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Dynamic linkages between Baltic and International stock markets

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Abstract[1]

The fact is that high integration between different capital markets leads to reduced international diversification opportunities for investors as well as to a greater transmission of market volatility. This study discusses the behavior of the three Baltic stock markets on the international financial arena and examines how these markets react on different inflows of information and economical shocks.

Evidence of cointegration between the Baltic markets is found, using a daily data set. Testing the time series bilaterally, more than one cointegrating relationship is found. Further, causality analysis is performed using both impulse response and variance decomposition approaches. As a result, no dramatic impacts are detected on the Baltic stock markets from the shocks on the international stock markets (US, EMU, Russia, Japan and China). It is also obvious that innovations in the international stock markets fail to explain any substantial part of error variances on Baltic stock markets.

Keywords: Baltic stock markets, unit root, Engle-Granger approach, Johansen cointegration test, causality, impulse response, variance decomposition.

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CONTENTS

1. INTRODUCTION

This section presents the paper's background and some relevant studies with empirical results. There is also discussed purpose and goal of the study, following by the reasons why exactly Baltic markets have been of such an interest.

1.1 BACKGROUND

One of the important issues in financial economics is a degree of interdependence between the the international equity markets. In particular, degree of integration among the world – wide stock markets has been studied closely, for example in the following papers: Syriopoulos T., Yang, Hsiao, Li and Wang (2005), Shamsuddin and Kim (2002), Ciner (2006) and especially accurate the periods before and after the stock market crashes as the ones in October 1987 and March 2000. Such studies, that investigating the international linkages among different countries, show that there exists a substantial degree of interdependence between the international equity markets. The fact is that high integration between the different capital markets as well as the greater transmission of market volatility lead to the reduced international diversification opportunities for investors. Moreover, the unexpected political or economical events, high growth rate and fast development of international dominant economies have shown to be important influencing factors for small emerging economies. In addition, the US stock market seems to be the most influencing one, where already in early studies, as for example Eun and Shim (1986), the researchers came to conclusion that the dominant role of the US in the world's economy can't be rejected which therefore makes the US the most important and influencing source of information affecting the world-wide stock markets.

A relevant issue here is cointegration. As a fact, stock market prices tend to reflect the local economic situation, which leads to the statement that these economic conditions might result in cointegrated stock markets. When stock prices or stock price indices are cointegrated it may be stated that they can't wander apart without bounds in the long run. Thus, the evidence of cointegration between some international stock prices or stock price indices leads to the conclusion that diversification opportunities disappear in the long run. For example, asset managers might be very interested in finding a lack of cointegration between international markets, between some particular branches or equities in order to use this information for better portfolio diversification, again, in the long run. Hence, a stock market's short- and long-run comovements with other markets have the utmost importance for the portfolio allocation and equity market risk.[2]

Looking at this issue from the other side, market efficiency is important to notice. The fact is that market efficiency requires that stock prices react promptly to both the information pertaining the domestic economy and international events. With other words: "in an informationally efficient market price changes must be unforecastable if they are properly anticipated, i.e. if they fully incorporate the expectations and information of all market participants."[3] However the theory and empirical evidence posit that enthusiasm for stocks in one market seems to bring around the enthusiasm for stocks in other markets. Also the reverse about the pessimistic reactions is true. This means that if different capital markets are highly integrated with each other then it may indicate that the benefits from the valuable international portfolio diversification would be reduced or even disappeared. Further, some researches as Granger (1986) and Baillie & Bollerslev (1989) argue that cointegration contradicts the efficient market hypothesis and moreover they suggest that in the presence of market efficiency the asset prices shouldn't be cointegrated. That is because it is impossible to predict price movements on one asset based on the historical returns on another asset.

Further, many studies have been focusing on investigating transmission mechanisms mainly on mature economies, where examining among other things: real estate, commodity and equity markets. Not surprisingly that researches investigating linkages between economies within the same geographical region might find some evidence of convergence, as outlined for example in the study of Asian equity markets by Anoruo, Ramchander and Thiewes (2003) and Manning (2002). Despite these empirical results, other studies that examining cointegration between international stock markets find just very week evidence of convergence, see for example the study of NAFTA equity markets by Ciner (2006) or the study of cointegration between international stock markets by Ahlgren and Antell (2002). Although cointegration has been detected in different empirical studies, these results are not completely consistent and besides might appear ambiguous and conflicting.[4]

One of the studies that investigate integration between Eastern European and former Soviet Union stock markets was provided by Verchenko (2000). He found absence of cointegration and no interdependence of stock market movements were detected.[5] Furthermore, Bessler and Yang (2003) investigated the structure of interdependence on the nine major stock markets (Asian: Australia, Japan, Hong Kong;

[2] Syriopoulos T., (2005)
[3] Campbell J. Y. (1997)
[4] Syriopoulos T., (2005)
[5] Syriopoulos T., (2005)

European: UK, Germany, France and Switzerland; North American: US and Canada) and found that stock index prices are cointegrated with one cointegrating vector. The researches showed that only US and Canadian markets respond on the perturbations in this long-run relationship. Interestingly, there has been, even in early studies, stated that the Japanese market is very exogenous and also that this market's innovations explain quite little of the stock price movements in other markets. Even other studies found Japanese stock market the least open among the other major stock markets, as outlined in Francis and Leachman (1998) as well as that Japanese stock market plays a relative passive role in transmitting information to other markets, as outlined in Malliaris and Urrutia (1992). Further, Eun and Shim (1989) showed that US market is the most exogenous and highly influenced by its own past innovations. Moreover, they found that the shocks caused by US market impact strongly the stock price movements in the other international markets and that this relationship may hold even in the longer-run, i.e. up to 30 days. Nevertheless, the study suggests that there exist some international diversification opportunities because the examined stock markets are neither fully integrated nor completely blocked from inside.

One of a few studies about Baltic stock markets is the one that investigated the integration between the Baltic and international stock markets, was written by Per-Ola Maneschiöld (2006). In particular, the author studied the Baltic stock markets and included in the study the following international stock markets: US, Japan, Germany, UK and France. As Maneschiöld points out, the diversification benefits in the Baltic stock markets using weekly data set, are more significant for long-run investments than for short-run investments. Further, as no cointegration was found among the Baltic stock markets, the author suggests, that investment positions in more then one of the Baltic stock markets in the same portfolio contribute to the diversification opportunities. Furthermore, he also points out that, because of the low degree of integration between the Baltic and international stock markets, the efficient allocation of the financial capital within the Baltic region might be of a big concern. Thus, Maneschiöld concludes that this feature may harm the growth potential of the Baltic States and as a consequence may interrupt the ability to catch up to European countries. Moreover he suggests that these capital markets must be deregulated in order to generate more efficient allocation of financial capital.

1.2 PURPOSE AND GOAL

The purpose of this paper is to investigate closely and deeply understand how the three Baltic stock markets behave on the international financial arena and how they react on different inflows of information and economic shocks from the international stock markets.

Specifically, the following questions are studied closely:

1. Does there exist a long run relationship among the Baltic stock markets as well as among the Baltic stock markets and the developed international stock markets? Afterwards it might be possible to make conclusions about how well the international diversification principles hold when investing in these emerging markets.
2. How much of the price movements in the Baltic stock markets can be explained by innovations of the included in the study developed international stock markets?
3. How rapidly are the price movements in the international stock markets transmitted to Baltic stock markets? With other words, the variance of a one particular stock market is examined after being directly affected by the shocks on international stock markets.

The reasons for this special interest in the Baltic economies are many. First of all, only few studies have been focusing on these little open economies and therefore not so much is known about the above mentioned issues for these particular stock markets. As all East European countries, the Baltic economies are developing fast and have reached the GDP-growth around 7-9 % annually under the last couple of years. This means however, among other things, that the Baltic economies with their high growth rate are considered to be the emerging markets with much higher investment risk than other already developed economies, comparably those with the GDP-growth around 2-3 % annually under the same time period. With the greater freedom of capital movements in the Baltic countries and the fact that these countries became members of the European Union in may 2004, the foreign stock markets are expected to have a great deal of influence on the three Baltic capital markets. The next reason for this special interest is that these Baltic countries have been economically isolated from the external international markets before the independence in early 90's. The fact is that the Baltic financial markets have been relatively recently opened up and as a consequence these financial markets are still weakly developed but have a good growth potential. Further, this study is using the daily horizon when investigating the role of, as noted above, US, EMU, Japan, China and Russia in influencing the Baltic stock markets.

Summing up, this paper investigates dynamic linkages between the three emerging Baltic stock markets and the large international stock markets as US's, EMU's, Japanese, Chinese and Russian markets. The major focus of this study lies on the determining both the long and short-run relationships as well as the presence of causality between the three Baltic stock markets and the large international stock markets and between the three Baltic stock markets only.

1.3 OUTLINE

This paper is organized as follows: section 2 considers a discussion around Baltic financial markets, where the focus lies on the discussions of the structure of the Baltic financial markets with some history as well as macroeconomic overview. Further, section 3 discusses methodology and this section describes different econometrical tests, their advantages and disadvantages in order to be able to perform this study as reliable as possible. These tests are: Johansen Cointegration test and Engle–Granger residual based approach, where a long run relationship is investigated between the markets; and further Causality tests where Impulse response and Variance decomposition analysis are discussed. Section 4 outlines description of the data, where the focus lies on the discussions of the differences of time zones for the examined stock markets and what for analytical difficulties it might bring around in further empirical analysis; as well as some statistical introduction to these particular stock markets in order to get a general overview. Furthermore, section 5 outlines empirical results, where the results from the above mentioned econometrical tests are presented. And finally, section 7 considers empirical analysis of the dynamic linkages between the Baltic and international stock markets, where both short summary and conclusions are discussed. As a finishing part of this study the REFERENCES, where different literature sources as well as APPENDIX with the figures from the causality tests are presented at the end of the paper. Thus, Appendix includes the figures (A1 – A8) from the Impulse response and Variance decomposition analyses.

2. BALTIC FINANCIAL MARKETS

In order to get more familiar with these financial markets the structure and some short history of the Baltic stock exchanges is presented in this section as well as the macroeconomic overview.

2.1 BALTIC STOCK EXCHANGES

The financial sectors of Estonia, Latvia and Lithuania have undergone considerable transformation after reestablishment of the independence in the early 1990s. In brief, some important measures have been taken in order to support liberalization, facilitate stability and strengthen the financial sector. For example, restrictions on currency exchange and administration regulation of bank's interest rates have been cancelled, the markets have been opened to foreign competition and capital flows have began moving freely in and out the Baltic markets, which made a great start for a development of their financial systems.[6]

2.1.1 Riga Stock Exchange short history[7]

Riga Stock Exchange was founded on the 7th of December 1993, just a couple of years after the reestablishment of independence. Further the official opening took place on the 25th of July 1995 with the launched trading as a consequence. That year, only 4 domestic companies were listed on the Riga Stock Exchange, and comparably on February 2007 the number of listed companies was 11. Although the number of listed companies was growing steadily all these years, however many of the companies were, at the same time delisted from stock exchanges for some reasons. At that time trading took place once a week, as a single price auction, whereas starting with February 1997 the trading run on each business day. Also noteworthy, Riga Stock Exchange was the first one of the Baltic Stock Exchanges to offer the investors the continuous trading facility based on the public order book on November 1997. Further, the direct trading via internet connection to the investors was allowed on 2000.

2.1.2 Vilnius Stock Exchange short history[8]

Vilnius Stock Exchange started working and held its first trading session on the 14th of September 1993. Precisely, trading took place twice a week from July 1995, and already was starting the daily trading on the 2nd of December 1996. Vilnius Stock Exchange launched the continuous trading in shares on the 1st of April 1998. Also noteworthy, 55 domestic companies were listed on the Vilnius Stock Exchange

[6] *Financial market in Latvia 2003*
[7] http://www.lv.omxgroup.com/?id=3294
[8] http://www.lt.omxgroup.com/?id=2845

when it was opened, but this number was constantly changing through years and on February 2007 the number of listed companies was 43. That is because some companies had been delisted, i.e. a constant inflow and outflow of companies on the stock exchange though time.

2.1.3 Tallinn Stock Exchange short history[9]

Tallinn Stock Exchange was established on the 19th of April 1995 and the trading was opened on the 31st of May 1996. That year only 6 securities were listed, but this number was constantly growing and on February 2007 the number of listed companies was 15. Specifically, the reason why the number of listed companies was not growing very fast in all three Baltic stock exchanges, might be explained by the fact that some companies went bankrupt, some got purchased by international players, etc.

And finally, Tallinn and Riga Stock Exchanges merged with OMX Group in 2004 and further started operating on the common Nordic platform on September that year. In May 2005, Vilnius Stock Exchange adopted the same trading system and become one of the members of the OMX Group. Being more detailed, it might be noticed that the OMX Group consisted of several stock exchanges by that time. So the OMX Group covers now both the Baltic and Nordic region and the fact is that OMX offers the same trading platform which reduces the costs of cross – border trading. Tallinn, Riga and Vilnius Stock Exchanges are now a part of the OMX Group as well with the same core idea of facilitating cross – border trading as well as attracting more investments to the region.[10]

2.2 MACROECONOMIC OVERVIEW[11]

The fact is that all three Baltic economies had the fastest growth rates in the EU resent years, for example: year 2005 Lithuania's growth rate was 7,5 %, Estonia's 9,8 % and lastly Latvia's 10,2 %. Comparably, looking at the year 2006 it can be noted that the economic growth rates were even higher. According to projected annual growth rate's estimates the Eastern European economies had outstripping the Euro-zone in recent years. Hence, the region as a whole is expanding more rapidly than the EU average.[12] Despite this fast economic growth, the analysts are expecting a soon slowdown, where the construction sector and the labor market become a big concern lastly.

Furthermore, the unemployment rate have been falling gradually and today it is around 4,9 % in Estonia, 5,4 % in Lithuania and 7,6 % in Latvia. However the future economic growth threatens such

[9] http://www.ee.omxgroup.com/?id=17488
[10] http://www.baltic.omxgroup/index.php?id=2681
[11] *Guide to the Baltic Market 2006*
[12] Syriopoulos T., (2005)

factors as a significant labor outflow, especially from Lithuania and Latvia, and a declining population in a working age, unless the governments begin to take some considerable steps in order to prevent this as well as the domestic companies begin to work seriously with productivity and efficiency issues.

Furthermore, the major growth driver in recent years has been the explosive domestic household spending, because of the increasing employment in the Baltic countries and increasing household incomes. At the same time a bank loans to the public have become explosive. For the first the interest rates have been relatively low, which mostly depends on the European Union's monetary policy, which leads to the conclusion that the interest rates generally follow the ECB's interest rates and consequently the central banks of the Baltic States can regulate the national interest rates only in certain bounders. Second, the increasing competition in the domestic financial sectors has also contributed to the beneficial lending terms.

As the interest rate has begun to increase, following the ECB's interest rate, the Baltic household's credit situation automatically became worse, which negatively influences the domestic consumption. This can, in turn, slow down the Baltic States economical growth the nearest years.

In addition, the impact of the EMU is expected to have some stronger effect on the Baltic equity markets than other economies taken in the study, mostly because of the recent joining of the European Union (May 2004), which should have increased degree of integration Baltic States with EMU country-members. Moreover, Baltic States are taking measures on order to become new EMU members as soon as possible, which however brings around some extra political and economical criterions to achieve.[13] These criterions will not be outlined here because it is not the primary goal of this study.

[13] Maneschiöld P., (2006)

3. METHODOLOGY

In order to answer the above-mentioned issues, from the purpose and goal section, some of the econometric approaches, such as: different unit root tests, Johansen cointegration test, Engle-Granger residual based approach as well as causality tests: variance decomposition and impulse response analyses will be discussed in this section.

3.1 COINTEGRATION

Briefly, if a linear combination of investigating non-stationary variables is stationary then the variables are said to be cointegrated. Many financial time series are non-stationary and some of them may move similarly over time. This implies that these time series are bound by some relationship in the long run. For example, some time series might wander apart without bound in the short run, however move along some common trend in the long run, i.e. there would be a binding long-run relationship between these time series.

In order to perform the cointegration test, the investigating time series should firstly be tested for the presence of a unit root. The following three unit root tests will be performed, because each test has its advantages and disadvantages. Thus, in order to secure the statistical results whether the time series are stationary or non-stationary, the following unit root tests will be performed: ADF, PP, KPSS and thereafter the series can be tested for cointegration.

3.1.1 Applied unit root tests

3.1.1.1 Augmented Dickey – Fuller test (ADF)

The following general regression should be used to estimate the ADF test:

$$\Delta y_t = \alpha_1 + \alpha_2 \cdot t + \psi \cdot y_{t-1} + \sum_{i=1}^{k} \beta_i \cdot \Delta y_{t-i} + \varepsilon_t \,;$$

where α_1, α_2 – are some constants and *t* – is a time trend.

Firstly it has to be specified whether to include a constant, a constant and linear trend, or neither in the test regression, which depends on the particular time series characteristics. Further, it may be noted that ADF test doesn't require the independence in the residuals, comparably with usual Dickey – Fuller test for a unit root. The *k* lags of the dependent variable appear in the ADF test in order to get rid of any dynamic structure present in the dependent variable, i.e. that is to ensure that the residuals are not autocorrelated. It's quite important to choose the optimal number of lagged differences – k – so that no autocorrelation persists in the regression residuals. Moreover including too many lagged differences will lead to the increased coefficient standard errors, whereas including too few will not remove the autocorrelation in the regression residuals. There is no obvious way of choosing the number of lagged differences, but the information criteria and frequency of the data as well as some economic intuition might be quite reliable tools.[14]

Further, if a random walk behavior is present in a particular time series, then these time series contains a unit root. The set of testing hypothesis is the following: H_0: $\psi=0$ and the alternative H_1: $\psi<0$. Specifically, if the null hypothesis can't be rejected then it denotes the presence of a unit root in these particular time series otherwise these time series is stationary.[15]

3.1.1.2 Phillips – Perron test (PP)

An alternative test is PP test for a unit root, which is basically very similar to the above noticed ADF test with the difference that PP test allows for autocorrelated residuals because an automatic correction is incorporated in the test procedure, i.e. the test allows for dependence as well as heterogeneity in the error term.[16] This correction is made by the adjustment the t – statistic of the γ coefficient from the AR(1) regression and taking into account the autocorrelation pattern in the error terms.[17] The presence of a unit may be tested using the following regression: $y_t = \alpha_1 + \alpha_2 \cdot t + \gamma \cdot y_{t-1} + e_t$; and the tested hypothesis are the following: H_0: $\gamma=1$ and the alternative H_1: $\gamma<1$. Thus, if the null hypothesis can't be rejected then it denotes the presence of a unit root in these particular time series otherwise these time series is stationary. As for the ADF test, it must be specified whether to include a constant, a constant and linear trend, or neither in the test regression.[18]

3.1.1.3 Criticisms of ADF and PP tests

The fact is that both ADF and PP unit root tests give almost always the same conclusions, and moreover these tests suffer from the similar limitations. The most important one is that the power of the test becomes low if a particular time series is stationary but with a coefficient from, for example, the AR(1) regression close to unity, i.e. close to the non-stationary boundary. This limitation confirms especially working with small sample sizes. This means that the time series with little information in

[14] Brooks C. (2002)
[15] Payne J. E., Sahu A. P. (2004)
[16] Payne J. E., Sahu A. P. (2004)
[17] Verbeek M. (2004)
[18] Payne J. E., Sahu A. P. (2004)

the sample will, as a role, described as stationary. With other words, the tests have a little power to distinguish between a near unit root and a unit root processes. In addition, the power of the test that includes many trend components is lower then a more specific model.[19]

3.1.1.4 KPSS (Kwaitkowski et al., 1992) test

In order to avoid the limitation of the low power of the above unit root tests the KPSS test can be employed. The null hypothesis here is testing whether a particularly time series is stationary and the alternative hypothesis in this case specifies the existence of a unit root. As a result of previous specifications as in ADF and PP tests, the null hypothesis of the presence of a unit root can never be accepted i.e. just rejected or not rejected. Thus, this gives the KPSS test the specification advantage because the problem of a failure to reject the null hypothesis of a unit root when the coefficient is close to the non-stationarity border disappears. Specifically, the KPSS test specifies a particularly time series as stationary by default if there is not much information in the sample.

Also noteworthy, the fact is that the KPSS test is a Lagrange multiplier test and can be computed by regressing the dependent variable, Y_t, upon an intercept and a trend, t, as: $Y_t = \alpha + \beta \cdot t + \varepsilon_t$. Afterwards, the partial sums, S_t, should be computed as: $S_t = \sum_{s=1}^{t} \varepsilon_s$, where ε_s are the saved residuals from the regression above. Further, the test statistic is given by: $KPSS = \sum_{t=1}^{T} S_t^{\,2} / \hat{\sigma}^2$, where $\hat{\sigma}^2$ is an estimator for error variance. In addition, the critical value for the KPSS test depends on whether a particular time series is trend stationary or just stationary, with omitted time trend.[20]

3.1.1.5 Summary of the three unit root tests

Table 3 presents the above discussed three unit root tests specification summary, where I(0) and I(1) stand for integrated of order zero and integrated of order one respectively. As it can be seen the ADF and PP unit root tests have the same null and alternative hypothesis. More precisely, in order to come to a conclusion of the presence of a unit root in a particular time series the ADF and PP tests should not reject the null, whereas the KPSS test should on the contrary reject it.[21]

[19] Brooks C. (2002)
[20] Verbeek M. (2004)
[21] Brooks C. (2002)

Table 3. The three unit root tests specification summary

ADF / PP	KPSS
H_0: $Y_t \sim I(1)$ H_1: $Y_t \sim I(0)$	H_0: $Y_t \sim I(0)$ H_1: $Y_t \sim I(1)$

3.1.2 Investigating long and short run relationships

3.1.2.1 Cointegration test

Working with a time series, as for example modeling and forecasting, one would need a particular time series to be covariance stationary. It is the usual condition in order to be able to perform such an econometric analysis. Alternatively, there is a way of how to make non-stationary time series stationary. The answer is: by taking the first differences of each of the I(1) variables and then starting modeling the process, and of course these first differences must be stationary. The fact is that a non-stationary time series may be of a great interest as well. So, when two or more time series are integrated of order one, i.e. have a unit root, they may be tested for cointegration. With other words, two or more non-stationary time series might have a common long – run relationship, i.e. move in the same trend tunnel.[22]

3.1.2.2 Engle-Granger approach

One of the methods that tests for cointegration is Engle-Granger residual based approach. As the theory states, all investigated time series should be stated as non-stationary in order to be applyable for this kind of test. If this condition is fulfilled then the test can be performed and it can be tested whether a long – run relationship exists between some examined variables and the following regression equation should be set up, as the one of general form: $Y_t = \beta_1 + \beta_2 \cdot X_{2,t} + \beta_3 \cdot X_{3,t} + ... + \varepsilon_t$. Afterwards, the saved residuals, $\hat{\varepsilon}_t$, from this regression must be tested for a presence of a unit root and autocorrelation as well. This is done by setting a regression equation as the one: $\Delta\hat{\varepsilon}_t = \psi_1\hat{\varepsilon}_{t-1} + \sum_{i=1}^{n} \lambda_i \Delta\hat{\varepsilon}_{t-i} + \xi_t$, where $\Delta\hat{\varepsilon}_t$ is the first difference of the estimated residuals.

[22] Brooks C. (2002)

A number of the parameters $\Delta\hat{\varepsilon}_{t-i}$ might be needed in the above regression equation in case when serial autocorrelation is present in the residuals, ξ_t. Thus, in order to get rid of serial autocorrelation, if this is the case, the appropriate number of these parameters is chosen so that the serial autocorrelation is minimized. The critical values for this special application are different than those for the usual DF test because the above test is applied to the residuals of the estimated models rather than on raw data, i.e. the Engle-Granger critical values are more negative. Furthermore, the ADF test is usually performed where the null and alternative hypotheses were discussed above in unit root section. If a presence of a unit root in these residuals is rejected then these non-stationary variables are cointegrated. Specifically, if $Y_t - \beta \cdot X_t \sim I(0)$ for some β then it is said that Y_t and X_t are cointegrated with β being called a cointegrated parameter. Further, it may be noted that the single – equation model has only one cointegrating vector $(1, -\beta)'$, whereas two or more cointegrating vectors can be found in the multivariate models.[23]

This Engle-Granger residual based approach is easily performed but the disadvantage of it is that it can't identify more than one cointegrating vector. This means that regardless of how many variables there are in the regression equation the test can only identify whether the cointegration relationship exists or not. Moreover, there are two problems that may arise in case when Engle-Granger residual based approach is applied. The first problem may arise because of the small sample issue, which is reflected in the lack of the power of both unit root and cointegration tests. The second problem includes simultaneous equation issue, which arises when causality between the two investigated variables runs in both directions. This means that a researcher must normalize the variables by their endogenity vers. exogenity, i.e. specify which one should be the dependent variable, whereas the rest – independent.[24] Sometimes neither economic theory nor intuition can give answers onto investigating the issue, which might be explained by the mutual causality, i.e. which runs in both directions.

Furthermore, a complication might occur when testing for unit roots in OLS residuals. Specifically, what OLS estimator does is minimizes a sample variance as much as possible, which influences the features of the residuals and makes them look as stationary as possible, even if the investigated variables are not cointegrated. Thus, the null will be rejected more often than it should. That's why the asymptotic critical values by Davidson and MacKinnon 1993, that are more negative than for the standard Dickey – Fuller tests, are used to be the appropriate ones.[25]

[23] Brooks C (2002)
[24] Brooks C (2002)
[25] Verbeek M. (2004)

3.1.2.3 Vector Autoregressive (VAR) model [26]

Generally, VAR models represent a system of regression equations and are actually expanded from Autoregressive (AR) models and Sims (1980) was the one of those who made these models popular in econometrics.

As there are three Baltic indices in the study, the VAR model would reasonably consist of three equations. Briefly, all three Baltic indices are further considered together rather than investigating them separately in a pair manner. Further in the study other stock markets are also taken into consideration and new VAR models are constructed, i.e. each Baltic index is considered with the five international stock indices jointly.

Generally, if a dependent variable ($\vec{Y}_t$) depends on different combinations of the previous $\vec{Y}_t$ values ($\vec{Y}_{t-p}$), then a general *VAR(p)* model can be written as:

$$\vec{Y}_t = \sum_{i=1}^{p} B_i \vec{Y}_{t-i} + \vec{Z}_t \; ;$$

where C_i is an intercept, a column vector of coefficients and $B_i = B_1,\ldots,B_p$ are the $k \times k$ matrices of coefficients, $Z_t \sim IID(0,\Sigma)$ is a column vector of forecast errors, $\vec{Y}_{t-p}$ are fixed values and p is a lag length. This means that *VAR(p)* systems regression model may be interpreted in this case as: the movements in each Baltic stock price index can be explained by some number of previous values of the three Baltic stock price indices, error terms and intercept. As it can be noted each equation contains the same parameters on the right hand side.

The fact is that the estimation output of the VAR modeling is difficult to interpret, i.e. the coefficients from the regression equations cannot be easily described intuitively. Already in 1980, Sims showed in his study that it is better to examine the system's moving average structure, i.e. the system's response to random shocks.[27] It has been mathematically shown that moving average representation can be derived from the general VAR model (see for example Johansen, 1988, 1990 for more details). Obviously, a moving average model is a linear combination of a current and previous disturbance terms.[28]

[26] Verbeek M. (2004)
[27] Eun C. S., Shim S. (1989)
[28] Brooks C., (2002)

Thus MA(∞): $\vec{Y}_t = \sum_{i=1}^{\infty} \Theta_i \vec{Z}_{t-i} + \vec{Z}_t$;

where Θ_i are matrix of the coefficients and $\vec{Z}_{t-i}$ are column vector that represents a current and previous innovations.

However the important property in VAR modeling is the condition of stationarity. With other words the examined variables must be stationary in order to be able to imply an appropriate *VAR(p)* model to the data. The fact that the financial time series are used to be non-stationary, the VAR model should be transformed into Vector Error Correction Model (VECM), where the differences of the variables are used in the equation system. Furthermore, VECM makes it possible to examine the cointegration relationship of non-stationary variables with the help of the Johansen technique.

3.1.2.4 Lag length selection

The important decision when modeling VAR is about the careful selection of lag length. Moreover, the determination of the appropriate lag length is one of the VAR's weaknesses because there is no one right solution to that problem.

In particular, the appropriate VAR(p) model has to be chosen by using the lag length selection test in EViews as well as some economic intuition. Thus, having in mind that the data is daily might seem reasonable to assume that a quite many lags should be taken into the model. Further, the information criteria such as Akaike's (AIC), Schwarz Bayesian (SBIC), Hannan-Quinn (HQ), etc. is a good and quite reliable tool when selecting the appropriate lag length. The problem is that these information criteria seldom denote the same lag length for a model. The most popular and usable of them are AIC and SBIC information criteria. Specifically, both criteria add a higher penalty for each additional number of regressors. The important difference between these two information criteria is that the SBIC adds more penalties and therefore tends to support more parsimonious models than AIC.[29] Also it can be noted that SBIC is consistent but not efficient, whereas AIC is inconsistent but efficient. Hence, SBIC used to deliver the model with fewer lags than it should, while AIC – too large model. Nevertheless, the wrong way of modeling is to set a priority to only one information criterion.[30] The important thing to have in mind is that the less harmful consequences are when choosing the model with too many lags (over-fitting) than with too few (under-fitting).[31]

[29] Verbeek M. (2004)
[30] Brooks C. (2002)
[31] Bessler D. A., Yang J. (2003)

3.1.2.5 Johansen approach – the multivariate case [32]

In order to perform the investigation of a long – run relationship between the variables in multivariate models, the Johansen cointegration technique will be applied in this study. Moreover, using the Johansen cointegration technique more then one cointegrating vector may be identified, the lack of power in residual-based test, as Engle-Granger approach, is avoided and the Johansen technique is the appropriate one even if only $Y_{2t},\ldots,Y_{kt}$ (not Y_{1t}) are involved in determining cointegrating vectors.

In order to analyze a short – run properties between a time series some conditions must be fulfilled. The important thing is that the investigated variables must be cointegrated. In this case it is said that there exists an error correction model that allows to analyze a short – run relationship of some particular I(1) variables. Further, the following assumptions must hold: [33]

- ΔY_t is stationary – where Y_t is non-stationary but can be transformed into I(0) by differencing.
- $(I - \Pi_1 L - \Pi_2 L^2 - \ldots - \Pi_k L^k)$ has all stationary roots
- $\Pi = \gamma\ \beta'$, where γ and β' are of a dimension $(k\times r)$ and denote matrices of weights and cointegrating vectors respectively, r are linear stationary combinations of $\vec{Y}_t$.

3.1.2.6 Vector Error Correction Model (VECM)

Noteworthy, a non-stationary time series should be transformed into stationary by taking the first differences of each of the variable. This transformation is necessary in order to be able to perform the further subsequent modeling process. However, if the relationship between these variables is important then this method is not quite adequate because the presence of the first differences in the regression equations makes it impossible to investigate the long run relationship. That is because it doesn't exist, i.e. no long run solution. Fortunately using the VECM modeling can solve this problem.[34] Thus, the *VAR(p)* model must be turned into a Vector Error Correction Model (VECM), so that the stationary differences of the examined variables, are included in the modeling instead of the originally non-stationary variables. This makes it possible to imply Johansen cointegration technique. A general form of the VECM may be written as the system of equations:[35]

[32] Brooks C. (2002)
[33] Ahlgren N., Antell J. (2002)
[34] Brooks C. (2002)
[35] Syriopoulos T., (2005)

$$\begin{cases} \Delta Y_{1t} = \alpha_1 + \sum_{i=1}^{k_1} \beta_{1i} \Delta Y_{t-i} + \sum_{i=1}^{m_1} \beta_{2i} \Delta X_{t-i} + \gamma_1 Z_{t-1} + \varepsilon_{1t} \\ \ldots \\ \Delta Y_{st} = \alpha_s + \sum_{i=1}^{k_p} \beta_{si} \Delta Y_{t-i} + \sum_{i=1}^{m_p} \beta_{si} \Delta X_{t-i} + \gamma_s Z_{t-1} + \varepsilon_{st} \end{cases}$$

where Z_{t-1} is a cointegrating vector and the coefficients γ_s can be interpreted as the speed of adjustment to equilibrium, Δ=(1-L) is the difference operator, L is the lag operator and $\varepsilon_t \sim NID(0,\Sigma)$ because normality is required by ML procedure. As it can be seen, this equation consists of first differences of *k* variables on the left-hand-side and (*k-1*) lags of the dependent variable with the coefficient matrix on the right-hand-side.

The Johansen technique is based on estimating the above-presented VECM and examining the coefficient matrix, which is also a long-run coefficient matrix. In particular, one needs to impose a restriction for a given value of *r*: $\Pi = \gamma\ \beta'$, where Π is the coefficient matrix. Thus, the test for cointegration performs by looking at the rank of the long-run matrix Π via its eigenvalues, i.e. characteristic roots. In particular, if the rank of the matrix is not significantly different from zero ($\lambda_i \approx 0$) then the investigated variables are not cointegrated.

The trace test statistic is given by:[36]

$$\lambda_{trace}(r_0) = -2\log(Q) = -T \sum_{i=r_0+1}^{k} \ln\left(1-\hat{\lambda}_i\right);$$

where $i = r+1, r+2, \ldots, k$. The tested null and alternative hypotheses are: H_0: $r \le r_0$ and H_1: $r_0 < r \le k$. The trace test examines whether the smallest ($k-r_0$) eigenvalues are significantly different from zero.
Alternatively, the maximum eigenvalue test can be performed, which is based on the estimated (r_0+1)th largest eigenvalue:[37]

$$\lambda_{\max}(r_0, r+1) = -2\log(Q) = -T\log(1-\hat{\lambda}_{r_0+1});$$

where the tested null and alternative hypotheses are: H_0: $r \le r_0$ and H_1: $r = r_0+1$.

[36] Syriopoulos T., (2005)
[37] Syriopoulos T., (2005)

Noteworthy, the rank *r* of the long-run coefficient matrix *Π* determines the number of cointegrating vectors in the system. Thus, there might be more than two linearly independent cointegrating vectors because the regression system consists of three or more variables. The easiest way of understanding cointegrating vectors might be when thinking of them as constrains that an economic system obliges on the movement of the variables in the long run. As a general pattern, the economic system may be stated as stable if there exist many cointegrating vectors. Thus, the more cointegrating vectors there are the more stable the system is. [38] In addition, the coefficients γ_s determine the speed of adjustment back to the long-run equilibrium and when these coefficients are large – the adjustment is fast, so that Z_{t-1} will be stationary and reversion to the long run equilibrium will be fast.

3.2 CAUSALITY

A further examination of the degree of integration of the Baltic markets can be performed by examining the following generalization: *Do changes in market A cause changes in market B?*. If this is the case, then the lags of the variable A should be statistically significant in the equation for variable B. In addition, it may be said that market A "Granger – causes" market B. And further, if vice versa is not the case then variable A is strongly exogenous, of course in the equation for market B. On the other hand, if neither set of lags of one variable is statistically significant in the equation for the other variable then these two variables are independent. These kinds of tests called – Causality tests.[39]

Thus, impulse responses and variance decomposition methods will be implemented in order to investigate whether the price movements in the Baltic stock markets can be explained by innovations of the included in the study international stock markets as well as to check whether the variance of the price movements in the Baltic stock markets transmitted to other international stock markets included in this study.

3.2.1 Impulse response and variance decomposition

One of the Granger – Causality tests is so called Impulse response analysis, which is used in empirical implementations when investigating how one market movements respond on changes from the other markets. In particular, Impulse response analysis examines in what extend previous shocks at time *t-i* on some markets influence the investigated market at time *t*.

[38] Ahlgren N., Antell J. (2002)
[39] Brooks C. (2002)

The generalized impulse response analysis is chosen before orthogonalized impulse response analysis because the results from the latter are very sensitive to the orthogonality assumption as well as might vary with the ordering of the variables in the VAR system.[40]

Another way of investigating the issue is the implementation of the variance decomposition analysis, which allows checking whether some particular examined market, at time *t*, responds on the past movements, at time *t-i*, of other stock markets. Thus, Impulse response and variance decomposition analysis generally examine the same issue but with two different methods.[41]

[40] Payne J. E., Sahu A. P. (2004)
[41] Brooks C. (2002)

4. DESCRIPTION OF THE DATA

As said before, the dynamic linkages between the Baltic stock markets, precisely Tallinn stock exchange, Riga stock exchange and Vilnius stock exchange and some international stock markets of large economies as US – Dow Jones Composite 65, EMU – DJ EMU STOXX 50, Japan – Topix index, China – Shanghai stock index and Russia – RTS index are investigated in this paper. In order to perform the study, the daily stock price indices are collected from the Datastream and the EcoWin databases. Afterwards these stock index prices are converted into the same currency – US Dollar. The sample period for the study has been chosen to 03/01/2000 – 30/03/2007; thus, the investigated sample period consists of T = 1890 daily observations.

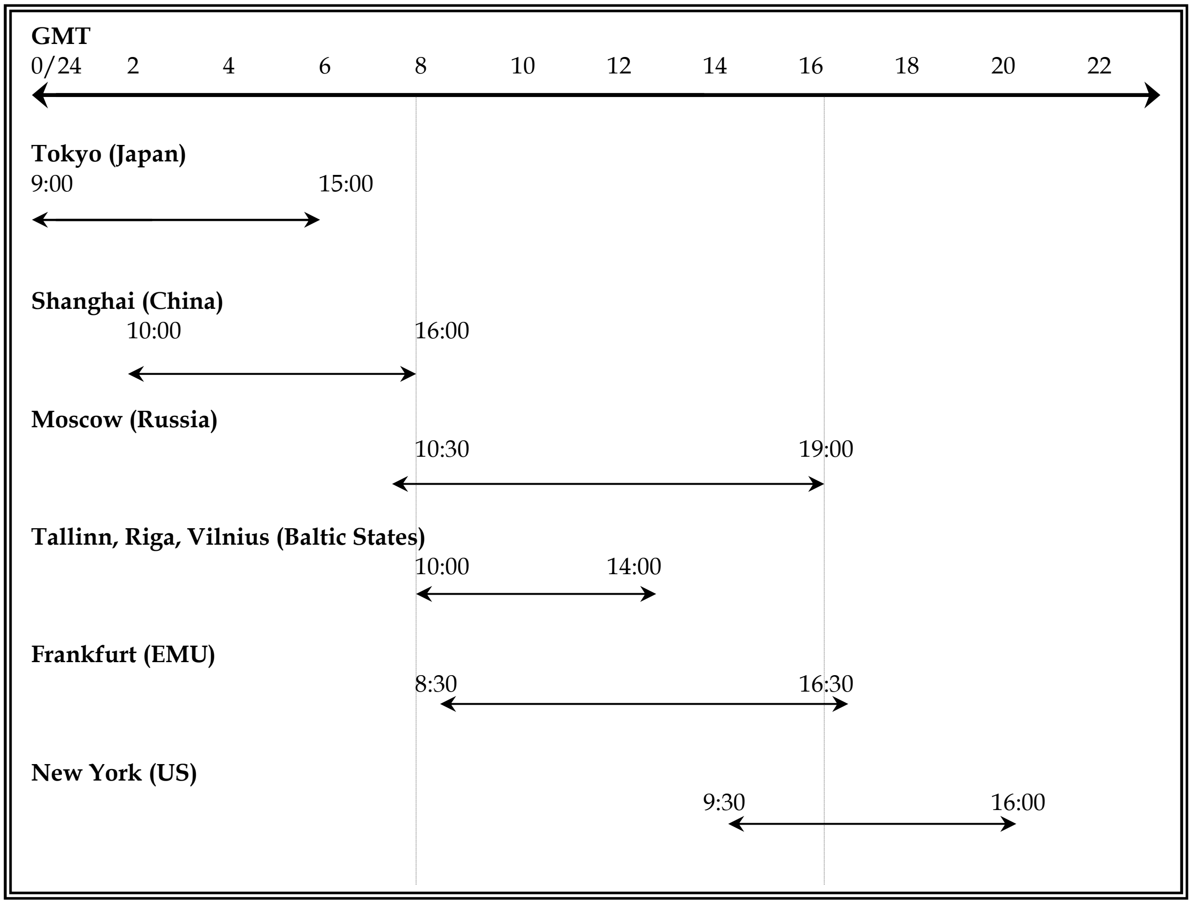
Furthermore, all the literature used as a source in this study was found partly in the financial books, reliable internet sources as well as on the ELIN@Lund online library of Lund University in a form of a science articles.

4.1 TIME ZONES FOR THE STOCK MARKETS

Analyzing different international markets on the daily basis, time zones are important to take into the account. In particular, the problem of non-synchronism arises when the examined national stock markets operate in different time zones with different opening and closing times.[42] This is very important to be aware of in order to be able to analyze the empirical results properly on the daily basis as in this study. Thus, the opening and closing times of each stock market are presented in figure 1. Obviously, the Asian stock exchanges (Tokyo and Shanghai) are already closed when the stock exchange in Moscow and the European stock exchanges (Tallinn, Riga, Vilnius and Frankfurt) are starting operate. It has been chosen to ignore the possibility that Moscow stock exchange might influence Shanghai stock exchange the same calendar day because of the overlapping of about 30 minutes. Furthermore, movements in the Moscow stock exchange, the stock exchanges in EMU region and of course the Asian stock exchanges might theoretically influence the three Baltic stock exchanges the same calendar day. Also noteworthy, the US stock exchange starts operating when the stock exchange in Moscow and the European stock exchanges have one and a half / two hours trading left the same calendar day. On the other hand, the US stock exchange can't possibly have any effect on the Baltic stock exchanges the same calendar day, as it can be seen in the figure 1.

[42] Eun C. S., Shim S. (1989)

Figure 1. Trading hours in eight stock markets



Thus, the Baltic stock exchanges are already closed when the US stock exchange opens for the day, and that's why for example causality analysis should be discussed carefully. In addition, a restriction is used to be imposed in order to make analysis of the empirical results clear. In particular, one may assume that one market, say (US), can't influence another market, say (Baltic), in contemporaneous time, in case if market (US) starts operating when (Baltic) has already closed for the day. This restriction is applied in many similar studies, such as in Bessler and Yang (2003), Koch (1991), Eun and Shim (1989). In addition, the US stock exchange might influence the stock exchange in Moscow and the European stock exchanges due to an overlap of around one or two hours, so it may be appropriate to examine both possibilities with and without US market influence in the same calendar day, when a study is focusing on investigating these particular stock markets.[43]

[43] Bessler D. A., Yang J. (2003)

4.2 SUMMARY STATISTICS

In order to get a general view of the included in the study time series the basic statistical properties of these stock market indices are investigated. The calculated returns are denominated in US Dollars, and therefore it might be mentioned that they are reflecting both the change of the local stock market index in domestic currency and the change in the US Dollar exchange rate.

Table 1. Descriptive statistics of the returns of the stock indices

Market	Mean, %	Standard deviation	Skewness	Excess kurtosis	Jarque-Bera test statistic
United States	0,016	0,010	-0,233	4,391	1534,4 **
EMU	0,007	0,014	-0,096	2,237	396,9 **
Russia	0,129	0,021	-0,561	3,187	898,5 **
China	0,484	0,014	0,371	6,196	306,7 **
Japan	-0,008	0,013	-0,179	2,006	326,9 **
Estonia	0,112	0,011	-0,013	4,451	1559,7 **
Latvia	0,103	0,016	-1,077	18,199	26432,8 **
Lithuania	0,108	0,011	-0,720	23,178	42446,22 **

*** Null hypothesis of normally distributed return series is rejected at the 1 % significance level*

As it can be seen from table 1, all markets but Japan's have positive average daily returns, which reflects in positive means. This might happen because Japanese economy has been in a stagnation period for a long time and just under the last couple of years began getting in some kind of financial and economic growth activity. Further, China shows the highest return mean of 0,48 %, following by Russia – 0,13 % and the Baltic markets – around 0,11 %, which indicate economies with the very high growth rate as well as fast economic development. On the other hand, Russia has the highest standard deviation of 0,021, which denotes the highest market volatility among the represented ones, whereas the US has a lowest standard deviation. High standard deviations may indicate the politically and economically instable countries as well.

Further, neither of the variables proves to have normally distributed returns, which is not so surprising. More precisely, skewness is negative for almost all markets and extremely negative for Latvian market, indicating the fat tails on the left-hand side of the distribution comparably with the right-hand side. On contrary, China has a positive skewness, which indicates the fat tails on the right-hand side of the distribution.

Further, correlations between the stock markets are examined in order to get a general understanding of the overall relationships between these markets. Thus, the correlation matrix is presented in table 2. In brief, a high correlation between two variables measures a degree of linear association between them, so table 2 confirms generally a quite low correlation between the examined stock markets. The highest one of 0,44 is noted between US and EMU markets, while the lowest is noted between Baltic markets and US, EMU, China and Japan markets. This fact is quite interesting because it might suggest a low integration degree between the Baltic and international stock markets. With other words it might be noted that there is a very weak linear association between the Baltic and other investigated markets. As a general pattern the correlations are low, which leads to the indication of possible diversification opportunities between the markets. Nevertheless, more advanced and reliable tests will be performed further in this study in order to investigate closely integration of the Baltic stock markets.

Table 2. Correlations between the stock markets

	US	**EMU**	**Latvia**	**Russia**	**China**	**Estonia**	**Japan**	**Lithuania**
US	1,000							
EMU	0,439	1,000						
Latvia	0,006	0,042	1,000					
Russia	0,162	0,310	0,041	1,000				
China	0,027	0,009	0,029	0,016	1,000			
Estonia	0,068	0,201	0,102	0,149	0,083	1,000		
Japan	0,102	0,178	0,058	0,179	0,089	0,195	1,000	
Lithuania	-0,002	0,032	0,121	0,100	0,035	0,114	0,099	1,000

5. EMPIRICAL RESULTS

This section is focusing on the analysis of the empirical results from the performed econometrical tests. All estimations have been performed in the econometrical software program EViews, whereas the ordinary calculations in Excel.

5.1 UNIT ROOT RESULTS

The three unit root tests have been performed in this study in order to check whether the time series are stationary or not. As it can be seen from the table 4 neither of the tests can reject the presence of a unit root in the examined time series in levels at 1 % significance level, which is marked with two stars. More precisely, the hull hypothesis of a unit root can't be rejected in both the ADF and PP tests, because the test statistics are less negative than the critical values and some of them are even positive (the critical values are given –2,863 at 5 % significance level and –3,433 at 1 % significance level) and therefore t-statistics are lying in the non-rejection of the null area. On the contrary, the hull hypothesis of no unit root is rejected in the KPSS test, which also indicates the presence of a unit root in the time series. The critical values for this test are: 0,463 at 5 % significance level and 0,739 at 1 % significance level, and here the test statistics are lying in the rejection of the null area.

Table 4. *t*-statistics for the three performed unit root tests for the stock market indices in levels

	t-statistic		
Market	**ADF**	**PP**	**KPSS**
United States	-0,732 **	-0,617 **	2,645 **
EMU	-1,054 **	-0,865 **	1,534 **
Russia	0.378 **	0,333 **	5,229 **
China	0,732 **	0,698 **	1,126 **
Japan	-1,551 **	-1,551 **	1,482 **
Estonia	1,047 **	0,92 **	5,376 **
Latvia	-0,725 **	-0,75 **	5,427 **
Lithuania	0,938 **	0,799 **	5,211 **

*** Unit root in the particular time series can't be rejected at the 1 % significance level, where MacKinnon (1991) critical values are used for ADF and PP tests*

Thus, these three different unit root tests reveal similar conclusions that all time series contain a unit root, which does not provide any support for the random walk hypothesis. Therefore first differences of the log level of the respective stock market indices are stationary. After these similar statistical results, denoting that all time series are non-stationary, the cointegration test can be performed.

5.2 TEST FOR COINTEGRATION

The idea of this section is to take a closer look at the cointegration relationship between the Baltic and international stock markets as well as between Baltic stock markets only. The Johansen cointegration test will be performed in this section because the groups of markets are chosen to be tested for cointegration and this particular test allows specifying more than one cointegration relationship, comparably with the Engle-Granger residual based approach, which will also be implemented further in this section, in order to test for cointegration however bilaterally.

5.2.1 Johansen cointegration test

In this study, the AIC information criterion is chosen as a leading indicator for the model's lag length selection, and the smallest value of AIC is preferable. As economic intuition suggests, there might be more than just one or two lags in the VAR for this particularly data set, because of daily observations. Nonetheless, it can be observed from Table 5 that the minimum number of lags is one for some groups of markets and the maximum number of lags is thirteen. Thus, the numbers of lags in VAR models differ in a quite wide spectrum, which might depend on some kind of uncertain and incomplete early trading data of the Baltic stock exchanges.

Furthermore, collected time series are transformed into logarithmic series. After investigating these time series, it may be concluded that all series have non-zero mean and look stochastic over time, i.e. have stochastic trend component. This notion is useful in further econometrical approach when, among other things, specifying the Johansen cointegration test. The estimation results for different groups of markets are presented in Table 5, where both critical values and trace and max-eigen statistics are given for the null hypothesis of no cointegrating vectors as well as the null hypothesis of at most one cointegrating vector. There also presents an appropriate number of lag lengths that were chosen for each VAR modeling.

Thus, the results from Table 5 show that 13 lag lengths are selected for Baltic markets, i.e. almost three weeks, because this number adjusts best the VAR model to these variables. The possible explanation for so many lags included for Baltic markets is that the shocks stay in the system relatively long time before they begin to decrease but never completely disappear.

Table 5. Johansen cointegration test

Markets	Cointegrating vectors	VAR lag length	Trace Statistic	Critical value	Max-Eigen Statistic	Critical value
Estonia, Latvia, Lithuania	none	13	36,97	29,8	24,20	21,13
	at most 1		12,77 *	15,49	12,54 *	14,26
Latvia, US, EMU	none	11	23,63 **	29,8	17,62 **	21,13
Latvia, Russia, China	none	5	45,82 **	47,86	28,29	27,58
and Japan	at most 1		17,52 *	29,79	11,19 *	21,13
Estonia, US, EMU	none	3	21,46 **	29,8	11,67 **	21,13
Estonia, Russia, China and Japan	none	1	43,31 **	47,86	26,16 **	27,58
Lithuania, US, EMU	none	3	30,06	29,8	20,48 **	21,13
	at most 1		9,58 *	15,49	8,07 *	14,26
Lithuania, Russia, China	none	1	57,60	47,86	41,05	27,58
and Japan	at most 1		16,55 *	29,78	12,71 *	21,13

** denote that the null hypothesis of at most one cointegrating vector is rejected at 5 % significance level*
*** denote that the null hypothesis of no cointegration can't be rejected at 5 % significance level*

The Johansen test statistics indicate non–rejection of the null hypothesis of no cointegrating vectors for many groups of the markets, which is denoted with two stars. However the null hypothesis of no cointegrating vectors is rejected, whereas the null hypothesis of at most one cointegrating vectors can't be rejected by both trace and max-eigen test statistics for the following groups of markets: *Lithuania, Russia, China and Japan* as well as for the three *Baltic markets*. This can be easily noted by looking at the cases where the test statistics are higher than critical values and these groups of markets are marked with one star in the table bellow. Hence, it may be stated that these two groups of markets have a long run relationship with one determined cointegrating vector. Furthermore, two groups of markets, namely: *Lithuania, USA, EMU* and *Latvia, Russia, China, Japan* yield some conflicting results as the trace statistic denotes one cointegrating vector, whereas the max-eigen statistic – none. The suggestion towards the solution of such cases is noted in Johansen and Juselius (1990), where these researches recommend examining the estimated cointegrating vector and making a possible economically intuitive interpretability of this particular cointegrating relationship, if it might be overall considered as interpretable.

It has been chosen to take a separate look at the *p*-values of the two groups of markets with uncertain cointegration relationships, where a short summary presents bellow in Table 6. As it can be clearly seen, all *p*-values in the cases of none cointegration relationship are quite close to the critical 5 % significance level. However, changing the significance level from 5 % to 1 % makes the test results more precise. Thus, it might be concluded that there doesn't exist any cointegration relationship between these groups of markets, if this very high precision is desirable. On the other hand, the fact of some weak evidence of cointegration relationship can't be completely ignored. However it might be mentioned that it sounds economically and intuitively odd to find some cointegration between Latvian and the group of the east stock markets examined in the study, having also in mind pretty weak correlation results between these stock markets. It would be more natural to find cointegration between the West stock markets (*US* and *EMU*), as the Baltic states have actually become more economically close to Europe resent years. So finally, these two groups of markets (*Lithuania, USA, EMU* and *Latvia, Russia, China, Japan*) might be considered as weakly cointegrated, however the results are not completely clear. This fact and these uncertain cointegration results suggest that the only one cointegration relationship may be reliably set by this study – is the one between the Baltic markets, and noteworthy with one cointegrating vector. This cointegration relationship supports both empirically and intuitively comparing with the other uncertain cointegration relationships.

Table 6. *p*-values for the groups of markets with conflicting results

Markets	Cointegrating vectors	Trace statistic *p*-value	Max-Eigen statistic *p*-value
Latvia, Russia, China, Japan	none	0,0768 **	0,0405
	at most 1	0,6013	0,6278
Lithuania, US, EMU	none	0,0466	0,0614 **
	at most 1	0,3145	0,3719

*** denote the rejection of the null hypothesis of no cointegration vectors at 5 % significance level*

5.2.2 Engle-Granger residual based approach

Further, a more detailed analysis of cointegration relationship might be of interest for the three Baltic markets and it can be performed bilaterally. For this reason Engle-Granger residual based approach is applied. As it was mentioned before simultaneous equation problem might arise when such a test is used, because causality between the two investigated variables may run in both directions. Since this study is focused on Baltic economies and the economic intuition says that small open economies can't have enough power to influence large major international economies – the Baltic stock indices are taken as the dependent variables in the regression equations, i.e. one way cointegration relationship is assumed.

Thus, the results from the Engle-Granger test is presented bellow in Table 7, with the test statistics for the ψ_1 from the following regression equations: $\Delta\hat{\varepsilon}_t = \psi_1\hat{\varepsilon}_{t-1} + \sum_{i=1}^{n}\lambda_i\Delta\hat{\varepsilon}_{t-i} + \xi_t$. The three columns with the bold names of Baltic markets outline the dependent variables, where all other markets in the first column to the left outline the independent variables. Further, it can be noted that cointegration between the Baltic markets is tested in both directions, because it is impossible to determine which of the markets is the influencing one.

In the table the special Engle-Granger critical values are also presented because the test is applied to the residuals of the estimated models rather than on raw data. These critical values are more negative than the usual DF critical values.[44]

Table 7. Cointegration in pairs, Engle-Granger residual based approach

	***t*-statistics**			**Engle-Granger critical values**		
	Estonia	**Latvia**	**Lithuania**	**0,01**	**0,05**	**0,1**
US	-1,534	-2,254	-1,701	-4,00	-3,37	-3,02
EMU	-1,066	-1,706	-1,221			
Russia	-2,211	-3,314 *	-1,716			
China	2,179	0,061	2,172			
Japan	-1,222	-1,767	-1,638			
Estonia	-	-3,414 **	-2,404			
Latvia	-3,160 *	-	-2,968			
Lithuania	-2,404	-3,151 *	-			

** denotes the rejection of the null hypothesis of I(1) series at 10 % significance level*
*** denotes the rejection of the null hypothesis of I(1) series at 5 % significance level*

Thus, the null hypothesis of a unit root in residual series is tested against the stationarity. It can be stated that the only one test statistic lies in the rejection area at 5 % significance level and it is for

[44] Brooks C. (2002), p. 392

Latvian and Estonian markets, where the Latvian market plays the dependent variable's roll (marked with two stars). And on the contrary, when the Estonian market is set up as the dependent variable the test statistic is somewhat higher (less negative) and lies in the rejection area at 10 % significance level. Hence, it can be concluded that Latvian and Estonian stock markets are cointegrated or with other words have a long-run relationship, which goes in both directions. The less obvious cointegration relationship that is denoted at 10 % significance level is found between Latvian and Lithuanian markets, where the Latvian market again plays the dependent variable's roll. The reversal cointegration relationship between Lithuanian and Latvian markets is rejected, however marginally. The third pair of markets (Lithuanian and Estonian markets) reveals the absence of cointegration, either direction.

In addition, a number of $\Delta\hat{\varepsilon}_{t-i}$ parameters is taken in the regression equation because of a serial autocorrelation in the data. Thus, the appropriate number of $\Delta\hat{\varepsilon}_{t-i}$ parameters is chosen so that the serial autocorrelation is minimized and this number for the Baltic markets is two.[45]

Furthermore, it can be stated that the only one test statistic lies in the rejection area at 10 % significance level when international stock markets are used as independent variables in the regression equations. It is for Latvian and Russian markets, where the Latvian market plays again the dependent variable's role. In addition, two lagged differences $\Delta\hat{\varepsilon}_{t-i}$ are taken in the regression equation so that the serial autocorrelation is minimized. Hence, one more cointegration relationship is revealed, however the last one.

5.3 IMPULSE RESPONSE AND VARIANCE DECOMPOSITION

As discussed above all investigated time series are non-stationary, and therefore the VECM is applied in order to be able to continue further analysis. Technically speaking, in order to perform impulse response and variance decomposition analysis the first differences of the logarithmic variables are created in the Eviews software, and further they are taken into the modeling, as VECM suggests. Moreover, VECM (1 2) is chosen, i.e. with one lag, because it supports by some studies of Johansen (1990, 1988).

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[45] The regression equations are not separately specified for each of the markets in this study. However one pair of markets can be taken as an example. Thus, $Y_{lv,t} = \beta_1 + \beta_2 X_{ee,t} + \varepsilon_t$ has run with OLS, and further the appropriate model for the saved residuals is specified as the following: $\Delta\hat{\varepsilon}_t = \psi\ \hat{\varepsilon}_{t-1} + \lambda_1\Delta\hat{\varepsilon}_{t-1} + \lambda_2\Delta\hat{\varepsilon}_{t-2} + \xi_t$; where the coefficient ψ to the variable $\hat{\varepsilon}_{t-1}$ is tested for stationarity.

5.3.1 Causality analysis between the Baltic markets only

As noted before, the issue of this study goes into investigating Baltic stock markets and further their integration with other international stock markets. Therefore the first VECM model consists of the three variables only: the three Baltic stock indices. Thus, after running impulse response analysis on the all three Baltic stock markets, a picture of integration between these neighbor markets becomes more clear. This relationship is investigated and the results are presented in the figures A1-A2 in Appendix. Generally, impulse response function traces the effect of a one- time shock to the innovations of one market on the values of the other investigated markets. It can be seen that the most significant response on the local shocks have the own domestic stock markets, talking about the same calendar day. As for example, some unexpected domestic news or events, whether negative or positive, influence directly one of the Baltic country's stock market and it can be also seen that each domestic stock market reaction on this local information shock that particular calendar day is really strong, i.e. very significant. On the next day (t=2), it can still be noted some reaction of the previous day's shock on each domestic stock market, however much less, but further it can be seen that this shock doesn't gradually die away. This might be the evidence of bad integration of Baltic stock markets. Noteworthy, no one of the Baltic stock markets proves to have much response to the shocks from their neighbor Baltic stock markets. It can be noticed very little response over time and these little responses stay in the system. As it can be seen from these figures, there is no response at all of the Latvian innovations on movements in Estonian stock market. Furthermore, very little but constant over time response of again Latvian innovations has Lithuanian stock market. The most response reveals Lithuanian market, which prove to react on the innovations of the Estonian market, however this influence is relatively little.

Variance decomposition is done in order to determine the proportion of the movements in the dependent variables due to their own shocks and the other shocks of the stock market movements. Investigating closely the movements in the all three Baltic stock markets in the figure 2A in Appendix it can be concluded that much of the variance of the Baltic stock market movements are noted only due their own shocks. For example: the shock in the Latvian stock market affects directly the local stock market movements. In other words the graph presents the variance of the stock markets after being directly affected by the shocks. On the other hand it means that variance of the each of the Baltic stock markets doesn't affect much their neighbor Baltic stock market movements.

Thus around 100 % of the Latvian stock market variance is explained by innovations in Latvia. Comparably, a slowly decreasing function of variance, from 100 to 90 percent over 10 days time period, of the Estonian stock market is explained by Estonian market innovations. And interestingly, a downward variance function is revealed in the case of Lithuania. Thus, the variance function goes from 100 down to 50 percent over 10 days time period, which means that the impact on the variance of the Lithuanian stock market movements, caused by the domestic shock, is decreasing. Furthermore, it can be seen that the variance function is constantly around zero for the Latvian market due to both Estonian and Lithuanian shocks. Hence, there is no response in variance of Latvian market movements on the neighbour stock market shocks. Interestingly, the shocks from Latvian stock market prove not to make any difference on the variances of the neighbour Baltic markets. However both Lithuanian and Estonian markets prove to have some more clear mutual connection with each other. For example, a slowly increasing function of the Estonian variance, from zero up to 10 percent over investigated 10 days time period, is explained by innovations in Lithuanian market. Comparably, an increasing function of the Lithuanian variance, from around 5 up to 50 percent over 10 days, is explained by innovations in Estonian market. Hence, for both markets the variance function has an increasing structure throughout the investigated time period.

5.3.2 Causality analysis between the Baltic and the rest of the international stock markets in the study

Further, each Baltic stock market was taken in the modeling with the other stock markets and therefore the three different VECM models were constructed where both impulse response and variance decomposition output is presented in figures A3-A8 in Appendix. Thus, what it is of interest now is to check whether the Baltic stock markets respond on the shocks of the other international stock markets as well as to check whether the variance of the Baltic stock market movements can be explained by the shocks of the international stock markets.

Thus, beginning with the impulse response analysis it can be stated that all responses are very little and insignificant. Starting with Estonia, it can be concluded that shocks on the Shanghai stock market don't have any influence on the Estonian market movements. Interestingly, shocks on the Japanese and Russian stock markets have negative influence on the Estonian stock market, having in mind that these responses are very significant and are fluctuating around zero anyway. Somewhat more significant responses are noticed from the shocks on the US and EMU stock markets. Because of the different time zones, the non-synchronism can be seen in these figures. The first reaction that the Baltic stock markets experience is on the second day after the shock on the US and EMU stock markets. Thus, Estonian stock market has the greatest response on the second day after these extern shocks on the US and EMU markets and further the response decreases but stays in the system, i.e. the consequence of a chock seems not to disappear as the days go. Almost the same picture can be noticed for Latvian and Lithuanian stock markets, where all impulse response functions are almost insignificant. In addition, it can be stated that Latvian stock market has the most insignificant responses on all international stock markets shocks. In figure A5, Appendix can be seen that the responses are so little that it might be stated that there is no response at all of Latvian stock market on the shocks on the international markets. Lithuanian stock market reveals somewhat more significant responses however only on the shocks on US and EMU markets. These are very similar to the ones on the Estonian stock market.

Further the variance decomposition analyses are presented in figures A4, A6 and A8 in the Appendix. It is obvious that the variance of the Baltic stock market movements can't be explained by the international stock market movements. Generally, the same conclusions can be made for the all three Baltic stock markets. Thus, the stock markets that are not able to explain the variance of the Baltic stock markets are: Japanese, Shanghai and Russian markets movements. In addition, the innovations in the international markets fail to explain any substantial part of error variances of Latvian stock market. Furthermore only around 2 – 3 percent of the variance of the Lithuanian and Estonian stock markets can be explained by the EMU stock markets. There is also an approximate response of around 2 – 3 percent of the Estonian stock market variance that might be explained be the innovations in US market.

6. SUMMARY AND CONCLUSIONS

6.1 SHORT SUMMARY

As mentioned before, the purpose of this paper is to investigate how the Baltic stock markets behave on the international arena and how they react on different inflows of information and economical shocks. Thus, this paper investigates the dynamic stock market linkages between the three emerging Baltic markets and some large major markets as: US's, EMU's, Japanese, Chinese and Russian markets. Briefly, the focus of this study lies on the determining both the long and short-run relationships as well as the presence of causality between the investigated markets.

In order to investigate whether there exist a long and/or short run relationship between the Baltic stock markets as well as between the Baltic and the named above international stock markets, the cointegration analysis has been performed. Briefly, if a linear combination of investigating non-stationary variables is stationary then the variables are said to be cointegrated. Some time series might move apart without bound in the short run, however move along some common trend in the long run, i.e. there would be a binding long-run relationship between these time series. Hence, in order to perform the cointegration test the investigating time series have firstly been tested for the presence of a unit root and the following three unit root tests (ADF, PP, KPSS) have been performed. These three unit root tests reveal similar conclusions that all time series contain a unit root, which provide support for the random walk hypothesis. After this the Johansen cointegration test has been performed and some conflicting results have been revealed. First, the long run relationship is determined for the following groups of markets: *Lithuania, Russia, China and Japan* as well as for the three *Baltic markets*. In addition, only one cointegrating vector is found in both cases, which means, however that the cointegration relationship is not very strong as it could be. This is because more cointegrating vectors tend to reveal stronger long-run relationship. Further, two groups of markets, namely: *Lithuania, USA, EMU* and *Latvia, Russia, China, Japan* yield some conflicting results as the trace statistic denotes one cointegrating vector, whereas the max-eigen statistic – none.

Further, a bilateral analysis of cointegration relationship - Engle-Granger residual based approach – is performed. As small open economies cannot have enough power to influence large major international economies – the Baltic stock indices are taken as the dependent variables in the regression equations, i.e. one way cointegration relationship is assumed. In addition, it can be noted that cointegration between the Baltic markets is tested in both directions, because it is impossible to determine which of the markets is the influencing one. An appropriate number of $\Delta\hat{\varepsilon}_{t-i}$ parameters is taken in the regression equation in order to get rid of a serial autocorrelation in the data. Thus, it can be stated that the only one bilateral relationship is significant when international stock markets are used as the independent variables in the regression equations and it is between Latvian and Russian markets.

Furthermore, causality analysis has been performed in order to check how much of the price movements in the Baltic stock markets might be explained by innovations of the included developed international stock markets as well as to check whether the variance of the price movements on the Baltic stock markets is affected by other international stock markets. Hence, impulse response and variance decomposition analyses have been applied to investigate this issue. As the evidence of non-stationarity is the fact, the VECM is applied in order to perform these analyses.

6.2 CONCLUSIONS

After joining the European Union, investigation of the dynamic linkages between three Baltic States and other international economies has become an important issue. Hence, behavior of the three Baltic stock markets on the international financial arena has been investigated in this study and as a result the Baltic stock markets reaction on different inflows of information as well as different economic shocks has been revealed. Firstly, long run relationship has been investigated both bilaterally and between different groups of markets. For this reason Engle-Granger residual based approach and Johansen cointegration test have been applied. And now it might be possible to make some conclusions about how well the international diversification principles hold.

Performing Johansen cointegration test, the null hypothesis of at most one cointegrating vectors can not be rejected for the following groups of markets: *Lithuania, Russia, China and Japan* as well as for the three *Baltic markets*. Hence, it may be stated that these two groups of markets have a long run relationship with one determined cointegrating vector. Furthermore, two groups of markets, namely: *Lithuania, USA, EMU* and *Latvia, Russia, China, Japan* yield some conflicting results as the trace statistic denotes one cointegrating vector, whereas the max-eigen statistic – none. Checking their *p*-values it can be noted that these are quite close to the critical 5 % significance level. Thus, the fact of some weak evidence of cointegration relationship can not be completely ignored.

However it might be mentioned that it sounds economically and intuitively odd to find some cointegration between Latvian/Lithuanian and the group of the east stock markets examined in the study, having also in mind pretty weak correlation results. It would be more natural to find cointegration between these Baltic and the West stock markets (as the possible one: *Lithuania, USA, EMU*), as the Baltic States have actually become more economically close to Europe resent years.

Further, performing Engle-Granger residual based approach, the null hypothesis of a unit root in residual series is tested against the stationarity. The only one pair of stock markets: Latvian and Estonian seem to be cointegrated at 5 % significance level, where the Latvian market plays the dependent variable's role. And on the contrary, when the Estonian market is set up as the dependent variable the somewhat weaker cointegration relationship is denoted. Anyway, it can be concluded that Latvian and Estonian stock markets have a long-run relationship, which goes in both directions. Further, a little weaker form of cointegration is found between Latvian and Lithuanian markets, where the Latvian market plays the dependent variable's roll. The reversal cointegration relationship between Lithuanian and Latvian markets is rejected, however marginally. The third pair of markets: Lithuanian and Estonian markets reveals the absence of cointegration, either direction. It may be concluded that diversification possibilities within the Baltic markets are limited for investors who would like to reduce the risk of asset allocation.

In addition, it can be stated that the only one test statistic lies in the rejection area (however at 10 % significance level), when international stock markets are used as independent variables in the regression equations and it is between Latvian and Russian markets.

As a fact, stock market prices tend to reflect the local economic situation, which leads to the statement that these economic conditions might result in cointegrated stock markets, as for example the Baltic. In addition, if a strong cointegration is expected between some groups of markets then this might be captured by the increasing number of cointegrating vectors[46], which however is not the case for the Baltic stock markets. A presence of a long-run relationship, however, is affecting asset valuations as well as portfolio diversification opportunities.

The results are somewhat different from those in Maneschiöld's study about Baltic capital markets. No cointegration was found there between the Baltic markets, however using weekly data set. This might depend on the short active life of Baltic stock exchanges with too few as well as changing number of traded securities under the examined period. Anyway, the results from both Maneschiöld's study and this particular one may suggest that Baltic markets are becoming more integrated with each other as

[46] Syriopoulos T., (2005)

well as with major international stock markets. That is why it might be expected a much stronger degree of integration between the Baltic stock markets in several years, which however will eliminate the valuable diversification possibilities for investors. The increasing degree of integration between these emerging Baltic markets is to be expected because of such factors as common geographical region, similar political conditions and priority, similar financial governance policies as well as similar structure of the capital markets. Furthermore, all three Baltic States have joined EU at the same time, because they could fulfill certain prerequisite economic criteria, which also lead us to the conclusion that these three small open emerging economies seem to have some common developing pattern with the adjusted macroeconomic policies.

Further, impulse response and variance decomposition approaches have been applied in order to investigate causality between the examined stock markets. Thus, impulse response function traces the effect of a one time shock to the innovations of one market on the values of the other investigated markets. It can be seen that the most significant response on the local shocks have the own domestic stock markets, talking about the same calendar day. It can be also seen that each domestic stock market reaction on this local information shock that particular calendar day is really strong, i.e. very significant. On the next day it can still be noted some reaction of the previous day's shock on each domestic stock market, however much less, but further it can be seen that this shock doesn't gradually die away. The most response reveals Lithuanian market, which prove to react on the innovations of the Estonian market, however this influence is relatively little.

In addition, because Baltic States are situated in the East Europe, in terms of time zone, investors in these countries cannot observe the trading activity on the US market on the same calendar day. That is why Baltic markets do not respond to a US as well as EMU's shocks this particular day. The reason why Baltic markets are not responding to EMU's shocks on the same calendar day might also be that Baltic exchanges are only open for around a half of a EMU's trading opening hours and, in turn, miss the EMU's afternoon reaction on the trading of the US futures, some important statistics from US as well as US shocks at the opening.

Variance decomposition, in turn, is done in order to determine the proportion of the movements in the dependent variables due to their own shocks and the other shocks of the stock market movements. The general conclusion is clear: much of the variance of the Baltic stock market movements are noted only due their own shocks. On the other hand it means that variance of the each of the Baltic stock markets does not affect much movements on the neighbor Baltic stock market.

Interestingly, a downward variance function is revealed in the case of Lithuania, which means that the impact on the variance of the Lithuanian stock market movements, caused by the domestic shock, is decreasing. Furthermore, both Lithuanian and Estonian markets prove to have some more clear mutual connection with each other. For example, the variance of the Lithuanian market movements is significantly increasing due to innovations on Estonian market. Hence, the variance function has an increasing structure throughout the investigated time period.

Thus, there is not found much evidence of shock transmission between Baltic and major international stock markets. However, it seems that Baltic markets are not completely informationally efficient because the responses from impulse response analysis do not fully disappear. This implies that it might still be possible to earn abnormal profits by investing in these particular markets based on observations of some external event in other markets. And finally, the dominant role of the US cannot be supported in the case of Baltic stock markets.

The general conclusion of this study is that Baltic markets tend to display stronger linkages with each other rather than with their mature counterparts, first and foremost because the Baltic economies follow a common path of growth. However the gradually stronger degree of integration between the Baltic and international markets is to be expected, because of constantly growing inflow of foreign investments as well as increasing trading activity of international investors.

6.3 FURTHER STUDIES

As Baltic Economies continue their successful financial development, the researches will get more deep and reliable information to study: financial and political risks, market sensitivity, adjustment of macroeconomic policies and so on. Investigating Baltic markets volatility with GARCH approach or applying non-linear models would be the next step in examining these financial markets.

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APPENDIX

Figure A1. Impulse response function for Baltic markets

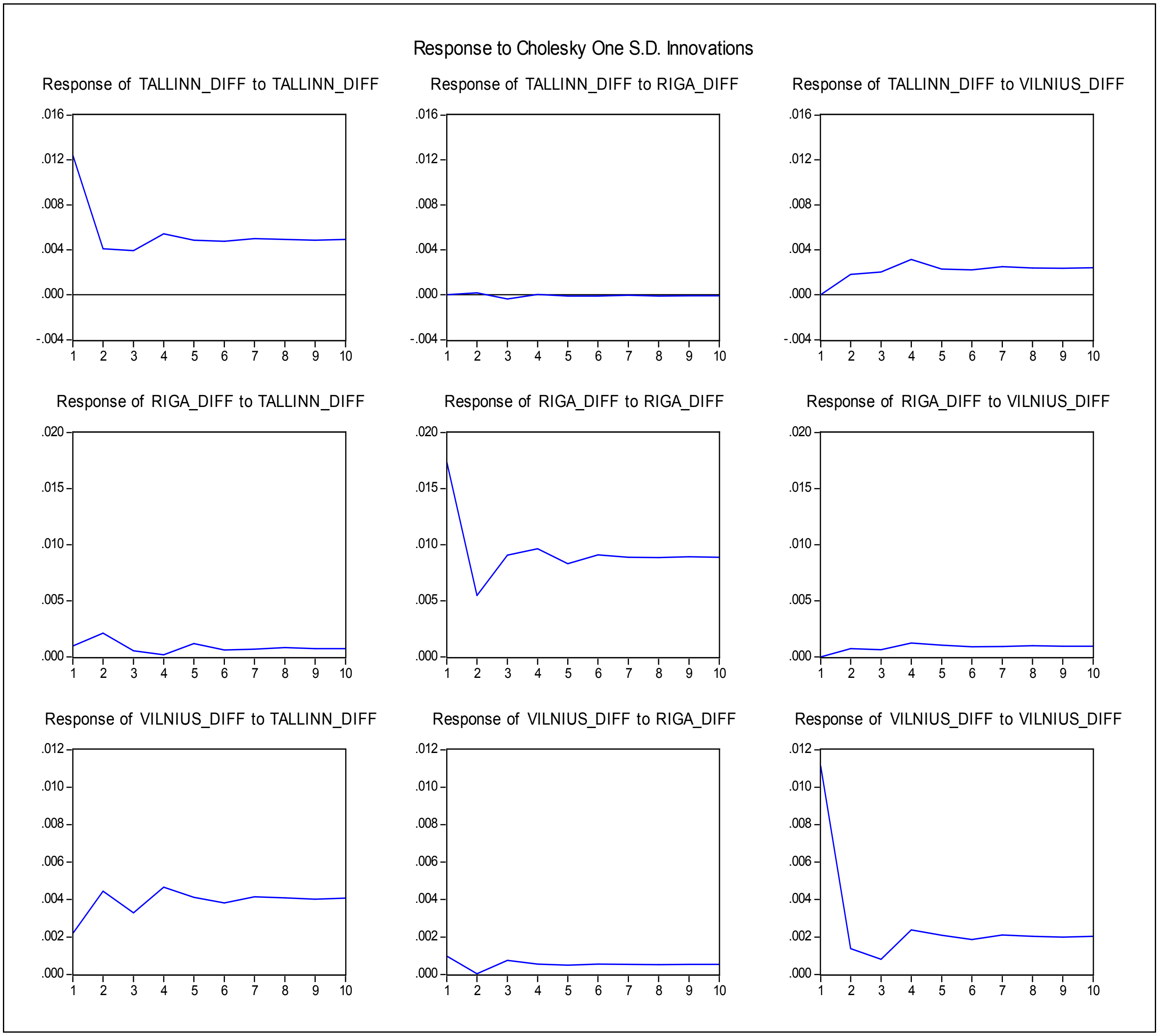

Figure A2. Variance decomposition function for Baltic markets

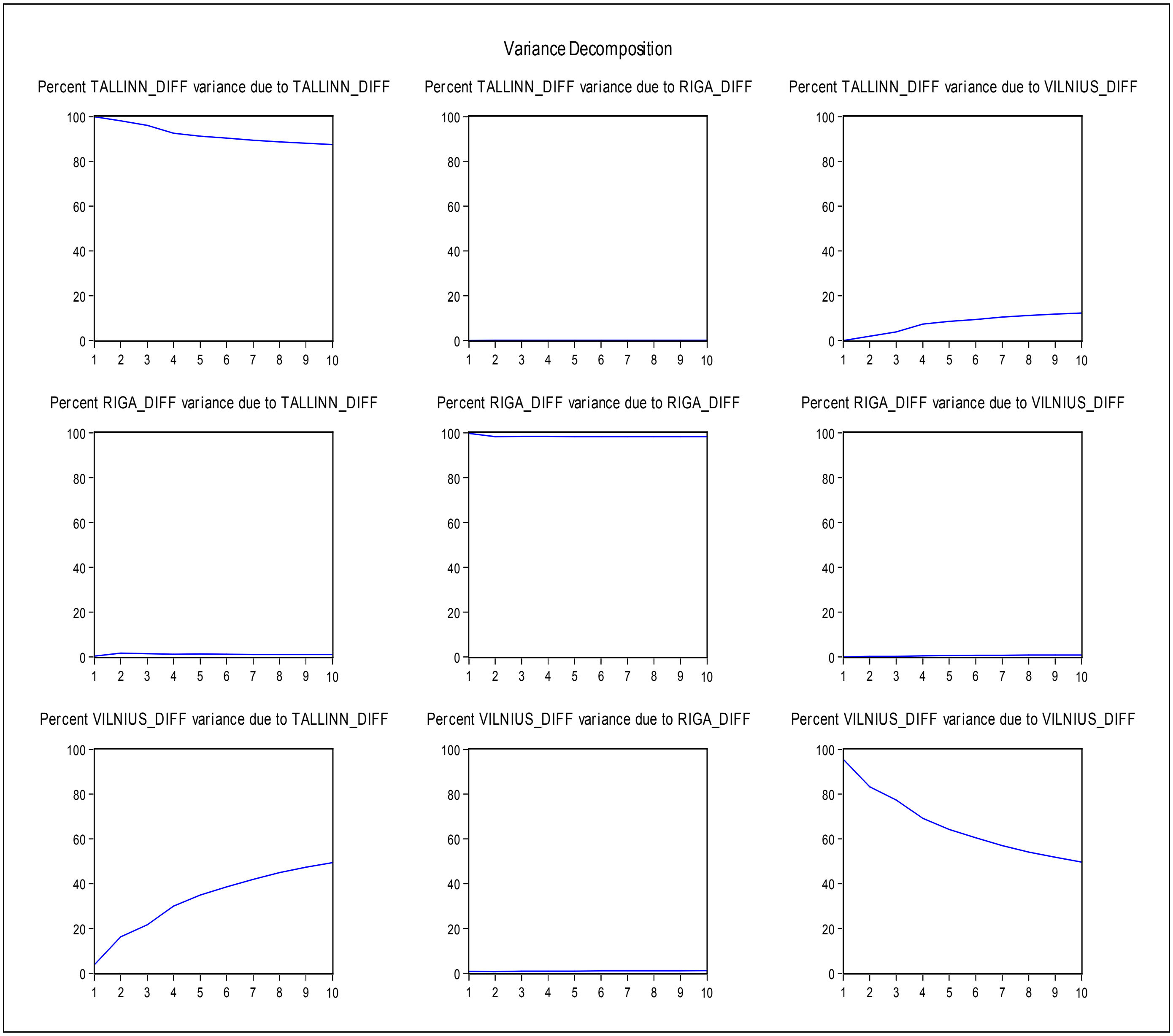

Figure A3. Impulse response function for the Tallinn Stock Exchange

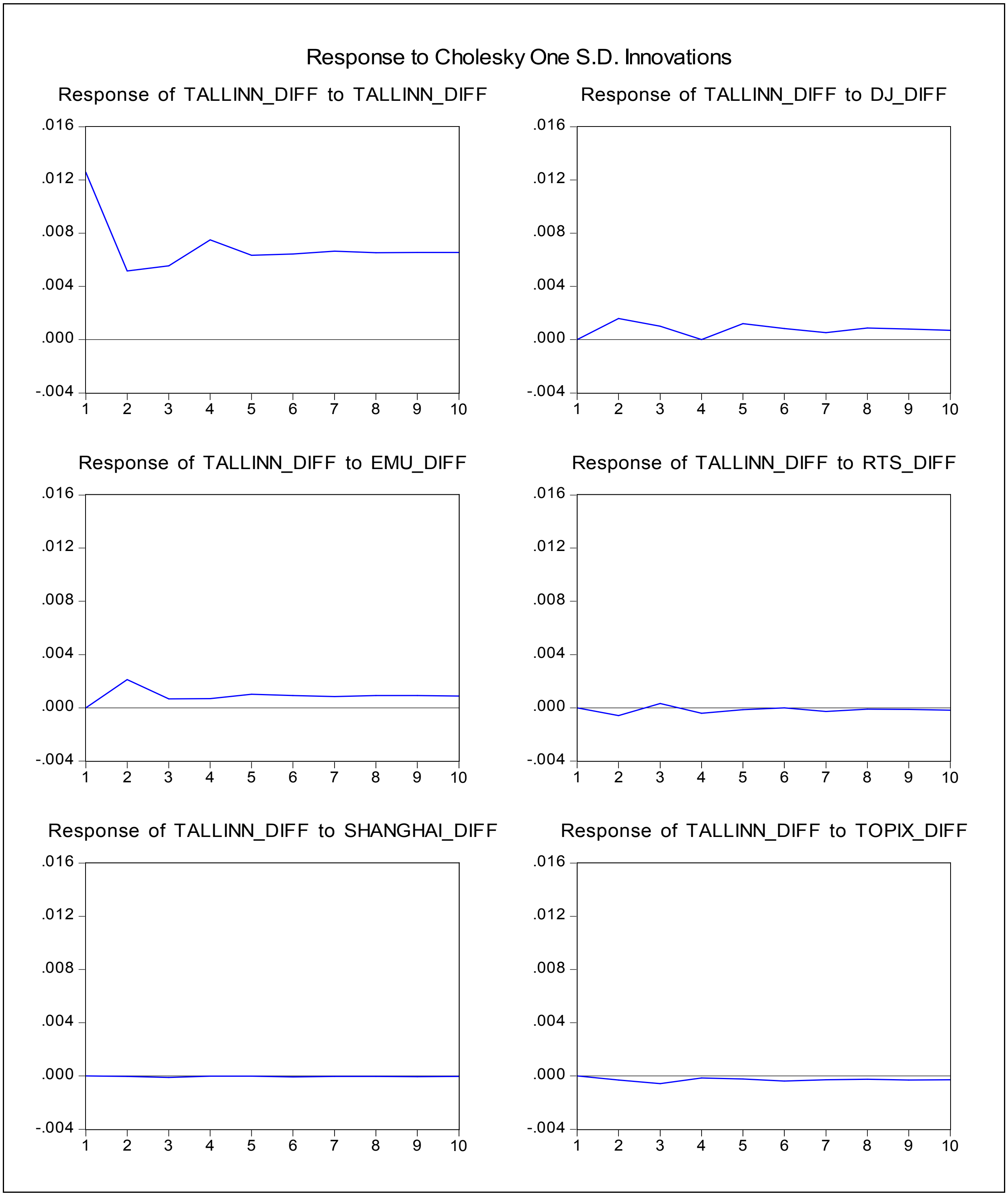

Figure A4. Variance decomposition function for the Tallinn Stock Exchange

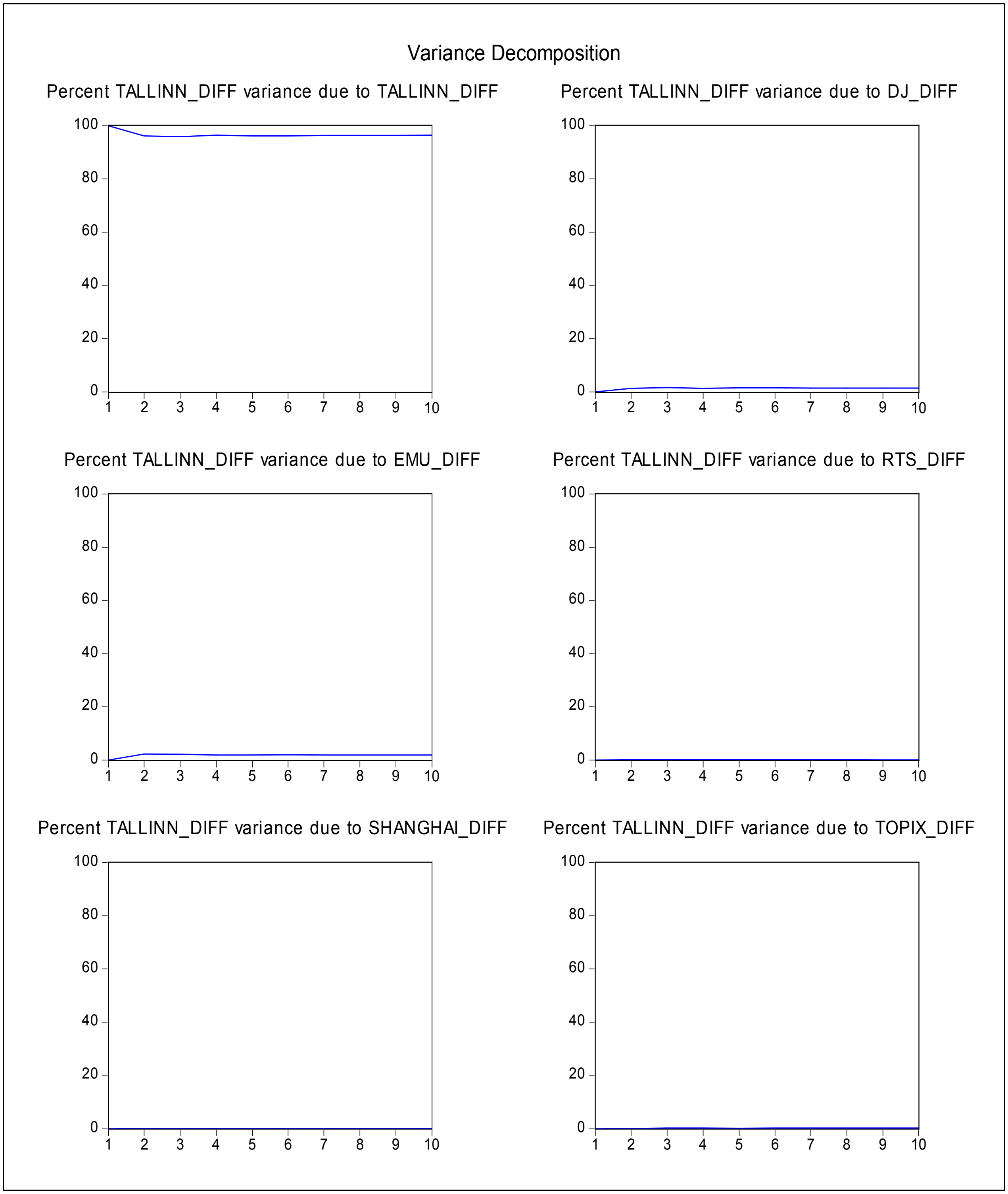

Figure A5. Impulse response function for the Riga Stock Exchange

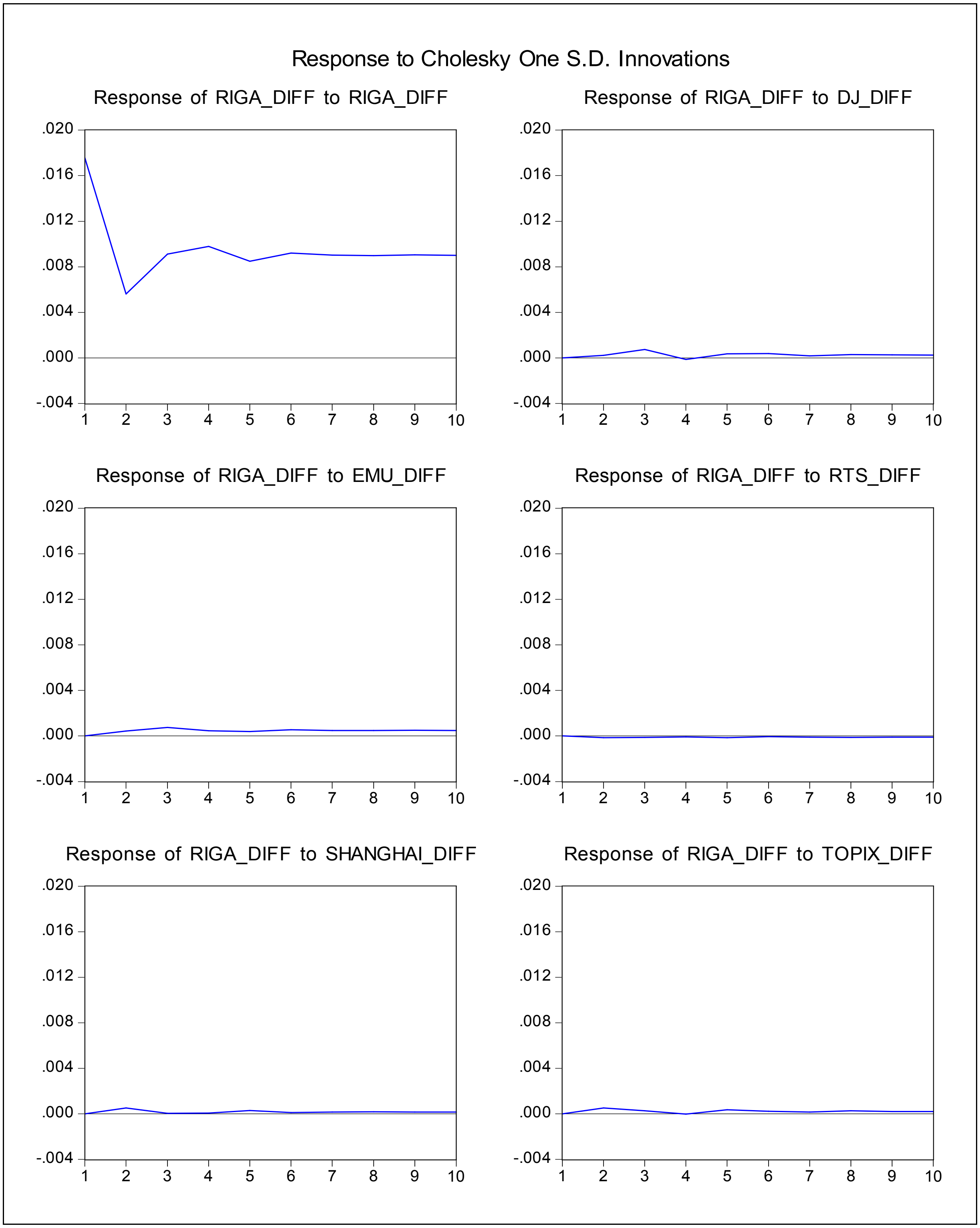

Figure A6. Variance decomposition function for the Riga Stock Exchange

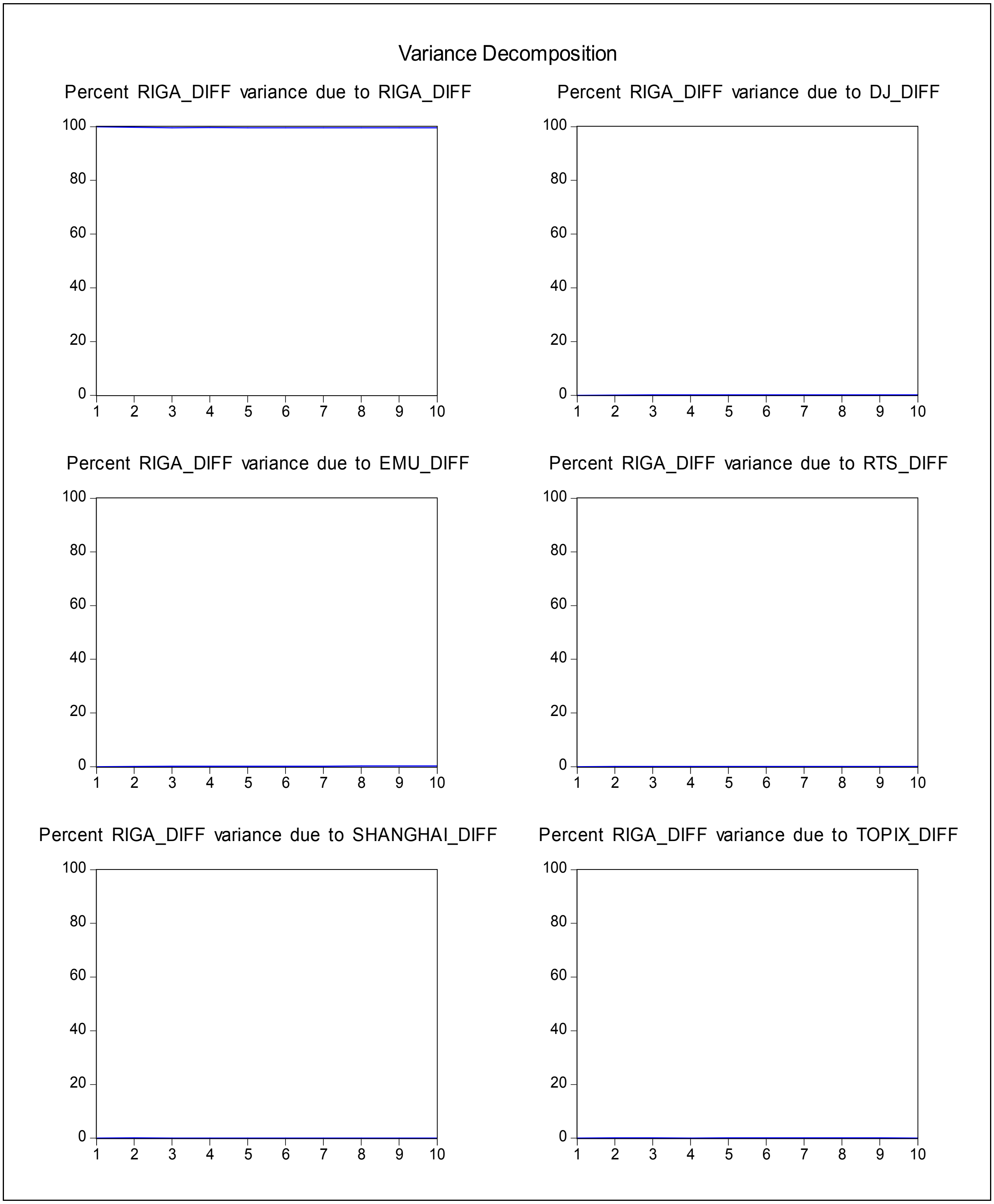

Figure A7. Impulse response function for the Vilnius Stock Exchange

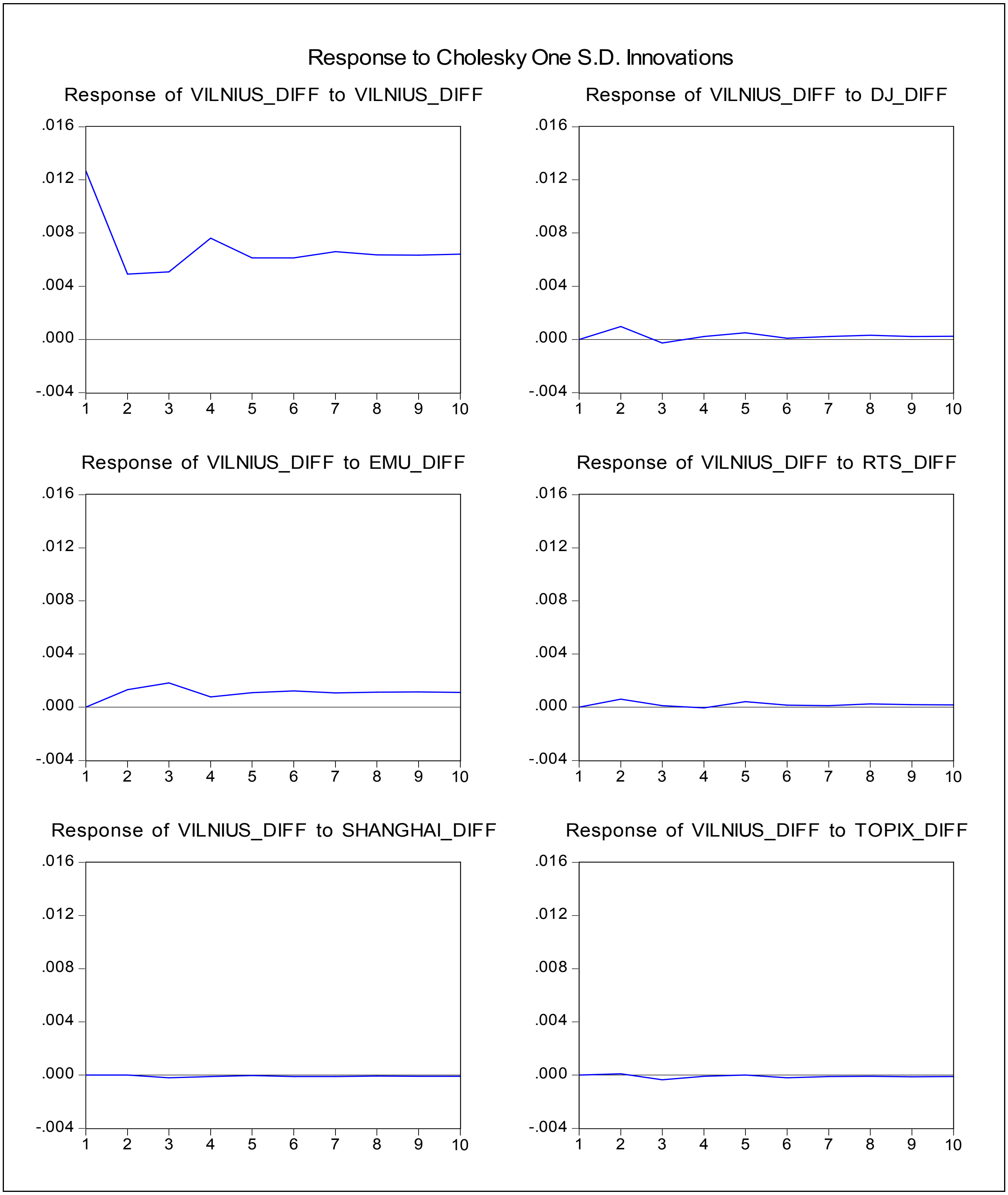

Figure A8. Variance decomposition function for the Vilnius Stock Exchange