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Global and regional links between stock markets - the case of Russia and China

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Tomasz Koźlu,[1] [2]

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Abstract

In a broad sample of developed and emerging economies over the past ten years we apply the approximate factor model in a search for common global and regional driving-forces in stock market returns and volatility. We focus particularly on two emerging stock markets - Russia and China, because of their unique characteristics and performance in the past years. We find that while Russian markets, like the CEEC region, substantially increased their integration with global stock markets, both the Chinese A- and B-share markets continued to move largely independently from global movements and only slightly increased in comovement with regional forces. We provide evidence of a general increase in global comovement of stock markets over the past decade and a decline in the role of regional forces, which imply a decrease of the effectiveness of cross-country hedging strategies.

Keywords: stock markets, financial integration, Russia, China, global and regional integration;
JEL Classification: F36, G11, G14.

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Tomasz Koźluk

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Tiivistelmä

Tässä tutkimuksessa selvitetään osakemarkkinoiden tuottoihin ja volatiliteettiin vaikuttaneita tekijöitä suuressa joukossa kehittyneitä ja kehittyviä talouksia kymmenen viime vuoden aikana. Likimääräisen faktorimallin avulla työssä pyritään identifioimaan yhteisiä globaaleja ja alueellisia tekijöitä, jotka vaikuttavat osakemarkkinoihin. Keskipisteenä on etenkin kaksi ainutlaatuista kehittyvää taloutta, Venäjä ja Kiina. Näiden maiden osakemarkkinoiden kehitys on ollut ainutlaatuista viimeisten kymmenen vuoden aikana. Tämän tutkimuksen tulosten mukaan Venäjän osakemarkkinat – kuten myös Keski- ja Itä-Euroopan markkinat – ovat integroituneet yhä enemmän maailmanlaajuisiin osakemarkkinoihin. Kiinan osakemarkkinoiden liikkeet ovat edelleen varsin riippumattomia muiden markkinoiden kehityksestä. Tutkitulla ajanjaksolla osakemarkkinoiden maailmanlaajuinen integraatio on yleisesti lisääntynyt, ja samaan aikaan alueellisten tekijöiden merkitys on vähentynyt. Tämä vähentää diversifioinnista saatavia hyötyjä.

Asiasanat: osakemarkkinat, finanssi-integraatio, Venäjä, Kiina, maailmanlaajuinen ja alueellinen integraatio

1 Introduction

In 2006 the Chinese and Russian stock markets both boomed, experiencing growth rates of broad market indexes and blue chip indexes which placed them among the top 5 markets.[3] Moreover, the two markets became by far the fastest growing in the world in terms of market capitalization and annual trading values, at the least doubling from previous year values. The same year saw high growth of most stock market indexes around the world, especially in emerging markets. This led us to ask how much of the growth in China and Russia was driven by common global, regional and emerging market forces and how much by idiosyncratic factors. This is essentially a question of the degree of financial integration of the two markets with global and regional forces. A large role for common forces could reflect spillovers of investor sentiment and herding or it may derive from close trade ties, or similarity of stock market structures or economic prospects. All of the above phenomena can be expected to accompany increasing global integration of Russia and China in a number of dimensions: trade integration; FDI; increasing, albeit still varying market access for international portfolio investors; and the high speed at which news and investor sentiment can spread across the world. On the other hand, heavy weighting of idiosyncratic components may reflect unique characteristics of the Russian and Chinese stock markets, the quoted companies, or the economies as a whole.

The determination of these links and their importance is crucial for understanding comovements of stock markets and can yield important insight for international portfolio hedging strategies. In order to assess the strength and evolution of the common and idiosyncratic forces, we apply the approximate factor model of Bai (2003) to a broad set of world stock market indexes over the last decade. Certainly, there are good reasons to expect that movements in both the Chinese and Russian markets may be relatively isolated from the rest of the world, but the reasons for this are substantially different in the two cases.

First of all, despite increasing trade integration, a large part of the Chinese market remains relatively inaccessible to the international investor, as severe restrictions limit both the possibilities for foreigners to buy Chinese stocks and for Chinese investors to buy stocks abroad. This lack of arbitrage possibilities leads to situations where large discrepan-

[3]For clarity, unless otherwise indicated, we employ USD-based indexes throughout this paper.

cies occur between returns on shares of the same company as quoted on the Shanghai and Hong Kong markets.[4]

On the other hand a sudden plunge of the Shanghai Composite index (down nearly 9%) on 27 February 2007 sparked a major sell-off in both developing markets as well as emerging markets,[5] most of which were growing strongly till then. Clearly this indicates that though trading restrictions limit the direct impact of and on Chinese markets, the links via investor sentiment, news and other indirect links can have a great influence on the co-movement.

The Russian market is, in contrast, relatively easily accessible to the international investor and Russian investors do not face particular obstacles in accessing international markets. However, the market remains shallow and is characterized by the domination of a handful of companies, mainly in the energy and natural resource sectors. The specific structure of the market makes it very different from most markets around the world and suggests a large idiosyncratic component. Moreover, the early years of our sample are characterized by strong effects of the 1998 Russian crisis.

On the other hand, the spectacular growth of both markets and examples like the above-quoted negative shock of February 2007, which hit both the Russian and Chinese markets in a similarly strong manner, signal the possibility of some importance of common forces. Whether incidents like the spectacular fall of world, and especially emerging stock markets are largely one-off phenomena, regime shifts, or the surfacing of more persistent connections remains to be seen. However, the evolution and assessment of the longer term global and regional linkages of Russian and Chinese markets are the focus of this paper.

The remainder of the paper is organized as follows. The next section reviews the main characteristics of the Chinese and Russian markets and the existing empirical work on the integration of the two markets with other world markets. Section 3 presents the data

[4]For example, in October 2006 shares of Northeast Electric where trading at the equivalent of 0.38 USD on the SSE, almost four times the price of 0.11 USD in Hong Kong (Zhang Shidong, Around the Markets: Mainlanders pay heavily for shares, IHT, 26 October 2006). Similarly, large differences between the same companies' A-shares and B-shares were present in the 1990s (see Ferland and Rogers, 2002).

[5] The Nikkei slid slightly on the same day (-0.3%), followed by a European slump FTSE 100 (-2.3%) and DAX (-3%) and finally the Dow Jones (-3.3%). Emerging markets were hit hard as the RTS (-3.3%) and the WIG (-4.4%), among others, experienced sharp declines (all figures in local currency terms).

and Section 4 presents the methodology used to assess the comovement levels. The results of our analysis are presented and discussed in Section 5, followed by the Conclusions.

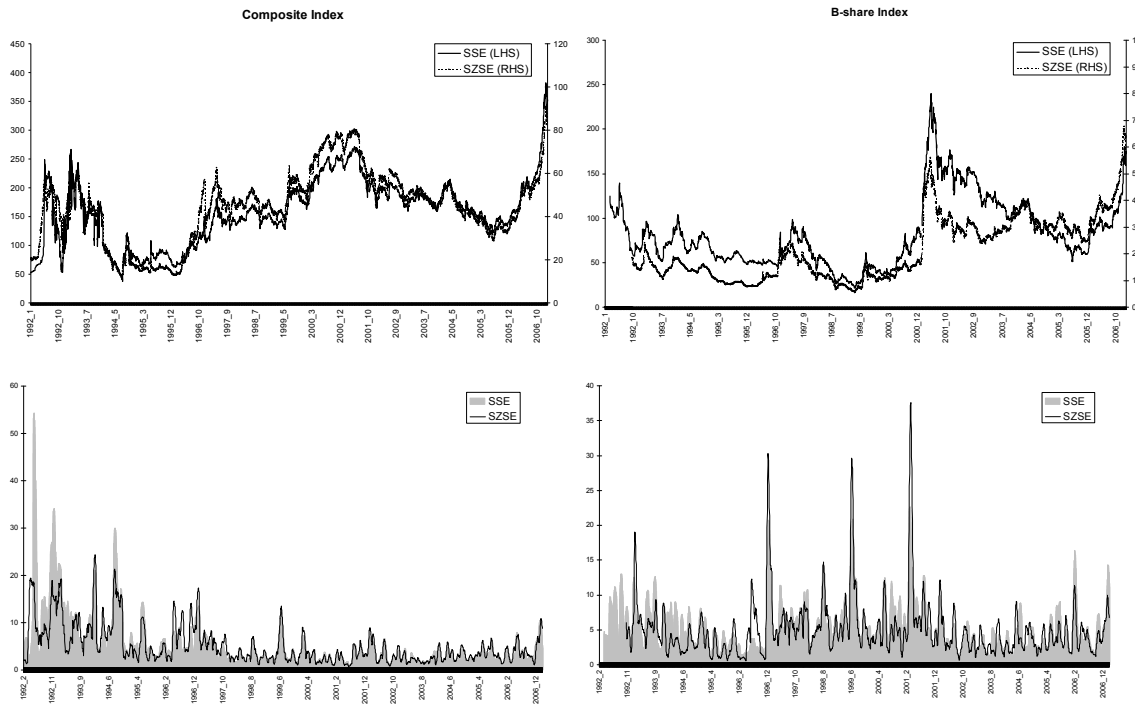
2 Stock markets in China and Russia

2.1 Stock Market in China

The modern stock exchanges in Shanghai (SSE) and Shenzhen (SZSE) were set up in late 1990 and 1991 respectively,[6] in order to provide capital for the reform of state-owned companies and reduce the banks' burdens of providing various types of financing. To this day, they remain relatively inaccessible to the international investor, due to participation and capital account restrictions. During the past 15 years, the main composite indexes evolved similarly across the two markets: trending strongly upward in the early 1990s, until early 1993, when expectations of state-owned shares becoming publicly traded caused fear and led, for example, to an 80% drop in the Shanghai Composite Index in mid 1994. Government intervention caused the index to recover sharply, followed by a 1.5 year recession, which ended in 1995. As can be seen in Figure 1, most of the year 1996 brought a steady rise in the indexes, while 1997 saw them somewhat more stabilized and the isolation of the Chinese market prevented large immediate repercussions of the Asian crisis and the Russian financial crisis. Mid 1999 marked the start of a two-year speculative bubble, amid a general slowdown in the economy. Mid 2001 saw the beginning of a 4 year slump, triggered by new rules on previously non-tradable state-owned shares, which led to a halving of the indexes and finally came to an end in mid 2005. Since then, both markets have been soaring at unprecedented rates.

[6] For a concise overview of the history and evolution of the Chinese stock markets, we refer the reader to Wentao (2007).

Figure 1 Daily evolution of Chinese stock market indexes (top row) and evolution of 30-day volatility (coefficient of variation, bottom row)



Notes: USD-based indexes. Composite index in left column, B-Share index in right column.

Notably, there are different categories of shares traded on the exchanges, the two most important being the A-shares, which are quoted in Chinese currency (RMB), and B-shares quoted in USD (Shanghai) or Hong Kong dollars (Shenzhen). The A-shares (often referred to, especially in the older literature, as 'domestic-only' shares) are available to mainland investors and, since the introduction of the QFII (Qualified Foreign Institutional Investor) scheme in October 2004, to a very restricted number of foreign institutional investors. The A-shares constitute a vast majority of the market, in terms of both capitalization and trading volume.[7]

The B-share market (or 'foreign-only') was set up in order to provide a Chinese stock market for foreign investors and was initially available only to the latter. However, since March 2001, it has been made available to mainland investors with foreign currency accounts. Due to a lack of arbitrage and other investment possibilities, the two types of

[7] In 2006, on the Shanghai Stock Exchange A-shares constituted roughly 97% of market capitalization of traded stocks and 99% of traded value of both types of stocks. The equivalent figures for the Shenzhen Stock Exchange were respectively 93% and 99%.

markets exhibited sharp discrepancies,8 especially in the 1990s, leading to a divergence in prices of the shares of the same company and high first-day appreciations; however there seems to be a tendency toward creating a single market for Chinese shares.

At the end of 2006 annual total trading volumes on the SSE and SZSE reached approximately USD 740bn and 420bn respectively, while the total market capitalizations of traded stocks were USD 915bn and 228bn, with 832 and 579 listed companies. This placed the two Chinese markets combined as the third largest Asian-Pacific stock market in terms of capitalization, after Japan and Hong Kong. Moreover, in terms of the two variables, the markets grew at the fastest (SSE) and second fastest (SZSE) rates in the world, increasing substantially in both categories over 2006.9

Among other distinct features of the Chinese markets is that initial public offerings were suspended between April 2005 and May 2006 due to share-reform aimed at reducing state ownership of listed shares. The markets remain characterized by a large amount of non-tradable shares (above 50% of market capitalization on the SZSE and above 60% on the SSE) held directly or indirectly by the state.

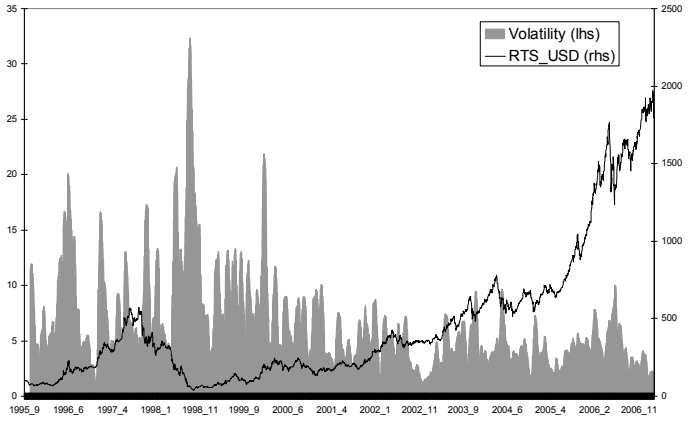
Generally, the stock markets remain relatively isolated, at least in terms of participation. Aforementioned restrictions in the A-share market limit the number of foreign participants and impose caps on their involvement, while the B-share market is relatively shallow and does not offer a wide range of companies. A limited number of shares have secondary listings of various forms on the Hong Kong Exchanges (H-shares), London Stock Exchange and New York Stock Exchange, but, as mentioned, the lack of arbitrage possibilities between the markets leads to large discrepancies between quotations in mainland China and the other markets. Moreover, capital account restrictions severely limit the possibilities for Chinese investors to buy stocks abroad.

[8] See for instance Fernald and Rogers (2002) for an analysis of relative price developments and relative volatility of B-shares, H-shares and equivalent A-shares.
[9] In 2006, according to the World Federation of Exchanges (2006), SSE domestic market capitalization in USD grew 220% yoy and trading values (USD) grew 209.4%. SZSE domestic market capitalization grew 97% yoy and trading value during the same period 174%.

2.2 Stock market in Russia

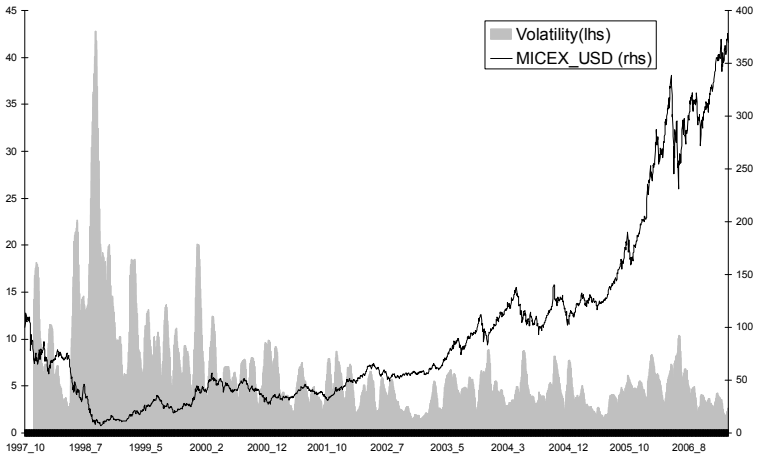
The two main stock trading platforms in Russia which we consider are the older but smaller RTS and the MICEX. The Moscow-based Russian Trading System (RTS) was established in the second half of 1995. By the end of 2006 RTS market capitalization of traded stocks was about USD 165bn, while total value of trading was over USD 16bn. The number of listed and traded stocks is near 300, but the relatively low yearly turnovers place the RTS below other regional markets like the Warsaw Stock Exchange and the Budapest Stock Exchange.

Figure 2. Values of daily RTS index (USD, solid black line, right scale) and 30-day volatility (coefficient of variation, grey line, left scale)



Note: Dates 1Sep1995-1Feb2007.

Figure 3. Values of daily MICEX Index (USD recalculated, 01Oct1997 =100) and 30-day volatility (coefficient of variation)

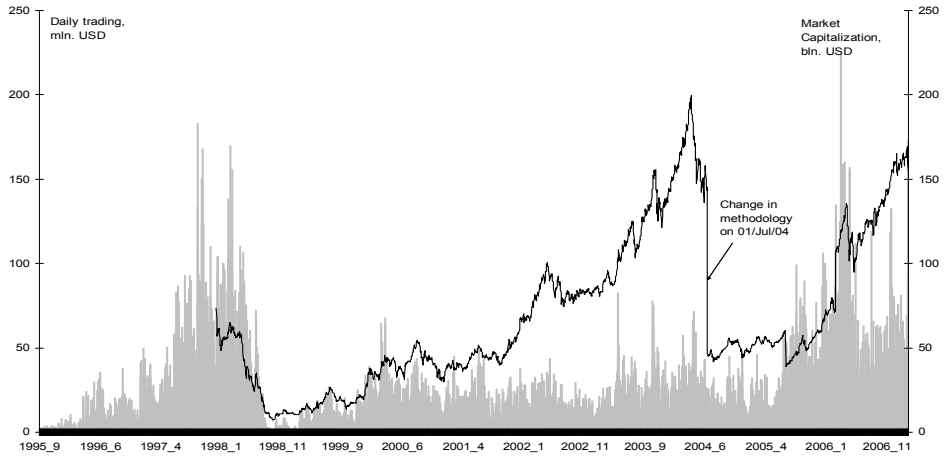


Note: Dates: 1Oct1997-1Feb2007

The other important market that we look at is the Moscow Interbank Currency Exchange (MICEX), which also provides for equity trading. Founded in 1992, it began with trading of non-government securities in 1997 and developed into the largest equity trading platform in Central and Eastern Europe. Currently it oversees over USD 550bn in total equity trading (2006) and USD 860bn in total market capitalization. The MICEX lists over 300 equities of 193 issuers.

The outbreak of the Asian crisis in July 1997 saw the RTS main index at record levels, and volatility increasing significantly (see Figures 2 and 3). The MICEX equity index was not yet calculated at that time, but since late 1997 the paths of both indicators have been very similar, as many of the main companies are traded in both markets. The index remained at high levels until the end of the year, when the sharp decline started. The following year saw the indexes lose over 90% of their USD value, amid the Russian financial crisis, which caused ruble devaluation, while volatility surged. Since the aftermath of the crisis volatility has decreased substantially despite being sparked by a series of events, including the troubles of Yukos in late 2004. Over the longer term, the main indexes grew steadily till about 2001, accelerating afterwards even further in 2005, to reach a cumulative return of above 1000% in the last 5 years and gaining over 65% in USD terms in 2006 alone, the second highest returns after the Chinese markets.

Figure 4 Total daily trading values (grey bars, left scale) and market capitalization (black line, right scale), Russian Trading System



Note: USD values.

A very important characteristic of both the MICEX and the RTS is their heavy reliance on large natural resource and energy companies. In 2006 this dependency increased further as global commodity prices surged, resulting in the top three MICEX companies (Gazprom, Rosneft and Lukoil) making up over 47% of its capitalization. As for the RTS, in terms of market capitalization at the end of 2006, the (same) top 3 companies, from the energy/resource sector, amounted to 45% of the total market capitalization.[10] Moreover, these stocks also tend to be the most liquid. In the RTS, the top 4 traded companies, all from the resource/energy sector, accounted for over 75% of annual (2006) trade value in USD.[11]

Several of the main Russian companies (Gazprom, Lukoil etc) are also quoted on the LSE, in the form of various depository receipts, while a smaller number are listed on the NYSE.

2.3 Empirical literature on stock market integration

There is a vast literature on financial integration which investigates comovements of stock markets, including emerging markets, but there is relatively little that focuses on the Russian or Chinese markets.

The basic approaches define financial integration of stock markets as that of first order, i.e. comovement in first moments, e.g. returns, and of the second order, i.e. comovement in second moments e.g. variance.[12] The spectrum of methodologies used to assess comovements is quite wide – ranging from simple or conditional correlations, to dynamic correlation spectra, VAR and multivariate GARCH models, and some attempts to apply Principal Component analysis (PCA). For example, Groenweold, Tang and Wu (2004) use cointegration and VAR analysis to determine interrelationships between stock

[10] In terms of market capitalization, the top ten companies constitute over 70% of the market. Of them, only two are not from the resource/energy sector: Sberbank (4th with 6.8% of market capitalization) and the mobile telecom operator MTC (10th with 1.77%). Gazprom makes up over 28% of market capitalization.

[11] Incidentally, the only two companies not operating in the resource/energy sector that were among the top 10 traded stocks, which accounted for 89% of trading, were Sberbank (4th with 4.81% of traded stock value) and Russian Telekom (10th with 1.06% of traded stock value). Gazprom itself accounted for almost 40% of traded stock value in 2006.

[12] See Corsetti, Pericoli and Sbracia (2002) for an overview of the empirical work.

market indexes in greater China (Shanghai and Shenzhen together as Mainland China, Hong Kong and Taiwan) in the time span of 1992-2001, i.e. before China's accession to the WTO. The results, unsurprisingly given the sample period, show a high degree of isolation of Mainland Chinese markets from the other two, with no interrelation found, while some linkage exists between Taiwan and Hong Kong. The link between the Mainland and the other two markets remains insignificant in both pre- and post-Asian crisis subsamples.

One of the most interesting analyses, from the point of view of this paper, is Li (2007), who estimates a four-variable GARCH for the Shanghai, Shenzhen, Hong Kong and New York markets. The author allows for time varying variance-covariance, in a 2000-2005 sample, but fails to find any integration of the Chinese markets with that in the US, while identifying a very weak link for spillovers of volatility from Hong Kong to the two Chinese markets.

Several other papers use a GARCH framework investigating interactions between Chinese A and B markets, which shows that the GARCH approach to investigating stock market integration (in returns and volatility) has a number of desirable characteristics, one of the most important being the ability to capture spillover direction between markets.[13] However the nature of the GARCH models precludes analysis of large sets of stock markets, as the number of parameters quickly becomes too large to be estimated.

Meric et al. (2006) use rolling correlations and principal component analysis to determine the integration of 7 Latin American economies in a sample of 1995-2005 weekly returns on stock market indexes. On the side, they perform a PCA analysis including the Latin American countries together with 7 major developed stock markets and 19 emerging stock markets. The results provided in the paper are hard to interpret, due to a lack of relevant details, but the authors claim to find a common emerging-Asian component with which China exhibits some comovement, while Russia seems to co-move with the large emerging Europe countries.

Our analysis has the benefit of being able to extract common forces from a vast set of stock market indexes, which is problematic in a GARCH or VAR framework. It also allows us to analyze the countries of interest in a global and regional context. Moreover, as our derived underlying forces (factors) are by definition mutually orthogonal, they allow the identification of mutually unrelated common driving forces.

[13] See Wang, Liu and Wang (2004) and Brooks and Ragunathan (2003).

Finally, a clarification. In our paper, we define the integration of stock markets as the degree of comovement, that is, we consider two markets to be the more integrated, the more they are found to be driven by common forces. This requires a distinction between two types of comovement - comovement in measured market returns, which we refer to as first-order financial integration, and comovement in volatility, i.e. second-order financial integration.

In order to provide a rough picture of stock market comovements Table 1 shows the average correlations of Chinese and Russian stock market indexes with markets around the world. Simple correlations are the most straightforward method of assessing comovement, and we are able to say that the correlation coefficients of Chinese indexes with other markets in the world, in Asia, in Europe and in emerging Europe, did not exceed 15% in the 1998-2007m1 sample and were lowest for the European markets. The correlation of B-share indexes tended to be slightly higher, but still about half of the average correlation of Russian indexes, which tended to show 30% correlation with markets around the world, Asia and Europe. Moving to the shorter sample of 2006-2007m1, we see correlation coefficients increase substantially – practically doubling. The Chinese markets show coefficients of around 20-30%, slightly higher with South East Asia, while the Russian markets show correlations of almost 60% on average and slightly higher values with Europe, suggesting some regional links.

Table 1. Correlations of smoothed daily returns

	China				Russia	
	Shanghai A-share	Shenzhen A-share	Shanghai B-share	Shenzhen B-share	RTS	MICEX
	1998-2007m1					
All	.12	.12	.13	.15	.29	.29
S.E. Asia*	.10	.09	.11	.14	.29	.30
Europe**	.08	.08	.09	.10	.28	.29
EM Eur.**	.10	.10	.11	.11	.26	.27
	2006-2007m1					
All	.25	.21	.26	.30	.56	.57
S.E. Asia*	.29	.23	.26	.32	.60	.61
Europe**	.22	.17	.23	.27	.65	.65
EM Eur.**	.21	.18	.27	.31	.60	.62

Note: (*) – excluding China, (**) excluding Russia.

Simple correlation coefficients, illustrative as they are, are unable to separate the degree of comovement common in the global, regional, emerging market or commodity producer dimension. In order to achieve the above, we switch to factor analysis, which allows us to identify the influence of common, mutually independent forces.

3 Data

Our broad data set is extracted from the Bloomberg database and supplemented with information from stock market websites. The full set consists of daily USD-based closing values of 135 stock market indexes for 75 countries. These include 10 countries are from Americas; 34, including Russia and Turkey, from Europe; 15 from Asia-Pacific; and 16 from the Middle East and Africa. Obviously, the time horizon varies by country, as many emerging market indexes are available only from the late 1990s or even 2000.[14] As we try to adopt the broadest (in terms of countries) perspective, we focus on a relatively broad sample since late 1998 and on subsamples of the latter. We experiment with various combinations of market indexes, tending to pick one index per market, but base our main conclusions on the main indexes of each market, i.e. the indexes calculated on a selected number of most traded or most capitalized stocks, such as the FTSE 100 and Nikkei 225.[15]

One of the issues in the literature is whether to use standardized or non-standardized data.[16] The former have the advantage of concentrating more on the relation to overall relative movements in each single market and thus the results are not dominated by stock indexes which generally exhibit large swings in values. Moreover, as the results are generally not so different,[17] we focus on the standardized specification. Due to the high

[14] Most of the reported results refer to a sample of 66 series for 59 countries which is a compromise between length of series in the time dimension (starting late 1998) and their number.

[15] Exact details of the selected indexes and dates can be found in the Appendix. The results tend to be robust to the exact choice of indexes (i.e. whether the total market or main index are chosen), which does not come as a surprise, as the total market indexes usually co-move with the main indexes.

[16] By standardization we mean subtracting the mean and dividing by the standard error in order to obtain a series with a zero mean and unit variance.

[17] The results, in terms of number of factors and explanatory power, with the exception of a few outliers, are generally very similar in the standardized and non-standardized cases. The major difference is obviously in the nominal size of the factor loadings, which are harder to present and compare in the non-standardized specification (largely reflecting the relative nominal differences in indexes). On the other hand, with stan-

degree of heteroscedasticity, the Bai and Ng (2002) information criteria may tend to overestimate the actual number of factors. Therefore we resort to an additional measure of discarding factors which explains less variance in the data set than can be explained by two single indexes together. This usually means discarding factors that are found to explain slightly less than 3% of the overall variance or below. However, in practice this additional restriction is exploited only in the shorter horizon volatility analyses.

Because of the different opening times of stock markets around the globe, we smooth the data, experimenting with 2-, 3- and 5-day moving averages; the exact choice of the specification does not affect the results. Weekends and most common holidays are excluded, while country-specific holidays are interpolated using simple averages. Our analysis is conducted in two-steps, where first-order financial integration assessment is based on log market returns, $\ln(X_t / X_{t-1})$, while second-order comovement is based on volatility measured as the coefficient of variance, i.e. $\sqrt{\text{var}(X)} / mean(X)$ over a 30-day moving interval.

4 Methodology

In order to answer our question of interest, we adopt the approximate factor model methodology set up by Bai (2003), decomposing the matrix *X* of *N* indexes *(T×N)* into *R* orthogonal common factors F^r *(T×1)* and an idiosyncratic component:

$$X_{it} = \sum_{r=1}^{R} F_t^r \cdot \lambda_i^r + e_{it} = \sum_{r=1}^{R} C_{it}^r + e_{it}$$

for *i=1..N* and *t=1..T*. The coefficients λ_i^r represent the loadings of factor *r* into series *i* and the relationship between *X* and *F* is assumed static throughout the sample. If the number of factors *R* is not known a priori, it can be determined automatically by select-

dardized indexes, the loadings are distributed over the [0,1] interval and proportional (exactly equal when squared) to the % of variance explained, making their comparison straightforward.

ing one of the information criteria developed by Bai and Ng (2002). In our application we use IC_{p1}:[18]

$$IC_{p1}(R) = \ln(V(R, F^R)) + R(\frac{N+T}{NT})\ln(\frac{N+T}{NT})$$

where $V(R,F^R)$ is the sum of squared residuals (divided by NT) from the OLS regression of X_i on the set of R factors F^R for all i.

In order to obtain the factors, loadings and thus the common component estimates, as shown in Bai (2003), we can apply principal component analysis (PCA) or extract the eigenvectors associated with the largest R eigenvalues of the $X'X/NT$ matrix. Notably, the factors, and consequently the loadings, are estimated up to a rotation and therefore not separately identifiable. Hence we will use the *varimax* procedure (see Kaiser, 1958) in order to obtain the rotation that maximizes the variance of the loadings, and thus facilitates their interpretation. They are standardized such that $F'F/T = I_R$, where I_R is the $R \times R$ identity matrix. In order to obtain the variance of the estimated factors and loadings, we exploit the asymptotic properties derived by Bai (2003). For large N and T, the estimated factors, loadings and common components follow a normal distribution. Both Monte Carlo simulations presented in Bai (2003) and the ones performed for the purpose of this paper show very good finite sample properties of the estimators. Having obtained the measures of significance, we turn to an analysis of the importance of the common factors.

PCA straightforwardly leads to an assessment of the shares of the variance of the total data set that are explained by each common factor. We can also decompose the variance of each series into shares of variance due to each single common component and the idiosyncratic component:

$$VAR(X_i) = VAR(\sum_{r=1}^{R} F^r \cdot \lambda_i^r + e_{it})$$

Exploiting the orthogonality property of factors with respect to each other and to the idiosyncratic component, we obtain

[18] Bai and Ng (2002) also develop alternative information criteria. Application of these to our data set does not affect the results.

$$VAR(X_i) = \sum_{r=1}^{R} VAR(F^r \cdot \lambda_i^r) + VAR(e_i)$$

Dividing both sides by the variance of Xi we obtain:

$$1 = \sum_{r=1}^{R} \frac{VAR(F^r \cdot \lambda_i^r)}{VAR(X_i)} + \frac{VAR(e_i)}{VAR(X_i)}$$

As λ_i^r is a scalar and the factors are standardized ($F'F/T = I_R$), the importance of each factor r is given by:

$$\frac{VAR(F^r \cdot \lambda_i^r)}{VAR(X_i)} = \frac{(\lambda_i^r)^2}{VAR(X_i)}$$

The derivation resembles taking the R^2 statistic from the regression of Xi on Fr.

Factor models have been applied in a vast area of empirical investigations, ranging from asset pricing models and business cycle analysis to forecasting and consumer theory (for a brief overview, see Bai, 2003 or Stock and Watson, 2001). An approach closer to ours uses the above methodology in the analysis of global and regional business cycles (see Cerqueira, 2006) to assess the level and dimension of comovement in GDP, consumption and investment. Other strands of business cycle literature apply dynamic factor models (see for example Forni and Reichlin, 2001; Kose et al., 2003), but in our setup this methodology has more shortcomings than advantages. First of all, the main driver of stock market co-movement is news, which travels and is incorporated in the market price quite quickly relative to the frequency of the data. In other words, the reaction to a shock in one market can be dubbed as instantaneous relative to the frequency that we use,19 thus the necessity of dynamic structure is not at all clear. Moreover, the dynamic factor methods impose ex ante both the number of common factors and the structure of regions, which are precisely the information that we want to extract from the data.

5 Results and discussion

We present results for the recursive factor extraction on data sets of both standardized stock market returns and volatilities in subsamples ranging from the longest (1996m1-2007m1) to the most recent (2006m1-2007m1).[20]

As can be seen from Tables 2 and 3 the extracted factors help to explain a large degree of variance in each data set - ranging from around 40% of variance explained by the top 3 factors in the standardized returns specification to over 80% for the 8 factors in case of volatilities. In all cases the first factor strongly dominates, suggesting the existence of a global comovement in both returns and volatilities. This structure is relatively robust, though the importance of factors seems to be increasing in the more recent samples, pointing to a higher degree of integration. We turn now to a more detailed analysis of the two types of integration. [21]

5.1 Comovement in returns

The summarized results for comovement in returns are reported in Table 2. In all the recursive specifications of the 66 series sample, the Bai and Ng (2002) algorithm selects the number of factors present in the data set to be 4. In all these cases the four common factors are able to jointly explain 40-50% of the variance of the data. However, this value increases as the sample is reduced, from just over 42% in the 1998-2007m1 sample to almost 56% in the 2006-2007m1 sample. This indicates a large number of idiosyncratic disturbances in the earlier period. Moreover, as the relative explanatory power of the second, third and fourth factors are almost unchanged, the notable increase in common movement is due to the first factor, which exhibited a gradual increase in explanatory power.[22]

[19] After adjusting for different market opening times.

[20] The exact estimation results are available from the author, including the results for a longer period 1996m1-2007m1, with a reduced number of available indexes. In our analysis we focus mainly on the more recent results, due to fact that they allow the inclusion of a larger set of series. However, to save space, we omitted some of the details.

[21] For the purpose of exposition in the sections below we focus mainly on graphing loadings and their confidence intervals. More estimation details are available from the author. Notably, the loadings coefficients and factors are estimated quite precisely due to the length of the series.

[22] It must be noted, however, that at this point there is no indication that the *n*-th factors estimated in two subsamples actually represent the same common movement – this issue is investigated below.

Table 2 Diagnostics for factor extraction – standardized returns (5-day smoothed)

Sample	1996m1 -2007m1	1998m1 -2007m1	2000m1 -2007m1	2002m1 -2007m1	2004m1 -2007m1	2006m1 -2007m1
no. obs. (T)	2847	2328	1821	1307	794	277
no. series (N)	58*	66	66	66	66	66
no. of factors (R)	3	4	4	4	4	4
% of var. explai-ned by all factors:	39	42	43	46	49	56
by 1st factor	29.2	28.48	28.88	30.92	35.38	42.89
by 2nd factor	5.76	5.49	5.43	6.22	5.37	5.83
by 3rd factor	4.39	4.3	4.39	4.41	4.3	3.9
by 4th factor		3.88	3.96	4	3.81	3.69

Note: Recursive estimation in subsamples, except for (*) which is a narrower sample with less series but a longer time dimension.

The first factor, which explains from 30 to over 40% of variance of the entire data set, is graphed in Figure 5 for the longest of the data samples. The fact that we can easily identify serious global financial market disruptions increases our confidence in labeling this common force as the GLOBAL factor. Moreover, in Figure 6 we graph the loadings of stock market indexes on the first factor, for both the long and shortest sample for all the analyzed indexes i.e. the broad sample. Clearly the factor in question is characterized by high and significant loadings from indexes in most developed countries, and the loadings exhibit an increase as we switch to the more recent samples, in line with the increase of the first factors' explanatory power, for most of the countries. Turning to the markets of interest, we see that the Russian markets showed a significant increase of loadings toward the end of our sample (see Figure 7), increasing from about 0.2 to 0.7, which is equivalent to an increase of explanatory power of the first common factor from below 5% to above 50%. The change is significant, and we interpret this as a sign of increasing integration of the Russian market with global forces. On the other hand no similar increase can be observed for the Chinese markets (Figure 8) where loadings on the first, GLOBAL, factor remained low regardless of the sample, indicating no explanatory power of the first factor in the case of both the A- and B-share indexes.

Figure 5 GLOBAL factor, 1996-2007m1 sample (95% confidence interval)

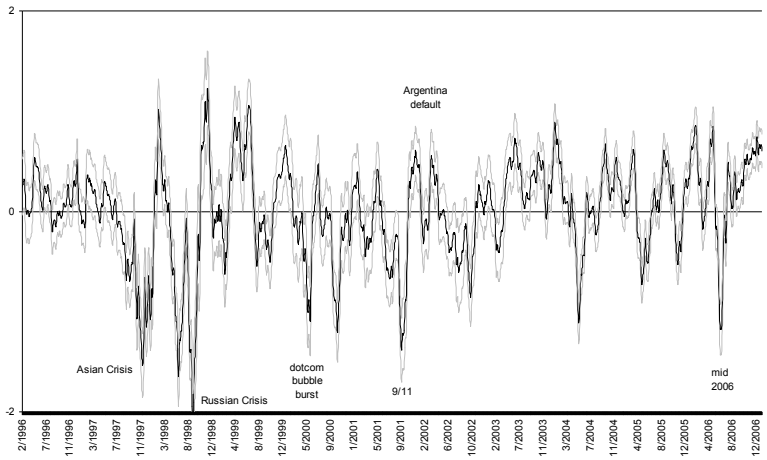


Figure 6 Loadings on GLOBAL factor, 1998-2007m1 sample (grey) and 2006-2007m1 sample (black)

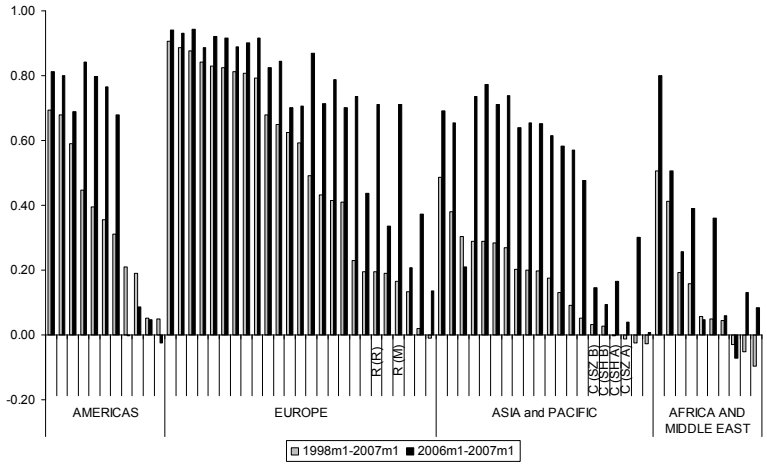
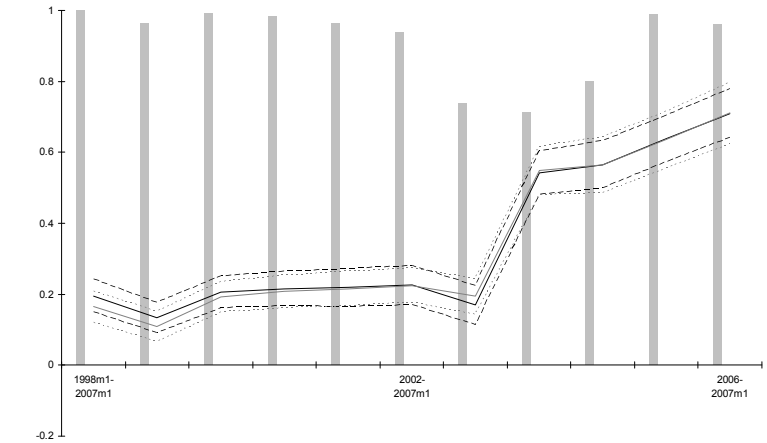
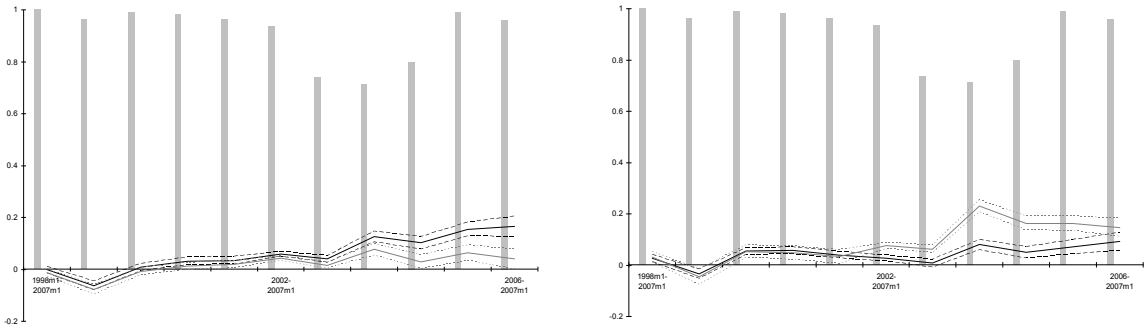


Figure 7 Loadings of Russian stock market (RTS - black and MICEX - grey) indexes on the GLOBAL factor



Note: Recursive estimation over subsamples with 95% confidence intervals. Grey bars represent correlation between global factor estimates over full sample and appropriate subsample.

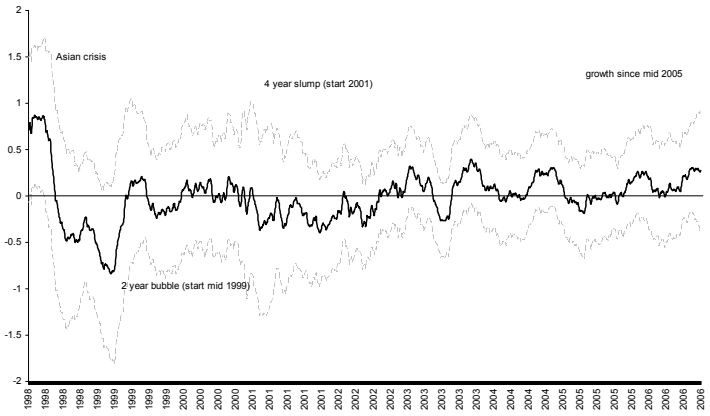
Figure 8 Loadings of Chinese stock market (Shanghai - black and Shenzhen - grey) A-share (left) and B-share (right) indexes on the GLOBAL factor



Note: See Figure 7.

Next, in all the subsample specifications we are able to identify a factor with high loadings from all four Chinese indexes, and rather low loadings from other series (see Figure 10). This points to the relative isolation of the Chinese markets, which exhibit strong common forces among each other, but have little in common with other markets. We can fairly confidently label this force as the CHINA factor. This factor, by construction, is orthogonal to any other common forces and to idiosyncratic forces in each of the markets. A CHINA factor seems to exist in all the subsamples, and the role of the force common to Chinese markets does not change across time (Figure 11), explaining roughly 70-90% of the variance of the individual indexes. The identification of specific events is not as clear as in the case of the GLOBAL factor. However, many events characteristic of the Chinese markets can be identified (Figure 9).

Figure 9 CHINA factor



Note: 100-day smoothed values. Dotted lines give 95% confidence interval.

Figure 10 Loadings on CHINA factor, 1998-2007m1 sample (grey) and 2006-2007m1 sample (black)

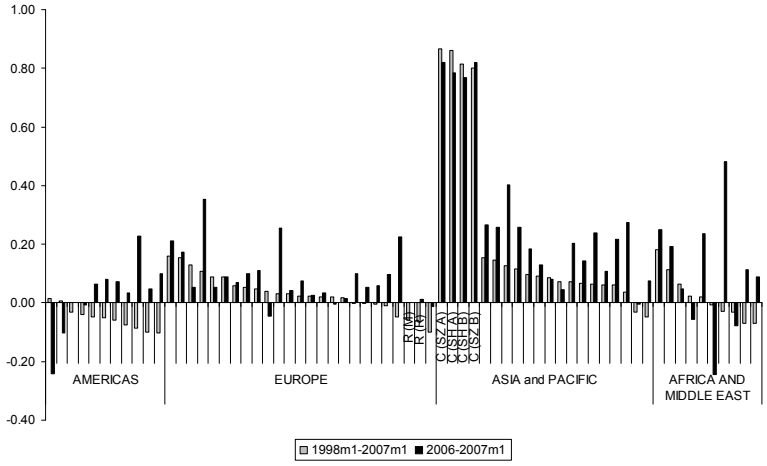
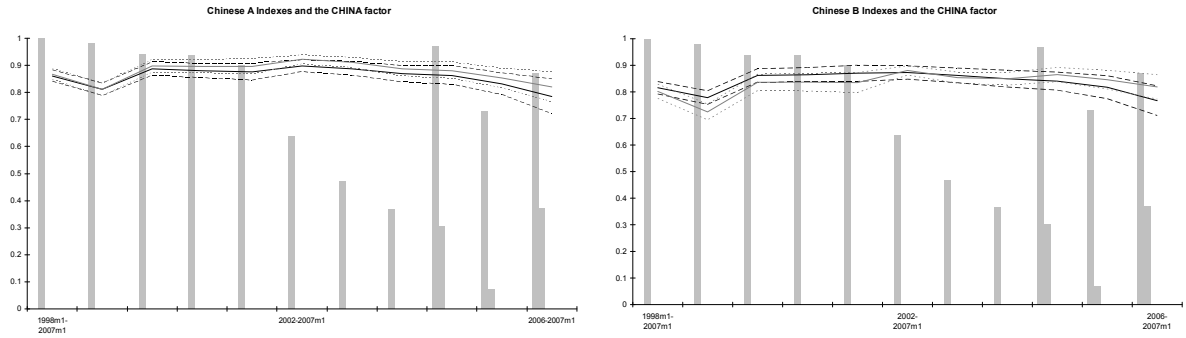


Figure 11 Loadings of Chinese stock market (Shanghai - black and Shenzhen - grey), A-share (left) and B-share (right) indexes on CHINA factor



Note: See figure 7.

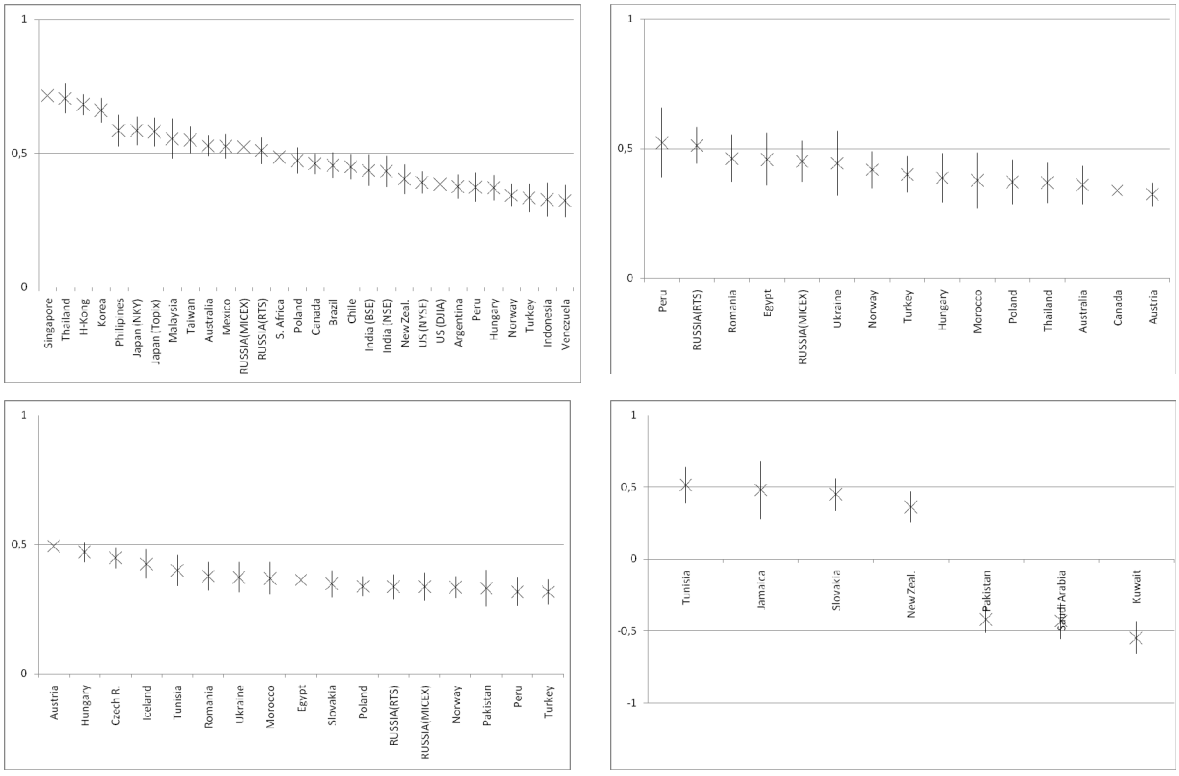
While in all subsample estimates the identification of the GLOBAL and CHINA factors is straightforward; labeling of the two other common forces identified is more problematic. We refrain from forcing an interpretation, but report the loadings on the third and fourth factor for the long and shortest samples in Figure 12. We report only loadings for markets in which the individual factors explain at least 10% of series variance. However, some rough observations on the pattern can be made.

As for the factor that explains the third largest share of variance, it clearly loads mainly on emerging markets. The strong presence of Asian and emerging European countries suggests this factor may be associated with the Asian and Russian crises. Moreover, the markets which exhibit strong influence of the third factor throughout the long sample seem to shift closer to the GLOBAL factor as we approach the shorter sample, supporting the idea that a large part of the common force may be associated with aftermaths of the

Russian or Asian crises. The fourth factor exhibits loadings from central and eastern Europe, north Africa, and five countries from other regions (Iceland, Norway, Pakistan and Peru).

As in the 2006-2007m1 sample most of the common movement of emerging Asia and emerging Europe ceases to be orthogonal to the global movements and exhibits increasing commonality with the GLOBAL factor. The third factor, in the case of the recent sample, has a similar composition of central and eastern European countries, i.e. north Africa, Norway and Peru, joined by Canada and Australia, and is hard to interpret.

Figure 12 Loadings on third (first row) and fourth (second row) factors



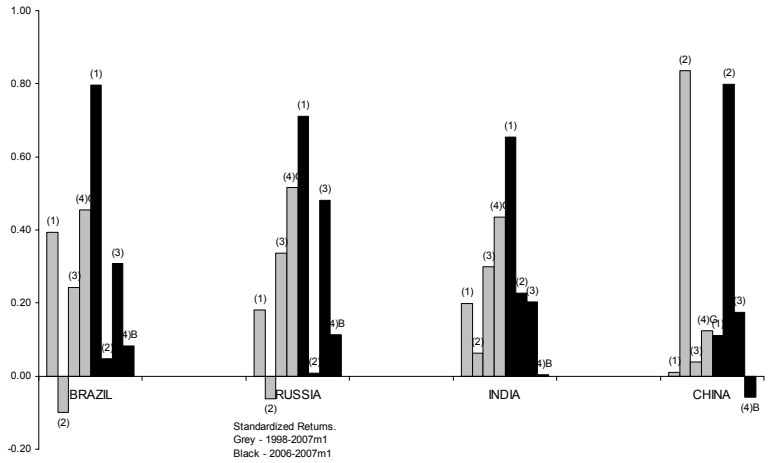
Note: Left panel – long sample 1998-2007m1, short sample 2006-2007m1. Only markets for which third or fourth factors explain at least 10% of the variance. 95% confidence intervals.

Finally, we compare factor loadings for a group of large, emerging market economies referred to as the BRICs.[23] Again, we compare the long and shortest sample, as in Figure 13. We see that the four common factors explain 42-43% of the variance in the Brazilian and

[23] The term BRICs encompasses the four large emerging markets Brazil, Russia, India and China and was first introduced by Goldman Sachs economists in 2003.

Russian indexes, 34% in the Indian series, and 70-80% in the Chinese series, in the 1998-2007m1 sample. Moving forward the common forces explain 70-80% of the variance in the Brazilian, Russian and Chinese series, and 53% in the Indian series, in the 2006-2007m1 sample. Looking at the loadings of the individual factors, we see that while Brazil, Russia and Indian are characterized by a fairly similar distribution of loadings in both samples with a large influence for the GLOBAL factor, China stands out from the other BRICs with very different loadings of the common forces which are dominated by the CHINA factor.

Figure 13 Factor loadings for BRICS (Brazil, Russia, India and China)



Note: Factors (1) – GLOBAL, (2) –CHINA, (3) Emerging market (tentative), (4).

5.2 Comovement in volatility

In order to assess the role of common forces in the movement of second moments, we repeat the above analysis using the coefficient of variation instead of simple returns. The diagnostics for the subsample estimates are reported in Table 3. Due to the tendency of the Bai and Ng (2002) algorithm to overestimate the number of factors in a highly heteroscedastic data set, we adopted an additional discrimination rule, eliminating any common factor with explanatory power less than 3%. This threshold roughly equals the variance of any two standardized series in our data set, and allowed us to limit the factors in the last three subsamples to those that are able to explain the equivalent share of variance as two (standardized) underlying indexes.

Table 3 Diagnostics for factor extraction, 30-day coefficient of variation * indicates longer sample with less series.

Sample	1996m1 -2007m1	1998m1 -2007m1	2000m1 -2007m1	2002m1 -2007m1	2004m1 -2007m1	2006m1 -2007m1
no. obs. (T)	2817	2302	1795	1281	769	251
no. series (N)	58*	66	66	66	66	66
no. of factors (R)	6	6	6	7	8	8
% of var. explained by all factors:	54	54	51	55	68	82
by 1st factor	28,4	28,4	26,1	28,1	30	40,6
by 2nd factor	8,2	8,9	7,5	8,9	8,5	10,5
by 3rd factor	5,5	5,3	6,1	5,9	6,4	7,9
by 4th factor	4,5	4,3	4,1	4,8	5,6	6,7

In general, we see that the number of selected factors is higher than for comovement of returns, varying from 6 to 8 in the subsamples. Their explanatory power is also higher and increases from just over 50% in the long samples to over 80% in the most recent sample. Again, we can clearly see a dominating common factor which explains from 26 to 41% of the variance in the data set. The first factor is clearly a candidate for being labeled the GLOBAL factor. The distribution of loadings, presented in Figure 14, confirms this, as the first factor is generally of large importance for the main markets around the world. Notably its importance for the US markets falls in the more recent sample as does the importance of the first factor for a number of booming markets (Spain, New Zealand and a number of Caribbean and Middle East markets), which displayed a recent increase in volatility.

Finally we look at the first factor itself, in Figure 15, and again are able to identify the main global developments in financial markets; therefore we can fairly confidently label the first factor as GLOBAL.

Figure 14 Loadings on GLOBAL factor, 1998-2007m1 (grey) and 2006-2007m1 (black)

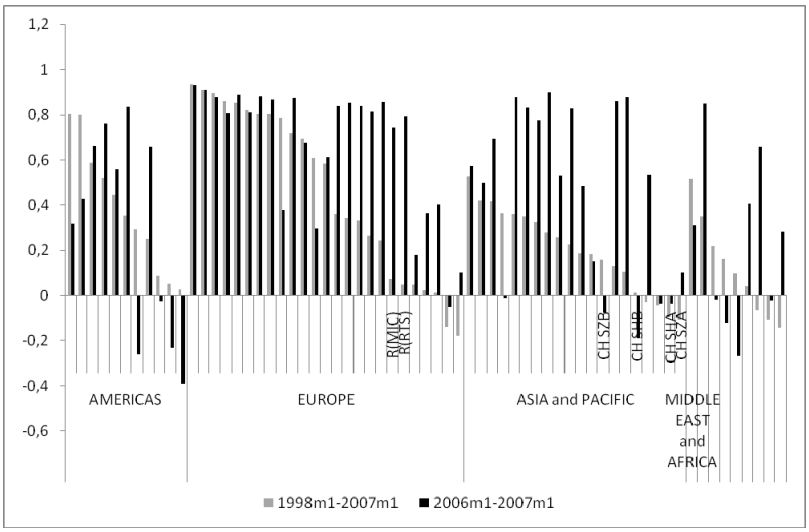
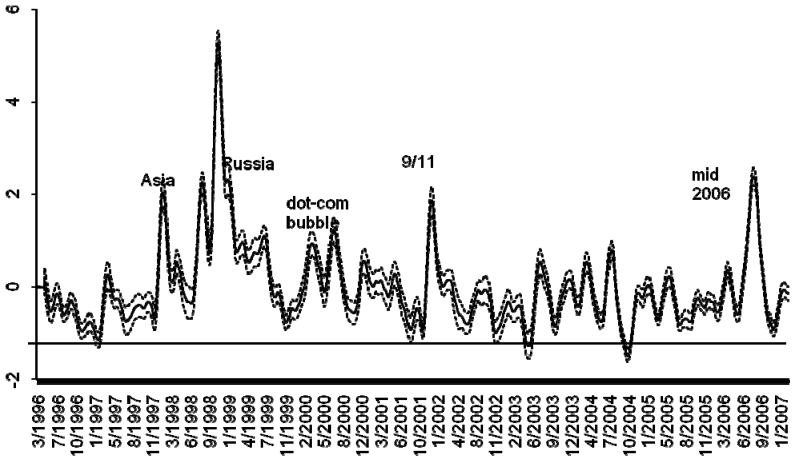
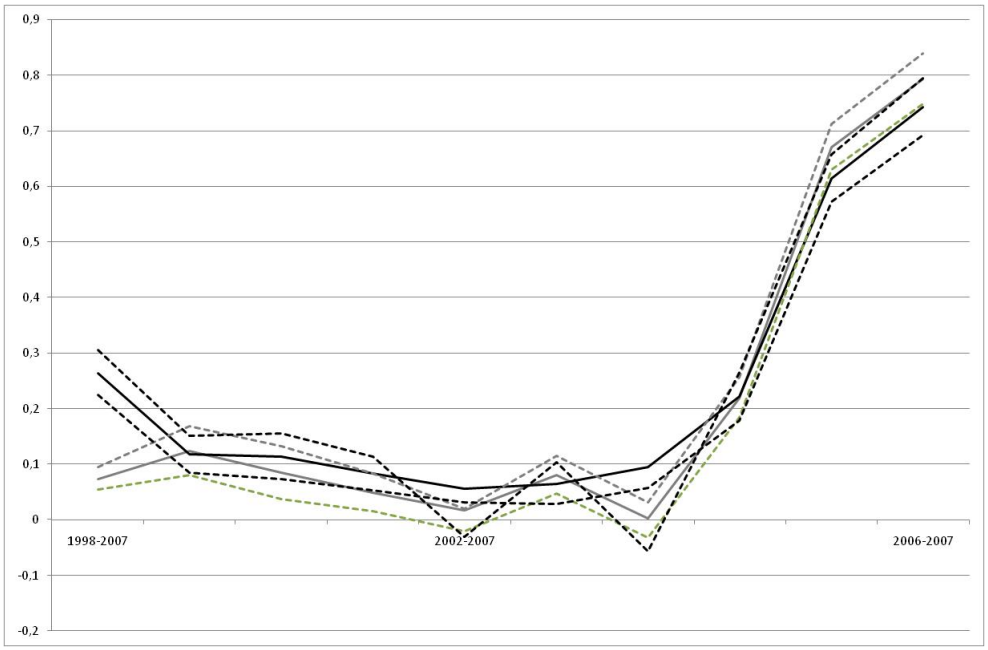


Figure 15 GLOBAL factor, 1996-2007m1 (with 95% confidence intervals)



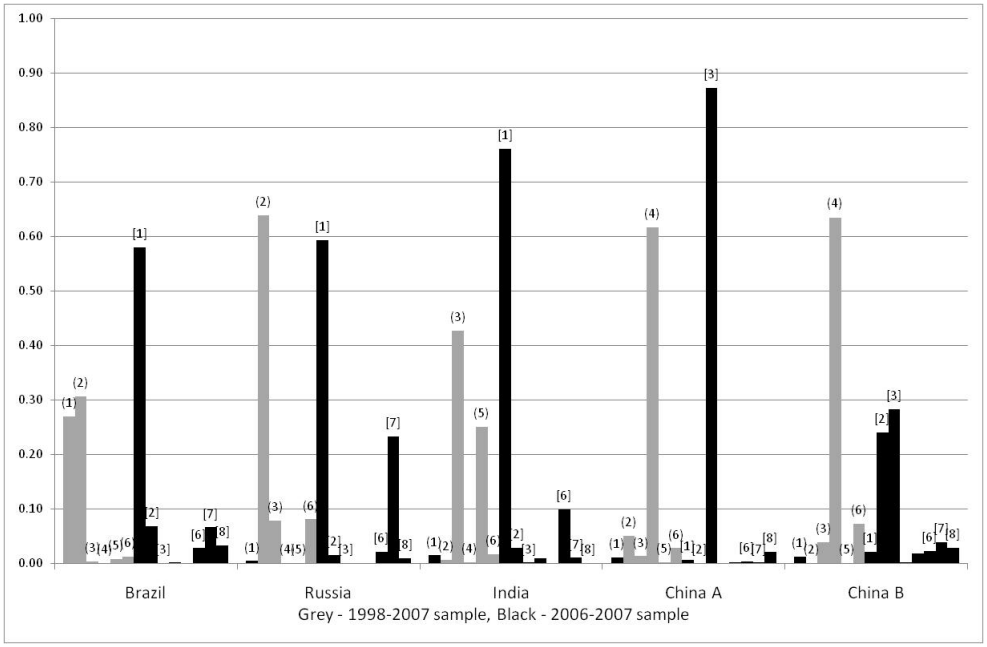
Concerning the markets of interest, the Russian markets have strong loadings on a factor that is common to most emerging markets – as in the case of the returns specification. However, the move toward the GLOBAL factor (see Figure 16) happens about one year later, suggesting that contagion in volatility is more persistent. The Chinese markets remain isolated throughout the whole sample, with A-shares exhibiting high loadings on a uniquely CHINA factor, while B-shares also exhibit some volatility common to other Asian economies.

Figure 16. Loadings of GLOBAL factor on Russian indexes



Note: dotted lines represent 95% confidence intervals.

Figure 17 BRICs, share of variance explained by individual factors



Turning to the BRICs, in Figure 17 we see that in the long sample the common GLOBAL factor had little influence on any of the markets except Brazil. In the latter, the first factor

could explain around 30% of the variance, but failed to have explanatory power for any of the other countries. Russia had high loadings on the second factor, which exhibited a strong influence on markets in central and eastern Europe, some countries in south east Asia and in Latin America. Therefore this can be roughly identified as a post-crisis factor, which is largely in line with the effects of the emerging market crises of the late 1990s. The volatility of Chinese markets is largely independent of other markets, as was in the case for returns, and can be explained by the fourth factor. As we move to the shorter sample, the resemblance between three of the BRICs emerges. As the post-crisis factor fades away, Brazil, Russia and India move more and more in line with the GLOBAL factor. Between 55% and 80% of the 30-day volatility of the stock markets in these countries can be explained by the first factor. For China, not only is the behavior again distinct from the other BRICs but, contrary to the specification of comovement in returns, there is a significant difference between the volatility of A- and B-shares. Both Shanghai and Shenzhen A-shares comove practically orthogonally to non-Chinese markets, while sharing some volatility with the B- share indexes. However, the latter exhibits an increasing component (second factor) which is independent of A-share movements, while showing some weak explanatory power in other emerging market indexes.

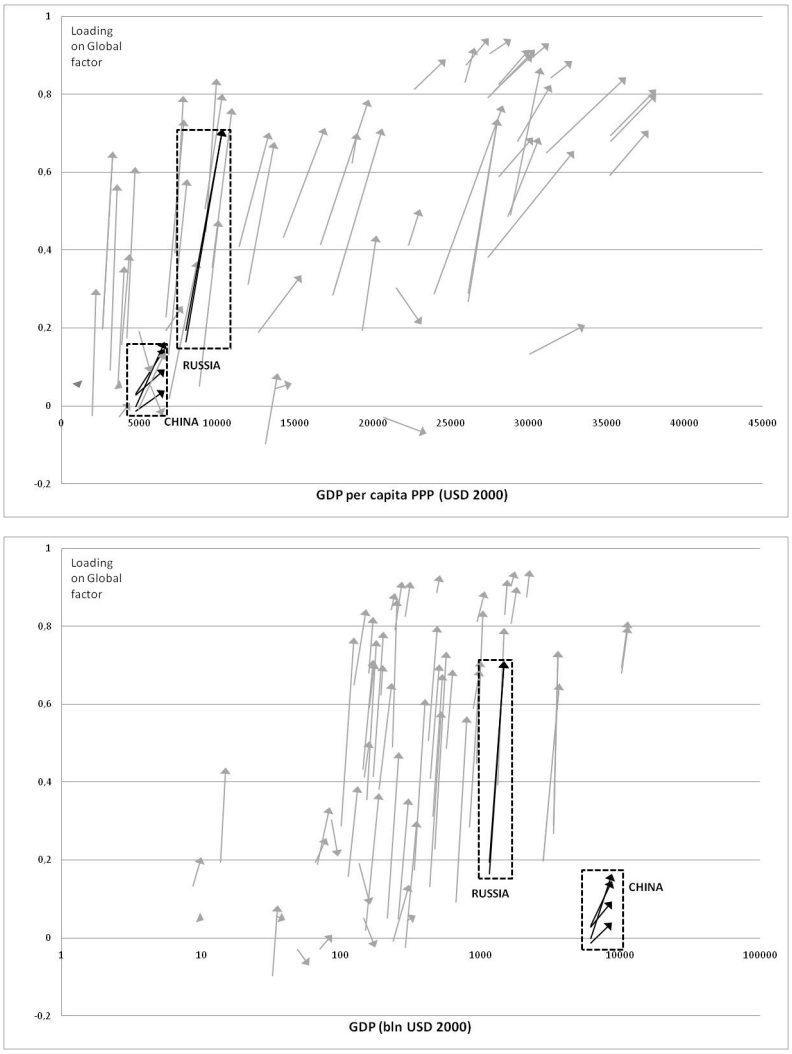
5.3 Discussion

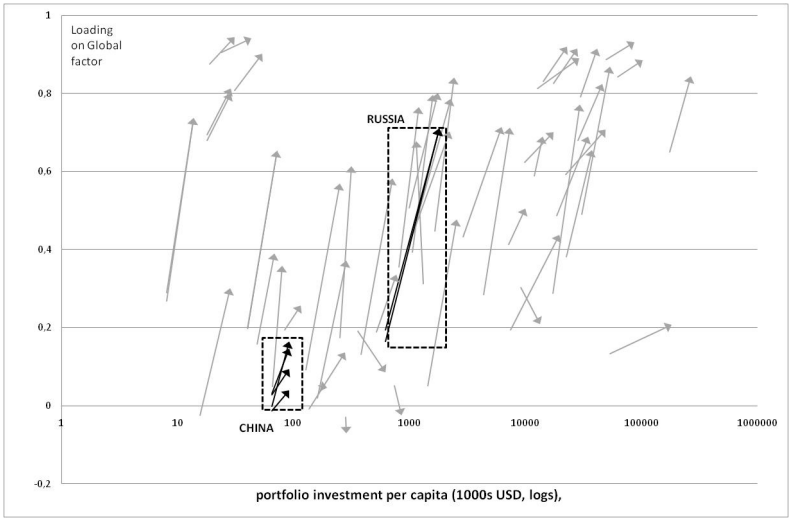
The results above suggest that the isolation of the Chinese markets, both A- and B-markets, is extremely persistent and did not change during our sample period. The movements of both Chinese returns and volatility remain largely orthogonal to the global stock market movements.

Contrarily, the integration of Russian market evolves within our sample – in the long sample, which is undoubtedly strongly influenced by the Russian crisis, Russian markets are strongly integrated with other emerging markets, especially from Central-Eastern Europe. As we move to the more recent samples, the integration of Russian markets with global movements increases, in a stronger manner than for most emerging markets. In Figures 18 and 19 we relate changes in loadings on the GLOBAL factor to various macroeconomic variables which seem important in explaining financial integration: GDP, inward portfolio investment, and value of traded stocks, in both total and per capita terms.

A simple regression of loadings on each of the macroeconomic variables shows that there are significant (at 99%) positive correlations between stock market trading (total and per capita) and loadings on the GLOBAL factor and similarly between these loadings and inward portfolio investment (total). These are visible in both the longer samples and the most recent, short sample. In case of portfolio investment, the relationship becomes insignificant in the shortest sample. No significant relationship can be found between loadings and GDP variables, which suggests that while financial openness is certainly related to financial integration (in the sense of comovement) it is not strongly related to the development of the country. Finally, it must be underlined that in all the relationships Russia fits in relatively well, while the Chinese values are strong outliers – loadings on the GLOBAL factor are low relative to the level of the chosen macro variables.

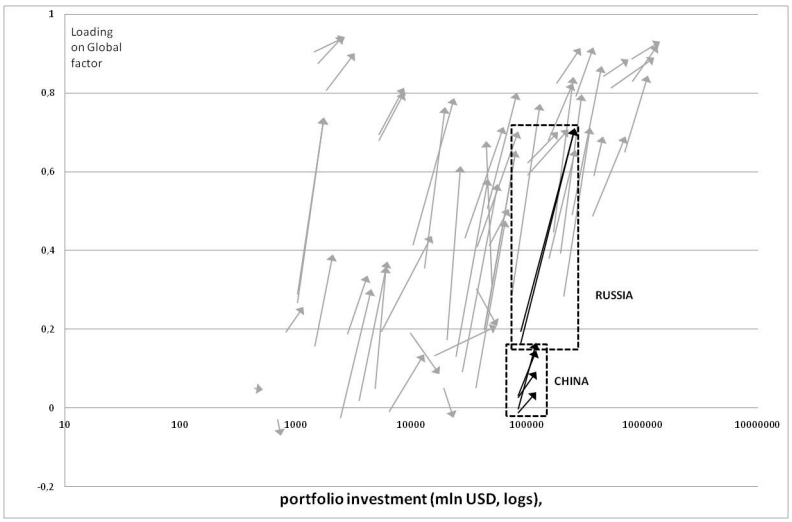
Figure 18 Macroeconomic variables (from top to bottom: GDP per capita, total GDP, foreign portfolio investment per capita) and loadings on GLOBAL factor, small and large sample

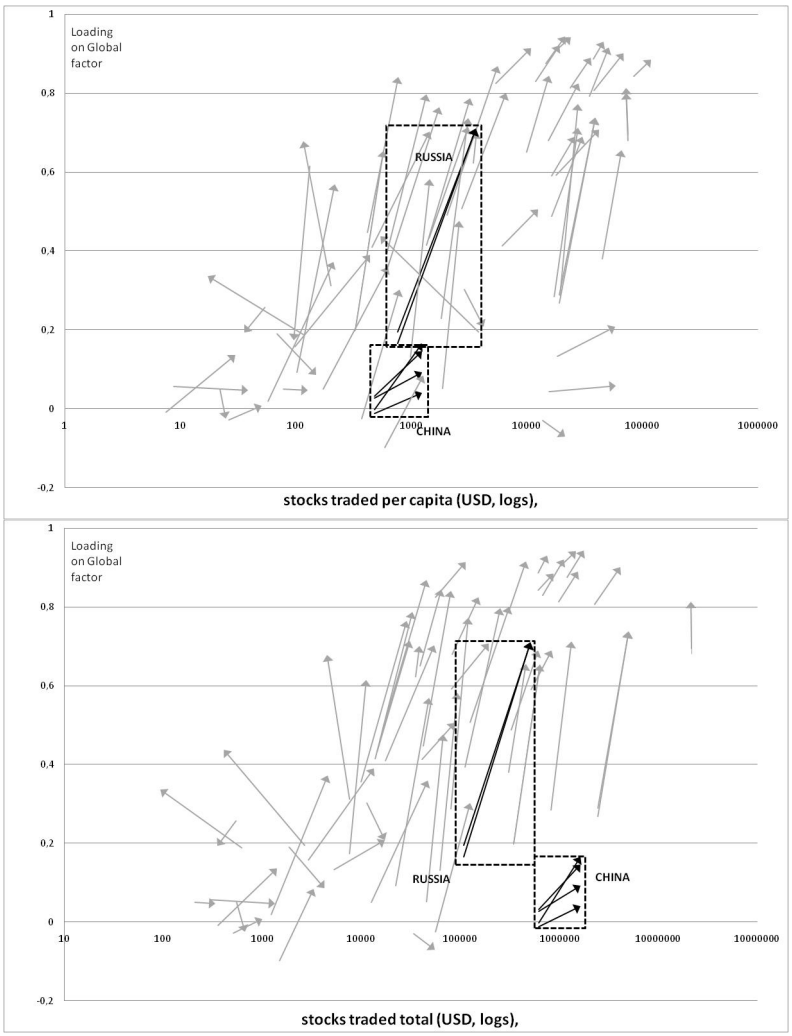




Note: Each arrow points from values for 1998m1-2007m1 sample to values for 2006m1-2007m1. Countries of interest in bold. Source: IMF (IFS). For macro variables, the values are averages for the sample or closest approximations if observations are unavailable.

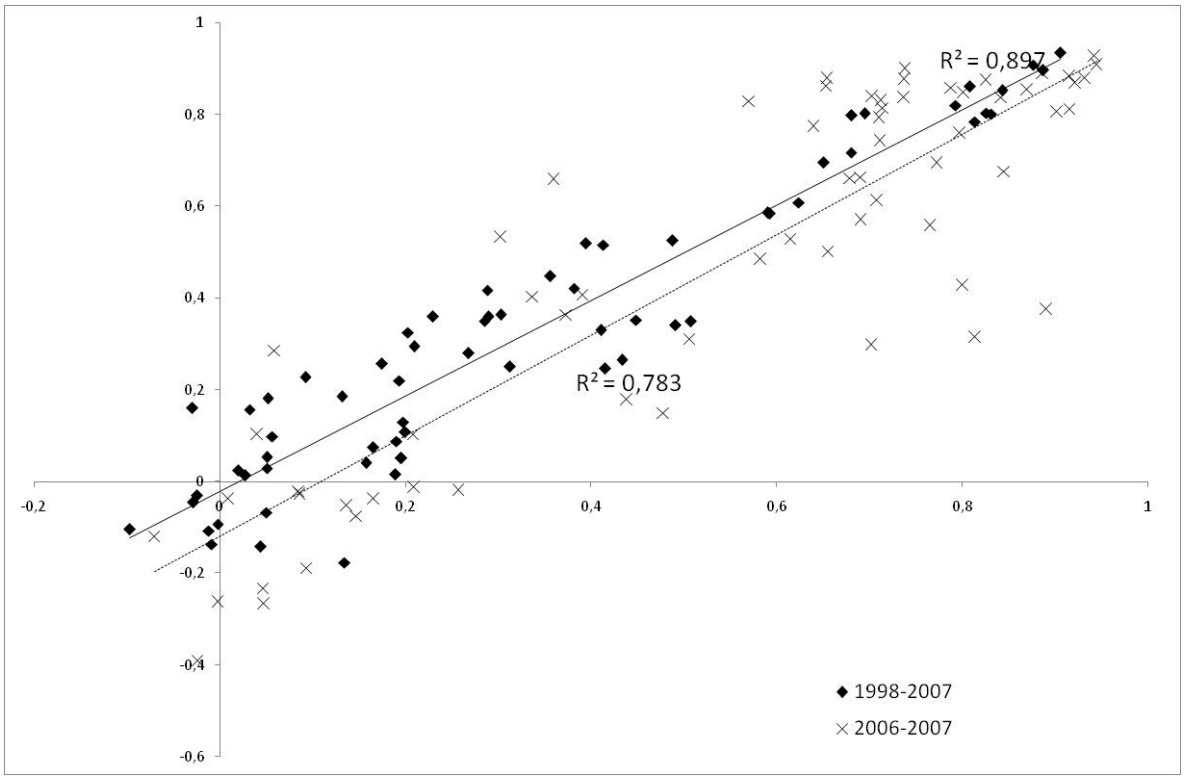
Figure 19. Macroeconomic variables (from top to bottom: total foreign portfolio investment, value of stocks traded per capita, total value of traded stocks) and loadings on GLOBAL factor, small and large sample





Note: Each arrow points from values for 1998m1-2007m1 sample to values for 2006m1-2007m1. Countries of interest in bold. Source: IMF (IFS). For macro variables, the values are averages for the sample or closest approximations if observations are unavailable.

Figure 20. Loadings on GLOBAL factor, returns specification (Y axis) against volatilities specification (X axis)



Note: Lines represent trend regressions

Finally, Figure 20 plots the loadings on the global factor for the long and short sample for both the returns and volatilities specification. Although in both cases financial integration, in the sense of returns, runs largely with financial integration in terms of volatility, this relation becomes slightly weaker in the more recent sample, suggesting an increase in the role of individual market volatility.

5.4 Robustness

In order to increase confidence in our results we performed simple robustness checks. Aside from the confidence intervals around our estimates, the main issue is confidence in whether, when running the factor extraction of different (and decreasing in size) sub-samples, we find the same common factors. In order to determine this, we ran sub-sample correlations of the actual factors extracted from different samples. For both the returns and volatility analyses, the results firmly supported the GLOBAL and CHINA factors. The grey bars in Figures 7 and 8 show the correlation of the first (GLOBAL) factor extracted

from different subsamples with the first factor extracted from the shortest sample. These correlations generally range between 0.95 and 0.99, dropping slightly in the samples starting in the area of 2003, but staying above 0.8. This generally increases our confidence that the global factor exists. The CHINA factor (similarly plotted in Figure 11) is a bit more problematic, since, although the correlations are generally as high, there is some evidence of a break in the factor in the sample of 2002m1-2007m1. The fact that both before and after this break the Chinese markets exhibit high loadings on the second factor, suggests that the break may be in the factor structure itself rather than in the comovement of the four Mainland markets. The factors of lesser importance appear less stable – an EMERGING market factor present in the longer samples, tends to fade away as the integration of emerging markets with the developed markets increases. The remaining factors do not show a strong pattern throughout the samples, for either the returns or the volatility specification.

6 Conclusions

The application of factor analysis to a broad sample of world stock indexes yields interesting results. First of all, we are able to identify a global factor that can explain a large and significant share of the movement in international markets. Though the degree to which this factor loads on the movement in individual countries varies, the explanatory power is high for the major developed countries, and increasing significantly for major emerging markets. Thought, by construction, independent of any of the other common factors and the idiosyncratic movements, it suffices to explain on average 30 to above 40% of the movements in over 60 very different stock markets around the world. This means that global markets are strongly interrelated, news travels very fast and investor sentiment is one of the key forces determining the direction of short term market fluctuations.

Second, the growing importance of this global factor points to the ongoing process of integration. Switching to more recent samples, we can confidently say that many of the emerging markets were moving more and more in line with the global factor, which may be a sign of a diminishing role of the developed economies versus emerging markets separation of the portfolio, or of the fact that the effects of the Asian and Russian crises are fad-

ing away with time. Both of these effects are visible regardless of whether stock market returns or stock market volatilities are used in the analysis.

Next, we find strong positive relationships between loadings on the global factor and received portfolio investment on one hand and volumes of stocks traded on the market on the other, while we fail to find relations between loadings and GDP (including per capita), confirming that openness is more important for stock market comovement than levels of development.

Turning to the two markets of interest, we find a confirmation of the fact that they behave very differently. First of all, the fact of easy investor access to the Russian market causes high co-movement of Russian indexes with most developed international markets toward the end of the sample. Russian markets show high resemblance to other emerging markets, especially those in central and eastern Europe. Together with the latter, they have moved increasingly in line with the developed markets in recent years, once we move away from the date of the Russian crisis. Therefore, the specific features of the Russian markets – small size and very strong domination by a handful of companies from the energy and natural resource sectors – have a decreasing effect on the direction of movement of Russian indexes. Moreover, as the first common factor explains up to 50% of the movement in Russian markets, the importance of the idiosyncratic component, which is specific only to the Russian markets, is surprisingly small, especially in recent years.

On the other hand, Chinese markets appear almost completely separated from global affairs and strongly inter-related. The fact that both A- and B-share indexes exhibit negligible co-movement with international markets but strong mutually common fluctuations suggests that B-shares, despite their general availability, are not very international per se. This isolation of Chinese markets is almost unaffected over the last 10 years, though a slight, hardly noticeable influence from regional movements was visible in the B-indexes, possibly in connection with to the Asian crisis. Despite all this, all four of the Chinese indexes move together very closely, exhibiting over 70% of common variation.

The results suggest that news and investor sentiment are more important for the direction of market movement than are the structure and size of the market. However, the Chinese B-share indexes, despite their availability to international investors, exhibit mostly comovement with A-share indexes, suggesting weak linkages with global financial markets. The comparison with macroeconomic variables yields a clear result: while Russian

markets demonstrate a level of comovement roughly in line with what can be expected from levels of other financial variables, Chinese markets comove much less.

Finally, looking at the distribution of the influence of common factors on the markets in the BRICs, we find that while Brazil, Russia and India had relatively much in common, China was very different from the other three.

As the above results hold for comovement in returns and even more strongly for comovement in volatility, they point to a limited and further decreasing possibility of hedging by simply holding assets (indexes) in different markets. We can fairly confidently say that there is little room for a global investor to diversify risk by holding Russian assets, while theoretically this could be done by including Chinese B-shares. But caution is advised, as the rapid growth of the B-share index is leading to increased discussion about overpricing of these shares.

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Appendix

A1. Indexes and Bloomberg codes (* denotes availability only for the wide sample):
Americas: US (DJIA-INDU & NYSE-OEX), Canada (SPTSX60), Mexico (MEXBOL), Argentina (MERVAL), Brazil (IBX50), Chile (IPSA), Peru(IGBVL), Venezuela (IBVC), Jamaica (JMSMX), Bermuda (BSX),

Europe: UK (UKX), Germany (DAX), France (CAC), Spain (IBEX), Switz. (SMI), Italy (MIB30), Portug. (PSI20), Ireland (ISEQ), Iceland (ICEXI15), Netherl. (AEX), Belgium* (BEL20), Denmark (KFX), Finland* (HEX25), Norway (OBXP), Sweden (OMX), Austria (ATX), Poland (WIG20), Czech R. (PX), Russia (RTS-RTSI$\$$ & MICEX), Hungary (BUX), Romania* (BET), Ukraine* (UKASW), Slovakia (SKSM), Turkey (XU100), Cyprus* (CYMMAP),

Asia & Pacific: Hong-Kong (HSI), Japan (Topix-TPXC30 & Nikkei-NKY), China (Shanghai A-SHASHR & Shenzhen A-SZASHR & Shanghai B-SHBSHR & Shenzhen b-SZBSHR), Taiwan (TWSE), Korea (KOSPI100), Australia (AS30), New Zeal.(NZSE), Pakistan (KSE100), Sri Lanka (CSEALL), Thailand (SET50), Indonesia (JCI), Singapore (STI), India (NSE-NIFTY & BSE-SENSEX), Malaysia (KLCI), Philippines (PCOMP),

Africa & Middle East: S. Africa (JALSH), Egypt* (CASE), Morocco (MCS), Tunisia (TUSISE), Kenya (KNSMIDX), Kuwait (KGGIGEN), Israel (TA-25), Saudi Arabia (SASEIDX), Oman (MSM30),

Oil (CCCCMID).

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