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INTERDEPENDENCE OF EMERGING EASTERN EUROPEAN STOCK MARKETS

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ABSTRACT

Elena Fedorova

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One of the main developments in the global economy during the past decades has been the growth of emerging economies. Projections for their long-term growth, changes in the investment climate, corporate transparency and demography point to an increasing role for these emerging economies in the global economy. Today, emerging economies are usually considered as financial markets offering opportunities for high returns, good risk diversification and improved return-to-risk ratios. However, researchers have noted that these advantages may be in decline because of the increasing market integration. Nevertheless, it is likely that certain financial markets and specific sectors will remain partially segmented and somewhat insulated from the global economy for the year to come.

This doctoral dissertation investigates several stock markets in Emerging Eastern Europe (EEE), including the ones in Russia, Poland, Hungary, the Czech Republic, Bulgaria and Slovenia. The objective is to analyze the returns and financial risks in these emerging markets from international investor's point of view. This study also examines the segmentation/integration of these financial markets and the possibilities to diversify and hedge financial risk.

The dissertation is divided into two parts. The first includes a review of the theoretical background for the articles and a review of the literature on EEE stock markets. It includes an overview of the methodology and research design applied in the analysis and a summary of articles from the second part of this dissertation and their main findings. The second part consists of four research publications.

This work contributes to studies on emerging stock markets in four ways. First, it adds to the body of research on the pricing of risk, providing new empirical evidence about partial stock market segmentation in EEE. The results suggest that the aggregate emerging market risk is a relevant driver for stock market returns and that this market risk can be used to price financial instruments and forecast their performance.

Second, it contributes to the empirical research on the integration of stock markets, asset prices and exchange rates by identifying the relationships between these markets through volatility and asset pricing. The results show that certain sectors of stock markets in EEE are not as integrated as others. For example, the Polish consumer goods sector, the Hungarian telecommunications sector, and the Czech financial sector are somewhat isolated from their counterparts elsewhere in Europe. Nevertheless, an analysis of the impact of EU accession in 2004 on stock markets suggests that most of the EEE markets are becoming increasingly integrated with the global markets.

Third, this thesis complements the scientific literature in the field of shock and volatility spillovers by examining the mechanism of spillover distribution among the EU and EEE countries. The results illustrate that spillovers in emerging markets are mostly from a foreign exchange to the stock markets. Moreover, the results show that the effects of external shocks on stock markets have increased after the enlargement of the EU in 2004.

Finally, this study is unique because it analyzes the effects of foreign macroeconomic news on geographically closely related countries. The results suggest that the effects of macroeconomic announcements on volatility are significant and have effect that varies across markets and their sectors. Moreover, the results show that the foreign macroeconomic news releases, somewhat surprisingly, have a greater effect on the EEE markets than the local macroeconomic news.

This dissertation has a number of implications for the industry and for practitioners. It analyses financial risk associated with investing in Emerging Eastern Europe. Investors may use this information to construct and optimize investment portfolios. Moreover, this dissertation provides insights for investors and portfolio managers considering asset allocation to protect value or obtain higher returns. The results have also implications for asset pricing and portfolio selection in light of macroeconomic news releases.

Keywords: Emerging Eastern Europe, Russia, CAPM, GMM, GARCH, stock markets, FX rates, volatility spillover, integration, inter- and intra-industry contagion, currency risk, asymmetry in volatility, leverage effect, macroeconomic announcements

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РЕЗЮМЕ

Елена Федорова

Взаимозависимость биржевых рынков развивающихся стран Восточной Европы

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Рассматривая мировую экономику за несколько последних десятилетий, необходимо отметить её глобальные изменения, а именно подъём развивающихся стран в мировой экономике. Прогнозы долгосрочного роста, изменения инвестиционного климата, корпоративной прозрачности и демографических изменений предвещают ещё более значимую роль развивающихся стран в мировой экономике.

На сегодняшний день страны с развивающейся экономикой часто рассматриваются в качестве привлекательных рынков для инвестиций, предоставляющие возможность диверсификации рисков и достижения более высоких показателей доходности. Однако, некоторые исследователи отмечают, что эти преимущества сокращаются в связи с устойчивым процессом интеграции рынков. Тем не менее, вероятнее всего некоторые финансовые рынки и их отдельные сектора будут частично сегментированными и в определённой степени изолированными в мировой экономике в последующих годах.

В данной докторской диссертации исследуются фондовые рынки развивающихся стран Восточной Европы, а именно Польши, Венгрии, Чешской Республики, Болгарии, Словении и России. Целью данной работы является анализ доходов и финансовых рисков фондовых рынков Восточной Европы с точки зрения международного инвестора. Помимо этого данное исследование изучает процесс сегментирования/интегрирования данных финансовых рынков и возможности хеджирования финансовых рисков.

Диссертация состоит из двух частей. Первая часть включает в себя теоретическую подготовку для изучения развивающихся стран Восточной Европы и обзор научной литературы в данной области. Также эта часть содержит описание исследовательских подходов и методологий, применяемых в данной работе, краткое содержание научных статей, а также их выводы и научный вклад. Вторая часть содержит четыре научные публикации, включённые в данную диссертацию.

Данная работа вносит научный вклад в исследование финансовых рынков развивающихся стран в четырёх направлениях. Во-первых, она дополняет

исследования финансовых рисков в данных странах путём выявления частичной сегментации фондовых рынков Восточной Европы. Результаты исследования показывают, что совокупный показатель биржевого рынка развивающихся стран является основополагающим показателем для определения цены финансового инструмента на рынках данных стран, а также для оценки стоимости и прогнозирования прибыльности акций.

Во-вторых, диссертация вносит вклад в изучение интеграции финансовых рынков и курса иностранных валют развивающихся стран Восточной Европы путем выявления взаимосвязей между этими рынками в волатильности и ценообразовании финансовых инструментов. Результаты исследования показывают, что сектора фондового рынка в развивающихся странах по-разному интегрированы в мировом экономическом сообществе. Так, например, польские потребительские товары, венгерские телекоммуникации и чешский финансовый сектор менее интегрированы с соответствующими секторами европейского рынка по сравнению с другими секторами биржевого рынка. Однако, результаты анализа последствий расширения ЕС в 2004 году и взаимосвязей между фондовыми рынками показывают, что развивающиеся страны Восточной Европы становятся более интегрированными с биржевыми рынками развитых стран.

В-третьих, данная диссертация дополняет научно-исследовательскую литературу в области внешних воздействий на финансовые рынки и на их волатильность, исследуя механизм их распространения среди развивающихся стран Восточной Европы и ЕС. Полученные результаты свидетельствуют о влиянии изменений курса национальных валют на фондовые рынки развивающихся стран. Кроме того, результаты исследования показывают, что масштаб влияния внешних факторов на фондовый рынок увеличился после расширения ЕС в 2004 году.

Наконец, данное исследование является уникальным, так как в нём изучается влияние макроэкономических новостей на биржевые рынки стран Восточной Европы. Результаты работы показывают, что макроэкономические новости значительно влияют на волатильность фондовых рынков, масштаб влияния которого варьируется в зависимости от сектора экономики. Помимо этого интересным результатом исследования является выявление того, что иностранные макроэкономические новости в большей степени влияют на рынки Восточной Европы, чем местные макроэкономические новости.

Данная диссертация может быть применена в различных областях экономики и различными специалистами. Она анализирует риски инвестирования в развивающиеся биржевые рынки Восточной Европы. Инвесторы и финансовые менеджеры могут использовать результаты данного исследования для формирования и оптимизирования инвестиционных портфелей. Помимо этого, данная работа предоставляет полезную информацию для инвесторов, рассматривающих перераспределение своих инвестиций для хеджирования финансовых рисков и получения более высоких доходов. Результаты диссертации, также, могут быть использованы для определения цены финансовых инструментов и формирования инвестиционных портфелей в период объявления макроэкономических показателей.

Ключевые слова: развивающиеся страны Восточной Европы, Россия, модель ценообразования активов (CAPM), обобщенный метод моментов (GMM), авторегрессионная условная гетероскедастичность (GARCH), фондовые биржи, курс иностранных валют, волатильность распространения, интеграция, меж- и внутриотраслевое влияние, валютный риск, ассиметрия волатильности, эффект левериджа, макроэкономические новости

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TIIVISTELMÄ

Elena Fedorova

Kehittyvien Itä-Euroopan maiden osakemarkkinoiden keskinäinen riippuvuus

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Kehittyvien talouksien kasvu on ollut yksi merkittävimmistä kehityssuunnista maailmantaloudessa viimeisten vuosikymmenien aikana. Pitkän aikavälin talouskasvun ennusteet, investointi-ilmapiirin muutokset, yritysten avoimuuden lisääntyminen sekä suotuisa demografinen kehitys ennustavat näille maille yhä suurempaa roolia globaalissa taloudessa. Kehittyvät taloudet ovatkin tarjonneet sijoittajille mahdollisuuden hyviin tuottoihin, riskin hajauttamiseen sekä hyvään tuotto-riskisuhteeseen. Toisaalta tutkijoiden mielestä nämä edut voivat olla katoamassa markkinoiden integraationa lisääntyessä. Jatkossakin tulee silti olemaan rahoitusmarkkinoita, jotka ovat osittain segmentoituneet ja hieman erillään maailmantaloudesta.

Tässä väitöskirjassa tutkitaan osakemarkkinoita kehittyvissä Itä-Euroopan maissa: Venäjä, Puola, Unkari, Tšekin tasavalta, Bulgaria sekä Slovenia. Tavoitteena on tutkia kyseisten maiden tarjoamia sijoitustuottoja ja -riskejä kansainvälisen sijoittajan näkökulmasta. Lisäksi tässä väitöskirjassa tutkitaan näiden maiden osakemarkkinoiden segmentoitumista ja integraatiota kansainvallisiin markkinoihin sekä mahdollisuuksia taloudellisten riskien hajauttamiseen.

Väitöskirja jakautuu kahteen osaan. Väitöskirjan ensimmäinen osa sisältää teoreettisen viitekehyksen aiempiin tutkimuksiin pohjautuen, tutkimuskirjallisuuskatsauksen kehittyvistä Itä-Euroopan osakemarkkinoista, metodologiakuvauksen sekä tutkimussuunnitelman. Ensimmäisessä osassa on myös yhteenveto varsinaisista esseistä sekä niiden tuloksista ja tieteellisestä kontribuutiosta. Toinen osa sisältää väitöskirjakokonaisuuden neljä julkaisua.

Väitöskirja kontribuoi alan tieteelliseen kirjallisuuteen ainakin neljällä tavalla. Ensinnäkin työ edistää empiiristä tutkimusta Itä-Euroopan osakemarkkinoilla. Keskeisenä mielenkiinnon kohteena on eri riskitekijöiden hinnoittelu ja vaikutus markkinoilla. Lisäksi työ tuo esiin uusia todisteita osakemarkkinoiden osittaisesta segmentoitumisesta. Tutkimus osoittaa, että yleinen kehittyvien markkinoiden riski on merkittävä tekijä osakemarkkinoiden tuotoille ja sitä voidaan käyttää hinnoittelussa sekä ennustettaessa tulevia tuottoja näissä maissa.

Toiseksi tutkimus osoittaa, että osake- ja rahoitusmarkkinat kehittyvissä Itä-Euroopan maissa vaikuttavat toisiinsa. Osakemarkkinat ovat tämän työn mukaan osittain segmentoituneet, mutta eri teollisuuden aloissa ja eri maissa on eroja segmentaation suhteen. Yleisesti ottaen markkinoiden integraatio on tulosten mukaan kasvanut EU:hun vuonna 2004 liittymisen jälkeen.

Kolmanneksi työ täydentää tutkimuskirjallisuutta analysoimalla shokkien ja volatiliteetin leviämisen mekanismia kehittyvien Itä-Euroopan-maiden sekä EU:n valuutta- ja osakemarkkinoiden välillä. Aiempien tutkimusten mukaan tämän tutkimuksen tulokset tukevat käsitystä, että valuuttamarkkinoilta on heijastusvaikutuksia osakemarkkinoille. Lisäksi tutkimustulokset osoittavat, että heijastusvaikutukset ovat kasvaneet EU:hun vuonna 2004 liittymisen jälkeen.

Neljänneksi tämä tutkimus on yksi ensimmäisestä, joka analysoi uutisten vaikutusta Itä-Euroopan markkinoilla. Uuden informaation vaikutus osakemarkkinoiden volatiliteettiin on ilmeinen ja vaikutus eroaa eri markkinoilla ja eri sektoreilla. Hieman yllättäen tulosten mukaan Itä-Euroopan markkinoilla ulkomaanuutiset ovat tärkeämpiä kuin paikalliset uutiset.

Tässä väitöskirjassa tarkastellaan Itä-Eurooppaan kohdistuvien sijoitusten riskejä sekä tuottoja. Väitöskirjan tulokset ovat hyödyllisiä esimerkiksi sijoittajille ja salkunhoitajille, jotka voivat tulosten avulla miettiä sijoitussalkkujen suojausta ja mahdollisuuksia saada suurempaa tuottoa. Lisäksi tulokset hyödyttävät kansainvälisten rahoituslaitosten ja salkunhoitajien työtä heidän arvioidessaan investointipäätöksiä makrotalouden uutistiedotteiden valossa.

Avainsanat: kehittyvä Itä-Eurooppa, Venäjä, CAPM, GMM, GARCH, osakemarkkinat, valuuttakurssit, volatiliteetin heijastusvaikutus, integraatio, riskien leviäminen toimialoittain, valuuttariski, epäsymmetrinen volatiliteetti, vipuvaikutus, makrotaloudelliset uutiset

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LIST OF PUBLICATIONS

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2. Fedorova, Elena and Kashif 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.

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The contribution of Elena Fedorova to the publications:

1. Prepared research plan together with the co-author. Collected the data. Analyzed the data together with the co-author. Wrote most of the manuscript with the help of co-author.
2. Prepared research plan together with the co-author. Collected the data. Analyzed the data with the help of co-author. Wrote most of the manuscript with the help of co-author.
3. Solely written by the present author.
4. Solely written by the present author.

PART I: OVERVIEW OF THE DISSERTATION

1 INTRODUCTION

1.1 Background and motivation

An important dynamic in the global economy in recent decades has been the rise of emerging economies. Projections for their long-term growth, changes in the investment climate, corporate transparency, and demography point to an ever-increasing role for these emerging economies in the global economy.

The turmoil of the recent global economic crisis revealed emerging markets to be surprisingly resilient to shocks. This unexpected development captured the attention of the international investment community, who began to see emerging economies as opportunities for investment, risk diversification and high return-to-risk ratios. However, many researchers point out that these advantages may be temporary because of the constant process of market integration, which ultimately denies investors the opportunity to diversify risk by minimizing the effects of global economic shocks. Nevertheless, it is likely that certain sectors will remain at least partially segmented and somewhat insulated from the global economy.

Many analysts consider the 2008 financial crisis to be the most serious financial crisis for the world economy since the Great Depression of the 1930s. Despite the lessons that the Great Depression taught us about the dangers of financial contagion and the prolonged depths of financial desperation caused by over-leveraged borrowing and lapses in financial prudence and oversight, the financial crisis that culminated in 2008 resulted from a liquidity shortfall in the US banking system caused by overvalued assets that were securitized and insured before being traded on international markets. In a sort of musical chairs of default, the meltdown spread quickly to European financial markets, causing a number of spectacular bankruptcies and corporate. However, financial systems that were less integrated into the global financial system, such as those of India and Brazil, escaped the brunt of the shock and emerged from the crisis largely unscathed.

When Greece's debt problems emerged in 2010, EU policymakers were already fully aware that financial problems in one country could undermine confidence generally and set off a wider financial crisis resulting from the interconnectedness of markets and investment. Designing measures to contain the damage of future financial crises is grounded in a thorough acceptance and understanding of the interconnections among European countries.

Emerging Eastern European (EEE) stock markets have attracted the interest of international financial researchers and policymakers over the past decade; these markets also attracted international investors because of their relatively high market capitalizations and opportunities for diversification. They have become more attractive and accessible for investment as a result of decreasing transactional restrictions, ongoing reform efforts and increasing financial transparency.

EU enlargement has created a unique landscape for financial research. Ease of foreign investment and the growth of world trade have exposed EEE to external shocks from global and regional financial markets. Thus, EEE stock markets provide a natural laboratory to view integration with other European markets and a chance to see whether they maintain control over their own development and whether they parry economic shocks better than Europe's more integrated financial markets. The possibility of moving capital to safe havens in the midst of widespread financial instability has obvious implications for portfolio managers and their risk diversification strategies.

This doctoral dissertation investigates several stock markets in EEE, including those in Russia, Poland, Hungary, the Czech Republic, Bulgaria and Slovenia. While all of these countries have made the transition from communist to capitalist systems, their individual paths to economic and political development have diverged at several junctures. Poland, Hungary, the Czech Republic and Slovenia joined the EU in May 2004; Bulgaria joined the EU in January 2007, and Russia has never even entertained the notion of EU membership. Slovenia is the only of these countries to have adopted the euro (in January 2007); the remaining countries have retained their own currencies. The sample countries were chosen because their stock markets have relatively high capitalizations. Moreover, these markets are fairly dynamic – all having experienced major economic reforms in the past two decades – and are more open and liquid than the other stock markets in Eastern Europe. Their growth has outstripped that of other markets in EEE, making them leaders in the region by inference. These countries are particularly interesting from a research perspective because their financial markets have become readily accessible to international investors as a result of greater financial transparency and reduced restrictions on foreign investment.

The objective of this dissertation is to gather information about the development of these stock markets and to identify opportunities and financial risks associated with investment in these emerging economies. This study also examines the segmentation/integration of financial markets and describes possible ways of diversifying financial risk and hedging investments to protect them from the effects of global contagion.

1.2 Previous research

International investors and researchers are drawn to emerging markets because of their rapid economic development, high returns, opportunities for diversification, and their progress in capital market reforms. The major challenges for researchers are devising ways to price risk, distinguishing global from local sources of risk in these markets, defining the extent of interdependence and risk transfers among emerging markets, and evaluating the effect of macroeconomic news on asset pricing.

The initial challenge to investing in an emerging market is to assess global and local sources of risk. Several empirical studies find market segmentation is typically greater in emerging markets than in developed markets, suggesting that local sources of risk are more important than international sources (e.g., Korajczyk, 1995; Shackman, 2005). However, the role for global sources of risk rises and the role for local sources of risk diminishes (Bekaert and Harvey, 1995).

The more recent literature remains mixed on the subject of financial integration. Tai (2007b) and de Jong and de Roon (2005) claim that markets become more integrated after equity market liberalization. However, Brooks and Del Negro (2002) find that Europe has become more integrated but that segmentation has increased elsewhere.

Other researchers see no evidence of increased integration over time (e.g., King and Segal, 2008). Most papers on currency risk in emerging markets conclude that this type of risk is priced into local stock markets (e.g., De Santis and Imrohoroglu, 1997; Tai, 2007b). However, the role of currency risk remains controversial. Several papers assume that investors can hedge country-specific currency risk and that multilateral currency risk is influential in explaining the behavior of average returns (e.g., Doukas et al., 1999). On the other hand, some researchers find evidence that supports the pricing of bilateral currency risk (see e.g., Antell and Vaihekoski, 2007).

A second challenge in examing of investing risks in emerging countries is defining linkages between the financial markets of emerging countries and extent of their interdependence. While the interdependence of equity markets has been extensively investigated, most studies have been limited to volatility spillovers in developed financial markets (e.g., Hamao et al., 1990; Theodossiou and Lee, 1993; Lin et al., 1994; Susmel and Engle, 1994; Karolyi, 1995).

A handful of studies, exploring emerging markets linkages are mainly focused on Asian, South American and Central European stock markets (e.g., Worthington et al., 2000; Kasch-Haroutounian and Price, 2001; Sola et al., 2002; Li, 2007).

The examination of Eastern European and Russian market linkages is limited. Of the rare studies that explore the linkages of these markets in terms of volatility and return, the works of Li and Majerowska (2008) and Scheicher (2001) study the linkages between the Czech Republic, Poland and Hungary.

Similarly, the literature on the linkages between equity and currency markets has primarily addressed the dynamics of these markets in developed economies (e.g., Yang and Doong, 2004; Francis et al., 2006; Dark et al., 2008). Those that do consider emerging economies tend to be inconclusive (e.g., Morales, 2008; Tai, 2007a; Yang and Chang, 2008). In particular, studies covering EEE and Russia are scarce.

The third challenge for investors, which is discussed in the dissertation, involves assessing risk transfer and contagion between the financial markets in emerging countries. Researchers remain divided over risk transmission mechanisms in stock markets. The most common view is that the country-risk effect dominates the sectoral-risk effect (e.g., Steliaros and Thomas, 2006; Kaltenhaeuser, 2003), but there is a strong minority that understands sectoral heterogeneity as an important determinant of contagion propagation (e.g., Phylaktis and Xia, 2009).

As a rule, studies of investment-risk transfer have focused on developed stock markets (e.g., Qiao, Liew and Wong, 2007; Malik and Hassan, 2004). Most of papers conclude strong interdependence, intradependence and event contagion among the stock markets (e.g., Cummins, Wei and Xie, 2007; Prokopczuk, 2010; Brewer and Jackson, 2002; Tawatnuntachai and D'Mello, 2009), which decrease during periods of crisis (e.g., Johnson, 2010). Moreover, stock market sectors have different extent of interdependence and integration (e.g., Pais and Stork, 2011; Kaltenhaeuser, 2002; Qiao, Liew and Wong, 2007). Each sector on the stock market participates in a volatility transmission mechanism, which supports the practices of information sharing 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).

Risk and portfolio managers choosing asset management strategies must decide how to diversify their currency and liquidity risks, in addition to deciding about the regional and sectoral allocation of their assets. One of the common points of view is that the industry-decomposition method of portfolio management is superior to the geographic-decomposition method (e.g., Ferreira and Gama, 2005; Black, Buckland and Fraser, 2002). The industry factors account for approximately one-third of the total systemic variance in stock returns (e.g., Heston and Rouwenhorst's, 1994 and 1995; Catão and Timmerman, 2003.) However, there are certern research findings saying that sectoral volatility predominantly determines stock market volatility overall (e.g., Morana and Sawkins, 2004).

In contrast, risk transfer in emerging markets has largely evaded analysis. Lee, Lin and Liu (1999) is one of studies on emerging markets demonstrating that emerging stock markets absorb shocks quickly and efficiently (research on Asian stock markets). Sarkar, Charkrabarti and Sen (2009) found to be the sectors that predominantly contribute to stock market volatility. However, Lin at al. (2004) observe that systemic risk and stock returns have a significantly positive relationship. Moreover, the financial industries are independent from other sectors (e.g., Wang, 2007). Hammoudeh, Yuan and McAleer (2009) point to an increased dominance of stock market volatility relative to past shocks in their study.

The final challenge to investing in EEE discussed here is the effect of macroeconomic announcements on stock markets. Even with the widely studied linkages between macroeconomic announcements and stock markets, researchers still disagree sharply over the effects of macroeconomic news on the financial markets. The stock market reactions depend on the source of the macroeconomic release (e.g., Entorf, Gross and Steiner, 2012), the type of release (Albuquerque and Vega, 2009) and whether the the release is positive or negative (Kim, McKenzie and Faff, 2004). Usually shocks from negative news generate more volatility in the market than shocks from positive news (a leverage effect) (De Goeij and Marquering, 2006).However, stock returns are most sensitive to releases of unexpected positive news (Brenner, Pasquariello and Subrahmanyam, 2009). For example, certain positive news, such as policy announcements, is found to affect stock market volatility more than negative news (Bomfim, 2001). Moreover, certain types of negative news released during boom periods, such as negative news about GDP growth or unemployment, can positively affect stock prices (a perverse effect) (e.g, Boyd, Hu and Jagannathan, 2005; Funke and Matsuda, 2006). Also the assert that the impact of macroeconomic news on the volatility of stocks is observed only in the presence of simultaneous news releases by multiple sources was published in Entorf, Gross and Steiner (2012).

The empirical literature distinguishes two types of news effects – news releases and surprises of news releases (Rangel, 2011). The impact of scheduled macroeconomic announcements depends on the extent to which they defy market expectations (announcement effect), while an unexpected macroeconomic announcement has an impact precisely because it was unexpected (surprise effect). A scheduled but unexpected announcement (say, a three-tenths of a percent departure from the forecasted GDP growth rate or a few pennies difference in a corporate dividend) tends to have a smaller impact than an unexpected surprise, which is usually more informative and significant for the market than a scheduled announcement (Kim, McKenzie and Faff, 2004). The day is published also has little impact on conditional market volatility (Rangel, 2011). All of these characteristics are evident in the US stock market, where the media ritualize data releases such as unemployment figures, inflation data and transcripts of Federal Reserve meetings. In contrast, European markets typically only show the surprise effect (Jiang, Konstantinidi and Skiadopoulos, 2012). Flannery and Protopapadakis (2002) conclude that the investor response (volatility) is more likely tied to the content of the macroeconomic announcements themselves than it is to the timing of the announcement (i.e., the scheduled announcement day).

The recent financial crisis and its accompanying contagion effects prompted a flurry of studies on the effects of macroeconomic news releases on stock markets. An area of particular interest has been the search for markets that are isolated, or at least insulated, from global turmoil. The Eastern European markets have thus become candidates for study in this regard. For example, Hanousek, Kočenda and Kutan (2009) study the reactions of the Polish, Hungarian and Czech stock markets to US, EU and local macroeconomic news (the type of news is not distinguished), finding that local announcements are the most determinative of asset pricing in Emerging Eastern European countries. However, foreign news is more important for local markets when the local news is released before the start of the working day. Hanousek and Kočenda (2011) study the impact of different types of macroeconomic releases on local markets, including the possibility of day-of-the-week effects. They find that the volatility effect on local markets tends to decrease as the business week proceeds.

The study by Rockinger and Urga (2001) on Eastern European stock markets investigates the foreign news effect on local markets, utilizing news releases from the US, the UK, and Germany. They report that the UK is the most influential market for Eastern European countries in terms of price and volatility spillovers. Interestingly, the Hungarian stock market has a rather low level of predictability because negative news generates less volatility than positive news. Moreover, the Russian market shows a particular convergence with efficient markets and a sensitivity to US shocks. Similar evidence of the integration of the Russian market with global markets is provided by Hayo and Kutan (2005), who further note that the Russian market became less integrated with developed countries after financial crisis of 1998 and no evidence of local news impact on stock market volatility. Büttner, Hayo and Neuenkirch (2012) study Emerging Eastern European (EEE) stock markets and the importance of US and EU macroeconomic news. They claim that the significance of EU news has increased over the last decade.

Despite the fact that the impact of macroeconomic news on Eastern European stock markets has been investigated, the empirical literature lacks evidence about the effect of macroeconomic news released in geographically proximate and otherwise closely related countries.

1.3 Hypothesis and research questions

International investors and researchers are interested in Emerging Eastern European markets (such as markets of Poland, Hungary, the Czech Republic, Bulgarian, Slovenia and Russia) because of their dynamism, their successful implementation of major economic reforms, their greater openness and their liquidity relative to other markets in Eastern Europe. In addition to growth opportunities, these stock markets may provide shelter from international shocks that spread throughout developed markets. From a research perspective, the interest relates to the evolving ease of access to these financial markets for international investors, in addition to the greater transparency and reduced restrictions on foreign investments. However, there are challenges and disagreements about pricing of risks over the existence of linkages and spillovers between financial markets, as well as the effect of macroeconomic announcements on Emerging Eastern European stock markets. The main purpose of the current thesis, therefore, is to investigate the financial risks of investing in Emerging Eastern European countries.

The following three basic hypotheses are tested in the study:

1. Stock markets in Emerging Eastern Europe are interdependent.
2. The interdependence of stock markets in Emerging Eastern Europe has increased, particularly since the 2004 EU enlargement.
3. Macroeconomic factors improve the price measurement of assets in Emerging Eastern European countries.

Eight questions are formulated to facilitate the analysis of various aspects of these markets that are relevant to these hypotheses. The first concerns the fundamental challenge for researchers of devising ways to price risk and distinguish the role of global and local sources of risk in emerging countries. Several empirical studies find that market segmentation is typically greater in emerging markets than in developed markets, suggesting that local sources of risk are more important than international sources (e.g., Korajczyk, 1995; Shackman, 2005). On the other hand, the role for global sources of risk rises and the role for local risk sources diminishes (e.g., Bekaert and Harvey, 1995). In any case, the role of currency risk remains controversial. Several papers assume that investors can hedge country-specific currency risk and that multilateral currency risk is a significant component in explaining the behavior of average returns (e.g., Doukas et al., 1999). Other papers have found support for the pricing of bilateral currency risk (e.g., Antell and Vaihekoski, 2007). Thus, the first question in Article 1 is the following:

Q1: Are global and local sources of risk priced into the stock markets of Emerging Eastern European countries?

The second question is a logical extension to answering the first, and it concerns the integration of financial markets in Eastern Europe. The interdependence between different equity markets has been investigated extensively. However, studies of linkages among financial markets tend to focus primarily on price and volatility spillovers within developed financial markets (e.g., Hamao et al., 1990; Theodossiou and Lee, 1993; Lin et al., 1994; Susmel and Engle, 1994; Karolyi, 1995). Among the studies exploring the relationships in emerging markets, Worthington et al. (2000) look at price linkages in Asian equity markets, Kasch-Haroutounian and Price (2001) examine Central Europe, and Sola et al. (2002) analyze volatility links between the stock markets of Thailand, South Korea and Brazil.

A few studies explore EEE markets in terms of volatility and return linkages. These include the studies of Li and Majerowska (2008) and Scheicher (2001), who study the linkages between the Czech Republic, Poland and Hungary, and Saleem (2009), who investigates the international linkages of the Russian market. This raises the following research question that is addressed in Article 2:

Q2: Are Emerging Eastern European markets integrated, and, if so, to what extent?

The third question follows from the second, which concludes that Emerging Eastern Europe stock and currency markets are partially integrated. This question concerns risk transmission and contagion effects in Emerging Eastern European stock markets at the sectoral level and is raised as researchers are divided about the risk transmission mechanism in emerging stock markets; it represents one of the fundamental aspects of the focus of this paper.

Moreover, 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. Certain industries appear to be predominant causes of stock market volatility and contribute significantly to stock market volatility. Lin, Penm, Wu and Chiu (2004) observe that systemic risk and stock returns have a significantly positive relationship in China, Taiwan and Hong Kong. However, as a rule, financial industries are independent of other sectors (e.g., Wang, 2007). Therefore, the following are the four questions studied in Article 3:

Q3: Are Emerging Eastern European stock markets involved in transferring financial risk to EU members?

If so, in contradistinction to the familiar rule that only developed markets define volatility, the fourth question is posed:

Q4: Which sectors of these stock markets play such a role?

The following two questions continue the discussion of contagion effects:

Q5: Are there certain stock markets sectors, which are partially isolated from the corresponding sectors of other European stock markets manifested in terms of stock returns and stock price volatility?

Q6: Was there a significant change in market interactions after the 2004 EU accessions of Poland, Hungary and the Czech Republic?

Building on these findings, the analysis turns to event contagions. Most financial analysts concede that markets react to a certain extent to macroeconomic news. The character of the market reaction depends on factors such as the level of development of the national economy, the type of financial market, the content of the news, and whether the news is truly unexpected or surprising.

Despite the fact that the impact of macroeconomic news on Eastern European stock markets has been investigated, the empirical literature is devoid of evidence concerning the effect of macroeconomic news released in closely related countries in the same geographical area. Therefore, the following two questions are posed in Article 4:

Q7: Do macroeconomic announcements affect the pricing of stocks, and, if so, what differences in the announcements make the stock market reaction vary?

Q8: Does foreign news from geographically proximate and otherwise closely related countries affect local stock markets?

This dissertation considers the financial risks in investing in Emerging Eastern European stock markets and hopefully yields some useful insights for investors and portfolio managers who are rethinking the allocation of their investment portfolios to protect value or obtain higher returns.

1.4 Structure of the dissertation

This dissertation is divided into two parts. The first includes a review of the theoretical background for the articles and a review of the literature on Emerging Eastern European stock markets. It includes an overview of the methodology and research design applied in the analysis and a summary of articles and their findings. The second part consists of four research publications.

2 THEORETICAL BACKGROUND AND RESEARCH DESIGN

2.1 Asset pricing theory

Asset pricing theory describes the methodologies involved in the evaluation and pricing of an asset. Asset pricing theory originates from the simple concept that the expected price is calculated as the expected discounted payoff. Other calculations of asset prices are special cases and applications of the central equation.

There are two approaches to asset pricing in the financial literature (Cochrane, 2005). The first, commonly used by academics, is *absolute pricing*, where the price of each asset is measured at a given level of risk and its future profit. The capital asset pricing model (CAPM) embodies this absolute pricing approach.

The second approach is *relative pricing*, which relies on pricing related assets and their associated risk factors to define asset price. This approach is limited because it overlooks many market characteristics. However, it provides a precision of calculation in many applications. The Black-Scholes option pricing model is a good example of this relative pricing approach.

This dissertation examines the risks of investing in Emerging Eastern Europe by applying the absolute approach of asset pricing theory. In particularly, the price for an asset is assumed to be:

$$P_t = E_t(\mu_{t+1} d_{t+1}), \quad (1)$$

where P_t is an asset price at time t, μ_{t+1} is a function of stochastic discount and risk factors and d_{t+1} is an expected asset payoff in $t+1$ period.

The interdependence of stock markets in Emerging Eastern Europe can be characterized as full integration or partial segmentation. Under full integration, the expected returns on assets should be the same after adjusting for their risk characteristics. A stock market is considered integrated when the state and the exchange impose no restrictions on the securities transactions of local or foreign investors seeking to diversify their investment portfolios in international capital markets. With financial market integration, it is assumed that assets in all national markets have the same set of risk factors and therefore the same risk premium for each factor (although not the same risk sensitivity).

Adler and Dumas (1983) note that the global value-weighted market portfolio is the relevant risk factor. If investors do not hedge against exchange-rate risks and a risk-free asset exists, the conditional version of the world CAPM implies the following restriction for nominal excess returns:

(2) $$E_t\left[r_{i,t+1}\right] = \beta_{i,t+1} E_t\left[r_{m,t+1}\right],$$

(3) $$\beta_{i,t+1} = \frac{Cov\left[r_{i,t+1}, r_{m,t+1}\right]}{Var\left[r_{m,t+1}\right]},$$

where $E_t[r_{i,t+1}]$ and $E_t[r_{m,t+1}]$ are the conditional expected excess returns on asset *i* and the global market portfolio, also known as market risk premium at time $t+1$. All returns are measured in excess of the risk-free rate of return r_{ft} for the period *t* to *t*+1 in the numeraire currency.

The empirical tests for this model are focused on implications of the zero intercept, the perfect beta capture of the cross-sectional variation of expected excess returns, and the positive-signed market risk premium. Currency risk is not priced; investors diversify out of it as they do with idiosyncratic company risk. This model also holds for the local market portfolio because the local market portfolio is tradable.

However, where the risk-free rate is unobservable, Black (1972) suggests a more general version of an absolute pricing model (Black-version CAPM), where the expected excess return of asset *i* and the global market portfolio can be used in excess of the zero-beta portfolio associated with *m*. This portfolio is assumed to have a minimum variance of all portfolios not correlated with *m*.

While the basic world CAPM may be used to obtain the expected excess returns of a fully integrated stock market, real-world markets are typically not fully integrated into the world equity market. Therefore, Errunza and Losq (1985) show that one has to include a local risk factor for partially (mildly) segmented markets. Thus, for any asset *i,* the excess return can be given as:

(4) $$E_t\left[r_{i,t+1}\right] = \beta^g_{i,t+1} E_t\left[r_{gm,t+1}\right] + \beta^l_{i,t+1} E_t\left[r_{lm,t+1}\right],$$

where *g* and *l* refer to the global and local market portfolios and betas, respectively.

However, investment in a foreign country must be considered as a combination of investment in the asset itself and development of the foreign currency relative to the currency in which the investor holds capital. In the absence of purchasing power parity, real returns are treated differently because investors seek to hedge an exchange rate risk (Adler and Dumas, 1983). Thus, the conditional asset pricing model for partially segmented markets implies the following restriction for the expected return of asset *i* in the numeraire currency (e.g., De Santis and Gérard, 1998):

(5) $$E_t\left[r_{i,t+1}\right] = \beta^g_{i,t+1} E_t\left[r_{gm,t+1}\right] + \beta^l_{i,t+1} E_t\left[r_{lm,t+1}\right] + \sum_{c=1}^{C} \beta^c_{i,t+1} E_t\left[r_{c,t+1}\right],$$

where $\beta_{c,t+1}$ is the conditional currency beta for currency *c*.

Note that this model becomes intractable when many currencies are examined simultaneously (i.e., when *C* is large). This model is therefore practical only in studying a subset of currencies. Following Ferson and Harvey (1998) and Harvey (1995b) regarding the use of a single aggregate exchange risk factor, Equation (5) may be reduced to the following three-factor model:

(6) $$E_t\left[r_{i,t+1}\right] = \beta^g_{i,t+1} E_t\left[r_{gm,t+1}\right] + \beta^l_{i,t+1} E_t\left[r_{lm,t+1}\right] + \beta^c_{i,t+1} E_t\left[r_{c,t+1}\right],$$

where $\beta_{c,t+1}$ is the conditional currency beta for a particular currency that is the official currency of trade for country *c*.

Discrete and continuous stochastic and multi-dimensional processes are frequently used in testing asset pricing models. Random walk, autoregressive and ARCH processes, for example, are commonly applied discrete stochastic processes in the finance field. In continuous stochastic processes such as Brownian motion, diffusion, Itô and jump processes, stochastic integrals and Itô Lemma are not avoided as methodological methods for studying the prices of assets. If market shocks in the model are continuous, then the model settings are considered to be framed by multi-dimensional Brownian motion and diffusion processes.

2.2 Methodological approaches

2.2.1 Generalized Method of Moments

Robust asset pricing models may be estimated using a generalized method of moments (GMM) for pricing global and local sources of risks (Article 1). The GMM was first introduced by Hansen (1982) for the estimation and testing of a wide range of econometric models and may be interpreted as an extension of a linear IV regression. It has since been used for a wide range of econometric applications.

The GMM approach is currently in wide use in parameter estimation and hypothesis testing of time-varying parameter CAPM. Three advantages of the GMM approach are worth noting: it does not rely on the assumption of normally distributed asset returns, the distribution of returns can be both serially dependent and conditionally heteroscedastic, and a robust covariance matrix of the estimators can be obtained (Campbell et al., 1999). These advantages of GMM are particularly beneficial in studies using returns from emerging markets because they are often found to be non-normally distributed with serial correlation (e.g., Harvey, 1995b).

The asset pricing model implies the following error terms for asset i, $\varepsilon_{it} = r_{it} - \alpha_i - \boldsymbol{F}_t\boldsymbol{\beta}_i$, where r_{it} is the realized excess return, α_i is the pricing error, $\boldsymbol{F}_t$ is a $1 \times K$ vector of excess risk factor returns, and $\boldsymbol{\beta}_i$ is a $K \times 1$ vector of risk sensitivities (betas). The asset pricing model implies that pricing errors (ε_{it}) are zero when the model holds and the risk factors used are multifactor-efficient. The model is fully identified because the number of orthogonality conditions and parameters are the same.

2.2.2 Generalized Autoregressive Conditional Heteroscedasticity models

2.2.2.1 Overview of GARCH models

Another issue is the choice of the model when dealing with emerging economies. The most common methodologies applied by researchers to study the volatility spillover effect are based on VAR analysis (e.g., Syriopoulos, 2007; Lucey and Voronkova, 2006). The Autoregressive Conditional Heteroscedasticity (ARCH) process proposed by Engle (1982) and the generalized ARCH (GARCH) proposed by Bollerslev (1986) have also been applied extensively to model volatility.

However, the standard GARCH (*p,q*) has several drawbacks that have resulted in the development of many extensions to this model. One disadvantage is that the non-negativity conditions of the model must be violated by placing artificial constraints on the coefficients. GARCH models are also not capable of capturing leverage effects in volatilities and equity returns. Finally, GARCH models do not consider direct iterations between the conditional mean and the conditional variance.

Several of the disadvantages associated with GARCH (i.e., weakness in modeling the asymmetric responses of volatility to positive and negative shocks and the need for artificial non-negativity constraints) may be overcome with the Exponential Generalized Autoregressive Conditional Heteroscedasticity (EGARCH) model proposed by Nelson (1991). The univariate EGARCH stands out among the methods for studying the impact of macroeconomic announcements on stocks and is widely used for estimating the volatility of financial markets. The EGARCH method uses logged conditional variance, implying that conditional variance remains positive and does not require artificial imposition of non-negativity constraints on the model parameters, even if the parameters have negative signs. Moreover, the EGARCH model allows asymmetries in volatilities in which the relationship between volatility and returns is negative.

However, in examining the linkages in volatility between two markets or assets, a multivariate GARCH approach is preferred over univariate settings. The BEKK parameterization proposed by Engle and Kroner (1995) provides a sufficient framework for checking the volatility linkage between a group of markets or assets. It also ensures positive definitiveness of the conditional variance-covariance matrix, which early models fail to guarantee, such as Bollerslev et al. (1988). The BEKK model complies with the hypothesis of constant correlation and allows for volatility spillover across markets.

2.2.2.2 A univariate representation

Nelson (1991) has proposed an exponential GARCH in order to overcome weaknesses of the general GARCH. In particular, he allows an asymmetric effect in volatilities from the positive and negative shocks of a financial series, including weighted innovation. A possible specification of the EGARCH (1,1) model, for example, could be:

(7) $$r_{i,t} = \mu_i + \varepsilon_{i,t},$$

(8) $$\varepsilon_{i,t} = \sigma_{i,t} z_{i,t},$$

(9) $$z_{i,t} \left| \Omega_{t-1} \sim \psi(0,1,\upsilon), \right.$$

(10) $$\ln(\sigma_{i,t}^2) = c_i + \alpha_i \frac{|\varepsilon_{i,t-1}|}{\sigma_{i,t-1}} + \gamma_i \frac{\varepsilon_{i,t-1}}{\sigma_{i,t-1}} + \beta_i \ln(\sigma_{i,t-1}^2),$$

where $r_{i,t}$ is a return on stock market index i at time t, μ_i is a constant (mean return) and $\sigma_{i,t}^2$ is a conditional variance. The standardized residuals, $z_{i,t}$, are from the set of information available in the previous period and $\psi(.)$ is a conditional density function with v being a vector of parameters, specifying the probability distribution. The variance equation is a function of four parameters, where c_i is a constant term, the estimated parameter α_i is a symmetric effect of the model, γ_i is a parameter showing whether the model has an asymmetric effect, and β_i is a parameter that measures the persistence in conditional volatility.

The presence of leverage effects in the model can be tested by the hypothesis that parameter γ_i is less than 0. In such a case, positive shocks in the market generate less volatility than negative shocks. In the case where γ_i is greater than 0, positive news destabilizes market volatility more than negative news. If γ_i is equal to 0 the model is symmetric with no significant either positive nor negative shocks.

The univariate EGARCH (1,1) methodology is applied to analyze the reaction of stock markets to local macroeconomic news releases. This model is utilized with a Gaussian normal distribution of errors to study the effect of macroeconomic announcement. The mean (Equation 7) and the conditional variance (Equation 10) are extended with parameters of macroeconomic announcements and stock market returns:

$$(11) \quad r_{i,t} = \mu_i + \boldsymbol{\omega}_i \boldsymbol{r}_{t-1}^{w} + \boldsymbol{\varphi}_i \boldsymbol{r}_{j,t-1} + \lambda_i D_{i,t} + \varepsilon_{i,t},$$

$$(12) \quad ln(\sigma_{i,t}^2) = c_i + \alpha_i \frac{|\varepsilon_{i,t-1}|}{\sigma_{i,t-1}} + \gamma_i \frac{\varepsilon_{i,t-1}}{\sigma_{i,t-1}} + \beta_i \, ln(\sigma_{i,t-1}^2) + \eta_i D_{i,t},$$

where $r_{i,t}$ is the daily return at time t for an emerging stock market i. $\mathbf{r}_{t-1}^{w}$ is a 2×1 vector of lagged stock market returns for the United States (US) and emerging Europe (EE). $\boldsymbol{\omega}_i$ is an 1×2 vector of parameters, which represent the autoregressive effects in returns of US and EE markets and presumably capture information that extends beyond macroeconomic announcements alone. The parameter $\boldsymbol{r}_{j,t-1}$ is an 3×1 vector lagged stock market returns for all the other sample countries in the study (i.e., $i \neq j$). $\boldsymbol{\varphi}_i$ is an 1×3 vector of parameters, which represent autoregressive effects of emerging stock markets. The parameter $D_{i,t}$ is a dummy for macroeconomic announcements that originate in each local market; each of these dummies takes a value of 1 on announcement days and 0 otherwise. Thus, the estimated coefficients λ_i and η_i are the contemporaneous effects of local macroeconomic news on domestic stock markets and on the volatilities of these markets, respectively.

To study the dependence of news on the type of release, local macroeconomic news are segregated into ten sectoral categories. At this step, mean and variance equations are replaced with the following equations:

$$(13) \quad \text{Model 1:} \quad r_{i,t} = \mu_i + \boldsymbol{\omega}_i \boldsymbol{r}_{t-1}^{w} + \boldsymbol{\varphi}_i \boldsymbol{r}_{j,t-1} + \boldsymbol{\lambda}_i \boldsymbol{D}_{i,t} + \varepsilon_{i,t}.$$

$$\text{Model 2:} \quad r_{i,t} = \mu_i + \boldsymbol{\omega}_i \boldsymbol{r}_{t-1}^{w} + \boldsymbol{\varphi}_i \boldsymbol{r}_{j,t-1} + \lambda_i D_{i,t} + \varepsilon_{i,t}.$$

$$(14) \quad \text{Model 1:} \quad ln(\sigma_{i,t}^2) = c_i + \alpha_i \frac{|\varepsilon_{i,t-1}|}{\sigma_{i,t-1}} + \gamma_i \frac{\varepsilon_{i,t-1}}{\sigma_{i,t-1}} + \beta_i \, ln(\sigma_{i,t-1}^2) + \eta_i D_{i,t}.$$

$$\text{Model 2:} \quad ln(\sigma_{i,t}^2) = c_i + \alpha_i \frac{|\varepsilon_{i,t-1}|}{\sigma_{i,t-1}} + \gamma_i \frac{\varepsilon_{i,t-1}}{\sigma_{i,t-1}} + \beta_i \, ln(\sigma_{i,t-1}^2) + \boldsymbol{\eta}_i \boldsymbol{D}_{i,t}.$$

Two models for each market are tested. In the mean equation for Model 1, $\boldsymbol{D}_{i,t}$is a $c\times 1$ vector of dummies for macroeconomic announcements taking place in category c at time t; each of these dummies takes a value of 1 on announcement days for a particular news category and takes a value of 0 otherwise. In the variance equation of Model 1, $D_{i,t}$ is a dummy for macroeconomic announcements; dummy takes a value of 1 on announcement days and 0 otherwise. In the mean equation of Model 2, $D_{i,t}$ is a dummy for macroeconomic announcements; again, the dummies take a value of 1 on announcement days and 0 otherwise. In the variance equation of Model 2, $\boldsymbol{D}_{i,t}$ is a $c\times 1$ vector of dummies for macroeconomic announcements; each of these dummies takes a value of 1 on announcement days for a particular news category and 0 otherwise. The dummies $\boldsymbol{D}_{i,t}$ are specific for each category even though for some categories the dummies are the same at particular time t. The estimated coefficients λ_i and η_i capture the contemporaneous effects of local macroeconomic news from different categories on domestic stock markets and on the volatilities of these markets, respectively.

For the effect on domestic stock markets of foreign macroeconomic news that is released in foreign countries, the mean and variance equations are estimated as follows:

(15) Model 1: $$r_{i,t} = \mu_i + \boldsymbol{\omega}_i \boldsymbol{r}_{t-1}^{w} + \boldsymbol{\varphi}_i \boldsymbol{r}_{j,t-1} + \boldsymbol{\lambda}_j \boldsymbol{D}_{j,t} + \varepsilon_{i,t}.$$

Model 2: $$r_{i,t} = \mu_i + \boldsymbol{\omega}_i \boldsymbol{r}_{t-1}^{w} + \boldsymbol{\varphi}_i \boldsymbol{r}_{j,t-1} + \lambda_i D_{i,t} + \varepsilon_{i,t}.$$

(16) Model 1: $$ln(\sigma_{i,t}^2) = c_i + \alpha_i \frac{|\varepsilon_{i,t-1}|}{\sigma_{i,t-1}} + \gamma_i \frac{\varepsilon_{i,t-1}}{\sigma_{i,t-1}} + \beta_i \, ln(\sigma_{i,t-1}^2) + \eta_i D_{i,t}.$$

Model 2: $$ln(\sigma_{i,t}^2) = c_i + \alpha_i \frac{|\varepsilon_{i,t-1}|}{\sigma_{i,t-1}} + \gamma_i \frac{\varepsilon_{i,t-1}}{\sigma_{i,t-1}} + \beta_i \, ln(\sigma_{i,t-1}^2) + \boldsymbol{\eta}_j \boldsymbol{D}_{j,t}.$$

Two models are estimated for each local market. In the mean equation of Model 1, the parameter $\boldsymbol{D}_{j,t}$ is a 3×1 vector of dummies for foreign macroeconomic announcements; each of these dummies takes a value of 1 on announcement days for a particular country and 0 otherwise. In the variance equation of Model 1, $D_{i,t}$ is a dummy for local macroeconomic announcements; the dummy takes a value of 1 on announcement days and 0 otherwise. In the mean equation of Model 2, the parameter $D_{i,t}$ is a dummy for local macroeconomic announcements; the dummy takes a value of 1 on announcement days and 0 otherwise. In the variance equation of Model 2, $\boldsymbol{D}_{j,t}$ is a *3×1* vector of dummies for foreign macroeconomic announcements; each of these dummies takes a value of 1 on announcement days for a particular country and 0 otherwise. The $D_{j,t}$, $\boldsymbol{D}_{j,t}$, $D_{i,t}$ and $\boldsymbol{D}_{i,t}$ are specific for each country even though for some countries the dummies are the same. The estimated coefficients λ_i, λ_j, η_i and η_j capture the contemporaneous effects of local and foreign macroeconomic news on domestic stock markets and on the volatilities of these stock markets, respectively.

The variance-covariance matrices may be optimized with the Berndt, Hall, Hall, and Hausman (1974) algorithm (Engle and Kroner, 1995). The BHHH is based on the determination of the first derivatives of the log-likelihood function with respect to the parameter values at each iteration. The BHHH method utilizes only first derivatives, but approximations to second derivatives are calculated.

From Equations (9), (11), and (13), the conditional log-likelihood functions, $L(\boldsymbol{\theta})$, is obtained for a sample of *T* observations:

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

(18) $$l_t(\boldsymbol{\theta}) = -log2\pi - 1/2log|\boldsymbol{H}_t(\boldsymbol{\theta})| - 1/2\varepsilon_t'(\boldsymbol{\theta})\boldsymbol{H}_t^{-1}(\boldsymbol{\theta})\varepsilon_t(\boldsymbol{\theta}),$$

where $\boldsymbol{\theta}$ represents the vector of all the unknown parameters. A numerical maximization of Equations (17) and (18) yields the maximum likelihood estimates with asymptotic standard errors.

The EGARCH models are F-tested to determine if they are correctly specified. Under the null hypothesis with normally distributed errors, the F-statistic should have an F-distribution with *k-1* numerator degrees of freedom and *T-k* denominator degrees of freedom, where *k* is the number of explanatory variables.

2.2.2.3 A multivariate representation

A multivariate representation of GARCH is applied to study volatility spillovers and risk transfer in Eastern Europe. Empirical specification starts with a bivariate GARCH(1,1) model that accommodates the returns of each market and the returns of other markets lagged by one period.[1]

(19) $$\boldsymbol{r}_t = \boldsymbol{\alpha} + \boldsymbol{\beta}\boldsymbol{r}_{t-1} + \boldsymbol{\varepsilon}_t,$$

(20) $$\boldsymbol{\varepsilon}_t|\Omega_{t-1} \sim N(0, \boldsymbol{H}_t),$$

where $\boldsymbol{r}_t$ 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 $\boldsymbol{\varepsilon}_t$ represents the innovation for each market at time t that is available from the information set Ω_{t-1} with its corresponding $n\times n$ conditional variance-covariance matrix $\boldsymbol{H}_t$. The $n\times 1$ vector, $\boldsymbol{\alpha}$, represents the constant.

The $\boldsymbol{\beta}$ is an $n\times n$ matrix, with elements that represent its own and the cross-market average autoregressive terms. This multivariate structure facilitates the measurement of the effects of innovations in the mean stock returns of one market on its lagged returns and those of the lagged returns of the other market.

Given the above expression, and following Engle and Kroner (1995), the conditional covariance matrix may be stated as:

(21) $$\boldsymbol{H}_t = \boldsymbol{C}_0'\boldsymbol{C}_0 + \boldsymbol{A}_{11}'\boldsymbol{\varepsilon}_{t-1}\boldsymbol{\varepsilon}_{t-1}'\boldsymbol{A}_{11} + \boldsymbol{G}_{11}'\boldsymbol{H}_{t-1}\boldsymbol{G}_{11},$$

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 partly 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 that captures the information of past volatility effects on conditional variance. With individual elements, Equation (21) takes the form:

(22) $$\boldsymbol{H}_t = \boldsymbol{C}_0'\boldsymbol{C}_0 + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}' \begin{bmatrix} \varepsilon_{1,t-1}^2 & \varepsilon_{1,t-1}\varepsilon_{2,t-1} \\ \varepsilon_{1,t-1}\varepsilon_{2,t-1} & \varepsilon_{2,t-1}^2 \end{bmatrix} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} + \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix}' \boldsymbol{H}_{t-1} \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix}.$$

[1] This model is based on the bivariate GARCH(1,1)-BEKK representation proposed by Engle and Kroner (1995).

Equation (22) for $\boldsymbol{H}_t$ further expanded for the bivariate GARCH (1,1) by matrix multiplication would be:

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

(24) $$\begin{aligned} h_{12,t} &= c_{11}c_{21} + a_{11}a_{12}\varepsilon_{1,t-1}^2 + (a_{21}a_{12} + a_{11}a_{22})\varepsilon_{1,t-1}\varepsilon_{2,t-1} + a_{21}a_{22}\varepsilon_{2,t-1}^2 + g_{11}g_{12}h_{11,t-1} \\ &+ (g_{21}g_{12} + g_{11}g_{22})h_{12,t-1} + g_{21}g_{22}h_{22,t-1}, \end{aligned}$$

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

The variance-covariance system can be optimized with the Berndt, Hall, Hall and Hausman algorithm that was proposed in 1974 (Engle and Kroner, 1995). From Equations (23) to (25), the conditional log likelihood function $L(\theta)$ is obtained for a sample of T observations:

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

(27) $$l_t(\boldsymbol{\theta}) = -log2\pi - 1/2log|\boldsymbol{H}_t(\boldsymbol{\theta})| - 1/2\varepsilon_t(\theta)\boldsymbol{H}_t^{-1}(\boldsymbol{\theta})\varepsilon_t(\boldsymbol{\theta}),$$

where $\boldsymbol{\theta}$ represents the vector of all the unknown parameters. A numerical maximization of Equations (26) and (27) yields the maximum likelihood estimates with asymptotic standard errors.

Finally, to test the null hypothesis that the model is correctly specified, and that the noise terms, μ_t, are random, the Ljung-Box Q-statistic is used. This is assumed to be asymptotically distributed as χ^2 with $(p - k)$ degrees of freedom, where k is the number of explanatory variables.

2.3 Data

The tests were conducted on Emerging Eastern European countries over the sample period from 1996 to 2010. Although most Eastern European countries opened stock markets in the early 1990s, the thinness of the initial trading makes the initial data unreliable. High-quality data series do not become available until mid-decade. Tests are conducted from a US investor's point of view; all returns are therefore measured in US dollars. Monthly, weekly, and daily asset returns of total return market indices are utilized. For calculating excess returns, a one-holding-period return is applied, calculated from the Eurodollar rate using the approach recommended in Vaihekoski (2007). All data are extracted from the ThomsonONE and Datastream databases, with the exception of the US currency index, which is taken from the US Federal Reserve Economic Data (FRED) database.

Russia, Poland, Hungary, the Czech Republic, Bulgaria and Slovenia are the markets from Emerging Eastern Europe selected for this dissertation. While all six sample countries have made the transition from communist to capitalist systems, their individual paths to economic and political development have diverged at several junctures. Poland, Hungary, the Czech Republic, and Slovenia joined the EU in May 2004; Bulgaria joined the EU in January 2007, and Russia has never entertained the notion of EU membership.

Slovenia adopted the euro in January 2007, while the other countries have retained their own currencies. While the sample countries had stock markets before WWI, these stock exchanges were closed during the communist era. Slovenia was the first to re-establish its exchange (Ljubljana Stock Exchange, 1989), followed by Hungary (Budapest Stock Exchange, 1990), Bulgaria (Bulgarian Stock Exchange-Sofia, 1991), and Poland (Warsaw Stock Exchange, 1991). The Russian stock market (Moscow Interbank Currency Exchange) opened in 1992 and the Czech stock market (the Prague Stock Exchange) opened in 1993. At the outset, the Russian and Czech stock markets were clearly in a league of their own in terms of size when compared to the other stock markets in the sample.

2.3.1 Defining global and local sources of risk

The study of global and local sources of risk is conducted on these six major Emerging Eastern European markets (Russia, Poland, Hungary, the Czech Republic, Bulgaria and Slovenia). The sample period is from January 1996 to December 2007. The countries were selected on the basis of availability of the Morgan Stanley Capital International (MSCI) and International Finance Corporation (IFC) total return stock market indices for the entire period. These indices are typically available only few years after the opening of the stock market. As a result, three potential countries were excluded from this study, Slovakia (Bratislava Stock Exchange, established in 1991), Romania (Bucharest Stock Exchange, 1995), and Ukraine (PFTS Stock Exchange, 1997).

As test assets in the analysis, market portfolios from each sample country are utilized. As a proxy for local market portfolios, the ever-popular MSCI and IFC indices are used. All indices strive to provide wide coverage while excluding the most illiquid companies. These indices are adjusted for stock splits and new issues, and include gross dividends (total pre-tax return for investors).

The pricing of three different sources of risk in Emerging Eastern Europe is tested. First, the source of risk, global market risk, is proxied using the global equity market portfolio with returns calculated from the MSCI world equity total return index. This approach has frequently been used in the literature (e.g., Bekaert and Harvey, 1995; De Santis and Gérard, 1998; and Hunter, 2006). The second source of risk related to market segmentation is proxied by using an aggregate emerging market portfolio. Returns are calculated by using the aggregate Datastream emerging market total return index.

The third source of risk is exchange rate risk, for which two proxies are considered. One is the broad, trade-weighted, US currency index (an aggregate, multilateral currency index that weights the average foreign exchange value of the US dollar against the currencies of 26 major US trading partners, including the euro zone, Canada, Japan, and several major emerging markets). The trade-weighted US currency index has also been used extensively in the literature (e.g., Harvey, 1995a). The other proxy used is the bilateral country-specific exchange rate change against the US dollar. Returns are calculated as the reverse logarithmic difference in the index or exchange rates.

Following earlier studies, conditioning variables are applied to model the time variation in the betas. The difference between the country's local interbank money market interest rate and the Eurodollar one-month rate change at the end of month t-1 was chosen as the local information variable. Similar interest differentials are frequently used to describe the financial picture and the economic stability of a country. Moreover, the concept of interest rate parity relates the interest rates to the expected change in the value of currencies. This variable is easily observable, comparable across countries, and available to investors on a timely basis. Because the interest differentials show extremely high autocorrelation, the first difference of the differential is applied in the following analysis.

2.3.2 Defining volatility spillovers

The tests in the study on volatility spillovers in Emerging Europe are conducted only on Poland, Hungary, the Czech Republic and Russia. The sample period is from January 1995 to December 2008. Weekly total return indices are used, which are based on weekend observations of total return market indices.

As test assets in the analysis, market portfolios from each of the sample countries are utilized. As a proxy for the market stock return, we use the Datastream indices. These indices were available for the countries under investigation over the long term and have frequently been used in similar studies. The market portfolio indices include gross dividends, i.e., they measure the total pre-tax return for investors.

As a proxy for the currency market, we use the single bilateral currency exchange rates of the Polish zloty, the Czech koruna, the Hungarian forint and the Russian ruble against the US dollar. As an alternative class of assets, the bond or derivative market might have been used. We chose the currency market primarily because of data availability. Moreover, the currencies of Poland, Hungary, the Czech Republic, and Russia have undergone several currency regimes (multiple devaluations and revaluations, and periods of fixed and floating exchange rates), making them an interesting natural experiment in interdependence. Furthermore, the currency market is interesting from the point of view of currency risk. All data were extracted from the Datastream database.

2.3.3 Defining financial risk transfer

The tests in the study of financial risk transfer utilize data from the stock markets of three Emerging countries from Eastern Europe (Poland, Hungary, and the Czech Republic). The sample period is from December 1998 to December 2009. As in related studies (e.g., Qiao, Liew and Wong, 2007), weekly total return indices are consistently used based on Wednesday observations of total-return market indices to alleviate day-of-the-week effects and the noise effects of daily data.

As test assets, market portfolios from each of the sample countries, stock market sectors and regional stock markets are used. 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. The indices include gross dividends (i.e., they measure the total pre-tax return for investors). All data are taken from the Datastream database.

2.3.4 Defining the effect of macroeconomic announcements

Macroeconomic announcement is a public or formal notice announcing macroeconomic indicators, i.e., statistics that indicate the status of the economy or particular area of the economy (e.g., industry, labor market or national accounts). Such news announcements are published on the regularly by the governmental agencies and the private sector. In this study, scheduled macroeconomic announcements, which are classified into one of ten categories defined and collected by Reuters and obtained from ThomsonONE, are utilized.

The analysis of the effect of macroeconomic announcements focuses on four emerging stock markets from Eastern Europe: Russia, Poland, Hungary and the Czech Republic. Market portfolios from each of the sample countries are utilized as test assets. To proxy Emerging Europe stock returns, Datastream's Emerging Europe Aggregate index is used. Datastream total return indices are used (including gross dividends) from the beginning of January 2006 through the end of December 2010 to calculate logarithmic stock market returns.

News is categorized as follows: consumer sector, external sector, government sector, industry sector, labor market, money and finance, national accounts, prices, surveys and cyclical indices and other. The consumer sector category includes news on retail sales. News from the external sector involves announcements concerning the foreign trade balance or national current account. The government sector is represented by news concerning budget balancing or the money supply. The industry sector category covers news on industrial production. The labor market category consists of announcements on the unemployment rate. The category money and finance contains news about national reserves and central bank interest rates. News releases covering national accounts include announcements of GDP. The prices category is defined as news concerning the CPI, PPI or inflation rates. News releases on business climate indices are included in the category of surveys and cyclical indices. News not falling in any of the above-described categories but having macroeconomic implications is categorized as other.

The macroeconomic announcements are distinguished between local news (news generated in the country of origin) and foreign news (macroeconomic news generated in the other three emerging Eastern European countries and not in the country of origin). Thus, an announcement released by the Russian media would be local news in Russia, but foreign news for Poland, Hungary and the Czech Republic. The effects of macroeconomic announcements are estimated in this study by applying news as a dummy variable for announcing the macroeconomic indicators. The dummies take a value of 1 on announcement days for a particular country and 0 otherwise. The dummies of macroeconomic announcements related to particular category of a news release take a value of 1 on announcement days for a particular news category and takes a value of 0 otherwise.

Our news sample consists of 2,547 macroeconomic announcements for all four selected emerging markets, with a total of 412 Russian, 611 Polish, 611 Hungarian, and 913 Czech announcements.

During the period 2006–2010, the most frequent macroeconomic announcements were observed in the Czech Republic (averaging 183 news announcements a year), while the most infrequent macroeconomic news was observed in Russia (averaging 82 news announcements a year). Interestingly, the negative local news for Hungary and the Czech Republic is significantly greater than the positive news; in Russia and Poland, the amount of positive and negative announcements is approximately equal. The most frequent news in analyzing countries concerns the prices category and varies between 26.7 % and 36.8 % of total announcements released. Announcements concerning surveys and/ cyclical indices are least frequent, comprising 0.7–5.4 % of the total number of releases.

3 FINANCIAL AND MACROECONOMIC BACKGROUND

3.1 Macroeconomic indicators for Emerging Eastern Europe

Financial and political trends in different countries can be compared with the help of ratings from risk analysis providers and credit rating agencies such as Moody's, Standard & Poor's, Emerging Europe Monitor, Business Monitor International, the Economist Intelligence Unit, and many others.

Country risk refers to an aggregate of risks associated with investing in a country and depends on the business environment in specific countries. For example, financial and political factors such as exchange rates, monetary policy, foreign debt and GDP growth, civil wars and other potential events might affect the operating profits and the value of assets in particular market. Therefore, risks associated with investing in an emerging country are compared from the political perspective, the economic perspective and the business environment perspective.

The political rating is a guide to the political stability of the country, which is seen as a prerequisite for a stable economy and business environment. In calculating the political rating, risk analysis providers and credit rating agencies consider such factors as democracy, corruption, legal structure, distribution of wealth in society, relationships with foreign countries, level of unemployment in the country, inflation and possible domestic and international conflicts.

The economic rating measures the how close the economy is to being a perfect market. The rating takes into account GDP growth, unemployment, inflation, real interest rates, exchange rates, fiscal balance, the current account balance and external debt, dependence on the primary sector, reliance on commodity imports, reliance on a single export sector and central bank independence.

The business environment rating is a guide to the investment climate in a specific country. The rating comprises a group of such factors, such as competitiveness, finance, openness and business environment. Moreover, the economic and political ratings given for a specific market are considered in the calculation of the business environment rating. This type of grading is the result more of the knowledge available for risk analysis providers than in easily quantifiable measures. The political, economic, and business environment risks are measured from 0 to 100 points, where 100 points is the riskiest indicator.

The Emerging Europe Monitor is a risk analysis provider that published its latest risk rating for emerging countries in February 2012. Table 1 reports the grades received by Emerging Eastern European countries.

Table 1. Risk rating for Emerging Eastern European countries

The source of the data is Emerging Europe Monitor. The risk rating was released in February 2012. The rating scale goes from 1 to 100 points, where 100 is riskiest.

Type of risk	Bulgaria	Cz. Rep.	Hungary	Poland	Russia	Slovenia
Political	69.6	82.1	66.9	76.5	71.7	65.0
Economic	54.4	59.6	54.6	63.5	75.4	64.6
Business environment	55.2	59.3	64.4	60.6	50.2	66.6

The Czech Republic posted the highest political rating among all Emerging Eastern European countries in this February 2012 ranking. Russia got the highest economic rating, i.e., economic policies in Russia are less stable than in other Emerging Eastern European markets. However, Russia was rated as the market with lowest business environment risk. The riskiest market in terms of business environment was Slovenia. The risk rating for Emerging Eastern European countries is shown graphically in Figure 1.

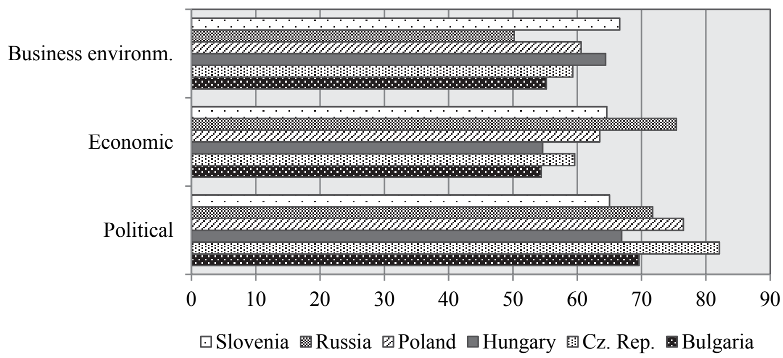

Figure 1. Risk rating for Emerging Eastern European countries

Macroeconomists forecast economic conditions of countries to provide a broader perspective of the overall health of an economy and development trends. They are important sources of information for investors because they contain information about potential risks in investing in a foreign country and may influence investment decisions.

Appendix 2 illustrates the macroeconomic indicators of Bulgaria, the Czech Republic, Hungary, Poland, Russia and Slovenia for year 2011 and their forecasts for 2012 and 2013. The forecast was produced by risk analysis providers and credit agencies in the first quarter of 2012. The sources of these forecasts are found in the notes after the table.

The forecast of Bulgarian macroeconomic indicators is bleak for 2012 but improves in 2013. The recovery in the labor market after the latest global financial crisis is expected as a result of economic recovery, but the recovery will not be as strong as it was projected at the end of 2011. The forecasts of macroeconomic indicators for the Czech Republic show a difficult 2012, with recovery in 2013. This forecast suggests recession in Hungary and Poland lasting through 2012. The beginning of market recovery is forecast for 2013, as shown by the decrease in the unemployment rate, the strengthening of national currencies and falling budget deficits.

The Economist sees the Russian economy likely to continue with its emphasis on coal production. This will help to insulate it from shocks emanating from changes in the global economy, to support growth on domestic market and to strengthen the national currency. The budget deficit is forecast to decrease over the next two years.

The most recent data released by the Slovenian Statistical Office suggest the unemployment rate in Slovenia decreased to 8.7 % in 2011. However, the level of unemployment remains well above the pre-crisis level. Unemployment is expected to further decrease as recovery proceeds.

Recapping the forecasts for Emerging Eastern European countries, the latest financial crisis continues to raise serious concerns about economic prospects in Eastern Europe. The recovery has lost momentum and several Eastern European economies are sinking back into recession. However, the reliance of the Russian economy on the oil and gas industry isolates local markets from certain shocks.

3.2 Development of Emerging Eastern European markets

3.2.1 Historical background of the stock markets

3.2.1.1 Bulgaria

The history of the Bulgarian capital market dates back to the beginning of the 20th century. The first Stock Exchange Act, adopted in 1907, regulated the structure and functions of the stock and commodity exchanges. In 1914, the first true stock exchange in Bulgaria, the Sofia Stock Exchange (SSE), was established (Bulgarian Stock Exchange-Sofia web-site).

After World War II, the SSE was closed. The Bulgarian capital market was revived in 1992, when the Bulgarian Stock Exchange JSC was registered. Approximately 20 new stock exchanges were founded in the country in the period 1992–1994. Bulgarian capital markets remained unregulated until July 1995, when most regional exchanges united under the banner of the Bulgarian Stock Exchange. In 1996, the Securities and Stock Exchange Commission introduced the new requirements for all listed companies. Trading operations were stopped for a year, as none of the companies at that time fulfilled the new requirements. At the end of 1997, operations resumed on the renamed Bulgarian Stock Exchange-Sofia (BSE-Sofia). The BSE-Sofia became a full member of the Federation of European Securities Exchanges (FESE) in 2007, which represented operators of Europe's regulated markets. It became a public company in 2010. The Bulgarian Stock Exchange-Sofia is currently a joint-stock company and the sole functioning stock exchange in Bulgaria.

The Bulgarian Stock Exchange publishes four indices: SOFIX, BG40, BGTR30 and BGREIT. The calculation of the SOFIX began in 2000 and the BG40 in 2005. The Bulgarian capital market began calculating two new indices, the BGTR30 and the BGREIT, in September 2007 to provide a broader overview of the market.

3.2.1.2 Czech Republic

Efforts to create a stock exchange in the Czech Republic date back to 1871, when the Prague Stock Exchange (PSE) was established (Prague Stock Exchange web-site).

Both securities and commodities were traded on the Prague exchange. However, after World War I, trading activity with commodities declined, and only securities were traded. For the Prague exchange, the interwar prosperity ended with the arrival of World War II, bringing an end to trading at the Prague exchange for over 60 years. The present-day PSE was established on November 24, 1992. The first trades were made on April 6, 1993.

There are currently two stock exchanges in the Czech Republic, the RM-SYSTEM and the PSE (SPAD and KOBOS) stock exchanges. Both exchanges offer dozens of stock titles, bonds and derivatives that may be traded in Czech koruna. In SPAD, stocks are traded as a fixed number of shares (in lots). In other segments of the Prague Stock Exchange, KOBOS, and RM-SYSTEM, small investors are able to buy and sell individual shares of individual titles.

The Prague Stock Exchange is the largest intermediary in the securities market in the Czech Republic and operates as a joint stock company. The exchange is based on a membership principle where only licensed securities traders who are exchange members have access to the trading system. In June 2001, the exchange was affiliated as an associate member of the FESE, and on May 1, 2004, it became a full member of the FESE as part of the Czech Republic's EU accession.

The Prague Stock Exchange publishes the PX and PX-GLOB indices. The PX index is the official index of the Prague Stock Exchange. The PX-GLOB was designed as an all-share index for the Czech stock market and comprises all stocks traded on the regulated market of the Prague Stock Exchange.

The RM-SYSTEM Stock Exchange is the market where stocks of the largest Czech and foreign companies are traded. It is the only open stock exchange in the Czech Republic. The RM-SYSTEM was established in January 1993 and opened for trading in May 1993. On December 1, 2008, the off-exchange was transformed into a standard exchange.

3.2.1.3 Hungary

The Hungarian Stock Exchange, the ancestor of the present Budapest Stock Exchange (BSE), began operations in 1864 (Budapest Stock Exchange web-site). Although the institution was set up as a stock exchange, four years after its inception, it became the Budapest Stock and Commodity Exchange (BSCE). It operated under this name for 80 years and was a leading stock exchange in Europe.

As in most European countries, the outbreak of World War I led to the exchange's closure in 1914, although trading did not cease entirely. Brokers continued trading during the war, and equity prices increased substantially. The exchange reopened after the war, with the post-war inflationary environment pushing exchange turnover to exceptional highs. This phenomenon was tempered by the introduction in 1925 of the country's new currency, the pengő. In 1931, the BSCE was closed again as a result of a German banking moratorium and a series of financial collapses of major banks.

World War II was followed by a period of hyperinflation, characterized by lively private stock and exchange trading in currencies and precious metals. The exchange officially reopened in August 1946 following the launch of the forint. Due to defaults of many companies, which failed to pay their shareholders after the war, the majority of private Hungarian firms was nationalized in 1948, the government officially dissolved the Budapest Stock and Commodity Exchange, and the exchange's assets became state property.

In 1990, the BSCE reopened its doors with 41 founding members as a single independent entity, the Budapest Stock Exchange (BSE). Traditional floor trading ceased entirely in September 1999.

The derivatives market of the BSE in futures and options contracts has been available to investors since 1995. In July 1998, the BSE was among the first exchanges in the world to introduce contracts based on individual equities. In 2002, the BSE was instituted as a limited company and, from 2006, as a private limited company. In 2010, the BSE became a member of the Central and Eastern European Stock Exchange Group (CEESEG).

The Budapest Stock Exchange calculates domestic, BUX and BUMIX, and regional, CETOP20, equity indices.

3.2.1.4 Poland

The history of the Polish capital market dates back to 1817, when the Warsaw Mercantile Exchange (WME) was established (Warsaw Stock Exchange web-site). In the first half of the 19th century, primarily bills, debentures and bonds were traded. Share trading on a broader scale developed later. The first public security traded on the WME was issued in 1826. In 1873, a new, more liberal, stock exchange act was passed, separating the trade in securities and commodities. Therefore, a separate Warsaw Commodities Exchange was founded in 1874. The Warsaw Mercantile Exchange grew steadily until World War I. In 1915, Warsaw was occupied by German and Austrian forces, and the exchange was closed. The Polish exchange was subject to the crash of 1929 but recovered in the second half of the 1930s. In 1939, Poland was occupied by German and Russian forces, and all Polish stock exchanges were again closed.

The present-day Warsaw Stock Exchange (WSE) was created as a joint-stock company in 1991. The WSE held its first trading session on April 16, 1991 with five listed companies.

The WSE calculates sixteen indices: four main (WIG, WIG20, mWIG40, and sWIG80) and twelve sectoral (WIG-BANKI, WIG-BUDOW, WIG-CHEMIA, WIG-DEWEL, WIG-ENERG, WIG-INFO, WIG-MEDIA, WIG-PALIWA, WIG-PL, WIG-SPOZYW, WIG-SUROWCE and WIG-TELKOM) indices.

3.2.1.5 Russia

The Russian stock market has traditionally been represented by the Moscow Interbank Currency Exchange (MICEX) and the Russian Trading System (RTS). Both exchanges were formed in the 1990s (Moscow Interbank Currency Exchange and Russian Trading System websites). The history of MICEX begins in 1992, when leading Russian banks and the Bank of Russia founded the Moscow Interbank Currency Exchange, a closed joint stock company. It initially intended to conduct trading exclusively in US dollars. MICEX was a universal financial exchange where trades were executed in currencies, government, municipal, and corporate bonds, shares and derivative instruments. In 2007, the World Exchange Federation approved MICEX as an affiliated member.

The Russian Trading System Stock Exchange was established in 1995 as the first regulated stock market in Russia consolidating various regional trading floors into one exchange, where the full range of financial instruments from cash equities to commodity futures were traded. Initially created as a non-profit organization, it was transformed into a joint-stock company. The key shareholders included global investment banks such as UBS, Credit Suisse and Deutsche Bank.

Russian capital markets experienced a series of radical reforms in 2011. The two Russian stock exchanges, the MICEX and the Russian Trading System, proposed on June 29, 2011 a plan to merge. The MICEX-RTS was officially established on December 19, 2011 and today is the largest stock exchange in Russia. It is based in Moscow and facilitates trading in equities, bonds, derivatives and currencies. The exchange is targeting an IPO in 2013. In 2012, the company launched T+N trading and created a single trading platform for spot and derivatives markets.

3.2.1.6 Slovenia

The first stock exchange in Ljubljana operated between 1924 and 1942. During World War II, trading on the old exchange was suspended and eventually banned by decree. The reestablishment and reopening of the Slovenian capital market occurred on December 26, 1989, when the Ljubljana Stock Exchange (LJSE) was officially established. The year 1997 saw a relaxation of limits on foreign portfolio investors. Foreign investors were allowed to buy Slovene securities without balancing their foreign exchange positions. In the same year, the LJSE was admitted as a full member to the International Association of Stock Exchanges-FIBV. Two years later, the LJSE was admitted to the Federation of European Stock Exchanges (FESE) as an associated member. In 2004, the Ljubljana Stock Exchange became a full member of the FESE (Ljubljana Stock Exchange web-site).

The Ljubljana Stock Exchange introduced its SBI TOP index in 2006. The SBI TOP is the first genuine LJSE blue-chip index and serves as the benchmark index for the Slovene capital market.

3.2.2 Overview of the stock markets

Structured financial markets in Emerging Eastern European countries were founded long before WWI. However, their stock exchanges were closed during the communist era. The stock exchanges reappeared after the collapse of the Soviet Union. Slovenia was the first to reestablish its exchange (Ljubljana Stock Exchange, 1989), followed by Hungary (Budapest Stock Exchange, 1990), Bulgaria (Bulgarian Stock Exchange, 1991; since 1997, Bulgarian Stock Exchange-Sofia) and Poland (Warsaw Stock Exchange, 1991). The Russian stock market (Moscow Interbank Currency Exchange) opened in 1992 and the Prague Stock Exchange opened in 1993.

For an overview of stock market development in Emerging Eastern European countries, several measurements of stock markets are introduced below. The size of a stock market may be measured in various ways, each of which may produce a different country ranking. A market size is positively correlated with the ability to mobilize capital and diversify financial risk.

Market capitalization or market value is an indicator of development of financial markets. Table 2 presents market capitalizations in Emerging Eastern European countries from 1995 to 2009. Market capitalization in the table is the overall size of the stock market at year end in US dollars.

Table 2. Market capitalizations in Emerging Eastern European countries

Market capitalization is reported as the year-end value in millions of US dollars. The sources of the data are the Global Stock Markets Factbook (2005, 2009) and World Development Indicators (2010).

	End of year (US dollars, millions)							
Market	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Bulgaria[1]	61	7	2	992	706	617	505	733
Cz. Rep.	15664	18077	12786	12045	11796	11002	9331	15893
Hungary	2399	5273	14975	14028	16317	12021	10367	13110
Poland	4564	8390	12135	20461	29577	31279	26017	28750
Russia[2]	15863	37230	128207	20598	72205	38922	76198	124198
Slovenia	311	663	1625	2450	2180	2547	2839	4606
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	
Bulgaria	1755	2804	5086	10325	21793	8858	7330	
Cz. Rep.	17663	30863	38345	48604	73420	48850	54477	
Hungary	16729	28711	32576	41935	47651	18579	30332	
Poland	37165	71102	93873	149054	207322	90233	147178	
Russia	230786	267957	548579	1321833	1503011	1321833	861424	
Slovenia[3]	7134	9677	7899	15182	28963	11772	12141	

The Russian stock market is a regional leader in terms of market growth. Market capitalization in all countries grew through 2007. Starting in 2008, all markets experienced declines in share prices.

The *number of listed domestic companies* is another measure of stock market size. Table 3 reports the number of listed companies on Emerging Eastern European stock markets from 1995 to 2009. The values are measured as the number of companies registered on stock exchanges at the end of a particular year.

[1] Statistics through 1997 represent companies listed on the now-defunct Bulgarian Stock Exchange. Thereafter, figures represent listed companies traded on the current Bulgarian Stock Exchange-Sofia.
[2] The ruble was revalued on January 1, 1998 with the new ruble equal to 1,000 old rubles. Data are the sum of the market value of RTS-listed stocks plus the market value of NASDAQ, NYSE, and LSE-listed S&P EMDB Russia Index constituents. Figures after November 1, 2002 include Gazprom GDRs listed on the London International Exchange.
[3] Starting from 2003, market capitalization includes data for both the official market and the free market. In January 2007, the euro became Slovenia's official currency.

Table 3. Number of listed companies on Emerging Eastern Europe stock markets

The number of listed companies is reported as of year-end. The sources of the data are the Global Stock Markets Factbook (2005, 2009) and World Development Indicators (2010).

	End of year							
Market	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Bulgaria[4]	26	15	15	998	828	503	399	354
Cz. Rep.	1635	1588	276	261	164	131	94	78
Hungary	42	45	49	55	66	60	57	48
Poland	65	83	143	198	221	225	230	216
Russia[5]	170	73	208	237	207	249	236	196
Slovenia	17	21	26	28	28	38	38	35
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	
Bulgaria	356	332	331	347	369	334	337	
Cz. Rep.	63	54	36	29	32	28	25	
Hungary	49	47	44	41	41	41	45	
Poland	203	225	248	267	328	349	354	
Russia	214	215	296	309	328	314	333	
Slovenia[6]	134	140	116	100	87	84	80	

Table 3 shows the number of listed companies changed significantly on the Bulgarian stock market in 1998, the Czech stock market in 1997 and the Slovenian stock market in 2003.

The number of listed companies on the Bulgarian Stock Exchange increased several-fold in 1998 as a result of multiple reforms; the Bulgarian Stock Exchange was officially licensed as a stock exchange by the Bulgarian Securities and Stock Exchanges Commission. The first trading session on the regulated market took place on October 21, 1997. A mass privatization program approved in the same year resulted in the listing of over 1,000 companies.

[4] Statistics through 1997 represent companies listed on the now-defunct Bulgarian Stock Exchange. Thereafter, figures represent listed companies traded on the current Bulgarian Stock Exchange-Sofia.
[5] Figures include data from RTS plus data from NASDAQ, NYSE, and LSE-listed S&P EMDB Russia Index constituents. Figures after November 1, 2002 include Gazprom GDRs listed on the London International Exchange.
[6] Starting from 2003, number of listed companies includes data for both the official market and the free market.

The Prague Stock Exchange in 1997 saw the launch of state privatization sales. Due to the lack of liquidity, many share issues were subsequently withdrawn. Thus, the number of listed companies on Prague Stock Exchange decreased several fold in 1997.

Trading value is another measurement of market size. Here it is introduced as a ratio of the total value of shares traded to GDP. This measurement represents *market liquidity*, i.e., the ability of investors to easily buy and sell securities. Liquidity is an important attribute of stock markets, as liquid markets improve the allocation of capital and enhance prospects for long-term economic growth. Table 4 reports liquidity of stock markets in Emerging Eastern Europe from 1995 to 2008.

Table 4. Market liquidity in Emerging Eastern Europe

Market liquidity is measured as the total value of shares traded divided by GDP. The sources of the data are Global Stock Markets Factbook (2005, 2009) and World Development Indicators (2010).

	Value of shares traded, % of GDP						
Market	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Bulgaria[7]	0.03	0.00	0.00	0.10	0.44	0.48	0.51
Cz. Rep.	6.98	14.56	13.34	8.53	7.55	12.96	5.50
Hungary	0.79	3.63	16.34	33.56	29.96	26.63	9.30
Poland	2.19	3.87	5.56	5.64	7.19	9.28	4.00
Russia[8]	0.14	0.71	3.72	3.79	1.47	8.09	7.47
Slovenia	1.84	2.12	1.93	3.60	3.65	2.56	4.05
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Bulgaria	1.10	0.99	2.10	5.11	4.77	13.90	3.31
Cz. Rep.	8.25	9.71	16.51	32.95	23.10	23.96	19.97
Hungary	9.06	9.98	12.92	21.69	27.58	34.31	19.91
Poland	3.05	4.05	6.84	9.86	16.11	20.04	12.87
Russia	10.47	18.77	22.22	20.84	51.93	58.49	33.48
Slovenia	4.53	2.64	3.59	2.21	2.62	5.75	2.58

The most liquid stock markets in Emerging Eastern Europe during the observation period were Russia, Hungary, and the Czech Republic, with liquidity ratios reaching as high as 58.49 %. However, this level of market liquidity in Eastern Europe is far

[7] Statistics through 1997 represents companies listed on the now defunct Bulgarian Stock Exchange. Since then, figures represent listed companies traded on the current Bulgarian Stock Exchange-Sofia.
[8] Data used for calculation of market liquidity are the sum of all trading on RTS and MICEX plus the trading in NASDAQ and NYSE listed S&P EMDB Russia Index constituents. Figures after November 1, 2002 include Gazprom GDRs listed on the London International Exchange.

from the liquidity of developed markets. For example, the market liquidity in the euro area in 2008 was 91.3 %.

Market liquidity decreased after 1998 and after 2007. The breakpoints reflect the Russian financial crisis in 1998 and the onset of the global financial crisis in 2007.

Another measurement showing stock market development is the *turnover ratio*. This benchmark is calculated as the value of shares traded divided by market capitalization. Table 5 shows the turnover ratio in Emerging Eastern European stock markets from 1995 to 2009.

Table 5. Turnover ratio on Emerging Eastern European stock markets

The turnover ratio is a value of shares traded as a percentage of market capitalization. The sources of the data are Global Stock Markets Factbook (2005, 2009) and World Development Indicators (2010).

	Value of shares traded, % of market capitalization							
Market	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Bulgaria[9]	-	0.1	0.0	2.3	6.6	9.2	12.9	28.4
Cz. Rep.	32.9	50.3	47.9	38.0	36.7	60.3	34.1	48.7
Hungary	17.3	41,6	73.4	113.9	95.8	90.7	44.4	52.2
Poland	71.5	84.8	78.4	54.4	45.8	49.9	26.1	22.4
Russia[10]	2.6	10.8	19.4	11.3	5.9	36.9	39.1	36.1
Slovenia	70.5	82.2	30.8	34.9	32.4	20.7	30.5	27.9
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	
Bulgaria	16.3	22.8	35.2	19.4	35.2	10.8	4.9	
Cz. Rep.	52.5	78.5	120.7	75.1	71.7	70.4	39.9	
Hungary	57.6	59.9	79.2	86.8	107.0	93.0	106.1	
Poland	26.6	33.1	37.3	45.7	49.2	45.7	56.0	
Russia	46.0	53.0	39.0	54.9	53.7	39.8	154.9	
Slovenia[11]	12.7	14.7	9.1	8.8	12.6	6.9	11.9	

[9] Statistics through 1997 represents companies listed on the now defunct Bulgarian Stock Exchange. Since then, figures represent listed companies traded on the current Bulgarian Stock Exchange-Sofia.
[10] Figures include data from RTS plus data from NASDAQ, NYSE, and LSE-listed S&P EMDB Russia Index constituents. From November 1, 2002, data include Gazprom GDRs listed on the London International Exchange in place of local Gazprom shares.
[11] Starting from 2003, trading value includes from both the official market and the free market.

Russian, Hungarian and Czech markets are the leaders beginning from 2001 in the value of shares traded as a percentage of the capitalization of local stock markets. The Russian stock market turnover ratio in 2009 was 154.9 %. This figure is close to the 2009 value for the euro area market (176.8 %). Interestingly, the deviation in the turnover ratio in Eastern European stock markets was the smallest in 2002. Appendix 3 graphically illustrates measurements of Emerging Eastern European stock markets.

Finally, the historical development of Emerging Eastern European stock return indices for 1995 to 2011 is presented in Figure 2.

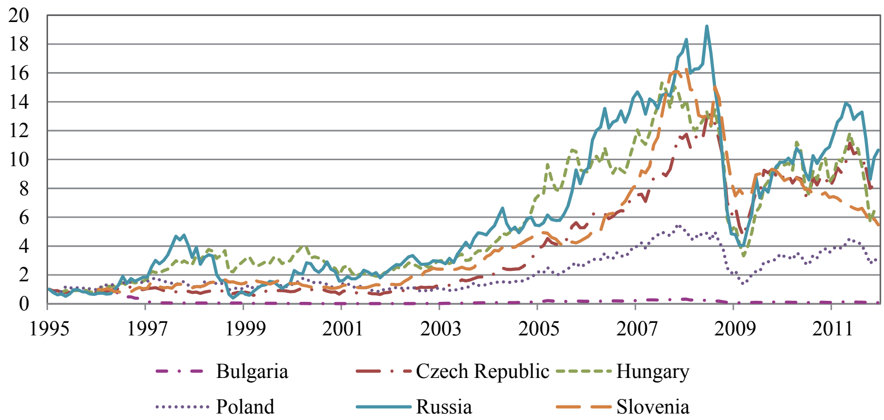

Figure 2. Development of Emerging Eastern European stock market indices[12]

The MSCI indices are utilized for the Czech Republic, Hungary, Poland and Russia, whereas IFC indices are used in Bulgaria and Slovenia, as the MSCI indices do not cover the entire period.

3.3 Integration of Emerging European stock markets

Financial integration is a process where one financial market or economy becomes more highly linked with other financial markets, economies and the rest of the world. In financially integrated markets, the law of one price holds; i.e., assets generate the same returns. Financial segmentation is the complement to financial integration; in

[12] All indices scaled to one in January 1995.

modern theory, it is defined as the process whereby comovements of financial markets do not significantly increase in response to shock effects in another market.

Many analyses of international stock markets suggest a steady process of increasing market integration, which entails increasing susceptibility to contagion and the risk of spreading financial instability. In recent years, international investors and researchers have been drawn to the study of the integration of financial markets in emerging countries due to their rapid economic development, high returns and potential for diversification.

Several empirical studies have found that market segmentation is typically larger in emerging markets than in developed markets, suggesting that local sources of risk are more critical than international sources (e.g., Korajczyk, 1995). Meanwhile, a growing body of literature has emerged on the issue of stock price comovements (Bekaert and Harvey,1995; Brooks and Del Negro, 2005, 2006; Forbes and Rigobon, 2002); Karolyi and Stulz, 1996; Lin et al., 1994; Longin and Solnik, 1995, 2001). Most of these studies conclude that comovements in stock prices vary over time.

Early studies finding that markets in Emerging Eastern Europe perform differently than developed markets include those by Barry, Peavy III and Rodriguez (1998), Bekaert et al. (1998), Harvey (1995a) and Divecha, Drach and Stefek (1992). Unlike developed markets, the researchers found that Emerging Eastern Europe is characterized by high stock market volatility and returns, segmentation from other financial markets, and less predictability of future returns. Moreover, European markets react more strongly to domestic political, regulatory and fiscal events.

The more recent literature is mixed on the subject of financial integration. Tai (2007) and de Jong and de Roon (2005) claim that markets become more integrated following equity market liberalization. Brooks and Del Negro (2002), on the other hand, note that Europe has become more integrated, whereas segmentation elsewhere has increased. Some researchers observe no evidence of increased integration over time (e.g., King and Segal, 2008).

4 SUMMARY OF ARTICLES AND RESULTS

This chapter provides short descriptions of each publication in this dissertation. Information included in this chapter has been partially discussed in Chapters 1, 2 and 5.

4.1 Global and local sources of risk in Emerging Eastern European stock markets[13]

Background and objective

The first article, co-authored with Mika Vaihekoski, addresses the question of whether global and local sources of risk are priced in Emerging Eastern European stock markets. The study is based on data from Russia, Poland, Hungary, the Czech Republic, Bulgaria and Slovenia for the period 1996 to 2007.

The motivation for the study is the controversial role of global and local sources of risk in the empirical literature. Several empirical studies find that market segmentation and significance of local sources of risk are typically larger in emerging markets than in developed markets (e.g., Korajczyk, 1995; Shackman, 2005). On the other hand, Bekaert and Harvey (1995) find evidence of a rising role for global sources of risk and a diminishing role for local risk sources. Most papers on currency risk in emerging markets conclude that it is priced on stock markets (e.g., De Santis and Imrohoroglu, 1997; Tai, 2007b; Saleem and Vaihekoski, 2008).

Results and contribution

This study assesses whether aggregate emerging market risk is priced in sample countries together with currency risk (bilateral or multilateral). A conditional version of the pricing model is also examined to allow betas to vary linearly over time on one variable.

Empirical tests are initially based on the world CAPM, where the sole source of risk is the global market, and on a partially segmented international CAPM, where the model is augmented with aggregate emerging market risk. Asset pricing models are

[13] An earlier version of this paper, Fedorova and Vaihekoski (2008), was published in the Bank of Finland Institute for Economies and Transition (BOFIT) Discussion Papers.

examined with estimations obtained using the Generalized Method of Moments (GMM).

Using an unconditional GMM estimation framework, it is found that most markets show considerable segmentation. The local aggregate emerging market portfolio (emerging market risk factor), rather than the global market portfolio, is found to be the most significant driver for the countries under study.

It is further shown that currency risk is a significant source of risk for US investors investing in Eastern European countries. In the tests, measures for both multilateral and bilateral currency exchange rate risk are used. The results, which support bilateral currency exchange risk, suggest that investors care most about country-specific currency risk. Finally, a model is estimated where the risk sensitivities (betas) are allowed to be time-varying with the country-specific interest rate difference from the world average. The results reveal that the selected conditioning variable is cross-sectionally significant, especially when modeling time variation in emerging market and bilateral currency risk.

The results do not lend strong and consistent support for the tested asset pricing models for partly segmented markets; in other words, the models are unable to explain adequately the relationship between risk and return in Emerging Eastern European countries. However, the approach used in the first article studies mostly the unconditional implications of the asset pricing models. Moreover, the segmentation is assumed to be time-invariant.

4.2 Volatility spillovers between stock and currency markets: Evidence from Emerging Eastern Europe

Background and objective

The second article, co-authored with Kashif Saleem, examines the stock and currency markets in Poland, Hungary, the Czech Republic and Russia over the period 1995 – 2008. Our empirical analysis investigates whether and to what extent these emerging markets are integrated with each other. The purpose of this study is threefold. First, the linkages between Emerging Eastern European equity markets are studied. Second, the relationships between the foreign exchange rates of Poland, Hungary, Russia, and the Czech Republic are investigated. Finally, the interdependence between Emerging Eastern European equity markets and FX rates are examined.

The linkages between different equity and currency markets have been extensively investigated. However, most studies focus on developed financial markets (e.g., Yang and Doong, 2004; Francis et al., 2006; Dark et al., 2008). Studies that do focus on emerging economies are inconclusive (e.g., Morales, 2008; Tai, 2007a; Yang and Chang, 2008) and by large do not consider Eastern Europe.

Results and contribution

The study investigates the relationships between Eastern European stock markets and FX rates using the GARCH process, adopting the BEKK representation developed by Engle and Kroner (1995). The relationships between stock markets, foreign exchange rates, and stock and FX rates within one country are tested. This research examines whether stock market moves influence the performance of FX rates and vice versa.

Evidence of direct linkages between the equity markets of Poland, Hungary, Russia, and the Czech Republic is found in terms of both returns and volatility. Similarly, interdependence between the FX rates of Poland, Hungary, Russia, and the Czech Republic is found. When analyzing the relationship between FX rates and stock markets, unidirectional volatility spillovers from foreign currency to stock markets in Poland, Hungary, and Russia are observed. However, Czech equity returns are also found to affect FX rates. Overall, the results of the second study show clear evidence of integration in Eastern Europe within the region. Moreover, the results show that currency risk matters, a finding consistent with earlier studies (Saleem and Vaihekoski, 2008, 2010).

4.3 Financial risk transfer in Emerging Eastern European stock markets: A sectoral perspective

Background and objective

The third article focuses on the contagion effects in Eastern European stock markets and changes in their interdependence following their accession to the EU in 2004. It examines specifically the relationships among the stock market sectors of Poland, Hungary, and the Czech Republic from 1998 to 2009 and their exposure to European stock markets.

Emerging economies that successfully weathered the recent crisis have attracted the interest of researchers. Over the past decade, these economies enjoyed higher GDP growth and demonstrated greater resilience to global shocks compared to their more advanced counterparts.

This study investigates the period when stock market sectors in Emerging Eastern Europe remained insulated from their counterparts in Western Europe, how well they retained a modicum of control over their own development, and whether they parried shocks that otherwise hit Europe's more integrated financial markets.

Results and contribution

The intra-industry relationship is examined for investment risk transfers in Emerging Eastern European stock markets and their linkage with the European Union stock market using a GARCH-BEKK model.

The results suggest that bidirectional shocks transfer risk between all local stock markets in Emerging Europe, highlighting the importance of the Polish, Hungarian, and Czech stock markets for other European stock markets.

Moreover, the results show that the Polish consumer goods sector, the Hungarian telecommunications sector and the Czech financial sector are all less integrated than their sectoral counterparts in Europe and other industries. Moreover, these sectors have unidirectional impact on the European stock markets. Thus, it is possible to construct the investment portfolio, which is partially isolated from changes in European economy, by investing in assets of these particular sectors.

Finally, the stock market interactions after EU accession are examined. The scope of shock transmissions between similar sectors on stock markets increases after EU accession, providing evidence of increasing integration of European stock markets and increasing susceptibility to contagion.

4.4 What types of macroeconomic announcements affect stock markets in Emerging Eastern Europe?

Background and objective

The fourth article continues the study of impacts from foreign and local macroeconomic announcements on Emerging Eastern Europe markets. The stock market and macroeconomic news data of Russia, Poland, Hungary, and the Czech Republic used cover the period 2006 to 2010. The study investigates whether the reaction of emerging stock markets to macroeconomic news is different from that in developed markets. Moreover, in this study the following question is addressed: whether foreign macroeconomic announcements are more significant for stocks than local macroeconomic news.

The effect of macroeconomic releases on stock markets has gained interest due to the recent financial crisis and contagion effects in financial markets. For investors seeking markets where their investments are isolated from global shocks, such markets may offer safe havens in the midst of widespread financial instability.

Although the impact of macroeconomic news on Eastern European stock markets has been widely investigated, the existing empirical literature does not address the impact of macroeconomic news released in geographically proximate and otherwise closely related countries.

Results and contribution

The results indicate the dependence of local stock markets from macroeconomic announcements generated in the same geographical area, supporting the hypothesis of stock market integration in Emerging Europe. The general finding is that macroeconomic news affects local stock market volatility and on rare occasions pricing of assets. The asymmetric effect in volatilities is more common for Emerging European stock markets, where shocks from negative news generate a higher level of next-period conditional volatility on the market compared with shocks from positive news.

The impact of local announcements across Emerging Eastern European countries varies depending on the identity of the news. Collectively, macroeconomic releases in Russia, Poland and the Czech Republic related to consumer, external and industry sectors, labor market or national accounts affect asset pricing. News related to external events, government and industry sectors, the labor market, money and finance, prices, surveys and cyclical indices impact volatility to some extent in all markets.

The impact of foreign macroeconomic announcements on market volatility is significant and differs across markets. In particular, volatility in the Russian market is affected by macroeconomic releases in the Czech Republic, whereas volatility in the Polish market follows macroeconomic indicator changes in Russia. Notably, the Polish and Hungarian releases do not significantly impact the volatilities of any emerging stock markets in the study, suggesting that Poland and Hungary are the least integrated of the selected Emerging European countries. The estimation outcomes show that foreign macroeconomic releases are more fundamental for Emerging Eastern European markets than local macroeconomic news.

5 DISCUSSION AND CONCLUSIONS

5.1 Empirical contributions

5.1.1 Contribution in the area of risk pricing

Habitual patterns for developed financial markets are not necessarily present in emerging markets; consequently, devising ways to price risk and distinguish the influences of global and local sources of risk are inherently challenging for researchers. Nevertheless, the rapid transformations of risk and capital market reforms offer a unique platform for an original analysis of risk pricing.

This thesis contributes to empirical research literature on the pricing of risk by providing evidence of stock market segmentation in Emerging Eastern Europe. Moreover, it is claimed that aggregate emerging market risk, as opposed to global market risk, appears to be the relevant driver of stock market returns that can be used for the pricing and forecasting of assets in emerging markets. Articles 1 and 2 of this dissertation demonstrate that currency risk is priced into emerging markets and that the difference between local and global interest rates may be used to model the time variation in the betas for global and local sources of risk. This variable is arguably key in measuring local economic conditions and financial stability and thus suitable for modeling risk sensitivity (Article 1).

5.1.2 Contribution in the area of market integration

Emerging Eastern European stock and currency markets are examined in a setting of regional influences. From the research perspective, these markets offer a dynamic natural experiment in opening up to foreign investment and world trade as well as increasing exposure to external shocks from global and regional financial markets.

Therefore, this thesis contributes to empirical research on financial market integration by providing evidence that equity markets and foreign exchange rates in Emerging Eastern Europe are linked in terms of both volatility and returns. The results show that pricing of securities at stock markets and FX rates are interdependent. With regard to interdependence between stock markets and FX rates, the spillovers found are primarily from FX rates to stock markets, suggesting that markets in Eastern Europe are integrated within the region (Article 2).

The study complements the research literature on integration effects and identifying opportunities for sectoral diversification in the selection of financial securities for investment portfolios. The importance of industries in Eastern European stock markets and the degree of market integration are considered before and after the 2004 accession to the EU. The study is the first to apply a GARCH-BEKK methodology to analyze interactions by sector in Emerging Eastern European markets (Article 3). The results presented in this thesis suggest that sectors of stock markets are interdependent in Emerging Eastern Europe. The Polish consumer goods sector, the Hungarian telecommunications sector and the Czech financial sector are to some extent less integrated with their sectoral counterparts compared to other industries. Thus, it is possible to construct the investment portfolio, which is partially isolated from changes in European stock market, by investing in assets of these particular sectors. Moreover, market integration after EU accession has increased, providing evidence of greater shock spillovers and, as consequence, susceptibility to contagion (Article 3).

The results further contribute to studies on integration by analyzing linkages between macroeconomic news releases and stock market performance in geographically proximate and otherwise related countries. The results suggest that stock markets follow macroeconomic announcements generated in the same geographical area. These findings support the hypothesis of integration in Emerging Eastern Europe (Article 4).

5.1.3 Contribution in the area of shocks and volatility spillovers

The results presented complement the empirical research literature on shocks and volatility spillovers. By studying linkages between financial markets in Eastern Europe, this thesis has shown the presence of shock and volatility spillovers in equity markets of Emerging Eastern Europe.

This study contributes to research on spillovers between foreign exchange rates and equity markets, providing evidence of unidirectional volatility spillovers from FX rates to stock markets in most of EEE countries. The study also finds the impact of the foreign exchange rates on asset returns in the period under study (Article 2).

Moreover, the results in this dissertation move knowledge on interactions between EEE countries and the EU. The estimated results suggest that shocks from one stock market spill over into other stock markets in Emerging Eastern Europe. However, there are particular stock markets sectors, which are partially segmented from European stock markets. Thus, utilizing the results of this dissertation it is possible to construct investment portfolio investing in these particular sectors, which will be partially segmented from European markets and might be more resistant to contagion effects. Moreover, the extent of spillovers between similar sectors increases after the 2004 EU accession (Article 3). Furthermore, macroeconomic news is found to affect commonly the volatility of the stock market and, in rare cases, asset pricing (Article 4).

5.1.4 Contribution in the area of macroeconomic announcements

The empirical literature lacks evidence on the impact of macroeconomic news released in geographically proximate and otherwise closely related areas on stock markets. The thesis contributes to the research on risk of contagion. The results in the dissertation show the significance of local and foreign macroeconomic releases on Eastern European stock markets.

The results provide evidence of the asymmetric effect in volatilities at the markets. Moreover, the impact of various types of news is diverse. Specifically, shocks from negative news impact future volatility greater than shocks from positive news. However, EEE markets follow identity of news, specifically, in Russia, Poland and the Czech Republic, macroeconomic releases related to consumer, external and industry sectors, the labor market and national accounts affect asset pricing. The news related to external, government and industry sectors, the labor market, money and finance, prices, surveys and cyclical indices impact price volatility to a lesser extent (Article 4).

The most important contribution in the area is that this study is among the first to analyze the impact of foreign macroeconomic news released in geographically proximate countries in Emerging Eastern Europe. The results suggest that the impact of foreign macroeconomic announcements (from closely geographically and otherwise related countries) on volatility differs significantly across markets. For example, Russian market follows macroeconomic releases from the Czech Republic, while Polish market follows changes in macroeconomic indicators in Russia. The Polish and Hungarian releases do not significantly impact any emerging stock markets in the study, suggesting that Poland and Hungary are less integrated with the EEE countries studied. Moreover, the foreign macroeconomic releases are more important for EEE markets compared with local macroeconomic news (Article 4).

5.2 Concluding remarks and implications

The main purpose of this dissertation was to investigate the returns and the financial risks involved in investing in Emerging Eastern European countries. The objective is to identify information on stock market development in Emerging Eastern Europe and the financial risks involved in investing in these markets. Armed with such knowledge, one could devise strategies for financial risk diversification to avoid global contagion effects. To study this hypothesis, eight research questions were posed.

The first article of the present dissertation answers the first question: *Are global and local sources of risk priced into Emerging Eastern European countries?* Motivating the study was the controversial role of global and local sources of risk in the empirical literature and challenges in devising ways to price risk in these markets. The conclusion of this article is that most markets exhibit extensive segmentation. The local aggregate emerging market portfolio, rather than the global market portfolio, is the primary driver for the countries. Moreover, country-specific currency and interest rate risks are significant sources of risk when investing in Eastern European countries, suggesting that investors care most about country-specific risks.

The second article asks: *Are Emerging Eastern European markets integrated, and if so, to what extent?* To answer this question, the relationships between stock prices and foreign exchange are investigated. The results of the study provide evidence of direct linkages between equity markets in terms of both returns and volatility. Similarly, interdependence between foreign exchange rates in Emerging Eastern Europe is found. Interestingly, while analyzing the relationship between foreign exchange and equity markets, unidirectional volatility spillovers from FX rates to stock prices is observed. Moreover, the Czech stock prices are found to affect the exchange rate. The overall results show that currency risk is a significant source of risk for investors and shows evidence of integration within the region for stock prices and exchange rates.

The third article focuses on contagion effects in Eastern European stock markets before and after the 2004 EU accession. This study addressed four questions. *Were Emerging Eastern 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 these stock markets play such a role?* Third: Are there certain stock markets sectors, which are partially isolated from the corresponding sectors of other European stock markets manifested in terms of stock returns and stock price volatility?*?* And finally: *Was there a significant change in the market interactions after the 2004 EU accessions of Poland, Hungary and the Czech Republic?*

The results suggest that bidirectional shocks transfer risk among all local stock markets. Moreover, the Polish consumer goods sector, Hungarian telecommunications sector and Czech financial sectors are found to be less integrated with their sectoral counterparts in Europe compared other industries. However, these sectors play a significant role for European markets, as their risk spills over to their counterparts, but they are strong enough to parry shocks from other market sectors. Finally, when the stock market interactions after the 2004 EU accession are examined, evidence of increased shock transmissions between similar sectors on stock markets is found. The results of this study support the hypothesis of increased integration in Eastern European markets and increasing susceptibility to contagion. These findings are consistent with those of Phylaktis and Xia (2009) and Kaltenhaeuser (2003). The third article provides evidence of partial segmentation in Eastern Europe and identifies opportunities for sectoral diversification in portfolio investments.

The fourth article examines Emerging Eastern European markets on the impact from foreign and local macroeconomic announcements. The final two questions asked are as follows: *Do macroeconomic announcements affect the pricing of stocks, and if so, what differences in the announcements make the stock market reaction vary?* And *does foreign news from geographically proximate and otherwise closely related countries affect local stock markets?* The estimated results show that Emerging

Eastern European stock markets depend on local and foreign macroeconomic announcements, supporting the hypothesis of stock market integration in Emerging Eastern Europe. The general finding is that macroeconomic news affects local stock market volatility and, in rare cases, even asset pricing in the long run. Moreover, an asymmetric effect on volatilities in the markets is found; shocks from negative news are found to generate higher levels of next-period conditional volatility compared to shocks from positive news.

The results show that the impacts of announcements are diverse for different categories of news. Nevertheless, macroeconomic news related to consumer, external and industry sectors, the labor market and national accounts as a rule affects asset pricing in Russia, Poland and the Czech Republic. News related to external, government and industry sectors, the labor market, money and finance, prices, surveys and cyclical indices impacts volatility in emerging Eastern European markets. The impact of foreign macroeconomic announcements on market volatility is obvious and varied across markets. In particular, volatility in the Russian market is influenced by macroeconomic releases from the Czech Republic, whereas volatility in the Polish market follows changes in Russian macroeconomic indicators. In both countries, foreign macroeconomic news is found to impact the stock markets by increasing the volatility of local markets. However, Polish and Hungarian releases are not found to impact the volatilities of any emerging stock markets in the study, suggesting that Poland and Hungary are less integrated with other Emerging European countries. The results reveal that foreign macroeconomic releases are more fundamental than local macroeconomic news for Emerging Eastern European markets.

This thesis begins with the proposal that some countries and particular industries are more highly integrated into regional and world financial processes than others and thus are more prone to contagion. The results of the analysis show that it is possible to ascertain markets providing risk-diversification opportunities and sectors isolated from changes in European financial markets. This finding would permit the application of portfolio management based on geographical and sectoral diversification to selected Emerging Eastern European markets. Assets in these countries and their industries may be treated as separate classes of investments. Moreover, this dissertation defines the risks in investing in Emerging Eastern

European markets and the most attractive markets with regard to return-to-risk ratios, enabling the construction of an effective investment portfolio based on the results of this study. The possibility of the flight to safe havens in the midst of widespread financial instability has obvious implications for portfolio managers in their risk diversification strategies.

Moreover, this thesis yields some useful insights for investors and portfolio managers rethinking the reallocation of their investment portfolios to protect value or obtain higher returns. The results have implications for asset pricing and portfolio selection for international financial institutions and portfolio managers assessing their investment decisions in light of macroeconomic news releases.

5.3 Limitations of the studies and suggestions for future research

The *first article* investigates whether global and local sources of risk are priced into Emerging Eastern European stock markets. The results do not provide strong and consistent support for the asset pricing model for partly segmented markets. Therefore, the relationship between risk and return in selected countries cannot be exhaustively explained by the CAPM model. Moreover, the approach uses unconditional implications of the asset pricing models. The country segmentation is based on the unlikely assumption of time-invariance.

The purpose of the *second article* is threefold: examine the linkages of Emerging Eastern European equity markets, investigate relationships between FX rates, and identify the interdependence between stock prices and exchange rates, if any. Unfortunately, this study mainly investigates intradependence among the financial markets within a particular country. It appears likely that equity markets are affected by both local currency markets and currencies of developed countries. The impact of such currencies on emerging countries is beyond the scope of this study.

The *third article* studies the contagion effects on Eastern European stock markets and changes in their interactions after the 2004 EU accession. It focuses on contagion effects in closely related countries in the same geographical area. However, Eastern European markets are part of the global financial community, and changes happening outside of Eastern Europe and the EU are likely to impact Eastern Europe. To further advance this research, it may be worthwhile to study the inter-industry dependence with the largest members of the EU and overseas markets. As in most studies of transition economies, the research method applied in this study does not consider changes in the global economy over a longer period. This research only covers the period 1998-2009, which includes the Russian financial crisis and the beginning of the global financial crisis in 2008. Regime-switching models may also be tested to obtain a more accurate description of stock market interactions and possible spillover effects in times of crisis.

The *fourth article* analyzes the impact of local and foreign macroeconomic announcements on Emerging Eastern European stock markets. This study is limited to releases in Emerging Eastern Europe. Macroeconomic announcements from other countries most likely also impact Eastern European stock markets and should be studied as well. Potential lines of research may be extended to studying the impacts of macroeconomic news releases in developed areas such as the EU (e.g., Germany and the UK) as well as the US and Japan. The research method applied does not consider changes in the global economy in the analyzed period. VAR models could be evaluated to determine whether they have greater explanatory power for certain effects of macroeconomic announcements on stock markets in Emerging Eastern Europe.

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Ministry of Finance of the Czech Republic www.mfcr.cz.

National Bank of Hungary www.mnb.hu.

National Bank of Poland www.nbp.pl.

Polish stock exchange www.wse.com.pl.

Russian stock exchanges www.micex.com, www.rts.ru, www.spbex.ru.

Slovenian stock exchange www.ljse.si.

Statistical office of the Republic of Slovenia www.stat.si.

The Economist: Economist Intelligence Unit www.eiu.co.

The World Bank www.worldbank.org.

United Nations Population Division www.un.org.

APPENDICES

Appendix 1. Definitions

Asset pricing

Financial science usually assumes asset pricing to be a process of determining the appropriate price of a financial security at given levels of risk and future profit. This approach serves as a model for pricing risky assets. General models for asset pricing are discussed in the theoretical literature with many refinements suggested. Among the commonly used methodologies is the Capital Asset Pricing Model, whereby the expected return of a security equals the rate of a risk-free security plus a risk premium multiplied by the systematic risk of the asset.

Country risk

Country risk in the financial literature refers to the group of risks associated with the investment of capital in securities of a particular country. Country risk varies across countries and sweeps within its umbra such risks as economic, political, exchange rate, sovereign and transfer risk, as well as other specific risks. Country risk must be considered when investing in a country, as this risk may reduce the expected return on an investment. Before making a foreign investment, the investor often compares the target country's risk to risk in stable, developed economies to develop a sense of the likelihood of the investment's success or failure.

Emerging markets

The term "emerging markets" was suggested in 1981 by Antoine W. Van Agtmael of the International Finance Corporation of the World Bank to replace the derogatory-sounding term "less economically developed countries."

The concept of an emerging market is generally understood to include countries making the transition from developing to developed status. The term "large emerging market economies" includes such countries as Brazil, China, Egypt, India, Indonesia, Mexico, the Philippines, Poland, Russia, South Africa, South Korea and Turkey.

What constitutes “emerging” is constantly evolving and difficult to establish. In 2010, Morgan Stanley Capital International classified as global emerging markets Brazil, Chile, China, Colombia, the Czech Republic, Egypt, Hungary, India, Indonesia, Malaysia, Mexico, Morocco, Peru, the Philippines, Poland, Russia, South Africa, South Korea, Taiwan, Thailand, and Turkey.

For the sake of brevity, other terms have come into use. These include BRIC (Brazil, Russia, India, and China), Next Eleven (Bangladesh, Egypt, Indonesia, Iran, Mexico, Nigeria, Pakistan, the Philippines, South Korea, Turkey, and Vietnam), and the CIVETS Group (Colombia, Indonesia, Vietnam, Egypt, Turkey, and South Africa).

Financial contagion

The financial contagion of economies reflects the susceptibility of the financial processes in an otherwise healthy economy to shocks from a financial institution, an industry, or another country. The collapse of Lehman Brothers in 2008, for example, undermined confidence in US financial markets, with this lack of confidence then spreading to Europe. The domino effect of financial problems in various countries highlighted both the interconnectedness of global financial institutions and the relative isolation of certain financial systems such as India and community banks in the US. Financial contagion has a generally negative connotation but also provides opportunities for speculators.

Financial integration

Financial integration is a process whereby one market or economy becomes more integrated with other markets, economies, and the rest of the world. Financial integration is attractive to providers of financial services, as it eliminates barriers across economies and allows for consolidation and economies of scale. Moreover, the law of one price is expected to hold in financially integrated markets, so assets may be expected to generate similar returns. Conversely, the process of integration deprives investors of opportunities for risk diversification and balancing returns against risk. The extent of financial integration of two or more economies may be measured by comparing the returns and cash flows of assets in these different economies.

Financial market segmentation

Financial market segmentation describes how a particular country's financial market differs from and is unique relative to markets elsewhere and thus provides investors with an opportunity for risk diversification. It is often difficult to determine how segmented, partially segmented, or integrated a county actually is, as countries are often too large to assess or too open to foreign investment. Many ways of defining the level of market segmentation are discussed in the research literature.

Leverage effect

The relationship between risk and return has been studied extensively in financial markets. A common finding in empirical studies is that an inverse correlation exists between shocks to stock returns and volatility. Therefore, the leverage effect in financial markets is an effect that corresponds to a negative correlation between past returns and future volatility. The various single correlations quantifying the leverage effect have been measured and discussed within GARCH models.

Macroeconomic announcement

A macroeconomic announcement may be a scheduled event, such as the release of information about national macroeconomic indicators. This announcement may be an economic index, an economic summary, or an earnings report. It may also be unscheduled news about economic indicators, such as the national unemployment rate, industrial production, gross domestic product, money supply, central bank rates, national reserves, the current account balance, the foreign trade balance, the business climate, or the consumer price index.

A macroeconomic announcement provides insight into national economic trends and may provide investors and financial institutions a basis for setting expected asset returns. Macroeconomic announcements may affect both domestic and foreign financial markets. The research literature distinguishes between scheduled macroeconomic announcements, where the strength of the effect is determined by the degree to which the information defies market expectations (announcement effect) and new information for the market in the form of unexpected macroeconomic announcements (surprise effect).

Spillover effect

A spillover effect in financial markets refers to the impact of economic activity elsewhere that somehow impacts economies, markets or sectors not directly involved in the activity. For example, a macroeconomic announcement released in one country may influence stock prices and currency exchange rates in another country. Globalization has made financial markets interdependent, so spillover effects are familiar. Political and economic reforms in financial markets in one country or region regularly influence market developments elsewhere.

Appendix 2. Macroeconomic indicators for Emerging Eastern Europe

Indicator	Bulgaria			Czech Republic			Hungary		
	2011	2012[f]	2013[f]	2011	2012[f]	2013[f]	2011	2012[f]	2013[f]
Population, mn[1]	7.4	7.4	7.3	10.5	10.6	10.6	10.0	9.9	9.9
Nominal GDP, US$ bn[2]	52.5	50.1	50.9	218.5	207.8	205.3	157.0	139.4	156.0
Nominal GDP, loc. curr. bn[3]	73.8	76.1	79.9	3864.8	3947.4	4073.2	30021.8	30796.9	32762.5
GDP per capita, US$[4]	7048	6774	6930	20744	19671	19387	15756	14010	15705
Real GDP growth, % change y-o-y[5]	2.1	1.1	2.3	1.7	0.1	1.3	1.6	-1.5	2.0
Unemployment, % of labor force[6]	11.4	12.0	10.5	8.6	8.3	6.5	10.7	10.0	7.0
Budget balance, % of GDP[7]	-2.1	-2.1	-1.7	-3.8	-3.6	-3.3	-5.8	-4.5	-3.0
Exchange rate® loc. curr./US$[8]	1.51	1.46	1.57	19.75	18.12	18.92	243.0	201.5	204.0
Exchange rate® loc. curr./EUR[9]	1.96	1.96	1.96	25.57	22.64	23.65	305.2	270.0	255.0
Total external debt stock, US$mn[10]	51726.4	49960.1	48922.2	92671.8	90810.0	91229.7	24537.7	25521.1	27329.2
Total external debt stock, % of GDP[11]	98.6	99.7	96.0	42.4	43.7	44.4	156.3	183.1	175.2

Sources: Bulgaria: 1 – World Bank/UN/BMI; 2, 3, 4 and 5 – National Statistical Institute; 6 – UN Population Division; 7 – Finance Ministry/BMI; 8 and 9 – BMI; 10 and 11 – Bulgarian National Bank/BMI. Local currency is a Bulgarian lev.

Czech Republic: 1 – World Bank/UN/BMI; from 2 till 6 – Czech Statistical Office/BMI; 7 – Czech Ministry of Finance/BMI; 8 and 9 – BMI; 10 and 11 – Czech National Bank/BMI. Local currency is a Czech koruna.

Hungary: 1 – World Bank/UN/BMI; 2, 3, 4, 5 and 6 – Hungarian Central Statistical Office/BMI; 7 – Hungarian Ministry of National Economy/BMI; 8 and 9 – BMI; 10 and 11 – National Bank of Hungary/BMI. Local currency is a Hungarian forint.

f – forecasts

® – value at end of year

Indicator	Poland			Russia			Slovenia		
	2011	2012[f]	2013[f]	2011	2012[f]	2013[f]	2011	2012[f]	2013[f]
Population, mn[1]	38.3	38.3	38.3	142.8	142.7	142.6	2.0	2.0	2.0
Nominal GDP, US$ bn[2]	516.5	513.8	609.1	1709.1	1737.5	2043.4	45.5	49.8	48.4
Nominal GDP, loc. curr. bn[3]	1531.0	1623.0	1717.1	50261.3	55064.4	60995.5	36.2	37.2	38.7
GDP per capita, US$[4]	13485	13410	15889	11966	12176	14334	24740	23495	23648
Real GDP growth, % change y-o-y[5]	4.0	2.6	3.2	3.3	3.2	4.2	0.5	0.3	1.7
Unemployment, % of labor force[6]	11.5	10.7	10.0	6.6	7.1	7.0	8.7	8.0	7.6
Budget balance, % of GDP[7]	-4.2	-3.3	-2.1	-1.4	-1.0	-0.3	-5.5	-4.5	-3.5
Exchange rate® loc. curr./US$[8]	3.15	3.09	3.05	32.18	31.20	28.50	0.77	0.80	0.80
Exchange rate® loc. curr./EUR[9]	4.07	3.86	3.81	40.42	41.81	35.63	1	1	1
Total external debt stock, US$mn[10]	359366.0	403184.4	439080.2	555560.9	657838.2	780836.0	4945.9	5732.0	5541.8
Total external debt stock, % of GDP[11]	69.6	78.5	72.1	32.5	37.9	38.2	108.7	115.1	114.5

Sources: Poland: 1 – World Bank/UN/BMI; 2 to 5 – EUROSTAT/BMI; 6 – UN Population Division; 7 – BMI/ Ministry of Finance; 8 and 9 – BMI; 10 and 11 – National Bank of Poland/BMI. Local currency is a Polish zloty.

Russia: 1 – World Bank/UN/BMI; from 2 till 5 – Federal State Statistics Service/BMI calculation; 6 – Rosstat/IMF; 7 – Ministry of Finance/BMI calculations; 8 – BMI; 9 – author's calculation; 10 and 11 – Central Bank of Russia/BMI calculation. Local currency is a Russian ruble.

Slovenia: 1 – World Bank/UN/BMI; 2 – author's calculation; from 3 till 5 – Statistical Office of Slovenia//BMI calculation; 6 – Statistical Office of Slovenia/IMF; 7 – BMI/ Ministry of Finance; 8 – BMI; 9 and 10 –Bank of Slovenia/BMI calculation. Local currency is an euro (since January 1, 2007).

[f] – forecasts

® – value at end of year

Appendix 3. Several measurements of Emerging Eastern European stock markets

Figure 1 shows the development of market capitalization in Eastern European stock markets. All market capitalization values are scaled to one in 1995.

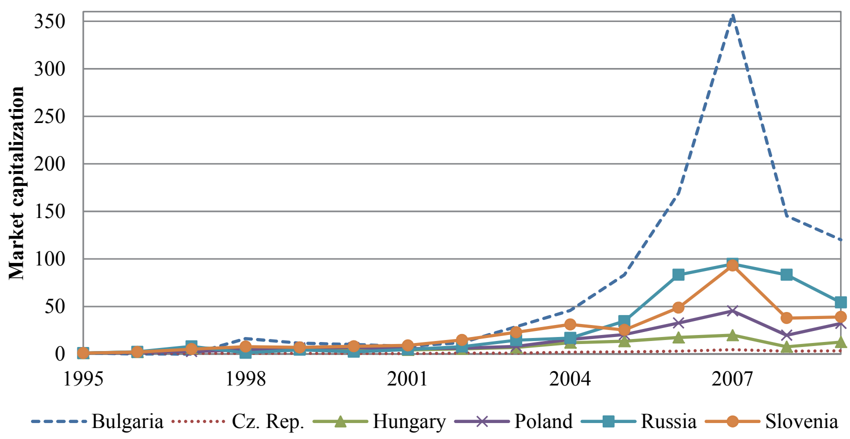

Figure 1. Development of market capitalizations in Emerging Eastern European countries

Figure 2 tracks the number of listed companies in Emerging Eastern European stock markets from 1995 to 2009.

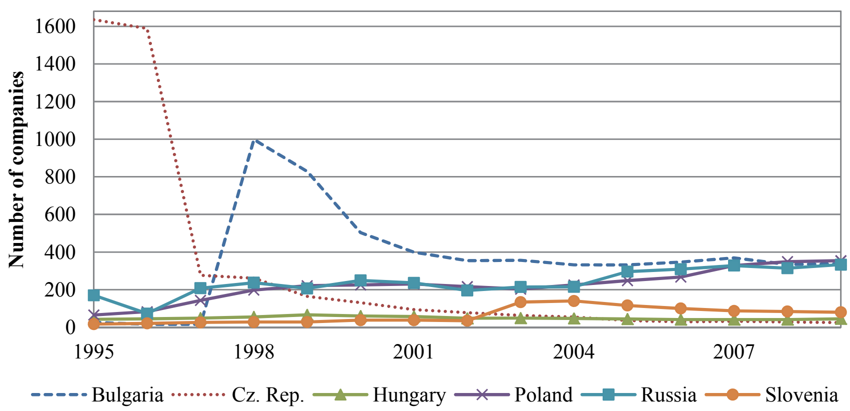

Figure 2. Number of listed companies on Emerging Eastern European stock markets

Trading value is another measure of market size. Here, it is introduced as the ratio of the total value of shares traded to GDP. In other words, this measurement represents *market liquidity*, which refers to the ability of investors to easily buy and sell securities. Figure 3 presents market liquidity in Eastern Europe.

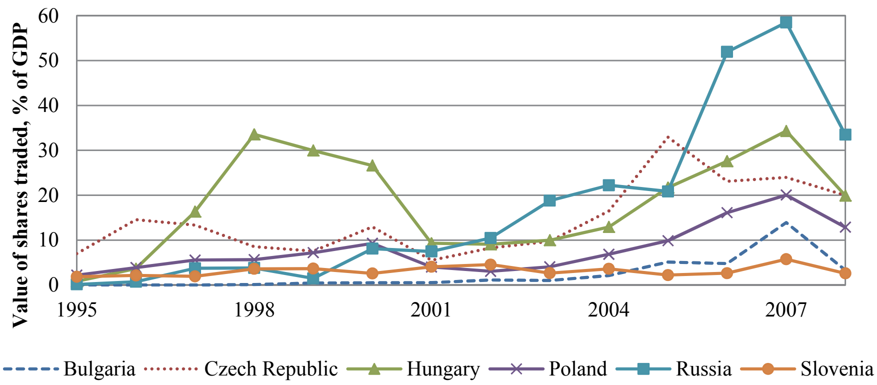

Figure 3. Market liquidity in Eastern European countries

Another measurement showing stock market development is the *turnover ratio*. This benchmark is calculated as the value of shares traded divided by market capitalization.

Figure 4 shows the turnover ratio for Eastern European markets from 1995 to 2009.

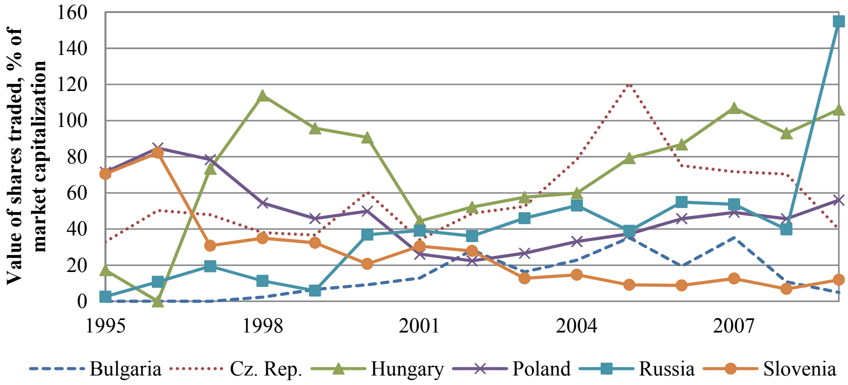

Figure 4. Turnover ratio on Emerging Eastern European stock markets

PART II: THE ARTICLES

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Global and Local Sources of Risk in Eastern European Emerging Stock Markets*

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Abstract
We study a pricing model for global and local sources of risk in six Eastern European emerging stock markets. Utilizing GMM estimation and an unconditional asset-pricing framework with and without time-varying betas, we perform estimations based on monthly data from 1996 to 2007 for Poland, the Czech Republic, Hungary, Bulgaria, Slovenia, and Russia. Most of these markets display considerable segmentation; the aggregate emerging market risk, as opposed to global market risk, is the significant driver for their stock market returns. It also appears that currency risk is priced into stock prices. The difference between local and global interest rates can be used to model the time-variation in the betas for both sources of risk.

1. Introduction

International investors and researchers have been drawn to emerging markets because of their rapid economic development, high returns, and potential for diversification as well as because of the series of reforms on these capital markets. The big challenges for researchers, in turn, have been devising ways to price risk and distinguish the roles of global and local sources of risk in these markets. Several empirical studies find market segmentation is typically larger in emerging markets than in developed markets, suggesting that local sources of risk are more critical than international sources (e.g. Korajczyk, 1995; Shackman, 2005). On the other hand, Bekaert and Harvey (1995), who test a two-factor asset-pricing model in which the conditional expected returns of a country are affected by global and local sources of risk, see evidence of a rising role for global sources of risk and a diminishing role for local risk sources.

The more recent literature is mixed on the subject of financial integration. Tai (2006) and de Jong and de Roon (2005) claim markets become more integrated after equity market liberalization. Brooks and Del Negro (2002), on the other hand, note that Europe has become more integrated while elsewhere segmentation has lately increased. Some researchers see no evidence of increased integration over time (e.g. King and Segal, 2008).

Most papers on currency risk in emerging markets conclude that it is priced on stock markets (e.g. De Santis and Imrohoroglu, 1997; Tai, 2006; Saleem and Vaihe-

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koski, 2008). However, the role of currency risk is still somewhat controversial. Several papers assume that investors can hedge country-specific currency risk and that multilateral currency risk is the sole form of currency risk that matters. Other papers have found support for the pricing of bilateral currency risk (see e.g. Antell and Vaihekoski, 2007).

Here, we study the role of global and local sources of risk in six Eastern European stock markets: Russia, Poland, Hungary, the Czech Republic, Bulgaria, and Slovenia. We test for whether aggregate emerging market risk in the sample countries is priced together with currency risk (bilateral or multilateral). In addition, we test a conditional version of the pricing model that allows the betas to vary over time linearly on one variable – the interest difference between local and global short-term interest rates. This variable is arguably key in measuring the local economic conditions and financial stability, and hence suitable for modeling risk sensitivity. Our sample period runs from 1996 to 2007. All sample countries displayed high growth during the observation period and offered local and foreign investors a wide range of investment opportunities.

The paper is organized as follows. The second section presents the theoretical background and the empirical formulation of the testable model. Section 3 introduces the sample countries and the data used in the study. Section 4 provides descriptive statistics for the data and presents the results from the analysis. Concluding remarks and suggestions for future research are stated in Section 5.

2. Research Methodology

2.1 Theoretical Background

Under full integration, expected returns on assets should be the same after adjusting for their risk characteristics. A stock market is considered legally integrated when the state and the exchange impose no restrictions on securities transactions of local or foreign investors seeking to diversify their investment portfolios in international capital markets. With financial market integration, we assume assets in all national markets have the same set of risk factors and accordingly the same risk premium for each factor (though not the same risk sensitivity).

Adler and Dumas (1983) contend that the global value-weighted market portfolio is the relevant risk factor. If investors do not hedge against exchange rate risks and a risk-free asset exists, the conditional version of the world capital asset-pricing model (CAPM) implies the following restriction for the nominal excess returns:

$$E_t\left[r_{i,t+1}\right] = \beta_{i,t+1} E_t\left[r_{m,t+1}\right] \quad (1)$$

where $E_t[r_{i,t+1}]$ and $E_t[r_{m,t+1}]$ are the conditional expected excess returns on asset i and the global market portfolio at time t. All returns are measured in excess of the risk-free rate of return r_{ft} for the period t to t+1 in the numeraire currency. Currency risk is not priced, as investors diversify away from it as they do for the idiosyncratic risk of companies. Note that the model also holds for the local market portfolio since the local market portfolio is tradable.

While the basic world CAPM can be used to get the expected excess returns on an integrated stock market, real-world markets are not fully integrated into the world equity market. Errunza and Losq (1985), therefore, suggest we include a local risk factor for partially segmented markets. Hence, for any asset *i,* the excess return is given by the following model:

$$E_t\left[r_{i,t+1}\right]=\beta_{i,t+1}^{g}E_t\left[r_{gm,t+1}\right]+\beta_{i,t+1}^{l}E_t\left[r_{lm,t+1}\right] \tag{2}$$

where *g* and *l* refer to the global and local market portfolios and betas, respectively.

Moreover, any investment in a foreign asset is always a combination of investment in the performance of the asset itself and the movement of the foreign currency relative to the domestic currency. Adler and Dumas (1983) show that where purchasing power parity (PPP) does not hold, investors treat real returns differently and thus seek to hedge against exchange rate risks.[1] Specifically, the risk induced by PPP deviations is measured as the exposure to inflation risk and the relevant currency risk. Assuming domestic inflation is non-stochastic over short periods of time, the PPP risk contains only the relative change in the exchange rate between the numeraire currency and the currency of C+1 countries (e.g. De Santis and Gérard, 1998). In this case, the conditional asset-pricing model for partially segmented markets implies the following restriction for the expected return of asset *i* in the numeraire currency:

$$E_t\left[r_{i,t+1}\right]=\beta_{i,t+1}^{g}E_t\left[r_{gm,t+1}\right]+\beta_{i,t+1}^{l}E_t\left[r_{lm,t+1}\right]+\sum_{c=1}^{C}\beta_{i,t+1}^{c}E_t\left[r_{c,t+1}\right] \tag{3}$$

where $\beta_{c,t+1}$ is the conditional currency beta for currency *c*. Unfortunately, this model becomes intractable when *C* is large. Thus, one must focus on a subset of currencies or use a more parsimonious measure for currency risk. Taking from Ferson and Harvey (1993) and Harvey (1995b) on the use of a single aggregate exchange risk factor to proxy for deviations from PPP, the model (3) boils down to a three-factor model.

2.2 Empirical Formulation and Econometric Considerations

We test our asset-pricing models with estimations obtained with the generalized method of moments (GMM).[2] The GMM is efficient among the class of instrumental estimators defined by orthogonality conditions (Greene, 2008). The GMM method also has the advantage of not relying on the assumption of normally distributed asset returns; a disturbance term can be both serially dependent and conditionally heteroskedastic (MacKinlay and Richardson, 1991). This feature of GMM is particularly beneficial in studies using returns from emerging markets, as they have often been found to be non-normally distributed and show serial correlation (e.g. Harvey, 1995b).

[1] Currency risk may enter indirectly into asset pricing if companies are exposed to unhedged currency risk (e.g. through foreign trade or foreign debt). Empirical evidence has found conflicting support for the pricing of foreign exchange rate risk (e.g. Jorion 1990, 1991; Roll, 1992; De Santis and Gérard, 1997, 1998; and Doukas, Hall, and Lang, 1999).

[2] The GMM was first introduced by Hansen (1982) for the estimation and testing of a wide range of econometric models. It has since been used for a wide range of econometric applications. Currently, the GMM approach predominates in parameter estimation and hypothesis testing of time-varying parameter CAPM and latent variables models.

The unconditional beta pricing relation here implies the following error terms for asset i, $u_{it} = r_{it} - \alpha_i - \boldsymbol{F}_t\boldsymbol{\beta}_i$, where r_{it} is the realized excess return, α_i is the pricing error (Jensen's alpha), $\boldsymbol{F_t}$ is a $1 \times K$ vector of excess risk factor returns, and $\boldsymbol{\beta}_i$ is a $K \times 1$ vector of risk sensitivities (betas). Since all our risk factors are tradable, the asset-pricing model implies that pricing errors are zero when the model holds and the risk factors used are multifactor-efficient. The orthogonality conditions implied by the model are against the risk factor returns and the constant. The model is fully identified, as the number of orthogonality conditions and parameters are the same.

3. Data

We conduct our tests on six Eastern European countries over the sample period of January 1996 to December 2007. Although most Eastern European countries opened stock markets in the early 1990s, thinness of trading makes the initial data unreliable. High quality data series do not become available until mid-decade as the markets find their feet. Tests are conducted from a US investor's point of view, so all returns are measured in US dollars. We use monthly continuously compounded asset returns based on month-end observations of total return market indices. For calculating excess returns, we apply a one-month holding period return calculated from the one-month Eurodollar rate using the approach recommended in Vaihekoski (2007). All data are extracted from Thomson Datastream, with the exception of the US currency index, which is taken from the US Federal Reserve Economic Data (FRED) database.

3.1 Sample Countries and Test Assets

While all six sample countries (Russia, Poland, Hungary, the Czech Republic, Bulgaria, and Slovenia)[3] have made the transition from communist to capitalist systems, their economic and political developments diverge in many respects. Five have joined the EU (Poland, Hungary, Czech Republic, and Slovenia in May 2004, and Bulgaria in January 2007), while Russia has never entertained the notion of EU membership. Slovenia adopted the euro in January 2007, while the other countries retain their own currencies.

While the sample countries had stock markets before WWI, their stock exchanges were closed during the communist era. Slovenia was the first to re-establish its exchange (Ljubljana Stock Exchange, 1989), followed by Hungary (Budapest Stock Exchange, 1990), Bulgaria (Bulgarian Stock Exchange–Sofia, 1991), and Poland (Warsaw Stock Exchange, 1991). The Russian stock market (Moscow Stock Exchange) opened in 1992 and the Prague Stock Exchange in the Czech Republic in 1993. At the outset, the Russian and Czech stock markets were clearly in a league of their own in terms of size compared to the other stock markets in the sample (see *Table 1*). During the sample period, the Russian stock market quickly emerged as the largest by far, even though all stock markets in the sample increased in size several fold.

[3] The countries were selected on the basis of availability of the MSCI or IFC total return stock market indices for the full sample period. These indices are typically available only few years after the opening of the stock market. As a result, three potential countries were excluded from this study: Slovakia (Bratislava Stock Exchange, established in 1991), Romania (Bucharest Stock Exchange, 1995), and Ukraine (PFTS Stock Exchange, 1997).

Table 1 Sample Market Capitalizations, 1995 and 2005
End-of-period levels (USD million)

Country	1995	2005
Bulgaria	61,0	5,086
Czech Republic	15,664	38,345
Hungary	2,399	32,576
Poland	4,564	93,873
Russia	15,863	548,579
Slovenia	1,235	7,899

Sources: Emerging Market Factbook (1999) and Global Stock Markets Factbook (2006).

As test assets in the analysis, we utilize market portfolios from each sample country. As a proxy for the local market portfolios, we use the ever-popular MSCI and International Finance Corporation (IFC) indices.[4] All indices strive to provide wide coverage, while excluding the most illiquid companies. They are also adjusted for stock splits and new issues, and include gross dividends (total pre-tax return for investors).

3.2 Risk Factors

We now test the pricing of three different sources of risk in our sample countries. Global market risk is proxied using the global equity market portfolio with returns calculated from the MSCI world equity total return index. This approach has frequently been used in earlier studies (e.g. Bekaert and Harvey, 1995; De Santis and Gérard, 1998; and Hunter, 2006).

Risk due to market segmentation is proxied using an aggregate emerging market portfolio. Returns are calculated from the aggregate Datastream emerging market total return index.

For exchange rate risk, we consider two proxies. The first is the broad, trade--weighted, US currency index – an aggregate, multilateral currency index that weights the average foreign exchange value of the US dollar against the currencies of 26 major US trading partners, including the euro area, Canada, Japan, and several major emerging markets. The trade-weighted US currency index has also been used in previous studies (e.g. Harvey, 1995a). Our second proxy is the bilateral country-specific exchange rate change against the US dollar. Returns are calculated as the reverse logarithmic difference in the index or exchange rates.[5]

Table 2 contains summary statistics for the monthly returns of the test assets and risk factors. Panel A in *Table 2* contains the first four moments. The average returns and volatilities are annualized. The mean returns for the world and emerging stock equity markets are 8.3 % and 14.1 % annually. The risk-free rate is 4.2 on average over the sample period. Out of the sample countries, the Russian stock market provides US investors with the highest returns 26.9 % per annum. The Bulgarian stock market performs the worst; its mean return is -9.2 % during the analyzed pe-

[4] We use mainly MSCI indices following earlier studies, but IFC indices are used in the case of Bulgaria and Slovenia as the MSCI indices do not cover the full sample period.

[5] Higher index values indicate US dollar appreciation. Thus, *ceteris paribus*, an investment in a foreign currency asset gives a negative return if the US dollar appreciates during the investment period.

Table 2 Descriptive Statistics for the Asset Returns

Panel A reports descriptive statistics for the continuously compounded returns on the world market portfolio, risk-free asset, emerging market aggregate portfolio, and six Eastern European emerging markets. *Panel B* reports pair-wise correlations for the return series. The index series are from Morgan Stanley Capital International (MSCI) and the International Finance Corporation (IFC). The sample period runs from January 1996 to December 2007 and includes 144 monthly observations. All returns are calculated in US dollars and include dividends (i.e., the total return). The risk-free rate is calculated from the Eurodollar rate. The values for the mean and standard deviation 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]				$Q(12)$[b]
Asset return series	(%)	(%)		kurtosis	(*p*-value)	ρ_1	ρ_2	ρ_3	ρ_{12}	
Panel A: Summary statistics										
World market portfolio	8.332	13.756	-0.804	4.171	<0.001	0.049	-0.057	0.041	0.096	0.781
Emerging markets, aggregate	14.108	21.826	-1.112	5.964	<0.001	0.175*	0.122*	0.013	0.008	0.425
Risk-free rate	4.178	0.529	-0.564	1.832	<0.001	0.970*	0.961*	0.951*	0.645*	<0.001
Russia	26.866	59.781	-1.216	8.786	<0.001	0.125	-0.139	0.051	-0.028	0.040
Poland	13.750	34.669	-0.538	4.914	<0.001	-0.088	-0.113	0.045	0.046	0.261
Hungary	23.604	34.826	-0.697	7.580	<0.001	-0.033	-0.205*	0.078	0.066	0.100
Czech Republic	22.378	28.053	-0.649	5.138	<0.001	0.035	-0.061	-0.086	-0.012	0.119
Bulgaria	-9.244	51.730	-1.697	10.685	<0.001	0.245*	0.208*	0.113*	0.063*	<0.001
Slovenia	23.231	25.753	0.705	5.340	<0.001	0.101	-0.009	0.006	0.072	0.833
Panel B: Pair-wise correlations	World	Risk-free	Russia	Poland	Hungary	Czech	Bulgaria	Slovenia	EM	
World market portfolio	1	0.009	0.485	0.558	0.534	0.357	0.027	0.115	0.679	
Risk-free rate		1	-0.040	-0.066	-0.095	-0.198	-0.275	-0.115	-0.158	
Russia			1	0.407	0.532	0.373	-0.084	0.027	0.678	
Poland				1	0.688	0.609	-0.024	0.165	0.659	
Hungary					1	0.627	-0.025	0.275	0.570	
Czech Republic						1	0.088	0.152	0.560	
Bulgaria							1	-0.075	0.090	
Slovenia								1	0.163	
Emerging markets, aggregate									1	

Notes: [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 that autocorrelation coefficients up to 12 lags are zero.

Table 3 Descriptive Statistics for Bilateral and Multilateral Exchange Rate Changes Against the US Dollar

Panel A reports descriptive statistics for the first logarithmic differences in several exchange rates against the US dollar, as well as the multilateral trade--weighted US currency index. *Panel B* reports pair-wise correlation coefficients between the variables. The sample period runs from January 1996 to De-cember 2007 and includes 144 monthly observations. The values for the mean and standard deviation 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]				$Q(12)$[b]
Currency exchange rate	(%)	(%)		kurtosis	(*p*-value)	ρ_1	ρ_2	ρ_3	ρ_{12}	
Panel A: Summary statistics										
Trade-weighted currency index	-0.288	4.288	-0.045	3.203	0.863	0.172*	-0.025	0.093	0.012*	0.041
Russia	-13.880	20.528	-7.200	59.283	<0.001	0.480*	0.138*	0.242*	0.032*	<0.001
Poland	0.112	10.548	0.003	2.962	0.996	0.074	-0.048	0.007	0.091	0.562
Hungary	-1.776	10.343	-0.018	3.296	0.766	-0.008	0.007	0.068	0.059	0.118
Czech Republic	3.219	11.692	0.156	3.421	0.439	0.003	0.017	0.111	0.043	0.935
Bulgaria	-24.461	38.083	-4.446	26.973	<0.001	0.485*	0.235*	0.155*	0.046*	<0.001
Slovenia	-2.221	9.166	0.146	3.026	0.773	0.123	0.035	0.012	0.054	0.360
Panel B: Pair-wise correlations	TWCI	Russia	Poland	Hungary	Czech R.	Bulgaria	Slovenia			
Trade-weighted currency index	1	0.046	0.618	0.668	0.646	0.283	0.701			
Russia		1	0.133	0.076	-0.004	-0.009	-0.046			
Poland			1	0.718	0.664	0.277	0.605			
Hungary				1	0.731	0.323	0.762			
Czech Republic					1	0.276	0.799			
Bulgaria						1	0.374			
Slovenia							1			

Notes: [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 that autocorrelation coefficients up to 12 lags are zero.

Table 4 Descriptive Statistics for the Country-Specific Information Variables

Panel A reports descriptive statistics for the country-specific interest rate difference between the country's short-term interest rate and the Eurodollar one-month rate change. The sample period runs from January 1996 to December 2007 and includes 144 monthly observations. The *p*-value for the Jarque-Bera test statistic of the null hypothesis of normal distribution is provided in the table.

D_INT_D	Mean (%)	Std. dev. (%)	Skewness	Excess kurtosis	Normality (p-value)	Autocorrelation[a]				Q(12)[b]
						ρ_1	ρ_2	ρ_3	ρ_{12}	
Panel A: Summary statistics										
Russia	-0.581	8.336	2.141	31.203	<0.001	-0.296*	-0.175*	0.185*	0.089*	0.011
Poland	-0.138	0.705	-0.008	7.252	<0.001	0.048	0.145	0.184*	-0.309*	<0.001
Hungary	-0.151	0.797	-0.380	11.843	<0.001	-0.119	0.208*	-0.066*	-0.010*	0.043
Czech Republic	-0.049	3.207	3.307	72.783	<0.001	-0.389*	-0.085*	-0.007*	0.011*	0.022
Bulgaria	-0.204	21.963	2.563	54.322	<0.001	-0.056	-0.111	-0.047	-0.054*	0.001
Slovenia	-0.033	0.998	0.008	4.829	<0.001	-0.271*	0.159*	0.063*	0.022*	0.025
Panel B: Pair-wise correlations	Russia	Poland	Hungary	Czech Rep.	Bulgaria	Slovenia				
Russia	1	0.080	0.129	-0.020	0.037	0.102				
Poland		1	0.178	-0.047	0.042	0.052				
Hungary			1	0.054	-0.012	0.273				
Czech Republic				1	-0.015	0.058				
Bulgaria					1	-0.086				
Slovenia						1				

Notes: [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 that autocorrelation coefficients up to 12 lags are zero.

riod.[6] As one would expect, the world portfolio and emerging market aggregate portfolio have the lowest standard deviations (13.76 and 21.83, respectively). All sample countries display surprisingly high volatility, with Russia having the highest standard deviation (59.78%).

To check the null hypothesis of normal distribution, we use the Jarque-Bera test statistic (*p*-values reported). All return series show evidence against normal distribution. In addition, we study the autocorrelation in the returns. We report the first three autocorrelation coefficients and Ljung-Box test statistic (12 lags) for each return series. Somewhat surprisingly, only Bulgaria shows evidence of first-order autocorrelation.

Panel B in *Table 2* reports pair-wise correlations among asset returns. The emerging market aggregate index is highly correlated with the world one (0.679). The highest correlation between the sample countries is between the Hungarian and Polish stock markets (0.688). Bulgaria and Slovenia show fairly low values of correlation.

Table 3 reports descriptive statistics for changes in bilateral and multilateral exchange rates. The values for the means and standard deviations are again annualized to get the average depreciation (appreciation) rate for the currency. Panel A shows the US currency was surprisingly stable during the sample period (volatility of 4.288 % per annum), depreciating only slightly overall (mean return 0.288 % p.a.) against the currencies of major trade partners. In sub-period analysis, the dollar appreciates up to 2003 before the trend reverses. This is not the case for most of the sample countries. The Bulgarian lev lost the most value against the dollar during sample period (-24.46 % per annum, on average). The Russian ruble also sees an annualized depreciation of -13.88 %. The Polish zloty and the Czech koruna, on average, appreciate slightly against of the dollar: 0.11 % and 3.22 %, respectively. All the sample countries also show high volatility in their exchange rate changes with Bulgarian lev having the highest standard deviation (38.08 % per annum). There is also evidence of autocorrelation for most of the currencies.

Panel B in *Table 3* reports pair-wise correlations among country bilateral and multilateral exchange rate changes. The Russian rouble exchange rates are not highly correlated with the exchange rates of the other countries in our analysis. The Bulgarian exchange rates correlate with most countries, but not as highly as the exchange rates of the other countries.

3.3 Information Variables

Following earlier studies, we use conditioning variables to model the time--variation in the betas. We choose local information variables to do this. Due to our short sample periods, we limit the number of parameters in the estimation and, as a result, we pick only one variable that potentially can show evidence of increases (or decreases) in a country's sensitivity to the selected sources of risk. The variable chosen here is the difference between the country's local interbank money market interest rate and the Eurodollar one-month rate change at the end of month *t*-1. Similar interest differentials are frequently used to describe the financial situation

[6] The negative return for investment on the Bulgarian stock market is mostly driven by the decreasing value of the Bulgarian currency against the US dollar. The change in the value of the Bulgarian currency in US dollars is -24.40% on average per annum.

and economic stability of a country. Moreover, the concept of interest rate parity relates the interest rates to the expected change in the value of currencies. This variable is easily observable, comparable across countries, and available to investors on a timely basis. Since the interest differentials show extremely high autocorrelation, we use the first difference of the differential in the following analysis.

Table 4 shows the descriptive statistics for the time series and pair-wise correlations.[7] All countries show decreasing interest differential on average, which implies that the interest rates in the sample countries are approaching the international average. We take this as evidence of an improving local economic situation and increased financial integration. The biggest changes are observed for Russia (-0.581 %) and Bulgaria (-0.204 %). The lowest value is observed for the case of Slovenia (-0.03 %). The highest volatility is observed in the case of Bulgaria (21.96 %). The autocorrelation coefficients are significant for all countries and up to twelve lags. The highest correlation between local information variables is between Hungary and Slovenia (0.27) and Hungary and Poland (0.18).

4. Empirical Results

4.1 Correlation Analysis

We start our analysis by studying the time-series development of the correlation between the sample countries and world equity portfolio returns. Potentially, the analysis can provide evidence on the development of integration between the sample countries and global equity markets. *Figure 1* gives the 12-month rolling-window correlation coefficients.

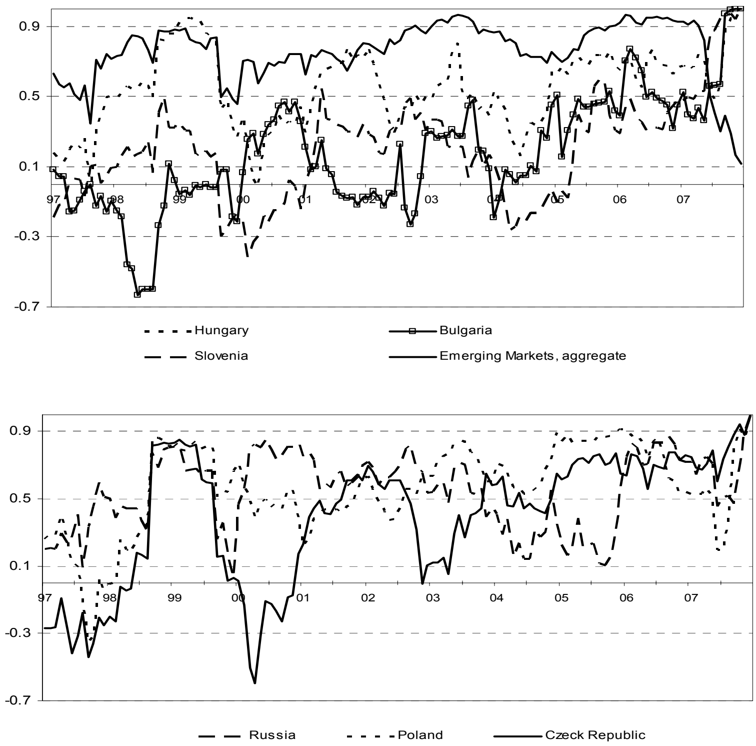
The overall observation from the figure is that the correlations increased during the sample period as one would expect. The correlation rises especially in the cases of Slovenia, the Czech Republic, and Bulgaria. The correlations for Russia, Hungary, and Poland first increase, then decrease, during the time period. This may express political instability and regulatory changes in equity markets in these countries. Exchange rate fluctuations may have also contributed to the changes in the correlation. The correlation between world equity portfolio returns and the returns of the aggregate emerging markets index varies slightly over the period of analysis. In the final year (2007), the correlation decreases based on the 12-month rolling correlation. Surprisingly, in the summer of 2007 the correlation of the emerging market aggregate index with the world equity index started to decrease rapidly, while the corresponding correlation of the sample country indices continues to show a tendency to increase.

4.2 Main Results

Our empirical tests of the asset-pricing models are based on GMM estimations. As a result of the descriptive analysis of the asset returns and the information variables, we apply the Newey-West (1987) autocorrelation and heteroskedasticity consistent covariance matrix estimator in our GMM estimation with lags set to one.

[7] The highest average interest rate differentials (not reported) between the local interbank money market rate and the Eurodollar one-month rate are observed for Russia (15.80 %) and Bulgaria (15.05 %), and the lowest for the Czech Republic (2.13 %) and Slovenia (2.38 %).

Figure 1 12-month Rolling Correlation between World Equity Market and Local Equity Markets as Well as Emerging Markets Aggregate Index Returns



We let the system do only one iteration over the weighting matrix.[8] The betas are initially assumed to be time invariant (i.e., constant in the estimation). The model is estimated jointly as a system for all test assets.

Our initial tests are based on the world CAPM, where the only source of risk is the global market, and on the partially segmented international CAPM, where the model is augmented with the aggregate emerging market risk. We test the model using six country portfolios. *Tables 5* and *6* report the results from the GMM estimation.

Table 5 shows that the world market risk is found to be statistically significant for all countries except Bulgaria. Somewhat surprisingly, the average pricing errors do not differ statistically significantly from zero. The result is in line with the world CAPM, but the overall level of the pricing errors is still almost at par with the average excess returns, which suggests that the model is not able to fully explain the relationship between risk and return.

[8] This two-stage procedure is asymptotically efficient. It would also be possible to iterate the procedure until the parameter estimates and minimized objective function converge. However, the iterative process improves the finite-sample performance of the GMM most when the number of parameters is large (see Campbell et al., 1997). As a robustness check, we compared the results using both methods. They are basically similar.

Table 5 Results for the World CAPM

The results from the tests on the unconditional world CAPM are reported below. Standard errors are reported below in alpha- and beta-parameter estimates. Significant parameters are marked with *, **, and *** (10%, 5%, and 1% levels of significance, respectively). The estimation is conducted using the GMM with the Newey-West (1987) autocorrelation and heteroskedasticity consistent covariance matrix with one iteration over the weighting matrix. The NW lags have been set to one. The model is fully identified. The Wald test is against the null hypothesis that the parameters in question are jointly zero for all assets (the *p*-value is provided in parenthesis). The sample period runs from January 1996 to December 2007 and includes 144 monthly observations. All returns are calculated from the month-end total return indices in US dollars and in excess of risk-free rate.

	Average		World market risk	Adj. R^2
	Excess return	Pricing error (α)	Beta (β)	One-factor model
Emerging Markets	0.008	0.004	1.087***	0.462
		0.004	0.127	
Russia	0.019	0.012	2.117***	0.237
		0.014	0.484	
Poland	0.008	0.003	1.413***	0.313
		0.007	0.221	
Hungary	0.017	0.011	1.366***	0.283
		0.007	0.258	
Czech Republic	0.015	0.013*	0.742***	0.125
		0.007	0.233	
Bulgaria	-0.011	-0.012	0.142	-0.006
		0.014	0.220	
Slovenia	0.016	0.015**	0.222*	0.007
		0.007	0.126	
Wald-test		10.909	138.587***	Aver. Adj. R^2
(*p*-value)		(0.143)	(<0.001)	0.202

The situation changes somewhat when we add the emerging market risk factor (note that there is one test asset less in *Table 6*). The overall level of the pricing errors is lower, even though the alpha parameter is marginally significant (*p*-value 9.7 %). The emerging markets risk is highly significant for most of the countries and the world market risk is no longer significant. In addition, including emerging market risk in the pricing model increases the overall explanatory power of the model (6.1% on average). Wald tests on the individual parameters across assets support the hypothesis that both the world market risk and emerging market risk factors have explanatory power over the excess returns for emerging markets in our analysis.[9]

Our next model adds currency risk into the model. Initially, we use two competing proxies for the currency risk. The first is an aggregate, multilateral currency index; the second is country-specific bilateral currency exchange rates. The results

[9] The Wald-test statistic is calculated as follows: $W = (\boldsymbol{Rb}-\boldsymbol{r})'(\boldsymbol{RCR}')^{-1}(\boldsymbol{Rb}-\boldsymbol{r}) \sim \chi^2$ with J degrees of freedom, where $\boldsymbol{R}$ and $\boldsymbol{r}$ are (J x M) and (J x 1) matrices of restrictions, $\boldsymbol{b}$ is the (M x 1) vector of the estimated coefficients, $\boldsymbol{C}$ is the estimated Newey-West covariance (M x M) matrix, J is the number of portfolios, and M is the number of equations times the number of parameters estimated in each equation. In the tests, $\boldsymbol{R}$ is a matrix of zeros, except for those coefficients that are currently tested, and $\boldsymbol{r}$ is a vector of zeros.

Table 6 Results for the Two-Factor APM

The results reported here are for the unconditional two-factor international asset-pricing model. The first risk factor is the world market portfolio. The second is aggregated emerging market portfolio. Standard errors are reported below in the alpha- and beta-parameter estimates. Significant parameters are marked with *, **, and *** (10%, 5%, and 1% levels of significance, respectively). The estimation is conducted using the GMM with the Newey-West (1987) autocorrelation and heteroskedasticity consistent covariance matrix with one iteration over the weighting matrix. The NW lags have been set to one. The model is fully identified. The Wald test is against the null hypothesis that the parameters in question are jointly zero (the *p*-value is provided in parenthesis). All returns are calculated from the month-end total return indices in US dollars and in excess of risk-free rate. The sample period runs from January 1996 to December 2007 and includes 144 monthly observations.

	Average		Beta		Adj.R^2
	Excess return	Pricing error α	World market risk	Emerging markets risk	Two-factor model
Russia	0.019	0.004	0.202	1.762***	0.452
		0.012	0.450	0.309	
Poland	0.008	-0.001	0.517**	0.824***	0.451
		0.006	0.215	0.137	
Hungary	0.017	0.009	0.695***	0.612***	0.358
		0.007	0.212	0.178	
Czech Republic	0.015	0.009	-0.083	0.760***	0.309
		0.006	0.231	0.133	
Bulgaria	-0.011	-0.013	-0.205	0.320	-0.003
		0.014	0.354	0.253	
Slovenia	0.016	0.014**	0.014	0.191	0.014
		0.006	0.184	0.135	
Wald-test		10.734*	31.648***	92.542***	Aver. Adj. R^2
(*p*-value)		(0.097)	(<0.001)	(<0.001)	0.264

are reported in *Table 7*. Adding the currency risk factor to the pricing model seems to increase the overall explanatory power (the *R*-squareds increase by 17.3 % on average from *Table 6*). Using a multivariate Wald-test statistic to test the joint significance of the risk factors, we find all four risk factors to be cross-sectionally significant. Ultimately, however, it seems that the emerging market risk and bilateral currency exchange rates are the most significant in explaining the returns. The cross-sectionally significant results for the two other risk factors are mostly driven by the highly significant returns for Hungary and Poland (as well as Russia in the case of multilateral currency risk).

4.3 Time-Varying Beta Model

Our final model drops the multilateral currency risk factor, as it was found to be cross-sectionally the least significant, and uses the other three risk factors from *Table 7*. In addition, we allow the betas to be linearly time-varying with one conditioning information variable. In practice, the beta is modeled as follows: $\beta_{it} = b_0 + b_1 Z_{it-1}$, where Z_{it-1} is the first difference of the interest rate differential between the local short-term interest rate and the Eurodollar one-month rate. In the estimation, it has been demeaned so that the value for the constant, b_0, can be interpreted as the unconditional, average beta. The error term is now made orthogonal to the cross-

Table 7 Results for the Four-Factor APM with Constant Betas

The results reported here are for the four-factor asset-pricing model. The risk factors used are: world market portfolio, aggregate emerging market portfolio, US currency index, and bilateral currency exchange rate. The world market portfolio is proxied by the MSCI world equity market index. The emerging market risk factor is measured using the aggregated emerging market portfolio. The US currency index is the official broad trade-weighted index. Standard errors are reported below in the alpha- and beta-parameter estimates. Significant parameters are marked with *, **, and *** (10%, 5%, and 1% levels of significance, respectively). The estimation is conducted using the GMM with the Newey-West (1987) autocorrelation and heteroskedasticity consistent covariance matrix with only one iteration over the weighting matrix. The NW lags have been set to one. The model is fully identified. The Wald test is against the null hypothesis that the parameters in question are jointly zero (the *p*-value is provided in parenthesis). All returns are calculated from month-end total return indices in US dollars and in excess of the risk-free rate. The sample period runs from January 1996 to December 2007 and includes 144 monthly observations.

	Pricing error α	World beta β_w	Emerging market beta β_{em}	Bilateral fx-beta $\beta_{fx,i}$	Multilateral fx-beta β_{fx}	Adj. R^2
Russia	0.011	0.313	1.690***	0.009***	-0.019**	0.558
	0.010	0.445	0.284	0.001	0.008	
Poland	-0.002	0.544***	0.714***	0.014***	-0.019***	0.551
	0.005	0.194	0.128	0.002	0.006	
Hungary	0.003	0.912***	0.677***	0.016***	-0.034***	0.467
	0.006	0.212	0.174	0.003	0.008	
Czech Republic	0.008	0.004	0.691***	0.010***	-0.006	0.422
	0.005	0.215	0.109	0.002	0.005	
Bulgaria	0.012*	-0.254	0.391**	0.010***	0.003	0.594
	0.007	0.275	0.163	<0.001	0.006	
Slovenia	0.016***	0.019	0.217	0.007**	-0.004	0.044
	0.006	0.186	0.152	0.003	0.008	
Wald-test	20.775***	43.857***	112.507***	921.041***	23.714***	Aver. Adj. R^2
(*p*-value)	(0.002)	(<0.001)	(<0.001)	(<0.001)	(<0.001)	0.439

-product of the risk factor and the conditioning variable.[10] Thus, the parameter results are similar to the OLS results.

The results for the three-factor time-varying beta pricing model are reported in *Table 8*. The explanatory power of the model with time-varying betas decreases slightly on average compared to the previous model. Somewhat surprisingly, the selected information variable is not found to be cross-sectionally significantly related to any of the risk factors at the standard significance level (the highest *p*-value is 6. % for the emerging market risk factor). Moreover, the unconditional world market risk is found to be significant for only two of the sample countries, showing evidence of segmentation. Thus, we re-estimate the model with just two risk factors. Again the beta is allowed to be time-varying. The results are reported in *Table 9*.

[10] The implied moment condition for asset *i* can be written as follows for the one-factor world CAPM:

$$E[r_{it} - \alpha_i - (b_0 + b_1 Z_{it-1}) r_{mt}] = 0$$

which is orthogonal to the constant and excess market returns (times one and Z_{it}).

Table 8 Results for the Three-Factor APM with Time-Varying Betas

The results reported here are for the three-factor asset-pricing model showing aggregate segmentation. The risk factors used here are: world market portfolio, bilateral currency exchange rate, and aggregate emerging market portfolio. The betas are allowed to be time-varying, and in practice are linear on the lagged short-term interest rate difference between the sample country and the one-month Eurodollar rate in excess of its mean. The emerging market risk factor is measured using the aggregated emerging market portfolio index. Standard errors are reported below in the alpha- and beta-parameter estimates. Significant parameters are marked with *, **, and *** (10%, 5%, and 1% levels of significance, respectively). The estimation is conducted using the GMM with the Newey-West (1987) autocorrelation and heteroskedasticity consistent covariance matrix with one iteration over the weighting matrix. The NW lags have been set to one. The model is fully identified. The Wald test is against the null hypothesis that the parameters in question are jointly zero (the *p*-value is provided in parenthesis). All returns are calculated from month-end total return indices in US dollars and in excess of the risk-free rate. The sample period runs from January 1996 to December 2007 (144 monthly observations).

	Pricing error	World beta		Emerging market beta		Bilateral currency beta		Adj. R^2
	A	β_0	β_{tv}	β_0	β_{tv}	β_0	β_{tv}	
Russia	0.016*	0.351	0.084	1.542***	0.026*	0.005	0.412*[a]	0.558
	0.010	0.437	0.072	0.300	0.017	0.003	0.237[a]	
Poland	0.002	0.471**	-0.478**	0.675***	0.309***	0.009***	-0.003	0.535
	0.005	0.187	0.235	0.114	0.114	0.002	0.002	
Hungary	0.016***	0.699***	0.496	0.522***	-0.244	0.008***	-0.013*	0.434
	0.006	0.198	0.544	0.165	0.437	0.002	0.007	
Czech Republic	0.011**	-0.034	0.019	0.661***	-0.034	0.008***	0.048[a]	0.410
	0.005	0.220	0.205	0.113	0.167	0.002	0.001	
Bulgaria	0.011	-0.240	-0.003	0.410**	0.003	0.010***	-0.006[a]	0.588
	0.008	0.281	0.004	0.171	0.007	0.392[a]	0.013[a]	
Slovenia	0.018***	-0.014	-0.077	0.201	0.008	0.006*	0.002	0.034
	0.006	0.188	0.210	0.137	0.106	0.003	0.002	
Wald-test	26.645***	29.057***	7.262	86.847***	11.701*	772.542***	10.152	Aver. Adj. R^2
(p-value)	(<0.001)	(<0.001)	(0.297)	(<0.001)	(0.069)	(<0.001)	(0.118)	0.427

Note: [a] The value reported in the table has been multiplied by 1000.

Table 9 Results for the Two-Factor APM with Time-Varying Betas

The results reported here are for the two-factor asset-pricing model showing aggregate segmentation. The risk factors used here are: bilateral currency exchange rate and aggregate emerging market portfolio. The betas are allowed to be time-varying. In practice, they are linear on the lagged short-term interest rate difference between the sample country and the one-month Eurodollar rate in excess of its mean. The emerging market risk factor is measured using the aggregated emerging market portfolio index. Standard errors are reported below in the alpha- and beta-parameter estimates. Significant parameters are marked with *, **, and *** (10%, 5%, and 1% levels of significance, respectively). The estimation is conducted using the GMM with the Newey-West (1987) autocorrelation and heteroskedasticity consistent covariance matrix with one iteration over the weighting matrix. The NW lags have been set to one. The model is fully identified. The Wald test is against the null hypothesis that the parameters in question are jointly zero (the *p*-value is provided in parenthesis). All returns are calculated from month-end total return indices in US dollars and in excess of the risk-free rate. The sample period runs from January 1996 to December 2007 (144 monthly observations).

	Pricing	Emerging market beta		Bilateral currency beta		
	error (α)	β_0	β_{tv}	β_0	β_{tv}	Adj. R^2
Russia	0.017	1.679***	0.015	0.006**	0.314[a]	0.555
	0.010	0.201	0.012	0.003	0.206[a]	
Poland	0.005	0.833***	0.136	0.010***	-0.005**	0.513
	0.006	0.100	0.098	0.002	0.002	
Hungary	0.016**	0.845***	0.126	0.008***	-0.012*	0.392
	0.007	0.160	0.265	0.002	0.007	
Czech Republic	0.011**	0.647***	-0.019**	0.008***	-0.045[a]	0.418
	0.005	0.075	0.007	0.002	0.137[a]	
Bulgaria	-0.011	0.134	-0.061***	0.011***	-0.591[a]	0.042
	0.013	0.185	0.014	0.004	0.245[a]	
Slovenia	0.014**	0.134*	-0.069***	0.006***	0.001***	0.122
	0.006	0.081	0.010	0.002	0.112[a]	
Wald-test	18.082***	200.205***	108.263***	63.880***	102.079***	Aver. Adj. R^2
(*p*-value)	(0.006)	(<0.001)	(<0.001)	(<0.001)	(<0.001)	0.340

Note: [a] The value reported in the table has been multiplied by 1000.

Almost all portfolios show significant sensitivity to emerging market and bilateral currency risk. Wald-test statistics support the pricing of these risk factors. Our conditioning instrument variable is also found to be cross-sectionally significant for both risk factors (although no clear pattern emerged from the estimation). The Wald test of the pricing errors (i.e., the multifactor efficiency of the risk factors) rejects the null hypothesis (the p-value is less than 0.1 %). Notably, the explanatory power of the model on average decreased by 7.4 %, suggesting further work is still needed to model the pricing of asset prices on emerging markets.

5. Conclusions and Suggestions for Further Research

In this paper, we studied the pricing of global and local sources of risk in six emerging Eastern European stock markets from a US investor's point of view. Using monthly data and an unconditional GMM estimation framework, we found that most markets show considerable segmentation. The local aggregate emerging market portfolio (emerging market risk factor), rather than the global market portfolio, was found to be the highly significant driver for the countries.

In addition, we showed currency risk to be a significant source of risk for US investors when investing in Eastern European countries. In the tests, we used measures for both multilateral and bilateral currency exchange rate risk. The results, which support bilateral currency exchange risk, suggest investors care most about country-specific currency risk. Finally, we estimated a model where the risk sensitivities (betas) were allowed to be time-varying with the country-specific interest rate difference vis-à-vis the world. The results reveal that the selected conditioning variable was cross-sectionally significant, especially when modeling time variation in emerging-market and bilateral currency risk.

The results did not give strong and consistent support for the asset-pricing model for partly segmented markets. However, the approach used here studied mostly the unconditional implications of the asset-pricing models. Moreover, the segmentation was assumed to be time-invariant. As a result, it would be interesting to study fully conditional models which allow for time-varying segmentation.

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PUBLICATION 2

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VOLATILITY SPILLOVERS BETWEEN STOCK AND CURRENCY MARKETS: EVIDENCE FROM EMERGING EASTERN EUROPE

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Volatility Spillovers between Stock and Currency Markets: Evidence from Emerging Eastern Europe*

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Abstract
The purpose of this study is threefold. First, we look at the linkages between Eastern European emerging equity markets and Russia. Second, we investigate the relationships between the currency markets of Poland, Hungary, Russia, and the Czech Republic. Finally, we examine the interdependence between Emerging Eastern European and Russian equity and currency markets. We estimate a bivariate GARCH-BEKK model proposed by Engle and Kroner (1995) using weekly returns. We find evidence of direct linkages between the equity markets in terms of both returns and volatility, as well as in the currency markets. When analyzing the relationships between currency and stock markets we find unidirectional volatility spillovers from currency to stock markets. The results show clear evidence of integration of Eastern European markets within the region and with Russia as well.

1. Introduction

Emerging Eastern European stock markets have come to interest international financial researchers and policy-makers during the last decade. These markets have attracted the attention of international investors due to their better diversification opportunities. They have become more attractive and accessible for investment due to decreasing restrictions on transactions, a series of reforms, and increasing financial transparency. Moreover, European Union enlargement creates a unique landscape for new financial investigations and analysis.

This paper examines the stock markets in Poland, Hungary, the Czech Republic, representatives of Eastern European stock markets, and Russia, in a setting of regional influences. Our empirical analyses attempt to investigate whether and to what extent these emerging markets are integrated with each other.[1] The purpose of this study is threefold. First, we look at the linkages between Eastern European emerging equity markets and Russia. Second, we investigate the relationships between the currency markets of Poland, Hungary, Russia, and the Czech Republic. Finally,

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[1] By market integration we mean the interdependence or linkage between two markets or classes of assets in both the short and long run.

we examine the interdependence between Emerging Eastern European and Russian equity and currency markets.

The interdependence between different equity markets has been extensively investigated. Most studies, however, have focused their attention on volatility spillovers within the developed financial markets (see, for example, Hamao et al., 1990; Theodossiou and Lee, 1993; Lin et al., 1994; Susmel and Engle, 1994; Karolyi, 1995). There are numerous studies exploring the relationships between the emerging markets of different regions, even though such work is still very scarce. For example, Worthington et al. (2000) look at the price linkages in Asian equity markets. Kasch-Haroutounian and Price (2001) examine Central Europe. Sola et al. (2002) analyze volatility links between the stock markets of Thailand, South Korea, and Brazil. More recently, Li (2007) studied the international linkages of Chinese stock exchanges. The examination of Eastern European and Russian market linkages, on the other hand, is limited and needs more investigation. Few studies explore these markets in terms of volatility and return linkages. Rare examples include Li and Majerowska (2008), Fedorova and Vaihekoski (2009), and Scheicher (2001), who study the linkages between the Czech Republic, Poland, and Hungary, whereas Saleem (2009) investigates the international linkages of the Russian market.

In the same way, the literature on the linkages between equity and currency markets mostly explains the dynamics of the currency and equity markets of developed economies (see, for example, Yang and Doong, 2004; Francis et al., 2006; Dark et al., 2005). There are some studies dealing with the emerging economies, but these are still inconclusive (see, for example, Morales, 2008; Tai, 2007; Yang and Chang, 2008). In particular, studies covering the emerging markets in Eastern Europe and Russia are very scarce.

This paper investigates the relationships between Eastern European and Russian stock and currency markets using the GARCH process, for which a BEKK representation developed by Engle and Kroner (1995) is adopted. We investigate the relationships between stock markets, between foreign exchange markets, and between stock and currency markets within one country. Our research examines whether changes on one market (for instance, a stock market) influence the performance of another market (for example, a currency market).

The sample period is from 1995 to 2008, covering Poland, Hungary, the Czech Republic, and Russia. All these countries experienced changes in their economies on the way from communist to capitalist regulation systems. Poland, Hungary, and the Czech Republic recently joined the European Union. These countries have the biggest stock markets in Emerging Eastern Europe in terms of market capitalization. On the other hand, Russia is one of the largest emerging markets in the world today. All the sample countries are growing fast given the wide range of opportunities for local and foreign investors.

We find evidence of direct linkages between the equity markets of Poland, Hungary, Russia, and the Czech Republic in terms of both returns and volatility. Similarly, interdependence between the currency markets of Poland, Hungary, Russia, and the Czech Republic is found. When analyzing the relationship between currency and stock markets we find unidirectional volatility spillovers from currency to stock markets in Poland, Hungary, and Russia. However, the Czech Republic returns are also found to affect the currency market. Overall, our results show clear evidence of integration of Eastern European markets within the region and with Russia as well.

The rest of the paper is organized as follows. The second section presents the theoretical background and the empirical formulation of the testable model. Section 3 introduces the sample countries, the data used in the study, and its descriptive statistics. Section 4 provides the results of the analysis. Concluding remarks are presented in Section 5.

2. Model Specification

Another issue addressed in this paper is the choice of model when dealing with emerging economies. The most common methodologies applied by researchers to study the volatility spillover effect are based on VAR analysis (see, for example, Syriopoulos, 2007; Lucey and Voronkova, 2006). The Autoregressive Conditional Heteroskedasticity (ARCH) process proposed by Engle (1982) and the generalized ARCH (GARCH) proposed by Bollerslev (1986) have also been extensively applied to model volatility. However, to examine the volatility linkages between two markets or assets a multivariate GARCH approach is preferred over univariate settings. The BEKK (Baba, Engle, Kraft, and Kroner) parameterization proposed by Engle and Kroner (1995) provides an appropriate framework for checking the volatility linkage between two markets. It also ensures positive definiteness of the conditional variance-covariance matrix, which early models, such as Bollerslev et al. (1988), fail to guarantee. The BEKK model complies with the hypothesis of constant correlation and allows for volatility spillover across markets.

We start our empirical specification with a bivariate GARCH(1,1) model that accommodates each market's returns and the returns of other markets lagged by one period.[2]

$$r_t = \alpha + \beta r_{t-1} + u_t \tag{1}$$

$$u_t \left| \Omega_{t-1} \sim N\left(0, H_t\right)\right. \tag{2}$$

where $\boldsymbol{r_t}$ is an $n \times 1$ vector of weekly returns at time t for each market. The $n \times 1$ vector of random errors $\boldsymbol{\mu_t}$ represents the innovation for each market at time t with its corresponding $n \times n$ conditional variance-covariance matrix $\boldsymbol{H_t}$. The market information available at time t-1 is represented by the information set Ω_{t-1}. The $n \times 1$ vector, $\boldsymbol{\alpha}$, represents the constant.

The own-market mean spillovers and cross-market mean spillovers are measured by the estimates of matrix $\boldsymbol{\beta}$ elements, the parameters of the autoregressive term. This multivariate structure thus facilitates measurement of the effects of innovations in the mean stock returns of one market on its own lagged returns and those of the lagged returns of other markets.

Given the above expression, and following Engle and Kroner (1995), the conditional covariance matrix can be stated as:

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

[2] This model is based on the bivariate GARCH(1,1)-BEKK representation proposed by Engle and Kroner (1995).

where the parameter matrices for the variance equation are defined as $\boldsymbol{C_0}$, which is restricted to be lower triangular, and two unrestricted matrices $\boldsymbol{A_{11}}$ and $\boldsymbol{G_{11}}$. Thus, the second moment can be represented by:

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

Following Engle and Kroner (1995) the above system can be estimated by maximum likelihood estimation, which can be optimized by using the Berndt, Hall, Hall, and Hausman (BHHH) algorithm.[3] From equation (4) we obtain the conditional log likelihood function $L(\theta)$ for a sample of T observations:

$$L(\theta) = \sum_{t=1}^{T} l_t(\theta) \tag{5}$$

$$l_t(\theta) = -\log 2\pi - 1/2\log\left|H_t(\theta)\right| - 1/2\varepsilon_t'(\theta)H_t^{-1}(\theta)\varepsilon_t(\theta) \tag{6}$$

where $\boldsymbol{\theta}$ denotes the vector of all the unknown parameters. Numerical maximization of equation (4) yields the maximum likelihood estimates with asymptotic standard errors.

Finally, to test the null hypothesis that the model is correctly specified, or equally that the noise terms, $\boldsymbol{\mu_t}$, are random, the Ljung-Box Q-statistic is used. This is assumed to be asymptotically distributed as χ^2 with $(p - k)$ degrees of freedom, where k is the number of explanatory variables.

3. Data and Descriptive Statistics

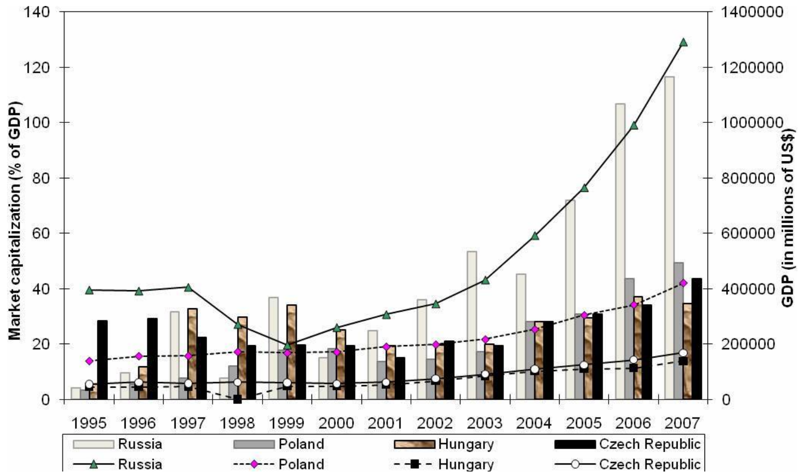
The tests in this paper are conducted on three major emerging countries from Eastern Europe and Russia. The sample period is from January 1995 to December 2008. Our analyses are from the perspective of U.S. investors, i.e., all returns are measured in U.S. dollars. We use weekly total return indices, which are based on week-end observations of total return market indices throughout the paper.

As test assets in the analysis we utilize market portfolios from each of the sample countries. As a proxy for the market stock return we use the Datastream indices. These indices were available for the countries under investigation for the long term and have frequently been used in similar studies. The market portfolio indices include gross dividends, i.e., they measure the total pre-tax return for investors.

As a proxy for the currency market, we use the single bilateral currency exchange rates of the Polish zloty, the Czech crown, the Hungarian forint, and the Russian ruble against the U.S. dollar. As an alternative class of assets one could select, for example, the bond or derivative market. However, we chose the currency market mainly due to data availability. Moreover, the currencies of Poland, Hungary, the Czech Republic, and Russia have undergone several currency regimes (multiple devaluations and revaluations, and periods of fixed and floating exchange rates), which make them an interesting test laboratory for the tests of interdependence. Furthermore,

[3] We also tried the Marquardt maximum likelihood method, but the BHHH algorithm was found to perform better.

Figure 1 Market Capitalization and GDP



Source: World Development Indicators

the currency market is interesting from the point of view of currency risk. All data was extracted from the DataStream database.

3.1 Sample Countries and Test Assets

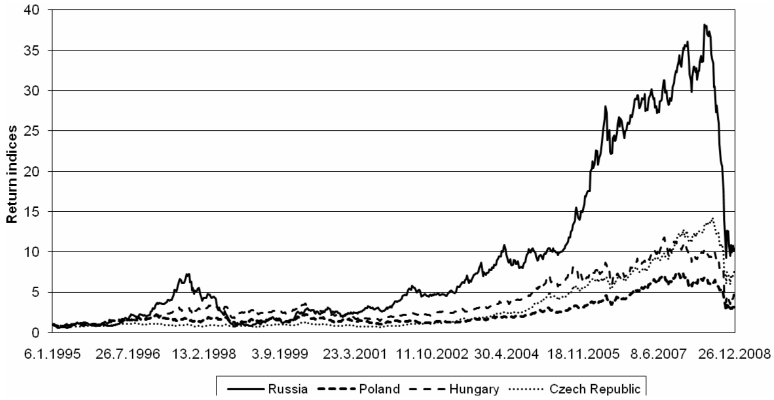
In our study we select sample countries such as Russia, Poland, Hungary, and the Czech Republic. All these economies are in transition from a communist system to a capitalist one, but in many ways their development has diverged. For example, Poland, Hungary, and the Czech Republic are relatively new European Union countries, having joined in May 2004. Russia, on the other hand, is not a member of the EU, but is one of the largest emerging markets in the world.

The stock markets of the sample countries were established during the 19th and early 20th centuries. However, during the communist regime, the stock exchanges were closed in all the countries. The first ones to open their stock markets after the end of the communist era were Hungary and Poland in mid-1991. The Russian stock market began operating in 1992. The Prague Stock Exchange in the Czech Republic was opened last, in 1993.

Figure 1 shows the stock market capitalization (in % of GDP, column graph) and GDP (in millions of US$, line graph) of these emerging countries over the sample period 1995–2007. The Russian Federation stands out from the others with its relatively high market capitalization, while Poland, Hungary, and the Czech Republic had an approximately equal level of capitalization over the last five years (2003–2007).

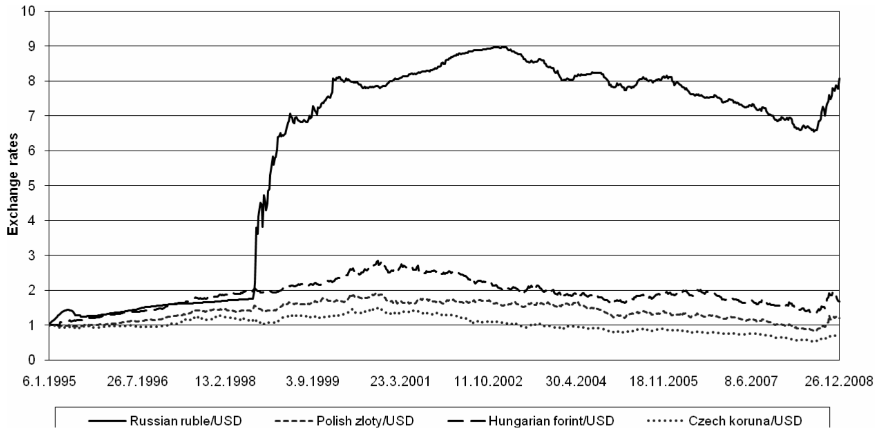
Figures 2 and *3* show the historical changes of the local return indices and exchange rates for the sample countries analyzed. The stock return graph reveals significant growth in the Russian stock market compared to the other stock markets from the middle of 1996 until the Russian financial crisis of August 17, 1998. A series of reforms was carried out at that time, including the redenomination of the Russian ruble, as reflected in *Figure 3* in a significant decline of the ruble. Stock

Figure 2 Stock Return Indices



Note: All indices are scaled to 100.

Figure 3 Exchange Rates Against the USD



Note: All exchange rates are scaled to 1.

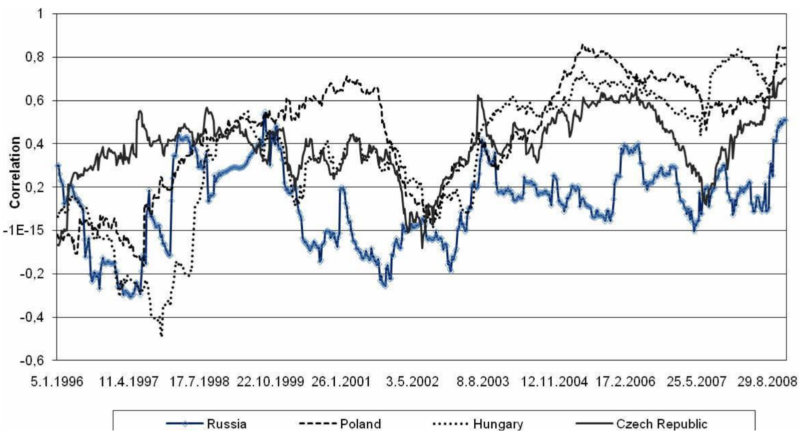
indices were growing and local currencies were getting stronger against the U.S. dollar thereafter. In the middle of 2008 the situation on the financial markets changed again. This phenomenon was reflected in an increase of the local currencies' exchange rates relative to the U.S. dollar. The descriptive statistics for asset returns and exchange rate changes are presented in *Tables 1* and *2*. *Figure 4* presents the 52-week rolling--window correlation between the stock and currency markets for each country; it is evident that the correlations were volatile during the sample period.

4. Empirical Results

4.1 Linkages between Equity Markets

Our empirical results answer the theoretical questions formulated in the previous sections. First, to examine the linkages between stock markets, six pairwise

Figure 4 52-Week Rolling Correlation between Local Equity Market and Local Currency Markets Returns



models are estimated using the bivariate GARCH(1,1) framework, for which a BEKK representation is adopted. The modeled pairs are Russia–Poland, Russia–Hungary, Russia–Czech Republic, Poland–Czech Republic, Poland–Hungary, and Hungary––Czech Republic. We use weekly total return indices calculated by Datastream from January 1995 to December 2008.

First, we look at matrix $\boldsymbol{\beta}$ in the mean equation – equation (1) – captured by the parameters β_i in *Table 3*, in order to see the relationship in terms of returns within the countries in each pair. The effects of Russian stock returns are found to be considerable on all the Eastern European stock markets, as the β_1 parameters for all the modeled pairs with Russia are statistically significant, while the β_1 parameters for all the modeled pairs with Poland except for Hungary are also found to be statistically significant, suggesting that the returns in Poland also influence those in neighboring countries. Similar results are found for Hungary and the Czech Republic.

Next, we examine the estimated results of the time-varying variance-covariance equation (4) in the system. Matrices $\boldsymbol{A}$ and $\boldsymbol{G}$, reported in *Table 3*, help us examine the relationship in terms of volatility as stated in equation (4). The diagonal elements in matrix $\boldsymbol{A}$ capture the ARCH effect, while the diagonal elements in matrix $\boldsymbol{G}$ measure the own GARCH effect. As shown in *Table 3*, the estimated diagonal parameters, a_{11}, a_{22} and g_{11}, g_{22}, are all statistically significant, indicating a strong GARCH(1,1) process driving the conditional variances of the six pairwise indices. In other words, own past shocks and volatility affect the conditional variance of the Polish, Czech, Hungarian, and Russian stock markets.

The off-diagonal elements of matrices $\boldsymbol{A}$ and $\boldsymbol{G}$ capture cross-market effects such as shock and volatility spillovers among the six pairs. First, we document shock transmissions between Russia and other markets. We find evidence of a unidirectional link between Russia and Poland and Russia and the Czech Republic, as well as Russia and Hungary. Interestingly the direction is from Russia to Poland, Hungary, and the Czech Republic, as only the off-diagonal parameter a_{12} is statistically significant at the 5% level of significance, meaning that Russian shocks (e.g., the Rus-

Table 1 Descriptive Statistics for the Asset Returns

Panel A reports descriptive statistics for the three Eastern European emerging market and Russia.
Panel B reports pairwise correlations for the return series.
Index series are from Datastream.
Sample period is from January 1995 to December 2008.
All returns are calculated in U.S. dollars and include dividends (i.e., total return).
The sample includes 730 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										
Russia	16.635	43.748	-0.180	6.736	<0.001	0.142*	0.102*	0.010*	-0.040*	<0.001
Poland	8.117	33.287	-0.447	6.169	<0.001	0.013	0.079	-0.006	-0.048	0.259
Hungary	10.806	33.527	-1.245	12.928	<0.001	0.015	0.101*	-0.027*	0.022*	0.024
Czech Republic	14.456	26.417	-0.717	10.424	<0.001	0.032	0.096*	-0.027*	0.026	0.156

Panel B: Pairwise correlations	Russia	Poland	Hungary	Czech
Russia	1	0.400	0.478	0.425
Poland		1	0.663	0.607
Hungary			1	0.646
Czech Republic				1

Notes: [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 that autocorrelation coefficients up to 12 lags are zero.

Table 2 Descriptive Statistics for Bilateral Exchange Rate Changes against the USD

Panel A reports descriptive statistics for the exchange rates of three Eastern European emerging markets and Russia against the USD.
Panel B reports pairwise correlation coefficients between the variables.
Sample period is from January 1995 to December 2008.
The sample includes 730 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.

Currency exchange rate	Mean (%)	Std. dev. (%)	Skewness	Excess Kurtosis	Normality (*p*-value)	Autocorrelation[a]				$Q(27)$[b]
						ρ_1	ρ_2	ρ_3	ρ_{27}	
Panel A: Summary statistics										
Russia	-14.881	18.379	-13.633	277.320	<0.001	0.070*	0.256*	0.145*	-0.011*	<0.001
Poland	-1.315	12.188	-1.453	17.587	<0.001	-0.061	0.040	0.098*	-0.020	0.514
Hungary	-3.724	11.927	-0.468	6.054	<0.001	0.024	-0.034	0.095*	-0.006	0.727
Czech Republic	2.844	11.6628	-0.090	13.377	<0.001	0.033	0.034	0.001	0.013	0.399
Panel B: Pairwise correlations	Russia	Poland	Hungary	Czech						
Russia	1	0.066	0.059	-0.049						
Poland		1	0.720	0.620						
Hungary			1	0.680						
Czech Republic				1						

Notes: [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 that autocorrelation coefficients up to 12 lags are zero.

Table 3 Mean and Volatility Spillovers for Stock Markets Estimated from a Bivariate GARCH(1, 1)-BEKK Model of Weekly Return Indices

The diagonal elements in matrix ***β*** represent the mean equation while matrix ***A*** captures own and cross-market ARCH effects. The diagonal and off 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%.

	Russia-Poland		Russia-Hungary		Russia-Czech R.		Poland-Hungary		Poland-Czech R.		Hungary-Czech R.	
Parameters	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.
	Panel A: GARCH(1, 1)-BEKK estimations											
β_1	0.005*	(0.002)	0.007*	(0.002)	0.005*	(0.002)	0.004*	(0.001)	0.002	(0.002)	0.004*	(0.002)
β_2	0.003**	(0.002)	0.004*	(0.001)	0.004*	(0.001)	0.004*	(0.001)	0.004*	(0.001)	0.005*	(0.001)
C_{11}	0.008*	(0.002)	0.007*	(0.002)	0.006*	(0.002)	0.010*	(0.002)	0.006*	(0.002)	0.016*	(0.003)
C_{12}	0.009*	(0.003)	0.021*	(0.002)	0.009*	(0.004)	0.014*	(0.003)	0.009*	(0.002)	-0.006	(0.005)
C_{22}	0.001	(0.014)	0.003	(0.030)	0.007*	(0.002)	0.075	(0.003)	0.003	(0.002)	0.009*	(0.004)
A_{11}	0.342*	(0.037)	0.325*	(0.0433)	0.259*	(0.032)	0.274*	(0.045)	0.158*	(0.029)	0.202*	(0.064)
A_{12}	0.162*	(0.067)	0.240*	(0.038)	0.069*	(0.024)	0.221*	(0.054)	0.071*	(0.031)	-0.122*	(0.054)
A_{21}	-0.088**	(0.048)	-0.085**	(0.044)	0.032	(0.088)	0.083	(0.052)	0.207*	(0.042)	0.364*	(0.064)
A_{22}	0.107*	(0.041)	0.278*	(0.058)	0.355*	(0.059)	0.279*	(0.058)	0.358*	(0.047)	0.388*	(0.049)
G_{11}	0.950*	(0.011)	0.952*	(0.009)	0.964*	(0.007)	0. 962*	(0.014)	0.982*	(0.007)	0.815*	(0.083)
G_{12}	-0.030*	(0.011)	-0.022*	(0.017)	-0.014*	(0.007)	-0.044*	(0.018)	-0.014	(0.010)	0.200*	(0.101)
G_{21}	-0.033	(0.023)	-0.006	(0.032)	-0.019	(0.047)	-0.063*	(0.028)	-0.064*	(0.022)	0.027	(0.085)
G_{22}	0.954*	(0.019)	0.733*	(0.053)	0.863*	(0.052)	0.869*	(0.043)	0.885*	(0.031)	0.723*	(0.107)
	Panel B: Diagnostic tests											
LogLik		2433.647		2451.999		2626.917		2739.468		2872.394		2899.752
LB_1		58.599*		59.893*		63.998*		31.349		31.070		38.436
LB_2		30.383		35.180		32.341		39.250		32.315		35.062
LB^2_1		18.995		23.224		21.342		14.858		13.914		14.589
LB^2_2		23.614		12.551		20.657		10.176		19.971		20.891

Table 4 Mean and Volatility Spillovers for Currency Markets Estimated from a Bivariate GARCH(1, 1)-BEKK Model of Weekly Return Indices

The diagonal elements in matrix $\boldsymbol{\beta}$ represent the mean equation while matrix $\boldsymbol{A}$ captures own and cross-market ARCH effects. The diagonal and off diagonal elements in matrix $\boldsymbol{G}$ 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%.

	Russia-Poland		Russia-Hungary		Russia-Czech R.		Poland-Hungary		Poland-Czech R.		Hungary-Czech R.	
Parameters	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.
Panel A: GARCH(1, 1)-BEKK estimations												
β_1	-0.024	(0.018)	-0.028*	(0.012)	-0.093*	(0.020)	-0.095*	(0.047)	0.006	(0.050)	-0.204*	(0.046)
β_2	0.087**	(0.048)	-0.012	(0.048)	0.092**	(0.051)	-0.152*	(0.046)	0.079	(0.052)	-0.003	(0.055)
C_{11}	0.144*	(0.038)	0.006	(0.033)	0.146*	(0.038)	0.428*	(0.100)	0.603*	(0.097)	-0.049	(0.044)
C_{12}	0.202*	(0.067)	0.138*	(0.036)	1.565*	(0.082)	-0.290*	(0.167)	0.481*	(0.089)	0.220*	(0.003)
C_{22}	0.111	(0.164)	-0.564	(0.842)	-0.049	(0.814)	0.168	(0.169)	0.165*	(0.049)	0.521	(1.313)
A_{11}	1.176*	(0.077)	1.056*	(0.057)	0.762*	(0.046)	0.175*	(0.045)	0.215*	(0.049)	0.268*	(0.049)
A_{12}	-0.069**	(0.039)	-0.037**	(0.021)	-0.088*	(0.027)	-0.082	(0.078)	0.332*	(0.044)	0.229*	(0.053)
A_{21}	0.199*	(0.017)	0.199*	(0.012)	-0.195*	(0.012)	0.274 *	(0.044)	0.330*	(0.048)	-0.029	(0.021)
A_{22}	0.313*	(0.028)	0.188*	(0.018)	-0.056**	(0.030)	0.077	(0.059)	-0.027	(0.049)	-0.225*	(0.004)
G_{11}	0.539*	(0.031)	0.605*	(0.020)	0.722*	(0.025)	0.776*	(0.065)	0.759*	(0.050)	1.199*	(0.016)
G_{12}	0.035*	(0.016)	0.016*	(0.009)	0.021	(0.037)	0.258**	(0.135)	-0.174*	(0.047)	1.181*	(0.056)
G_{21}	-0.022*	(0.010)	-0.009	(0.005)	-0.136**	(0.027)	0.129*	(0.040)	0.052**	(0.030)	-0.427*	(3.552 [a])
G_{22}	0.947*	(0.012)	0.979*	(0.004)	0.180	(0.246)	0.785*	(0.131)	0.989*	(0.024)	-1.188*	(0.065)
Panel B: Diagnostic tests												
LogLik		-2122.660		-2114.480		-2035.696		-2413.859		-2497.435		-2466.651
LB_1		128.000*		150.954		259.866		23.656		28.141		26.431
LB_2		22.570		28.970		28.156		27.495		23.537		26.324
LB^2_1		2.542		4.279		30.988		21.290		18.128		9.464
LB^2_2		12.534		14.491		119.145		16.575		35.140		33.351

Table 5 Mean and Volatility Spillovers for Stock and Currency Markets Estimated from a Bivariate GARCH(1, 1)-BEKK Model of Weekly Return Indices

The diagonal elements in matrix ***β*** represent the mean equation while matrix ***A*** captures own and cross-market ARCH effects. The diagonal and off 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%.

	Russia		Poland		Hungary		Czech Republic	
Parameters [a]	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.
	Panel A: GARCH(1, 1)-BEKK estimations							
β_1	0.004*	(0.002)	0.001	(0.001)	0.002	(0.001)	0.003*	(0.001)
β_2	-0.090*	(0.012)	-0.049	(0.052)	-0.150*	(0.048)	0.098 **	(0.057)
C_{11}	0.006*	(0.001)	0.001	(0.001)	0.014*	(0.002)	0.008*	(0.002)
C_{12}	-0.009	(0.047)	0.282*	(0.086)	-0.055	(0.045)	0.233	(0.181)
C_{22}	0.002	(0.054)	-0.112	(0.938)	0.109*	(0.053)	0.014	(0.508)
A_{11}	0.217*	(0.021)	0.194*	(0.025)	0.452*	(0.048)	0.209*	(0.053)
A_{12}	3.464*	(0.277)	2.734*	(1.134)	0.959	(1.222)	-1.702	(2.305)
A_{21}	0.004*	(0.001)	0.002*	(0.001)	0.002*	(0.001)	0.005*	(0.001)
A_{22}	0.730*	(0.075)	0.275*	(0.043)	0.241*	(0.026)	0.182*	(0.040)
G_{11}	-0.975*	(0.005)	0.980*	(0.004)	0.819*	(0.041)	0.973*	(0.027)
G_{12}	0.151	(0.505)	-0.369	(0.247)	-0.074	(0.583)	8.348*	(1.418)
G_{21}	0.010*	(0.002)	-0.548 **	(0.327)	0.001**	(0.001)	-0.004*	(0.001)
G_{22}	0.783*	(0.025)	0.942*	(0.023)	0.967*	(0.008)	0.887*	(0.019)
	Panel B: Diagnostic tests							
LogLik	405.934		31.514		35.475		186.567	
LB_1	67.558*		30.648		40.523*		30.456	
LB_2	219.233*		22.232		28.674		27.597	
LB^2_1	45.894*		14.023		12.913		27.654	
LB^2_2	16.205		15.745		10.380		20.029	

Note: [a] 1 represents the stock markets and 2 represents the currency markets.

sian crisis of 1998) affected the mean returns on the Czech, Hungarian, and Polish equity markets. While analyzing shock transmissions between Poland and the Czech Republic and the Czech Republic and Hungary we find bidirectional effects. Poland and Hungary exhibit unidirectional shock transmission.

Second, we explain the volatility spillovers between the modeled pairs. We find very interesting results: for example, the Russian effect dominates in the case of Russia and Poland as well as Russia and the Czech Republic, and Russia and Hungary. The Hungarian effect dominates in the case of Hungary and the Czech Republic, and the Czech Republic volatility spillovers to Poland dominate in the case of the Poland and Czech Republic modeled pair. Between Poland and Hungary we find bidirectional spillovers. These results clearly demonstrate integration of Eastern European markets within the region and with Russia as well.

4.2 Linkages between Currency Markets

Next, we answer our second question: the linkages between the currency markets of selected Eastern European markets and Russia. Again, using the BEKK framework, we estimate the six pairwise models explained in the previous section.

While documenting the shock transmissions between the Russian ruble and other currencies, we find a bidirectional relation between the Russian ruble and the Czech koruna. At the same time, sudden shocks to the Polish zloty and the Hungarian forint are found to affect the movements of the Russian ruble, whereas volatility on the Russian currency market clearly has spillovers between the modeled pairs. In the case of the three selected Eastern European currency markets, we find evidence of unidirectional volatility spillovers between Poland and Hungary as well as Poland and the Czech Republic. Bidirectional volatility transmissions are found in the case of Hungary and the Czech Republic. The estimated results are reported in *Table 4.* Again, our results show clear evidence of integration of Eastern European currency markets within the region and with Russia as well.

4.3 Linkages between Stock and Currency Markets

Finally, we examine the transmission of shocks and volatility between the stock markets and currency markets of Russia, Poland, Hungary, and the Czech Republic. We present our analysis in the same fashion as in previous sections. Four pairwise models are estimated as before.

We start with the mean equation of the system. The results, reported in *Table 5*, show a significant effect of currency market returns on the stock market returns in Russia, Hungary, and the Czech Republic.

Next, we document the shocks and volatility spillovers represented by vectors $\boldsymbol{a}_{ij}$ and $\boldsymbol{g}_{ij}$. In all the modeled pairs we find evidence of strong ARCH and GARCH effects, as in every case the diagonal elements of matrices $\boldsymbol{A}$ and $\boldsymbol{G}$, $\boldsymbol{a}_{ii}$ and $\boldsymbol{g}_{ii}$, are highly significant, which captures within-market effects such as shock and volatility spillovers between the two assets. This indicates the suitability of our model selection.

Then we explain the shock and volatility spillovers between the modeled pairs. The off-diagonal elements of matrix $\boldsymbol{A}$ capture the cross-market shock effects. The Russian stock and currency markets as well as the Polish stock and currency markets show evidence of bidirectional effects, meaning that changes in the currency market also influence the stock market. In the same way, fluctuations in the stock market affect the currency market. Currency market shocks are found to dominate in the case of Hungary and the Czech Republic. Finally, we present the off-diagonal elements of matrix $\boldsymbol{G}$, which capture the cross-market volatility spillovers. In all the modeled pairs, currency market volatility is found to significantly affect the stock market. Only the Czech Republic returns are found to affect the currency market.

5. Summary and Conclusions

In this paper we study the relationships between the emerging markets of Eastern European and Russia in a regional setting. Both stock and foreign exchange markets are analyzed using a multivariate GARCH process. The sample period is from January 1995 to December 2008. First, we look at the linkages between the three fastest-growing Eastern European emerging equity markets, namely, Poland, Hungary, and the Czech Republic, and Russia. Second, we investigate the relationships between the currency markets of these countries. Finally, we examine the interdependence between the equity market and currency market of Poland, Hungary, Russia, and the Czech Republic. Specifically, we estimate a bivariate GARCH--BEKK model proposed by Engle and Kroner (1995) using weekly returns.

We find support for interaction of stock markets through their returns and volatilities in Poland, Hungary, Russia, and the Czech Republic. Moreover, a direct linkage is found between the currency markets of Poland, Hungary, Russia, and the Czech Republic in terms of both returns and volatility. The analyses of stock and currency markets provide evidence of unidirectional volatility spillovers from currency markets to stock markets in all the countries with the exception of the Czech Republic, where the stock market is also found to affect the currency market. These findings show that currency risk matters, which is consistent with earlier findings (see, for example, Saleem and Vaihekoski, 2008, 2010). Overall, our results show evidence of the integration of Eastern European markets within the region and with Russia as well.

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

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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 rapidly impacted advanced economies but spared financial systems that were less developed and less integrated with the global economy. The present study focuses on the contagion effects on Eastern European stock markets and the changes in the interconnections among these markets after the 2004 expansion of the EU. In particular, we investigate the relationships among the stock markets of Poland, Hungary and the Czech Republic during 1998−2009 and the exposure of financial risk to these markets. The evidence suggests the existence of direct linkages between different stock market sectors with respect to returns and volatilities. The transmission of equity shocks between markets is increased after the EU accession in 2004. Notably, the intra-industry contagion in emerging Europe has increased after this accession. 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 often considered to be the most serious financial crisis for the world economy since the Great Depression of the 1930s. The recent global financial crisis began from a liquidity shortfall in the US banking system that was caused by actors that had been allowed to overvalue and securitize assets. These assets were then traded and insured by international markets. Thus, in a process that could be regarded as a “musical chairs” of default, the meltdown spread quickly to several sectors of Europe’s financial markets. The resulting financial distress caused a number of spectacular bankruptcies and business collapses worldwide (e.g., Erkens at al., 2012). However, financial systems that were not particularly integrated into the global financial network, such as the financial systems of India and Brazil, escaped the brunt of the 2008 shock and emerged largely unscathed from this crisis. Thus, the process of understanding and assessing risk transfer among countries and their financial markets has been embraced as an essential aspect of designing measures to contain the damage from future financial crises (e.g., Grabel, 2003; Niemira and Saaty, 2004).

Emerging economies have attracted researcher interest in studying the impact of the global financial crisis (Aloui et al., 2011). Over the past decade, these economies have enjoyed higher GDP growth and demonstrated greater resilience to global shocks than their more advanced counterparts. As a result, emerging economies are regarded as markets that provide opportunities for investment, currency-risk diversification and alternative pathways to enrichment. Certain researchers, however, have noted that these advantages are fleeting because of sustained financial market integration (e.g., Savva and Aslanidis, 2010), which ultimately deprives investors of the ability to avoid the impacts of global economic shocks on their investments. Nevertheless, it is likely that certain financial markets and specific sectors will remain partially segmented and somewhat insulated from the global economy for the year to come. The availability of data for a number of Eastern European countries makes it possible to determine whether these advantages have a temporal decay. The possibility of flight to these potential safe havens in the midst of widespread financial instability has obvious implications for portfolio managers with respect to their risk diversification strategies. Thus, utilizing the results of this paper it will be possible to construct investment portfolio with assets from these particular sectors, which will be partially segmented from European markets and might be more resistant to contagion effects.

The present study considers four research questions. First, were emerging Eastern European stock markets involved in transferring financial risk to EU members? If this phenomenon, which would contradict the familiar rule that volatility is mostly driven by the developed markets, actually occurred, then the next question is what are the industrial sectors in the emerging European countries that contributed most to this? Third, are there certain stock markets sectors, which are partially isolated from the corresponding sectors of other European stock markets 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 the effects of integration (or lack thereof) in Eastern Europe and to identify opportunities for sectoral diversification in financial securities selection for portfolio investment during the observed time period.

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 of the study, descriptive statistics and preliminary results based on correlation analyses. Section 5 provides the main results from the estimation. Concluding remarks and suggestions for future research are offered in Section 6.

2 BACKGROUND

Researchers disagree about risk transmission mechanisms in stock markets. Although the most commonly held belief regarding this topic is that the effects of country risk dominate the effects of sectoral risk (e.g., Steliaros and Thomas, 2006; Kaltenhaeuser, 2003), certain researchers consider sectoral heterogeneity to be an important determinant of contagion propagation (e.g., Phylaktis and Xia, 2009).

As a rule, studies of investment risk transfer have 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 of the bank and insurance sectors, which reveal strong evidence of not only inter- and intra-dependence in these sectors but also event contagion. Other authors (e.g., Johnson, 2010) declare that a decrease in contagion in the banking and insurance markets occurs during times of crisis. To explain intra-industry risk transfer, Tawatnuntachai and D'Mello (2009) study the intra-industry reaction to stock split announcements. The sectoral study of Pais and Stork (2010), who utilize Extreme Value Theory, demonstrates that the highest level of dependence occurs between the property and banking sectors.

Risk and portfolio managers who are choosing asset management strategies must decide how to diversify not only their currency and liquidity risks but also the regional and sectoral allocation of their assets. Ferreira and Gama (2005) and Black, Buckland and Fraser (2002) argue that the industry-decomposition method is superior to the geographical decomposition method with respect to portfolio management. Catão and Timmerman (2003), who test Heston and Rouwenhorst's (1994, 1995) dummy-factor model for decomposition stock returns, find that industry factors account for one third of the total systematic variance in stock returns. Using the two-regime Markov switching model, Morana and Sawkins (2004) reach the opposite conclusion that sectoral volatility predominantly determines overall stock market volatility.

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

By contrast, risk transfer in emerging markets has largely evaded analysis. Sarkar, Charkrabarti and Sen (2009) study the volatility transmission channels among the Indian, Brazilian, Argentine and Indonesian stock markets. Traditional sectors, such as the capital goods and consumer durables sectors, are found to be the predominant sectors for this volatility transmission; these sectors contribute significantly to the volatility of the Indian stock market. Lin, Penm, Wu and Chiu (2004), who study the banking sectors in China, Taiwan and Hong Kong, observe that systemic risk and stock returns have a significantly positive relationship with the banking industry. Among banks of various sizes, larger banks evince higher levels of industry effects in China and Hong Kong, whereas small and medium-sized banks demonstrate the greatest industry effects in Taiwan. However, the financial industries are independent from other sectors in these countries (e.g., Wang, 2007). Hammoudeh, Yuan and McAleer (2009) note the existence of an increased dominance of stock market volatility relative to past shocks.

In this study, we investigate the importance of industries in the stock markets of selected Eastern European countries and the degree of stock market integration in these countries before and after their EU accessions in 2004 (e.g., Caporale and Spagnolo, 2011). We hope to find certain stock market sectors to be at least partially segmented from the corresponding sectors in European markets. Thus, it will be possible to construct investment portfolio, which will be partially segmented from European markets and might be more resistant to regional and global contagion effects.

We apply a GARCH (1,1) methodology that allows for the investigation of the relationship and information spillover effects of more than one asset and uses causality in determinations of means and variances. To the best of our knowledge, this particular methodology has not been used previously to analyze interactions by sector in emerging Eastern European stock markets. We study the linkages among different stock markets and the sectoral indices of these markets; we hope that the resulting analysis provides at least partial answers to the four questions that are posed in our introduction.

3 MODEL SPECIFICATION

The Generalized Autoregressive Conditional Heteroscedasticity (GARCH) process, which was developed independently by Bollerslev (1986) and Taylor (1986), is widely used for volatility modeling in financial markets. In this model, conditional variance is considered to be dependent on its previous lags. Due to the quadratic nature of the variance terms, the BEKK (Baba-Engle-Kraft-Kroner) parameterization, which was proposed by Engle and Kroner (1995), requires no restrictions on parameters to obtain 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 that contains three parameters in the conditional variance equation and allows the past squared errors to influence the current conditional variance:

$$\boldsymbol{r}_t = \boldsymbol{\beta}\boldsymbol{r}_{t-1} + \boldsymbol{\varepsilon}_t, \tag{1}$$

$$\boldsymbol{\varepsilon}_t | \Omega_{t-1} \sim N(0, \boldsymbol{H}_t), \tag{2}$$

where $\boldsymbol{r}_t$ 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 $\boldsymbol{\varepsilon}_t$ represents the innovation for each market at time t that is available from the information set Ω_{t-1} with its corresponding $n \times n$ conditional variance-covariance matrix $\boldsymbol{H}_t$.

The $\boldsymbol{\beta}$ is an $n \times n$ matrix, with elements that represent its own and the cross-market average autoregressive terms. This multivariate structure facilitates the measurement of the effects of innovations in the mean stock returns of one market on its lagged returns and those of the lagged returns of the other market.

The BEKK parameterization constrains the estimated variances to be non-negative and may be expressed as follows:

$$\boldsymbol{H}_t = \boldsymbol{C}'_0\boldsymbol{C}_0 + \boldsymbol{A}'_{11}\boldsymbol{\varepsilon}_{t-1}\boldsymbol{\varepsilon}'_{t-1}\boldsymbol{A}_{11} + \boldsymbol{G}'_{11}\boldsymbol{H}_{t-1}\boldsymbol{G}_{11}, \tag{3}$$

where $\boldsymbol{C_0}$ is a 2×2 lower triangular matrix with three parameters. In Equation (3), $\boldsymbol{A_{11}}$ is a 2×2 square matrix of parameters that indicates the correlation of conditional variances with prior 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 that captures the information regarding past effects of volatility on conditional variance. With individual elements, Equation (3) takes the following form:

(4) $$\boldsymbol{H}_t = \boldsymbol{C}_0'\boldsymbol{C}_0 + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}' \begin{bmatrix} \varepsilon_{1,t-1}^2 & \varepsilon_{1,t-1}\varepsilon_{2,t-1} \\ \varepsilon_{1,t-1}\varepsilon_{2,t-1} & \varepsilon_{2,t-1}^2 \end{bmatrix} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} + \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix}' \boldsymbol{H}_{t-1} \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix}.$$

If Equation (4) for $\boldsymbol{H}_t$ is further expanded for the bivariate GARCH (1,1) through matrix multiplication, the following results are obtained:

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

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

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 $L(\boldsymbol{\theta})$ for a sample of T observations:

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

(9) $$l_t(\boldsymbol{\theta}) = -log2\pi - 1/2log|\boldsymbol{H}_t(\boldsymbol{\theta})| - 1/2\varepsilon_t'(\boldsymbol{\theta})\boldsymbol{H}_t^{-1}(\boldsymbol{\theta})\varepsilon_t(\boldsymbol{\theta}),$$

where $\boldsymbol{\theta}$ represents the vector of all of the unknown parameters. The 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., to determine whether the error terms ε_t are randomly distributed, by applying the Ljung-Box Q-statistic. This parameter is assumed to be asymptotically distributed as χ_t^2 with ($p - k$) degrees of freedom, where k is the number of explanatory variables in the study.

4 DATA AND DESCRIPTIVE STATISTICS

4.1 Sample countries

Our sample period extends from December 1998 to December 2009 and covers Poland, Hungary and the Czech Republic. These countries joined the European Union in May 2004 but have yet to join the euro zone and continue to retain their own national currencies. These local markets were chosen for their relatively high stock market capitalizations. Moreover, these markets are relatively dynamic and have gone through major economic reforms since the early 1990s (including the privatization of state assets). These markets are more open and liquid than other markets in Eastern Europe. Moreover, the growth of these markets has outstripped that of other markets in emerging Eastern European countries; therefore, we infer that these markets enjoy leadership roles in the region. From our research perspective, these markets are also interesting because the opening of these markets to foreign investment and world trade exposed them to external shocks from global and regional financial markets.

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 Index and European Aggregate Index. Datastream indices are constructed on a uniform basis across countries; the stock market sectoral structure for these indices is comprehensive, and the indices for selected countries exist for the entire sample period. The indices include gross dividends (i.e., they measure the total pre-tax return for investors). All of the study data are obtained from the Datastream database. We conduct our analysis from a US investor's point of view, i.e., returns are measured in US dollars. In accordance with related studies (e.g., Qiao, Liew and Wong, 2007), we consistently use weekly total return indices based on Wednesday observations of market indices for total returns to alleviate the noise effects of daily data and day-of-the-week effects.

Figures 1, 2 and 3 illustrate the historical development of local stock return indices for the selected sample countries. These figures reveal an insignificant non-stationary process in all of the studied markets at the beginning of the analysis period. Beginning in 2005, all of the examined stock markets demonstrate marked gains. After the 2008 financial crisis, we observe the beginnings of stock market recovery in emerging Europe during approximately the spring of 2009. From 2005 onward, the oil & gas industry outperforms local markets in all of the examined countries. In Poland, the consumer goods, financial and basic materials sectors also outperform the market. In Hungary, high returns help the financial sector outperform the local market. In fact, the financial sector is the most attractive sector for local and international investors during the final five years of the observation period. Interestingly, the consumer services, telecommunications and industrial sectors demonstrate below-average profitability in all of the countries that are analyzed.

Table 1 summarizes the weekly local asset returns. Panel A of Table 1 contains the first four moments. The average returns and standard deviations are annualized. The risk-free rate, which is calculated from the Eurodollar rate, provides a 3.40 % average return during the examined time period, with a low standard deviation of 0.27 %, as one would expect. Among the emerging markets that were analyzed, the Czech stock market has the highest return and the lowest standard deviation; in particular, this market provides a 21.26 % annual return for US investors over the examined time period. The poorer Polish and Hungarian stock market performances still produce average returns of 10.41 % and 10.01 % per year, respectively, during this time. All of the sample countries display high volatility; among the examined markets, the highest standard deviation (33.86 %) was observed for the Hungarian market.

A Jarque-Bera test was conducted to check the null hypothesis of normal distribution. The p-values for this test are reported in panel A of Table 1. All of the return series demonstrate significant evidence against the presence of a 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 a year) for each return series are reported. Only the risk-free rate shows evidence of first-order autocorrelation. Somewhat surprisingly, Poland, the Czech Republic, and both the Emerging Europe and European Union aggregates demonstrate first-order autocorrelation in the third lag, although this correlation is not economically significant.

Panel B of Table 1 reports the pairwise correlations among asset returns. All of the examined stock markets are highly correlated, with the highest correlation between the Hungarian and Polish stock markets (0.716). The risk-free rate demonstrates fairly low values of correlation with the sample countries, and these correlations have negative coefficients.

Table 2 presents the descriptive statistics for Polish asset returns from a sectoral perspective. Once again, the values for means and standard deviations are annualized. The basic materials sector provides the highest return for investors, at 21.42 %, whereas the highest standard deviation is observed in the telecommunications industry (39.45 %). The autocorrelation analysis reveals significant autocorrelation in the basic materials and consumer goods sectors; in the third lag, autocorrelation appears for not only these two sectors but also the financial sector. All of the examined sectors exhibit high volatility in their asset returns. Panel B of Table 2 demonstrates significant pairwise correlations between all of the examined sectors; among these sectors, the financial sector demonstrates the greatest correlations with the other examined sectors.

Table 3 displays the descriptive statistics for Hungarian sectoral asset returns. The values for means and standard deviations, which are presented in Panel A, are annualized. Among the examined sectors, the financial sector has the highest return, at 18.51 % per year, and the highest volatility. All of the sectors exhibit high volatility in their asset returns. Only the industrial sector has a negative average asset return on average of (-5.50 % per year). Significant autocorrelation coefficients are observed for the consumer goods and oil & gas sectors in the first and second lags, respectively. Panel B of Table 3, which reports the pairwise correlation coefficients for the examined sectors, reveals that significant correlations exist between each pair of sectors that is assessed; similarly to the result for Poland, the financial sector is the sector that is the most highly correlated with the other examined industries.

Table 4 provides descriptive statistics for the asset returns of Czech industries, including annualized means and standard deviations. The highest asset returns in the Czech stock market during the sample period are obtained in the financial sector (29.59 % per year), whereas the highest volatility is in the consumer services sector (55.13 % per year). The consumer services sector is the only industry that produces a negative return (-0.08 % per year). The autocorrelation analysis demonstrates the presence of autocorrelation for the industrial sector in the first lag, for the telecommunications sector in the third lag, and for the oil & gas sector in the second and third lags. The pairwise correlation analysis once again indicates that the financial sector is highly correlated with the other examined sectors.

4.2 Correlation analysis

We begin our investigation by examining the time series development of correlations in returns between local stocks and the Emerging Europe Index for each country. Figures 4, 5 and 6 present the 52-week (one-year) rolling-window correlation coefficients for these analyses.

The observed correlations during the sample period are volatile. Interestingly, almost all of the Polish stock market sectors, with the exception of telecommunications, are not highly correlated with the Emerging Europe Index at the beginning of the period. However, beginning in summer 2006, the Polish stock market sectors become highly correlated with other stock market sectors in emerging European countries. Our figures reveal that after the summer of 2006, sectors in emerging Europe demonstrate an increased correlation with the sectors of both the Hungarian and Czech stock markets. The moving-average trend lines for correlations 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 reveal an increase in correlation among the examined markets, supporting the hypothesis that during the examined period, these local markets become increasingly integrated with emerging European markets.

5 EMPIRICAL RESULTS

We begin from the premise that certain industries are more integrated into regional and world financial processes than other industries and are therefore more prone to contagion. If this hypothesis holds true, it should be possible to identify industries that provide risk-diversification opportunities and sectors that are isolated from changes in the European financial markets. This information would allow for the application of portfolio management based on sectoral diversification to selected emerging markets, and assets of these industries could be treated as a separate class of investments. The objective of this study is defining the sectors in our selected markets, which have a unidirectional impact on local and European markets to facilitate the construction of an investment portfolio from partially segmented sectors. Our analysis is geared to understanding the volatility and shock transmission mechanism between emerging Eastern European countries and the EU.

5.1 Linkages between equity markets

Our empirical analysis is geared towards answering the questions that are formulated in the introduction to this paper. First, we analyze interactions both within and among the examined local markets, the Emerging Europe Index and European Union aggregates to obtain an overview of the Polish, Hungarian and Czech stock markets.

5.1.1 The interactions of local stock markets with emerging Europe

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

Matrix ***B*** in Equation (1) (the mean equation) exhibits this relationship in terms of the returns of the examined countries. Table 5 reveals the dependence of Polish, Hungarian and Czech returns on their first lags, which is evidenced by the fact that the $\boldsymbol{\beta}_i$ parameters are statistically significant for all of the modeled pairs, including the Emerging Europe Index and local markets. The returns of emerging Europe markets also depend on their first lags in all of the modeled pairs involving local markets.

Next, we examine matrices ***A*** and ***G*** to assess risk transfer with respect to mean and volatility and report the estimated results in Table 5. The diagonal elements in matrix ***A*** focus on the role of ARCH effects in the risk transfer process, whereas the diagonal elements in matrix ***G*** illustrate the power of the GARCH effect. The estimated a_{11}, a_{22}, g_{11} and g_{22} parameters are statistically significant, indicating a strong GARCH (1,1) process; this process represents the way in which local effects drive the shock and volatility shifts in the conditional variances of the Polish, Hungarian, Czech and emerging European indices.

Shock and volatility spillover effects are captured by the off-diagonal elements of matrices ***A*** and ***G***. The results show shock transmissions from Hungary to the other selected local markets and emerging Europe. The analysis of shock transmission between Poland and the Czech Republic revealed the existence of bidirectional effects. Similarly, we find bidirectional shock transmissions between all three of the emerging Eastern European countries (the off-diagonal parameters a_{12} and a_{21} are highly statistically significant, indicating the presence of shock transfers from Poland, Hungary and the Czech Republic to emerging Europe and effects on the mean returns in local markets due to 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 modeled pairs exhibit several interesting results. There are significant bidirectional volatility spillovers between Poland and Hungary and between the Czech Republic and emerging Europe, whereas the Czech Republic spillover effect dominates in the modeled pairs of the Czech Republic and either Poland or Hungary. We do not find volatility spillover effects between Hungary and emerging Europe (EE). These results may be regarded as evidence of integration in emerging Eastern European markets.

5.1.2 The interactions 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 respect to market risk transfer. We study four pairs: Poland-EU, Hungary-EU, Czech Republic-EU and EE-EU. The results of these analyses are presented in Table 6. Notably, all of the local markets have the distinguishing feature that their stock market returns are dependent on their previous performance. The EU stock market performance also depends on its previous performance in all four of the aforementioned modeled pairs.

Our results show in the modeled pairs a risk of shock transfer from the Czech Republic or emerging Europe to the EU. Shocks to the EU market affect the Hungarian and Czech stock markets. We document bidirectional volatility transmission almost for all modeled pairs, besides one pair with Hungary.

An over-arching feature of these findings is the importance of emerging European stock markets for European Union market performance. Thus, an understanding of 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 The 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 in local markets are defined by how they affect overall local stock market performance and how well they can fend off external shocks. We estimate seven pairwise models for each country using the BEKK framework. In all of the modeled pairs, the local stock market is tested with various sectors, including the oil & gas, basic materials, industrial, consumer goods, consumer services, telecommunications and financial sectors. A matrix of risk transfers for local stock markets is constructed based on the data that are reported in Table 7 (estimates are available from the author upon request).

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

5.3 The inter-dependence of stock market sectors

We now examine risk transfer between the same sectors among the selected countries and the European Union. In this section, we define the sectors of local markets that affect the EU market and are independent from external factors. For this analysis, the 21 modeled and tested pairs are $Poland_i$-EU_i, $Hungary_i$-EU_i and the Czech $Republic_i$-EU_i, where $i = 1,...,7$ is a sectoral index. A matrix of risk transfers between local and EU stock market sectors is constructed based on the estimated results (which are available upon request); this matrix is presented in Table 8.

The results of the analysis reveal unidirectional transmissions from local markets to the EU in respect to shocks and volatilities. We find support for shock transmissions from the Polish market to the EU in the consumer goods sector, indicating that in Poland, this sector is less integrated with the European stock market than the other examined sectors. Thus, the consumer goods sector of the Polish stock market appears to have been a good candidate for use in a risk diversification portfolio strategy; in fact, this sector demonstrated an average return of 14.86 % per year over the course of the past decade and was more profitable than the overall Polish stock market, which produced an average return of 10.42 % per year.

The Hungarian telecommunications sector exhibits risk transmission to the EU via both shocks and volatilities. Interestingly, the Hungarian telecommunications stock market sector affected the overall local stock market but not itself affected. This sector was found to be significant in unidirectional risk transmissions with the EU as well. Thus, the Hungarian telecommunications stock market sector might be considered for the construction of a risk-diversified asset portfolio. However, the average return in this sector was 1.53 % per year during the past decade; this return is well below the average return of the local stock market as a whole.

In this study, the financial sector was found to have no effect on local markets. However, in an analysis of transmissions to the EU, this sector demonstrated its importance for volatility transfer from the Czech Republic to the EU. Again, it must be noted that the Czech financial sector transfers shocks to the EU stock market but is not itself affected. The Czech financial sector produced an average annual return of 29.59 % during the past decade. Thus, this sector exhibited higher profitability than the local market as a whole.

5.4 Stock market interactions following EU accession in 2004

Finally, we attempt to identify whether the three emerging Eastern European countries that 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 during each of two periods; the results of these estimations are reported 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 the potential effects of EU accession in 2004 and the global financial crisis that began in 2008.

Our results reveal a change in the risk of shock transfer and volatility spillovers after EU expansion. Following this expansion, the basic materials, consumer services and telecommunications sectors become more integrated within the region, whereas the consumer goods sector becomes less integrated. Notably, the overall stock market risk of shock transmission increases significantly after the EU's 2004 enlargement, whereas the average risk of volatility transfers remains the same. This change in stock markets provides evidence of increased stock market integration in Eastern European markets on the sectoral level. The interaction of stock markets with the industrial and oil & gas sectors through shocks increases after accession, whereas the risk of volatility transfer from one regional stock market to another stock market decreases. After accession, financial markets interact more closely because the examined countries share information on asset pricing and related investment risks. Interactions via volatilities in the financial stock market sector in the selected countries increase, whereas stock market interaction in this sector through shocks decrease. The overall results are clear evidence of stock market integration and increased intra-industry contagion in Europe after the EU accession 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 of Tables 5 to 6 and Tables 9 to 15. These tests are used to assess whether the selected model is correctly specified and whether it describes the time series. We report both standardized and standardized squared residuals up to lag 24 for each modeled pair. The results demonstrate no series dependence in the squared standardized residuals, indicating the appropriateness of the GARCH-BEKK model for the study of risk transfer in emerging Eastern European stock markets. Given the large, complicated time series models of this study, we also adopt the appropriate approach of performing an augmented Dickey-Fuller (ADF) test for stock market sector cointegration. The null hypothesis of no cointegration is rejected for each modeled pair at the 1 % level of significance. The results suggest the presence of interactions and co-integration between the corresponding sectors in local stock markets and the EU and linkages between sectors and their foreign counterparts. The estimated results are available upon 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 span the period from December 1998 to December 2009. Our analysis began with an examination of the interdependence and investment risk transfers among local markets, the aggregated emerging European markets and the aggregated European Union stock markets. Subsequently, we considered the interactions between local stock market sectors and overall stock market performance. Third, we examined the interdependence of sectors in emerging stock markets with corresponding European Union stock market sectors. Finally, we discussed investment risk changes in emerging Eastern European countries over the course of the past decade.

The analysis of local stock market interactions with emerging Europe and the EU exhibited bidirectional shock transmissions between the examined local stock markets and emerging Europe. This outcome answered our first research question in the affirmative and emphasized the importance of the Polish, Hungarian and Czech stock markets for other European stock markets. The estimated results are encouraging for the more detailed study of these emerging stock market sectors. The estimations indicate that the emerging European stock markets transfer volatility risk to the Polish and Czech markets, whereas the volatility in the Czech market affected the mean returns of the emerging European markets. Bidirectional interactions of volatilities between the examined local markets and the European Union were observed. These results are consistent with the findings of earlier research with respect to spillover effects between stock markets (e.g., Egert and Kocenda, 2007).

To answer our second question, we investigated which sectors were important for local stock markets. Our results indicate that the oil & gas sector of the Polish stock market affects the local market through shock transfers, whereas the consumer goods and financial sectors do not interact with sudden shocks to the Polish stock market. Evidence of volatility transfers between local sectors of the Polish market was found for all of the examined sectors except the financial sector. The Polish oil & gas and consumer services sectors were shown to be relatively segmented, as these sectors affect mean returns on the Polish market but remain unaffected themselves. On the Hungarian stock market, the consumer goods, consumer services and financial sectors were not linked to the local market with respect to either shock or volatility transfers. Telecommunications was found to be an important sector for the Hungarian stock market that affected this market through volatility changes. The industrial and consumer services sectors were significant originators of risk spillovers in the Czech stock market with regard to volatility changes. Interestingly, the oil & gas sector did not transfer risk to the Czech stock market. Thus, we successfully defined the particular sectors that are important for contagion propagation in the examined local stock markets.

To address the major (third) question, we assessed the significance of local stock market interactions with the EU at the sectoral level. The estimated results revealed that among the examined industrial sectors, the Polish consumer goods, Hungarian telecommunications and Czech financial sectors demonstrate relatively low levels of integration with the equivalent sectors of European markets. Moreover, these sectors have unidirectional impact on the European markets. Thus, it is possible to construct the investment portfolio by investing in assets of these particular sectors, which is partially segmented from European economy. Such portfolio will have lower level of event contagiousness from occurring changes in European countries.

Finally, we examined the stock market interactions after the EU accession of 2004. The scope of shock transmissions between similar sectors in stock markets has increased after EU accession, indicating that accession led to increased integration in European stock markets; thus, these markets are increasingly susceptible to contagion. These findings are consistent with the results of earlier research with respect to both the increased integration of European countries (e.g., Fedorova and Vaihekoski, 2009) and transfers among different stock market sectors (e.g., Phylaktis and Xia, 2009).

To extend this research, it might be productive to study inter-industry dependence in the markets of other emerging European countries and the significance of these emerging European markets for various European and overseas stock markets. The analysis that is provided in the current study would also benefit from an investigation of the interdependence among emerging European stock markets and the largest members of the EU economy. Regime-switching models could also be tested to obtain a more accurate description of stock market interactions during times of crisis.

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Table 1. Descriptive statistics for the asset returns

Panel A reports descriptive statistics for risk-free assets 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 the pairwise correlations for the return series. The index series are the Datastream indices. The sample period extends from November 1998 to December 2009. All of the returns are calculated in US dollars and include dividends (i.e., total return). The sample includes 580 weekly observations. The 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 a 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. The index series are the Datastream indices. The sample period extends from November 1998 to December 2009. All of the returns are calculated in US dollars and include dividends (i.e., total return). The sample includes 580 weekly observations. The 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
Industrial	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
Financial	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.	Industrial	Con. goods	Con. serv.	Telecom	Financial			
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			
Industrial			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			
Financial							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 a year) are zero.

Table 3. Descriptive statistics for the Hungarian sectoral asset returns

Panel A reports descriptive statistics for the continuously compounded returns of the Hungarian stock market. Panel B reports pairwise correlations for the sectoral return series. The index series are the Datastream indices. The sample period extends from November 1998 to December 2009. All of the returns are calculated in US dollars and include dividends (i.e., total returns). The sample includes 580 weekly observations. The 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
Industrial	-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
Financial	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.	Industrial	Con. goods	Con. serv.	Telecom	Financial			
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			
Industrial			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			
Financial							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 a year) are zero.

Table 4. Descriptive statistics for the Czech sectoral asset returns

Panel A reports descriptive statistics for the continuously compounded returns of the Czech stock market. Panel B reports pairwise correlations for the sectoral return series. The index series are the Datastream indices. The sample period extends from November 1998 to December 2009. All of the returns are calculated in US dollars and include dividends (i.e., total returns). The sample includes 580 weekly observations. The 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	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
Industrial	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
Financial	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.	Industrial	Con. goods	Con. serv.	Telecom	Financial			
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			
Industrial			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			
Financial							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 a year) are zero.

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

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

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] These values are multiplied by 1,000,000.

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

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

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] These values are multiplied by 10,000.

Table 7. The matrix of risk transfers on local stock markets

Industries	Poland		Hungary		Czech Republic	
	Shocks[1]	Volatilities	Shocks	Volatilities	Shocks	Volatilities
Oil & Gas	↑	↑	⇆	⇆		
Basic Materials	⇆	⇆	←	←	⇆	⇆
Industrial	⇆	⇆	⇆	⇆	⇆	↑
Consumer Goods		⇆			←	←
Consumer Services	←	↑			⇆	↑
Telecom.	⇆	⇆	←	↑	⇆	⇆
Financial					⇆	←

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

Table 8. The 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	⇆	⇆	↑	↑	↑	↑
	Industrial	↑	⇆	↑	↑	⇆	⇆
	Consumer Goods	←	←			↑	⇆
	Consumer Services	↑	↑	↑	↑	⇆	⇆
	Telecom.	↑	↑	⇆	←	↑	↑
	Financial			⇆	↑	←	⇆

[1] ↑ indicates unidirectional intra-industry spillovers in shocks or volatilities from the European Union to a local market;
⇆ indicates bidirectional spillovers in shocks or volatilities between the European Union and a local market;
← indicates unidirectional intra-industry spillovers in shocks or volatilities from a local market to the European Union.

Table 9. Risk transfer for the oil & gas sectors of local stock markets, estimated with sub-periods

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

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] These values are multiplied by 100,000.

Table 10. Risk transfer for the basic materials sectors of local stock markets, estimated with sub-periods

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

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

	1998–2003 Poland-Hungary	1998–2003 Poland-Czech R.	1998–2003 Hungary-Czech R.	2004–2009 Poland-Hungary	2004–2009 Poland-Czech R.	2004–2009 Hungary-Czech R.
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] These values have been multiplied by 10,000.

Table 11. Risk transfer for the industrial sectors of local stock markets, estimated with sub-periods

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

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

	Industrial											
	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] These values are multiplied by 10,000.

Table 12. Risk transfer for the consumer goods sectors of local stock markets, estimated with sub-periods

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

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

	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	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) These values have been multiplied by 10,000.

Table 13. Risk transfer for the consumer services sectors of local stock markets, estimated with sub-periods

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

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] These values have been multiplied by 100,000.

Table 14. Risk transfer for the telecommunications sectors of local stock markets, estimated with sub-periods

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

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

	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	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) These values have been multiplied by 10,000.

Table 15. Risk transfer for the financial sectors of local stock markets, estimated with sub-periods

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

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

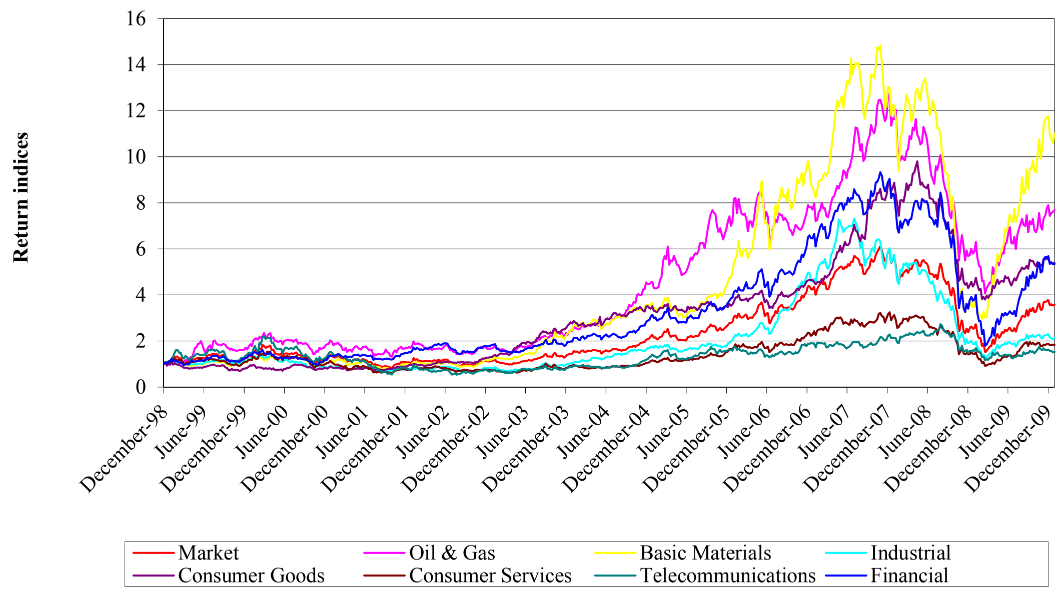
	Financial											
	1998–2003						2004–2009					
	Poland-Hungary		Poland-Czech R.		Hungary-Czech R.		Poland-Hungary		Poland-Czech R.		Hungary-Czech R.	
Parameters	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.	Coef.	SE.
β_1	0.002	(0.002)	0.002	(0.002)	0.004	(0.003)	0.007*	(0.002)	0.007*	(0.002)	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*

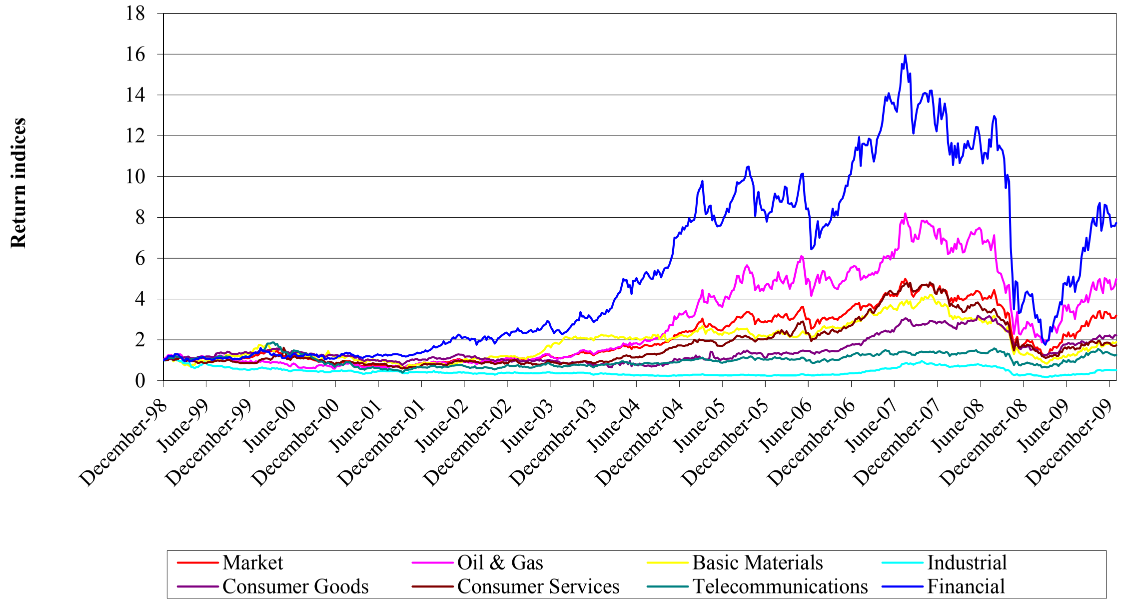
[a] These values have been multiplied by 10,000.

Figure 1. Polish stock return indices.



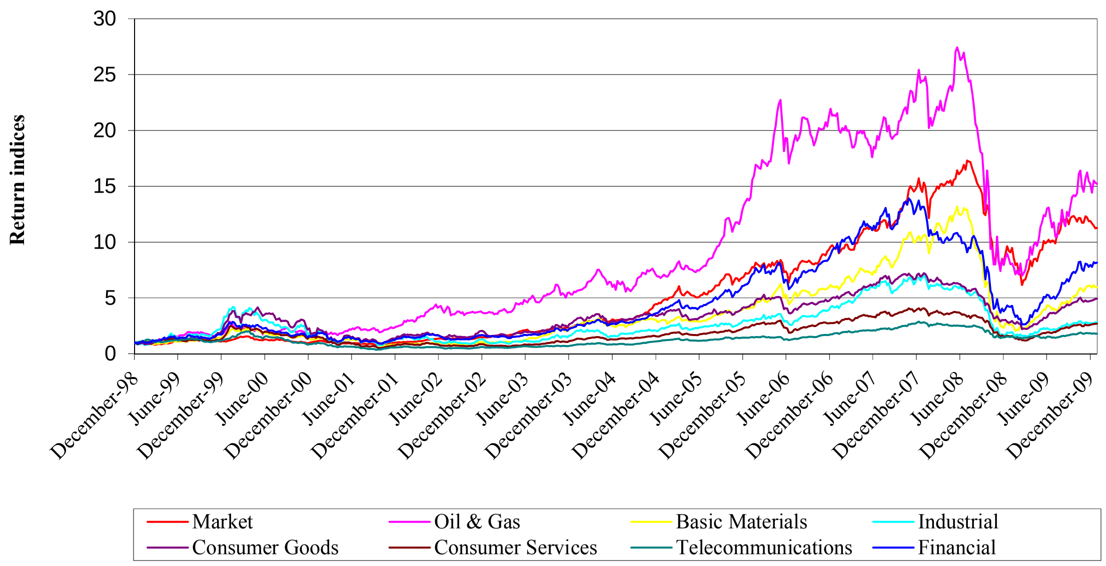
All indices are scaled to one in December 1998.

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. The 52-week rolling correlation between the Polish equity market and emerging Europe.

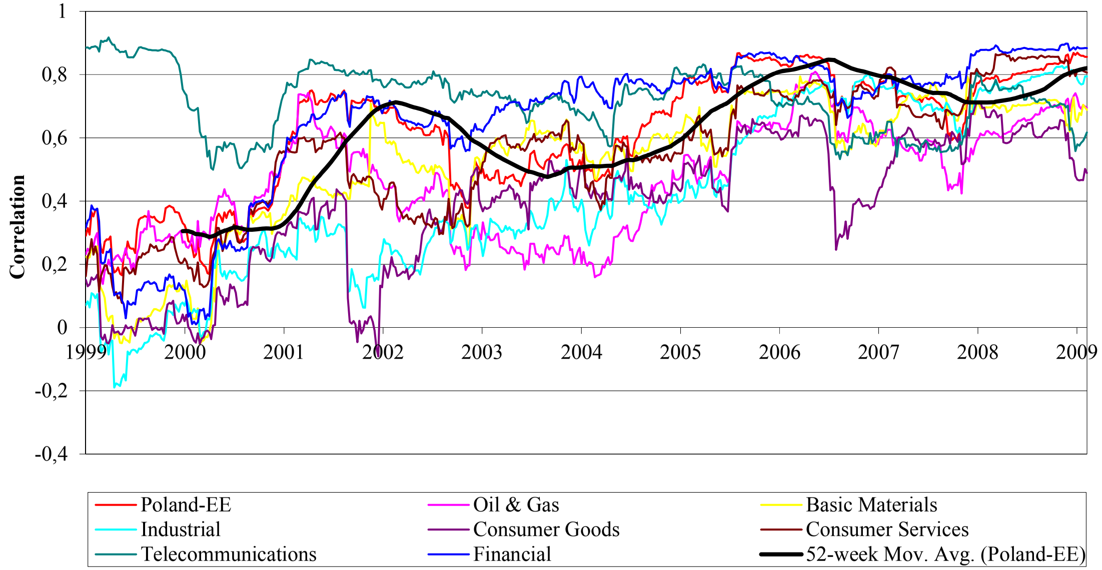


Figure 5. The 52-week rolling correlation between the Hungarian equity market and emerging Europe.

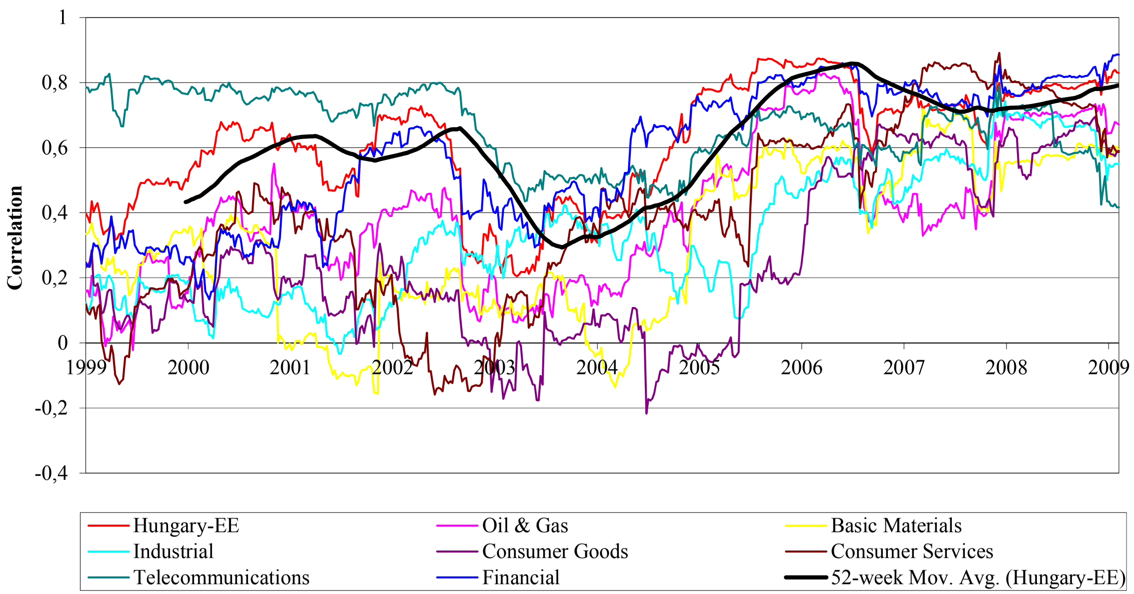
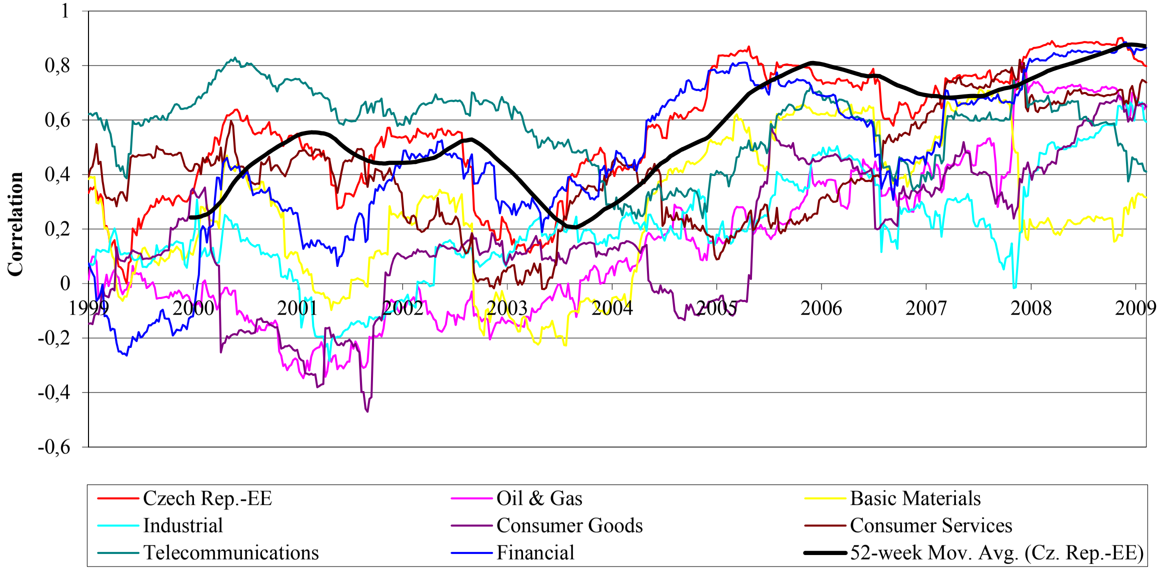


Figure 6. The 52-week rolling correlation between the Czech equity market and emerging Europe.



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WHAT TYPES OF MACROECONOMIC ANNOUNCEMENTS AFFECT STOCK MARKETS IN EMERGING EASTERN EUROPE?

Elena Fedorova*

ABSTRACT

This study considers the impact of foreign and local macroeconomic announcements on emerging Eastern European stock markets. Stock market and macroeconomic news from 2006–2010 for Russia, Poland, Hungary and the Czech Republic are analyzed for differences across countries and to determine whether foreign macroeconomic announcements have a greater impact on stock performance than local macroeconomic news. The direct linkage between stock markets and macroeconomic announcements is found, as well as evidence of integration among the stock markets in emerging Eastern Europe. Macroeconomic news appears to affect local market volatility and, in rare instances, stock returns themselves. Negative news has a leverage effect for emerging Eastern European stock markets, as greater volatility in the stock market is generated by negative news than by positive news. The results of this study have implications for asset pricing and portfolio selection for international financial institutions and for portfolio managers who are assessing their investment decisions with respect to macroeconomic news releases.

JEL classification: C32, F36, G12, G15

Keywords: macroeconomic announcements, stock market integration, spillovers, leverage effect, emerging markets, Eastern Europe, EGARCH.

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1 INTRODUCTION

Macroeconomic news causes reactions on financial markets, at least to a certain extent. The character of this market reaction depends on various factors, such as the level of development of the national economy, the type of financial market, the content of the news and whether the news in question is truly unexpected. Entorf, Gross and Steiner (2012) point out the difference of stock market reactions on whether the macroeconomic news is released by governmental agencies or the private sector, whereas Albuquerque and Vega (2009) examine the type of news release that occurs, and Kim, McKenzie and Faff (2004) focus on the news releases and their positive and negative effects to stock markets. De Goeij and Marquering (2006) note that shocks from negative news generate more volatility in the market than shocks from positive news (so-called leverage effect). By contrast, Brenner, Pasquariello and Subrahmanyam (2009) find that stock returns are most sensitive to releases of unexpected positive news (e.g., announcement of GDP value which is on 0.5% higher than was expected). In fact, certain types of positive news have been found to affect stock market volatility more than negative news (Bomfim, 2001). Boyd, Hu and Jagannathan (2005) and Funke and Matsuda (2006) also note that a perverse effect of news can occur; in particular, certain types of negative news (e.g., announcements about GDP growth or unemployment) during boom periods can positively affect stock prices. In addition, Entorf, Gross and Steiner (2011) claim that an impact of macroeconomic news on the volatilities of stocks is observed only in the presence of simultaneous news releases from multiple sources.

The empirical literature distinguishes two sources of news effects (e.g., Rangel, 2011): scheduled macroeconomic announcements that defy observer expectations (the announcement effect) and unexpected macroeconomic announcements (the surprise effect). Scheduled but unexpected announcements (e.g., a GDP growth rate that differs by three tenths of a percent from the expected GDP growth rate or a corporate dividend that differs from expectations by a few pennies) tend to have less impact than surprise announcements, which are typically more informative and significant for the market than scheduled announcements (e.g., Kim, McKenzie and Faff, 2004). The day on which news is published has little impact on conditional market volatility (Rangel, 2010). Both the announcement effect and the surprise effect are apparent in the US stock market; in this market, the media ritualize the releases of various types of data, such as unemployment statistics, inflation rates, or transcripts of Federal Reserve meetings. By contrast, European markets typically only exhibit the surprise effect (Jiang, Konstantinidi and Skiadopoulos, 2010). Flannery and Protopapadakis (2002) conclude that the investor response (volatility) to an announcement is more likely to be associated with the content of the macroeconomic announcements themselves rather than with the announcement's timing (i.e., whether the announcement occurs on a scheduled announcement day).

The recent financial crisis and its accompanying contagion effects prompted a flurry of studies on the effects of macroeconomic releases on stock markets. One area of particular interest has been the search for markets that are isolated (or at least insulated) from global turmoil. Candidate markets include the markets of Eastern Europe. For example, Hanousek, Kočenda and Kutan (2009) examine the reactions of the Polish, Hungarian and Czech stock markets to US, EU and local macroeconomic news (without distinguishing between different types of news). These researchers find local announcements to be the most determinative types of news with respect to asset pricing in emerging Eastern European countries. However, foreign news is more important for local markets if local news is released prior to the start of the working day. Hanousek and Kočenda (2011) study the impact of different types of macroeconomic releases on local markets, including possible day-of-the-week effects. These researchers find that volatility in local markets tends to decrease as the business week proceeds.

Rockinger and Urga (2001) conduct a study of Eastern European stock markets that investigates the foreign news effect on these markets; in particular, these researchers examine the impacts of news from the US, the UK and Germany. They report that the UK is the most essential market for Eastern European countries with respect to price and volatility spillovers. Interestingly, the Hungarian stock market has a rather low level of predictability; in this market, negative news generates less volatility than positive news. Moreover, the Russian market demonstrates convergence with efficient markets and sensitivity to shocks from US economic news. Similar evidence of the integration of the Russian market with global markets is provided by Hayo and Kutan (2005), who also observe that the Russian market became less integrated with developed countries after the financial crisis of 1998. Büttner, Hayo and Neuenkirch (2011) study Emerging Eastern European (EEE) stock markets and the importance of US and EU macroeconomic news. These researchers claim that the significance of EU news has increased over the last decade.

Although the impact of macroeconomic news on Eastern European stock markets has been investigated by researchers, the empirical literature lacks evidence regarding the impact of macroeconomic news releases in geographically proximate and otherwise closely related countries.

This study investigates the impact of macroeconomic news from geographically and otherwise closely related countries in EEE what for the best of author's knowledge was not done earlier. For that the following questions are addressed:

- Do macroeconomic announcements affect the pricing of stocks?
- What are the differences in these announcements make the stock market reaction vary?
- Does foreign news from geographically proximate and otherwise closely related countries affect local stock markets? If there is an impact from this type of news, then what is the extent of this impact?

The aim of this study is to produce a number of useful insights for investors and portfolio managers that have invested in the EEE markets. Possessing of information on the impact of macroeconomic news releases on stock markets it is possible to reconstruct investment portfolios in order to hedge investments from event contagion and gain higher returns.

An EGARCH (1,1) methodology is applied in this study that allows for asymmetries in volatilities if the relationship between volatility and returns is negative. The sample period extends from 2006 to 2010, and such countries as Russia, Poland, Hungary and the Czech Republic are examined. The macroeconomic news announcements are collected by Reuters and include 2,547 observations for these four countries. The macroeconomic announcement dataset consists of announcements regarding retail sales, foreign trade balances, current accounts, budget balance, the money supply, industrial production, the unemployment rate, national reserves, central bank rates, GDP, CPI, PPI, inflation rates, business climate indices and construction output.

The remainder of this paper is organized as follows. Section 2 presents the theoretical background of the model and the specifications that are used to define the effects of macroeconomic announcements on local stock markets. Section 3 provides descriptive statistics for the stock markets and macroeconomic announcements that are examined in this study. Section 4 presents the results from the model estimation of this study. Section 5 concludes the paper and provides suggestions for future research.

2 MODEL SPECIFICATIONS

2.1 Baseline model

The Exponential Generalized Autoregressive Conditional Heteroscedasticity (EGARCH) model that was proposed by Nelson (1991) is one of the pre-eminent methods for examining the impact of macroeconomic announcements on stocks; this approach and is widely used to estimate volatility in financial markets (see, e.g., Koutmos and Booth, 1995). It provides several advantages over the ordinary GARCH specification. For instance, the EGARCH approach uses logged conditional variances; thus, even if the model parameters have negative signs, the conditional variance remains positive. Therefore, in contrast to GARCH specifications, the EGARCH approach does not require the artificial imposition of non-negativity constraints on the model parameters. Moreover, the EGARCH model allows asymmetries in volatilities if the relationship between volatility and returns is negative. A possible specification of the EGARCH (1,1) model, for example, can be expressed as follows:

(1) $$r_{i,t} = \mu_i + \varepsilon_{i,t},$$

(2) $$\varepsilon_{i,t} = \sigma_{i,t} z_{i,t},$$

(3) $$z_{i,t} \left| \Omega_{t-1} \right. \sim \psi(0,1,\upsilon),$$

(4) $$\ln(\sigma_{i,t}^2) = c_i + \alpha_i \frac{|\varepsilon_{i,t-1}|}{\sigma_{i,t-1}} + \gamma_i \frac{\varepsilon_{i,t-1}}{\sigma_{i,t-1}} + \beta_i \ln(\sigma_{i,t-1}^2),$$

where $r_{i,t}$ is the return on stock market index i at time t, μ_i is a constant (the mean return) and $\sigma_{i,t}^2$ is a conditional variance. The standardized residuals, $z_{i,t}$, are obtained from the set of information available in the previous period, $\psi(.)$ is a conditional density function and v is a vector of parameters that specifies the probability distribution. The variance equation is a function of four parameters, where c_i is a constant term, the estimated parameter α_i represents the symmetric effects of the model, γ_i is a parameter indicating whether the model has an asymmetric effect, and β_i is a parameter that measures the persistence of conditional volatility.

The presence of leverage effects in the model can be tested by the hypothesis that parameter γ_i is less than 0. If this is the case, positive shocks in the market generate less volatility than negative shocks. If γ_i is larger than 0, then market volatility is increased more by positive news than by negative news. The model is symmetric if γ_i is equal to 0.

2.2 The effects of local macroeconomic announcements

The empirical tests begin by analyzing the reactions of stock markets to local macroeconomic releases. A univariate EGARCH (1,1) model with a Gaussian normal distribution of errors is utilized to study the effects of macroeconomic announcements. The mean (Equation 1) and the conditional variance (Equation 4) are extended to incorporate parameters for macroeconomic announcements and stock market returns:

$$r_{i,t} = \mu_i + \boldsymbol{\omega}_i \boldsymbol{r}_{t-1}^{w} + \boldsymbol{\varphi}_i \boldsymbol{r}_{j,t-1} + \lambda_i D_{i,t} + \varepsilon_{i,t}, \tag{5}$$

$$ln(\sigma_{i,t}^2) = c_i + \alpha_i \frac{|\varepsilon_{i,t-1}|}{\sigma_{i,t-1}} + \gamma_i \frac{\varepsilon_{i,t-1}}{\sigma_{i,t-1}} + \beta_i \, ln(\sigma_{i,t-1}^2) + \eta_i D_{i,t}, \tag{6}$$

where $r_{i,t}$ is the daily return at time t for an emerging stock market i. $\mathbf{r}_{t-1}^{w}$ is a 2×1 vector of lagged stock market returns for the United States (US) and emerging Europe (EE). $\boldsymbol{\omega}_i$ is an 1×2 vector of parameters, which represent the autoregressive effects in returns of US and EE markets and presumably capture information that extends beyond macroeconomic announcements alone. The variable $\boldsymbol{r}_{j,t-1}$ is an 3×1 vector lagged stock market returns for all the other sample countries in the study (i.e., $i \neq j$). $\boldsymbol{\varphi}_i$ is an 1×3 vector of parameters, which represent autoregressive effects of emerging stock markets. The variable $D_{i,t}$ is a dummy for macroeconomic announcements that originate in each local market; each of these dummies takes a value of 1 on announcement days and 0 otherwise. Thus, the estimated coefficients λ_i and η_i capture the contemporaneous effects of local macroeconomic news on domestic stock markets and on the volatilities of these markets, respectively.

2.3 The dependence of the impact of news on the category of a news release

To study further the impact of macroeconomic news as a function of the type of news release, local macroeconomic news are segregated into ten sectoral categories. At this step, the mean and variance equations are replaced with the following expressions:

(7) Model 1: $r_{i,t} = \mu_i + \boldsymbol{\omega}_i \boldsymbol{r}_{t-1}^{w} + \boldsymbol{\varphi}_i \boldsymbol{r}_{j,t-1} + \boldsymbol{\lambda}_i \boldsymbol{D}_{i,t} + \varepsilon_{i,t}.$

Model 2: $r_{i,t} = \mu_i + \boldsymbol{\omega}_i \boldsymbol{r}_{t-1}^{w} + \boldsymbol{\varphi}_i \boldsymbol{r}_{j,t-1} + \lambda_i D_{i,t} + \varepsilon_{i,t}.$

(8) Model 1: $ln(\sigma_{i,t}^2) = c_i + \alpha_i \frac{|\varepsilon_{i,t-1}|}{\sigma_{i,t-1}} + \gamma_i \frac{\varepsilon_{i,t-1}}{\sigma_{i,t-1}} + \beta_i \, ln(\sigma_{i,t-1}^2) + \eta_i D_{i,t}.$

Model 2: $ln(\sigma_{i,t}^2) = c_i + \alpha_i \frac{|\varepsilon_{i,t-1}|}{\sigma_{i,t-1}} + \gamma_i \frac{\varepsilon_{i,t-1}}{\sigma_{i,t-1}} + \beta_i \, ln(\sigma_{i,t-1}^2) + \boldsymbol{\eta}_i \boldsymbol{D}_{i,t}.$

Two models for each market are tested. In the mean equation for Model 1, $\boldsymbol{D}_{i,t}$is a $c \times 1$ vector of dummies for macroeconomic announcements taking place in category *c* at time *t*; each of these dummies takes a value of 1 on announcement days for a particular news category and a value of 0 otherwise. In the variance equation of Model 1, $D_{i,t}$ is a dummy for macroeconomic announcements; dummy takes a value of 1 on announcement days and 0 otherwise. In the mean equation of Model 2, $D_{i,t}$ is a dummy for macroeconomic announcements; again, the dummies take a value of 1 on announcement days and 0 otherwise. In the variance equation of Model 2, $\boldsymbol{D}_{i,t}$ is a $c \times 1$ vector of dummies for macroeconomic announcements; each of these dummies takes a value of 1 on announcement days for a particular news category and 0 otherwise. The dummies $\boldsymbol{D}_{i,t}$ are specific for each category even though for some categories the dummies are the same at particular time *t*. The estimated coefficients λ_i and η_i capture the contemporaneous effects of local macroeconomic news from different categories on domestic stock markets and on the volatilities of these markets, respectively.

2.4 The effects of foreign macroeconomic announcements

In the final step of the empirical study, the impact of macroeconomic news released in foreign countries on domestic stock markets is examined. To perform this analysis, the following mean and variance equations are estimated:

(9) Model 1: $r_{i,t} = \mu_i + \boldsymbol{\omega}_i \boldsymbol{r}^w_{t-1} + \boldsymbol{\varphi}_i \boldsymbol{r}_{j,t-1} + \boldsymbol{\lambda}_j \boldsymbol{D}_{j,t} + \varepsilon_{i,t}.$

Model 2: $r_{i,t} = \mu_i + \boldsymbol{\omega}_i \boldsymbol{r}^w_{t-1} + \boldsymbol{\varphi}_i \boldsymbol{r}_{j,t-1} + \lambda_i D_{i,t} + \varepsilon_{i,t}.$

(10) Model 1: $ln(\sigma^2_{i,t}) = c_i + \alpha_i \frac{|\varepsilon_{i,t-1}|}{\sigma_{i,t-1}} + \gamma_i \frac{\varepsilon_{i,t-1}}{\sigma_{i,t-1}} + \beta_i \, ln(\sigma^2_{i,t-1}) + \eta_i D_{i,t}.$

Model 2: $ln(\sigma^2_{i,t}) = c_i + \alpha_i \frac{|\varepsilon_{i,t-1}|}{\sigma_{i,t-1}} + \gamma_i \frac{\varepsilon_{i,t-1}}{\sigma_{i,t-1}} + \beta_i \, ln(\sigma^2_{i,t-1}) + \boldsymbol{\eta}_j \boldsymbol{D}_{j,t}.$

Two models are estimated for each local market. In the mean equation of Model 1, the variable $\boldsymbol{D}_{j,t}$ is a *3×1* vector of dummies for foreign macroeconomic announcements; each of these dummies takes a value of 1 on announcement days for a particular country and 0 otherwise. In the variance equation of Model 1, $D_{i,t}$ is a dummy for local macroeconomic announcements; the dummy takes a value of 1 on announcement days and 0 otherwise. In the mean equation of Model 2, the variable $D_{i,t}$ is a dummy for local macroeconomic announcements; the dummy takes a value of 1 on announcement days and 0 otherwise. In the variance equation of Model 2, $\boldsymbol{D}_{j,t}$ is a *3×1* vector of dummies for foreign macroeconomic announcements; each of these dummies takes a value of 1 on announcement days for a particular country and 0 otherwise. The $D_{j,t}$, $\boldsymbol{D}_{j,t}$, $D_{i,t}$ and $\boldsymbol{D}_{i,t}$ are specific for each country even though for some countries the dummies are the same. The estimated coefficients λ_i, λ_j, η_i and η_j capture the contemporaneous effects of local and foreign macroeconomic news on domestic stock markets and on the volatilities of these stock markets, respectively.

The variance-covariance matrices can be optimized with the Berndt, Hall, Hall and Hausman (1974) algorithm (see Engle and Kroner, 1995). The BHHH algorithm is based on the determination of the first derivatives of the log-likelihood function with respect to the parameter values at each iteration of the model estimation. The BHHH method utilizes only first derivatives, but approximations of second derivatives are calculated.

From Equations (6), (8) and (10), we obtain the conditional log-likelihood functions $L(\theta)$ for a sample of T observations:

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

(12) $$l_t(\boldsymbol{\theta}) = -log2\pi - 1/2log|\boldsymbol{H}_t(\boldsymbol{\theta})| - 1/2\varepsilon_t'(\boldsymbol{\theta})\boldsymbol{H}_t^{-1}(\boldsymbol{\theta})\varepsilon_t(\boldsymbol{\theta}),$$

where $\boldsymbol{\theta}$ represents the vector of all of the unknown parameters. The numerical maximization of Equations (11) and (12) produces the maximum likelihood estimates with asymptotic standard errors.

The EGARCH models are tested to determine whether they are correctly specified. Under the null hypothesis with normally distributed errors, the used F-statistic should have an F-distribution with *k-1* numerator degrees of freedom and *T-k* denominator degrees of freedom, where *k* is the number of explanatory variables that are examined.

3 DATA AND DESCRIPTIVE STATISTICS

3.1 Stock markets

The analysis in this study focuses on the major emerging stock markets in Eastern Europe: Russia, Poland, Hungary and the Czech Republic. All of these countries have made at least part of the transition from command to market economies. Poland, Hungary and the Czech Republic joined the European Union in May 2004 but remain outside the euro zone and retain their national currencies. By contrast, EU membership has never been a consideration for Russia. The sample countries boast financial markets that are more open, more liquid and faster growing than other markets in Eastern Europe. From this observation, these countries enjoy leadership roles in this region. The markets of these countries are also interesting from a research perspective because the opening of these markets to foreign investment and world trade has increased their exposure to external shocks from global and regional markets.

The market portfolios from each of the sample countries are utilized as test assets. Datastream's Emerging Europe index is used as a proxy for stock returns in emerging European countries. We conduct our analysis from a US investor's point of view; therefore, returns are measured in US dollars. Total return indices (including gross dividends) from the beginning of January 2006 through the end of December 2010 are obtained from Datastream and used to calculate logarithmic stock market returns.

Table 1 presents descriptive statistics for daily market returns from the examined European countries, the aggregate of emerging European countries and the US. Panel A in Table 1 provides the first four moments. The average returns and standard deviations are annualized. The Hungarian stock market averages a 0.62% return during the analyzed period; among the selected markets that are assessed in this study, this market produces the lowest rate of return and the second highest standard deviation (40.90%). The Czech stock market produces the highest return among the emerging countries that are analyzed; in particular, this market provides a return of 8.98% a year for investors. The US stock market averages a 2.88% return and demonstrates the lowest standard deviation (24.19%) among the examined markets. All of the sample countries display high volatility, although the Russian market evinces the highest standard deviation (43.62%).

A Jarque-Bera test is conducted to assess the null hypothesis of normal distribution. The relevant *p*-values are reported in Panel A. All of the return series present evidence against the existence of a normal distribution. In addition, the autocorrelation of returns is calculated. The first three autocorrelation coefficients and the Ljung-Box test statistic (30 lags ≈ 1.5 months) are reported for each return series. The returns for Poland, Hungary and the aggregate of emerging Europe demonstrate evidence of first-order autocorrelation. Somewhat surprisingly, the returns for Hungary and the Czech Republic possess first-order autocorrelation in the second lag, and the US returns evince autocorrelation in the third lag.

Panel B in Table 1 reports pairwise correlations among the examined asset returns. All of the stock markets are highly correlated. The greatest observed correlation occurs between the Russian market and the emerging European market (0.917). The US market demonstrates lower values of correlation with the sample countries but is most closely correlated with the Hungarian stock market. Although these highly correlated coefficients produce multicollinearity in the explanatory variables of this study, this is not a concern as long as the model is otherwise adequate. After all, one of our goals is to investigate whether local stock prices are influenced by more factors than simply macroeconomic announcements and to identify these fundamental determinants of stock prices in EEE.

Figure 1 illustrates the historical development of local stock return indices for the selected Eastern European countries, the US, and emerging Europe aggregate. This figure indicates the presence of non-stationary returns in all of the examined markets during the analyzed period. In particular, we note the presence of stock market growth in 2006, the market collapse in the autumn of 2008 that was caused by the recent financial crisis, and the market recovery that commenced in approximately the spring of 2009.

3.2 Macroeconomic announcements

Macroeconomic announcement is a public or formal notice announcing macroeconomic indicators, i.e., statistics that indicate the status of the economy or particular area of the economy (e.g., industry, labor market or national accounts). Such news announcements are published on the regularly by the governmental agencies and the private sector. In this study, scheduled macroeconomic announcements, which are classified into one of ten categories defined and collected by Reuters and obtained from ThomsonONE, are utilized.

Macroeconomic news releases for the period from 2006 to 2010 are included in the analysis. The following categories of news announcements are examined: consumer sector, external sector, government sector, industry sector, labor market, money & finance, national accounts, prices, surveys/ cyclical indices and other. The consumer sector category refers to news about retail sales. News in the external sector involves announcements regarding foreign trade balances or national current accounts. The government sector includes news about balancing the budget or the money supply. The industry sector category encompasses industrial production news. The labor market category consists of announcements that address the unemployment rate. The category of money & finance contains news announcements that relate to national reserves or central bank interest rates. News in the national accounts category includes releases of GDP statistics. The prices category refers to news about the CPI, the PPI or inflation rates. News releases that discuss business climate indices are included in the category of surveys/ cyclical indices. News that does not fit any of the categories that are described above but nonetheless possesses macroeconomic implications is assigned to the other category. In practice, this category primarily consists of news about construction activity. The details regarding the examined announcements are presented in Table 2.

The local macroeconomic news is a news announcement generated in a country of origin, and foreign macroeconomic news is a news announcement generated in a country of origin, but in one of the other three emerging Eastern European countries. Thus, an announcement that is released by the Russian media would be local news in Russia but those released in Poland, Hungary and the Czech Republic, are considered as foreign news.

The effects of macroeconomic announcements are estimated in this study by applying news as a dummy variable for announcing the macroeconomic indicators. The dummies take a value of 1 on announcement days for a particular country and 0 otherwise. The dummies of macroeconomic announcements related to particular category of a news release take a value of 1 on announcement days for a particular news category and takes a value of 0 otherwise.

Table 2 summarizes the descriptive statistics for 2,547 macroeconomic announcements in ten categories for the selected emerging markets; in particular, a total of 412 Russian announcements, 611 Polish announcements, 611 Hungarian announcements and 913 Czech announcements from the analyzed period were examined. The timing of each release is clearly noted. News that was announced after a stock market trading session is considered to be news released on the next working day for the purposes of this study. Announcements are collected and considered for each country in the study separately. Thus, quantity of macroeconomic news which is announced on the same day is insignificant (less than 0.01%). The trading hours are 10:00-18:45 (GMT +3 hours) for the Russian stock market, 10:00–16:00 (GMT +1 hour) for the Polish stock market, 9:00–16:30 (GMT +1 hour) for the Hungarian stock market, and 9:00–16:00 (GMT +1 hour) for the Czech stock market. Most news releases in all of the examined countries are announced prior to stock market trading sessions.

During the 2006–2010 time period, among the countries that are examined in this study, the Czech Republic (which averaged 183 news announcements per year) produced the greatest number of macroeconomic news announcements, whereas Russia (averaging 82 news announcements a year) produced the least number of macroeconomic news announcements. The most frequent news announcements in the analyzed countries were classified into the prices category; this category accounted for between 26.7% and 36.8% of the total relevant news announcements that were released in each examined country. Announcements about surveys/ cyclical indices were the least frequent category of news announcements; in particular, only 0.7–5.4% of the total relevant news releases in each examined country consisted of this category of announcements.

Figure 2 illustrates the percentage distribution of macroeconomic announcements in our four EEE markets. The structure of macroeconomic releases clearly varies across these markets. Notably, news releases that refer to prices and announcements that address the industrial, government, external and consumer sectors have been the most frequent types of announcements in EEE countries over the course of the five years that are examined in this study.

4 EMPIRICAL RESULTS

4.1 Local macroeconomic announcements

To study the impact of macroeconomic announcements, four models are estimated in which local macroeconomic releases are allowed to affect the mean and volatility equations for each local stock market. The estimated results are reported in Table 3.

Panel A in Table 3 reports the outcomes of the estimated mean equation; this panel indicates that each emerging stock market in the study is highly dependent on the performance of all of the other examined emerging stock markets during previous periods, as evidenced by the statistical significance of all of the φ_i coefficients. This result suggests that stock markets in emerging Europe have predictability with respect to the pricing of assets. Interestingly, the Russian stock market displays a reverse dependence from the other stock markets; a decrease in stock market returns in Russia is observed if asset prices rise in Poland, Hungary and/or the Czech Republic. Moreover, the trend for emerging European stock markets as a whole has a direct impact on local emerging stock markets with the Russian market experiencing the greatest influence, as evidenced by the positive and significant ω_{EE} coefficients of this panel. A rise in the US market has a negative impact on the Polish and Hungarian stock markets, as evidenced by the negative and statistically significant ω_{US} coefficients for these two stock markets. On the whole, local macroeconomic news does not impact the pricing of assets in local markets, given that the λ_i coefficients demonstrate no statistical significance in the modeled equations.

Panel B in Table 3 illustrates the results of the estimated volatility equation and reveals the market responses to macroeconomic news across the examined markets. Although a certain degree of variation is observed, the homogeneity of the markets that were selected for this analysis is evident. In each of the examined markets, the market volatilities are highly dependent on the market volatility values during the previous period (as evidenced by the positive and significant β_i coefficients), i.e., these volatilities are persistent. Moreover, the γ_i coefficients are statistically significant and negative for Russia and the Czech Republic, indicating that negative shocks (negative news) generate more volatility than positive shocks (positive news) in these two markets. These findings are consistent with existing empirical studies that address news spillover effects to stock markets (e.g., Kim, 2003; Nguyen, 2011). As evidenced by the η_i coefficients of the estimates in Panel B of Table 3, macroeconomic releases in general significantly affect stock market volatility in Hungary but not in Russia, Poland or the Czech Republic.

In all of the estimated equations, the GARCH estimates are significant, as demonstrated by the α_i and β_i coefficients of these estimates. The magnitudes of these coefficients indicate that the explanatory power of the estimated model is most powerful for the Russian market with respect to describing the effects of macroeconomic announcements on an emerging stock market.

4.2 The dependence of the impact of news on the category of a news release

Four models are estimated in which different categories of local macroeconomic news are allowed to affect returns on local stock markets (mean equations), whereas general local macroeconomic information affects volatilities (volatility equations). The results of these estimations are reported in Model 1 of Table 4.

The results of the estimated mean equation that the local market responses to announcements vary across the markets based on the news category that is examined. Announcements from the categories of industrial sector and national accounts affect stock returns in the Russian market. The outcomes for the Polish market reveal that stock returns in this market are most greatly affected by news from the labor market, consumer and external sector categories. Announcements from the government sector are the category of announcements with the largest spillover effects on stock prices in the Czech Republic. Interestingly, no single category of macroeconomic release impacts the stock returns in the Hungarian market. However, there is evidence that news announcements as a whole have a significant impact on market volatility in Hungary (given the positive and significant η_{all} coefficient for Hungary).

The results of the estimated volatility equations indicate that asymmetric effects are observed in Russia and the Czech Republic (as evidenced by the negative and significant γ_i coefficients for these countries), i.e., in these two countries, more volatility is generated in the markets by negative news than by positive news. This finding contrasts with the results of our model estimations for Poland and Hungary, which do not reveal significant asymmetries in the volatility effects from news announcements. Interestingly, macroeconomic announcements affect stock returns in Russia, Poland and the Czech Republic, whereas these announcements affect volatility for the Hungarian market. The GARCH estimates in all of the models are significant, as demonstrated by the α_i and β_i coefficients for each of these models.

At the second step again four models are estimated in which the mean equation is affected by local macroeconomic information and the volatility equation is affected by different categories of local macroeconomic news (Table 4, Model 2). Panel A of Table 4 reports the news coefficients in the mean equation, demonstrating that announcements have no significant impact on returns in all of the estimated models. However, the type of macroeconomic news determines the degree of importance of a particular news release and the extent of this release's impact on stock market volatility (Panel B in Table 4). In particular, as evidenced by the significance of the $\eta_{\text{External sector}}$ coefficients in Table 4, trade balance news significantly impacts volatility in three markets (Poland, Hungary and the Czech Republic). Government and industry sector announcements increase volatility in the Russian and Hungarian markets; this phenomenon is indicated by the fact that the $\eta_{\text{Government sector}}$ and $\eta_{\text{Industry sector}}$ coefficients are positive and significant for these markets. Interestingly, stock market volatilities are significantly decreased by labor market announcements in Russia and the Czech Republic (as evidenced by the negative and significant $\eta_{\text{Labor market}}$ coefficients in these markets) and by news on surveys/ cyclical indices in Russia and Poland. Moreover, the outcomes of the model estimation reveal the importance of news about money & finance with respect to the volatility of the Russian stock market and the importance of news about prices and construction output with respect to the volatility of the Czech market (as indicated by the significance of the $\eta_{\text{Money \& finance}}$, η_{Prices} and η_{Other} coefficients in these two markets).

The GARCH estimates reveal that different types of news exert asymmetric effects on volatilities in the markets of Russia and the Czech Republic (as indicated by negative and significant γ_i coefficients for these markets). Consistent with the findings of Brenner, Pasquariello and Subrahmanyam (2009), in these two countries, more volatility in these markets is generated by negative news than by positive news, whereas roughly symmetric effects of both types of news are observed for the Polish and Hungarian markets (which have insignificant γ_i coefficients). A strong GARCH (1,1) process indicates that the estimated models have good explanatory power for assessing the effects of macroeconomic news.

4.3 Effects of foreign macroeconomic announcements

To study the effects of foreign macroeconomic announcements, four models are estimated in which foreign macroeconomic news is allowed to affect the returns of the local stock market (the mean equation) but local macroeconomic releases affect volatility (Table 5, Model 1). Panel A in Table 5 reveals that the only significant impact of foreign news on local stock market returns in the examined markets occurs for Polish macroeconomic announcements on Czech stock returns (as indicated by the significance of the λ_{Poland} coefficient for the Czech market). Panel B in the same table shows the impact of local news on market volatility. Similarly to the effect of macroeconomic announcements, the Hungarian market demonstrates a dependence on local announcements with respect to volatility. A leverage effect is revealed for Russia and the Czech Republic, i.e., for these two nations, negative shocks in the markets raise the conditional volatility in the next period more than positive shocks of the same magnitude. Interestingly, the spillover of Polish macroeconomic announcements into the Czech stock market also appears to affect volatility. In all of the estimated equations, the GARCH terms reveal the model's explanatory power for analyzing the effects of foreign macroeconomic news.

Finally, four models are estimated in which local macroeconomic news are allowed to impact stock returns (mean equation) and foreign macroeconomic announcements to affect stock market volatility (Table 5, Model 2). The outcomes of these models reveal that local macroeconomic news has no significant impact on stock market returns in any of the examined markets. However, the estimated results do identify an effect of foreign announcements on local market volatility. In particular, Russian macroeconomic news tends to increase stock market volatility in Poland. Furthermore, Czech macroeconomic releases increase volatility in the Russian market. Interestingly, Polish and Hungarian macroeconomic announcements do not significantly impact the volatility of the examined emerging European markets; this result suggests that relative to the Russian and Czech markets, the Polish and Hungarian markets are less integrated with the markets of other emerging European countries.

Significantly negative γ_i coefficients for the Russian, Hungarian and Czech markets indicate asymmetric effects on volatilities in these markets, suggesting that in these markets, negative foreign news generates higher market volatility than positive foreign news. These stock market asymmetries are consistent with the findings of Kim (2003) and of De Goeij and Marquering (2006). Moreover, the estimation results show that foreign macroeconomic releases are more significant than local macroeconomic news for emerging Eastern European markets (a finding that is consistent with the results of Hanousek, Kočenda and Kutan, 2009). In all of the estimated equations, the GARCH terms indicate that the conditional variance is defined and that the model has sufficient explanatory power to analyze the impact of foreign macroeconomic news on local markets.

4.4 Diagnostic tests

The results of diagnostic tests are reported in Panel C of Tables 3 to 5. The adjusted R-squared values in these panels measure how well the regression predicts the values of the dependent variable of the sample. The results for all of the estimated models indicate their explanatory power for measuring the future stock market values in EEE countries. The F-statistic that is reported after each estimated equation is derived from a test of the hypothesis that all of the slope coefficients (excluding the intercept) are equal to zero. Both the F-statistic and the p-values for each F-statistic are reported, which denote the marginal significance level of each F-test. In all of the estimated models, the null hypothesis is rejected, i.e., all of the models are correctly specified and can be used to study the effects of macroeconomic announcements on stock markets in EEE countries.

Moreover, the extent to which the results of Tables 3 to 5 might depend on the particular specifications of Equations 5 and 6 is examined. The robustness of conclusions in this study is evaluated by adding the explanatory variables to the original model specifications and performing the same test with a GARCH methodology. The fully estimated results are not reported here due to space considerations but are available upon request.

The specifications of Equation 5 and 6 could include the European Union's stock market aggregate and dummy variables for the day of the week, the day of an announcement, positive news and negative news. The incorporation of the aggregate into the model specification does not significantly affect the estimated results because the European Union's stock market is highly correlated with the individual stock markets from this study that are already included in the estimations of this study. To test for effects that relate to the day of the week or the day of an announcement, first GARCH (1,1) and EGARCH (1,1) models are estimated that include dummies for days of the week and subsequently perform the same estimations but include dummies for the days of macroeconomic announcements. It was found that stock market volatility significantly increases on Mondays in Poland and the Czech Republic but decreases on Mondays in Russia and Hungary. The model estimations for assessing the effects of the day of an announcement reveal that the day of the week on which an announcement is released has no significant effects on either asset pricing or market volatility.

The effects of macroeconomic announcements are estimated also by applying news as values of macroeconomic indicators and their first differences. The overall results from this approach indicate that the application of changes in macroeconomic values instead of dummies for macroeconomic announcements does not change either the identified factor candidates or the significance levels of these factors from the results that are reported in Tables 3 to 5.

5 CONCLUSIONS

This study investigated the impact of macroeconomic news from geographically and otherwise closely related countries in Emerging Eastern Europe what for the best of author's knowledge was not done earlier. Moreover, it is studied whether the category of a news announcement has an impact on these stock markets and completed the essential step of assessing whether foreign or local news is more determinative for EEE stock markets.

The analyses revealed that local stock markets are influenced by macroeconomic announcements from the same geographical area; this result supports the hypothesis of stock market integration in emerging European countries. The general finding is that macroeconomic news affects local stock market volatility; in rare cases, this news can even affect asset pricing. Moreover, there is an asymmetric effect on volatilities in several of the examined markets; higher levels of next-period conditional volatility in the market are generated by shocks from negative news than by shocks from positive news.

An assessment of the effects of local macroeconomic announcements revealed that the Russian stock market displays a reverse dependence relative to the other emerging European stock markets; thus, a decrease in the returns of the Russian market occurs if market returns increase in the Polish, Hungarian or Czech markets. This phenomenon may reflect investor strategy; other EEE markets may act as an alternative market for investment if the political situation in Russia becomes too unstable or if Russian economic activity declines (and vice versa). Emerging European stock markets significantly influence the pricing of assets in all of the countries in this study. With respect to stock prices, the US stock market affects the Polish and Czech stock markets but not the other markets that are examined in this study; in particular, there is a decline in the Polish and Czech markets if the returns of the US stock market increase.

Diverse impacts of announcements are observed for different categories of news. In general, macroeconomic news that is related to the consumer sector, the external sector, the industry sector, the labor market and national accounts affects asset prices in Russia, Poland and the Czech Republic. News that is related to the external sector, the government sector, the industry sector, the labor market, money & finance, prices and surveys/ cyclical indices impacts volatility in the markets that are examined in this study.

After the main assessments of empirical tests were completed, the impacts of foreign macroeconomic news on emerging European stock markets and their volatilities are analyzed. The results of this analysis suggest the existence of information spillovers from Poland to the Czech Republic with respect to stock returns. The impact of foreign macroeconomic announcements on market volatility is obvious and varies across markets. In particular, the volatility of the Russian market is influenced by macroeconomic releases from the Czech Republic, whereas the volatility of the Polish market is affected by changes in Russian macroeconomic indicators. In both countries, foreign macroeconomic news impacts the stock markets by increasing the volatility of local markets. However, the Polish and Hungarian releases do not significantly impact the volatilities of any of the emerging stock markets in this study, suggesting that relative to the Russian and Czech markets, the Polish and Hungarian markets are less integrated with the selected emerging European countries of this investigation. The estimation outcomes demonstrated that for EEE markets, foreign macroeconomic releases are more significant than local macroeconomic news.

The aim of this study stated in the introduction to this paper was to produce a number of useful insights for investors and portfolio managers who invested in the EEE markets. The results of this study might be utilized by investors in their investment strategies in order to hedge investments from event contagion and gain higher returns.

The stream of research on emerging European stock markets could potentially be extended in the future by assessing the impact of macroeconomic news from economically developed areas, such as parts of the EU (e.g., Germany and the UK), the US and Japan, on these emerging stock markets. Regime-switching models could also be useful for examining the impacts of financial crises and the global integration of financial markets.

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Table 1. Descriptive statistics for the asset returns

Panel A reports descriptive statistics for the continuously compounded returns of four emerging Eastern European stock markets, the stock markets of emerging Europe (as an aggregate) and the US. Panel B reports pairwise correlations for the return series. The index series are the Datastream indices. The sample period extends from 2006 to 2010. All of the returns are calculated in US dollars and include dividends (i.e., total returns). The sample includes 1,305 daily observations for each stock. The means and standard deviations in the table 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_{30}	Q(30)[b]
Panel A: Summary statistics										
Emerging Europe	6.675	32.454	-0.549	11.485	<0.001	0.133*	0.046	0.012	0.020	<0.001
US	2.875	24.193	-0.267	11.728	<0.001	-0.076	0.013	0.131*	-0.038	<0.001
Russia	7.700	43.623	-0.263	14.908	<0.001	0.017	0.018	0.006	-0.021	<0.001
Poland	7.000	35.724	-0.215	6.894	<0.001	0.092*	-0.014	0.017	0.011	0.009
Hungary	0.623	40.899	0.018	10.237	<0.001	0.096*	-0.079*	0.007	0.010	<0.001
Czech Republic	8.975	34.328	-0.003	15.990	<0.001	0.042	-0.080*	-0.052	0.043	<0.001
Panel B: Pairwise correlations	EE	US	Russia	Poland	Hungary	Czech Rep.				
Emerging Europe	1	0.376	0.917	0.767	0.698	0.754				
US		1	0.334	0.392	0.429	0.344				
Russia			1	0.654	0.597	0.641				
Poland				1	0.783	0.760				
Hungary					1	0.707				
Czech Republic						1				

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

b) The *p*-value of the Ljung-Box test statistic for the null hypothesis that autocorrelation coefficients for up to 30 lags (approximately 1.5 months) are zero.

Table 2. Macroeconomic announcements

News announcements are collected by Reuters and obtained from the Thomson ONE database. The sample period extends from 2006 to 2010 and includes 2,547 macroeconomic announcements.

Announcements	Russia		Poland		Hungary		Czech Republic	
	Abs.	%	Abs.	%	Abs.	%	Abs.	%
Consumer sector	NA	(NA)	59	(9.7)	57	(9.3)	59	(6.5)
External sector	49	(11.9)	60	(9.8)	82	(13.4)	120	(13.1)
Government sector	47	(11.4)	61	(10.0)	57	(9.3)	114	(12.4)
Industry sector	35	(8.5)	40	(6.6)	61	(10.0)	66	(7.2)
Labor market	41	(9.9)	81	(13.3)	104	(17.0)	53	(5.8)
Money & finance	33	(8.0)	72	(11.8)	15	(2.5)	79	(8.7)
National accounts	60	(14.6)	19	(3.1)	39	(6.4)	30	(3.3)
Prices	141	(34.2)	215	(35)	163	(26.7)	336	(36.8)
Surveys/ cyclical indices	6	(1.5)	4	(0.7)	33	(5.4)	6	(0.7)
Other	NA	(NA)	NA	(NA)	NA	(NA)	50	(5.5)
Total	412	(100)	611	(100)	611	(100)	913	(100)

[a] News items are categorized as follows:
Consumer sector = retail sales; external sector = foreign trade balance and current account; government sector = budget balance and money supply; industry sector = industrial production; labor market = unemployment; money & finance = national reserves and central bank rates; national accounts = GDP; prices = Consumer Price Index, Producer Price Index and inflation rates; surveys/ cyclical indices = business climate index; other = construction activity.

[b] NA indicates that data for a particular type of announcement are unavailable.

Table 3. Macroeconomic announcements and their effects on stock markets

The parameter estimates for the mean equation are reported in Panel A and the parameter estimates for the volatility equation are reported in Panel B. The sample period extends from 2006 to 2010. The index series are the Datastream indices. All of the returns are calculated in US dollars and include dividends (i.e., total returns). The sample includes 1,305 daily observations for each stock and 2,547 observations of macroeconomic announcements from four emerging countries. Panel C reports the results of diagnostic tests. The *F*-statistic and the probability for the *F*-test of the null hypothesis that all of the slope coefficients (excluding the intercept) are equal to zero are provided in the table.

	Russia		**Poland**		**Hungary**		**Czech Republic**	
Parameters	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.
Panel A: Mean equation								
μ_i	-0.283 [b]**	0.153 [b]	-0.133 [b]	0.327 [b]	-0.016 [b]	0.395 [b]	-0.169 [b]	0.342 [b]
ω_{US}	-0.016	0.013	-0.070*	0.023	0.161*	0.027	-0.033	0.022
ω_{EE}	1.424*	0.009	0.697*	0.049	0.424*	0.055	0.494*	0.044
φ_{Russia}	-	-	-0.258*	0.032	-0.135*	0.035	-0.131*	0.028
φ_{Poland}	-0.166*	0.014	-	-	0.495*	0.024	0.242*	0.021
$\varphi_{Hungary}$	-0.096*	0.010	0.329*	0.017	-	-	0.157*	0.019
$\varphi_{Czech\ Rep.}$	-0.079*	0.010	0.217*	0.019	0.207*	0.027	-	-
λ_i	-0.029 [b]	0.324 [b]	0.801 [b]	0.544 [b]	-0.958 [b]	0.672 [b]	0.005[b]	0.532 [b]
Panel B: Volatility equation								
c_i	-0.233*	0.035	-0.174*	0.040	-0.394*	0.059	-0.392*	0.079
α_i	0.203*	0.018	0.125*	0.018	0.178*	0.021	0.221*	0.027
γ_i	-0.054*	0.016	-0.012	0.012	-0.019	0.014	-0.076*	0.017
β_i	0.991*	0.003	0.992*	0.003	0.974*	0.005	0.976*	0.007
η_i	-0.019	0.024	0.016	0.029	0.104 *	0.039	0.022	0.036
Panel C: Diagnostic tests								
Adj. R^2		0.837		0.730		0.660		0.648
Log-likelihood		4665.885		4082.203		3822.789		4076.034
F-statistic		611.436		318.350		230.1812		218.500
Prob (F-statistic)		<0.001		<0.001		<0.001		<0.001

a) Coefficients that differ from zero at the 5% and 10% significance levels are marked with * and **, respectively.

b) This value has been multiplied by 1,000.

Table 4. The dependence of the impact of a news release on its category

Parameter estimates for the mean equation are reported in Panel A, and parameter estimates for the volatility equation are provided in Panel B. The sample period extends from 2006 to 2010. The index series are the Datastream indices. All of the returns are calculated in US dollars and include dividends (i.e., total returns). The sample includes 1,305 daily observations for each stock and 2,547 observations of macroeconomic announcements from four emerging countries. Panel C reports the results of diagnostic tests. The *F*-statistic and the probability for the *F*-test of the null hypothesis that all of the slope coefficients (excluding the intercept) are equal to zero are provided in the table.

	Russia				**Poland**			
	Model 1		**Model 2**		**Model 1**		**Model 2**	
Parameters	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.
Panel A: Mean equation								
μ_i	-0.328 ^{b}*	0.153 ^{b}	-0.258 ^{b}	0.164 ^{b}	0.003 ^{b}	0.320 ^{b}	-0.238 ^{b}	0.319 ^{b}
ω_{US}	-0.010	0.013	-0.015	0.014	0.071*	0.023	0.073*	0.024
ω_{EE}	1.423*	0.010	1.424*	0.011	0.665*	0.049	0.686*	0.051
φ_{Russia}	-	-	-	-	-0.241*	0.032	-0.256*	0.033
φ_{Poland}	-0.171*	0.014	-0.167*	0.014	-	-	-	-
$\varphi_{Hungary}$	-0.095*	0.010	-0.096*	0.010	0.334*	0.017	0.332*	0.018
$\varphi_{Czech\ Rep.}$	-0.074*	0.011	-0.075*	0.011	0.220*	0.020	0.227*	0.021
λ_{all}	-	-	-0.067 ^{b}	0.327 ^{b}	-	-	0.831 ^{b}	0.564 ^{b}
$\lambda_{\text{Consumer sector}}$	-	-	-	-	0.007*	0.002	-	-
$\lambda_{\text{External sector}}$	0.287 ^{b}	0.923 ^{b}	-	-	0.003*	0.001	-	-
$\lambda_{\text{Govern. sector}}$	-0.306 ^{b}	0.001	-	-	0.002	0.001	-	-
$\lambda_{\text{Industry sector}}$	-0.002*	0.001	-	-	0.001	0.002	-	-
$\lambda_{\text{Labor market}}$	-0.254 ^{b}	0.001	-	-	-0.005*	0.002	-	-
$\lambda_{\text{Money \& finance}}$	-0.397 ^{b}	0.001	-	-	-0.390 ^{b}	0.001	-	-
$\lambda_{\text{Nation. accounts}}$	0.001**	0.534 ^{b}	-	-	-0.498 ^{b}	0.002	-	-
λ_{Prices}	0.681 ^{b}	0.665 ^{b}	-	-	-0.001	0.913 ^{b}	-	-
$\lambda_{\text{Surv./ cyc. indices}}$	0.001	0.002	-	-	0.851 ^{b}	0.008	-	-
λ_{Others}	-	-	-	-	-	-	-	-
Panel B: Volatility equation								
c_i	-0.234*	0.035	-0.233*	0.038	-0.233*	0.047	-0.185*	0.043 ^{b}
α_i	0.204*	0.019	0.196*	0.020	0.137*	0.020	0.113*	0.020
γ_i	-0.049*	0.016	-0.048*	0.016	-0.014	0.013	-0.012	0.015
β_i	0.991*	0.003	0.991*	0.003	0.987*	0.004	0.990*	0.004
η_{all}	-0.017	0.025	-	-	0.022	0.032	-	-
$\eta_{\text{Consumer sector}}$	-	-	-	-	-	-	-0.160	0.169
$\eta_{\text{External sector}}$	-	-	-0.143	0.134	-	-	0.339**	0.187
$\eta_{\text{Govern. sector}}$	-	-	0.265*	0.137	-	-	0.025	0.190
$\eta_{\text{Industry sector}}$	-	-	0.327*	0.112	-	-	0.151	0.145
$\eta_{\text{Labor market}}$	-	-	-0.363*	0.109	-	-	-0.102	0.104
$\eta_{\text{Money \& finance}}$	-	-	-0.303*	0.135	-	-	0.027	0.108
$\eta_{\text{Nation. accounts}}$	-	-	0.030	0.083	-	-	0.067	0.137
η_{Prices}	-	-	0.100	0.089	-	-	0.006	0.098
$\eta_{\text{Surv./ cyc. indices}}$	-	-	-0.480*	0.238	-	-	-0.568**	0.330
η_{Others}	-	-	-	-	-	-	-	-
Panel C: Diagnostic tests								
Adj. R^2		0.837		0.838		0.729		0.728
Log-likelihood		4670.855		4673.387		4088.676		4091.513
F-statistic		372.665		375.285		186.051		184.259
Prob (F-statistic)		<0.001		<0.001		<0.001		<0.001

Table 4. The dependence of the impact of a news release on its category (cont.)

	Hungary				Czech Republic			
	Model 1		Model 2		Model 1		Model 2	
Parameters	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.
Panel A: Mean equation								
μ_i	-0.010[b]	0.382[b]	-0.132[b]	0.396[b]	-0.360[b]	0.327[b]	-0.149[b]	0.337[b]
ω_{US}	0.161*	0.027	0.164*	0.029	-0.036**	0.022	-0.032	0.023
ω_{EE}	0.426*	0.055	0.393*	0.061	0.485*	0.044	0.488*	0.048
φ_{Russia}	-0.137*	0.055	-0.119*	0.042	-0.129*	0.029	-0.118*	0.032
φ_{Poland}	0.495*	0.024	0.516*	0.026	0.241*	0.022	0.239*	0.023
$\varphi_{Hungary}$	-	-	-	-	0.158*	0.020	0.157*	0.019
$\varphi_{Czech\ Rep.}$	0.203*	0.027	0.196*	0.027	-	-	-	-
λ_{all}	-	-	-0.725[b]	0.658[b]	-	-	0.205[b]	0.540[b]
$\lambda_{\text{Consumer sector}}$	-0.621[b]	1.626[b]	-	-	-0.424[b]	0.001	-	-
$\lambda_{\text{External sector}}$	-0.481[b]	1.407[b]	-	-	-0.056[b]	0.901[b]	-	-
$\lambda_{\text{Govern. sector}}$	-0.001	0.002	-	-	0.002*	0.844[b]	-	-
$\lambda_{\text{Industry sector}}$	0.001	0.001	-	-	-0.001	0.001	-	-
$\lambda_{\text{Labor market}}$	0.190[b]	1.098[b]	-	-	0.002	0.002	-	-
$\lambda_{\text{Money \& finance}}$	-0.003	0.004	-	-	-0.001	0.001	-	-
$\lambda_{\text{Nation. accounts}}$	-0.001	0.002	-	-	0.477[b]	0.001	-	-
λ_{Prices}	-0.001	0.001	-	-	0.767[b]	0.001	-	-
$\lambda_{\text{Surv./ cyc. indices}}$	-0.003	0.003	-	-	0.001	0.007	-	-
λ_{Others}	-	-	-	-	0.001	0.002	-	-
Panel B: Volatility equation								
c_i	-0.387*	0.063	-0.205*	0.051	-0.407*	0.084	-0.296*	0.063
α_i	0.178*	0.022	0.118*	0.018	0.227*	0.029	0.164*	0.025
γ_i	-0.019	0.014	0.012	0.015	-0.080*	0.017	-0.067*	0.016
β_i	0.975*	0.006	0.988*	0.004	0.975*	0.007	0.981*	0.006
η_{all}	0.102*	0.042	-	-	0.017	0.037	-	-
$\eta_{\text{Consumer sector}}$	-	-	-0.161	0.114	-	-	-0.090	0.116
$\eta_{\text{External sector}}$	-	-	-0.523*	0.104	-	-	0.262**	0.146
$\eta_{\text{Govern. sector}}$	-	-	0.387*	0.155	-	-	-0.087	0.090
$\eta_{\text{Industry sector}}$	-	-	0.551*	0.140	-	-	-0.019	0.132
$\eta_{\text{Labor market}}$	-	-	0.064	0.089	-	-	-0.453*	0.150
$\eta_{\text{Money \& finance}}$	-	-	-0.035	0.107	-	-	0.191	0.128
$\eta_{\text{Nation. accounts}}$	-	-	-0.017	0.119	-	-	0.136	0.163
η_{Prices}	-	-	0.028	0.100	-	-	-0.248**	0.129
$\eta_{\text{Surv./ cyc. indices}}$	-	-	0.109	0.081	-	-	0.110	0.306
η_{Others}	-	-	-	-	-	-	0.266*	0.132
Panel C: Diagnostic tests								
Adj. R^2		0.657		0.669		0.645		0.649
Log-likelihood		3824.388		3860.524		4080.670		4086.101
F-statistic		132.317		126.062		119.288		120.851
Prob (F-statistic)		<0.001		<0.001		<0.001		<0.001

a) Coefficients that differ from zero at the 5% and 10% significance levels are marked with * and **, respectively.

b) These values have been multiplied by 1000.

Table 5. The effects of foreign macroeconomic announcements

Parameter estimates for the mean equation are reported in Panel A and parameter estimates for the volatility equation are reported in Panel B. The sample period extends from 2006 to 2010. The index series are the Datastream indices. All of the returns are calculated in US dollars and include dividends (i.e., total returns). The sample includes 1,305 daily observations for each stock and 2,547 observations of macroeconomic announcements from four emerging countries. Panel C reports the results of diagnostic tests. The *F*-statistic and the probability for the *F*-test of the null hypothesis that all of the slope coefficients (excluding the intercept) are equal to zero are provided in the table.

	Russia				**Poland**			
	Model 1		**Model 2**		**Model 1**		**Model 2**	
Parameters	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.
Panel A: Mean equation								
μ_i	-0.228 [b]	0.210 [b]	-0.286 [b]**	0.151 [b]	0.374 [b]	0.396 [b]	-0.138 [b]	0.325 [b]
ω_{US}	-0.014	0.013	-0.014	0.014	0.072*	0.023	0.070*	0.024
ω_{EE}	1.411*	0.010	1.425*	0.009	0.702*	0.049	0.701*	0.049
φ_{Russia}	-	-	-	-	-0.256*	0.032	-0.257*	0.032
φ_{Poland}	-0.162*	0.014	-0.168*	0.015	-	-	-	-
$\varphi_{Hungary}$	-0.097*	0.010	-0.097*	0.010	0.324*	0.017	0.328*	0.017
$\varphi_{Czech\ Rep.}$	-0.079*	0.010	-0.076*	0.010	0.213*	0.020	0.215*	0.020
λ_{Russia}	-	-	-0.022 [b]	0.329 [b]	-0.001	0.669 [b]	-	-
λ_{Poland}	-0.330[b]	0.292 [b]	-	-	-	-	0.882 [b]	0.555 [b]
$\lambda_{Hungary}$	0.432 [b]	0.280 [b]	-	-	-0.418 [b]	0.568 [b]	-	-
$\lambda_{Czech\ Rep.}$	-0.306 [b]	0.261 [b]	-	-	0.231 [b]	0.556 [b]	-	-
Panel B: Volatility equation								
c_i	-0.235*	0.035	-0.262*	0.042	-0.185*	0.041	-0.171*	0.044 [b]
α_i	0.208*	0.018	0.200*	0.018	0.128*	0.019	0.121*	0.019
γ_i	-0.057*	0.016	-0.052*	0.016	-0.012	0.012	-0.005	0.012
β_i	0.991*	0.003	0.991*	0.003	0.991*	0.004	0.992*	0.004
η_{Russia}	-0.020	0.024	-	-	-	-	0.043*	0.020
η_{Poland}	-	-	-0.028	0.033	0.020	0.030	-	-
$\eta_{Hungary}$	-	-	0.034	0.041	-	-	-0.066	0.043
$\eta_{Czech\ Rep.}$	-	-	0.059**	0.031	-	-	0.049	0.035
Panel C: Diagnostic tests								
Adj. R^2		0.837		0.838		0.728		0.728
Log-likelihood		4668.040		4667.683		4082.903		4085.037
F-statistic		514.952		517.753		269.030		269.260
Prob (F-statistic)		<0.001		<0.001		<0.001		<0.001

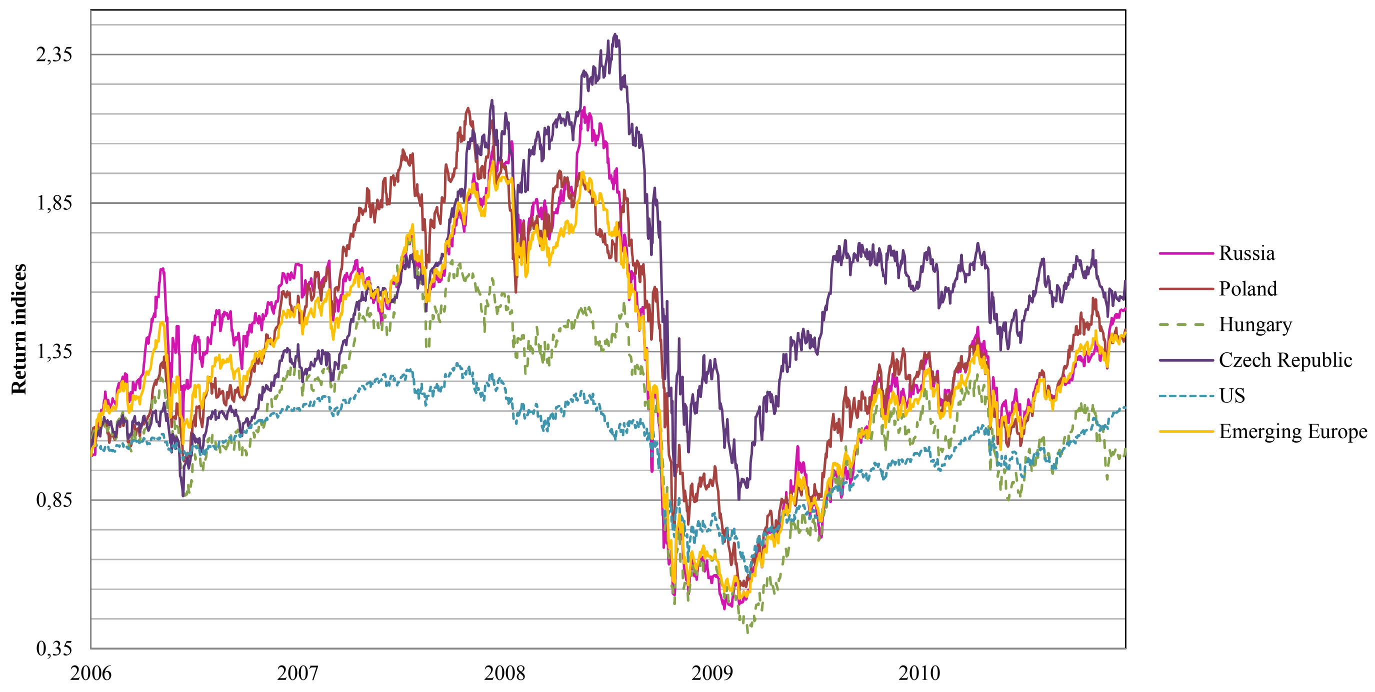
Table 5. The effects of foreign macroeconomic announcements (cont.)

	Hungary				Czech Republic			
	Model 1		Model 2		Model 1		Model 2	
Parameters	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.
Panel A: Mean equation								
μ_i	-0.612[b]	0.473[b]	-0.033[b]	0.403[b]	0.473[b]	0.397[b]	-0.137[b]	0.342[b]
ω_{US}	0.160*	0.028	0.158	0.027	-0.036*	0.022	-0.037**	0.022
ω_{EE}	0.431*	0.056	0.417*	0.055	0.473*	0.045	0.490*	0.045
φ_{Russia}	-0.143*	0.035	-0.131*	0.034	-0.120*	0.029	-0.122*	0.031
φ_{Poland}	0.498*	0.024	0.500*	0.024	0.242*	0.022	0.242*	0.022
$\varphi_{Hungary}$	-	-	-	-	0.159*	0.019	0.162*	0.020
$\varphi_{Czech\ Rep.}$	0.210*	0.027	0.205*	0.026	-	-	-	-
λ_{Russia}	0.392[b]	0.771[b]	-	-	-0.590[b]	0.677[b]	-	-
λ_{Poland}	0.371[b]	0.688[b]	-	-	-1.696[b]*	0.544[b]	-	-
$\lambda_{Hungary}$	-	-	-0.959[b]	-0.655[b]	0.103[b]	0.541[b]	-	-
$\lambda_{Czech\ Rep.}$	0.264[b]	0.644[b]	-	-	-	-	-0.010[b]	0.533[b]
Panel B: Volatility equation								
c_i	-0.376*	0.056	-0.500*	0.082	-0.380*	0.079	-0.410*	0.085
α_i	0.171*	0.020	0.198*	0.024	0.219*	0.027	0.223*	0.027
γ_i	-0.017	0.014	-0.034*	0.015	-0.080*	0.017	-0.072*	0.017
β_i	0.976*	0.005	0.965*	0.008	0.978*	0.007	0.976*	0.007
η_{Russia}	-	-	0.060	0.043	-	-	-0.029	0.033
η_{Poland}	-	-	0.053	0.044	-	-	0.039	0.046
$\eta_{Hungary}$	0.106*	0.042	-	-	-	-	0.054	0.048
$\eta_{Czech\ Rep.}$	-	-	0.041	0.036	0.025	0.037	-	-
Panel C: Diagnostic tests								
Adj. R^2		0.658		0.660		0.645		0.649
Log-likelihood		3822.206		3824.327		4081.166		4103.981
F-statistic		194.126		194.835		182.998		172.700
Prob (F-statistic)		<0.001		<0.001		<0.001		<0.001

a) Coefficients that significantly differ from zero at the 5% and 10% significance levels are marked with * and **, respectively.

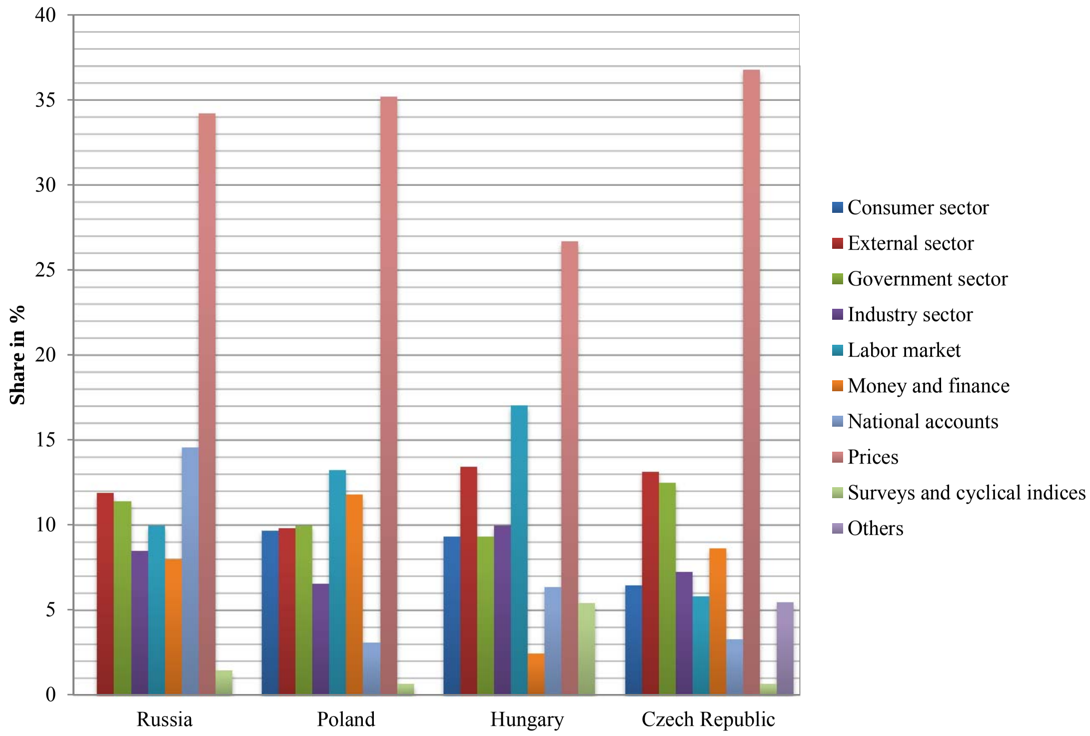
b) These values have been multiplied by 1000.

Figure 1. Stock return indices



All indices are scaled to one in January 2006.

Figure 2. The distribution of macroeconomic announcements



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