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Transfer of financial risk in emerging eastern European stock markets: A sectoral perspective

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TRANSFER OF FINANCIAL RISK IN EMERGING EASTERN EUROPEAN STOCK MARKETS: A SECTORAL PERSPECTIVE

Elena Fedorova*

September 8, 2011

Tiivistelmä

Tutkimuksessa tarkastellaan Puolan, Unkarin ja Tsekin osakemarkkinoiden kehitystä vuosina 1998-2009. Tarkastelussa keskitytään pörssien eri sektoreiden kehitykseen ja sektorikohtaisten shokkien välittymiseen markkinoilta toiselle. Tulokset osoittavat markkinoiden integraation lisääntyneen EU-jäsenyyden seurauksena, ja erityisesti sektorikohtaisten shokkien välittyminen näiden maiden kesken on voimistunut. Tuloksilla voi olla vaikutuksia sijoittajien hinnoittelu- ja portfoliokäyttäytymiseen.

JEL-koodit: C32, F36, G12, G15

Avainsanat: osakemarkkinat, sektorikohtaisten shokkien välittyminen, Puola, Unkari, Tsekki

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TRANSFER OF FINANCIAL RISK IN EMERGING EASTERN EUROPEAN STOCK MARKETS: A SECTORAL PERSPECTIVE

Elena Fedorova*

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ABSTRACT

With the rise of interconnected global financial systems, there is an increased risk that a financial crisis in one country may spread to others. The contagion effects of the 2008 global financial crisis hit advanced economies fast and hard while sparing less developed and less integrated financial systems. The present study focuses on the contagion effects at Eastern European stock markets and changes in their interconnections after EU accession in 2004. Specifically, we investigate the relationship among the stock market sectors of Poland, Hungary and the Czech Republic during 1998–2009 and their exposure to on-shored financial risk. The evidence suggests direct linkages between different stock market sectors with respect to returns and volatilities with increased equity-shock transmission between markets after EU accession in 2004. Of particular note is the intra-industry contagion in emerging Europe. Our findings have implications for asset pricing and portfolio selection for international financial institutions and financial managers.

JEL Classification: C32, F36, G12, G15

Keywords: GARCH-BEKK, international risk transfer, emerging Eastern Europe, spillovers, intra- and inter-industry contagion

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1. **INTRODUCTION**

The 2008 financial crisis is considered by many to be the most serious financial crisis for the world economy since the Great Depression of the 1930s. Despite the lessons of the Great Depression about the dangers of financial contagion and the prolonged depths of financial desperation that can stem from over-leveraged borrowing and lapses in prudential oversight, the 2008 financial crisis emerged with a liquidity shortfall in the US banking system caused by actors that had been allowed to overvalue and securitize assets that were then traded and insured by international markets. In a sort of musical chairs of default, the meltdown spread quickly to some sectors of Europe's financial markets. The distress caused several spectacular bankruptcies and business collapses. Financial systems less integrated into the global financial system such as India and Brazil, however, escaped the brunt of the shock and emerged from the crisis largely unscathed.

By 2010, when Greece's debt problems emerged, EU policy-makers were already quite aware that financial problems in one country, through the interconnectedness of markets and investment, could readily undermine confidence generally and set off a wider financial crisis. Understanding and assessing risk transfer among European countries has been embraced as an essential aspect of designing measures to contain the damage of future financial crises.

Emerging economies that weathered the recent crisis in good shape have attracted researcher interest. Over the past decade, their economies enjoyed higher GDP growth and demonstrated greater resilience to global shocks than their more advanced counterparts. As a result, emerging economies are seen as providing opportunities for investment, currency-risk diversification and alternative pathways to enrichment. Some researchers note that these advantages are fleeting; sustained financial market integration (e.g. Savva and Aslanidis, 2010) ultimately deprives investors of avoiding the impacts of global economic shocks on their investments.

The ready availability of data for a number of Eastern European countries make it possible to determine the temporal decay of this advantage. We can see how long their stock market sectors remained insulated from their counterparts in Western Europe, if they maintained a modicum of control over their own development and how well they were able to parry shocks to Europe's most integrated financial markets.

The possibility of flight to such safe havens in the midst of widespread financial instability has obvious implications for portfolio managers in their risk diversification strategies. The present study considers four research questions. First, were our selected emerging European stock markets involved in transferring financial risk to EU members? If so, and in contradiction to the familiar rule that only developed markets define volatility, which sectors of those stock markets of emerging European countries played such a role? Third, is the isolation of industries from shocks on European stock markets seen in these sectors manifested in terms of stock returns and stock price volatility? Finally, was there a significant change in market interactions after the 2004 accessions of Poland, Hungary and the Czech Republic to the EU? This analysis seeks to provide evidence of integration or lack of integration effects in Eastern Europe and identify opportunities for sectoral diversification in financial securities selection for portfolio investment during the period observed.

The paper is organized as follows. Section 2 presents the theoretical background. Section 3 describes the empirical formulation of the testable model. Section 4 introduces the sample countries, the data used in the study, descriptive statistics and preliminary results based on correlation analysis. Section 5 provides the main results from the estimation. Concluding remarks and suggestions for future research are offered in Section 6.

2. **BACKGROUND**

Researchers are divided over risk transmission mechanisms in stock markets. While the wider belief is that country-risk effect dominates the sectoral-risk effect (e.g. Steliaros and Thomas, 2006; Kaltenhaeuser, 2003), others seen the sectoral heterogeneity as an important determinant of contagion propagation (e.g. Phylaktis and Xia, 2009).

As a rule, students of investment-risk transfer focused on developed stock markets (e.g. Qiao, Liew and Wong, 2007; Malik and Hassan, 2004). Cummins, Wei and Xie (2007), Prokopczuk (2009) and Brewer and Jackson (2002) apply event study analysis in their studies on bank and insurance sectors, find strong evidence of inter-, intra-dependence and event contagion. Others (e.g. Johnson, 2010) declare a decrease in contagion in banking and insurance markets during crisis. Tawatnuntachai and D’Mello (2009) study the intra-industry reaction of stock split announcements to explicate intra-industry risk transfer. The sectoral study of Pais and

Stork (2010), who apply Extreme Value Theory, report the highest level of dependence between the property and banking sectors.

Risk and portfolio managers choosing asset management strategies must decide on how to diversify their currency and liquidity risks, as well as the regional and sectoral allocation of their assets. Ferreira and Gama (2005) and Black, Buckland and Fraser (2002) argue the industry-decomposition method is superior to portfolio management over the geographical decomposition method. Catão and Timmerman (2003), testing Heston and Rouwenhorst's (1994, 1995) dummy-factor model for decomposition stock returns, find industry factors account for a third of total systematic variance in stock returns. Using the two-regime Markov switching model, Morana and Sawkins (2004) conclude quite the opposite, i.e. that sectoral volatility predominantly defines stock market volatility overall.

ARCH models have been widely applied to study shocks and volatility spillovers in developed stock markets. Kaltenhaeuser (2002), focusing on US, UK and European equity markets, finds information technology and non-cyclical services sectors have become the most integrated sectors worldwide, while basic industries, non-cyclical consumer goods, resources and utilities remain less integrated. Qiao, Liew and Wong (2007) claim that the information technology market in US plays a leading role in volatility risk transfer to counterpart markets in other countries. In addition, each sector on the stock market participates in a volatility transmission mechanism, supporting the idea of sharing information and cross-market hedging by investors (e.g. Hyytinen, 1999; Hassan and Malik, 2004 and 2007; Cotter and Stevenson, 2006; and Buguk, Hudson and Hanson, 1999).

In contrast, risk transfer in emerging markets has largely evaded analysis. Sarkar, Charkrabarti and Sen (2009) study the volatility transmission channel among Indian, Brazilian, Argentine and Indonesian stock markets. Traditional sectors such as capital goods and consumer durables are found to be the predominant sectors, contributing significantly to Indian stock market volatility. Lin, Penm, Wu and Chiu (2004), studying the banking sectors in China, Taiwan and Hong Kong, observe that systemic risk and stock returns have a significantly positive relationship to the banking industry. Larger banks reveal a higher level of the industry effect in China and Hong Kong, as do small and medium-sized banks in Taiwan. However, financial industries are independent from other sectors in these countries (e.g. Wang, 2007). Hammoudeh, Yuan and McAleer (2009) point to an increased dominance of stock market volatility relative to past shocks.

In this study, we investigate the importance of industries in Eastern European stock markets and the degree stock market integration before and after EU accession in 2004 (e.g. Caporale and Spagnolo, 2011). We apply a GARCH (1,1) methodology that allows investigation of the relationship and information spillover effects of more than one asset, using causality in means and variance. To the best of our knowledge, this particular methodology has not been used earlier to analyze interactions by sector in emerging Eastern European stock markets. We study linkages of different stock markets and their sectoral indices. Hopefully, the resulting analysis answers, at least partly, the four questions posed in our introduction.

Our sample period runs from December 1998 to December 2009, and covers Poland, Hungary and the Czech Republic. The local markets were chosen for their relatively high stock market capitalizations. Moreover, these markets and fairly dynamic, have gone through major economic reforms since the early 1990s (including privatization of state assets). These markets are more open and liquid than other markets in Eastern Europe. Their growth has outstripped that of other markets in emerging Eastern European countries, so we infer that they enjoy leadership roles in the region. From our research perspective, they are also interesting as opening to foreign investment and world trade had put exposed these markets to external shocks from global and regional financial markets. Our analysis is geared to understanding the volatility and shock transmissions mechanism between emerging Eastern European countries and the EU.

We start with the proposal that some industries to be more integrated into regional and world financial processes than others, and thus more prone to contagion. If so, it should be possible to ascertain industries providing risk-diversification opportunities and sectors isolated from changes on the European financial markets. This, in turn, would permit application of portfolio management based on sectoral diversification to selected emerging markets (here, defining sectors with unidirectional impact on European markets), and assets of these industries could be treated as a separate class of investments. One objective here is defining the most profitable sectors in our selected markets, so we can construct an effective investment portfolio and a large reason why we like the explanatory power of the GARCH-BEKK methodology for shock and volatility transfers in emerging Eastern Europe. Our findings are consistent with earlier research as regards of increased European countries integration (e.g. Fedorova and Vaihekoski, 2009) and for transfers among different stock market sectors (e.g. Phylaktis and Xia, 2009).

3. **MODEL SPECIFICATION**

The Generalized Autogressive Conditional Heteroscedasticity (GARCH) process, developed independently by Bollerslev (1986) and Taylor (1986), is widely used for volatility modelling in financial markets. Conditional variance in this model is considered dependent on its previous own lags. Due to the quadratic nature of the variance terms, the BEKK (Baba-Engle-Kraft-Kroner) parameterization, proposed by Engle and Kroner (1995), requires no restrictions on parameters to get positive definite values of the variance-covariance matrix. Our model complies with the hypothesis of constant correlation and allows for volatility spillover across markets (Fedorova and Saleem, 2010).

Our empirical analysis starts with a bivariate GARCH (1,1) model containing three parameters in the conditional variance equation and allowing the past squared errors to influence the current conditional variance:

(1) $$r_t = \beta r_{t-1} + \varepsilon_t,$$

(2) $$\varepsilon_t | \Omega_{t-1} \sim N(0, H_t),$$

where r_t is an $n \times 1$ vector of weekly returns at time t for each local stock market or its sector. The $n \times 1$ vector of random errors ε_t represents the innovation for each market at time t available from information set Ω_{t-1} with its corresponding $n \times n$ conditional variance-covariance matrix $\boldsymbol{H_t}$.

The BEKK parameterization imposes estimated variances to be non-negative and is given as:

(3) $$H_t = C_0' C_0 + A_{11}' \varepsilon_{t-1} \varepsilon_{t-1}' A_{11} + G_{11}' H_{t-1} G_{11},$$

where $\boldsymbol{C_0}$ is a 2×2 lower triangular matrix with three parameters. $\boldsymbol{A_{11}}$ is a 2×2 square matrix of parameters showing the correlation of conditional variances with part squared errors. The $\boldsymbol{A_{11}}$ matrix elements capture the effects of stock market shocks on conditional variance. $\boldsymbol{G_{11}}$ represents a 2×2 square matrix of parameters capturing the information of past volatility effects on conditional variance. With individual elements, Equation (3) takes the form:

(4) $$H_t = C_0'C_0 + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}' \begin{bmatrix} \varepsilon_{1,t-1}^2 & \varepsilon_{1,t-1}, \varepsilon_{2,t-1} \\ \varepsilon_{1,t-1}, \varepsilon_{2,t-1} & \varepsilon_{2,t-1}^2 \end{bmatrix} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} + \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix}' H_{t-1} \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix}.$$

Equation (4) for $\boldsymbol{H_t}$ further expanded for the bivariate GARCH (1,1) by matrix multiplication would be:

(5) $$h_{11,t} = c_{11}^2 + a_{11}^2 \varepsilon_{1,t-1}^2 + 2a_{11}a_{21}\varepsilon_{1,t-1}\varepsilon_{2,t-1} + a_{21}^2 \varepsilon_{2,t-1}^2 + g_{11}^2 h_{11,t-1} + 2g_{11}g_{21}h_{12,t-1} + g_{21}^2 h_{22,t-1},$$

(6) $$h_{12,t} = c_{11}c_{21} + a_{11}a_{12}\varepsilon_{1,t-1}^2 + (a_{21}a_{12} + a_{11}a_{22})\varepsilon_{1,t-1}\varepsilon_{2,t-1} + a_{21}a_{22}\varepsilon_{2,t-1}^2 + g_{11}g_{12}h_{11,t-1} + (g_{21}g_{12} + g_{11}g_{22})h_{12,t-1} + g_{21}g_{22}h_{22,t-1},$$

(7) $$h_{22,t} = c_{21}^2 + c_{22}^2 + a_{12}^2 \varepsilon_{1,t-1}^2 + 2a_{12}a_{22}\varepsilon_{1,t-1}\varepsilon_{2,t-1} + a_{22}^2 \varepsilon_{2,t-1}^2 + g_{12}^2 h_{11,t-1} + 2g_{12}g_{22}h_{12,t-1} + g_{22}^2 h_{22,t-1}.$$

The variance-covariance system can be optimized with the Berndt, Hall, Hall and Hausman (1974) algorithm (see Engle and Kroner, 1995). From Equations (5) to (7) we obtain the conditional log likelihood function *L(θ)* for a sample of *T* observations:

(8) $$L(\theta) = \sum_{t=1}^{T} l_t(\theta),$$

(9) $$l_t(\theta) = -\log 2\pi - 1/2 \log |H_t(\theta)| - 1/2 \varepsilon_t'(\theta) H_t^{-1}(\theta) \varepsilon_t(\theta),$$

where θ represents the vector of all the unknown parameters. Numerical maximization of Equations (8) and (9) yields the maximum likelihood estimates with asymptotic standard errors.

We test our GARCH-BEKK model for correctness, i.e. whether error terms ε_t are randomly distributed, applying the Ljung-Box Q-statistic. This is assumed to be asymptotically distributed as χ_t^2 with (*p* – *k*) degrees of freedom, where *k* is the number of explanatory variables.

4. DATA AND DESCRIPTIVE STATISTICS

Our tests use data from stock markets of three emerging countries from Eastern Europe. The sample period is from December 1998 to December 2009. We conduct our analysis from a US investor's point of view, i.e. returns are measured in US dollars. As in related studies (e.g. Qiao, Liew and Wong, 2007), we consistently use weekly total return indices based on Wednesday observations of total-return market indices to alleviate noise effects of daily data and day-of-the-week effects.

As test assets, we use market portfolios from each of the sample countries, stock market sectors and regional stock markets. As a proxy for the regional market stock returns, we use Datastream's Emerging Europe and European Aggregate indices. Datastream indices are constructed on a uniform basis across countries, the stock market sectoral structure is comprehensive and the indices for selected countries cover the sample period. Indices include gross dividends (i.e. they measure the total pre-tax return for investors). All data is taken from the Datastream database.

4.1 Sample countries and test assets

Our selected sample countries (Poland, Hungary and the Czech Republic) all experienced the transition from communism to market economies. They joined the European Union in May 2004, but have yet to join the euro zone and still retain their own national currencies.

Figures 1, 2 and 3 show the historical development of local stock return indices for the selected sample countries. These figures show an insignificant non-stationary process in all studied markets in the beginning of the analysis period. These stock markets showed marked gains starting in 2005. Post-crisis, we see the beginnings of stock market recovery in emerging Europe around spring 2009. The oil & gas industry in all countries starting from 2005 outperforms local markets. In Poland, consumer goods, financials and basic materials also outperform the market. In Hungary, high returns help the financial sector outperform the local market. The financial sector is the most attractive sector for local and international investors for the last five years of the observation period. Interestingly, sectors such as consumer services, telecommunications and industrials in all countries analyzed showed below-average profitability.

Table 1 summarizes weekly local asset returns. Panel A in Table 1 contains the first four moments. Average returns and standard deviations were annualized. The risk-free rate, calculated from the Eurodollar rate, gives on average a 3.40 % return in the period of analysis with a lower standard deviation of 0.27 %, as one would expect. The Czech stock market has the highest return among the emerging countries analyzed, providing 21.26 % per annum for US investors with the lowest standard deviation. The poorer Polish and Hungarian stock market performances still averaged 10.41 % and 10.01 % per annum, respectively. All sample countries display high volatility, with the highest standard deviation (33.86 %) for the Hungarian market.

A Jarque-Bera test was conducted to check the null hypothesis of normal distribution. P-values are reported in panel A. All return series show evidence against normal distribution. In addition, the autocorrelation in the returns was investigated. The first three autocorrelation coefficients and the Ljung-Box test statistic (27 lags = half year) for each return series are reported. Only the risk-free rate shows evidence of first-order autocorrelation. Somewhat surprisingly, Poland, the Czech Republic, emerging Europe and the European Union aggregates show first-order correlation in the third lag not being economically significant.

Panel B in Table 1 reports pairwise correlations among asset returns. All stock markets are highly correlated, with the highest correlation between the Hungarian and Polish stock markets (0.716). Risk-free rate shows fairly low values of correlation with sample countries with reverse sign.

Table 2 reports the descriptive statistics for Polish asset returns in a sectoral perspective. The values for mean and standard deviation are again annualized. The basic materials sector provides the highest return for investors of 21.42 %, while the highest standard deviation is in the telecommunications industry (39.45 %). The autocorrelation analysis shows insignificant autocorrelation in basic materials and consumer goods, and in the third lag, the financial sector. All sectors exhibit high volatility in their asset returns. Panel B shows significant correlation between all sectors where financials most highly correlate with others.

Table 3 shows the descriptive statistics for Hungarian sectoral asset returns. The values for mean and standard deviation, presented in Panel A, are annualized. The financial sector has the highest return of 18.51 % per annum; the highest volatility is reported for the same sector. All sectors exhibit high volatility in their asset returns. Only the industrial sector has a negative asset return on average of -5.50 % per annum. Significant autocorrelation coefficients are observed for the consumer goods and oil & gas sectors in first and second lags, respectively. Panel B, which presents the correlation coefficients, exhibits significance of all sectors, with financials most highly correlated with other industries, even in the case of Poland.

Table 4 provides descriptive statistics for Czech industries asset returns with annualized means and standard deviations. The highest asset return on the Czech stock market in sample period is in the financial sector at the level of 29.59 % per annum, while the highest volatility is in the consumer services sector (55.13 %). Consumer services is the only industry giving a negative return of -0.08 % per annum. The autocorrelation analysis yields its presence for the industrial sector in the first lag, for telecommunications in the third lag, and for the oil & gas sector in the second and third lags. Pairwise correlation analysis shows financials to be highly correlated with other sectors for all three countries.

4.2 Correlation analysis

We start our investigation by studying the time series development of correlations in returns between local stock and emerging Europe for each country. Figures 4, 5 and 6 present the 52-week (one year) rolling-window correlation coefficients.

The observed correlations during the sample period are volatile. Interestingly, almost all Polish stock market sectors, with the exception of telecommunications, are not highly correlated with emerging Europe at the beginning of the period. Starting from summer 2006, however, the Polish stock market sectors become highly correlated with stock market sectors in emerging Europe. Our figures show increased correlation between Hungarian and Czech stock market sectors with sectors in emerging Europe after summer 2006. The moving-average trend lines for correlation between local market indices and the emerging Europe aggregate index are obtained to smooth the data fluctuations and clarify the trend. Overall, the stock market dynamics shows an increase in correlation between these markets supporting the hypothesis of increasing integration of the local markets with emerging European markets.

5. EMPIRICAL RESULTS

5.1 Linkage between equity markets

Our empirical analysis is geared to answering the questions formulated in the introduction to this paper. First, we analyse interactions between Poland, Hungary, the Czech Republic, emerging Europe and the European Union aggregates to have an overview of studied stock markets.

5.1.1 Interaction of local stock markets with emerging Europe

We examine local stock market mean and volatility spillovers by estimating pairwise models between all three countries and local stock markets against emerging Europe aggregate, using our bivariate GARCH (1,1) framework with BEKK representation.

Matrix $\boldsymbol{B}$ in the mean Equation (1) exhibits the relationship in terms of returns between countries. Table 5 shows dependence of Polish, Hungarian and Czech returns on their first lags as far as parameters β_i are statistically significant in all modelled pairs with emerging Europe and local markets. Emerging Europe returns depend on their first lags in all modelled pairs with local markets as well.

Next, we study matrices $\boldsymbol{A}$ and $\boldsymbol{G}$ for risk transfer in mean and volatility, reporting estimated results in Table 5. The diagonal elements in matrix $\boldsymbol{A}$ focus on exposure of ARCH effects in the process, while the diagonal elements in matrix $\boldsymbol{G}$ show the power of the GARCH effect. The outcomes indicate a strong GARCH (1,1) process as far as the estimated parameters a_{11}, a_{22} and g_{11}, g_{22} are statistically significant, driving their own shocks and volatility effects on the conditional variance of Polish, Hungarian, Czech and emerging European indices.

Shock and volatility spillover effects are captured by the off-diagonal elements of matrices $\boldsymbol{A}$ and $\boldsymbol{G}$. The results show shock transmissions from Hungary to other selected local markets and emerging Europe. Analyzing shock transmission between Poland and the Czech Republic revealed bidirectional effects. Similarly, we find bidirectional shock transmissions between all three emerging Eastern European countries and emerging Europe (the off-diagonal parameters a_{12} and a_{21} are highly statistically significant, meaning of shock transfers presence from Poland, Hungary and the Czech Republic to emerging Europe and affected mean returns in local markets by shocks from emerging Europe). By contrast, we do not find shock transmissions either from the Polish to the Hungarian stock market or from the Czech to the Hungarian stock market.

Finally, the volatility spillovers between the six modelled pairs shows some interesting results. There are significant bidirectional volatility spillovers between Poland and Hungary and between the Czech Republic and emerging Europe, while the Czech Republic spillover effect dominates in the case of the modelled pair with Poland and Hungary. We do not find volatility spillover effects between Hungary and emerging Europe (EE). These results may be taken as evidence of integration in emerging Eastern European markets.

5.1.2 Interaction of local stock markets with the European Union

In the next part of the analysis we would like to define the significance of local stock markets for the European Union with regard to market risk transfer. We study four pairs: Poland-EU, Hungary-EU, Czech Republic-EU and EE-EU. The results of the analysis are presented in Table 6. Notably, all local markets have a distinguishing feature of stock market return dependence on their previous values. EU stock market performance depends on its previous values in the modelled pairs with local markets and emerging Europe.

Our results show a risk of shock transfer from a local stock market to the EU in pairs modelled with the Czech Republic and emerging Europe. Shocks to the EU market, in turn, affect the Hungarian and Czech stock markets. We document bidirectional volatility transmission between emerging Eastern European countries, emerging Europe and the EU, and the modelled pair with Hungary.

An over-arching feature of these findings is the importance of emerging European stock markets for European Union market performance. Thus, understanding how emerging European stock markets interact with the EU at the sectoral level can reveal which stock market sectors are integrated or not integrated with EU stock market sectors and clarify each sector's potential for risk diversification strategies in asset management.

5.2 Intra-dependence of stock market sectors

Before answering our main questions, we examine the intra-dependence of stock market sectors in emerging Eastern European countries. Sectors on local markets are defined by how they affect overall local stock market performance and how well they parry external shocks.

We estimate seven pairwise models for each country with the BEKK framework. In all modelled pairs, the local stock market is tested with sectors including oil & gas, basic materials, industrials, consumer goods, consumer services, telecommunications and financials. A matrix of risk transfers for local stock markets is constructed based on the reported in Table 7 (estimates available from author on request).

The Polish stock market exhibited unidirectional volatility spillovers from oil & gas and consumer services sectors to the Polish stock market, evidencing the importance of these sectors. Volatility spillover analysis of Hungarian stock market gives interesting results in the case of telecommunications. Unidirectional volatility transmission occurs from the telecommunications sector to the local stock market, suggesting sector's significance in contagion propagation. For the Czech stock market, unidirectional volatilities in industrials and consumer services sectors are found to affect local market performance. A distinguishing feature in all local markets is that the financials sector does not affect local markets through volatility spillovers. Moreover, the industrials sector interacts with local markets in each country, transferring risk of shocks and volatility to overall local market performance. Hence, the sectors significantly affecting the local stock market's performance are identified in each country.

5.3 Inter-dependence of stock market sectors

We now examine risk transfer between the same sectors among the selected countries and the European Union. Here, we define the sectors on local markets that affect the EU market and are independent from external factors. For this analysis, 21 modelled and tested pairs are Poland$_i$-EU$_i$, Hungary$_i$-EU$_i$ and the Czech Republic$_i$-EU$_i$, where $i = 1,\dots,7$ is a sectoral index. Matrix of risk transfers between local and EU stock market sectors is constructed based on the estimated results (available on request) and reposted in Table 8.

The results of analysis show unidirectional transmissions from local markets to EU in shocks and volatilities. We find support for shock transmissions from Polish to the EU consumer goods, indicating that this stock market sector is less integrated with the European stock market for all sectors. Thus, the Polish consumer goods stock market sector appears to have been a good candidate for use in risk diversification portfolio strategy as it had an average return of 14.86 % per year in the last decade and was more profitable than the overall Polish stock market which had an average return of 10.42 % per year.

Hungarian telecommunications exhibit risk transmission to the EU via shocks and volatilities. Interestingly, while the Hungarian telecommunications stock market sector affected the overall local stock market, it was unaffected itself. This sector was found to be significant in unidirectional risk transmissions in linkage with the EU as well. Thus, the Hungarian telecommunications stock market sector might be considered in constructing a risk-diversified asset portfolio. However, average return in this sector in was 1.53 % per year in the past decade, i.e. profitability below the overall local stock market average.

The financials sector in this study was found not to affect local markets. Analysing transmissions to the EU, this sector showed importance in volatility transfer from the Czech Republic to the EU. Again, it should be noted that the Czech financials sector transfers shocks to the EU stock market, while being unaffected itself. The Czech financials sector gave an average annual return of 29.59 % in the past decade. It had higher profitability than the overall local market.

5.4 Stock market interactions after EU accession of 2004

Finally, we attempt to identify whether the three emerging Eastern European countries we examine became more integrated after their EU accessions in 2004 (i.e. more prone to transmit investment risks from one market to another). To answer this question, we estimate three pairwise models for each stock market sector in two periods, reporting the estimated results in Tables 9 to 15. The first period, 1998−2003, captures the Asian financial crisis and its impact on European stock markets. The second period, 2004−2009, captures potential effects of EU accession in 2004 and the global financial crisis that began in 2008.

Our results show a change in risk of shock transfer and volatility spillovers after EU enlargement. Basic materials, consumer services and telecommunications become more integrated within the region, while and the consumer goods sector becomes less integrated. Notably, the overall stock market risk of shock transmission increased significantly after the EU's 2004 enlargement, while the risk of volatility transfers on average remained the same. This change at stock markets evidences increased stock market integration in Eastern European markets on the sectoral level. The interaction of stock markets on industrials and the oil & gas sector through shocks increased after accession, while the risk of volatility transfer from one regional stock market to another stock market decreased. Financial markets interact more closely, sharing information on asset pricing and related investment risks.

Interactions via volatilities in the financials stock market sector in selected countries increased, while stock market interaction in this sector through shocks decreased. The overall results are clear evidence of stock market integration and increased intra-industry contagion in Europe after the EU memberships of Poland, Hungary and the Czech Republic.

5.5 Diagnostic tests

The diagnostic test results representing the Ljung-Box Q-statistic are reported in Panel B in Tables from 5 to 6 and from 9 to 15. These tests are used to check whether the selected model is correctly specified and if it describes the time series. We report both standardized and standardized squared residuals up to lag 24 for each modelled pair. The results show no series dependence in the squared standardized residuals, indicating the appropriateness of the GARCH-BEKK model for risk transfer studying on emerging Eastern European stock markets. As is appropriate for large, complicated time series models, we also perform an Augmented Dickey-Fuller (ADF) test for stock market sector cointegration. The null hypothesis of no cointegration is rejected for each modelled pair at 1 % level of significance. The results suggest interactions and cointegration between the same sectors on local stock markets and EU and linkage with their foreign counterparts. (The estimated results are available on request.)

6. SUMMARY AND CONCLUSIONS

In this paper, we analyzed financial risk and mechanisms of transfer in emerging European stock markets. We studied the intra-industry relationship for investment risk transfers in emerging Eastern European stock markets (specifically, Poland, Hungary and the Czech Republic) and their linkage with the European Union stock market using a GARCH-BEKK model. Our weekly data covers the period from December 1998 to December 2009. Our analysis started with an examination of interdependence and investment risk transfers between local markets, emerging European and European Union stock markets. Next, we looked at the interactions between local stock market sectors and overall stock markets performance. Third, we examined the emerging stock market sectors interdependence with European Union stock market sectors. Finally, we discussed investment risk changes in emerging Eastern European countries over the past decade.

Analysis of local stock market interactions with emerging Europe and the EU exhibited bidirectional shock transmissions between all local stock markets and emerging Europe. This answered our first research question in the affirmative, and highlighted the importance of the Polish, Hungarian and Czech stock markets for other European stock markets. The estimated results are encouraging for more detailed study of these emerging stock market sectors. The emerging European stock market was shown to transfer volatility risk to the Polish and Czech markets, while volatility on the Czech market affected the mean returns on the emerging European market. Bidirectional interactions of volatilities between local markets and the European Union were observed, as well as interactions with the Hungarian market. These results are consistent with findings of earlier research with regard to spillover effects between stock markets (e.g. Egert and Kocenda, 2007).

To answer to our second question, we investigated which sectors were important for local stock markets. It was shown that the oil & gas sector of the Polish stock market affects the local market through shock transfers, while the consumer goods and financials sectors do not interact with sudden shocks to the Polish stock market. Evidence of volatility transfers between local sectors on the Polish market was found for other sectors besides the financials industry. Oil & gas and consumer services where show to be for the Polish stock market as they affect mean returns on the Polish market, while remaining unaffected themselves. On the Hungarian stock market the consumer goods, consumer services and financials sectors were not linked to the local market with regards to either shock or volatility transfers. Telecommunications was found to be an important sector for the Hungarian stock market, affecting it through volatility changes. The industrials and consumer services sectors were significant originators of risk spillovers in the Czech stock market with regards to volatility changes. Interestingly, the oil & gas sector did not transfer risk to the Czech stock market. Thus, we defined the particular sectors important for contagion propagation in local stock markets.

For our third question, we checked the significance of local stock market interactions with the EU at the sectoral level. The estimated results showed that the Polish consumer goods, Hungarian telecommunications and Czech financials sectors are less integrated with the equivalent sectoral European markets than other industries. Even so, they play a significant role for European markets with regards to risk transfer through sudden shocks and volatility. Finally, we took a look at the stock market interactions after EU accession of 2004. The scope of shock transmissions between similar sectors on stock markets has increased after EU accession, evidencing increasing integration in European stock markets that are increasingly susceptible to contagion. These findings are consistent with earlier research (e.g. Fedorova and Vaihekoski, 2009; Phylaktis and Xia, 2009; Kaltenhaeuser, 2003).

To take this research further, it might be worthwhile to study inter-industry dependence in other emerging European countries, and their significance for European and overseas stock markets. The analysis here would also benefit from investigation of interdependence among emerging European stock markets and the biggest members of the EU economy. Regime switching models might also be tested to get a more accurate description of stock market interactions in times of crisis.

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REFERENCES

Berndt, E., B. Hall, R. Hall and J. Hausman, 1974. Estimation and Inference in Nonlinear Structural Models. Annals of Economic and Social Measurement, Vol. 3, 653-665.

Black, A., R. Buckland and P. Fraser, 2002. Efficient portfolio diversification: Changing UK stock market sector and sub-sector volatilities, 1968-2000. Managerial Finance, Vol. 28, No. 9, 26-43.

Bollerslev, T., 1986. General Autoregressive Conditional Heteroscedasticity. Journal of Econometrics, Vol. 31, 309-328.

Brewer, E. and W. Jackson, 2002. Inter-industry contagion and the competitive effects of financial distress announcements: Evidence from commercial banks and life insurance companies. Federal Reserve Bank of Chicago, unpublished working paper No. 23.

Buguk, C., D. Hudson and T. Hanson, 2003. Price volatility spillover in agricultural markets: An examination of US catfish markets. Journal of Agricultural and Resource Economics, Vol. 28, No.1, 86-99.

Caporale, G. and N. Spagnolo, 2011. Stock market integration between three CEECs, Russia and the UK. Review of International Economics, Vol. 19, No. 1, 158-169.

Catão, L. and A. Timmerman, 2003. Country and industry dynamics in stock returns, IMF Working paper No. 52.

Cotter, J. and S. Stevenson, 2006. Multivariate modeling of daily REIT volatility. The Journal of Real Estate Finance and Economics, Vol. 32, 305-325.

Cummins, J., R. Wei and X. Xie, 2007. Financial sector integration and information spillovers: Effects of operational risk events on U.S. banks and insurers. Unpublished working paper available at http://ssrn.com/abstract=1071824.

Egert, B. and E. Kocenda, 2007. Interdependence between Eastern and Western European stock markets: Evidence from intraday data. Economic Systems, Vol. 31, 184-203.

Engle, R. and K. Kroner, 1995. Multivariate Simultaneous Generalized ARCH. Econometric Theory, Vol. 11, 122-150.

Fedorova, E. and K. Saleem, 2010. Volatility Spillovers between Stock and Currency Markets: Evidence from Emerging Eastern Europe. Czech Journal of Economics and Finance, Vol. 60, No. 6, 519-533.

Fedorova, E. and M. Vaihekoski, 2009. Global and local sources of risk in Eastern European emerging stock markets. Czech Journal of Economics and Finance, Vol. 59, No. 1, 2-19.

Ferreira, M. and P. Gama, 2005. Have world, country and industry risks changed over time? An investigation of the volatility of developed stock markets. The Journal of Financial and Quantitative Analysis, Vol. 40, No. 1, 195-222.

Hammoudeh, S., Y. Yuan and M. McAleer, 2009. Shock and volatility spillovers among sectors of the Gulf Arab stock markets. The Quarterly Review of Economics and Finance, Vol. 49, 829-842.

Hassan, S. and F. Malik, 2004. Modeling volatility in sector index returns with GARCH models using an iterated algorithm. Journal of Economics and Finance, Vol. 28, No. 2, 211-225.

Hassan, S. and F. Malik, 2007. Multivariate GARCH modeling of sector volatility transmission. The Quarterly Review of Economics and Finance, Vol. 47, 470-480.

Hyytinen, A., 1999. Stock return volatility on Scandinavian stock markets and the banking industry. Bank of Finland Discussion Papers No.19/99 available at http://ssrn.com/abstract=1021220.

Johnson, W., 2010. International financial freedoms, banks, contagion and the market crisis of 2007-2009. Unpublished working paper available at http://ssrn.com/abstract=1459517.

Kaltenhaeuser, B., 2002. Return and volatility spillovers to industry returns: Does EMU play a role? Global Finance Journal, Vol. 17, No. 1, 1-22.

Kaltenhaeuser, B., 2003. Country and sector-specific spillover effects in the euro area, the United States and Japan. European Central Bank Working Paper No. 286 available at http://www.ecb.int ISSN 1725-2806.

Lin, S., J. Penm, S. Wu and W. Chiu, 2004. A Factor-GARCH approach to conditional risk and return in banking stocks: Comparison of industry effects in Taiwan, Hong Kong and Mainland China. Unpublished working paper available at http://ssrn.com/abstract=485882.

Morana, C. and J. Sawkins, 2004. Stock market volatility of regulated industries: An empirical assessment. Portuguese Economic Journal, Vol. 3, 189-204.

Pais, A. and P. Stork, 2010. Contagion risk in the Australian banking and property sectors. Forthcoming in Journal of Banking and Finance available at http://ssrn.com/abstract=1461144.

Phylaktis, K. and L. Xia, 2009. Equity market comovement and contagion: A sectoral perspective. Financial Management, Vol. 38, No. 2, 381-409.

Prokopczuk, M., 2009. Intra-industry contagion effects of earnings surprises in the banking sector. SSRN Banking and Insurance eJournal available at http://ssrn.com/abstract=1546468.

Qiao Z., V. Liew and W. Wong, 2007. Does the US IT stock market dominate other IT stock markets: Evidence from multivariate GARCH model? Economics Bulletin, Vol. 6, No. 27, 1-7.

Sarkar, A., G. Chakrabarti and C. Sen, 2009. Indian stock volatility in recent years: Transmission from global and regional contagion and traditional domestic sectors. Journal of Asset Management, Vol. 10, 63-71.

Savva, C. and N. Aslanidis, 2010. Stock market integration between new EU member states and the Euro-zone. Empirical Economics, Vol. 39, 337-351.

Sercu, P. and L. De Moor, 2009. Country v sector effects in equity returns: Are emerging market firms just small firms? Small Business Economics, published online, ISSN 0921-898X.

Steliaros, M. and D. Thomas, 2006. The cross-sectional variability of stock-price returns: Country and sector effects revisited. Journal of Asset Management, Vol. 7, 273-290.

Tawatnuntachai, O. and R. D'Mello, 2009. Intra-industry reactions of stock split announcements. The Journal of Financial Research, Vol. 25, No. 1, 39-57.

Wang, L., 2007. The contingent asymmetric volatility, structural change detect, long run equilibrium – accession vicious cross-strait macroeconomic relationship and sector effects. Working paper available at http://ssrn.com/abstract=970517.

Table 1. Descriptive statistics for the asset returns

Panel A reports descriptive statistics for risk-free asset and the continuously compounded returns for three emerging Eastern European stock markets, emerging European and EU stock markets. The risk-free rate is calculated from the Eurodollar rate. Panel B reports pairwise correlations for the return series. Index series are the Datastream indices. The sample period is from November 1998 to December 2009. All returns are calculated in US dollars and include dividends (i.e. total return). The sample includes 580 weekly observations. Means and standard deviations have been annualized. The *p*-value for the Jarque-Bera test statistic of the null hypothesis of normal distribution is provided in the table.

Asset return series	**Mean** (%)	**Std. dev.** (%)	**Skewness**	**Excess Kurtosis**	**Normality** (p-value)	**Autocorrelation**[a] ρ_1	ρ_2	ρ_3	ρ_{27}	**Q(27)**[b]
Panel A: Summary statistics										
Risk-free rate	3.401	0.273	0.041	1.545	<0.001	0.991*	0.981*	0.970*	0.748*	<0.001
European Union	5.013	21.724	-0.819	6.167	<0.001	-0.076	0.013	0.131*	-0.038	<0.001
Emerging Europe	18.132	33.031	-1.196	9.591	<0.001	0.008	0.013	0.186*	-0.041	<0.001
Poland	10.416	32.614	-0.775	6.563	<0.001	-0.034	0.050	0.143*	-0.063	<0.001
Hungary	10.015	33.855	-1.204	10.096	<0.001	0.021	-0.044	0.101	-0.064	<0.001
Czech Republic	21.263	27.988	-0.942	6.675	<0.001	-0.002	0.029	0.168*	-0.058	0.003
Panel B: Pairwise correlations	Rf	EU	EE	Poland	Hungary	Czech				
Risk-free rate	1	-0.051	-0.071	-0.037	-0.096	-0.080				
European Union		1	0.657	0.654	0.684	0.638				
Emerging Europe			1	0.648	0.676	0.647				
Poland				1	0.716	0.633				
Hungary					1	0.692				
Czech Republic						1				

a) Autocorrelation coefficients significantly (5%) different from zero are marked with an asterisk (*).

b) The *p*-value for the Ljung-Box test statistic for the null hypothesis that autocorrelation coefficients up to 27 lags (= half year) are zero.

Table 2. Descriptive statistics for the Polish sectoral asset returns

Panel A reports descriptive statistics for the continuously compounded returns of the Polish stock market. Panel B reports pairwise correlations for the sectoral return series. Index series are the Datastream indices. The sample period is from November 1998 to December 2009. All returns are calculated in US dollars and include dividends (i.e. total return). The sample includes 580 weekly observations. Means and standard deviations have been annualized. The *p*-value for the Jarque-Bera test statistic of the null hypothesis of normal distribution is provided in the table.

Asset return series	**Mean** (%)	**Std. dev.** (%)	**Skewness**	**Excess Kurtosis**	**Normality** (p-value)	**Autocorrelation**[a] ρ_1	ρ_2	ρ_3	ρ_{27}	**Q(27)**[b]
Panel A: Summary statistics										
Oil & gas	17.898	36.256	-0.244	4.283	<0.001	-0.072	-0.007	0.086	-0.068	0.448
Basic materials	21.424	36.563	-0.793	7.539	<0.001	0.095*	0.015	0.174*	-0.078	<0.001
Industrials	7.644	32.265	-0.503	3.912	<0.001	0.004	0.022	0.099	-0.009	0.004
Consumer goods	14.856	27.042	-0.573	5.913	<0.001	-0.090*	0.052	0.083*	0.003	0.030
Consumer services	4.414	35.146	-0.415	5.477	<0.001	-0.078	0.022	0.081	-0.031	0.440
Telecommunications	2.943	39.449	0.096	4.606	<0.001	-0.060	0.036	0.068	-0.018	0.443
Financials	13.822	35.491	-1.272	10.855	<0.001	-0.043	0.047	0.131*	-0.058	<0.001

Panel B: Pairwise correlations	Oil & gas	Basic mat.	Industrials	Con. goods	Con. serv.	Telecom	Financials
Oil & gas	1	0.618	0.505	0.505	0.642	0.608	0.651
Basic materials		1	0.729	0.625	0.691	0.564	0.761
Industrials			1	0.593	0.617	0.466	0.702
Consumer goods				1	0.584	0.477	0.601
Consumer services					1	0.672	0.747
Telecommunications						1	0.637
Financials							1

a) Autocorrelation coefficients significantly (5%) different from zero are marked with an asterisk (*).

b) The *p*-value for the Ljung-Box test statistic for the null hypothesis that autocorrelation coefficients up to 27 lags (= half year) are zero.

Table 3. Descriptive statistics for the Hungarian sectoral asset returns

Panel A reports descriptive statistics for the continuously compounded returns for the Hungarian stock market. Panel B reports pairwise correlations for the sectoral return series. Index series are the Datastream indices. The sample period is from November 1998 to December 2009. All returns are calculated in US dollars and include dividends (i.e. total return). The sample includes 580 weekly observations. Means and standard deviations have been annualized. The *p*-value for the Jarque-Bera test statistic of the null hypothesis of normal distribution is provided in the table.

Asset return series	**Mean** (%)	**Std. dev.** (%)	**Skewness**	**Excess Kurtosis**	**Normality** (p-value)	**Autocorrelation**[a] ρ_1	ρ_2	ρ_3	ρ_{27}	**Q(27)**[b]
Panel A: Summary statistics										
Oil & gas	13.863	42.501	-0.675	8.254	<0.001	-0.006	-0.111*	0.078	-0.069	0.002
Basic materials	4.966	35.171	-0.510	6.157	<0.001	0.043	-0.029	0.018	-0.005	0.576
Industrials	-5.496	39.642	-0.258	5.366	<0.001	-0.050	0.065	0.025	-0.061	0.012
Consumer goods	6.822	34.224	0.238	11.652	<0.001	-0.155*	0.030	0.009	0.037	0.001
Consumer services	5.060	35.104	-0.520	10.092	<0.001	0.059	-0.061	0.038	-0.005	0.535
Telecommunications	1.534	36.823	-0.428	5.035	<0.001	-0.028	-0.050	0.050	-0.010	0.591
Financials	18.512	46.922	-1.305	12.645	<0.001	-0.002	0.013	0.056	-0.067	<0.001
Panel B: Pairwise correlations	Oil & gas	Basic mat.	Industrials	Con. goods	Con. serv.	Telecom	Financials			
Oil & gas	1	0.543	0.475	0.350	0.562	0.603	0.690			
Basic materials		1	0.484	0.325	0.492	0.551	0.574			
Industrials			1	0.313	0.481	0.479	0.534			
Consumer goods				1	0.369	0.396	0.372			
Consumer services					1	0.496	0.570			
Telecommunications						1	0.659			
Financials							1			

a) Autocorrelation coefficients significantly (5%) different from zero are marked with an asterisk (*).

b) The *p*-value for the Ljung-Box test statistic for the null hypothesis that autocorrelation coefficients up to 27 lags (= half year) are zero.

Table 4. Descriptive statistics for the Czech sectoral asset returns

Panel A reports descriptive statistics for the continuously compounded returns on the Czech stock market. Panel B reports pairwise correlations for the sectoral return series. Index series are the Datastream indices. The sample period is from November 1998 to December 2009. All returns are calculated in US dollars and include dividends (i.e., total return). The sample includes 580 weekly observations. Means and standard deviations have been annualized. The *p*-value for the Jarque-Bera test statistic of the null hypothesis of normal distribution is provided in the table.

	Mean	**Std. dev.**	**Skewness**	**Excess**	**Normality**		**Autocorrelation**[a]			
Asset return series	(%)	(%)		**Kurtosis**	(p-value)	ρ_1	ρ_2	ρ_3	ρ_{27}	**Q(27)**[b]
Panel A: Summary statistics										
Oil & gas	23.681	32.542	-0.409	8.318	<0.001	-0.048	0.113*	0.084*	-0.044	<0.001
Basic materials	20.956	31.650	-2.137	21.497	<0.001	0.038	0.012	0.057	-0.019	0.826
Industrials	17.857	24.089	2.411	32.387	<0.001	0.150*	-0.018	0.055	-0.015	0.037
Consumer goods	14.331	32.133	0.971	14.576	<0.001	0.035	0.020	0.073	0.015	0.374
Consumer services	-0.081	55.129	-0.901	13.460	<0.001	0.087*	0.092*	0.208*	-0.132*	<0.001
Telecommunications	9.402	36.727	-0.379	5.029	<0.001	-0.055	-0.015	0.128*	-0.042	0.053
Financials	29.588	37.700	-0.523	9.327	<0.001	-0.031	-0.015	0.072	-0.014	<0.001
Panel B: Pairwise correlations	Oil & gas	Basic mat.	Industrials	Con. goods	Con. serv.	Telecom	Financials			
Oil & gas	1	0.321	0.287	0.229	0.327	0.302	0.452			
Basic materials		1	0.256	0.194	0.219	0.322	0.433			
Industrials			1	0.200	0.182	0.178	0.235			
Consumer goods				1	0.141	0.094	0.273			
Consumer services					1	0.342	0.470			
Telecommunications						1	0.477			
Financials							1			

a) Autocorrelation coefficients significantly (5%) different from zero are marked with an asterisk (*).

b) The *p*-value for the Ljung-Box test statistic for the null hypothesis that autocorrelation coefficients up to 27 lags (=half of the year) are zero.

Table 5. Risk transfers between local stock markets and emerging Europe

The diagonal elements in matrix β represent the mean equation while matrix A captures own and cross-market ARCH effects. The diagonal elements in matrix G measure own and cross-market GARCH effects. LB and LB^2 present the Ljung-Box Q-statistic for standardized and standardized squared residuals. (*) denotes the significance level at 5%, (**) denotes the significance level at 10%.

Panel A: GARCH(1,1)-BEKK estimations

	Poland-Hungary		Poland-Czech R.		Hungary-Czech R.		Poland-EE		Hungary-EE		Czech R.-EE	
Parameters	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.
β_1	0.005*	(0.002)	0.005*	(0.002)	0.005*	(0.002)	0.003*	(0.002)	0.003*	(0.002)	0.007*	(0.001)
β_2	0.005*	(0.002)	0.007*	(0.001)	0.007*	(0.001)	0.005*	(0.002)	0.005*	(0.002)	0.006*	(0.001)
C_{11}	0.006*	(0.003)	0.009*	(0.001)	0.013*	(0.003)	0.009*	(0.002)	0.013*	(0.002)	0.012*	(0.001)
C_{12}	0.016*	(0.002)	0.012*	(0.002)	-0.013*	(0.004)	0.010*	(0.002)	0.007*	(0.002)	0.011*	(0.002)
C_{22}	-0.145 [a]	(0.010)	0.004 [a]	(0.005)	-0.529 [a]	(0.012)	0.004*	(0.001)	0.008*	(0.002)	0.242 [a]	(0.002)
A_{11}	0.221*	(0.053)	0.243*	(0.047)	0.199**	(0.105)	0.124*	(0.057)	0.248*	(0.080)	0.321*	(0.029)
A_{12}	-0.039	(0.059)	0.083**	(0.044)	0.090**	(0.054)	-0.158*	(0.064)	-0.121**	(0.071)	0.209*	(0.017)
A_{21}	0.153*	(0.047)	0.217*	(0.064)	0.060	(0.143)	0.158*	(0.048)	0.156*	(0.061)	0.133*	(0.037)
A_{22}	0.406*	(0.056)	0.355*	(0.058)	0.408*	(0.073)	0.405*	(0.043)	0.391*	(0.048)	0.302*	(0.039)
G_{11}	1.055*	(0.024)	0.963*	(0.013)	0.399*	(0.159)	0.975*	(0.018)	0.891*	(0.050)	0.881*	(0.005)
G_{12}	0.145*	(0.039)	-0.018	(0.014)	-0.078	(0.130)	0.016	(0.022)	0.018	(0.040)	-0.129*	(0.005)
G_{21}	-0.195*	(0.025)	-0.126*	(0.026)	0.702*	(0.166)	-0.054*	(0.022)	-0.024	(0.043)	-0.044*	(0.017)
G_{22}	0.769*	(0.030)	0.865*	(0.026)	0.866*	(0.150)	0.901*	(0.021)	0.897*	(0.032)	0.930*	(0.019)
Panel B: Diagnostic tests												
LogLik		2243.670		2273.340		2302.370		2221.683		2226.198		2295.696
LB_1		31.497		31.216		31.266		29.081		27.874		33.286
LB_2		29.122		35.086		36.621**		40.434*		40.150*		37.127**
LB^2_1		23.056		19.444		19.165		22.763		12.434		14.998
LB^2_2		16.502		21.402		20.986		20.973		21.283		17.185

a) Multiplied by 1,000,000.

Table 6. Risk transfers between local stock markets and European Union

The diagonal elements in matrix β represent the mean equation while matrix A captures own and cross-market ARCH effects. The diagonal elements in matrix G measure own and cross-market GARCH effects. LB and LB^2 presents the Ljung-Box Q-statistic for standardized and standardized squared residuals. (*) denotes the significance level at 5%, (**) denotes the significance level at 10%.

Panel A: GARCH(1,1)-BEKK estimations

	Poland-EU		Hungary-EU		Czech Republic-EU		EE-EU	
Parameters	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.
β_1	0.004*	(0.002)	0.004*	(0.001)	0.007*	(0.001)	0.006*	(0.002)
β_2	0.003*	(0.001)	0.003*	(0.001)	0.003*	(0.001)	0.003*	(0.001)
C_{11}	0.018*	(0.003)	0.014*	(0.002)	0.013*	(0.002)	0.010*	(0.002)
C_{12}	0.007*	(0.002)	0.003	(0.002)	0.005*	(0.001)	0.006*	(0.001)
C_{22}	0.004 [a]	(0.003)	0.005*	(0.002)	0.002 [a]	(0.003)	0.002*	(0.001)
A_{11}	-0.056	(0.176)	0.197*	(0.054)	0.369*	(0.058)	0.344*	(0.045)
A_{12}	-0.065	(0.070)	-0.064	(0.049)	0.142*	(0.035)	0.081*	(0.032)
A_{21}	0.138	(0.178)	0.445*	(0.089)	0.164*	(0.076)	0.024	(0.083)
A_{22}	0.527*	(0.079)	0.482*	(0.055)	0.299*	(0.051)	0.306*	(0.061)
G_{11}	0.637*	(0.082)	0.901*	(0.045)	0.844*	(0.034)	0.929*	(0.018)
G_{12}	-0.205*	(0.030)	0.033	(0.061)	-0.073*	(0.015)	-0.024**	(0.013)
G_{21}	0.530*	(0.093)	-0.144*	(0.062)	-0.045**	(0.027)	-0.055**	(0.031)
G_{22}	1.032*	(0.051)	0.850*	(0.072)	0.945*	(0.016)	0.920*	(0.024)

Panel B: Diagnostic tests

	Poland-EU	Hungary-EU	Czech Republic-EU	EE-EU
LogLik	2451.563	2474.560	2563.643	2469.653
LB_1	35.139	27.086	34.820	38.702*
LB_2	31.222	32.684	31.537	29.683
LB^2_1	30.887	13.151	17.964	19.836
LB^2_2	28.049	26.112	21.226	19.726

a) Multiplied by 10,000.

Table 7. Matrix of risk transfers on local stock markets

Industries	Poland		Hungary		Czech Republic	
	shocks[1]	volatilities	shocks	volatilities	shocks	volatilities
Oil & Gas	↑	↑	↰	↰		
Basic Materials	↰	↰	←	←	↰	↰
Industrials	↰	↰	↰	↰	↰	↑
Consumer Goods		↰			←	←
Consumer Services	←	↑			↰	↑
Telecom	↰	↰	←	↑	↰	↰
Financials					↰	←

[1] ↑ means unidirectional spillovers in shocks or volatilities from particular industry to overall stock market;
↰ means bidirectional spillovers in shocks and volatilities between particular sector and overall stock market;
← means unidirectional spillovers in shocks or volatilities from overall stock market to particular industry.

Table 8. Matrix of risk transfers between local and European Union stock market sectors

	Industries	Poland		Hungary		Czech Republic	
		shocks[1]	volatilities	shocks	volatilities	shocks	volatilities
European Union	Oil & Gas		↑	↑	↑		↑
	Basic Materials	↰	↰	↑	↑	↑	↑
	Industrials	↑	↰	↑	↑	↰	↰
	Consumer Goods	←	←			↑	↰
	Consumer Services	↑	↑	↑	↑	↰	↰
	Telecom	↑	↑	↰	←	↑	↑
	Financials			↰	↑	←	↰

[1] ↑ means unidirectional intra-industry spillovers in shocks or volatilities from European Union to local market;
↰ means bidirectional spillovers in shocks and volatilities between EU and local market;
← means unidirectional intra-industry spillovers in shocks or volatilities from local market to European Union.

Table 9. Risk transfer on local oil & gas stock markets sectors estimated with sub-periods

The diagonal elements in matrix β represent the mean equation, while matrix A captures own and cross-market ARCH effects. The diagonal elements in matrix G measure own and cross-market GARCH effects. LB and LB^2 presents the Ljung-Box Q-statistic for standardized and standardized squared residuals. (*) denotes the significance level at 5%, (**) denotes the significance level at 10%.

Panel A: GARCH(1,1)-BEKK estimations

	Oil & Gas											
	1998-2003						2004-2009					
	Poland-Hungary		Poland-Czech R.		Hungary-Czech R.		Poland-Hungary		Poland-Czech R.		Hungary-Czech R.	
Parameters	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.
β_1	0.003	(0.003)	0.002	(0.003)	0.003	(0.003)	0.005*	(0.002)	0.005*	(0.003)	0.007*	(0.003)
β_2	0.002	(0.002)	0.006*	(0.002)	0.008*	(0.002)	0.006*	(0.003)	0.005*	(0.001)	0.005*	(0.001)
C_{11}	0.001	(0.007)	0.005*	(0.002)	0.017	(0.011)	0.036*	(0.005)	0.015*	(0.007)	0.046*	(0.003)
C_{12}	0.008**	(0.004)	-0.034*	(0.003)	-0.015*	(0.007)	0.005	(0.008)	0.004*	(0.001)	-9.493 [a]	(0.001)
C_{22}	0.189 [a]	(0.047)	-0.155 [a]	(0.092)	0.023	(0.022)	0.048 [a]	(0.015)	-0.032 [a]	(0.006)	-0.003 [a]	(0.003)
A_{11}	0.208*	(0.060)	0.223*	(0.065)	0.235*	(0.072)	0.093	(0.123)	0.096	(0.081)	0.357*	(0.067)
A_{12}	0.072	(0.054)	-0.005	(0.110)	-0.161*	(0.067)	0.215	(0.138)	-0.072*	(0.033)	-0.084*	(0.022)
A_{21}	-0.239*	(0.066)	-0.223*	(0.105)	0.077	(0.114)	0.278*	(0.087)	0.237*	(0.066)	-0.363*	(0.107)
A_{22}	0.165*	(0.051)	0.267*	(0.137)	-0.309*	(0.118)	0.238*	(0.091)	0.500*	(0.057)	0.520*	(0.057)
G_{11}	0.555*	(0.047)	0.935*	(0.042)	0.886*	(0.089)	0.252	(0.319)	0.928*	(0.066)	-0.050	(0.209)
G_{12}	-0.587*	(0.039)	0.039	(0.065)	0.391*	(0.057)	0.358**	(0.202)	-0.015	(0.018)	0.030	(0.046)
G_{21}	0.664*	(0.042)	0.356**	(0.193)	-0.386*	(0.183)	0.246	(0.163)	-0.053**	(0.028)	0.789*	(0.139)
G_{22}	0.955*	(0.041)	0.189	(0.317)	0.573*	(0.124)	0.717*	(0.115)	0.896*	(0.021)	0.879*	(0.042)

Panel B: Diagnostic tests

LogLik	881.372	934.546	957.975	1049.496	1159.848	1084.808
LB_1	21.098	21.384	18.894	42.328*	39.106*	39.094*
LB_2	17.864	36.967**	35.221	33.012	21.235	23.280
LB^2_1	18.453	20.369	26.575	22.819	19.594	33.690
LB^2_2	18.019	40.966*	29.189	27.016	25.898	25.944

a) Multiplied by 100,000.

Table 10. Risk transfer on local basic materials stock markets sectors estimated with sub-periods

The diagonal elements in matrix β represent the mean equation while matrix A captures own and cross-market ARCH effects. The diagonal elements in matrix G measure own and cross-market GARCH effects. LB and LB^2 presents the Ljung-Box Q-statistic for standardized and standardized squared residuals. (*) denotes the significance level at 5%, (**) denotes the significance level at 10%.

Panel A: GARCH(1,1)-BEKK estimations

	Basic Materials											
	1998-2003						2004-2009					
	Poland-Hungary		Poland-Czech R.		Hungary-Czech R.		Poland-Hungary		Poland-Czech R.		Hungary-Czech R.	
Parameters	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.
β_1	0.004**	(0.002)	0.004**	(0.002)	0.004	(0.003)	0.007*	(0.002)	0.006*	(0.002)	0.001	(0.002)
β_2	0.005**	(0.003)	0.005*	(0.002)	0.006*	(0.002)	0.001	(0.002)	0.004**	(0.002)	0.004	(0.003)
C_{11}	0.028*	(0.007)	0.033*	(0.006)	0.012	(0.009)	0.021*	(0.002)	0.001	(0.004)	0.009**	(0.005)
C_{12}	-0.012*	(0.006)	0.002	(0.005)	0.031*	(0.002)	1.291 [a]	(0.004)	-0.022*	(0.005)	0.029*	(0.004)
C_{22}	0.865 [a]	(0.017)	-0.001	(0.010)	0.004 [a]	(0.047)	-0.001 [a]	(0.003)	0.022*	(0.003)	-0.045	(0.030)
A_{11}	0.278*	(0.142)	0.359*	(0.140)	0.311*	(0.069)	0.161*	(0.039)	0.246*	(0.071)	0.393*	(0.080)
A_{12}	-0.267*	(0.098)	0.095	(0.081)	-0.118*	(0.059)	0.411*	(0.043)	-0.509*	(0.078)	-0.183	(0.124)
A_{21}	-0.019	(0.064)	-0.138	(0.110)	0.382*	(0.149)	0.360*	(0.048)	0.138**	(0.078)	0.169*	(0.054)
A_{22}	0.438*	(0.095)	0.147*	(0.059)	0.354*	(0.099)	-0.032	(0.056)	0.851*	(0.104)	0.325*	(0.089)
G_{11}	0.530	(0.379)	0.335	(0.353)	0.843*	(0.044)	0.631*	(0.023)	1.014*	(0.025)	0.939*	(0.058)
G_{12}	0.414	(0.315)	-0.166	(0.120)	-0.044	(0.084)	-0.266*	(0.028)	0.368*	(0.055)	0.367*	(0.108)
G_{21}	0.190	(0.161)	0.156	(0.141)	0.108	(0.245)	0.396*	(0.034)	-0.266*	(0.076)	-0.309*	(0.041)
G_{22}	0.730*	(0.199)	0.997*	(0.022)	0.201	(0.309)	0.986*	(0.039)	0.032	(0.122)	0.596*	(0.082)

Panel B: Diagnostic tests

	Poland-Hungary 1998-2003	Poland-Czech R. 1998-2003	Hungary-Czech R. 1998-2003	Poland-Hungary 2004-2009	Poland-Czech R. 2004-2009	Hungary-Czech R. 2004-2009
LogLik	927.932	1027.692	972.792	1106.459	1033.180	1083.786
LB_1	24.316	25.091	16.624**	59.375*	53.170*	24.361
LB_2	18.854	33.017	37.414	19.860	16.220	13.355
LB^2_1	10.429	11.687	28.669	28.225	33.577	23.906
LB^2_2	21.903	19.058	28.334	36.757**	6.702	2.397

[a)] Multiplied by 10,000.

Table 11. Risk transfer on local industrials stock markets sectors estimated with sub-periods

The diagonal elements in matrix β represent the mean equation while matrix A captures own and cross-market ARCH effects. The diagonal elements in matrix G measure own and cross-market GARCH effects. LB and LB^2 presents the Ljung-Box Q-statistic for standardized and standardized squared residuals. (*) denotes the significance level at 5%, (**) denotes the significance level at 10%.

Panel A: GARCH(1,1)-BEKK estimations												
	Industrials											
	1998-2003						**2004-2009**					
	Poland-Hungary		**Poland-Czech R.**		**Hungary-Czech R.**		**Poland-Hungary**		**Poland-Czech R.**		**Hungary-Czech R.**	
Parameters	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.
β_1	0.002	(0.003)	3.642 [a]	(0.002)	-0.003	(0.003)	0.005*	(0.002)	0.006*	(0.002)	0.004	(0.003)
β_2	-0.001	(0.003)	0.003	(0.002)	0.001	(0.002)	0.003	(0.003)	0.004*	(0.001)	0.005*	(0.001)
C_{11}	0.013	(0.009)	0.002	(0.023)	0.006 [a]	(0.006)	0.002	(0.006)	0.008*	(0.002)	0.023*	(0.004)
C_{12}	0.025*	(0.010)	-0.009	(0.008)	0.001 [a]	(0.004)	-0.020*	(0.006)	-0.001	(0.002)	-0.001	(0.006)
C_{22}	-0.038	(0.027)	0.038*	(0.001)	0.001 [a]	(0.004)	0.026*	(0.005)	-0.001 [a]	(0.003)	-0.001 [a]	(0.008)
A_{11}	0.210*	(0.070)	0.206**	(0.114)	0.123*	(0.047)	0.315*	(0.060)	0.347*	(0.048)	0.274*	(0.089)
A_{12}	0.320*	(0.098)	-0.106	(0.091)	0.192*	(0.028)	0.315*	(0.111)	0.081*	(0.019)	0.130*	(0.025)
A_{21}	-0.137*	(0.063)	0.114	(0.072)	0.043	(0.044)	0.082**	(0.051)	-0.056	(0.090)	-0.255	(0.158)
A_{22}	0.229*	(0.082)	0.194*	(0.095)	0.023	(0.039)	0.251*	(0.099)	0.184*	(0.037)	0.258*	(0.073)
G_{11}	0.588*	(0.063)	0.833*	(0.152)	0.874*	(0.022)	0.971*	(0.022)	0.916*	(0.021)	0.725*	(0.060)
G_{12}	-0.793*	(0.153)	-0.029	(0.244)	-0.295*	(0.017)	0.141	(0.101)	-0.028*	(0.007)	-0.156*	(0.027)
G_{21}	0.448*	(0.077)	-0.511*	(0.239)	0.563*	(0.036)	-0.079**	(0.048)	0.045	(0.032)	0.740*	(0.238)
G_{22}	0.662*	(0.125)	-0.118	(0.260)	0.905*	(0.025)	0.615*	(0.149)	0.980*	(0.009)	0.927*	(0.028)
Panel B: Diagnostic tests												
LogLik		901.922		961.852		909.795		1044.893		1284.868		1210.967
LB_1		37.706**		37.354**		50.185*		41.526*		39.890*		47.444*
LB_2		49.274*		27.010		30.507		42.913*		28.842		28.011
LB^2_1		25.266		20.811		13.229		35.560		35.759**		42.959*
LB^2_2		15.778		2.494		5.190		32.528		14.774		20.221

a) Multiplied by 10,000.

Table 12. Risk transfer on local consumer goods stock markets sectors estimated with sub-periods

The diagonal elements in matrix β represent the mean equation, while matrix A captures own and cross-market ARCH effects. The diagonal elements in matrix G measure own and cross-market GARCH effects. LB and LB^2 presents the Ljung-Box Q-statistic for standardized and standardized squared residuals. (*) denotes the significance level at 5%, (**) denotes the significance level at 10%.

Panel A: GARCH(1,1)-BEKK estimations

	Consumer Goods											
	1998-2003						2004-2009					
	Poland-Hungary		Poland-Czech R.		Hungary-Czech R.		Poland-Hungary		Poland-Czech R.		Hungary-Czech R.	
Parameters	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.
β_1	0.005*	(0.002)	0.006*	(0.002)	0.005*	(0.002)	0.003**	(0.002)	0.003*	(0.002)	0.006*	(0.002)
β_2	-0.001	(0.002)	0.009*	(0.002)	0.007*	(0.003)	0.004**	(0.002)	0.001	(0.001)	-0.001	(0.002)
C_{11}	0.021*	(0.005)	-0.010*	(0.005)	0.034*	(0.003)	0.018*	(0.007)	0.013*	(0.004)	0.008*	(0.004)
C_{12}	0.024*	(0.007)	0.025*	(0.005)	0.008	(0.007)	0.010*	(0.003)	0.006	(0.008)	0.023*	(0.011)
C_{22}	0.019*	(0.007)	-0.002 [a]	(0.023)	0.002	(0.010)	0.018 [a]	(0.004)	0.001 [a]	(0.004)	0.019*	(0.008)
A_{11}	0.557*	(0.104)	0.442*	(0.093)	-0.351*	(0.096)	0.460*	(0.110)	0.413*	(0.072)	0.279*	(0.065)
A_{12}	0.168*	(0.085)	0.101	(0.082)	0.778*	(0.179)	0.115**	(0.067)	0.231*	(0.052)	-0.081	(0.061)
A_{21}	0.071	(0.115)	0.059	(0.059)	-0.032	(0.056)	0.006	(0.059)	-0.031	(0.047)	-0.045	(0.100)
A_{22}	0.253*	(0.118)	0.350*	(0.080)	0.431*	(0.087)	0.199*	(0.043)	0.215*	(0.075)	0.344*	(0.116)
G_{11}	0.609*	(0.136)	0.577*	(0.086)	-0.166	(0.309)	0.738*	(0.188)	0.742*	(0.081)	0.961*	(0.021)
G_{12}	-0.340*	(0.134)	-0.513*	(0.084)	0.626*	(0.157)	-0.163**	(0.099)	-0.418*	(0.183)	0.048	(0.032)
G_{21}	-0.367	(0.297)	0.490*	(0.050)	-0.129	(0.106)	0.007	(0.021)	0.194*	(0.170)	-0.055	(0.118)
G_{22}	0.331	(0.249)	0.664*	(0.079)	-0.426*	(0.100)	0.979*	(0.013)	0.987*	(0.337)	0.642*	(0.166)
Panel B: Diagnostic tests												
LogLik		1030.843		966.897		979.428		1131.844		1181.431		1050.121
LB_1		30.225		28.692		22.348		29.692		27.880		22.590
LB_2		21.385		19.693		30.453		23.868		35.521*		34.401
LB^2_1		25.093		16.259		15.658		27.209		21.327		6.081
LB^2_2		15.708		6.822		23.729		7.156		21.984		19.710

a) Multiplied by 10,000.

Table 13. Risk transfer on local consumer services stock markets sectors estimated with sub-periods

The diagonal elements in matrix β represent the mean equation, while matrix A captures own and cross-market ARCH effects. The diagonal elements in matrix G measure own and cross-market GARCH effects. LB and LB^2 presents the Ljung-Box Q-statistic for standardized and standardized squared residuals. (*) denotes the significance level at 5%, (**) denotes the significance level at 10%.

Panel A: GARCH(1,1)-BEKK estimations												
	Consumer Services											
	1998-2003						2004-2009					
	Poland-Hungary		Poland-Czech R.		Hungary-Czech R.		Poland-Hungary		Poland-Czech R.		Hungary-Czech R.	
Parameters	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.
β_1	0.001	(0.003)	14.566 [a]	(0.003)	0.001	(0.002)	0.006*	(0.002)	0.005*	(0.002)	0.006*	(0.002)
β_2	29.891 [a]	(0.003)	0.005	(0.004)	0.002	(0.004)	0.006*	(0.002)	0.005*	(0.002)	0.007*	(0.002)
C_{11}	0.010	(0.007)	0.040*	(0.005)	0.009	(0.006)	0.015*	(0.008)	0.022*	(0.005)	0.034*	(0.002)
C_{12}	-0.022*	(0.005)	-0.004	(0.005)	0.058*	(0.004)	-0.016*	(0.003)	0.006*	(0.003)	0.003	(0.002)
C_{22}	0.117	(0.019)	0.012 [a]	(0.007)	-0.005	(0.076)	-0.018	(0.029)	-0.001 [a]	(0.002)	-0.001 [a]	(0.003)
A_{11}	-0.236*	(0.073)	-0.126	(0.096)	0.125	(0.109)	0.400*	(0.109)	-0.191*	(0.075)	0.331*	(0.069)
A_{12}	0.124*	(0.059)	0.150*	(0.051)	0.685*	(0.151)	0.446*	(0.080)	0.114*	(0.050)	0.121*	(0.038)
A_{21}	-0.014	(0.075)	-0.129*	(0.056)	0.228*	(0.048)	-0.084	(0.113)	0.101*	(0.042)	0.271*	(0.054)
A_{22}	0.458*	(0.085)	0.245*	(0.065)	0.158**	(0.092)	0.097	(0.075)	0.363*	(0.047)	0.427*	(0.055)
G_{11}	0.949*	(0.059)	0.382**	(0.221)	0.630*	(0.138)	-0.216	(0.215)	0.828*	(0.084)	0.227*	(0.115)
G_{12}	0.206*	(0.072)	0.053	(0.134)	-0.172	(0.192)	0.460*	(0.181)	-0.021	(0.040)	-0.097	(0.088)
G_{21}	0.006	(0.071)	0.208*	(0.074)	0.369*	(0.132)	1.008*	(0.143)	0.049**	(0.029)	0.108*	(0.043)
G_{22}	0.681*	(0.102)	0.941*	(0.049)	0.018	(0.134)	0.416*	(0.179)	0.927*	(0.022)	0.941*	(0.019)
Panel B: Diagnostic tests												
LogLik		880.036		806.156		805.670		1139.302		1058.420		1063.305
LB_1		23.079		27.008		26.615		21.618		21.062		31.860
LB_2		28.899		14.592		18.674		30.396		35.035		29.523
LB^2_1		19.820		22.095		22.322		46.104*		38.379*		20.136
LB^2_2		22.154		12.825		26.162		19.762		7.877		6.232

[a)] Multiplied by 100,000.

Table 14. Risk transfer on local telecommunications stock markets sectors estimated with sub-periods

The diagonal elements in matrix β represent the mean equation, while matrix A captures own and cross-market ARCH effects. The diagonal elements in matrix G measure own and cross-market GARCH effects. LB and LB^2 presents the Ljung-Box Q-statistic for standardized and standardized squared residuals. (*) denotes the significance level at 5%, (**) denotes the significance level at 10%.

Panel A: GARCH(1,1)-BEKK estimations												
	Telecommunications											
	1998-2003						**2004-2009**					
	Poland-Hungary		**Poland-Czech R.**		**Hungary-Czech R.**		**Poland-Hungary**		**Poland-Czech R.**		**Hungary-Czech R.**	
Parameters	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.
β_1	1.030 [a]	(0.003)	-4.456 [a]	(0.003)	0.001	(0.003)	0.002	(0.002)	0.003	(0.002)	0.003	(0.002)
β_2	8.751 [a]	(0.003)	-3.573 [a]	(0.004)	0.001	(0.003)	0.001	(0.002)	0.005*	(0.002)	0.005*	(0.002)
C_{11}	0.020*	(0.008)	0.020*	(0.007)	0.007	(0.010)	0.028*	(0.006)	0.030*	(0.005)	0.014*	(0.003)
C_{12}	-0.006	(0.004)	0.006	(0.015)	-0.011	(0.013)	0.002	(0.005)	-0.003	(0.007)	-0.003	(0.005)
C_{22}	0.005	(0.007)	0.001 [a]	(0.018)	0.054	(0.038)	-0.001 [a]	(0.006)	0.004	(0.025)	0.021	(0.011)
A_{11}	0.099	(0.092)	0.365*	(0.063)	0.308*	(0.077)	-0.071	(0.093)	0.207*	(0.103)	0.307*	(0.081)
A_{12}	-0.234*	(0.055)	0.076	(0.066)	-0.098	(0.110)	-0.212**	(0.119)	0.058	(0.087)	0.192*	(0.053)
A_{21}	-0.235*	(0.084)	-0.218*	(0.065)	0.052	(0.065)	0.514*	(0.104)	-0.011	(0.144)	0.232*	(0.071)
A_{22}	0.284*	(0.070)	-0.213*	(0.062)	0.311*	(0.073)	0.457*	(0.084)	0.409*	(0.101)	0.216*	(0.061)
G_{11}	0.858*	(0.067)	0.620*	(0.052)	1.097*	(0.054)	0.715*	(0.166)	0.070	(0.314)	0.800*	(0.034)
G_{12}	0.048	(0.032)	-0.510*	(0.039)	0.906*	(0.069)	0.293*	(0.091)	0.631*	(0.096)	-0.146*	(0.030)
G_{21}	0.169*	(0.066)	0.465*	(0.067)	-0.590*	(0.054)	-0.142	(0.101)	0.844*	(0.256)	0.157*	(0.065)
G_{22}	0.916*	(0.040)	1.019*	(0.048)	0.274*	(0.073)	0.730*	(0.066)	0.229	(0.179)	0.996*	(0.023)
Panel B: Diagnostic tests												
LogLik		826.067		760.678		841.805		1110.642		1147.498		1152.680
LB_1		24.910		25.682		34.377		18.857		16.241		30.004
LB_2		32.423		30.700		22.300		35.328**		26.909		30.049
LB^2_1		23.148		18.822		26.834		29.563		25.129		25.209
LB^2_2		17.539		25.632		19.585		34.381		32.567		34.934

a) Multiplied by 10,000.

Table 15. Risk transfer on local financials stock markets sectors estimated with sub-periods

The diagonal elements in matrix β represent the mean equation, while matrix A captures own and cross-market ARCH effects. The diagonal elements in matrix G measure own and cross-market GARCH effects. LB and LB^2 presents the Ljung-Box Q-statistic for standardized and standardized squared residuals. (*) denotes the significance level at 5%, (**) denotes the significance level at 10%.

Panel A: GARCH(1,1)-BEKK estimations

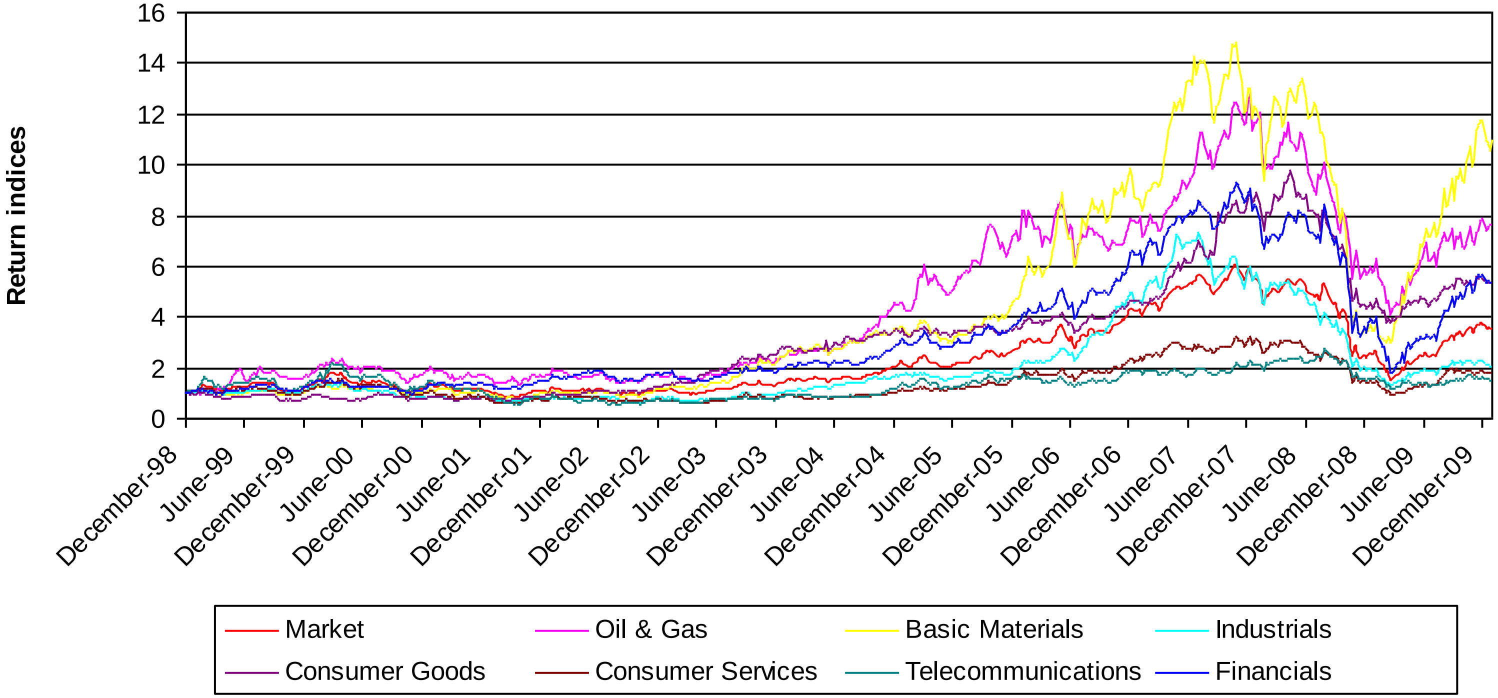
	Financials											
	1998-2003						2004-2009					
	Poland-Hungary		Poland-Czech R.		Hungary-Czech R.		Poland-Hungary		Poland-Czech R.		Hungary-Czech R.	
Parameters	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.
β_1	0.002	(0.002)	0.002	(0.002)	0.004	(0.003)	0.007*	(0.002)	0.007*	(0.002)	0.008*	(0.003)
β_2	0.004	(0.003)	0.006*	(0.002)	0.008*	(0.002)	0.008*	(0.003)	0.008*	(0.002)	0.009*	(0.002)
C_{11}	0.021*	(0.007)	0.026*	(0.006)	0.004	(0.005)	0.012*	(0.002)	0.018*	(0.004)	0.012*	(0.005)
C_{12}	0.009	(0.010)	-0.002	(0.006)	0.012*	(0.002)	-0.661 [a]	(0.006)	-0.015*	(0.004)	-0.026*	(0.003)
C_{22}	0.010	(0.009)	0.008*	(0.004)	-0.014	(0.025)	-0.001	(0.011)	-0.003 [a]	(0.017)	-0.003	(0.050)
A_{11}	0.178**	(0.106)	0.127	(0.090)	-0.002	(0.058)	0.191**	(0.117)	0.143	(0.130)	0.280*	(0.072)
A_{12}	0.276*	(0.126)	-0.142	(0.093)	-0.273*	(0.056)	0.470*	(0.097)	0.402*	(0.073)	0.005	(0.051)
A_{21}	-0.250*	(0.094)	0.343*	(0.133)	-0.258*	(0.071)	0.036	(0.066)	0.013	(0.151)	0.104	(0.162)
A_{22}	0.033	(0.115)	0.225*	(0.103)	0.220*	(0.073)	0.099	(0.075)	0.170*	(0.085)	0.685*	(0.098)
G_{11}	0.668*	(0.193)	0.545**	(0.294)	0.924*	(0.023)	0.762*	(0.045)	0.530*	(0.134)	0.302*	(0.135)
G_{12}	-0.259	(0.291)	0.030	(0.194)	-0.054	(0.036)	-0.244*	(0.046)	-0.002	(0.083)	0.284*	(0.097)
G_{21}	0.136*	(0.066)	0.048	(0.111)	0.135*	(0.049)	0.170*	(0.052)	0.456*	(0.114)	0.842*	(0.155)
G_{22}	0.992*	(0.081)	0.944*	(0.053)	0.918*	(0.034)	1.042*	(0.033)	0.830*	(0.085)	0.366*	(0.136)

Panel B: Diagnostic tests

	Poland-Hungary 1998-2003	Poland-Czech R. 1998-2003	Hungary-Czech R. 1998-2003	Poland-Hungary 2004-2009	Poland-Czech R. 2004-2009	Hungary-Czech R. 2004-2009
LogLik	988.965	1007.858	965.181	1055.252	1098.418	995.204
LB_1	48.458*	45.690*	23.562	42.727*	42.479*	25.472
LB_2	23.727	15.662	16.409	18.959	29.920	32.078
LB^2_1	25.269	19.917	28.816	15.138	14.166	22.169
LB^2_2	26.250	24.734	27.779	14.728	26.958	42.948*

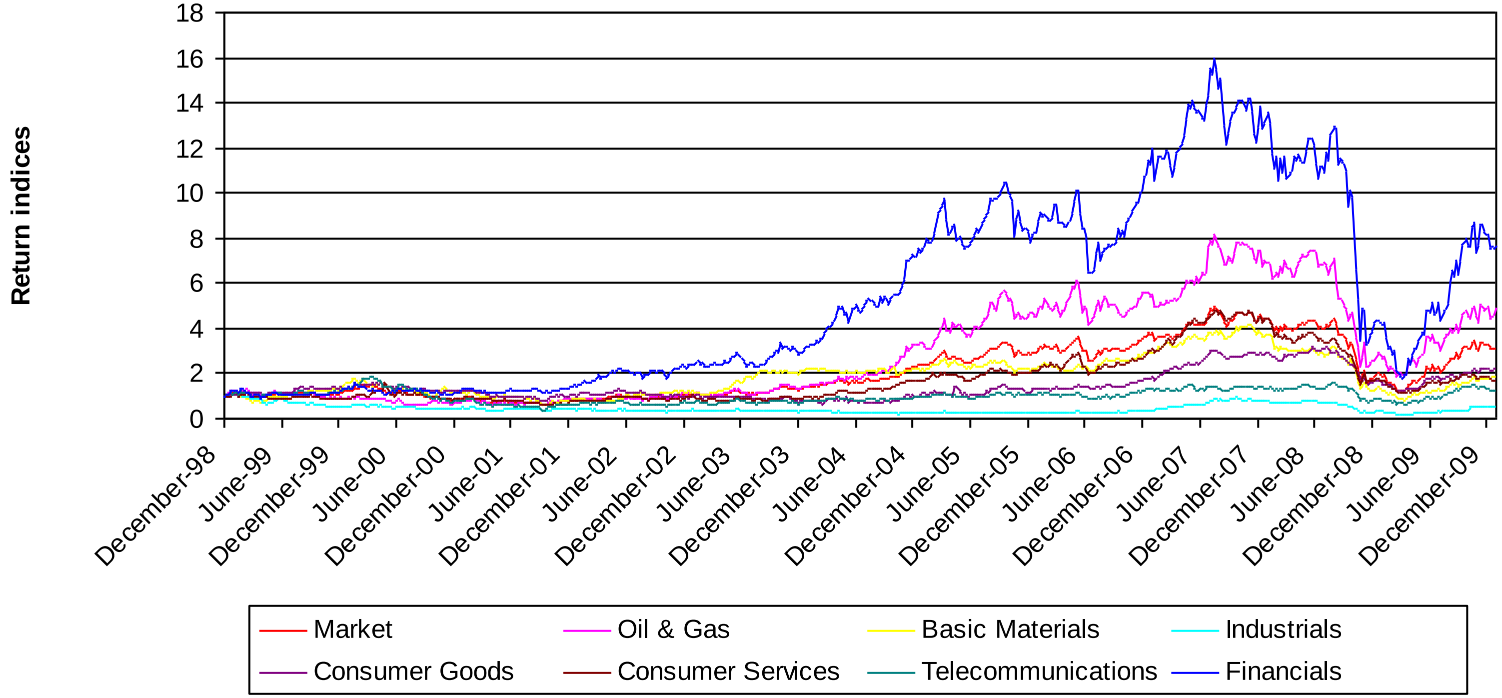
a) Multiplied by 10,000.

Figure 1. Polish stock return indices.



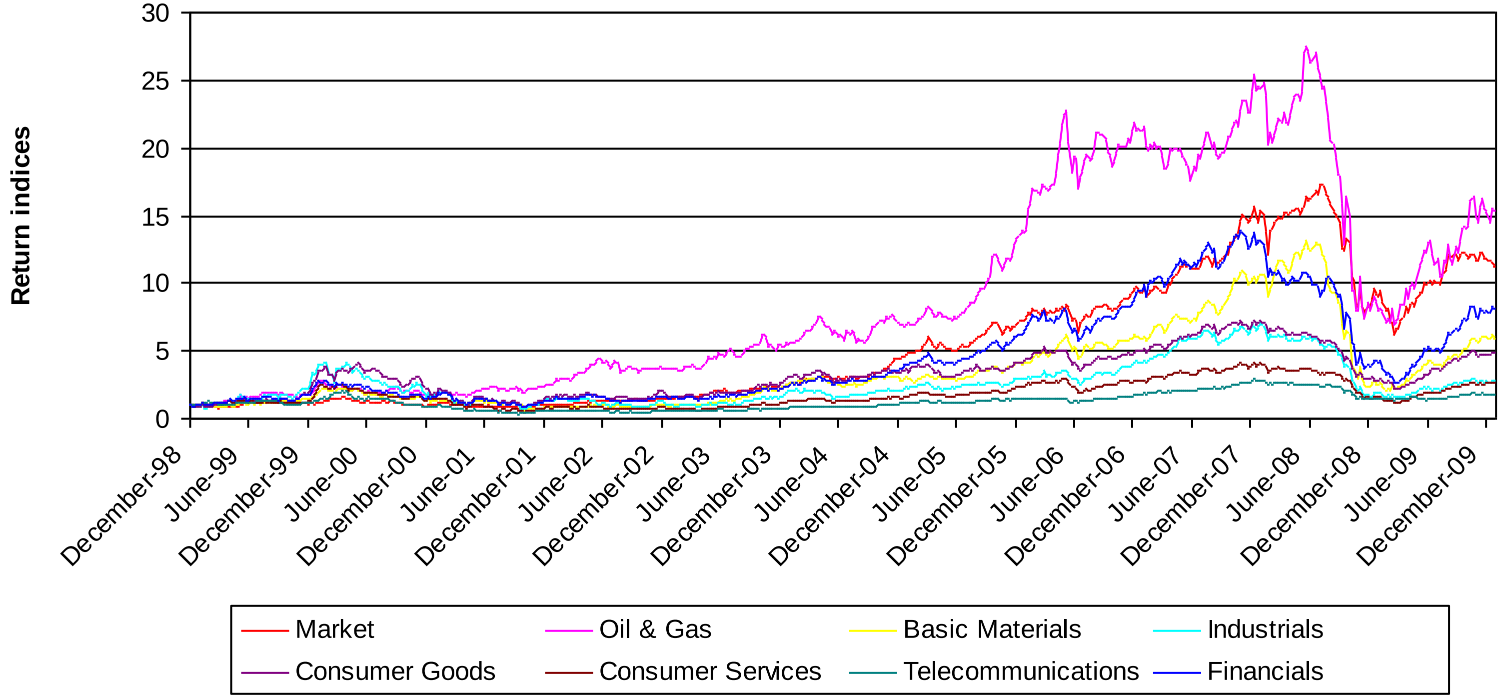
All indices are scaled to one in December 1998.

Figure 2. Hungarian stock return indices.



All indices are scaled to one in December 1998.

Figure 3. Czech stock return indices.



All indices are scaled to one in December 1998.

Figure 4. 52-week rolling correlation between Polish equity market and emerging Europe.

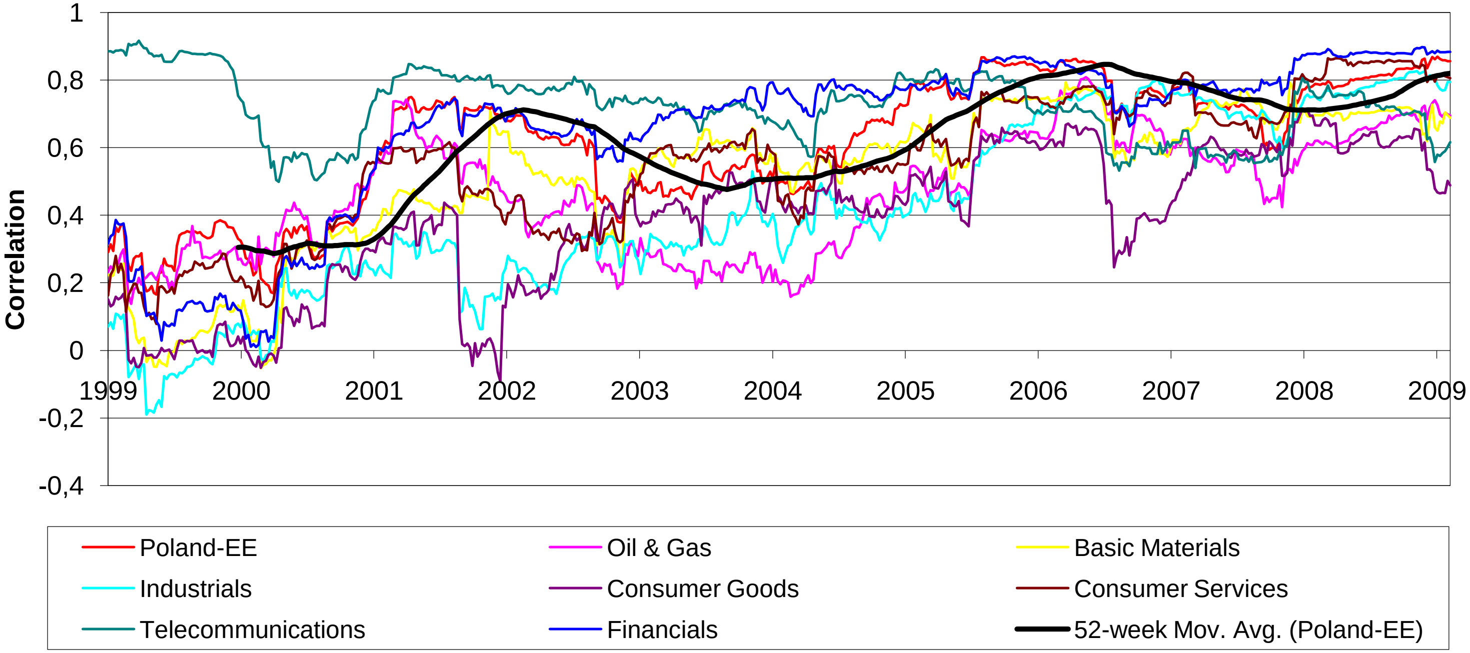


Figure 5. 52-week rolling correlation between Hungarian equity market and emerging Europe.

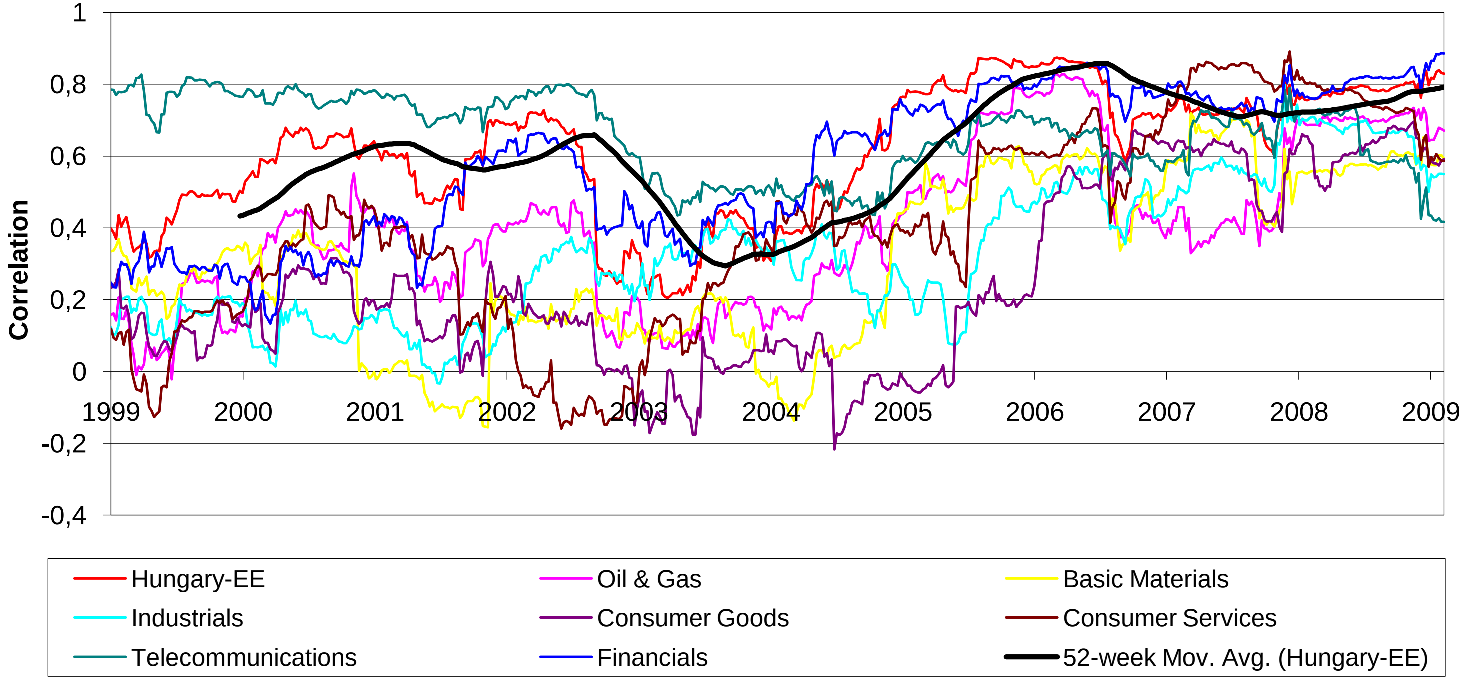
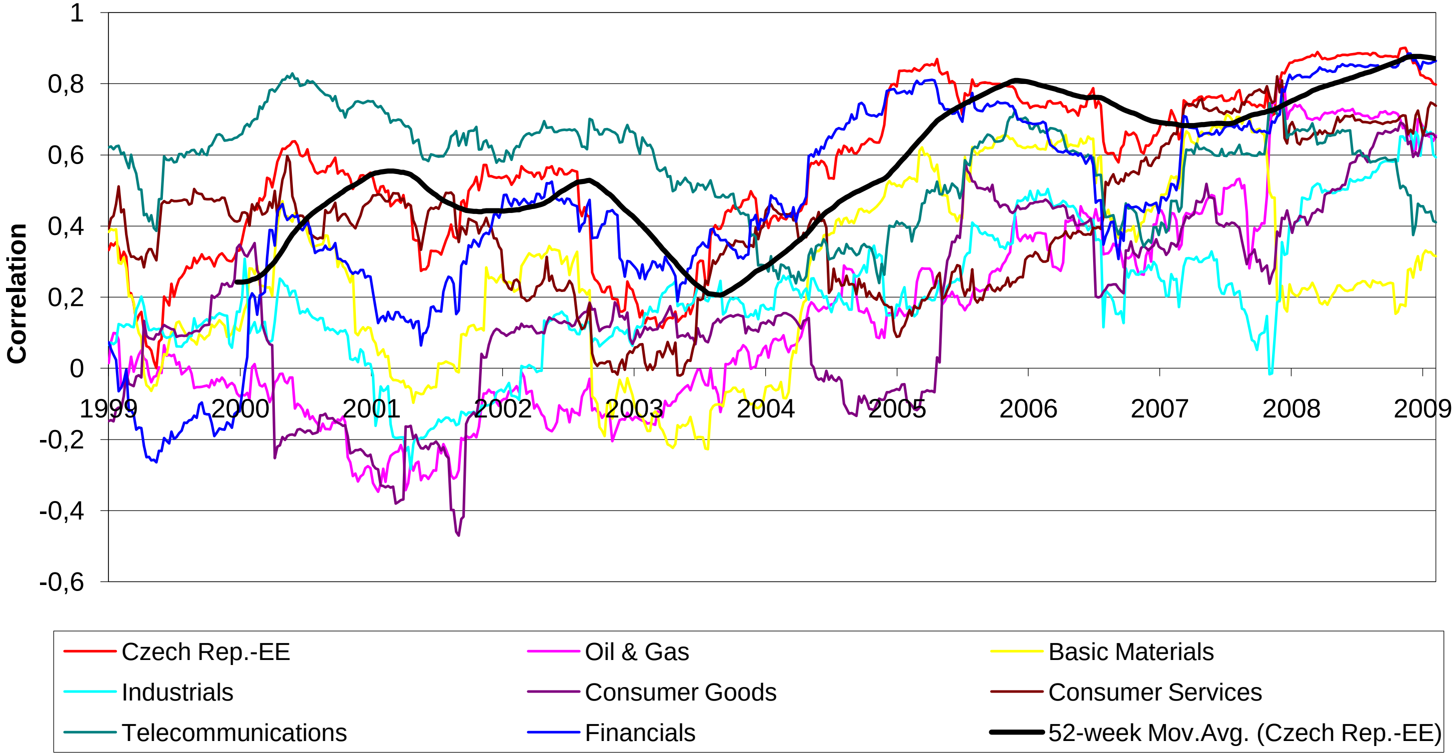


Figure 6. 52-week rolling correlation between Czech equity market and emerging Europe.



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