CONVERGENCE OF RETURNS ON CHINESE AND RUSSIAN STOCK MARKETS WITH WORLD MARKETS: NATIONAL AND SECTORAL PERSPECTIVES

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Interest in examining the financial linkages of economies has increased in the wake of the 2008/9 global financial crisis. Applying the concepts of beta- and sigma-convergence of stock market returns, we assess changes over time in the degree of stock market integration of Russia and China with each other, as well as with respect to the United States, the Euro Area, and Japan. Our analysis is based on national and sectoral data spanning the period September 1995 to October 2010. Overall, we find evidence for gradually increasing convergence of stock market returns after the 1997 Asian financial crisis and the 1998 Russian financial crisis. Following a major disruption caused by the 2008/9 global financial crisis, the process of stock market return convergence resumes between Russia and China, as well as with world markets. Notably, the episode of sigma-divergence from the 2008/9 crisis is stronger for China than for Russia. We also find that the process of stock market return convergence and the impact of the recent crisis have not been uniform at the sectoral level, suggesting the potential for diversification of risk across sectors.

Keywords: Stock market integration; beta-convergence; sigma-convergence; China; Russia; sectoral and national analysis

JEL Classifications: C23; G15; G12

1. Introduction

The economic and financial crisis of 2008/9 brought wider awareness that financial integration bundles considerable non-negligible costs with the much-touted benefits. Assessment of the costs and benefits of financial integration dates back to the work of Agénor (2003), who proposes that the benefits of financial integration outweigh the costs when mechanisms for maintaining financial stability are in place.[1] (Examples of these mechanisms are discussed in Agénor *et al*., 2011). When these mechanisms are overlooked, however, the costs of financial integration generated by a crisis can be considerable. Therefore, monitoring the degree of financial integration is useful both in good times, when the long-run benefits of economic growth are realised, and in bad times, when the costs of financial integration (e.g. through contagion) are manifest. Even leading policymakers now note the importance of assessing financial integration in both normal and crisis times (e.g. Trichet, 2010, 2008, 2007; Papademos, 2010, 2008a, 2008b; and Yam, 2006).

While this topic is vast, the objectives of our study are to help resolve mixed findings on the integration of Chinese and Russian stock markets with key world markets. In fact, there is no consensus in the literature on the extent of stock market integration of China and Russia with world markets. In the view of some scholars (e.g. Groenewold *et al*., 2004; Li, 2007; and Koźluk, 2008), Chinese stock markets move largely independently of global movements, while Russian stock markets show evidence of rising integration with global (particularly EU) stock markets (Koźluk, 2008). Other studies reach an opposite conclusion, i.e. Chinese stock markets continue to integrate with the global financial system,

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while the Russian stock market remains isolated. Chow *et al.* (2011) argue that China's stock market has become "more and more integrated" into the world market. Rizavi *et al.* (2011) report stock market integration has deepened between China and its Asian neighbours. The claim of Verchenko (2000) that the Russian stock market is not integrated with the stock markets of neighbouring countries is backed by the assessment of Tirkkonen (2008) on a set of benchmark countries made up of the US, China, Japan, and several EU countries.

To help fill in the gap in the existing literature, we focus on China and Russia to examine stock market integration between these two countries, as well as their integration with global benchmarks including the US, the Euro Area, and Japan. Deepening of trade, economic and financial Chinese-Russian ties[2] raises questions as to the extent to which the two countries' stock markets are interrelated, as well as how these links have evolved over time both in absolute terms and relative to world stock markets.

As we discuss in the literature review, there is substantial empirical evidence on Chinese and Russian stock markets, but few studies that compare links between them, and even fewer works that present disaggregated evidence from sectoral or regional perspectives. Indeed, to our knowledge, there is no study on Chinese and Russian stock market links based on sectoral data. This study also is novel in its examination of stock market integration in China and Russia over time at both national and sectoral levels, and in quantifying the impact of the 2008/9 crisis.

Acknowledging the importance of assessing the cost–benefit aspects of financial integration and the effects expressed in various crises, we focus on quantifying the degree of stock market integration for China, Russia, and key world markets, as well as the time dynamics of this integration over the period 1995–2010. Stock markets continue to grow in size, yet these linkages represent an increasingly important, but mostly ignored, aspect of the financial system. According to Baele *et al.* (2004), financial integration, particularly stock market integration, can be assessed using three types of measures: (1) price-based, (2) news-based, and (3) 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. The second class of measures makes possible identification of existing market imperfections such as frictions and barriers; in the integrated area, new information of a local character should have less impact on particular assets than global news. The third class of measures quantifies the effects of legal and other non-price frictions and barriers from both the supply and demand sides of the investment decision-taking process. We focus on the first dimension, the price-based indicators of stock market integration. They can be operationalised and the required stock market data are available, allowing cross-country comparison. Price-based measures can also be quantified by means of beta- and sigma-convergence. As applied to stock markets, beta-convergence characterises the speed at which differences in stock market returns between individual markets are eliminated, while sigma-convergence captures the dispersion of return differentials and its change over time.

Our study contributes to the literature in addressing the following three questions that have received little attention to date:

1. Is there convergence of stock market returns on the national and sectoral level between China and Russia, or conversely, with the US, the Euro Area and Japan? And if there is convergence, how fast is it?

2. How does the degree of stock market return convergence change over time? In particular, are Chinese and Russian stock markets becoming more integrated with each other or are they integrating with the major global markets such as the US, Japanese or Euro Area stock markets?

3. What are the effects of the current financial crises on analysed stock market integration?

The structure of the paper is as follows. Section 2 discusses the relevant literature focusing on the integration of stock markets generally and on studies that deal mainly with Chinese and Russian stock markets. Section 3 provides stylised facts on the development of Chinese and Russian stock markets at the national and sectoral levels. The fourth section provides a discussion of the theoretical approaches to estimating stock market integration. Section 5 gives an empirical evaluation of stock market integration and compares our findings with previous results in the literature. The last section concludes.

2. Literature review

This section provides an overview of the general studies on stock market integration and some specific works on China and Russia. A price-based concept is explored in these studies and a variety of alternative techniques is used, ranging from beta- and sigma-convergence

of stock market returns to cointegration analysis of stock prices, variance decomposition, and conditional correlations of returns. With regard to Western Europe, an overview of studies on capital market integration at national levels is presented in Hartmann *et al.* (2003); examples of decomposition of stock returns into country- and industry-specific effects are given in studies by Heston and Rouwenhorst (1995) covering the time period from 1978 to 1992 and Baca *et al.* (2000) focusing on 1979–99. Portes and Rey (2005) employ the gravity equation framework to describe the determinants of cross-border equity flows amongst the main world markets in 1989–96.

A new feature – change of integration over time – is introduced by Bekaert and Harvey (1995), who construct a time-varying measure of financial integration. Their results show that world capital markets overall became increasingly integrated in 1975–92, but that delinkage also occurred for some individual countries. 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 period 1990–9. Bekaert *et al.* (2000) also find that the degree of integration amongst emerging equity markets in 1980–96 is higher than previously thought when endogenous structural breaks in the series are taken into account. Applying the time-varying framework along the lines of Bekaert and Harvey (1995), Hardouvelis *et al.* (2006) examine whether steps towards the creation of the Euro Area in 1992–8 were accompanied by stock market integration. The degree of integration is found to have increased with the formation of the European Monetary Union (EMU), particularly since 1995. In contrast, Ekinci *et al.* (2007) propose a new metrics of *de facto* integration and report evidence of a low degree of capital market integration amongst the mature EU members in 1995–2003 relative both to their theoretical prediction and judged against the US. Berger and Pozzi (2011) revisit time-varying integration of stock markets amongst the US, Japan and selected European countries in 1970–2010, deriving the country-specific risk premia upon a capital asset pricing model and a GARCH-type estimation technique. They find evidence of rising stock market integration among all countries, except Japan.

A number of studies evaluate the extent of stock market integration in non-OECD countries. Applying the cointegration approach, Azman-Saini *et al.* (2002) find limited evidence of long-run relationships among five Asian equity markets between 1988 and 1999. Yang *et al.* (2003) present further evidence on co-movements among ten Asian emerging stock markets and in relation to the US and Japan in 1995–2001. They distinguish long- and short-run linkages, and explicitly control for the Asian financial crisis of 1997–8. The degree of integration amongst the Asian countries is found to increase for the post-Asian-crisis period. Employing the vector autoregression (VAR) framework, Phylaktis and Ravazzolo (2002) simultaneously examine financial and economic linkages for the Pacific Basin countries in 1980–98. Financial integration was found to occur along with economic integration. This observation has particular relevance for China and Russia as they strengthen economic ties between themselves and with the rest of the world.

Application to China

The research applied to China's stock market integration can be divided into four categories:

1. Integration within mainland China (mainly between Shanghai and Shenzen market),

2. Integration within greater China (mainland China, Hong Kong and Taiwan),

3. Integration of mainland or greater China compared to other countries, and

4. Sectoral analysis of the Chinese stock markets.

Studies in the first two categories commonly find evidence of stock market integration. There is no consensus as to whether Chinese stock markets are integrated with world stock markets or not, and the evidence from sectoral analysis is quite limited. Our paper, therefore, concentrates on empirical analysis of the third and fourth categories. However, a brief overview of all four categories may be useful before proceeding to our analysis.

***Mainland China*:** Huang *et al.* (2000) report cointegration linkages between Shanghai and Shenzen stock exchange market and their significant feedback relationships from 1992 to 1997. Los and Yu (2008) apply advance signal processing aimed at detecting the degree of persistence, stationarity, and independence of Chinese A- and B-share Shanghai and Shenzen mainland markets in 1990–2005. The gradual improvement found in these characteristics is in line with the process of deregulation. Mainland Chinese stock markets are shown to behave efficiently and are integrated into a single Chinese stock market.

***Greater China*:** Huang *et al*. (2000) also analyse causality and cointegration amongst the US, Japan and greater China. It is shown that the dynamics of returns on the US market has stronger influence on greater China than on the Japanese market in 1992–7. US stock market returns are found to be useful predictors for Hong Kong and Taiwan returns. Groenewold *et al*. (2004) focus on integration among greater China's stock exchange markets, i.e. mainland China, Hong Kong and Taiwan, using a VAR approach and Granger-causality tests for the period 1992–2001. Their results reveal that mainland China's markets are strongly interconnected, while the Hong Kong and Taiwan stock markets are relatively isolated. Evidence of rising links between the mainland markets and Hong Kong, however, is noted after the 1997 Asian crisis. Hatemi and Roca (2004) study integration between greater China and Singapore in 1993–2001 using the causality test based on the bootstrap method. The authors find a gradually rising interdependency between mainland China, Hong Kong, and Taiwan after the 1997 Asian crisis.

***Cross-country comparisons*:** There is a broad group of studies that investigate integration of the stock markets of mainland China or greater China vis-à-vis other stock markets. Employing the same methodology and time framework as in the above analysis of stock markets within mainland China, Groenewold *et al*. (2004) find mainland China's markets to be relatively isolated from the Hong Kong and Taiwan stock markets. However, following the Asian crisis, there is weak evidence of spillovers from Hong Kong to greater China's stock markets. Using VAR models, Bahng and Shin (2003) test for the existence of asymmetric responses among national stock exchange indices of China, Japan, and South Korea over 1991–2000, finding pattern asymmetry amongst all three indices. The variance decomposition of the forecast errors reveals that the Chinese index is least explained by variations of the other two markets. When the US index is incorporated into this analysis, however, the US stock market appears to have a significant effect on the Chinese market. Hsiao *et al*. (2003) use pair-wise and VAR analyses to identify financial linkages in daily variations in stock prices indices between the US and Asia-Pacific region for 2001–2, and then test for the Granger-causality of these linkages. The authors report that a drop in the US stock market does not Granger-cause similar behaviour in the Chinese mainland stock market, but does cause a drop in stock markets in Japan, Korea and Taiwan, suggesting a certain degree of isolation of the Chinese mainland stock market.

These early conclusions are supported by the more recent literature. Girardin and Liu (2007), for example, investigate whether China's A-share market is integrated at the national level with the European, US, and Hong Kong markets. Application of the cointegration method to daily, mid-week, and average week data for 1992–2005 yields different results. There is no cointegration for daily and mid-week data, but evidence of co-integration between the Chinese Shanghai A-share market and the European S&P500. Using a multivariate GARCH framework, Li (2007) points out the relative isolation of Chinese stock markets from world markets in 2000–5. A large cross-country study by Koźluk (2008), which will be further discussed below in relation to Russian stock markets, concludes that Chinese stock markets are "almost completely separated from global affairs", but "strongly inter-related" themselves. More recently, Chow *et al*. (2011) find evidence of rising integration of the Chinese and world stock markets in 1992–2010, measured in terms of co-movements of Shanghai and New York Stock exchange prices. Rizavi *et al*. (2011) also report beta- and sigma-convergence of stock market returns between the Shanghai stock exchange and nine Asian markets with respect to a global benchmark (proxied by the Merrill Lynch Major 11 International Index) over the period 1999–2009.

***Sectoral analysis*:** The sectoral analysis of Chinese stock markets is much less elaborated in comparison with analysis of national stock exchange indices. To our knowledge, the study of Demirer and Lien (2005) is the only one that examines firm-level returns across 18 sectors. The authors employ a Granger-causality test and correlation analysis to detect stock market correlations during the periods of rising and declining returns in 1999–2002. When a majority of investors were buying stocks, the correlation was markedly higher compared to the case of selling stocks.

Application to Russia

Evidence on integration of Russian stock markets with other countries' stock markets is mixed. Studies of Russian stock markets can be broken into three groups:

1. Russian stock markets extensively interconnected with global (particularly European) stock markets,

2. Russian stock markets are isolated, and

3. There are one-way spillovers from or into Russian stock markets.

Koźluk (2008) provides one of the rare studies that

includes the stock markets of both Russia and China as part of a much broader analysis (135 indices for 75 countries in total from the early 1990s to 2007). The results of the approximate factor model (which allows the identification of global versus regional factors) show that while Russian stock markets behave like a 'typical' emerging market, i.e. characterised by rising integration with world markets, China's A-share and B-share markets move largely independently from global markets. Employing a VAR-GARCH-type model, Caporale and Spagnolo (2011) identify stock market volatility spillovers running in one direction from Russia to three Central and Eastern European countries in 1996–2008.

Using correlation and cointegration analysis, Verchenko (2000), in contrast, finds no interconnection between stock market returns in Russia and nine neighbouring transition economies from 1997 to 2000. Similarly, employing VAR and cointegration methods, Tirkkonen (2008) argues that Russian stock markets over the period 2003 to 2007 are relatively isolated from global markets such as the US, China, Japan, UK, Germany, as well as nearby Poland and the Czech Republic.

One-way stock market spillovers, from Russia to the Central and Eastern European countries in 1995–8, are found by Jochum *et al*. (1999) by means of variance decomposition. However, this result is obtained in relation to the effects of the Russian crisis of 1998, which is not surprising. Employing a rolling regression analysis, Anatolyev (2008) finds evidence for rising spillovers from the US stock markets in 1995–2004, and also from European stock markets when considering a larger set of countries (Anatolyev, 2005) to the Russian stock market, over the same time period. There is no robust indication for rising bilateral stock market integration, however, at either regional or sectoral levels.

3. Development of Chinese and Russian stock markets: stylised facts

National stock market indices

Table 1 provides information on the national stock market indices used in our study. Daily stock market indices for the period September 1995 to October 2010 were downloaded from Thomson Reuters and converted to weekly averages. The weekly indices were then expressed in USD equivalents to account for nominal exchange rate changes and rescaled using the first observation of 2007 as the 100 value. Figure 1 illustrates the resulting stock exchange indices for China and Russia compared with our three benchmark territories: the United States, the Euro Area, and Japan.

Table 1. National stock market indices (September 1995 to October 2010)

Code	Territory	Stock market price index	Thomson Reuters code
CH	China	SHANGHAI SE A SHARE	CHSASHR
EA	Euro Area	DJ EURO STOXX $	DJEURS$
JAP	Japan	NIKKEI 225 STOCK AVERAGE	JAPDOWA
RU	Russia	RUSSIA RTS INDEX	RSRTSIN
US	USA	S&P 500 COMPOSITE	S&PCOMP

Source: Thomson Reuters.

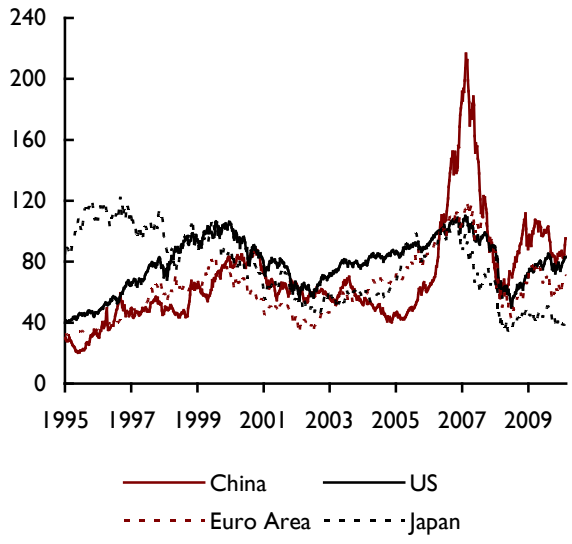
Figure 1(a) shows that the Chinese stock exchange index grows ahead of the Asian crisis of 1997, revives in 1999–2001, and then enjoys robust growth in 2006–7. A massive drop takes place between September 2007 and November 2008, with gradual recovery thereafter. The Russian stock exchange index in figure 1(b) rises until 1997. Growth returns after the Russian crisis of 1998 and continues until the global crisis in 2008. After a sharp drop in 2008, growth resumes in 2009. A comparison of national stock market indices amongst the five territories under review highlights the role of the recent crisis, which clearly affected all stock markets. However, the magnitude of impact and the timing differ from country to country. The Chinese stock market shows particularly high growth prior to 2007, so its plunge is proportional. The Russian stock market index is the last to fall after the arrival of the global crisis.

A complementary indicator that characterises the importance of stock markets to the economy is stock market capitalisation. Figure 2 shows that the highest market capitalisations (as a percentage of GDP) are observed for the United States, Japan and the Euro Area.[3] Since 2004–5, the market capitalisation for both China and Russia has increased sharply. By the end of 2008, the levels of market capitalisation were to the US level (and exceeding the Euro Area and Japanese benchmarks).

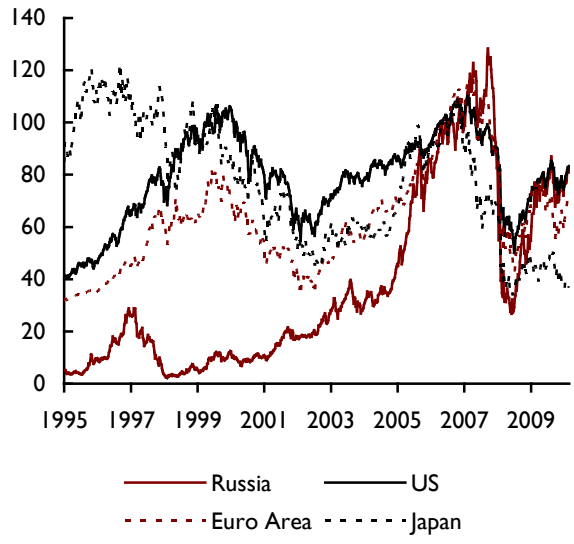
Other characteristics of stock markets studied here are summarised in figures A1–A3 in the Appendix (total number of listed domestic companies, total value of traded stocks as a percentage of GDP, and turnover ratio of stocks traded in per cent). These indicators cover the period 1996–2009 at yearly frequency. One can see that the capital market in China plays a greater role in comparison with Russia, as demonstrated by

Figure 1. National stock market indices (September 1995 to October 2010, weekly)

(a) China with benchmark territories



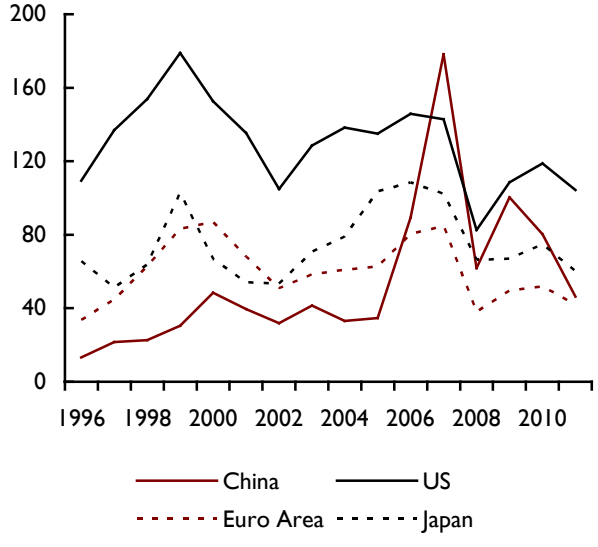
(b) Russia with benchmark territories



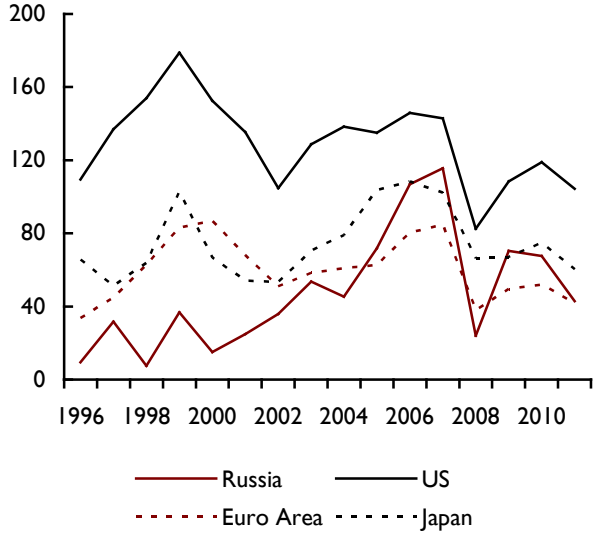
Source: Thomson Reuters.
Note: The stock market indices are first expressed in USD equivalents to account for nominal exchange rate changes, then rescaled with the first observation of 2007 as the 100 value.

Figure 2. Stock market capitalisation (as a percentage of GDP, 1996–2011)

(a) China with benchmark territories



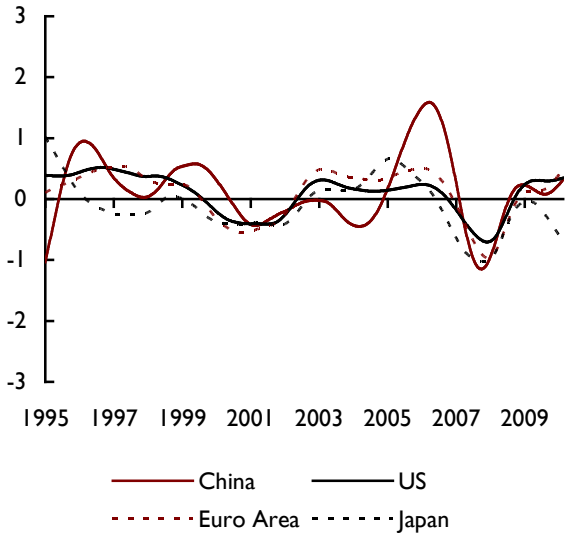
(b) Russia with benchmark territories



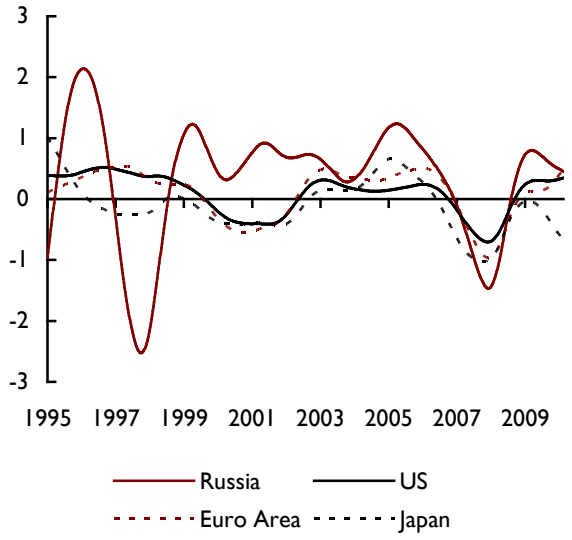
Source: The World Bank.

Figure 3. National stock market returns (September 1995 to October 2010, weekly)

(a) China with benchmark territories



(b) Russia with benchmark territories



Source: Authors' calculation based on Thomson Reuters data.
Note: Trend values obtained by means of the H-P filter with the smoothing parameter λ=270400. The H-P filter is used only for charts and not in the subsequent calculation of sigma convergence.

each of the three indicators shown in figures A1–A3. Not only are the corresponding numbers of listed domestic companies, total value of stock traded and the turnover ratio significantly higher in China compared with Russia, the dynamics of these indicators is richer in China as well. This reflects the fact that China has recently become the second-largest economy in terms of GDP, surpassing Japan. Nevertheless, the number of listed domestic companies in China is still lower as compared to the United States, the Euro Area and Japan (figure A1), while in terms of the total value of stock traded and the turnover ratio China surpassed the Euro Area and Japan by the end of the sample period (figures A2 and A3).

Figure 3 shows the trends in the returns of the national stock market indices. Returns Y_t are calculated as weekly growth rates of stock market indices according to the expression: $Y_t=100*[\ln SE_t - \ln SE_{t-1}]$, where SE_t denotes the stock exchange index at time t, taken in USD equivalent to account for nominal exchange rate changes.[4] For graphical illustration, trend values are obtained by means of the Hodrick-Prescott filter with the smoothing parameter λ = 270 400, which corresponds to the weekly data. While original stock market indices are found to be integrated of order one, the returns of these indices appear to be stationary according to standard unit root tests (ADF and PP) and non-stationarity test (KPSS).

Figure 3 reveals that the global financial crisis of 2008 resulted in a somewhat lower drop in Russian stock market returns than in the Russian 1998 financial crisis. In contrast, the recent global crisis has had much stronger effects for China and other monitored territories than the earlier turbulent episodes during the examined period, including the 1997 Asian crisis. This will be formally tested in our analysis. Moreover, the dynamics of returns (and indices) amongst the United States, Euro Area and Japan are more similar than with respect to either China or Russia, which implicitly gives an indication of higher stock market integration amongst our three benchmark territories.

Sectoral stock market indices

Table 2 describes data sources of the sectoral stock market indices used in our analysis. Multiple graphs showing the index trends relative to the US, Euro Area and Japan during 1995–2010 are presented in our discussion paper (Babecký *et al.*, 2012) for China and Russia. An immediate impression is the large variation

Table 2. Sectoral stock market indices (September 1995 to October 2010)

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

Source: Thomson Reuters (all sectors except pharmacy in China) and Bloomberg LP (pharmacy, China).
Note: The acronyms stand for the Thomson Reuters codes of the series (Bloomberg LP code for the pharmacy sector in the case of China). * Periods shortened due to data unavailability.

of indices across sectors, even if the 2008 crisis impacts all sectoral stock market indices without exception. In several sectors, the stock market indices fully recover by the end of 2010, reaching or even exceeding their pre-crisis levels. These include Beverages, Brewers, Pharmacy and Software for China, and Banks, Mining, Pharmacy and Telecom for Russia.

The development of sectoral returns for both the Chinese stock market and the Russian stock market against our benchmark territories is illustrated in full in Babecký *et al*. (2012). Similar to the dynamics of national returns, sectoral stock market returns are stationary in levels in the unit root tests (ADF, PP) and the stationarity test (KPSS). Several notable features are in evidence: (1) an opposite cyclical behaviour of Chinese and Russian stock market returns in some periods and sectors (e.g. Airlines, Automobile and Brewers) compared to the sectoral returns of the three benchmark territories; (2) a lower alignment of some sectors, not only between Chinese and Russian markets, but also among sectors of the Euro Area, US and Japanese stock markets (e.g. Real estate and Mining); and (3) a clear impact of past crises (the 1997 Asian crisis, the 1998 Russian crisis, and the global financial crisis of 2008/9) and bubbles (the 2000 dot-com bubble and the run-up to the 2008/9 crisis) on sectoral returns.

4. Approaches to measuring stock market integration

As outlined in Section 2, there are a number of alternative ways to operationalise the price-based concept of stock market integration. Cointegration analysis, vector autoregression (VAR), conditional correlations (GARCH-type framework), beta and sigma convergence are some of the most common approaches. Each of these methods is best suited to answer particular aspects of stock market integration given the data available. For example, cointegration analysis serves to determine whether there is a stable long-term relationship between stock prices or returns. Due to structural breaks or distinct differences between the markets analysed, such a long-term relationship might not always exist. The short-run dynamics can then be analysed using VAR models. These models are also well suited to test for the direction of causality (in the Granger sense) amongst fluctuations in stock market indices. However, the underlying assumption of linearity limits the applicability of VAR and cointegration techniques. General autoregressive conditional heteroscedastic (GARCH) models explicitly take account of non-linearity in stock market volatility. However, as there are many forms of non-linearity, which are also specific to the particular stock market data used, finding an optimal GARCH specification is not a trivial task.

Beta- and sigma-convergence measures of stock markets returns abstract from the direction of causality and allow the assessment of an overall degree of stock market integration in a relatively heterogeneous sample, as is the case in our study.[5] In particular, we face several types of heterogeneity, namely at the country level, at the sectoral level, and across time (since our sample contains several crisis episodes including the 2008/9 global financial turmoil). Thus, we explore a price-based approach to measuring financial integration that involves estimating beta- and sigma-convergence.

As discussed in Adam *et al.* (2002), any proper measure of financial integration of stock markets should account for asset pricing, which is empirically difficult to operationalise. We follow a common practice (Ayuso and Blanco, 2000; Hartmann *et al.*, 2003) of examining links between stock market returns that leave asset pricing aside. Strictly speaking, our results for the stock market should be interpreted as evidence of beta- and sigma-convergence of returns rather than integration, as we are unable to distinguish whether there is an underlying process of financial integration, whether financial shocks become stronger, or whether risk premia change. Even with this caveat, assessment of stock market convergence in returns (synchronisation) provides valuable new evidence on the interdependencies amongst the economies discussed. We explore a price-based approach to measuring financial integration that involves estimating beta- and sigma-convergence as advocated by Adam *et al.* (2002) and elaborated in Babecký *et al.* (2010).

The concept of beta-convergence

Beta-convergence enables identification of the speed at which differences in returns are eliminated on individual stock markets (selected against a benchmark). A negative beta coefficient indicates the existence of convergence. The closer the value of the beta coefficient is to –1, the higher the speed of convergence. To quantify beta-convergence, the following regression is estimated:

$$\Delta R_t = \alpha + \beta_t R_{t-1} + \sum_{l=1}^{L} \gamma_l \Delta R_{t-1} + \varepsilon_t \qquad (1)$$

where $R_t = Y_t - Y_t^B$ represents the difference between the stock market return of country (or sector) i and the selected reference territory (a benchmark, B) at time t, Δ is the difference operator, α is the constant term, l is the lag length and ε_t is the white-noise disturbance. The stock market return Y_t is calculated as the period-to-period growth rate of the underlying stock market index: Y_t=100*[ln(SE_t)–ln(SE_{t-1})] , where SE_t denotes the stock exchange index at week t taken in USD equivalent to account for nominal exchange rate changes. The lag length l is based upon the Schwarz information criterion; the maximum lag length L is taken as four, as we are using weekly data and the memory of stock markets is short.

The size of coefficient β is a direct measure of the speed of convergence. A negative beta coefficient indicates the occurrence of convergence. The β coefficient can take values ranging from –2 to 0. The closer the β coefficient to –1, the faster the rate of convergence. If $\beta = 0$ or $\beta = -2$, no convergence is observed. β values from –1 to 0 indicate monotonous convergence, while oscillating convergence occurs for β values from –2 to –1.

The concept of sigma-convergence

Sigma-convergence focuses on the cross-sectional dispersion of returns on individual stock markets at a given moment of time. It thus identifies the degree of integration vis-à-vis the benchmark country achieved at that moment amongst the selected national (or sectoral) markets. Sigma-convergence increases as the sigma parameter falls to zero. If the cross-sectional dispersion converges to zero, full integration is achieved. To quantify sigma-convergence, a calculation is used of the (cross-section) standard deviation (σ), according to the formula:

$$\sigma_t = \sqrt{\left(\frac{1}{N}\right)\sum_{i=1}^{N}[\log(Y_{it}) - \log(\overline{Y}_t)]^2} \qquad (2)$$

where Y_{it} is the stock market return i at time t, and $\overline{Y}_t$ is the cross-section mean value of the return at time t, and i stands for the individual countries or sectors (i = 1, 2, …, N). For the purposes of this analysis, we use N = 2; i.e. we examine, at the national level or by sector, the evolution of sigma-convergence over time between our benchmark territories (the US, Euro Area, and Japan) and China or Russia.[6] By definition, σ takes only positive values. The lower the σ value, the higher the level of convergence. In theory, full integration is achieved when the standard deviation falls to zero, while high (several digit) σ values reflect very low degrees of integration. For graphical illustration, the results are normalised over the full time period and filtered using a Hodrick-Prescott (H-P) filter with the recommended weekly time series coefficient λ = 270 400.

Note that the two convergence indicators contain different information: beta-convergence does not imply sigma-convergence. There *could* be cases of beta-convergence along with sigma-divergence, of course.[7] However, the essential idea here is that both aspects of

convergence need to be assessed to make an inference about stock market integration. Beta- and sigma-convergence are estimated for China and Russia at the national and sectoral level, in comparison with the three benchmark territories.

5. Empirical results

In this section, we examine whether, and how quickly, the national (and sectoral) stock markets of China and Russia are integrated with each other and with our three global benchmarks (the US, Euro Area, and Japan). To analyse stock market integration over time, our estimation period is divided into three sub-periods for beta-convergence, while in the case of sigma-convergence the estimations are by definition available at each moment of time. For beta-convergence, the sub-periods are September 1995 to December 1998, January 1999 to December 2008, and January 2007 to October 2010. The first sub-period includes the 1997 Asian crisis and the 1998 Russian crisis. The second sub-period could be described as a relatively tranquil episode. The last sub-period includes the 2008/9 global financial crisis.

Beta-convergence

Table 3 shows the beta-convergence analysis results for the national stock markets. Equation (1) was estimated by OLS with robust standard errors. All beta-coefficients are negative and significant; hence there is convergence of stock market returns between China, Russia and the corresponding benchmarks. The values of the β coefficient are close to minus one, which means that the levelling of newly arising differences in stock market returns between the relevant national economy and the reference country can be labelled as fast. Indeed, the shock half-life, defined as the period during which the magnitude of a shock to the return differential between two countries becomes half of the initial shock, is between about one to two days, as indicated in the shaded areas in table 3.[8] Notice, however, that the use of weekly data for calculation of beta-convergence gives us the advantage of minimising noise (holiday effects and time zone differences playing a greater role on daily frequency) and at the same time 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. A comparison of the sub-periods 1995–8, 1999–2006 and 2007–10 suggests no clear systematic pattern in the rate at which shocks to return differentials dissipate.

Similarly, at the sectoral level (table A1 in the Appendix), the beta coefficients are close to minus one for most sectors; the corresponding shock half-lives vary between one and three days, and there are cases of both rising and declining half-lives over time that lack any clear systematic pattern. However, the sectoral dimension brings more variety into the results. In the case of China, the slowest speed of convergence in the return differential is observed for the sectors Electricity and Utilities (both with respect to the US) during the 2007–10 period. The corresponding half-life of shocks is six days. For Russia, there are two sectors characterised by the slowest convergence (both in the 1995–8 period): Automobiles (15.9 days, vis-à-vis Japan) and Telecom (15.4 days vis-à-vis the United States and 11.6 days vis-à-vis the Euro Area).

A finding of beta-convergence at national and sectoral levels suggests that Chinese and Russian stock markets

Table 3. Beta-convergence of national returns: coefficients and half-lives of shocks

Territory i	China vis-à-vis territory i						Russia vis-à-vis territory i					
	1995–1998		1999–2006		2007–2010		1995–1998		1999–2006		2007–2010	
China	–		–		–		–0.90	2.1	–1.06	1.7	–1.11	2.2
Euro Area	–0.99	1.0	–1.10	2.1	–1.01	1.1	–0.87	2.4	–0.93	1.8	–0.98	1.3
Japan	–1.00	0.6	–1.00	0.9	–0.98	1.3	–0.88	2.2	–1.10	2.1	–1.07	1.8
Russia	–0.90	2.1	–1.06	1.7	–1.11	2.2	–	–	–	–	–	–
United States	–1.01	1.1	–1.02	1.3	–0.98	1.2	–0.90	2.1	–1.09	2.0	–0.95	1.7
Mean	–0.98	1.2	–1.05	1.5	–1.02	1.5	–0.89	2.2	–1.05	1.9	–1.03	1.8

Source: Authors' calculations based on Thomson Reuters data.

Note: Estimations of equation (1) on weekly data. Half-lives of shocks (number of days) in shaded areas. All beta coefficients are statistically significant at the 5% level. Beta coefficient equalling –1 corresponds to full convergence. The half-life (H-L) of a shock to the return differential between two territories is a period during which the shock declines to one half of its initial value. Lower H-L values correspond to faster beta-convergence.

can hardly be labelled as 'isolated'. Indeed, the shock half-life, typically much less than a week, means that there could not be persistent differences in returns amongst the stock markets of these two countries or with respect to the three global benchmarks. This finding is broadly in line with evidence on beta-convergence of stock markets at the national level for China and other Asian economies (Rizavi *et al.*, 2011) and amongst European countries (Babecký *et al.*, 2010, 2011). Studies of beta-convergence on the sectoral level also find higher heterogeneity of outcomes, amongst e.g. West European countries (Erdogan, 2009) and New EU Member States (Babetskii *et al.*, 2007). Notice that a finding of beta-convergence is generally not granted for any type of financial markets. For example, regarding real estate markets, Srivatsa and Lee (2010) report cases of beta-divergence in rents and yields amongst the office markets in seven European capitals during 1982–2009.

Sigma-convergence

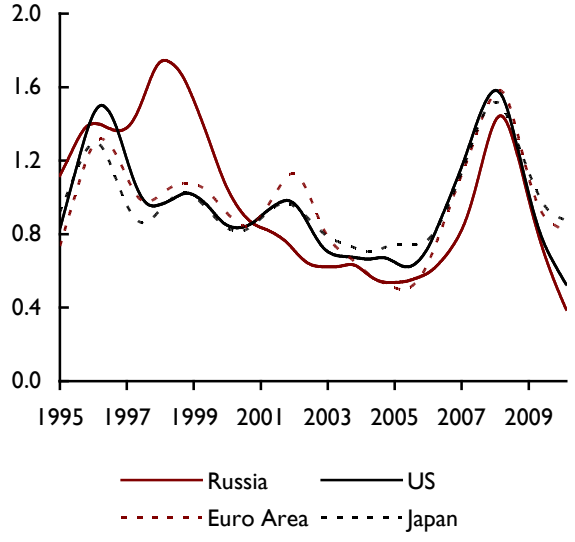
For each period of the sample, cross-section standard deviation (σ) was calculated according to formula (2) Sigma-convergence occurs if the cross-section deviation declines over time. We make four observations about figure 4, which presents the sigma-convergence analysis for the Chinese and Russian national stock markets.

First, the Chinese and Russian stock markets share common dynamics; there is an increase in return dispersion ahead of the 1997 Asian crisis and the 1998 Russian crisis, followed by a trend convergence that lasts through the mid-2000s. We then see a sharp increase in dispersion after 2006/7 that corrects back toward convergence in 2009.

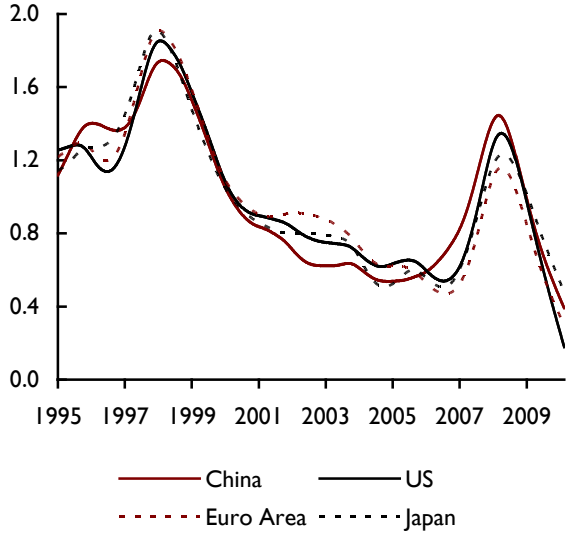
Second, the Chinese stock market had much lower dispersion with respect to the stock markets of the US, Euro Area, and Japan prior to 2001 than Russia (see figure 4a). This situation reverses around 2002. For most of 2002–10, the dispersion of Chinese-Russian stock market returns is lower than in benchmark territories. The development of stock market indices and returns displayed in figures 1 and 3 helps to interpret this result. In the early sample years, the 1997 Asian crisis and the 1998 Russian crisis were the main reasons for an increase in dispersion between the Chinese and Russian stock market returns. After 2002, the dynamics of Chinese and Russian stock market

Figure 4. Sigma-convergence at the national level (September 1995 to October 2010)

(a) China vis-à-vis other territories



(b) Russia vis-à-vis other territories



Source: Authors' calculation based on Thomson Reuters data.
Note: Trend values obtained by means of the H-P filter with the smoothing parameter λ=270400. The H-P filter is used only for charts and not in the calculation of cross-section standard deviation.

indices are characterised by substantial co-movement. We see a common rise in indices through 2003, moderation (and decline) in 2004, robust growth in 2006–7, and a massive fall during the global crisis.

Third, a comparison of the left and right charts in figure 4 shows the relative importance of the global crisis of 2008/9 against the earlier Asian and Russian crises of 1997–98. For China vis-à-vis the US, Euro Area, and Japan (figure 4a), the dispersion of returns was somewhat higher in 2008 (1.50–1.60) compared to the 1997 Asian crisis (1.30–1.50). For Russia (figure 4b), the 2008 global crisis is accompanied by much lower dispersion (1.15–1.33) than during the 1998 Russian crisis (1.85–1.90).

Fourth, the Chinese stock market is characterised at the end of our sample (October 2010) by the lowest dispersion with respect to the stock markets of Russia (0.39) and the US (0.53), followed by the Euro Area (0.82) and Japan (0.88). The Russian stock market has an overall lower dispersion (i.e. higher sigma-convergence) with all reference territories, in particular the US (0.18) and Euro Area (0.30), followed by China (0.39) and Japan (0.48).

Babecký *et al.* (2012, figures 9 and 10) show the sigma-convergence analysis of Chinese and Russian stock markets respectively at the sectoral level, in 1995–2010. The results are illustrated for sixteen sectors in the case of China and the three reference territories (the United States, Euro Area and Japan), while thirteen sectors are available for the Russian stock market (the data are unavailable for Industrials, Real Estate and Software), and the periods for which Russian sectoral data are available are shorter. We offer four observations on the development of sectoral σ.

First, all sectors have been affected by the financial crisis of 2008/9. There is also clear evidence of substantial impacts of the previous (Asian and Russian) crises and the burst of bubbles (for example, the dot-com bubble) preceding the unfolding of crisis events in 2008. However, the relative importance of the previous and recent crisis differs across sectors. At the national level, the Russian stock market experienced higher dispersion in 1998 compared to 2008. At the sectoral level, however, one can identify industries that were affected to a comparable degree by both crises (e.g. Airlines and Automobiles). The impact of the 2008 crisis on dispersion was also much milder compared to the 1998 crisis for several sectors in Russia (e.g. Banks, Financials, and Telecom).

Second, the magnitude of the dispersion varies substantially across sectors. Overall, the most integrated sectors (i.e. lowest dispersion) appear to be Software for China, and Oil & Gas and Telecom for both China and Russia). An interesting sector-specific example is for Automobiles in the case of Russia. During the 2008 crisis, the lowest dispersion of sectoral returns was observed between Russian and Chinese markets (1.15), followed by the pairs Russia-US (1.29), Russia-Euro Area (1.37) and Russia-Japan (1.54). Arguably a strong decline in stock markets indices in the automobile industry in both China and Russia contributed to the observed synchronicity in stock market returns between these two countries.

Babecký *et al.* (2012, figures 9 and 10) present evidence of sigma convergence at the sectoral level; cross-sectional dispersions of returns exhibit a downward-sloped trend over time; the effects of the 2008/9 crisis fade out by the end of 2010. Heterogeneity of the results at the sectoral level indicates potential for diversification of risk.

Our finding of sigma-convergence between Russian and Chinese stock markets, as well as with respect to the stock markets of the US, Euro Area, and Japan in 1995–2010, corroborates the similar conclusion of sigma-convergence amongst the stock markets of selected EU member states with respect to the US and Euro Area over the comparable period (Babecký *et al.*, 2010, 2011). There is recent evidence for China of sigma-convergence between China and other Asian stock markets in 1999–2009 (Rizavi *et al.*, 2011). This result, however, is sensitive to sample length. In fact, the Asian stock markets are characterised by sigma-divergence during 2004–9. The assessment of sigma-convergence thus substantially depends on the time horizon considered. The results of our study illustrate that the sub-sample of 2004–9 is characterised by sigma-divergence amongst China, Russia, and the three global benchmarks. This was a period of rising dispersion of returns amongst the analysed territories; rising asset prices initially drive dispersion, then a fall in stock market indices during the global crisis. However, extending the sample to 1995–2010 leads to an overall finding of sigma-convergence as the effects of the 2008/9 crisis fade and the downward-sloped trend in return dispersion re-emerges. A declining trend in return dispersion (i.e. sigma-convergence) is particularly clearcut when considering an even longer period, such as the 1973–2008 observation period, at both national and industry levels for the stock markets of seven Western European countries reported in Erdogan (2009).

Why do we observe sigma-convergence in stock market returns worldwide? Apparently globalisation (and related deepening of economic and financial links) is a key factor for sigma-convergence of such distinct stock markets as those of China, Russia, the Euro Area, EU countries outside the Euro Area, the US, and Japan. Quantification of the determinants of global convergence of stock market returns could be a prospective avenue for future research.

The evidence of sigma-convergence, on the one hand, means decreasing opportunities for risk diversification. On the other hand, as our results suggest, there is still room for risk sharing over the short- to medium-term horizon, when sigma-divergence could happen. This was evident in particular in the period from 2004 to 2009, characterised by substantial sigma-divergence. A non-negligible potential for risk-sharing also exists at the level of industries as sectoral stock markets do not necessarily follow the dynamics of national indices.

6. Conclusions

In this paper, we have investigated the convergence of returns on Chinese and Russian stock markets in comparison with the United States, the Euro Area, and Japan at both national and sectoral levels from September 1995 to October 2010 using weekly averages of daily indices. We tested for its existence and analysed the dynamics of stock market integration based on a price-based approach. Our measures of stock market integration were built upon the two complementary concepts: beta-convergence (measuring the rate at which differences in returns are eliminated between the selected stock markets) and sigma-convergence (measuring cross-sectional dispersion of return differentials at a given moment).

We find evidence of beta-convergence of stock market return differentials between China and Russia, as well as with respect to the US, Euro Area, and Japan. Convergence is observed at both national and sectoral levels. Beta-convergence means that return differentials are not persistent; that is, stock market returns in China or Russia cannot permanently deviate from the returns in other analysed territories. The results of beta-convergence could be alternatively formulated in more intuitive terms of shock half-lives. Our results imply that stock market shocks, which are represented by deviations of returns vis-à-vis benchmark territories, dissipate with a half-life of about one to three days.

We do not find a systematic effect of the 2008/9 crisis on beta-convergence nor clear sectoral patterns. The rate at which shocks dissipate can be labelled as fast, both between China and Russia and with respect to our global benchmarks. This suggests that stock markets offer limited arbitrage possibilities, contrary to, for example, real estate markets where beta-divergence of rents and yields is not uncommon (Srivatsa and Lee, 2010).

Contrary to beta-convergence, sigma-convergence clearly changes over time and the effects of the recent (and past) financial crises are well tracked. We find overall evidence of sigma-convergence in 1995–2010 at both national and sectoral levels. However, the assessment of sigma-convergence critically depends on the period analysed. For example, our results indicate sigma-convergence of the Chinese and Russian stock markets with respect to the world markets after the 1997 Asian crisis and the 1998 Russian crisis until about 2005/6, when we see sharp sigma-divergence and a return to convergence after the 2008/9 crisis.

Sigma-convergence exhibits strong sector-specific patterns. At the sectoral level in particular, the difference in sigma-convergence becomes pronounced during crisis episodes, suggesting the potential for diversification of risk across sectors.

The answer to the question of whether Chinese and Russian stock markets become more interrelated amongst themselves or with respect to the global benchmarks ultimately depends on the assessment of sigma-convergence and, thus, the period considered. This is because, in terms of beta-convergence, we do not find any systematic differences over the time period analysed. Shocks to return differentials dissipate rapidly, with half-lives less than a week. A high degree of beta-convergence has already been achieved during the 1990s. The assessment of overall convergence of stock market returns is therefore driven by the sigma-convergence results.

In terms of sigma-convergence, we find that the Chinese stock market is more interrelated with the US, Euro Area, and Japanese stock markets than with the Russian stock market during 1998–2000. The situation reverses from the second half of 2001 until the end of our sample in October 2010. During that period, return dispersion between the Chinese and Russian stock markets was lower than between the Chinese-US, Chinese-Euro Area, and Chinese-Japanese stock markets. The reasons for this finding require examination of stock market indices and their returns. In 1998–2000, when Russia was largely affected by the 1998 crisis, its stock markets experienced substantially different dynamics compared

to stock markets in China and the three benchmarks. On the other hand, China's entry into the WTO in December 2001 enhanced similarity in stock market dynamics between China and Russia (that is lower return dispersion) than with respect to the US, Euro Area, and Japan. In the aftermath of the 2008/9 crisis, there is also an indication of rising sigma-convergence between the Chinese and US stock market returns, although these are only just marginally lower than for the Chinese-Russian duo.

From the viewpoint of Russia, its stock market interrelation was higher with the US, Western Europe and Japan during 1996–7 than with China, as Chinese stock markets were affected by the Asian crisis. Since about 1998 to 2006 the Russian-Chinese stock market return dispersion was somewhat lower compared to the cases of Russia versus the three global benchmarks. Starting from the second half of 2006 and to mid-2010, the lowest dispersion emerged between the Russian and Euro Area stock markets, reflecting strong bilateral exchanges. Sectoral patterns of sigma-convergence of returns bring more diversity. For some sectors, (e.g. Automobiles after 2008), the highest degree of sigma-convergence is observed between the Russian and Chinese stock markets, followed by such pairs as Russia-Japan, Russia-Euro Area and Russia-US, which stresses the role of sector-specific factors. It can also be the case that in Russia trading in most sectors is very thin, with low volumes and a large share of the free float in the hands of foreign investors. This may result in spurious correlations for some sectors.[9]

Returning to the comparison of our results with findings from the literature discussed at the end of the previous section, one salient fact emerges: a *global* convergence in stock market returns over the past decades measured in terms of beta- and sigma-convergence. A finding of convergence of returns amongst stock markets of the Asian economies, EU countries, the US, China and Russia suggests the presence of common global factors. International trade and cross-border portfolio investment could be examples of such factors (Lee *et al*., 2012). In addition, there are also complex nonlinearities involved in international stock market spillovers (Amira *et al*., 2011). Identifying the determinants of international stock market return convergence would be a fruitful direction for future research.

One should also keep in mind the limitations of the considered price-based measures of stock market interlinkages. Such price-based measures present the results in terms of stock market return convergence (or synchronicity) which only characterise an upper bound of the underlying stock market integration. It remains a challenge for future research to understand whether the finding of stock market return convergence is driven by (1) effects of global shocks (whose incidence for the national economies becomes stronger in the globalised world), (2) changes in asset pricing (which is empirically difficult to operationalise), or (3) changes in country (sector) risk premia.

NOTES

1 The most frequently mentioned benefits of financial market integration include: (i) consumption smoothing due to international diversification of risks (reduction of the large country-specific shocks), (ii) the positive effect of capital flows on domestic investment and economic growth, (iii) improving efficiency of the financial system, and (iv) increasing prudence of financial market agents and the attainment of a high level of financial stability. The major costs include: (i) insufficient access to funding at times of financial instability, including capital concentration and procyclicality, (ii) inappropriate allocation of capital flows, (iii) loss of macroeconomic stability, and (iv) herd behaviour amongst investors, financial contagion and high volatility of cross-border capital flows.

2 Some examples of growing cooperation between Russia and China are: (i) establishing a joint private-equity fund in June 2012; (ii) setting a goal in 2012 of more than doubling bilateral trade between both countries (from $83.5bn in 2011 to $200bn in 2020), (iii) cooperating in the transfer of raw materials (the first pipeline from Russia to China was finished in 2011).

3 Historically, the financial structure in the USA is more capital market-oriented and less bank-oriented than that of the Euro Area and Japan, where banks play the dominant role in financial intermediation.

4 Notice that payments of dividends have an influence on the price of individual shares and the returns are not fully measured when dividend yields are excluded, although the omission of dividend yields is typical of literature in general. Bekaert and Harvey (1995) argue that a decreasing trend in dividend yields could be one of the manifestations of capital market integration. Nevertheless the importance of dividends is arguably higher in the advanced country markets than Russia or China, where a larger proportion of firms are in 'growth mode'.

5 The terms beta-convergence and sigma-convergence originate from the literature on dynamics of economic growth (e.g. Barro and Sala-i-Martin, 1992, 1995).

6 For country pairs, the calculated sigma values in each period are essentially equal to half the square of the return differential.

7 See Quah (1993) for details.

8 The half-life is calculated as $H\text{-}L = \ln(0.5)/\ln(|\beta + 1|)$ and expressed in number of days.

9 Low liquidity in some sectoral stock markets represents another caveat. Accounting for the size of sectoral stock markets and their liquidity represents one possible extension for future research.

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Appendix A

Table A1. Beta-convergence of sectoral returns: coefficients and half-lives of shocks

Sector	Territory i	China vis-à-vis territory i						Russia vis-à-vis territory i					
		1995–1998		1999–2006		2007–2010		1995–1998		1999–2006		2007–2010	
Airlines	US	–1.12	2.3	–1.12	2.3	–1.04	1.5	n.a.	n.a.	–1.03	1.4	–1.08	1.9
	EA	–1.09	2.0	–1.15	2.6	–1.14	2.5	n.a.	n.a.	–1.04	1.4	–1.01	0.9
	Japan	–1.15	2.5	–1.13	2.3	–0.96	1.6	n.a.	n.a.	–1.04	1.5	–1.07	1.9
Autos	US	–1.09	2.0	–1.00	0.9	–0.96	1.5	–1.50	7.0	–0.97	1.4	–1.00	0.7
	EA	–0.98	1.3	–1.03	1.4	–1.20	3.0	–1.52	7.5	–0.96	1.6	–1.22	3.2
	Japan	–1.05	1.6	–1.10	2.1	–1.02	1.2	–1.74	15.9	–0.99	1.0	–1.02	1.3
Bank	US	–0.81	2.9	–1.05	1.7	–1.10	2.1	–1.14	2.5	–0.88	2.3	–1.09	2.0
	EA	–0.82	2.9	–1.01	1.0	–1.08	1.9	–1.10	2.1	–0.85	2.6	–1.05	1.6
	Japan	–0.83	2.8	–0.98	1.3	–1.03	1.4	–1.11	2.2	–0.96	1.5	–1.11	2.2
Beverages	US	–1.14	2.5	–1.04	1.6	–1.02	1.2	n.a.	n.a.	–0.97	1.3	–0.97	1.4
	EA	–1.13	2.4	–1.00	0.8	–1.01	1.0	n.a.	n.a.	–0.89	2.2	–0.99	1.1
	Japan	–1.14	2.4	–0.99	1.1	–0.96	1.5	n.a.	n.a.	–0.93	1.8	–1.02	1.3
Brewers	US	–1.17	2.7	–1.04	1.5	–1.04	1.5	n.a.	n.a.	–0.95	1.6	–0.89	2.2
	EA	–1.14	2.4	–0.99	1.1	–0.97	1.3	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Japan	–1.13	2.4	–0.96	1.5	–0.97	1.4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Chemicals	US	–1.09	2.0	–0.91	2.0	–1.07	1.8	n.a.	n.a.	n.a.	n.a.	–1.07	1.9
	EA	–1.06	1.8	–0.88	2.3	–1.10	2.1	n.a.	n.a.	n.a.	n.a.	–0.93	1.8
	Japan	–1.03	1.3	–0.92	1.9	–1.10	2.1	n.a.	n.a.	n.a.	n.a.	–1.09	2.0
Electricity	US	–1.22	3.2	–1.05	1.6	–1.44	6.0	–1.22	3.2	–1.10	2.1	–1.06	1.8
	EA	–1.25	3.5	–1.00	0.9	–1.11	2.2	–1.23	3.3	–1.08	1.9	–1.09	2.0
	Japan	–1.28	3.8	–0.99	0.9	–0.98	1.2	–1.19	2.9	–1.06	1.7	–1.00	0.9
Financials	US	–1.07	1.8	–1.08	2.0	–1.23	3.3	–1.13	2.4	–0.88	2.3	–1.14	2.5
	EA	–1.06	1.7	–1.07	1.9	–1.24	3.4	–1.11	2.2	–0.84	2.7	–1.06	1.7
	Japan	–1.02	1.3	–1.05	1.6	–1.11	2.2	–1.10	2.1	–0.98	1.2	–1.12	2.3
Industrials	US	–1.14	2.5	–0.92	1.9	–1.11	2.2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	EA	–1.17	2.7	–0.93	1.8	–1.16	2.7	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Japan	–1.13	2.3	–0.98	1.2	–0.92	1.9	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Mining	US	–1.13	2.3	–1.11	2.2	–1.13	2.3	n.a.	n.a.	–1.18	2.8	–1.21	3.1
	EA	–1.17	2.7	–1.08	2.0	–1.09	2.0	n.a.	n.a.	–0.85	2.5	–1.04	1.5
	Japan	n.a.	n.a.	–1.24	3.4	–0.90	2.1	n.a.	n.a.	–1.05	1.6	–1.02	1.3
Oil & Gas	US	–1.20	3.0	–1.18	2.9	–1.08	1.9	–1.40	5.3	–1.11	2.2	–1.22	3.2
	EA	–1.19	2.9	–1.18	2.8	–1.08	1.9	–1.37	4.9	–1.11	2.2	–1.12	2.3
	Japan	–0.76	3.4	–1.12	2.3	–1.00	0.9	–1.36	4.8	–1.00	0.8	–1.38	5.0
Pharmacy	US	n.a.	n.a.	–1.10	2.1	–1.03	1.4	n.a.	n.a.	n.a.	n.a.	–0.97	1.4
	EA	n.a.	n.a.	–1.16	2.6	–1.07	1.8	n.a.	n.a.	n.a.	n.a.	–1.05	1.6
	Japan	n.a.	n.a.	–1.06	1.7	–1.09	2.0	n.a.	n.a.	n.a.	n.a.	–1.19	2.9
Real Est.	US	–1.06	1.7	–1.01	1.0	–1.05	1.6	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	EA	–1.08	1.9	–1.01	1.0	–1.03	1.4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Japan	–0.99	1.1	–1.03	1.4	–0.92	1.9	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Software	US	–0.94	1.7	–1.11	2.2	–1.04	1.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	EA	–1.08	2.0	–1.02	1.3	–1.10	2.1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Japan	–0.93	1.8	–1.04	1.5	–1.10	2.1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Telecom	US	–1.06	1.7	–0.96	1.5	–1.02	1.2	–1.73	15.4	–0.97	1.4	–0.91	2.0
	EA	–1.08	1.9	–1.00	0.5	–1.04	1.6	–1.66	11.6	–1.00	0.9	–0.91	2.1
	Japan	–1.04	1.5	–0.98	1.2	–0.92	1.9	–1.28	3.8	–1.04	1.5	–1.13	2.4
Utilities	US	–1.23	3.3	–1.04	1.5	–1.44	5.9	–1.22	3.2	–1.11	2.2	–1.06	1.7
	EA	–1.24	3.4	–1.00	0.7	–1.09	2.0	–1.23	3.3	–1.07	1.8	–1.08	1.9
	Japan	–1.27	3.7	–0.99	0.9	–0.98	1.2	–1.19	2.9	–1.05	1.7	–1.01	1.1

Source: Authors' calculations based on Thomson Reuters and Bloomberg LP data.
Note: Estimations of equation (1) on weekly data. Half-lives of shocks (number of days) in shaded areas. All beta coefficients are statistically significant at the 5 per cent level. A beta coefficient of –1 corresponds to full convergence. The half-life (H-L) of a shock to the returns differential between two territories is the period in which the shock declines to half its initial value. A lower H-L value means faster beta-convergence.

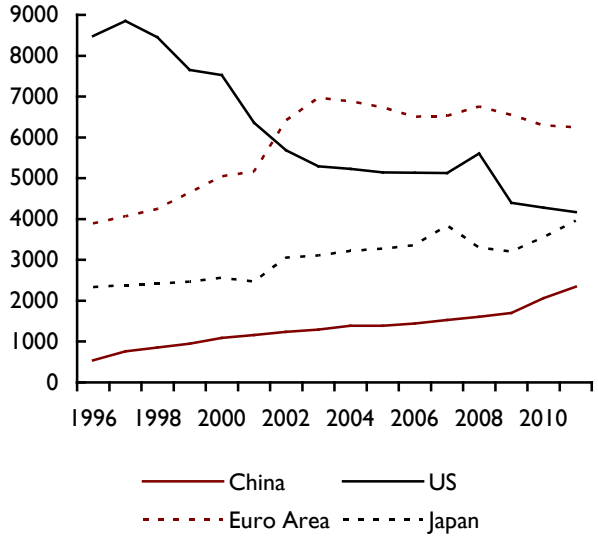
Table A2. Beta-convergence of sectoral returns: coefficients and half-lives of shocks – mean values across sectors

Sector	China vis-à-vis territory i						Russia vis-à-vis territory i					
	1995–1998		1999–2006		2007–2010		1995–1998		1999–2006		2007–2010	
Airlines	–1.12	2.3	–1.13	2.4	–1.05	1.9	n.a.	n.a.	–1.04	1.4	–1.05	1.6
Automobiles	–1.04	1.6	–1.04	1.5	–1.06	1.9	–1.59	10.1	–0.97	1.3	–1.08	1.7
Bank	–0.82	2.9	–1.01	1.3	–1.07	1.8	–1.12	2.3	–0.90	2.1	–1.08	1.9
Beverages	–1.14	2.4	–1.01	1.2	–1.00	1.2	n.a.	n.a.	–0.93	1.8	–0.99	1.3
Brewers	–1.15	2.5	–1.00	1.4	–0.99	1.4	n.a.	n.a.	–0.95	1.6	–0.89	2.2
Chemicals	–1.06	1.7	–0.90	2.1	–1.09	2.0	n.a.	n.a.	n.a.	n.a.	–1.03	1.9
Electricity	–1.25	3.5	–1.01	1.1	–1.18	3.1	–1.21	3.1	–1.08	1.9	–1.05	1.6
Financials	–1.05	1.6	–1.07	1.8	–1.19	3.0	–1.11	2.2	–0.90	2.1	–1.11	2.2
Industrials	–1.15	2.5	–0.94	1.6	–1.06	2.3	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Mining	–1.15	2.5	–1.14	2.5	–1.04	2.1	n.a.	n.a.	–1.03	2.3	–1.09	2.0
Oil & Gas	–1.05	3.1	–1.16	2.7	–1.05	1.6	–1.38	5.0	–1.07	1.7	–1.24	3.5
Pharmacy	n.a.	n.a.	–1.11	2.1	–1.06	1.7	n.a.	n.a.	n.a.	n.a.	–1.07	2.0
Real Estate	–1.04	1.6	–1.02	1.1	–1.00	1.6	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Software	–0.98	1.8	–1.06	1.7	–1.08	1.9	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Telecom	–1.06	1.7	–0.98	1.1	–0.99	1.6	–1.56	10.3	–1.00	1.3	–0.98	2.2
Utilities	–1.25	3.5	–1.01	1.0	–1.17	3.0	–1.21	3.1	–1.08	1.9	–1.05	1.6

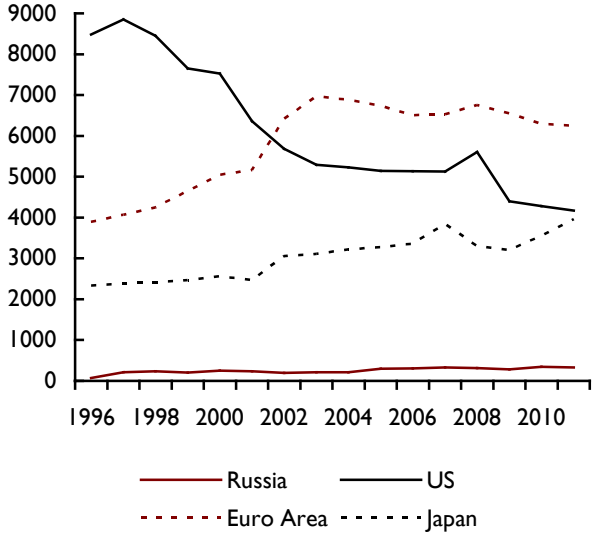
Source: Authors' calculations based on Thomson Reuters and Bloomberg LP data.
Note: Estimations of equation (1) on weekly data. Half-lives of shocks (number of days) in shaded areas. All beta coefficients are statistically significant at the 5 per cent level. A beta coefficient of –1 corresponds to full convergence. The half-life (H-L) of a shock to the returns differential between two territories is the period in which the shock declines to half its initial value. A lower H-L value means faster beta-convergence.

Figure A1. Total number of listed domestic companies (1996–2011)

(a) China with benchmark territories



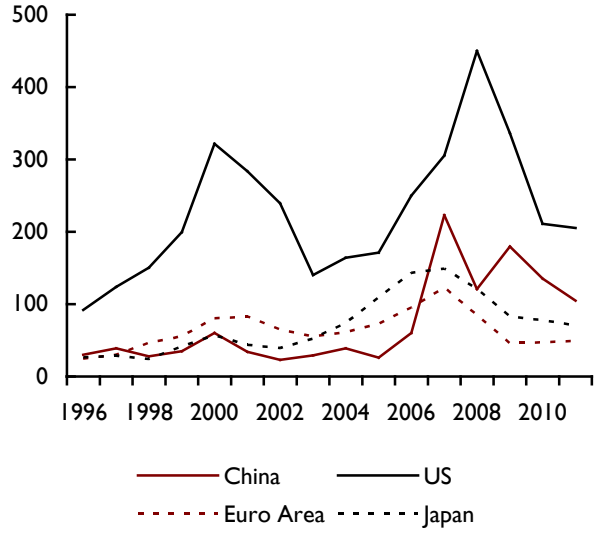
(b) Russia with benchmark territories



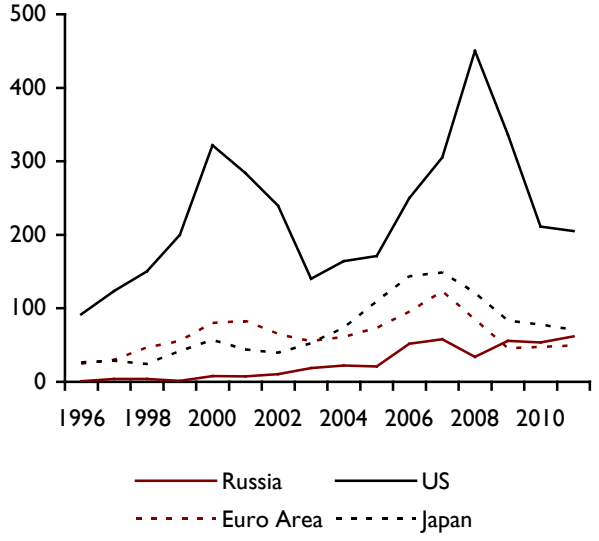
Source: The World Bank.

Figure A2. Stocks traded, total value (as a percentage of GDP, 1996–2011)

(a) China with benchmark territories



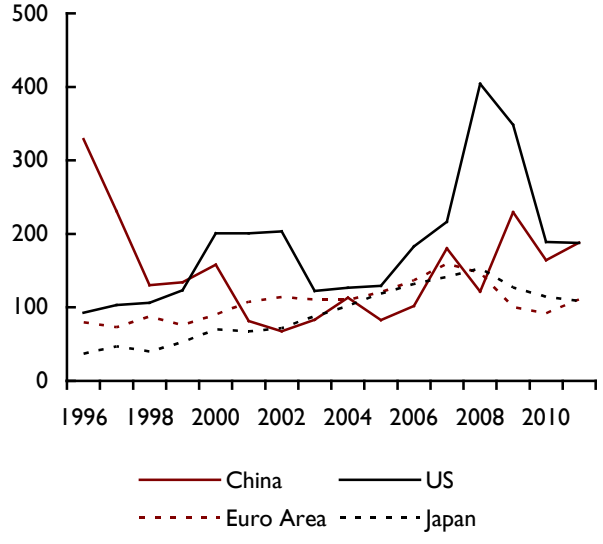
(b) Russia with benchmark territories



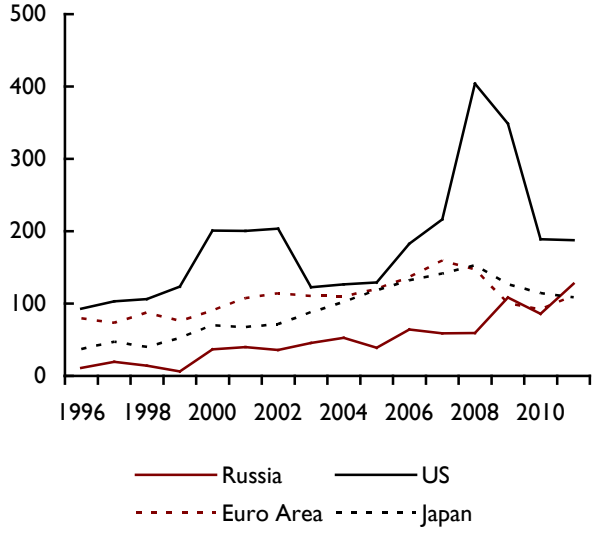
Source: The World Bank.

Figure A3. Stocks traded, turnover ratio (as a percentage, 1996–2011)

(a) China with benchmark territories



(b) Russia with benchmark territories



Source: The World Bank.