National and Sectoral Integration of Chinese and Russian Stock Market with World Markets

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Abstract

In this paper we empirically assess the degree of stock market integration of Russia and China vis-à-vis the euro area, United States and Japan (on both national and sectoral levels) using weekly data covering 9/1995–10/2010. Our first goal is to check how strong the financial links among these countries at the national level are. Our second goal is to test for stock market integration of China and Russia with the euro area, US and Japan at the level of 16 sectors. Our analysis is unique for several reasons. First, it is the first application of beta- and sigma-convergence to the Chinese and Russian stock markets vis-à-vis the world stock markets, namely the US, the euro area and Japan. Second, we apply these approaches not only on the national, but also on the sectoral level. Third, our analysis identifies the effects of recent financial crisis on these sectors and markets.

JEL Codes: C23, G15, G12.
Keywords: Financial integration, beta-convergence, sigma-convergence, stock markets, China, Russia, sectoral and national analysis

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Nontechnical Summary

As stock markets grow in size, they represent an increasingly important but not yet well-examined segment of the financial system. Our main objective is to test for the existence and determine the degree of financial integration of the Chinese and Russian stock markets with the world markets, i.e. with the euro area, US and Japan. The analysis is performed at the country level (using national stock exchange indices) and at the sectoral level (considering 16 sectors: airlines, automobiles, banks, beverages, brewers, chemicals, electricity, financials, industrials, mining, oil and gas, pharmacy, real estate, software, telecom and utilities). Our empirical evaluation consists of (i) the application of the concept of beta-convergence (to identify the speed of integration) and (ii) the application of sigma-convergence (to measure the degree of integration).

This paper addresses the following three main questions, similar to those raised earlier by Adam et al. (2002) with respect to the euro area: *(i) Is there convergence of stock markets on the national and sectoral level between China and Russia on one side and the US, the euro area and Japan on the other side? (ii) If there is convergence, how fast is it? (iii) How does the degree of financial market convergence change over time? In particular, what are the effects of the current financial crises on stock markets, especially in China and Russia?*

Overall, we find evidence of beta-convergence of return differentials between China and Russia, and with respect to the euro area, US and Japan. Convergence is observed at both national and sectoral levels. Beta-convergence means that return differentials are not persistent; in other words, returns in either China or Russia cannot permanently deviate from the returns in other countries (no arbitrage possibilities, taking into account country-specific risk factors). We find that shocks, which are represented by deviations of returns vis-à-vis benchmark countries, dissipate with the half-life of about two to four days. We do not find a systematic effect of the current crisis on beta-convergence; the speed at which shocks dissipate has been already quite fast.

Contrarily to the beta-convergence, sigma-convergence clearly changes over time and the effects of the current (and past) financial crises are well tracked. We find overall evidence of sigma-convergence since the end of Asian 1997 and Russian 1998 crises till 2006/2007, followed by sharp divergence afterwards and sings of convergence since the beginning of 2009. Moreover, sigma-convergence shows strong sector specific patterns. In particular, at the sectoral level, there is a pronounced difference in sigma-convergence between Russian and Chinese stock markets: In China, sectoral results practically mimic the national ones vis-à-vis the US, the euro area and Japan, suggesting little room available for diversification across sectors (in other words, we observe evidence of the so-called national factor). On the other hand, in the case of Russia, we discover significant differences in sectoral patterns of sigma-convergence of return differentials. Thus, sector-specific factors/shocks dominate.

1. Introduction

As financial markets expand, their fluctuations have stronger effects on real economic variables such as private consumption. Thus, along with a number of benefits, financial integration brings certain costs; a detailed discussion of the costs and benefits of financial integration is provided by Agénor (2003). It is widely believed that the benefits outweigh the costs, provided that mechanisms of controlling for financial stability are implemented. The importance of the financial integration is also emphasized by many policy makers, for example, Trichet (2008, 2007, 2006, 2005), Papademos (2008a, 2008b) or Yam (2006).

Integration of financial markets (e.g. money, credit, bond, and equity markets) plays the key role in assuring the effective transmission of the common monetary policy, which is important particularly in the monetary union. A high degree of financial market integration implies that world-wide shocks dominate; hence, the common monetary policy can be effectively applied to react to common shocks. On the other hand, in the case of weak financial market integration, local (i.e. country-specific) shocks prevail, which diminishes the effectiveness of the common monetary policy. In addition, financial integration changes the structure of the financial system. The assessment of financial integration in the region brings further motivation to this study.

This paper focuses on financial integration among stock markets in China and Russia in comparison with the US, the euro area and Japan. As stock markets grow in size, they represent an increasingly important but not yet well-examined segment of the financial system. Our main objective is to test for the existence and determine the degree of financial integration of the Chinese and Russian selected new member states relative to above mentioned financial markets. The empirical analysis is conducted at the country level (using national stock exchange indices for 3 benchmark territories, i.e. United States, the euro area and Japan and at the sectoral level (considering 16 sectors: airlines, automobiles, banks, beverages, brewers, chemicals, electricity, financials, industrials, mining, oil and gas, pharmacy, real estate, software, telecom and utilities).

How can the degree of financial market integration be measured in practice? Financial market integration is a broad concept. Baele et al. (2004) propose to quantify financial integration using three main dimensions, namely (i) price-based, (ii) news-based and (iii) quantity-based measures. The first class of measures could be viewed as a direct check of the law of one price on the condition that the compared assets have similar characteristics. Price-based measures can then be quantified by means of, for example, beta- and sigma-convergence. The second class of measures makes it possible to identify existing market imperfections such as frictions and barriers, because in the integrated area new information of a local character should have a smaller impact on particular assets than global news. The third class of measures quantifies the effects of mainly legal and other non-price frictions and barriers from both the supply and demand sides of the investment decision-taking process.

In this paper we make use of the price-based approach to measure stock market integration, while fully acknowledging the importance of alternative measures.[1] Adam et al. (2002) argue

[1] Quantity-based measures require the use of different data and estimation techniques; such an analysis could be a subject for future research.

that "financial markets are integrated when the law of one price holds."[2] Given this definition, stock market integration implies convergence of returns on assets that are issued in different countries and generate identical cash flows – see Adjouté and Danthine (2003), Baele et al. (2004) and Bekaert and Harvey (1997). In a hypothetical example of perfectly integrated stock markets, assets which have the same risk factor and yield are priced identically by the markets, regardless of the particular location where such assets are traded. Identifying such assets is a difficult task, however.

In reality, the law of one price could not hold true in the case of different assets, i.e. different national stock exchange indices, which are calculated based not on the same underlying stock exchange assets. In addition, the law of one price does not necessarily hold true in the presence of market frictions. Nevertheless, while the law of one price represents rather a very long-term phenomenon, an alternative argument for why we could expect equalization of stock market returns in the long- to medium-run is based on the Walras law of markets as applied to the financial system: if n–1 (financial) markets are in equilibrium (i.e. the exchange rate, money and bond markets), then the last (stock exchange) market cannot be in disequilibrium. Another reason for convergence in stock market returns is based on the practical investor's point of view, where assets are considered on sectoral rather than on national levels. Indeed, the investments of many funds are made based on a general index which includes shares of different territories (for example, the Morgan Stanley Capital International index, MSCI). It is for this reason that we include in our analysis both national and sectoral stock market indices. Furthermore, it can be seen that liberalization of capital movements and removal of barriers for institutional investors, but also globalization of businesses lead to integration of stock markets.

Notice that even if the underlying assets are not identical, comparing asset returns gives insight into their degree of synchronicity. Co-movement between asset returns could then be due to similarity of the underlying assets, to common shocks, or to a mixture of both effects.

This paper addresses the following three main questions, similar to those raised earlier by Adam et al. (2002) with respect to the euro area: *(i) Is there convergence of stock markets on the national and sectoral level between China and Russia on one side and the US, the euro area and Japan on the other side? (ii) If there is convergence, how fast is it? (iii) How does the degree of financial market convergence change over time? In particular, what are the effects of the current financial crises on analyzed stock markets?*

The structure of the paper is as follows. Section 2 briefly discusses the relevant literature focusing on the integration of stock markets generally and point out studies which was oriented to the Chinese and Russian stock markets. Section 3 provides some stylized facts on the development of the Chinese and Russian stock markets at the national level and at the sectoral level (considering 16 sectors: airlines, automobiles, banks, beverages, brewers, chemicals, electricity, financials, industrials, mining, oil and gas, pharmacy, real estate, software, telecom and utilities). Section 4 provides a discussion of the theoretical approaches to estimating financial integration. Section 5 gives an empirical evaluation of the financial integration. Section 6 concludes.

[2] See also Baele et al. (2004) and Goldberg and Verboven (2001).

Our analysis is unique for several reasons. First, it is the first application of beta- and sigma-convergence to the Chinese and Russian stock market with world stock markets, i.e. United States, European and Japanese stock markets. Second, we apply these approaches not only to the national, but also to the sectoral level. Third, we identify the effects of the recent financial crisis.

2. Review of the Literature

The research on stock market integration is largely conducted as applied to the developed OECD countries and the Asian emerging markets.[3] With regard to Western Europe, analysis of capital market integration on national levels is reported by the European Commission (1999) and by Hartmann, Maddaloni and Manganelli (2003); analysis on national and sectoral levels is performed by Baca, Garbe and Weiss (2000) and Heston and Rouwenhorst (1995). Portes and Rey (2005) employ the gravity equation framework to describe the determinants of cross-border equity flows. A new aspect – change of integration over time – is introduced by Bekaert and Harvey (1995), who construct a time-varying measure of financial integration. Overall, their results show that world capital markets are becoming more integrated. Yet on the individual country level there are some cases of declining integration. Applying an alternative time-varying approach, Ayuso and Blanco (2000) find that financial market integration between the stock markets of the euro area countries increased during the 1990s. Besides this, Bekaert, Campbell and Lumsdaine (2000) find that when structural breaks in the series are accounted for, the degree of integration among emerging equity markets is higher than was thought before. The impact of the introduction of the euro on capital markets has been studied by, for example, Hardouvelis, Malliaropulos and Priestley (2006). The degree of integration is found to have increased with the formation of the European Monetary Union (EMU), particularly since 1995.[4]

A number of studies evaluate the extent of stock market integration in non-OECD countries. Piesse and Hearn (2002) employ the co-integration approach to test for long-run relationships and Granger causality links between equity market indices in the Southern Africa Customs Union countries. Several cases of co-integration are reported. Applying similar techniques, Azman-Saini et al. (2002) find limited evidence of long-run relationships among five Asian equity markets. Yang et al. (2003) present further evidence on co-movements among ten Asian emerging stock markets and in relation to the U.S. and Japan. A distinction is made between long- and short-run linkages, and the Asian financial crisis of 1997–1998 is explicitly controlled for. The degree of integration among Asian countries is found to increase for a post-crisis period; particularly strong financial linkages are detected during the crisis episode. Phylaktis and Ravazzolo (2002), by simultaneously examining financial and economic linkages for Pacific-Basin countries, report that "financial integration is accompanied by economic integration" (p. 23). This observation gains relevance for the new EU member states, which are in the process of economic integration with the euro area.

[3] Solnik (1974) started to solve similar problems in the course of the 1970s in order to determine optimum trends in international capital diversification.

[4] Ekinci, Kalemli-Ozcan and Sorensen (2007) report striking evidence of a low degree of capital market integration among the mature EU members, as compared to the theoretical prediction and as judged against the United States.

2.1 Application to China

The research applied to China financial integration by means of different techniques and approaches could be divided to three main categories – (i) among mainland China (mainly between Shanghai and Shenzen market), (ii) among greather China[5] (mainland China, Hong Kong and Taiwan), (iii) among mainland or greater China in comparison with other countries and (iv) sectoral analysis of the Chinese stock market. Our paper includes the empirical analysis of the above mentioned dimensions (iii) and (iv).

Huang, Yang and Hu (2000) confirmed cointegration linkages between Shanghai and Shaenzen stock exchange market and their significant feedback relationship. Los and Yu (2008) applied advance signal processing with the aim to detect the degree of persistence, stationarity and independence among Chinese A and B Shanghai and Shenzen mainland market. They found gradual improvement in these characteristic, which is in line with the process of deregulations. Mainland Chinese stock markets behave efficiently, i.e. more like Geometric Brownian Motions process, and are integrated to one Chinese stock market.

Huang, Yang and Hu (2000) studied causality and cointegration relation among the US, Japan and greater China. He showed that returns behavior from US market have stronger influence to greater China than to Japanese market. These US returns could be used to predict those from Hong Kong and Taiwan returns by 1 day. Goenewold, Tang and Wu (2004) focused on integration among greater China stock exchange markets, i.e. mainland China, Hong Kong and Taiwan by means of Granger-causality tests. They results confirm no week existence of interconnection between mainland China and two other highly developed markets. Hatemi and Roca (2004) also study integration among greater China and Singapore using the causality test based on the bootstrap method. They found gradual rising interdependency of mainland China, Hong Kong and Taiwan after 1997 Asian crises.

There is relatively broad group of papers, which investigate the integration of mainland China or greater China stock market vis-à-vis other stock markets. Bahng and Shin (2003) study, by means of the VAR models, the existence of asymmetric responses among national stock exchange indices of China, Japan and South Korea. They found, among others the existence of pattern asymmetry between all three indices and importantly accordingly to the variance decomposition of the forecast errors the Chinese index was the least explained by the variations of other two markets. Similarly, when the US index was incorporated to such analysis, the US effect was not found on China. Hsiao, Hisiao and Yamashita (2003) used pairwise and VAR analysis and Granger causality test to identify among others the financial linkages in terms of daily stock prices indices between the US and Asia-Pacific region and to test the of these linkages. They confirm that the drop in the US stock market will not cause similar behavior in the Chinese mainland stock market, but will cause Japan, Korea and Taiwan. These results from earlier studies are also still confirmed by more recent ones. Girardin and Liu (2007) investigate whether the Chinese A-share market is integrated on the national level with the European, US and Hong Kong markets. They applied cointegration method to daily, mid-week and average week data from 10/1992 to 3/2005, with different result – no cointegration for daily and mid-week data and evidence of cointegration between Chinese Shanghai A-share market and European S&P500. Groenweold et al. (2008) or Li (2007) also point at isolation of Chinese stock markets. Meric et al. (2006) used weekly

[5] mainland China, Honk Kong and Taiwan

returns of stock market indexes. He found relative isolation of Chinese stock market from the world market. Kozluk (2008) found that Chinese stock markets are „almost completely separated from global affairs", however „strongly inter-related" within themselves.

The sectoral analysis of Chinese stock market is much less elaborated in comparison with analysis of national stock exchange indices. To our knowledge, we found only paper by Demirer and Lien (2005) and indirectly as well as by Kozluk (2008), which are oriented to Chinese market. Demirer and Lien (2005) study firm-level returns among Chinese stock exchange through return dispersions. They present Granger-causality test and correlations with the view to detect their behavior during bull and bear markets. When a majority of investors were buying stocks, the correlation were markedly higher compare to the opposite situation.

2.2 Application to Russia

The similar investigation to Russia was made with relatively better results related to the speed and level of financial market integration. Anatolyev (2005) does not find a robust evidence for rising stock market integration, at either regional or sectoral levels. However, there is an indication of recently rising spillovers from world stock markets, particularly from the European ones. Meric et al. (2006) using weekly returns of stock market indexes, found evidence of stock market co-movement of Russia with Eastern Europe. Kozluk (2008) found that Russian stock market behave like „typical" emerging market. Besides, Russian stock market behavior is particularly linked to Central and Eastern European Stock Markets.

3. Development of the Chinese and Russian Stock Markets: Stylized Facts

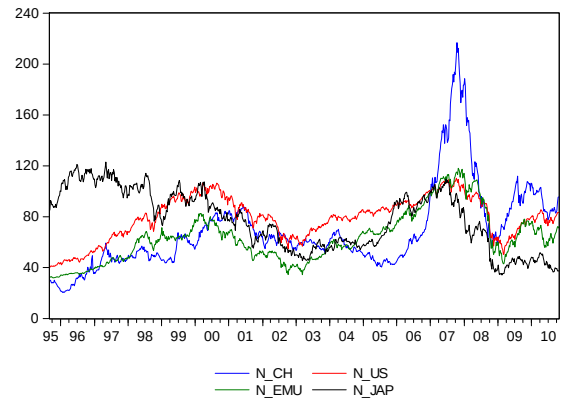
3.1 National Stock Market Indices

Figure 1 displays the history of stock exchange indices in China and Russia compared to benchmark territories, i.e. United States, the euro area and Japan, dating back more than ten years. We apply the price-based approach to these countries[6], which currently have similar exchange rate arrangements and therefore accommodate exogenous shocks in a similar way. Nevertheless, we cannot distinguish between genuine financial integration (integration of the legislative system, of markets, etc.) and the effects of common shocks in a satisfactory way. From this point of view we measure the degree of financial synchronization rather than financial integration.

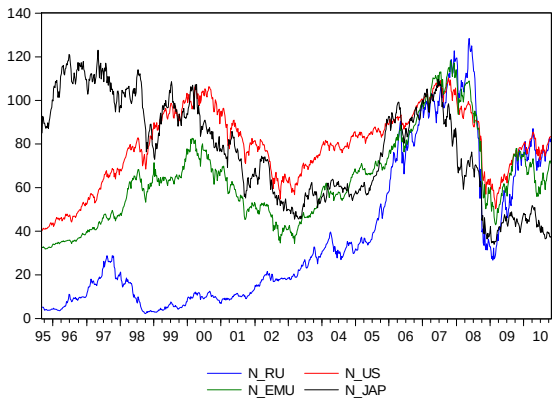
[6] See Section 4.

Figure 1: National stock market indices

a) China with benchmark countries



b) Russia with benchmark countries



Source: Thomson DataStream.
Notes: CH – China, EMU – the euro area, JAP – Japan, RU – Russia, US – United States. The stock market indices were first expressed in USD equivalents in order to account for nominal exchange rate changes, then rescaled taking the first observation of 2007 as 100.

It can be seen that the stock exchange indices of China and Russia jointly increase until the Russian crisis in August 1997, then again from 2005 and finally sharply drop between September 2007 and November 2008, followed by gradual recovery afterwards. Interestingly, a sharp increase of the Chinese and Russian index can be observed from approximately the beginning of 2006 until the Lehman Brothers collapse. Next, *Table 1* describes all employed stock-exchange indices, including their mnemonic, data source and time period for which the data are available and used in our analysis.

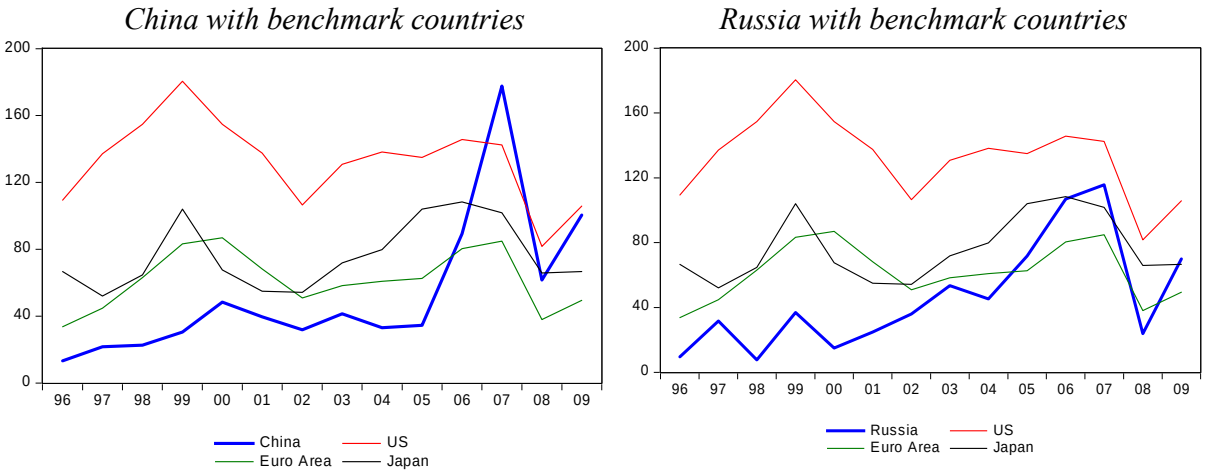
Table 1: National stock market indices

Code	Country	Index	Mnemonic	Coverage
CH	China	SHANGHAI SE A SHARE - PRICE INDEX	CHSASHR	09/1995-10/2010
EMU	Euro Area	DJ EURO STOXX $ - PRICE INDEX	DJEURS$	09/1995-10/2010
JAP	Japan	NIKKEI 225 STOCK AVERAGE - PRICE INDEX	JAPDOWA	09/1995-10/2010
RU	Russia	RUSSIA RTS INDEX - PRICE INDEX	RSRTSIN	09/1995-10/2010
US	USA	S&P 500 COMPOSITE - PRICE INDEX	S&PCOMP	09/1995-10/2010

Source: Thomson DataStream.

Figure 2 shows that the highest market capitalization (as % of GDP) is not surprisingly in the United States following by Japan and the euro area. Since 2004-2005 market capitalization for both China and Russia has been sharply increasing, by the end of 2008 being comparable to the levels of US market capitalization (and exceeding the euro area and Japanese benchmarks). The other characteristics of the stock markets under study are summarized in *Figures A1 – A3* in the appendix, namely the number of listed domestic companies, market capitalization of listed companies (as % of GDP and in USD) and the total value of traded stocks (as % of GDP, in USD and as turnover ratio in %). These indicators cover the time period from 1995 to 2009.

Figure 2: Stock market capitalization *(as % of GDP)*



Source: WDI, World Bank.

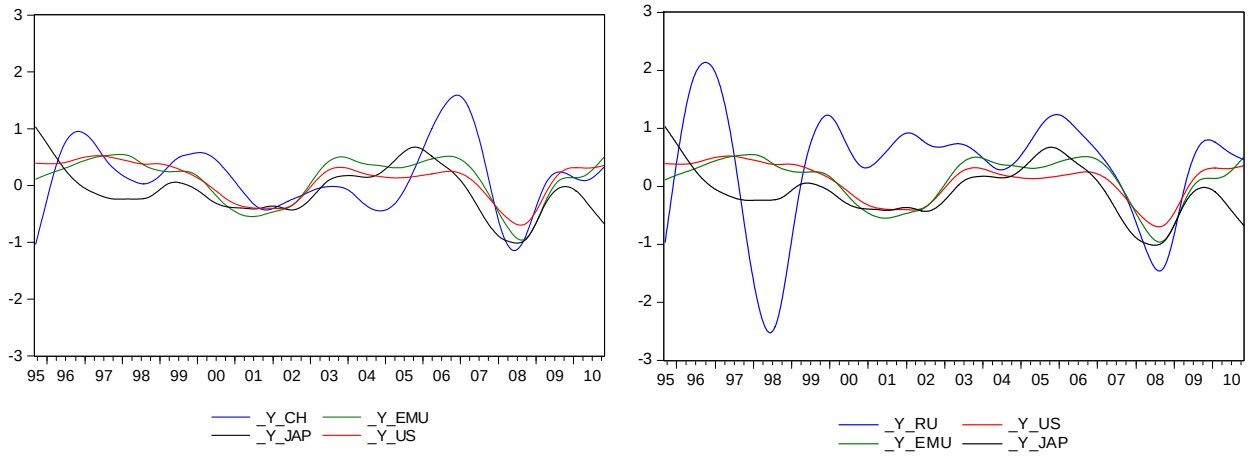
Based on the national stock exchange indexes, available over 9/1995–10/2010 at daily frequency, we construct the weekly averages to be used in our analysis. *Figure 3* shows the trends in the yields of the national stock market indices. Trend values are obtained by means of the Hodrick-Prescott filter with the smoothing parameter $\lambda = 270\,400$, which corresponds to weekly data. All original series are found to be integrated of order one. The yields of these series appear to be stationary, according to the standard unit root tests (ADF and PP) and the alternative non-stationarity test (KPSS)[7].

Interestingly, from the second half-year of 2008 we observe the above-average growth of the yields, which is similar to the pre-crisis period. From *Figure 3* it can be also seen that in the case of Russian stock market the current financial crisis has slightly lower effect on the Russian stock market compared to the previous, so called Asian (1997) and Russian (1998) crises. On the other hand, for other monitored countries the current financial crisis has much stronger effects than previous turbulent episodes during the examined period (9/1995–10/2010). The levels of yields are on average higher in the case of China than Russia compared to the benchmark countries. Furthermore, the dynamics of yields and also indices among benchmark countries look similar, which implicitly gives an indication of substantial stock market integration. This will be formally tested in our analysis.

[7] The results are available upon request. ADF – Augmented Dickey Fuller test, PP – Phillips-Perron test (for both tests, the null hypothesis is that the series has a unit root), KPSS – Kwiatkowski, Phillips, Schmidt and Shin test (the null hypothesis is that the series is stationary).

Figure 3: Yields of the national stock market indices (9/1995 – 10/2010)

China with benchmark countries *Russia with benchmark countries*



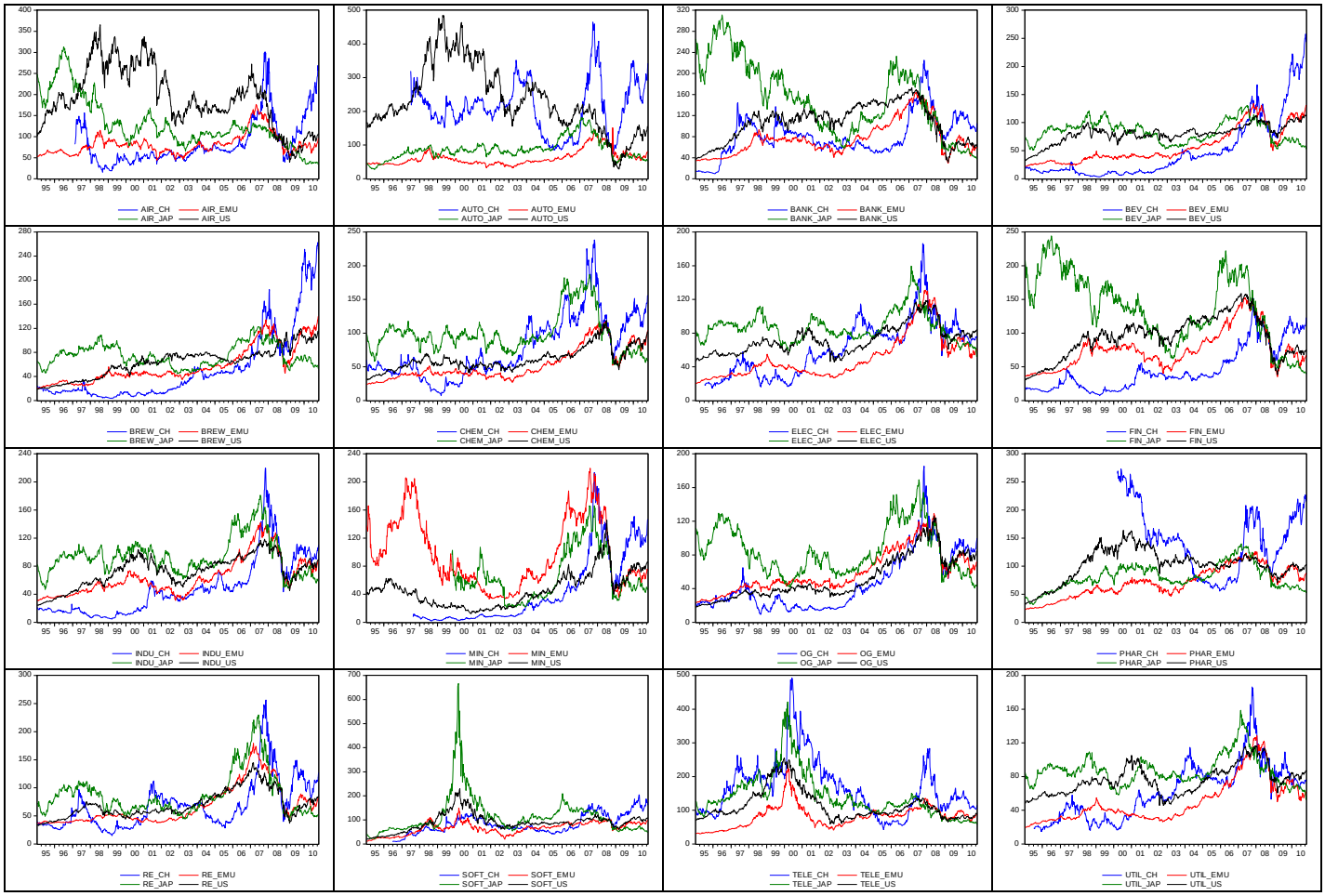
Source: author's calculations based on Thomson DataStream and Bloomberg.
Notes: CH – China, EMU – the euro area, JAP – Japan, RU – Russia, US – United States. Yields Y are calculated as: $Y = 100 * [\ln SE_t - \ln SE_{t-1}]$, where SE denotes the stock exchange index. Trend values are obtained by means of the Hodrick-Prescott filter with the smoothing parameter $\lambda = 270\,400$.

3.2 Sectoral Stock Market Indices

As stock markets become more integrated, the country-specific component in stock returns should decrease. We try to estimate the extent to which stock returns are determined by sector rather than the country effect and hence we also conduct our analysis of sectoral indices for the Chinese and Russian capital markets compared to the benchmark group of countries, namely the United States, the euro area and Japan. *Figure 4 and Figure 5* show the development of the 16 sectoral indices (i.e. airlines, automobiles, banks, beverages, brewers, chemicals, electricity, financials, industrials, mining, oil and gas, pharmacy, real estate, software, telecom and utilities[8]) for both China and Russia, in comparison with the same sectors of the three benchmark territories, namely the euro area, US and Japan. In the case of the Chinese stock market one can see a stronger reaction (i.e. a sharper rise and decline) of the stock exchange indices among most of the sectors comparing to the Russian stock market and also benchmark territories, i.e. the euro area, US and Japan. Furthermore, these sectoral indices can be compared with the national ones (Figure 1), but from this analysis we can not answer a question whether integration is higher on national or sectoral levels.

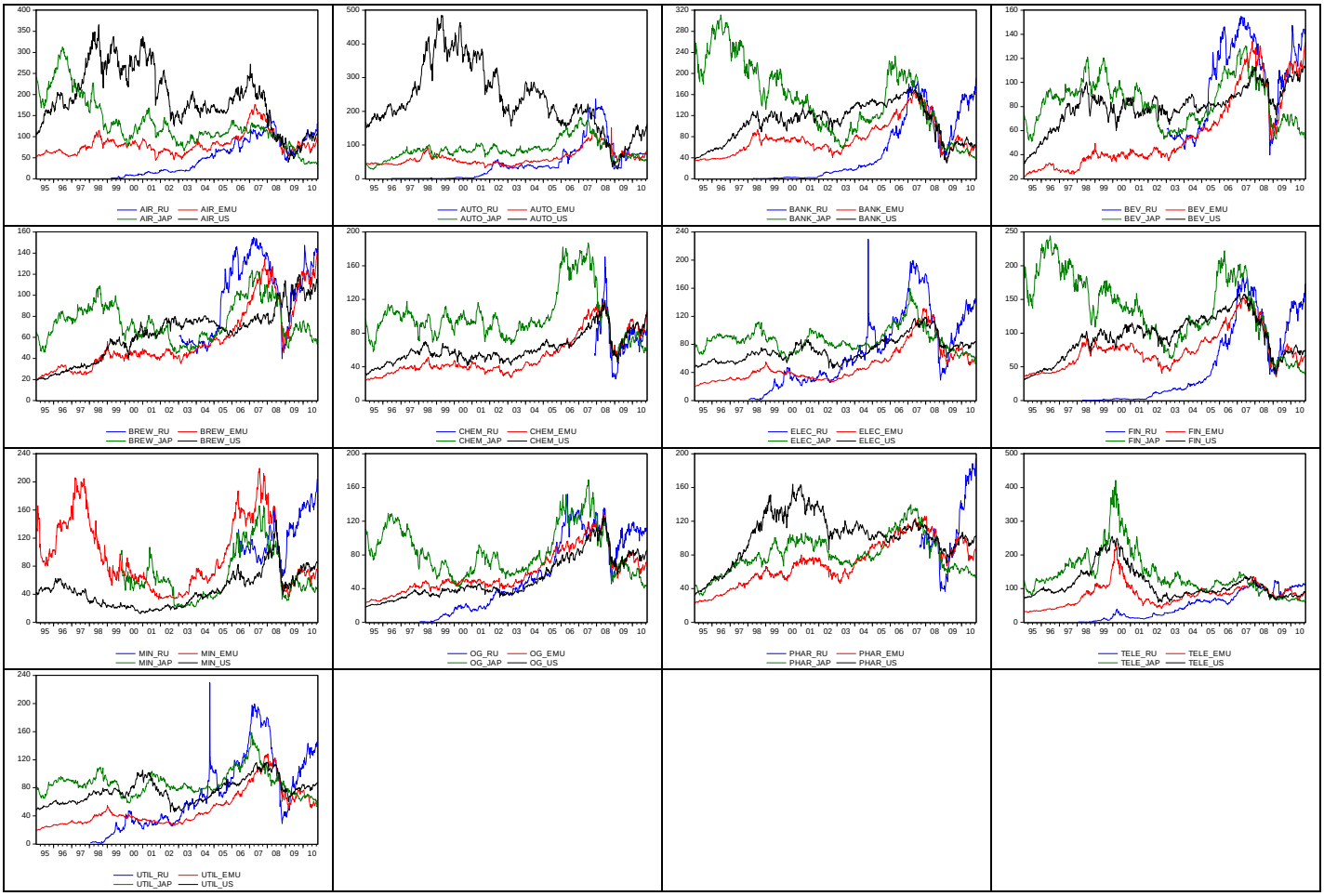
[8] For Russia the data are unavailable for three sectors (INDU – industry, RE – Real Estate and SOFT – software), for four new EU Member States no sectoral indices are available (mainly due to the relatively small size of their stock exchange markets).

Figure 4: Sectoral indices - China against benchmark countries (9/1995 – 10/2010)



Source: Thomson DataStream, Bloomberg.
Notes: AIR – airlines, AUTO – automobiles, BANK – banks, BEV – beverages, BREW – brewers, CHEM – chemicals, ELEC – electricity, FIN – financials, INDU – industrials, MIN – mining, OG – Oil & Gas, PHAR – pharmacy, RE – Real Estate, SOFT – software, TELE – Telecom, UTIL – Utilities; CH – China, EMU – the euro area, JAP – Japan, RU – Russia, US – United States. The stock market indices were first expressed in USD equivalents in order to account for nominal exchange rate changes, then rescaled taking the first observation of 2007 as 100.

Figure 5: Sectoral indices -Russia against benchmark countries (9/1995 – 10/2010)



Source: Thomson DataStream, Bloomberg.
Notes: AIR – airlines, AUTO – automobiles, BANK – banks, BEV – beverages, BREW – brewers, CHEM – chemicals, ELEC – electricity, FIN – financials, MIN – mining, OG – Oil & Gas, PHAR – pharmacy, TELE – Telecom, UTIL – Utilities; CH – China, EMU – the euro area, JAP – Japan, RU – Russia, US – United States. The stock market indices were first expressed in USD equivalents in order to account for nominal exchange rate changes, then rescaled taking the first observation of 2007 as 100.

Table 2 describes data sources of the sectoral stock market indices used in our analysis. The development of the trends of sectoral yields for Chinese and Russian stock market compared to the benchmark territories are illustrated in *Figure 6 and 7*.

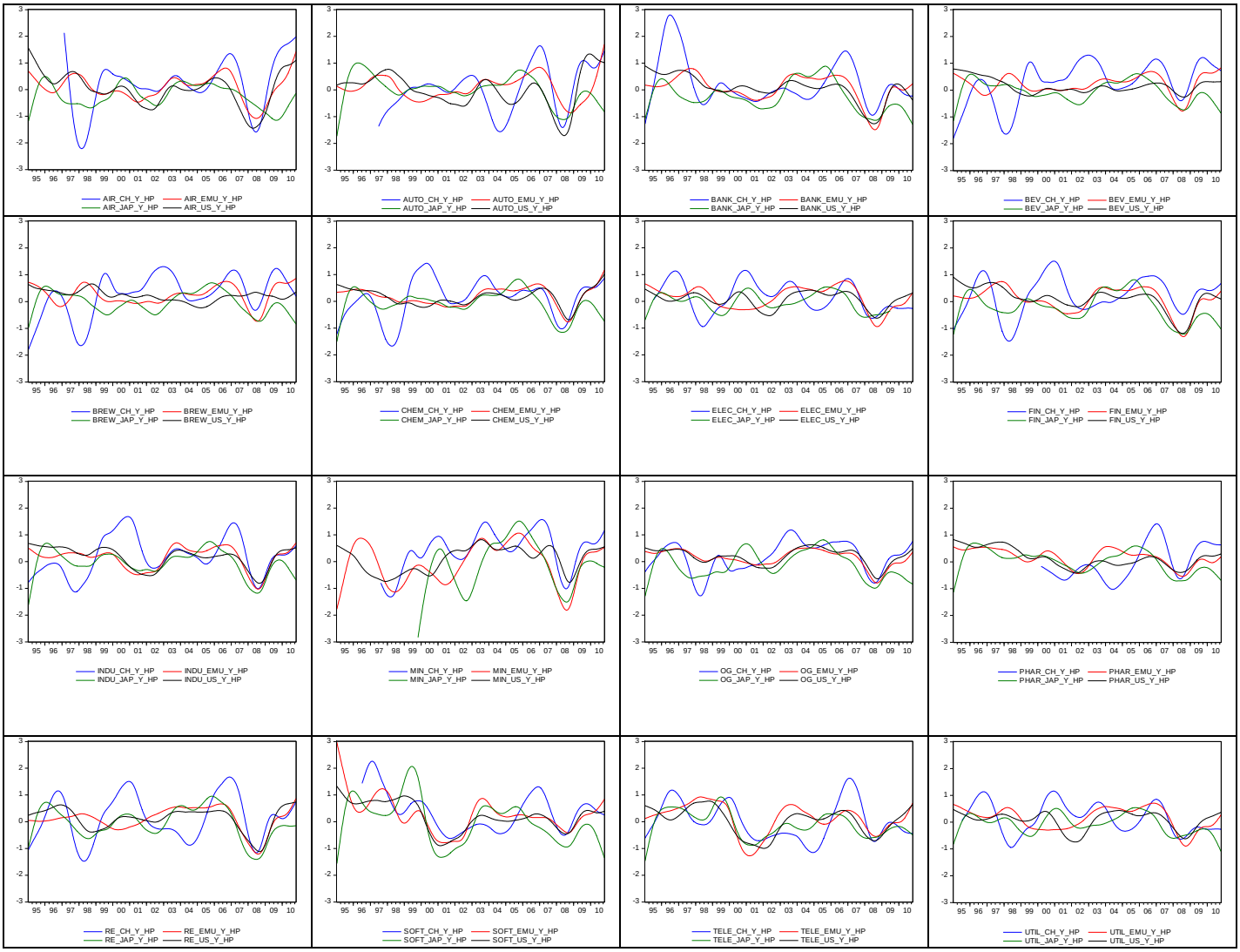
Table 2: Data description of the sectoral stock market indices

Code	Sector	Index	Mnemonics				
			China	EMU	Japan	Russia	USA
AIR	Airlines	#-DS Airlines - PRICE INDEX	AIRLNCH*	AIRLNEM	AIRLNJP	AIRLNRS*	AIRLNUS
AUTO	Automobiles	#-DS Automobiles - PRICE INDEX	AUTOSCA*	AUTOSEM	AUTOSJP	AUTOSRS*	AUTOSUS
BANK	Banks	#-DS Banks - PRICE INDEX	BANKSCA	BANKSEM	BANKSJP	BANKSRS	BANKSUS
BEV	Beverages	#-DS Beverages - PRICE INDEX	BEVESCH	BEVESEM	BEVESJP	BEVESRS	BEVESUS
BREW	Brewers	#-DS Brewers - PRICE INDEX	BREWSCH	BREWSEM	BREWSJP	BREWSRS	BREWSUS
CHEM	Chemicals	#-DS Chemicals - PRICE INDEX	CHMCLCH	CHMCLEM	CHMCLJP	CHMCLRS*	CHMCLUS
ELEC	Electricity	#-DS Electricity - PRICE INDEX	ELECTCH	ELECTEM	ELECTJP	ELECTRS	ELECTUS
FIN	Financials	#-DS Financials - PRICE INDEX	FINANCH	FINANEM	FINANJP	FINANRS	FINANUS
INDU	Industrials	#-DS Industrials - PRICE INDEX	INDUSCH	INDUSEM	INDUSJP	INDUSRS	INDUSUS
MIN	Mining	#-DS Mining - PRICE INDEX	MNINGCH*	MNINGEM	MNINGJP	MNINGRS*	MNINGUS
OG	Oil & Gas	#-DS Oil & Gas - PRICE INDEX	OILGSCH	OILGEM	OILGSJP*	OILGSRS	OILGSUS
PHAR	Pharmacy	#-DS Pharm - PRICE INDEX X)	PHRMCCA *	PHRMCEM	PHRMCJP	PHRMCRS*	PHRMCUS
RE	Real Estate	#-DS Real Estate - PRICE INDEX	RLESTCH	RLESTEM	RLESTJP	RLESTRS*	RLESTUS
SOFT	Software	#-DS Software - PRICE INDEX	SOFTWCA*	SOFTWEM	SFTCSJP	N.A.	SOFTWUS
TELE	Telecom	#-DS Telecom - PRICE INDEX	TELCMCA	TELCMEM	TELCMJP	TELCMRS	TELCMUS
UTIL	Utilities	#-DS Utilities - PRICE INDEX	UTILSCH	UTILSEM	UTILSJP	UTILSRS	UTILSUS

Source: Thomson DataStream, Bloomberg.
Notes: * - shorter periods due to data unavailability; # - general symbol added by authors for appropriate country name, i.e. "CHINA", "EMU", "JAPAN", "RUSSIA", "US"; X) - FTSE W CHINA PHARM & BIO $ - PRICE INDEX (Bloomberg);

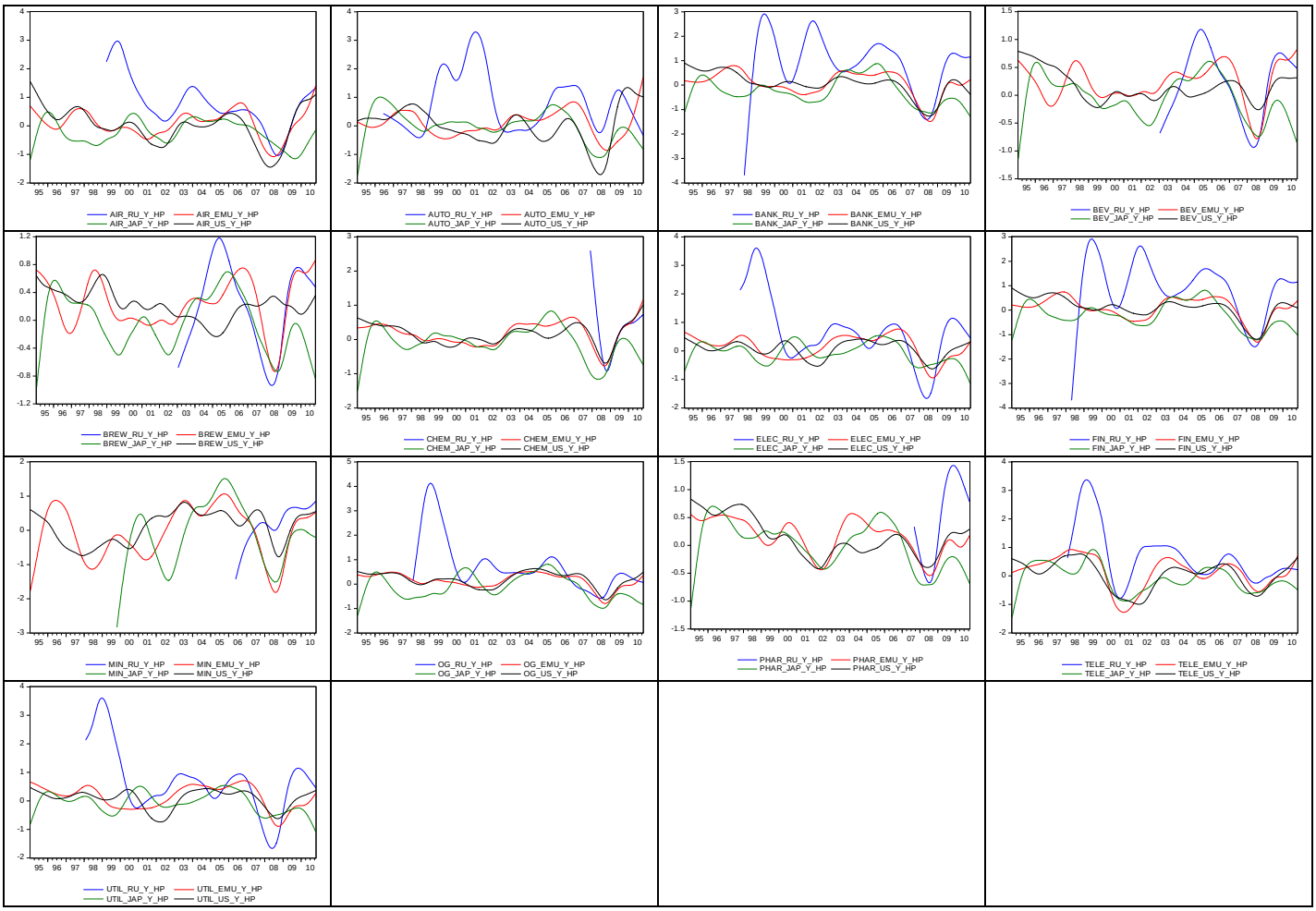
As with the yields of national indices, the sectoral yields are stationary. From *Figure 6* and *Figure 7* one can see several interesting observations, i.e. (i) an opposite cyclical behavior of Chinese and Russian yields in some periods and sectors (for example in airlines, automobile or in brewers sectors) compared to the three benchmark yields, (ii) a lower alignment of some sectors, not only between Chinese and Russian markets, but also among sectors of the European, US and Japanese stock markets (for example in the real estate or mining sectors), (iii) a clear evidence of last crises (Asian and Russian) and bubbles (Dot-com bubble in the beginning of the new millennium and recent bubble preceding the current crisis).

Figure 6: Yields of the sectoral stock market indices – China against benchmark countries



Source: Thomson DataStream and Bloomberg, authors' calculations.
Notes: AIR – airlines, AUTO – automobiles, BANK – banks, BEV – beverages, BREW – brewers, CHEM – chemicals, ELEC – electricity, FIN – financials, INDU – industrials, MIN – mining, OG – Oil & Gas, PHAR – pharmacy, RE – Real Estate, SOFT – software, TELE – Telecom, UTIL – Utilities; CH – China, EMU – the euro area, JAP – Japan, RU – Russia, US – United States. Trend values are obtained by means of the Hodrick-Prescott filter with the smoothing parameter $\lambda = 270\,400$.

Figure 7: Yields of the sectoral stock market indices – Russia against benchmark countries



Source: Thomson DataStream and Bloomberg, authors' calculations.
Notes: AIR – airlines, AUTO – automobiles, BANK – banks, BEV – beverages, BREW – brewers, CHEM – chemicals, ELEC – electricity, FIN – financials, INDU – industrials, MIN – mining, OG – Oil & Gas, PHAR – pharmacy, RE – Real Estate, SOFT – software, TELE – Telecom, UTIL – Utilities; CH – China, EMU – the euro area, JAP – Japan, RU – Russia, US – United States. Trend values are obtained by means of the Hodrick-Prescott filter with the smoothing parameter λ = 270 400.

4. Approaches to Measuring Financial Integration

4.1 Concept of β-Convergence

The concept of β-convergence originated in the growth literature. Following the approach advocated by Adam et al. (2002), we make use of this concept to determine the speed of convergence of returns of the underlying stock market series. This measure involves estimating the following regression (in time series or panel frameworks):

$$\Delta R_{i,t} = \alpha_i + \beta R_{i,t-1} + \sum_{l=1}^{L} \gamma_l \Delta R_{i,t-l} + \varepsilon_{i,t} \qquad (1)$$

where $R_{i,t}$ represents the return spread of specific assets (national or sectoral stock exchange index) between country i and the benchmark rate (Dow Jones EURO STOXX, DJES) at time t, Δ is the difference operator, α_i is the country-specific constant, and $\varepsilon_{i,t}$ is the white-noise

disturbance.[9] The lag length L is based upon the Schwarz information criterion; the maximum length is taken as 4 since we are using weekly data and the memory of stock markets is quite short. The size of β is a direct measure of the speed of convergence in the overall market. To analyze whether the speed of convergence is greater in one period relative to another, one can decompose β as $\beta = \beta_1 I + (1 - I)\beta_2$, where I is a dummy variable that takes on the value of 1 in a particular sub-period. An alternative way to address the dynamics is to put equation (3) into the state-space form:

(2)

$$\beta_t = \beta_{t-1} + \mu_t \tag{3}$$

where β_t is the time-varying parameter and $\varepsilon_{i,t}$ and μ_t are the white-noise disturbance.[10]

Estimates of β_t could be directly obtained by applying the Kalman filter. The interest in using the state-space representation is that it addresses the issue of structural changes: the speed of convergence is allowed to change over time. Details on the space-state model are provided by Bekaert and Harvey (1995); its application to the Czech, Hungarian, Polish and Slovak stock exchange markets is available in Babecký, Komárek and Komárková (2007).

While β-convergence measures the speed of convergence, it does not indicate to what extent markets are already integrated. To answer this question, we have to move to the concept of sigma-convergence, which was also proposed by Adam et al. (2002).

4.2 Concept of σ-Convergence

Like the concept of β-convergence, the concept of σ-convergence was also originally used in the growth literature. Its application to financial markets involves calculating the cross-sectional dispersion in the return spread of specific assets (again national stock exchange indices) as a measure of the degree of integration. In the present context, the degree of financial integration increases when the cross-sectional standard deviation of a variable, such as interest rates, is trending downward (typically one calculates the standard deviation of the log values of the variable of interest). If the cross-sectional distribution collapses to a single point, and the standard deviation converges to zero, full integration is achieved.

For quantification of σ-convergence, a calculation is used of the (cross-section) standard deviation (σ), according to the formula:

$$\sigma_t = \sqrt{\left(\frac{1}{N-1}\right)\sum_{i=1}^{N}\left[\log(y_{it}) - \log(\bar{y}_t)\right]^2} \tag{4}$$

where y_{it} is the yield on asset i at time t, and $\bar{y}_t$ is the cross-section mean yield at time t. Index i can stand for separate countries or sectors (i = 1, 2, …, N). For the purposes of this analysis, we introduce N = 2, i.e. we examine the development of the σ-convergence over time between

[9] To apply this specification, the original series have to be first-difference stationary, which is the case with the national as well as sectoral indices. An alternative empirical strategy to measure financial integration is to make use of the co-integration approach.

[10] We assume that the beta coefficient follows a random walk, since we could not reject the null hypothesis of a unitary autoregressive coefficient.

the benchmark countries (US, the euro area, Japan) and one of the countries or sectors under review . By definition, σ takes only positive values. The lower σ is, the higher the level of convergence that has been reached. In theory, full integration is reached when the standard deviation is zero, while high values of σ reflect a very low degree of integration. For chart-type expression, the results were filtered using the Hodrick-Prescott filter with the recommended weekly time series coefficient $\lambda = 270\,400$.

It is important to note that the two convergence indicators have different information contents: β-convergence does not imply σ-convergence. In fact, β-convergence could even be associated with σ-divergence – see Quah (1993) for further details on this issue. Therefore, we propose both notions of convergence to assess financial integration. β- and σ-convergence are estimated for the China and Russia on the national and sectoral level, in comparison with three benchmark territories and four new EU Member States.

5. Empirical Results

5.1 β-Convergence[11]

The time-series estimates of (1) reveal tat all beta-coefficients are negative and significant; hence there is convergence of stock market returns. The absolute values of the β-coefficient are close to one for all of the countries, which means that the leveling of newly arising differences in return differentials between the relevant national economy and the euro area can be labeled as fast. Indeed, the shock half-life, defined as the period during which the magnitude of a shock becomes half of the initial shock, is less than a week, see *Table 3*.[12] Notice, however, that we can still discriminate between countries, in other words the beta-coefficients do not equal unity in all cases. Should such an outcome occur, the use of higher frequency data (e.g. daily indices) would be more appropriate. Next, a comparison of the periods 1995–1998, 1999-2006 (pre-crisis) and 2007–2010 (crisis) reveals that the pace at which shocks to return differentials dissipate ranges from broadly two to three days and there is no clear systematic pattern regarding the direction of the change. Similarly, on the sectoral level (Table A1 in the annex), the shock half-life is between one and five days, and there are cases of both rising or declining half live over time.

Table 3: Beta-convergence (H-L) of national returns

Country *i*	**China** vis-à-vis country *i*			**Russia** vis-à-vis country *i*		
	1995-1998	1999-2006	2007-2010	1995-1998	1999-2006	2007-2010
China	--	--	--	2.1	1.7	2.2
Euro Area	1.0	2.1	1.1	2.4	1.8	1.3
Japan	0.6	0.9	1.3	2.2	2.1	1.8
Russia	2.1	1.7	2.2	--	--	--
United States	1.1	1.3	1.2	2.1	2.0	1.7

Source: Thomson DataStream and Bloomberg, authors' calculations.
Notes: Half-life (H-L) in the number of days. Lower values mean faster convergence.

[11] Preliminary, based on time-series estimates of (1).

[12] The half-life is calculated as $H\text{-}L = \ln(0.5)/\ln(|\beta + 1|)$. H-L is 0.6 of a week for β equal to 0.7 and 0.3 of a week if β equals 0.9.

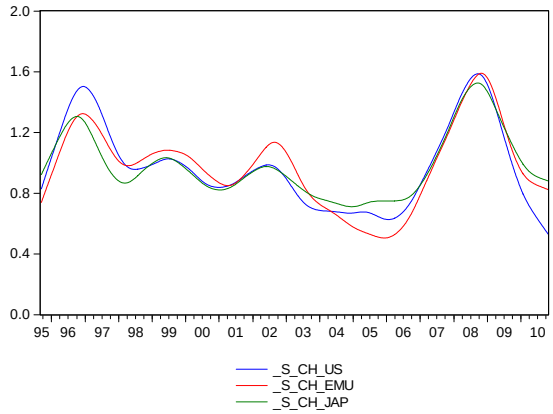
5.2 σ-Convergence

From the patterns of sigma-convergence at the national level displayed on Figure 8 one can draw several features. First, what is common to both Chinese and Russian stock markets is the overall dynamics: rise in return volatility till the Asian (1997) and the Russian (1998) crisis respectively followed by a trend convergence till the mid 2000's, then a sharp increase in volatility since 2006/2007 with correction towards convergence noticeable since the end of 2008/beginning of 2009. Second, while in the past Chinese and Russian stock market experiences roughly similar degree of sigma-convergence with respect to the choice of alternative benchmarks (US, euro area or Japan), since 2008 the convergence vis-à-vis US becomes much lower, particularly for Russia.

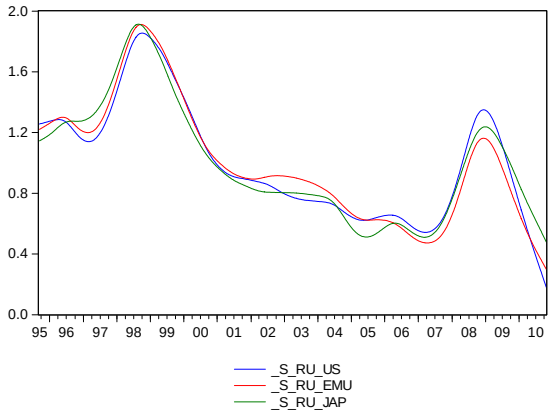
Regarding the country-specific features, in China the current crisis appears to be characterized by higher sigma-divergence (1.6) as compared to the Asian crisis of 1997 (1.3-1.4). However, for Russia the impact of the 1998 crisis on cross-sectional dispersion (1.9) was higher than the present crisis (1.1-1.3).

Figure 8: σ-Convergence on national level

a) China with benchmark countries



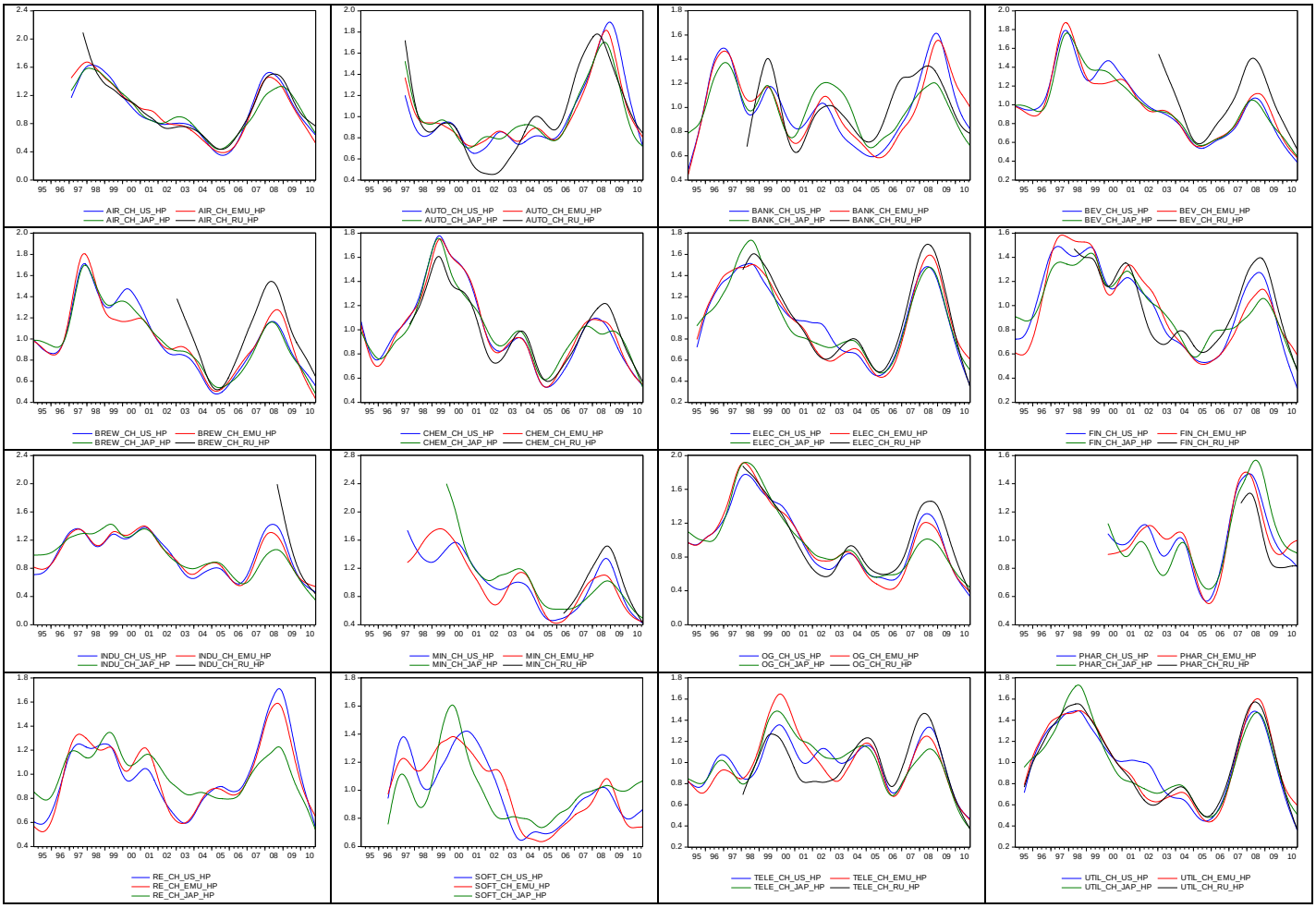
b) Russia with benchmark countries



Source: author's calculations based on Thomson DataStream and Bloomberg.
Notes: CH – China, EMU – the euro area, JAP – Japan, RU – Russia, US – United States. Trend values are obtained by means of the Hodrick-Prescott filter with the smoothing parameter λ = 270 400.

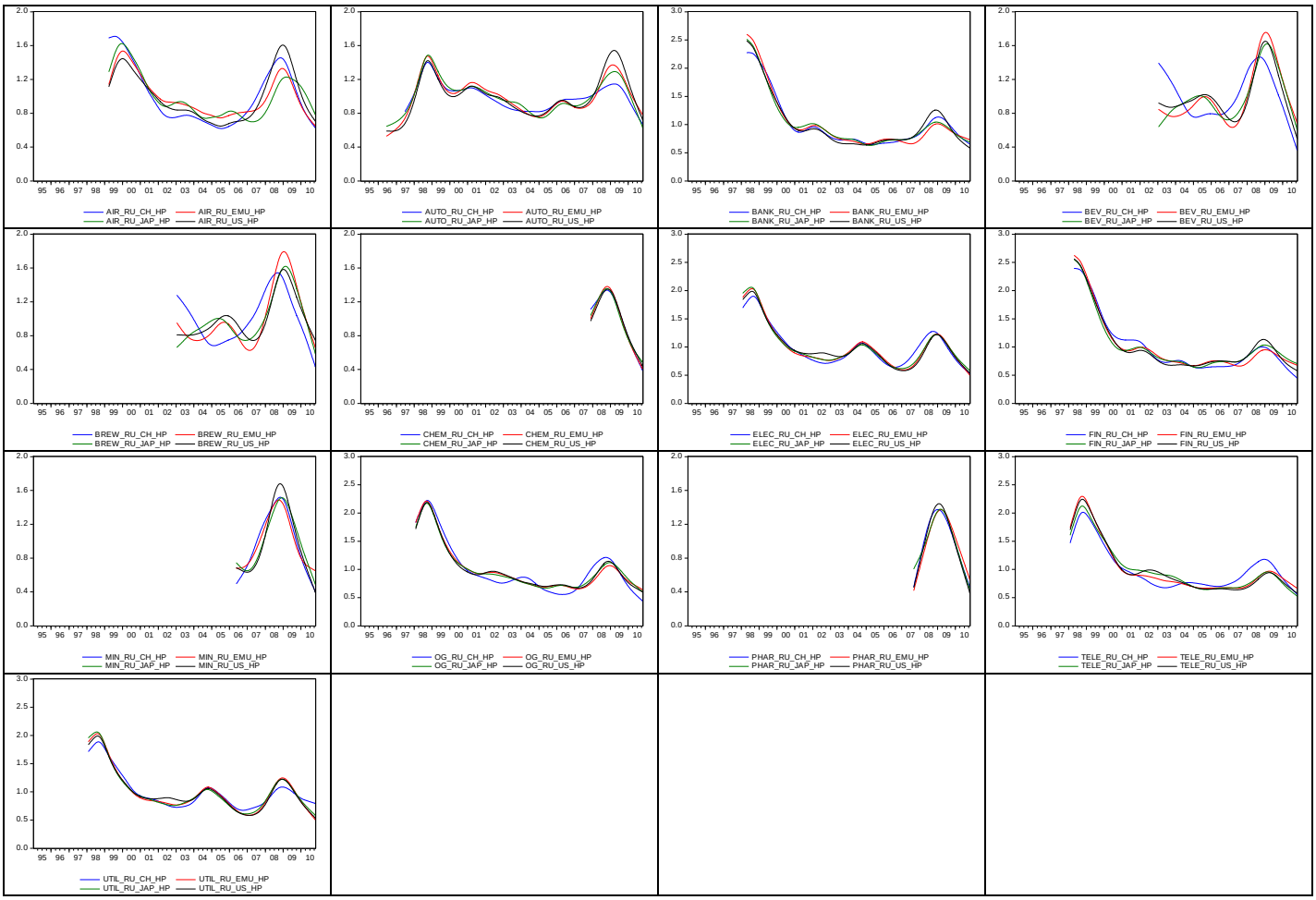
Next, *Figure 9* and *Figure 10* illustrate the levels of stock market integration among all 16 individual sectors against 3 benchmark territories and also the sectoral stock market integration between China and Russia. The development of σ shows: (i) that all sectors have been affected by the current financial crisis, (ii) a clear evidence of previous crises (Asian and Russian) and burst of bubbles (for example the Dot-com bubble) preceding the current crisis, (iii) the most integrated sectors appear to be beverages, brewers, telecom and oil & gas in the case of China and chemical, utilities, electricity and oil & gas in the case of Russia, but the differences among sectors are not enormous, (iv) maybe surprisingly and except some relatively short time period, the integration of Chinese sectors with Russian sectors seems to be similar to their integration with benchmark territories, i.e. the euro area, US and Japan, and (v) there are strong sector specific patterns. While in China sectoral results practically mimic the national ones, suggesting little room available for diversification across sectors, in the case of Russia there are more differences across sectors.

Figure 9: σ-Convergence of China on the sectoral level



Source: author's calculations based on Thomson DataStream and Bloomberg.
Notes: AIR – airlines, AUTO – automobiles, BANK – banks, BEV – beverages, BREW – brewers, CHEM – chemicals, ELEC – electricity, FIN – financials, INDU – industrials, MIN – mining, OG – Oil & Gas, PHAR – pharmacy, RE – Real Estate, SOFT – software, TELE – Telecom, UTIL – Utilities; CH – China, EMU – the euro area, JAP – Japan, RU – Russia, US – United States. Trend values are obtained by means of the Hodrick-Prescott filter with the smoothing parameter $\lambda = 270\,400$.

Figure 10: σ-Convergence of Russia on the sectoral level



Source: Thomson DataStream and Bloomberg, authors' calculations.
Notes: AIR – airlines, AUTO – automobiles, BANK – banks, BEV – beverages, BREW – brewers, CHEM – chemicals, ELEC – electricity, FIN – financials, INDU – industrials, MIN – mining, OG – Oil & Gas, PHAR – pharmacy, RE – Real Estate, SOFT – software, TELE – Telecom, UTIL – Utilities; CH – China, EMU – the euro area, JAP – Japan, RU – Russia, US – United States. Trend values are obtained by means of the Hodrick-Prescott filter with the smoothing parameter $\lambda = 270\,400$.

6. Conclusion

In this paper we have discussed selected aspects of financial integration of Russia and China in the comparison with the euro area, US and Japan financial markets by means of national and sectoral integration. The objective of this paper was to test for the existence and analyze the dynamics of integration in the stock markets with reference to the adopted definition based on the law of one price. Our measures of financial integration were built upon complementary concepts, namely β-convergence (measuring the speed of convergence) and σ-convergence (measuring the degree of financial integration), for which the original series have to be stationary in first differences. The empirical assessment was based on the time series regressions.

Overall, we find evidence of beta-convergence of return differentials between China and Russia, and with respect to the euro area, US and Japan. Convergence is observed at both national and sectoral levels. Beta-convergence means that return differentials are not persistent;

in other words, returns in either China or Russia cannot permanently deviate from the returns in other countries (no arbitrage possibilities, taking into account country-specific risk factors). We find that shocks, which are represented by deviations of returns vis-à-vis benchmark countries, dissipate with the half-life of about two to four days. We do not find a systematic effect of the current crisis on beta convergence; the speed at which shocks dissipate has been already quite fast.

Contrarily to the beta-convergence, sigma-convergence clearly changes over time and the effects of the current (and past) financial crises are well tracked. We find overall evidence of sigma-convergence since the end of Asian 1997 and Russian 1998 crises till 2006/2007, followed by sharp divergence afterwards and sings of convergence since the end of 2008/beginning of 2009. Moreover, sigma-convergence shows strong sector specific patterns. In particular, at the sectoral level, there is a pronounced difference in sigma-convergence between Russian and Chinese stock markets: In China, sectoral results practically mimic the national ones vis-à-vis the US, the euro area and Japan, suggesting little room available for diversification across sectors (in other words, we observe evidence of the so-called national factor). On the other hand, in the case of Russia, we discover significant differences in sectoral patterns of sigma-convergence of return differentials. Thus, sector-specific factors/shocks dominate.

In the future research we would like to: (a) apply on the national and sectoral level advanced empirical techniques such as the state-space techniques as in Babetskii, Komárek and Komárkova (2007) and Bayesian estimates, (b) analyze, how strong is the convergence between Chinese and Russian stock markets vis-à-vis the selected developing economies, especially those of Asia (on the national level[13]), (c) prepare the empirical analysis of the news-based approach as in Babecký, Komárek and Komárková (2009). Another avenue for future research is to assess financial integration under alternative exchange rate arrangements. The degree of accommodation shocks and ultimately financial integration may depend, inter alia, on the particular exchange rate regime, e.g. fixed versus floating.

[13] Sectoral data are not available for the most of developing countries in this region.

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Appendix

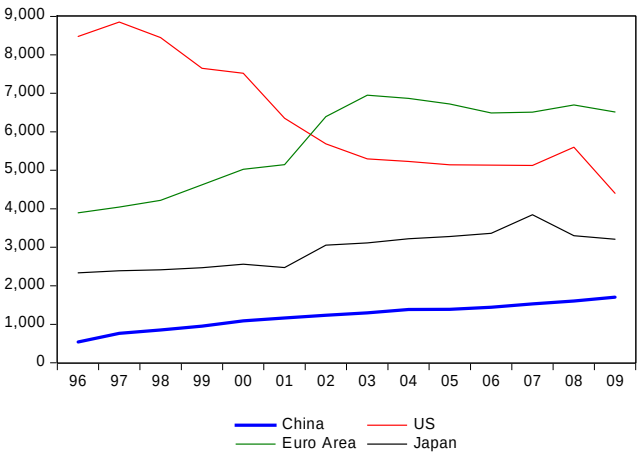
Table A1: Beta-convergence (H-L) of sectoral returns

Sector	Country i	**China** vis-à-vis country i			**Russia** vis-à-vis country i		
		1995-1998	**1999-2006**	**2007-2010**	**1995-1998**	**1999-2006**	**2007-2010**
AIR	United States	2.3	2.3	1.5	n.a.	1.4	1.9
	Euro Area	2.0	2.6	2.5	n.a.	1.4	0.9
	Japan	2.5	2.3	1.6	n.a.	1.5	1.9
AUTO	United States	2.0	0.9	1.5	7.0	1.4	0.7
	Euro Area	1.3	1.4	3.0	7.5	1.6	3.2
	Japan	1.6	2.1	1.2	15.9	1.0	1.3
BANK	United States	2.9	1.7	2.1	2.5	2.3	2.0
	Euro Area	2.9	1.0	1.9	2.1	2.6	1.6
	Japan	2.8	1.3	1.4	2.2	1.5	2.2
BEV	United States	2.5	1.6	1.2	n.a.	1.3	1.4
	Euro Area	2.4	0.8	1.0	n.a.	2.2	1.1
	Japan	2.4	1.1	1.5	n.a.	1.8	1.3
BREW	United States	2.7	1.5	1.5	n.a.	1.6	2.2
	Euro Area	2.4	1.1	1.3	n.a.	n.a.	n.a.
	Japan	2.4	1.5	1.4	n.a.	n.a.	n.a.
CHEM	United States	2.0	2.0	1.8	n.a.	n.a.	1.9
	Euro Area	1.8	2.3	2.1	n.a.	n.a.	1.8
	Japan	1.3	1.9	2.1	n.a.	n.a.	2.0
ELEC	United States	3.2	1.6	6.0	3.2	2.1	1.8
	Euro Area	3.5	0.9	2.2	3.3	1.9	2.0
	Japan	3.8	0.9	1.2	2.9	1.7	0.9
FIN	United States	1.8	2.0	3.3	2.4	2.3	2.5
	Euro Area	1.7	1.9	3.4	2.2	2.7	1.7
	Japan	1.3	1.6	2.2	2.1	1.2	2.3
INDU	United States	2.5	1.9	2.2	n.a.	n.a.	n.a.
	Euro Area	2.7	1.8	2.7	n.a.	n.a.	n.a.
	Japan	2.3	1.2	1.9	n.a.	n.a.	n.a.
MIN	United States	2.3	2.2	2.3	n.a.	2.8	3.1
	Euro Area	2.7	2.0	2.0	n.a.	2.5	1.5
	Japan	n.a.	3.4	2.1	n.a.	1.6	1.3
OG	United States	3.0	2.9	1.9	5.3	2.2	3.2
	Euro Area	2.9	2.8	1.9	4.9	2.2	2.3
	Japan	3.4	2.3	0.9	4.8	0.8	5.0
PHAR	United States	n.a.	2.1	1.4	n.a.	n.a.	1.4
	Euro Area	n.a.	2.6	1.8	n.a.	n.a.	1.6
	Japan	n.a.	1.7	2.0	n.a.	n.a.	2.9
RE	United States	1.7	1.0	1.6	n.a.	n.a.	n.a.
	Euro Area	1.9	1.0	1.4	n.a.	n.a.	n.a.
	Japan	1.1	1.4	1.9	n.a.	n.a.	n.a.
SOFT	United States	1.7	2.2	1.5	n.a.	n.a.	n.a.
	Euro Area	2.0	1.3	2.1	n.a.	n.a.	n.a.
	Japan	1.8	1.5	2.1	n.a.	n.a.	n.a.
TELE	United States	1.7	1.5	1.2	15.4	1.4	2.0
	Euro Area	1.9	0.5	1.6	11.6	0.9	2.1
	Japan	1.5	1.2	1.9	3.8	1.5	2.4
UTIL	United States	3.3	1.5	5.9	3.2	2.2	1.7
	Euro Area	3.4	0.7	2.0	3.3	1.8	1.9
	Japan	3.7	0.9	1.2	2.9	1.7	1.1

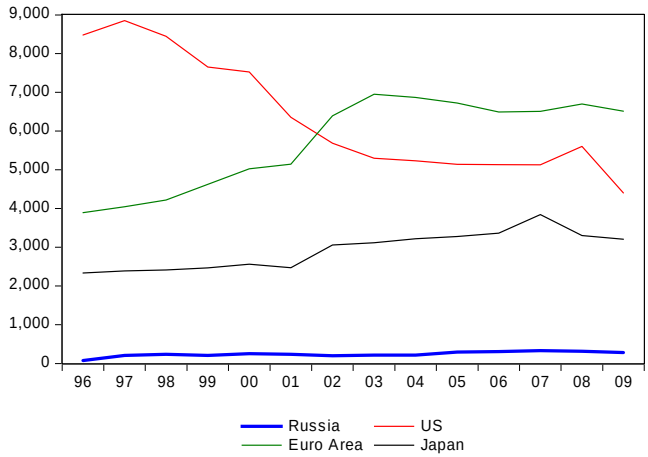
Note: Half-life in the number of days. Lower values mean faster convergence.

Figure A1: Total number of listed domestic companies

China with benchmark countries



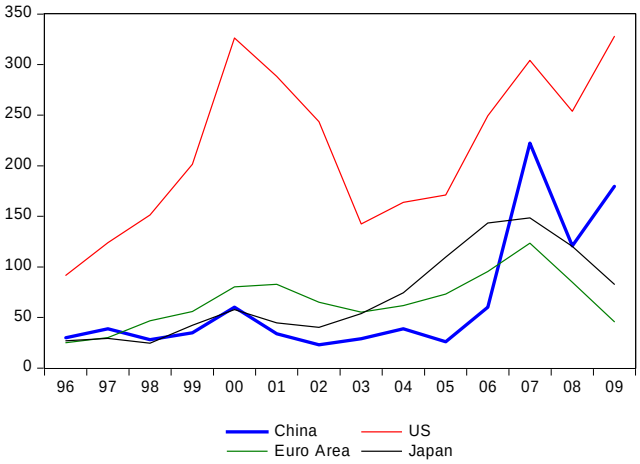
Russia with benchmark countries



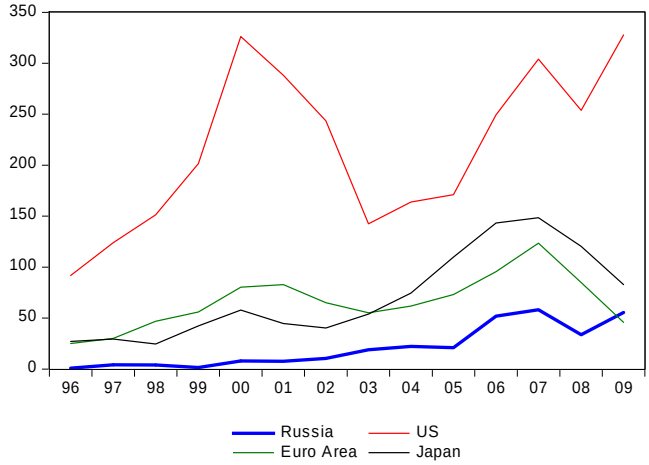
Source: WDI – World Bank.

Figure A2: Stocks traded, total value (% of GDP)

China with benchmark countries



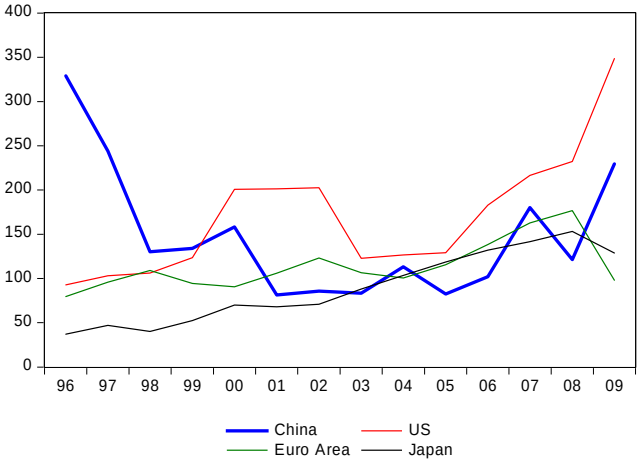
Russia with benchmark countries



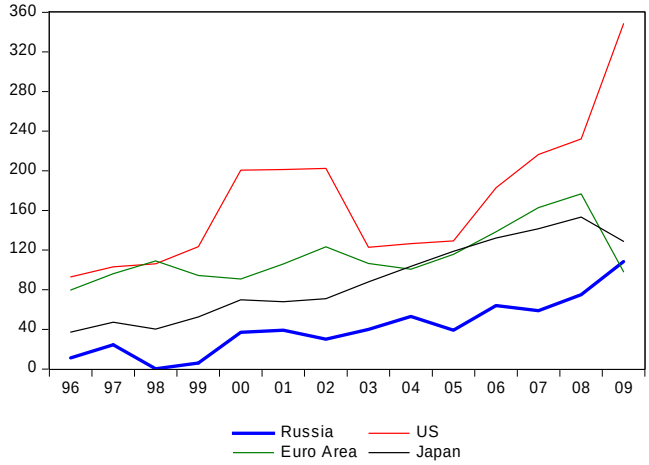
Source: WDI – World Bank.

Figure A3: Stocks traded, turnover ratio (%)

China with benchmark countries



Russia with benchmark countries



Source: WDI – World Bank.