cumulative sum as a reasonable proxy for the stock of FDI as the major surge in FDI inflows took place in the late 1990s.

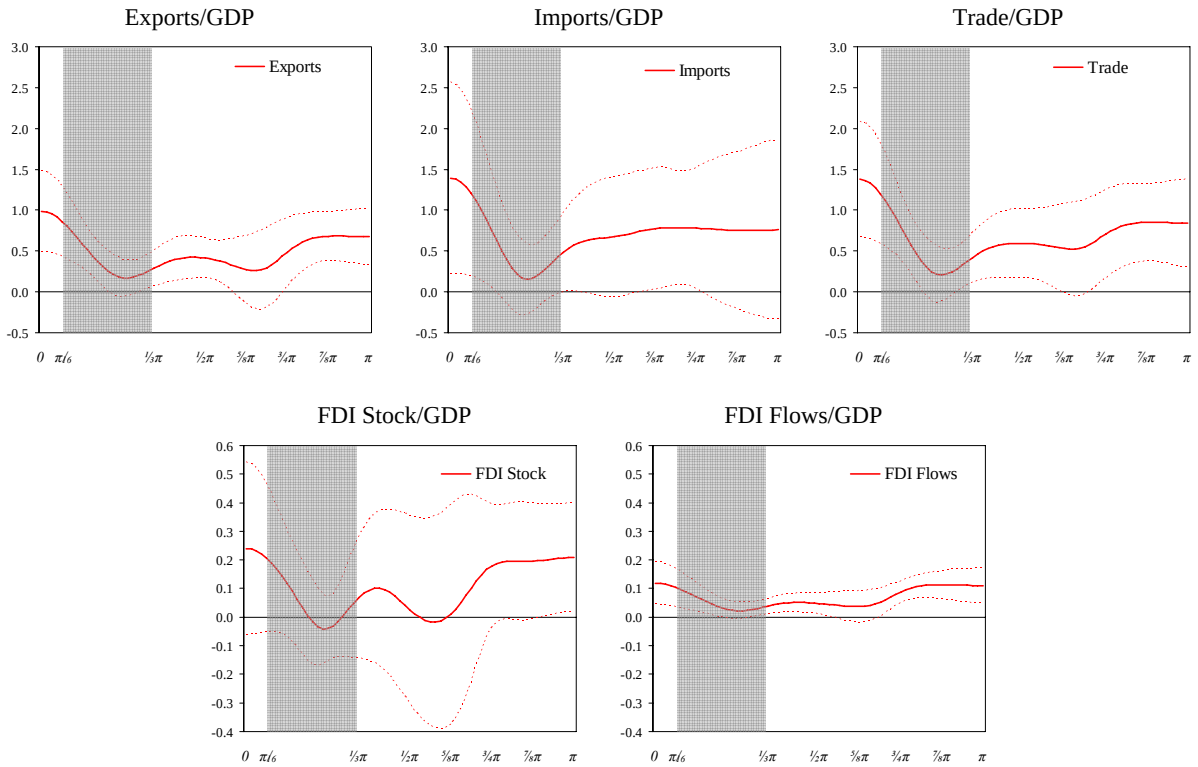
In the previous section, we calculated the dynamic correlation between Chinese GDP growth and growth in 23 OECD countries. As seen earlier, correlations differ greatly among OECD countries. Therefore, we estimate the set of following estimations for the dynamic correlation at all frequencies λ,

$$\rho_i(\lambda) = \beta_1(\lambda) + \beta_2(\lambda)x_j + \varepsilon_i(\lambda). \tag{3}$$

As explanatory variables, denoted by x, we take the ratio of bilateral exports, imports, trade, FDI stock, and flows (between 2001 and 2005) recorded between OECD countries j and China to GDP of the analyzed OECD countries. This shows the importance of economic and financial links from the perspective of the OECD countries. Given the low number of available countries and high correlation of the explanatory variables, we include the explanatory variables separately into various specifications of (3). We present the parameter β_2 for the explanatory variables and the individual frequencies in Figure 3.

Although these results should be taken very cautiously, our findings largely confirm the stylized facts of the previous section. Economic integration between the OECD countries and China tends to have low and insignificant effects on dynamic correlation of GDP at the business cycle frequencies. In turn, all selected indicators have a positive and almost always statistically significant effect on the correlation of GDP movements at the short-run frequencies (see Figure 3).

The results for the business cycle frequencies stand in a sharp contrast to positive relationship found usually for the OECD countries in the earlier literature following Frankel and Rose (1998), which we also confirmed for dynamic correlations of business cycles of OECD countries (see upper left



Note: Each figure corresponds to a regression set, which includes a selected indicator of economic links between the OECD countries and China. Confidence bands are constructed as 1.96 standard errors. Business cycle frequencies are marked by the shadow area. For better comparison, explanatory variables have been rescaled to yield coefficients of the same size.

Figure 3: Regression Results, Determinants of Dynamic Correlations of Business Cycles of OECD Countries with Chinese Business Cycle

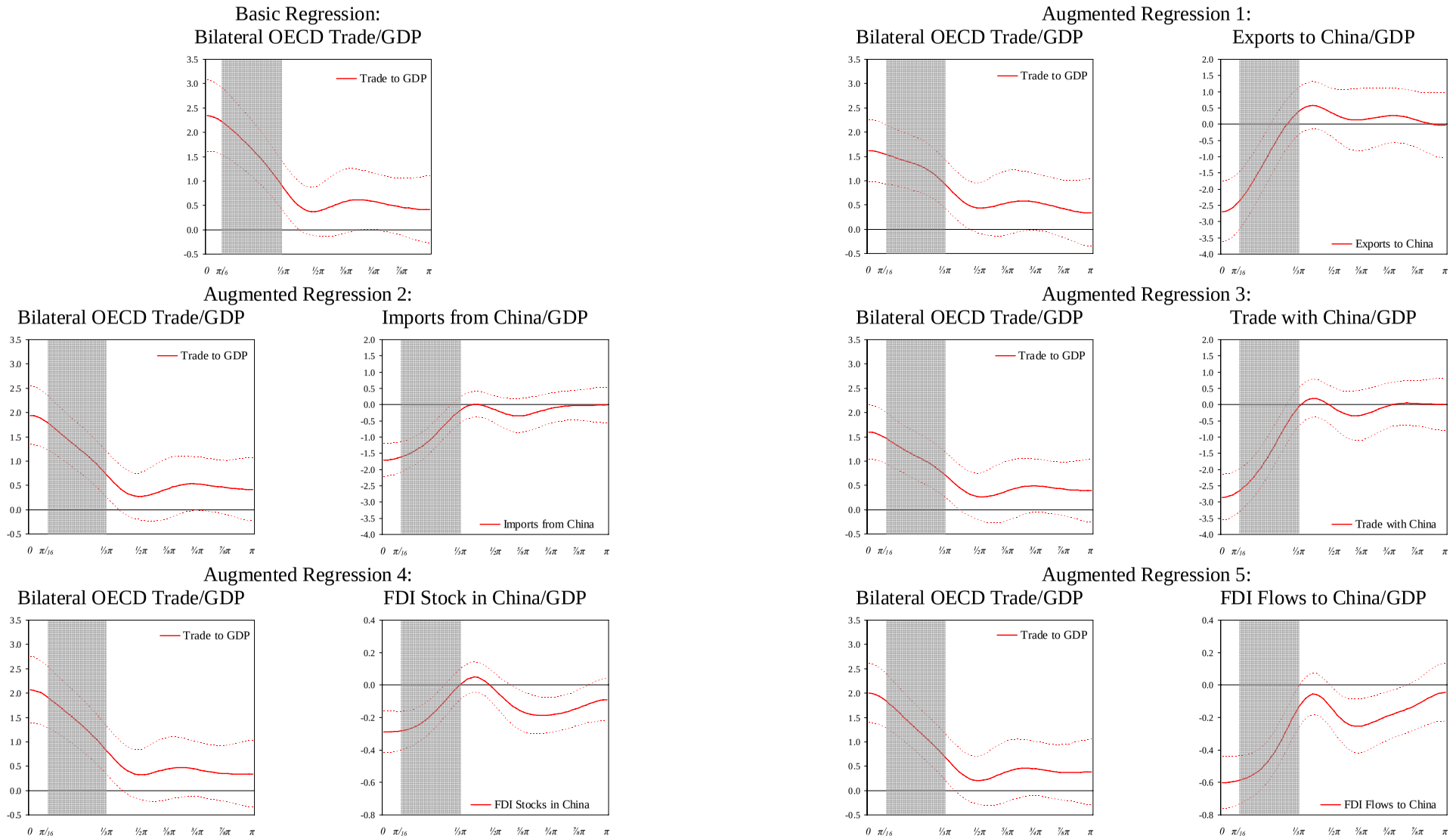
block of Figure 4). Furthermore, negative coefficients found for exports of OECD countries to China confirm the Krugman's specialization hypothesis for the impact of China on the business cycles in the world economy.

However, as evident in the previous section, there are large differences between correlations at different frequencies. When we look at business-cycle frequency or shorter-term fluctuations, our variables do not seem to correlate at all with the dynamic correlation measure. This may reflect the fact that China, despite its global importance, is still a relatively minor trading partner for many of OECD countries. For example, in 16 of our 23 countries the share of China in total exports was under 2% between 1995-2006, although it has in most cases risen considerably during that period. Therefore, we also looked whether the dynamic correlation and our trade and FDI variables are more connected in the countries with more extensive ties with China (which would imply a nonlinear relationship) in the sensitivity analysis (available upon request). Indeed, the relationship is significantly larger than for the full sample. The same is true for the overall dynamic correlations, although the relationship at business-cycle and shorter frequencies remains practically non-existent. However, the results are also more speculative, because the individual regressions use even a lower number of observations.

Thus, we are able to identify some linkages between foreign trade and investments as well as dynamic correlations. More extensive trade ties do increase business cycle correlation, although the effect seems to be felt mostly in the short-run.

6 Exposure to a globalization shock and business cycles of OECD countries

The stylised facts of the previous sections show that the business cycles in China and in the OECD countries are generally speaking not synchronized. Furthermore, the intensity of economic links with China differs quite a lot between the OECD countries. This can influence the business cycles of the individual OECD countries as shown partially in the previous section. In addition to increased synchronisation of movements at particular frequencies, the synchronisation between OECD countries may decline as a result of different exposure to the 'globalization' or 'China' shock. Alternatively, different specialization patterns achieved during the globalization period may lead also to increasing dissimilarities in business cycles of the OECD countries despite similar exposure to trade and financial integration with China and other emerging markets.



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 constructed as 1.96 standard errors. Business cycle frequencies are marked by the shadow area. For better comparison, explanatory variables have been rescaled to yield coefficients of the same size.

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

Therefore, we extend our analysis to the business cycle correlation between the OECD countries (excluding Korea, Mexico and Israel from the previous sample because they are possibly more similar to emerging economies and due to data reasons). We start with the estimation of the traditional OCA endogeneity equation which follows Frankel and Rose (1997) for individual frequencies,

$$\rho_{ij}(\lambda) = \gamma_1(\lambda) + \gamma_2(\lambda) b_{ij} + \upsilon_i(\lambda). \tag{4}$$

where ρ is the bilateral dynamic correlation at frequency λ and b_{ij} stands for trade to GDP ratio of countries i and j. Because estimating (4) by OLS may be inappropriate (see Imbs, 2004), we use two stage OLS.[3] This reflects that bilateral trade flows might be influenced by exchange rate policies. Therefore, trade and FDI intensities have to be instrumented by exogenous determinants of bilateral trade and financial flows. Such instruments are provided by the so-called 'gravity model' (Bussière et al., 2008) including the log of GDP and GDP per capita, log of distance between trading partners, a dummy for geographic adjacency, countries with a common language, and a dummy for the 15 earlier member states of the EU and the NAFTA.

The results are reported in the first upper block of Figure 4. We can see that the positive relationship between business cycle similarities and the degree of trade integration is fully confirmed for the business cycle frequencies as well as for the long-run frequencies in OECD countries. Somewhat surprisingly, the relationship is positive but no longer significant for the short-run frequencies.

In the next step, we extend equation (4) to

$$\rho_{ij}(\lambda) = \gamma_1(\lambda) + \gamma_2(\lambda) b_{ij} + \delta(\lambda) x_i + \delta(\lambda) x_j + \omega_i(\lambda). \tag{5}$$

where x represents the measures of economic and financial integration with China used in the previous section, which enters for both countries i and j. We restrict the coefficient for economic and financial integration with China, δ, to be the same for both countries, as the differences between them are caused by different ordering of the countries in the data matrix. This reflects also that we use only one half of the all possible combinations of n countries, because the indicators are the same (except for possible errors in trade statistics) for the country pair i and j as well as for the pair j and i.[4]

[3] The OLS results are available from the authors upon request.

[4] The sum of both trade shares, $(x_i + x_j)$, used in equation (5) is highly correlated with $|x_i - x_j|$. By intuition, the smaller x_i and x_j, the smaller $|x_i - x_j|$. In our sample, the correlation coefficient is 0.87 for the ratio of export to China to GDP of OECD countries. The results for estimations using the difference in absolute terms are available upon request

In contradiction to trade integration between OECD countries, Figure 4 shows that x has negative sign and is highly significant especially at the longer-term business cycles 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 to China has a negative effect on country's synchronisation with business cycles of other OECD countries. For the short-run frequencies, the estimated coefficients are insignificant and in few cases they have positive signs.

In all estimations, the effects of bilateral OECD trade intensity remains positive and significant for the business cycle frequencies (especially those at the right-hand spectrum). However, the size of the coefficients is slightly lower in all estimations when economic ties with China are included.

7 Conclusions

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

We show that the interdependence between the economic development in China and in developed economies is generally relatively small. However, many countries show a relatively high correlation of the short-run fluctuations. Many transnational companies use China as a significant part of their production chain, 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 (cycles with periods between 1.5 and 8 years). It seems that countries with more intensive economic and financial relationships with China also have higher dynamic correlation with Chinese economy. This seems to be especially true with regards to long-term developments.

Overall, our results confirm a 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) have also more similar cycles with China over all frequencies. Despite the increased trade links between the countries, Chinese business cycle remains in general rather different from the rest of the world.

from authors.

Finally, we show that countries engaged intensively in trade 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 strengthen 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 dissynchronization effects of trade specialization between China and OECD countries on their business cycles as described by Krugman (1993), while synchronization effects prevail between the OECD countries (Frankel and Rose, 1998).

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