BALTIC STOCK MARKETS AND THE FINANCIAL CRISIS OF 2008-2009

Jussi Nikkinen [a,*], Vanja Piljak [a,**], Janne Äijö [a,***]

[a] *University of Vaasa, Department of Accounting and Finance*

October, 27, 2011

Abstract

This study presents new evidence on stock market integration by investigating the linkages between developed European stock markets and emerging stock markets. We focus on three countries in the Baltic region, namely Estonia, Latvia and Lithuania with particular attention to the recent financial crisis of 2008-2009. The study is motivated by traditional stock market studies of integration, which show that developed stock markets are highly integrated, while emerging markets may be segmented. How integrated these emerging stock markets are in a crisis period with respect to the EUROSTOXX50 stock index is an empirical question investigated in this study. While the results of this study demonstrate that the Baltic stock markets were apparently segmented before the crisis, they were highly integrated during the crisis. The results of the variance decomposition analysis show that a large proportion of the forecast variance of the Baltic stock markets can be explained by the EUROSTOXX50 during the crisis. The results from the quantile regressions demonstrate that during the crisis the returns of the lowest quantile were most sensitive to the EUROSTOXX50 stock index. All these results imply less diversification benefits during crises when investors would need them the most.

JEL classification: G10

Keywords: Stock market integration, Financial crisis

The financial support of the Academy of Finland (project number 132913) and the Paulo Foundation is gratefully acknowledged.

[*] Corresponding author. Jussi Nikkinen is a Professor of Accounting and Finance at the University of Vaasa, Vaasa, Finland. *Address:* University of Vaasa, Department of Accounting and Finance, P.O. Box 700, FI-65101 Vaasa, Finland; *Tel.* +358 6 324 8541; *E-mail address:* jn@uwasa.fi

[**] Vanja Piljak is a researcher at the University of Vaasa, Vaasa, Finland. *Address:* University of Vaasa, Department of Accounting and Finance, P.O. Box 700, FI-65101 Vaasa, Finland; *Tel.* +358 6 324 8262; *E-mail address:* vanpil@uwasa.fi

[***] Janne Äijö is a Professor of Accounting and Finance at the University of Vaasa, Vaasa, Finland. *Address:* University of Vaasa, Department of Accounting and Finance, P.O. Box 700, FI-65101 Vaasa, Finland; *Tel.* +358 6 324 8276; *E-mail address:* jja@uwasa.fi

1. Introduction

An observation according to which the stock markets behaved very similarly across different continents and countries during the global financial crisis of 2008-2009 casts serious doubts on the usefulness of the traditional portfolio theory during crisis periods[1]. This is the case in particular if the less integrated frontier emerging markets become fully integrated during global crises. From the perspective of portfolio theory, a relevant question is therefore whether there are still some markets that are less integrated and as such could provide better diversification benefits, also during global crises.

In this study, we examine the integration of a subset of European emerging markets, namely the Baltic stock markets (of Estonia, Latvia and Lithuania), with the developed European stock markets, paying particular attention to the financial crisis period. Our study is motivated by the traditional stock market studies of integration (e.g. Bekaert and Harvey, 1995; Bessler and Yang, 2003; Kim et al., 2005; Carrieri et al., 2007), which generally show that while developed stock markets are highly integrated, emerging markets may still be segmented (e.g. Mateus, 2004; Chambet and Gibson, 2008; Yu and Hassan, 2008; Cheng et al., 2010). The specific goal of our study is to examine how integrated the emerging Baltic stock markets were during the 2008-2009 crisis with respect to the European stock markets.

[1] This is not surprising given the evidence of globally integrated stock markets (see e.g. Lin et al., 1994; Longin and Solnik, 2001).

Our research problem is timely and relevant as indicated by the large number of related studies on financial crises on various other markets. These include, for example, foreign exchange markets (see e.g., Baba and Packer, 2009; Fratzscher, 2009; Melvin and Taylor, 2009), fixed income markets (see e.g., Acharya et al., 2009; Dwyer and Tkac, 2009; Hartmann, 2010) and stock markets (see e.g., Bartman and Bodnar, 2009; Dooley and Hutchison, 2009; Billio and Caporin, 2010; Chudik and Fratzscher, 2011; Schwert, 2011; Syllignakis and Kouretas, 2011). The studies show that several asset classes and markets were significantly affected by the financial crisis of 2008-2009.

Our study contributes to both the financial crisis literature and studies on the Baltic markets by examining the effects of the financial crisis, specifically on the integration of the Baltic countries during the recent global crisis. The work most closely related to ours is that by Syllignakis and Kouretas (2011), who examine the correlation dynamics for seven Eastern European countries during the financial crisis, whereas studies focusing on the Baltic stock markets are scarce.[2] Of the few existing studies focusing on the integration of the Baltic equity markets, Maneschiöld (2006) examines long-run and short-run integration of the Baltic stock markets with several international markets (US, Japan, Germany, UK, and France) during the period 1996-2005, while Mateus (2004) investigates the Baltic markets within the sample of the 13 EU accession countries during the period 1997-2002. Maneschiöld (2006) shows that the Baltic markets exhibit

[2] Generally, the stock markets in the Baltic region provide an interesting environment for further research given their fast economic growth in the years prior to the global financial crisis of 2008-2009, as well as the status of regulated markets associated with the benefits of EU membership. Earlier studies on the stock market integration of the European emerging markets have focused on larger markets in Central and Eastern Europe such as those of Poland, Hungary and the Czech Republic (Gilmore and McManus 2002; Voronkova 2004; Chelley-Steeley, 2005; Gilmore et al., 2008), and more recently on the Balkan markets (Samitas et al., 2006; Syriopoulos, 2011), while the evidence from the Baltic region is limited.

a low degree of integration with developed international markets and therefore can provide diversification benefits for international investors, especially on a long-term investment horizon. Furthermore, Mateus (2004) presents evidence about the partial integration of the Baltic stock markets with respect to the world market. In sum, the literature on the integration of the Baltic stock markets suggests that these emerging markets are indeed segmented. In this study, we contribute to the existing literature by examining the cross-dependence of the Baltic countries with particular attention to the financial crisis, which has not been previously investigated.

Several studies have documented that the degree of integration among stock markets tends to change over time, particularly in time of crisis. For instance, Yang et al. (2003) find that ten Asian emerging stock markets have generally been more integrated during and after the 1997-1998 Asian financial crisis than before the crisis. Similarly, Yang et al. (2006) present evidence of the significant impact of the 1998 Russian financial crisis on the integration of four major Eastern European emerging stock markets (Czech Republic, Hungary, Poland, and Russia). Given that the literature has documented that the Baltic stock markets are segmented (Mateus, 2004; Maneschiöld, 2006), it is particularly interesting to investigate how these markets behave during a financial crisis.

Our results demonstrate that while the Baltic stock markets were segmented before the crisis, they became highly cross-correlated during the crisis. This indicates that they are closely linked to the developed European stock markets, proxied by the EUROSTOXX50 index. This is also evident from the results of the variance decomposition analysis, which show that a large proportion of the forecast variance of

the Baltic stock markets can be explained by the EUROSTOXX50 index during the crisis. Finally, the results from the quantile regression analysis provide further evidence that during the crisis the returns of the lowest quantile were most sensitive to the EUROSTOXX50 index. Taken together, these results imply that during stock market turbulence, the segmented Baltic markets also become integrated with the developed European stock markets.

The remainder of this paper is organized as follows. Section 2 presents an overview of the market environment and economies of the Baltic countries, while Section 3 describes the data. Section 4 presents the econometric methodology used to analyze stock market integration. It also presents the empirical results. Section 5 concludes.

2. Baltic market environment

The Baltic stock markets (Estonia, Latvia and Lithuania) have a rather brief history compared to the developed equity markets in Europe. The initial establishment of the Tallinn Stock Exchange in Estonia, the Riga Stock Exchange in Latvia and the Vilnius Stock Exchange in Lithuania took place respectively in 1920, 1926 and 1937, but these exchanges were closed at the beginning of the Second World War. After the collapse of the Soviet Union the Baltic stock exchanges resumed trading in the middle of the 1990's. The first stock exchange to reopen in the Baltic region was the Vilnius Stock Exchange in 1993, followed by the Riga Stock Exchange and Tallinn Stock Exchange in 1995.

During the period 2002-2004 the Baltic stock exchanges became part of the OMX Group, which owns and operates exchanges in the Nordic countries. In 2007, NASDAQ acquired the OMX Group, creating the world's largest exchange company, the NASDAQ OMX Group. This acquisition led to the harmonization of trading rules and practices, resulting in an increased interest in investments in the Baltic region. The Baltic stock exchanges have a common list which includes all listed Baltic companies divided into four different segments: Baltic Main List, Baltic Secondary List, Baltic Funds List and Baltic Bond List. The main purpose of a common list and sharing the same trading system is to make securities more attractive to foreign investors.

The Baltic countries are classified as high income (Estonia) and upper-middle income (Latvia and Lithuania) economies according to the World Bank. However, despite the relatively high developmental level, all three Baltic stock markets are categorized as frontier stock markets (i.e. the special subset of emerging markets in the S&P classification of the stock markets) due to their small size.

Table 1 provides an overview of the stock market characteristics of the Baltic markets, including the number of listed companies, market capitalization, total value of stocks traded, and turnover ratio[3]. The market capitalization of the Baltic Stock Exchanges amounts to 8.95 billion US dollars, as of the end of December 2009. The biggest stock market is Lithuania, accounting for 50% of the region's market capitalization (4.47

3 The turnover ratio is defined as the total value of shares traded during the period divided by the average market capitalization for the period.

billion US dollars), followed by Estonia with 29% (2.65 billion US dollars) and Latvia with 21% (1.82 billion US dollars). The most active market in terms of trading activity (as measured by the turnover ratio) is the Estonian market, with the turnover ratio peaked at 51.1% in 2005 (the lowest level was 16.2% in 2009). On the other hand, the Latvian market shows rather thin trading activity, with the turnover ratio ranging from the highest level of 8.1% in 2004 to the lowest of 1.1% in 2009.

Prior to their EU accession all three Baltic countries liberalized their financial markets[4], which in conjunction with the privatization of state-owned enterprises and lifting of all restrictions on movement of capital enhanced their investment profiles. The actual status of the EU Member State, obtained in May 2004, additionally promoted the Baltic markets as an attractive destination for foreign direct investments (FDI). In particular, all three Baltic markets recorded significant increases of inward FDI during the period 2004-2007. For instance, the level of inward FDI for Estonia rose from 965 million US dollars in 2004 to 2,728 million US dollars in 2007. However, due to the financial crisis the inflow of FDI decreased in 2008 and 2009.

(Insert Table 1 about here)

Besides having a similar stock market environment, the Baltic markets are also characterized by similarities in the macroeconomic background. The region as a whole

4 The legal restrictions on foreign participation in the Baltic markets were removed gradually during the period 1996-1999. The first American Depositary Receipts (ADR) was issued in Lithuania in 1996, followed by Estonia and Latvia in 1997.

was growing more rapidly than the EU average in terms of GDP annual growth in the period 2004-2007. For instance, the GDP annual growth rates of Latvia ranged from 8.67% to 12.23%, those of Estonia between 6.91% and 10.56%, and those of Lithuania between 7.35 % and 9.83%; while the EU average GDP growth rates in the corresponding time period were between 2% and 3%. The fast economic growth, however, ceased in 2008 and 2009 due to the global economic slowdown caused by the financial crisis. A more detailed description of the main macroeconomic indicators is provided in Table 2.

(Insert Table 2 about here)

3. Data

The data used in our empirical analysis consist of the EUROSTOXX50 index (hereafter EUROPE) and three Baltic stock markets, namely the Estonian, Lithuanian, and Latvian stock markets. We use total return (dividend adjusted) stock indices available from the web pages of the respective stock exchanges[5]. The sample period is from January 3, 2004 to June 30, 2009. The starting period is selected based on the fact that the Baltic countries joined the EU in spring 2004, while the endpoint corresponds to the end of the crisis. In our analysis, we use two different sample periods to examine the effect of crisis on stock market linkages, namely: i) pre crisis (1/2004-12/2007) ii) crisis period

5 Baltic markets (http://www.nasdaqomxbaltic.com/market/?pg=charts) and Eurostoxx50 (http://www.stoxx.com/indices/index_information.html?symbol=SX5E)

(1/2008-6/2009)[6]. As can be seen from Panel A of Table 3, all pre-crisis mean returns are positive and seem to be somewhat higher for the Baltic indices than for EUROPE. However, in the crisis period the mean returns are all negative and, interestingly, they are significantly more negative for the Baltic markets. Volatilities measured by standard deviations of returns increase for all stock markets during the crisis. Typically all return series exhibit excess kurtosis relative to the normal distribution.

(Insert Table 3 about here)

Panel B of Table 3 reports Pearson's correlation coefficients for pre-crisis and crisis periods. The results from this preliminary analysis of the cross-dynamics of the stock markets imply that the correlations are low before the crisis (2004-2007). The highest contemporaneous, although very low, correlation between EUROPE and the Baltic stock markets is between EUROPE and Estonia (0.196) and the lowest correlation is between EUROPE and Latvia (0.042). However, the results are remarkably different in the crisis period, as, for example, the correlation between EUROPE and Lithuania is 0.371. All the correlations increase statistically significantly, which is verified by the *Z*-statistic. The test is performed with Fisher's transformed correlations as in Hon et al. (2004). Therefore, the results indicate that the stock markets become more closely correlated during the crisis period.

6 The results are not sensitive to differently chosen periods. For example, the results remain virtually the same if we use (1/2003-12/2006) and (1/2007-6/2009) as pre-crisis and crisis periods respectively.

4. Results and Methodology

To investigate the integration of the Baltic stock markets with European developed stock markets in pre-crisis and crisis periods, the Granger (1969) causality test and vector autoregressive analysis (VAR) are applied. These methods provide broad information for the analysis of the linkages of the markets. They are suitable given that the time series are stationary. To investigate the stationarity of the return series, the augmented Dickey-Fuller and Phillips-Perron tests of a unit root are applied to the return series of each stock index. The results show (not tabulated) that all the return series are stationary at the 1% significance level, implying that the VAR analysis can be investigated. Therefore, the following VAR(p) system is used separately in both periods investigated:

$$\Delta x_t = \alpha + \sum_{i=1}^{p} \beta_i \Delta x_{t-i} + \varepsilon_t \qquad (1)$$

where $\Delta x_t = (\Delta X_{EUROPE,t}, \Delta X_{ESTONIA,t,} \Delta X_{LATVIA,t,} \Delta X_{LITHUANIA,t})'$ is a covariance stationary 4×1 vector of stock returns, X_t, α is a 4×1 vector of intercepts, $\{\beta_i, i=1, 2, 3, 4\}$ is a 4×4 matrix of autoregressive coefficients, ε_t is a 4×1 vector of random disturbances with zero mean and positive definitive covariance matrix, and p defines the lag order of the system. The model is estimated with the OLS. As White´s (1980) test indicates the presence of volatility persistence, the standard errors based on the Monte Carlo simulation are used.

To verify the appropriate number of lags for the VAR(*p*) system, Akaike´s (AIC) and Schwartz´s (SIC) information criteria, final prediction error (FPE) and Lutkepohl´s modified likelihood ratio (LR) test statistics are used. Furthermore, if the number of lags is suitable, there should be no autocorrelation left in the residuals. Therefore, the adequacy of the number of lags is confirmed with the Breusch-Godfrey LM test. The results from these analyses (not tabulated) suggest that a lag length of six (three) is appropriate for the VAR(*p*) model in the crisis (pre-crisis) period.

Table 4 presents the results of the Granger causality analysis for the stock markets investigated. The statistics reported are for a lag order of three for the pre-crisis period and lag order of six in the crisis period. The results indicate that at a 1% level of significance Europe is leading all Baltic stock markets before the crisis, while Europe is not affected by the Baltic markets. On the other hand, the results suggest that during the crisis period there is two-way causality, which implies some kind of feedback effect between the markets. The results also imply that the Estonian market leads the Latvian stock market.

(Insert Table 4 about here)

Panel A of Table 5 reports the summary statistics of the VAR(3) and VAR(6) models examining the pre-crisis and crisis periods respectively. The *F*-statistics show that the VAR models are significant for all Baltic stock markets. In the pre-crisis period, the adjusted R^2 ranges from 0.000 to 0.047, while in the crisis period they range from 0.086

to 0.154. The Ljung-Box statistic for 10 lags shows that no autocorrelation remains, indicating that the chosen VAR models are adequate. Panel B of Table 5 reports the contemporaneous residual correlations between the markets. The results show that before the crisis the correlations between EUROPE and the Baltic stock markets are low. However, consistent with the previous results, they increase during the crisis period. The highest instantaneous correlation is between EUROPE and the ESTONIA (coefficient of 0.339) and lowest, though highly significant, between EUROPE and the LATVIA (coefficient of 0.235). These are consistent with earlier findings. Table 5 also reports the correlations between the Baltic markets, which are high and increase in the crisis period.

(Insert Table 5 about here)

Variance decomposition analysis is used to ascertain how important the innovations of the other variables in the system are in explaining the fraction of variable *i´*s at different steps ahead forecast variances. The variance decompositions are presented separately in Tables 6 and 7 for pre-crisis and crisis periods respectively. The results in Table 6 (pre-crisis period) further provide clear evidence of the independence of EUROPE among the markets investigated, as its forecast variance is only caused by its own innovations. Additionally, EUROPE seems to explain only a fraction (ranging approximately from 1% to 6%) of the different step-ahead forecast variances of the Baltic stock markets. Consistent with the previous results, EUROPE has a significantly higher impact on the Baltic stock markets during the crisis period (see Table 7). For example, the index explains about 17% of the five days ahead forecast error variance of the Estonian stock markets. Furthermore, the index explains about 10% (17%) of the five days ahead

forecast error variance of the Latvian (Lithuanian) stock markets. These findings further demonstrate that a larger proportion of the forecast variance of the Baltic stock markets can be explained by EUROPE during the crisis. Additionally, it is found that the Estonian markets can explain about 9% (28%) of the forecast variance of Latvian (Lithuanian) stock markets during the crisis.

(Insert Tables 6 and 7 about here)

Finally, in addition to analyzing the conditional mean of a dependent variable, we are also interested in examining other aspects of the conditional distribution. For this purpose we use a quantile regression approach (see e.g. Koenker and Bassett, 1978). This approach is especially suitable for our purpose, as we are interested in examining the dynamic dependencies between EUROPE and the Baltic stock markets under different market conditions. Thus, we use the quantile regression approach separately for pre-crisis and crisis periods. In our case, the method provides the estimates of the linear relationship between the returns of the EUROSTOXX50 index (independent variable) and a specified quantile of Baltic stock returns (dependent variable) as follows:

$$r_{i,t} = \alpha_i + \beta_i r_{europe,t} + \varepsilon_{i,t} \qquad Q_r\left(q \middle| r_{europe,t}\right) = \alpha_i(q) + \beta_i(q) r_{europe,t} \qquad (2)$$

where r_i is the return on the Baltic stock markets (i = Estonia, Latvia, Lithuania) and r_{europe} is the return on the EUROSTOXX50 index. $Q_r\left(q\middle|r_{europe,t}\right)$ defines the q-th quantile of $r_{i,t}$.

The results from the quantile regressions are reported in Table 8. The results demonstrate that the impact of EUROPE on the Baltic stock markets is stronger in the crisis period than before the crisis. The coefficients are much lower and in many cases they are not even statistically significant in the pre-crisis period (see Latvia 0.5-0.9 quantiles and Lithuania 0.9 quantile). However, in the crisis period all the coefficients are statistically significant and in the lowest quantiles (0.1-0.3) the coefficients are higher than in the highest quantiles (0.7-0.9). These results imply that the Baltic stock markets are much more sensitive to EUROPE during the crisis, when the returns are highly negative. These results provide further evidence of the high stock market integration of the Baltic stock markets with developed European markets during the crisis, which casts doubts on the usefulness of the traditional portfolio theory when it should be most useful for investors.

(Insert Table 8 about here)

5. Conclusions

The purpose of this study is to provide new evidence on stock market integration by investigating the linkages between developed European stock markets and emerging stock markets from the Baltic region, namely the Estonian, Latvian, and Lithuanian stock markets with particular attention to the financial crisis period 2008-2009. The study is motivated by traditional stock market studies of integration, which show that developed stock markets are highly integrated, while emerging markets may be segmented. How integrated these emerging stock markets are in a crisis period with respect to developed European stock markets proxied by the EUROSTOXX50 stock index is an empirical question investigated in this study.

The results of this study demonstrate that while the Baltic stock markets seem to be segmented before the crisis, the correlations increase significantly during the crisis. These findings indicate that the Baltic stock markets are closely linked to the major European stock markets. The results of the variance decomposition analysis show that a large proportion of the forecast variance of the Baltic stock markets can be explained by the EUROSTOXX50 index during the crisis. Finally, the results from the quantile regressions demonstrate that during the crisis the returns of the lowest quantile are most sensitive to the EUROSTOXX50 index. These results provide further evidence of the high stock market integration of the developed Baltic stock markets especially during the crisis period, which casts doubts on the usefulness of portfolio diversification when it should be most useful for investors.

References

Acharya, V., Phlippon, T., Richardson, M., Roubini, N., 2009. The financial crisis of 2007-2009: causes and remedies. *Financial Markets, Institutions & Instruments* 18:2, 89–137.

Baba, N., Packer, F., 2009. From turmoil to crisis: dislocations in the FX swap market before and after the failure of Lehman Brothers. *BIS working paper* No. 285.

Bartman, S., Bodnar, G., 2009. No place to hide: The global crisis in equity markets in 2008/09. *Journal of International Money and Finance* 28, 1246–1292.

Bekaert, G., Harvey, C.R., 1995. Time-varying world market integration. *Journal of Finance* 50, 403-444.

Bessler, D. A., Yang, J., 2003. The structure of interdependence in international stock markets. *Journal of International Money and Finance* 22, 261-287.

Billio, M., Caporin, M., 2010. Market linkages, variance spillovers, and correlation stability: Empirical evidence of financial contagion. *Computational Statistics & Data Analysis* 54:11, 2443–2458.

Carrieri, F., Errunza, V., Hogan, K., 2007. Characterizing world market integration through time. *Journal of Financial and Quantitative Analysis* 42, 915-940.

Chambet, A., Gibson, R., 2008. Financial integration, economic instability and trade structure in emerging markets. *Journal of International Money and Finance* 27, 654-675.

Chelley-Steeley, P. L., 2005. Modeling equity market integration using smooth transition analysis: a study of Eastern European stock markets. *Journal of International Money and Finance* 24, 818-831.

Cheng, A-R., Jahan-Parvar, M. R., Rothman, P., 2010. An empirical investigation of stock market behavior in the Middle East and North Africa. *Journal of Empirical Finance* 17, 413-427.

Chudik, A., Fratzscher, M., 2011. Identifying the global transmission of the 2007-2009 financial crisis in a GVAR model. *European Economic Review* 55, 325-339.

Dooley, M., Hutchison, M., 2009. Transmission of the U.S. subprime crisis to emerging markets: Evidence on the decoupling-recoupling hypothesis. *Journal of International Money and Finance* 28, 1331-1349.

Dwyer, G., Tkac, P., 2009. The financial crisis of 2008 in the fixed income markets. *Journal of International Money and Finance* 28, 1293–1316.

Fratzscher, M., 2009. What explains global exchange rate movements during the financial crisis? *Journal of International Money and Finance* 28, 1390-1407.

Gilmore, C.G., McManus, G.M., 2002. International portfolio diversification: US and Central European equity markets. *Emerging Markets Review* 3:1, 69-83.

Gilmore, C.G., Lucey, B.M., McManus, G.M., 2008. The dynamics of Central European equity market comovements. *The Quarterly Review of Economics and Finance* 48:3, 605-622.

Granger, C. W. J., 1969. Investigating causal relations by econometric models and cross-spectral methods. *Econometrica* 37:3, 424-438.

Hartmann, P., 2010. Interaction of market and credit risk. *Journal of Banking and Finance* 34, 697–702.

Hon, M., Strauss, J., Yong, S-J, 2004. Contagion in financial markets after September 11: Myth or reality? *Journal of Financial Research* 27, 95-114.

Kim, S. J., Moshirian, F., Wu, E., 2005. Dynamic stock market integration driven by the European Monetary Union: An empirical analysis. *Journal of Banking and Finance* 29, 2475-2502.

Koenker, R., Bassett, G., 1978. Regression Quantiles. *Econometrica* 46, 33-50.

Lin, W., Engle, R., Ito, T., 1994. Do bulls and bears move across borders? Transmission of international stock returns and volatility. *Review of Financial Studies* 7, 507-538.

Longin, F., Solnik, B., 2001. Extreme correlation of international equity markets. *Journal of Finance* 56:2, 649–676.

Maneschiöld, P., 2006. Integration between the Baltic and international stock markets. *Emerging Markets Finance and Trade* 42:6, 25-45.

Mateus, T., 2004. The risk and predictability of equity returns of the EU accession countries. *Emerging Markets Review* 5:2, 241-266.

Melvin, M., Taylor, M., 2009. The crisis in the foreign exchange market. *Journal of International Money and Finance* 28, 1317-1330.

Samitas, A., Kenourgios, D., Paltalidis, N., 2006. Short and long run parametric dynamics in the Balkans stock markets. *International Journal of Business, Management and Economics* 2, 5-20.

Schwert, W., 2011. Stock volatility during the recent financial crisis. *NBER working paper* No. 16976.

Syriopoulos, T., 2011. Financial integration and portfolio investments to emerging Balkan equity markets. *Journal of Multinational Financial Management* 21, 40-54.

Syllignakis, M., Kouretas, G., 2011. Dynamic correlation analysis of financial contagion: Evidence from the Central and Eastern European markets. *International Review of Economics and Finance* 20, 717-7.

Voronkova, S., 2004. Equity market integration in Central European emerging markets: A cointegration analysis with shifting regimes. *International Review of Financial Analysis* 13, 633-647.

White, H., 1980. A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. *Econometrica* 48, 817-838.

Yang, J., Hsiao, C., Li, Q., Wang, Z., 2006. The emerging market crisis and stock market linkages: further evidence. *Journal of Applied Econometrics* 21, 727-744.

Yang, J., Kolari, J.W., Min, I., 2003. Stock market integration and financial crises: the case of Asia. *Applied Financial Economics* 13, 477-486.

Yu, J-S., Hassan, K., 2008. Global and regional integration of the Middle East and North African (MENA) stock markets. *The Quarterly Review of Economics and Finance* 48, 482-504.

Table 1. Financial indicators (Source: World Bank).

Panel A: Estonia

Subject Descriptor	Units	Scale	2004	2005	2006	2007	2008	2009
Listed domestic companies. Total	Companies	Unit	13	15	16	18	18	16
Market capitalization of listed companies	Percent of GDP		51.6	25.1	35.9	28.2	8.3	13.9
Market capitalization of listed companies	U.S. dollars	Billions	6.203	3.495	5.963	6.037	1.951	2.654
Stock traded. total value	Percent of GDP		6.9	17.8	5.9	9.8	3.3	2.0
Stock traded. turnover ratio	Percent change		17.5	51.1	20.5	34.9	25.4	16.2
Foreign direct investments, net inflows	U.S. dollars	Millions	965	2,941	1,787	2,728	1,745	1,751

Panel B: Latvia

Subject Descriptor	Units	Scale	2004	2005	2006	2007	2008	2009
Listed domestic companies. total	Companies	Unit	39	45	40	41	35	34
Market capitalization of listed companies	Percent of GDP		12.0	15.8	13.6	10.8	4.8	7.0
Market capitalization of listed companies	U.S. dollars	Billions	1.655	2.527	2.705	3.111	1.609	1.824
Stock traded. total value	Percent of GDP		0.8	0.6	0.6	0.5	0.1	0.1
Stock traded. turnover ratio	Percent change		8.1	4.6	4.3	4.8	1.8	1.1
Foreign direct investments, net inflows	U.S. dollars	Millions	636	713	1,664	2,315	1,357	93

Panel C: Lithuania

Subject Descriptor	Units	Scale	2004	2005	2006	2007	2008	2009
Listed domestic companies. total	Companies	Unit	43	43	44	40	41	40
Market capitalization of listed companies	Percent of GDP		28.7	31.5	33.9	25.9	7.7	12.0
Market capitalization of listed companies	U.S. dollars	Billions	6.463	8.183	10.191	10.134	3.625	4.477
Stock traded. total value	Percent of GDP		2.1	2.9	7.0	2.6	1.0	0.8
Stock traded. turnover ratio	Percent change		9.8	10.1	22.8	10.1	59.9	7.5
Foreign direct investments, net inflows	U.S. dollars	Millions	773	1,031	1,840	2,017	1,839	230

Table 2. Macroeconomic indicators (Source: International Monetary Fund, World Economic Outlook Database).

Panel A: Estonia

Indicator	**Units**	**Scale**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Gross domestic product, current prices	U.S. dollars	Billions	12.03	13.90	16.80	21.69	23.70	19.30
Gross domestic product per capita current prices	U.S. dollars	Units	8,905.05	10,317.77	12,499.60	16,160.24	17,651.19	14,402.46
Inflation, average consumer prices	Percent change		3.04	4.09	4.43	6.59	10.36	-0.08
Unemployment rate	Percent of total labor force		9.65	7.91	5.90	4.65	5.51	13.76
Population	Persons	Millions	1.35	1.34	1.34	1.34	1.34	1.34
GDP growth	Annual %		7.22	9.43	10.56	6.91	-5.06	-13.89

Panel B: Latvia

Indicator	**Units**	**Scale**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Gross domestic product, current prices	U.S. dollars	Billions	13.76	16.04	19.94	28.79	33.86	25.92
Gross domestic product per capita current prices	U.S. dollars	Units	5,933.74	6,955.25	8,689.97	12,622.46	14,912.92	11,465.61
Inflation, average consumer prices	Percent change		6.18	6.89	6.57	10.08	15.25	3.26
Unemployment rate	Percent of total labor force		10.61	8.82	6.99	6.20	7.82	17.31
Population	Persons	Millions	2.31	2.30	2.29	2.28	2.27	2.26
GDP growth	Annual %		8.67	10.60	12.23	9.97	-4.24	-17.95

Panel C: Lithuania

Indicator	**Units**	**Scale**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Gross domestic product, current prices	U.S. dollars	Billions	22.54	25.97	30.08	39.09	47.17	37.11
Gross domestic product per capita current prices	U.S. dollars	Units	6,562.96	7,608.24	8,863.06	11,582.12	14,047.46	11,115.06
Inflation, average consumer prices	Percent change		1.16	2.65	3.78	5.77	11.13	4.16
Unemployment rate	Percent of total labor force		11.37	8.27	5.62	4.29	5.84	13.70
Population	Persons	Millions	3.43	3.41	3.39	3.37	3.35	3.33
GDP growth	Annual %		7.35	7.80	7.84	9.83	2.92	-14.74

Table 3. Summary statistics and correlations between stock markets.

Table reports the summary statistics and correlations between the markets. (z) statistics are Fisher transformations testing for the equality of pre-crisis correlations with crisis period correlations and they are presented in the square brackets.

Panel A: Summary statistics

	Pre-Crisis				Crisis			
	Europe	Estonia	Latvia	Lithuania	Europe	Estonia	Latvia	Lithuania
Mean	0.001	0.001	0.001	0.001	-0.001	-0.002	-0.002	-0.003
Median	0.001	0.001	0.000	0.001	-0.001	-0.002	-0.002	-0.001
Maximum	0.029	0.072	0.049	0.037	0.104	0.057	0.092	0.110
Minimum	-0.034	-0.059	-0.068	-0.038	-0.082	-0.070	-0.079	-0.091
Std. Dev.	0.009	0.009	0.009	0.009	0.024	0.016	0.019	0.018
Skewness	-0.350	-0.191	-0.025	-0.201	0.181	-0.457	0.029	-0.272
Kurtosis	4.015	14.908	7.857	5.983	6.062	5.547	6.010	11.605
Jarque-Bera	65.152	6080.432	1010.455	387.942	151.734	116.816	144.597	1186.320
Probability	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	1028	1028	1028	1028	383	383	383	383

Panel B: Correlations

	Pre-Crisis				Crisis			
	Europe	Estonia	Latvia	Lithuania	Europe	Estonia	Latvia	Lithuania
Europe								
Estonia	0.196				0.350			
t-statistic	(6.397)				(7.289)			
(z): Pre-Crisis = Crisis					[-2.777]			
Latvia	0.042	0.179			0.244	0.347		
t-statistic	(1.352)	(5.825)			(4.906)	(7.219)		
(z): Pre-Crisis = Crisis					[-3.440]	[-3.014]		
Lithuania	0.091	0.275	0.187		0.371	0.619	0.532	
t-statistic	(2.918)	(9.161)	(6.090)		(7.798)	(15.379)	(12.272)	
(z): Pre-Crisis = Crisis					[-4.972]	[-7.341]	[-6.731]	

Table 4. Granger causalities of the stock markets.

Pre-Crisis is defined as (1/2004-12/2007) and Crisis is (1/2008-6/2009). Values of t-statistics that are statistically significant at the 5% level are presented in bold face.

	Pre-Crisis		Crisis	
	t-stat	p-value	t-stat	p-value
Estonia --> Europe	0.420	0.738	**4.206**	0.000
Europe --> Estonia	**3.238**	0.022	**7.481**	0.000
Latvia --> Europe	0.186	0.906	**2.637**	0.016
Europe --> Latvia	1.630	0.181	**4.927**	0.000
Lithuania --> Europe	1.050	0.370	0.878	0.511
Europe --> Lithuania	2.441	0.063	**7.777**	0.000
Latvia --> Estonia	2.338	0.072	0.948	0.461
Estonia --> Latvia	**4.169**	0.006	**2.311**	0.033
Lithuania --> Estonia	1.411	0.238	**2.386**	0.028
Estonia --> Lithuania	**3.640**	0.013	**3.296**	0.004
Lithuania --> Latvia	**4.188**	0.006	**2.454**	0.024
Latvia --> Lithuania	**2.915**	0.033	0.470	0.831

Table 5. Summary statistics of the VAR models.

Panel A of the table presents the summary statistics of VAR(3) model estimation of the pre-crisis period (VAR(6) in the crisis period). The analysis is based on the following equation:

$$\Delta x_t = \alpha + \sum_{i=1}^{p} \beta_i \Delta x_{t-i} + \varepsilon_t$$

where $\Delta x_t = (\Delta X_{EUROPE,t}, \Delta X_{ESTONIA,t}, \Delta X_{LATVIA,t}, \Delta X_{LITHUANIA,t})'$ is a covariance stationary 4×1 vector of term structures ΔX_t, α is a 4×1 vector of intercepts, $\{\beta_i, i=1, 2, 3, 4\}$ is a 4×4 matrix of autoregressive coefficients, ε_t is a 4×1 vector of random disturbances with zero mean and positive definitive covariance matrix, and p defines the lag order of the system. The model is estimated with the OLS. As the White´s (1980) test indicates the presence of volatility persistence, the standard errors based on the Monte Carlo simulation are used to define the 95 percent confidence intervals to the impulse responses. Panel B reports the contemporaneous residual correlations between the markets.

	Pre-Crisis					Crisis			
Panel A									
	Europe	Estonia	Latvia	Lithuania		Europe	Estonia	Latvia	Lithuania
Adj. R	0.000	0.047	0.014	0.041	Adj. R	0.109	0.142	0.086	0.154
F-statistic	1.030	5.224	2.234	4.667	F-statistic	3.920	4.955	3.258	5.334
Q(10)	2.781	7.963	15.586	8.847	Q(10)	1.874	10.386	8.978	8.297
p-value	0.986	0.632	0.112	0.547	p-value	0.997	0.407	0.534	0.600
Panel B									
	Europe	Estonia	Latvia	Lithuania		Europe	Estonia	Latvia	Lithuania
Europe	---				Europe	---			
Estonia	0.212	---			Estonia	0.339	---		
Latvia	0.054	0.160	---		Latvia	0.235	0.291	---	
Lithuania	0.108	0.242	0.170	---	Lithuania	0.338	0.577	0.484	---

Table 6. Variance decomposition in pre-crisis period (1/2004-12/2007).

Pre-Crisis

Variance Decomposition of Europe:

Period	S.E.	Europe	Estonia	Latvia	Lithuania
1.000	0.008	100.000	0.000	0.000	0.000
2.000	0.009	99.650	0.006	0.005	0.339
3.000	0.009	99.480	0.119	0.063	0.339
4.000	0.009	99.429	0.119	0.084	0.368
5.000	0.009	99.423	0.119	0.089	0.369

Variance Decomposition of Estonia:

1.000	0.009	4.501	95.499	0.000	0.000
2.000	0.009	5.831	93.773	0.265	0.131
3.000	0.009	6.081	93.322	0.434	0.162
4.000	0.009	6.093	92.970	0.734	0.203
5.000	0.009	6.105	92.918	0.754	0.224

Variance Decomposition of Latvia:

1.000	0.009	0.294	2.323	97.383	0.000
2.000	0.009	0.867	2.742	96.145	0.246
3.000	0.009	0.871	2.983	95.571	0.575
4.000	0.009	0.873	3.253	95.124	0.750
5.000	0.009	0.884	3.277	95.086	0.753

Variance Decomposition of Lithuania:

1.000	0.009	1.168	5.022	1.738	92.072
2.000	0.009	2.160	5.019	2.040	90.780
3.000	0.009	2.157	5.026	2.169	90.648
4.000	0.009	2.129	6.044	2.532	89.295
5.000	0.009	2.154	6.172	2.545	89.128

Table 7. Variance decomposition in the crisis period (1/2008-6/2009).

Crisis

Variance Decomposition of Europe:

Period	S.E.	Europe	Estonia	Latvia	Lithuania
1.000	0.022	100.000	0.000	0.000	0.000
2.000	0.022	99.168	0.258	0.445	0.129
3.000	0.023	96.083	1.225	2.441	0.251
4.000	0.023	94.201	1.194	3.267	1.338
5.000	0.024	89.802	5.635	3.046	1.517

Variance Decomposition of Estonia:

1.000	0.015	11.465	88.535	0.000	0.000
2.000	0.016	18.146	80.707	1.082	0.064
3.000	0.016	17.425	79.858	1.059	1.659
4.000	0.016	17.155	79.208	1.419	2.218
5.000	0.016	17.766	77.150	1.374	3.710

Variance Decomposition of Latvia:

1.000	0.018	5.537	5.046	89.417	0.000
2.000	0.019	9.178	5.365	84.873	0.584
3.000	0.019	9.979	6.193	83.251	0.577
4.000	0.019	10.076	7.730	81.244	0.950
5.000	0.019	9.885	9.016	79.870	1.229

Variance Decomposition of Lithuania:

1.000	0.017	11.401	24.163	9.685	54.751
2.000	0.017	15.217	23.498	9.232	52.053
3.000	0.017	14.653	26.523	8.962	49.862
4.000	0.018	16.461	27.711	8.569	47.259
5.000	0.018	17.248	28.342	8.446	45.964

Table 8. Quantile regression approach: Sensitivity of Baltic stock markets to Europe stock returns.

$r_i = \alpha_q + \beta_{q,i} r_{europe} + \varepsilon_i \qquad Q_r\left(q \middle| r_{europe,t}\right) = \alpha_i(q) + \beta_i(q) r_{europe,t}$

where r_i is the return on Baltic stock markets (i=Estonia, Latvia, Lithuania) and r_{europe} is the return on EUROSTOXX50 index. $Q_r\left(q \middle| r_{europe,t}\right)$ defines the q-th quantile of $r_{i,t.}$ Table reports the beta coefficients for each country with quantiles (0.1, 0.3, 0.5, 0.7 and 0.9). Coefficients that are statistically significant at the 5% level are in bold face.

Pre-crisis				Crisis			
Estonia				Estonia			
Quantile	Coefficient	t-Statistic	Prob.	Quantile	Coefficient	t-Statistic	Prob.
0.100	**0.268**	6.020	0.000	0.100	**0.200**	4.312	0.000
0.300	**0.099**	3.326	0.001	0.300	**0.227**	5.784	0.000
0.500	**0.075**	2.775	0.006	0.500	**0.220**	4.744	0.000
0.700	**0.089**	3.266	0.001	0.700	**0.236**	5.604	0.000
0.900	**0.189**	2.450	0.015	0.900	**0.263**	2.927	0.004
Latvia				Latvia			
0.100	**0.116**	2.781	0.006	0.100	**0.262**	4.086	0.000
0.300	**0.080**	2.603	0.009	0.300	**0.227**	3.890	0.000
0.500	0.040	1.262	0.207	0.500	**0.184**	2.913	0.004
0.700	-0.007	-0.175	0.861	0.700	**0.152**	2.631	0.009
0.900	-0.118	-1.531	0.126	0.900	**0.228**	5.278	0.000
Lithuania				Lithuania			
0.100	**0.219**	4.430	0.000	0.100	**0.417**	7.658	0.000
0.300	**0.114**	3.048	0.002	0.300	**0.234**	6.860	0.000
0.500	**0.072**	2.404	0.016	0.500	**0.169**	4.380	0.000
0.700	**0.071**	2.442	0.015	0.700	**0.150**	3.981	0.000
0.900	0.049	0.831	0.406	0.900	**0.241**	2.821	0.005