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SYMMETRY OF MACROECONOMIC SHOCKS: IS ANY OF THE BALTIC STATES READY FOR THE EURO?

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Is any of the Baltic States ready for the euro?

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Abstract

This paper addresses the issue of symmetry of macroeconomic shocks between the Baltic States and Germany/Russia. It focuses on the Optimum Curency Area (OCA) theory to determine the readiness of a country to participate in a monetary union. The main aim of the study is to identify whether the Baltic States are prepared to join the eurozone according to OCA theory. The study is based on a combination of a Structural Vector Autoregression (SVAR) approach and the Kalman filter procedure. As a result, the authors identify that none of the Baltic States are ready to adopt the euro. The Estonian convergence process is not yet stable enough, Latvia shows very idiosyncratic behaviour, and Lithuania still experiences a large Russian influence.

Keywords: SVAR, Kalman filter, structural shocks, euro, the Baltic States

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1 Introduction

Having regained their independence in 1991 and having successfully joined the European Union in 2004, the Baltic States now face another major integration challenge: euro adoption. Although the euro implies many benefits for the small and open Baltic economies, one should also consider the fact that those benefits will outweigh the costs only if the Baltic States constitute an Optimum Currency Area with the eurozone.

OCA theory states that the economies forming a monetary union should be well aligned; otherwise, they will experience costly adjustment processes in case of asymmetric shocks which are deviations from the long term equilibrium values of macroeconomic variables. Thus, it is important to assess whether the Baltic economies satisfy the OCA convergence requirement to evaluate their readiness for euro adoption. Consequently, *our research question is: what is the degree of synchronization of structural shocks between the Baltic States and Germany/Russia. The sub-question of the study is: how has this correlation of structural shocks evolved over time.* High and stable correlation of macroeconomic shocks would imply readiness to adopt the euro. Although no precise definition of high correlation exists, most of research papers specify the correlation of 30-50% as sufficient.

In this research paper the authors use a SVAR approach to extract structural macroeconomic shocks between the Baltic States and Germany and Russia as well as to obtain a structural decomposition of the impulse response functions. Russia has been determining the development of the Baltic economies for several decades, whereas Germany is the chief economy of the European Union. Comparing the correlation of the Baltic States with these two large economies will allow us to understand whether the Baltics were able to reorient themselves from Russian influence towards the eurozone. Next, the authors apply the Kalman filter procedure to obtain time varying coefficients, which describe the dependence of shocks between countries over time. Combining these two methods will allow us not only to estimate the correlation of the shocks but also to analyze whether the Baltic States have a clearly identifiable time trend in their convergence process with Germany.

The authors show that although convergence processes have started in all three countries, none of the Baltic States have economies stable enough to be ready to join the EMU. The main finding is that though Estonia has the highest correlation with the eurozone, its real convergence with Germany is not sufficiently strong. Latvia has shown very idiosyncratic behaviour and needs to stabilize its economy first. The Lithuanian economy is still significantly influenced by Russia due to its large trade relationship with it.

The novelty of this study lies in the fact that the authors are the first to apply the SVAR methodology in combination with the Kalman filter procedure to all three Baltic States and to analyze in parallel the impact of both Germany and Russia in different time periods. To the best of our knowledge, the method of individual SVAR specifications for each country was not applied to the Baltic States before as well. Additionally, since the time period in our data spans several quarters into the current crisis, this is a unique opportunity to assess the robustness of the convergence processes against the background of global macroeconomic changes.

The rest of the paper is structured as follows. Section two provides review of literature on the OCA theory and research on the Baltic States. Section three is devoted to the theoretical framework and methodology description. Section four includes data analysis procedure and empirical findings. Section five presents discussion on all three Baltic countries. Finally, section six contains concluding remarks.

2 Literature Review

The aim of this section is to acquaint the reader with the development of the Optimum Currency Area (OCA) theory as well as to present recent research in this field. The authors describe the origins of OCA criteria, including the endogeneity hypothesis as well as the OCA related academic discussion on the European Economic and Monetary Union and Eastern Europe.

Origins of OCA Theory

The conceptual framework of the methodology used by the authors is based on the Optimum Currency Area (OCA) theory first developed by Mundell, 1961. The idea proposed by Mundell is that idiosyncratic shocks are very costly for individual countries in the monetary union, because a country cannot respond with monetary and exchange rate policies. A government can pursue only fiscal policy in order to stabilize the economy once it has joined a common currency area.

Another important criterion for the OCA introduced by Mundell (1961) in his first seminal paper was international factor mobility, with emphasis on labour migration. He proposed that international factor mobility can be seen as an effective substitute for an exchange rate mechanism. He also mentioned that industrial and geographical dimensions as well as the level of technological development are important for a country to be better aligned with the other participants in a given monetary union.

Further, McKinnon (1963) suggested that to benefit from joining a monetary union a country has to have a high degree of openness. He also argued that wage and price rigidity with respect to the real exchange rate fluctuations are less problematic for open economies. Additionally, he was concerned with the fact that small economies can be very vulnerable to exchange rate fluctuations and therefore advocated the idea that small countries' currencies should be fixed to stronger ones.

Additionally, Kenen (1969) pointed out the importance of the degree of product diversification; because the more differentiated products a country manufactures, the less it is subject to sector specific shocks. He also suggested establishing a system of fiscal transfers which would help to equalize shocks in the common currency area.

Lately, possible additional criteria were mentioned, such as economic policy preferences and development of inflation rate (Dixit, 2000). Carlin, Glyn and Van Reenen (2001) argued that high inflation results in the loss of competitiveness due to an appreciating real exchange rate. Therefore, an external correction is later needed to regain competitiveness.

Endogeneity of OCA Criteria

Recently, a new subfield has evolved in the literature, disputing whether satisfying all criteria ex ante is a decisive factor for successful participation into a common currency area. In 1973 Mundell proposed the idea that the more heterogeneous countries are the more optimal risk sharing exists among them. This was the first deviation from his 1961 theory, which put significant requirements on the countries wishing to join the common economic zone.

Much later, Frankel and Rose (1997) developed this idea and postulated that the correlation in business cycles and the degree of trade openness are jointly endogenous variables. In their research they found that greater synchronization in business cycles will actually be achieved only *after* the country enters a currency union rather than before that. This finding was supported by further research by Frankel and Rose (1998, 2002), and Rose (2000, 2004).

As summarized by Akiba and Iida (2009), the following aspects motivate self-fulfilment of integration into the common currency area: 1) decreased transaction costs, 2) decreased real exchange rate volatility as a result of more flexible wages and prices, 3) increased capital mobility stemming from more developed financial markets and 4) more efficient allocation of scarce resources among countries forming the monetary union. Hence, Akiba and Iida concluded that a country has a higher probability to satisfy the criteria for entry into a currency union *ex post* rather than *ex ante*. This finding also became known as the endogeneity of OCA criteria or “pro-synchronization” hypothesis.

However, the research world was not unanimous about the endogeneity of OCA criteria. For example, Krugman (1993) argued in favour of the “anti-synchronization” hypothesis. He stated that with further integration countries feel more need for openness and trade. The interdependence promotes Ricardian specialization as countries concentrate on producing the goods they have more comparative advantage in. Therefore, business cycles of individual countries become less correlated while shocks become more asymmetric showing the reverting trend of OCA endogeneity. His view was supported by Bayomi and Eichergreen who earlier found (1992) that the USA is a more integrated common currency area than the EMU, but the USA also has higher asymmetry of demand shocks as a result of regional specialization.

Kalemli-Ozcan et al. (2001) also argued that higher welfare levels can be achieved if business cycles are less integrated. Furthermore, Kennen (2000) and Hughes Hallett and Piscitelli (2001) proved that increased trade does not necessarily result in declining asymmetric shocks.

To conclude this sub-section, the authors would like to emphasize that the OCA concept is relatively young (less than 50 years), and the discussion on the correct application of the theory continues up to this date.

The Economic and Monetary Union of the European Union

The creation of the Economic and Monetary Union in 1999 has stimulated a particular interest in the OCA theory. The EMU was by any measure seen as the largest experiment in the field of international monetary policy. It was widely recognized that the EMU did not meet conditions for the common currency area at the time it was created. However, the endogeneity of OCA criteria was promoted as the justifier for the monetary union in Europe.

The findings on the EMU compromise each other sometimes. However, the majority of researchers agree that to a certain extent convergence among European countries was achieved. Thus, even before the creation of the euro, Artis and Zhang (1995) proposed that the formation of the Exchange Rate Mechanism promoted integration of European markets. Fidrmuc in 2001 proved that convergence in the European business cycles is caused by increased trade intensity. The findings were complemented by Babetski (2004) who researched the correlation of structural shocks and found partial support for Rose and Frankel's proposition of 1997. Later, Tondl and Traistaru-Siedschlag (2006) studied EU trade intensification more deeply and found that it had a strong positive effect on the synchronization of local business cycles, whereas industrial specialization and exchange rate uncertainty were drivers of divergence. His conclusion was that endogeneity of OCA criteria holds in terms of demand shocks, whereas the picture is still unclear for supply shocks. Baldwin (2006) disagreed with the previous findings and was able to accept only the modest impact of the euro on international trade.

To summarize the knowledge on the common currency area, De Grauwe and Mongelli (2005) looked at the various benefits of euro adoption in a European Central Bank working series paper. They pointed out that, after the creation of the euro, prices in the euro area became more homogeneous, there was more risk-sharing, liquidity and the depth of financial markets increased in combination with improved labour market flexibility. The effect of the euro on trade as well as expected correlation among structural shocks was still seen as ambiguous. Overall, they concluded that the future of the euro looked promising.

Turning to the most recent research, Warin, Wunnava and Janicki (2009) have estimated the model which incorporates Heckscher–Ohlin variables, European convergence variables, and interactions between them for the EU-15 countries. Their results support the view that Europe is slowly becoming an optimum currency area especially with respect to capital allocation which corresponds to Mundell II theory of Optimum Currency Area (1973).

Finally, additional attention is paid to the so-called Maastricht criteria which are used to *officially* assess the readiness of a country to join the euro. The criteria are set by the Treaty of Maastricht and include the following:

- *Government budgetary position*: The budget deficit 12 months prior the date of assessment should not exceed the reference value of 3% of GDP;
- *Public debt*: Public debt 12 months prior to the date of assessment should not exceed the reference value of 60% of GDP;
- *Inflation*: Annual inflation 12 months prior to the date of assessment should not exceed the reference value defined as the average inflation rate of the three EU

member states (not just EMU members) with the lowest inflation by more than 1.5 percentage points;

- *Interest rate*: The nominal long-term interest rate 12 months prior to the date of assessment should not exceed the reference value of the average nominal long-term interest rate of the three lowest inflation countries by more than 2 percentage points;
- *Stability of the exchange rate*: A country has to participate in the ERM II for at least two years. During this time it should not allow currency fluctuation in excess of set margins and should not devalue on its own initiative;
- *Independence of the Central Bank* of the country ensures the independence of monetary policy of the fiscal means and political issues
(The Treaty on European Union, 1992).

Though the roots of Maastricht criteria are supposed to be found in the optimum currency area theory, they only deal with the aspects of nominal convergence and are mainly concentrated on targeting inflation. In the research world they are seen as a tool for enforcing fiscal discipline and preparing the country for a common monetary policy (Artis, 2003). Additionally, the arbitrariness of criteria on debt and governmental deficit was proved by Buiter, Corsetti, and Roubini back in 1992. Thus, Maahstricht criteria are useful for preparing a country for the entrance into the EMU; however, they do not necessarily motivate economic convergence in the real terms.

Consequently, in this paper the authors focus on the OCA theory per se as the determinant whether the country is really fit to introduce the euro.

The Case of the Baltic States

Further, the authors turn to the expansion of the European Union in 2004, when ten new states joined. By doing this, the new EU-members have committed themselves to participate in the European Economic and Monetary Union after they have satisfied the Maastricht criteria. The Baltic States were three of those ten new members and became participants of the Exchange Rate Mechanism II. On the one hand, being small and open economies the Baltic States hoped to benefit a lot by joining the euro. On the other hand, some of the benefits were already captured by the fixed exchange rate and, additionally, the countries were below the average of the European Union in their economic development. The latter fact caused so-called Balassa-Samuelson effect and resulted in higher inflation rates as an evidence of the catch-up process. Additionally, the Baltic States experienced large economic reconstruction after regaining independence from the USSR; therefore, they had a high probability of experiencing asymmetric shocks (Babetski, Boone and Maurel, 2002).

The interest in Estonia, Lithuania, and Latvia increased again with the current crisis, especially taking into account the measures Latvia has taken to avoid change in the peg of the lat to the euro and Estonia's application for joining the eurozone in 2011.

However, despite the topicality of the issue, the literature on the Baltic States is fairly contradictive. Back in 2003, Jan Fidrmuc (2003) argued that at that time new EU candidate countries were not ready for the EMU, since their business cycles were not sufficiently correlated. He viewed the EMU as a great international project and a beneficial initiative for the long-run; however, he emphasized that it would be wiser for the newcomers not to run into the euro before they could achieve sufficient convergence. His view was partially supported by the earlier paper of Babetski, Boone and Maurel (2002), who found the increased correlation of demand shocks, but the divergence of supply shocks of the new states with the euro area. Later in 2004 Fidrmuc and Korhonen proposed that the Baltic counties were the most distinct members of the EU as they were still significantly dependent on Russia. Using structural VAR analysis Horvath and Rafai (2004) concluded that the correlation between shocks in NMS and in the EU is high, whereas Fidrmuc and Korhonen (2001 and 2003), and Frenkel and Nickel (2005) did not find any significant synchronization. At the same time using a similar approach Eickmeier and Jorg Breitung (2006) found that only Estonia is an appropriate candidate for the euro zone out of three Baltic States, and this claim was supported by the later work of Fidrmuc and Korhonen (2006).

By contrast, other authors investigating real exchange rate movements suggested that the Baltic States were ready to adopt the euro. Horvath (2005) examined exchange rate volatility and pressures in the new accession countries, arguing that they are quite well aligned with the euro area, especially Estonia. Caporale, Ciferri, and Girardi (2008) found that the general purchasing power parity held for all three Baltic States. Moreover they stated that there had been a significant real convergence to the euro and the Harad-Balassa-Samuelson effect played only a modest role.

The abovementioned approach is discussable as the Baltic States have already given up their exchange rate mechanism by pegging the currencies. Consequently, the largest amount of literature on the Baltic States is related to the investigation of structural shocks, but the findings still contradict each other, depending on the time span and model used.

Studying the evolvement of correlation in structural shocks over time also gave contradictory proposals. Babetski et al. (2004) determined that supply shocks do not converge due to the presence of Balassa-Samuelson effect. At the same time, they found that demand shocks become more integrated over time, indicating real synchronization. Artis et al. (2004) and Darvas and Szapary (2005) found that the correlation coefficients increase over time. However, Mikek (2006) was not able to identify any time trend.

Darvas and Szapary (2007) employed deep SVAR analysis and investigated the correlation between major expenditure and sectoral components of the Gross Domestic Product (namely, private consumption, investments, exports, imports, industrial production, and services). They actually found that the Baltic States are the least integrated group of countries among the new EU members, supporting the earlier view of Firdrmuc and Korhonen. To provide a better overview of the findings, Table 1 below summarizes the main results from the OCA theory related research on the Baltic States.

As discussed, disagreeing findings in the literature pose the natural need for identifying the true degree of convergence as it has important political and economic implications. The most recent methodology estimating synchronization of supply and demand shocks for the new accession countries was developed by Mikek (2007). However, he omitted the Baltic States in his research due to the small size of their economies. Therefore, our aim is to apply this methodology to the Baltic countries to clarify the degree of their alignment with the eurozone and to judge the readiness of the Baltic States to adopt the euro. Moreover, the authors are going to compare the Baltic States with the Russian federation to fill in the gap created by undersized attention to the individual features of the Baltic States in terms of their historical connection with Russia in the western research world.

Table 1 *Previous findings on the case of the Baltic States*

Author	Method used	Countries studied	Control country/(ies)	Russia	Results
Nabil (2008)	Hodrick-Prescott (HP) filter; SVAR	Bulgaria, Croatia, Estonia,Hungary, Latvia, Lithuania, Malta, Poland, Czech Republic, Romania, Slovakia, Slovenia	the euro area	not included	• shocks are asymmetric in the Baltic States and the euro area; • Estonia has the highest supply shock correlation coefficients with the EMU; • demand shocks are found to be harmonized with the euro area also for other countries.
Jurgutyte (2006)	SVAR	Lithuania	the euro area	not included	• positive business cycle correlation in 2002-2005; • increasing synchronization in the euro area; • partial confirmation of the endogeneity of OCA theory.
Eickmeier and Breitung (2006)	SVAR	Poland, Estonia, Latvia, Lithuania, Czech Republic, Slovakia, Hungary, Slovenia	EU-12	not included	• Estonia is a suitable candidate for the EMU, having a similar industrial structure; • Lithuania has low correlation with the euro area.

Karmann and Weimann (2004)	VAR	Czech Republic, Hungary, Estonia, Lithuania, Latvia, Poland, Slovenia, Slovakia	Ireland, Luxembourg, the Netherlands, Portugal, Spain, Germany, Belgium, Italy, Finland, France, Greece, Portugal Control group: USA; Norway, United Kingdom, Denmark, Sweden	not included	• Lithuania experiences asymmetric shocks.
Darvas and Szapary (2005)	Analysis of leads/lags, volatility and persistence of cycles; Studying Impulse Response functions; Hodrick-Prescott filter (HP); Band-Pass filter (BP)	Estonia, Czech Republic, Hungary, Latvia, Lithuania, Poland, Slovak Republic, Slovenia	Austria, Belgium, France, Finland, Germany, Ireland, Italy, Netherlands, Portugal, Spain, Denmark, Sweden, the UK, Switzerland and Norway, The United States, Japan, Russia	included	• in 1993–97 strong correlation between business cycles in the Baltic States and Russia: 0.4–0.7; • in 1998–2002 weak correlation between the Baltic states and Russia: 0.1; • weak correlation of business cycles among the Baltic states.
Traistaru (2004)	Bilateral correlations	CE-EU-8: The Czech Republic, Hungary, Estonia, Lithuania, Latvia, Poland, Slovenia, Slovakia	Belgium, Finland, Germany, France, Italy, Greece, Spain, the Netherlands, Austria, Portugal	not included	• Lithuania is the least correlated with the euro area out of the three Baltic states, whereas Estonia is the most correlated with the EMU.
Berger et al. (2004)	Hodrick-Prescott (HP) filter	Czech Republic, Hungary, Estonia, Lithuania, Latvia, Poland, Slovenia, Slovakia, Cyprus, Romania, Bulgaria, Malta	Austria, Belgium, Finland France, Spain, Portugal, Netherlands, Germany, Greece, Ireland, Italy, Luxembourg	not included	• Estonia is the only Baltic country having some correlation with the euro area.
Artis et al. (2004)	Hodrick-Prescott HP Filter	Czech Republic, Hungary, Estonia, Lithuania, Latvia, Poland, Slovenia, Slovakia	Germany, Austria, Italy. Additional control group: Denmark, Sweden, UK	not included	• The Baltic countries are highly correlated among themselves, • Estonia is the best performer in terms of business cycle correlations with the euro zone.
Babetski, Boone, Maurel (2002)	SVAR Kalman filter	Bulgaria, Czech republic, Hungary, Poland, Romania, Slovakia, Slovenia, Estonia, Latvia, Lithuania	Ireland, Portugal, Spain and the United States	not included	• OCA theory is relevant for Estonia and Latvia.
Horvath and Ratfai (2004)	SVAR	Czech Republic, Hungary, Estonia, Lithuania, Latvia, Poland, Slovenia, Slovakia	Germany	not included	• No correlation of shocks between the new accession countries and Germany.

3 Methodology

The aim of this section is to describe the data the authors of this study use for the analysis as well as to present the theoretical model and chosen methodological framework. First, time series and their composition are described. Further, the authors continue with the neoclassical economic framework to explain the idea behind further econometric modelling. Next, a decomposition of shocks following the methodology of Blanchard and Quin (1989) is presented. Finally, the authors describe the Kalman filter, which allows for the estimation of time varying coefficients and judgements about the evolution in shock correlation over time.

Data

In this research the authors use quarterly data on the real GDP and the consumer price index (CPI) for the Baltic countries, Germany, Russia, and the USA. Quarterly data is most appropriate because the number of annual observations is insufficient, whereas, according to Boone (1997) using monthly statistics would introduce too much noise.

Real GDP is used for the estimation of supply shocks as it directly reflects the production side of the economy, whereas CPI is used for the estimation of demand shocks. The general formulae for the calculation of these two measures are presented below.

Real GDP is calculated by multiplying the GDP deflator with GDP in nominal prices. The GDP deflator is calculated as a Paashe price index:

$I_{PA}^{T/0}=\Sigma w_j^{T}*I_j^{T/0}$, where

w_j^T – the weight of good j in the economy's output in period T

$I_j^{T/0}$ – the price index of good j in the period T, compared to the base period (0)

Laspeyres formula is applied to calculate Consumer Price Index:

$I_{LA}^{T/0}=\Sigma w_j^{0}*I_j^{T/0}$, where

w_j^0 – the weight of good j in the consumer basket in the base period (0)

$I_j^{T/0}$ – the price index of good j in the period T, compared to the base period (0)

The data on real GDP and CPI for the Baltic States, Germany, Russia and the USA is available from the IMF statistics database. The data period is from the first quarter of 1995 to the third quarter of 2009. Overall there are 59 observations on both variables[1].

[1] There are slight differences among the countries in the calculation procedure for GDP volume index (whether chain-linked or base year methods is used) and the inflation definition (HCPI vs CPI). Details are available from the authors or from the IMF International Financial Statistics browser for January 2010.

Theoretical Framework

To explain the idea behind the estimation of macroeconomic shocks, the authors depart from the theoretical AS/AD framework as described by Bayomi and Eichengreen (1992). The simple AS/AD diagram is presented in Figure 1 below.

The aggregate demand curve (AD) is downward sloping as lower prices motivate increase in demand. Wages are assumed to be sticky in the short term (AS_{sr}), consequently aggregate supply curve is upward sloping in the short run. However, the neoclassical supply curve is vertical in the long run (AS_{lr}), as the real wages adjust to the changes in the price level (see Figure 1).

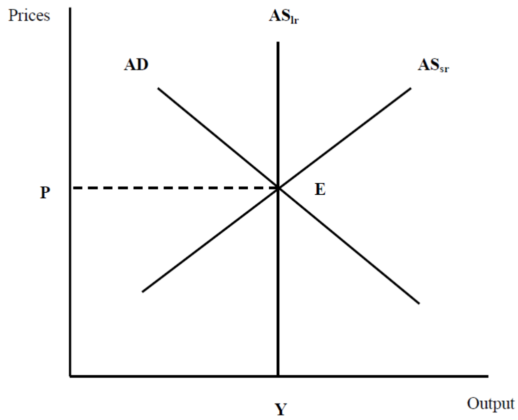

Figure 1. AS/AD framework.

Further, the authors proceed with the analysis of impact demand and supply shocks have on price level and the real GDP. The shock to the aggregate demand makes the AD curve shift to its new level $AD_{1,}$ boosting output and prices. In the long run the supply curve takes a vertical position and output returns to its previous levels, whereas prices adjust upwards (see Figure 2).

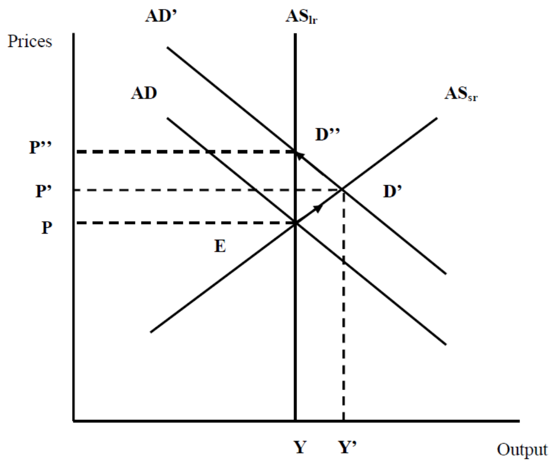

Figure 2. Demand shock in AS/AD framework.

However, the shock to aggregate supply (for example, increase in productivity – technological shock) has a different effect from the shock to the aggregate demand. If the shock is positive the long run output potential increases. This simultaneously shifts both short run and long run aggregate supply curves to the right. In the short run prices start to follow the increase in output. In the long run the prices decrease further with output increasing even more (see Figure 3).

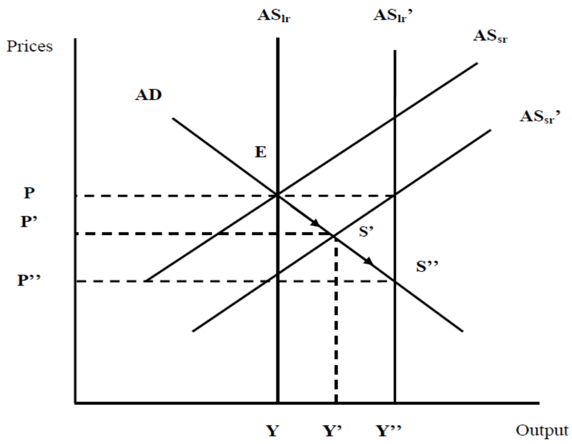

Figure 3. Supply shock in AS/AD framework

Consequently, whereas demand shocks imply only changes in prices, supply shocks represent changes in output. The direction of shocks is opposite: positive demand shocks lead to an increase in prices while positive shocks to supply cause a decrease in the overall price level.

Methodological Framework

The methodological framework applied in this work dates back to 1989 when Blanchard and Quin separated temporary and permanent shocks using VAR. It was later extended by Bayoimi and Eichengreen (1992). This study uses the version developed by Bayomi and Eichengreen which they applied for the EU-11 countries to separate the shocks as well as to trace their dynamics over time.

First, the infinite MA (Moving Average) process can be modelled as:

$X_t = A_0\varepsilon_t + A_1\varepsilon_{t-1} + A_2\varepsilon_{t-2} + A_3\varepsilon_{t-3} + A_4\varepsilon_{t-4} + A_5\varepsilon_{t-5}$... or

$$X_t = \sum_{i=0}^{\infty} L^i A_i \varepsilon_t, \qquad (1.0)$$

where A_i matrices are impulse response functions of the shocks to the variable X.

If X_t represents the change in output and prices and ε_t stands for demand and supply shocks, the previous expression can be written as the two-variable model presented below.

$$\begin{bmatrix} \Delta y_t \\ \Delta p_t \end{bmatrix} = \sum_{i=0}^{\infty} = L^i \begin{pmatrix} a_{11i} & a_{12i} \\ a_{21i} & a_{22i} \end{pmatrix} \begin{bmatrix} \varepsilon_{dt} \\ \varepsilon_{st} \end{bmatrix} \qquad (1.1)$$

where Y_t and P_t are the logarithms of changes in output and prices, respectively, and ε_{dt} and ε_{st} are independent supply and demand shocks (error terms), and a_{11}, a_{12}, a_{13}, a_{14} represent the elements of matrix A

The theoretical framework presented above showed that demand shocks have temporary effects on output as opposed to supply shocks, and both types of shocks have permanent effects on prices. From above the cumulative effect of demand shocks on the output should be equal to zero. Consequently, theoretical framework implies the following restriction (1.2):

$$\sum_{i=0}^{\infty} a_{11i} = 0 \qquad (1.2)$$

The model (1.1, 1.2) can be estimated using VAR regressing X_t on all of its subsequent elements.

$$\begin{aligned} x_t &= \beta_1 X_{t-1} + \beta X_{t-2} + \cdots + \beta_n X_{t-n} + e_t = \\ &= \left(I - \beta(L)\right)^{-1} e_t = \\ &= \left(I + \beta(L) + \beta(L)^2 + \cdots\right) e_t = \\ &= e_t + D_1 e_{t-1} + D_2 e_{t-2} + D_3 e_{t-3} + \cdots, \end{aligned} \qquad (1.3)$$

e_t representing the residuals.

Or, in more precise form, demand and supply shocks are identified as e_{yt} and e_{pt}.

$$\begin{bmatrix}\Delta Y_t\\ \Delta P_t\end{bmatrix} = B_1\begin{bmatrix}\Delta Y_{t-1}\\ \Delta P_{t-1}\end{bmatrix} + B_2\begin{bmatrix}\Delta Y_{t-2}\\ \Delta P_{t-2}\end{bmatrix} + \cdots + \begin{bmatrix}e_{yt}\\ e_{pt}\end{bmatrix}, \quad (1.4)$$

which equals

$$\begin{bmatrix}\Delta Y_t\\ \Delta P_t\end{bmatrix} = (1 - B(L))^{-1}\begin{bmatrix}e_{yt}\\ e_{pt}\end{bmatrix} = (I + B(L) + B(L)^2 + \cdots)\begin{bmatrix}e_{yt}\\ e_{pt}\end{bmatrix}, \quad (1.5)$$

or equivalently

$$\begin{bmatrix}\Delta Y_t\\ \Delta P_t\end{bmatrix} = \sum_{i=0}^{\infty}\begin{pmatrix}d_{11i} & d_{12i}\\ d_{21i} & d_{22i}\end{pmatrix}\begin{bmatrix}e_{yt}\\ e_{pt}\end{bmatrix} \quad (1.6)$$

To obtain the model estimated by equations (1.1) and (1.2), the residuals from the regression above have to be converted into shocks. To determine the model, equations (1.1) and (1.6) are combined.

$$\sum_{i=0}^{\infty}\begin{pmatrix}d_{11i} & d_{12i}\\ d_{21i} & d_{22i}\end{pmatrix}\begin{bmatrix}e_{yt}\\ e_{pt}\end{bmatrix} = \sum_{i=0}^{\infty} L^i\begin{pmatrix}a_{11i} & a_{12i}\\ a_{21i} & a_{22i}\end{pmatrix}\begin{bmatrix}\varepsilon_{dt}\\ \varepsilon_{st}\end{bmatrix} \quad (1.7)$$

Then we can express residuals via shocks:

$$\begin{bmatrix}e_{yt}\\ e_{pt}\end{bmatrix} = \left(\sum_{i=0}^{\infty}\begin{pmatrix}d_{11i} & d_{12i}\\ d_{21i} & d_{22i}\end{pmatrix}\sum_{i=0}^{\infty} L^i\begin{pmatrix}a_{11i} & a_{12i}\\ a_{21i} & a_{22i}\end{pmatrix}\right)\begin{bmatrix}\varepsilon_{dt}\\ \varepsilon_{st}\end{bmatrix} = C\begin{bmatrix}\varepsilon_{dt}\\ \varepsilon_{st}\end{bmatrix} \quad (1.8)$$

Further, matrix C is defined, where $e_t = C\varepsilon_t$ with four restrictions (for two-by-two case). Two of the restrictions are simple variances of the individual shocks ε_{dt} and ε_{st}. The general assumption is to set these variances equal to one. The final assumption is zero covariance (orthogonality) between the demand and supply shocks. From the previous assumption we can generate the third restriction defining matrix Z=C'C which also equals the covariance matrix between e_{yt} and e_{pt}.

The last important assumption for the C matrix to be uniquely defined and for the shocks to be identified is that demand shocks should only have a temporary effect on the output (restriction 1.2). However, this assumption is related only to output, and responses of prices are not determined by the restriction (responses of the prices to can be seen as over-identifying restrictions). Combining assumption 1.3 with the 1.8 gives us the following model:

$$\sum_{i=0}^{\infty}\begin{pmatrix}d_{11i} & d_{12i}\\ d_{21i} & d_{22i}\end{pmatrix}\begin{pmatrix}c_{11} & c_{12}\\ c_{21} & c_{22}\end{pmatrix} = \begin{bmatrix}0 & \cdot\\ \cdot & \cdot\end{bmatrix} \quad (1.9)$$

Model 1.9 allows us to estimate demand and supply shocks series of the structural VAR model as proposed by Bayomi and Eichengreen (1992).

Kalman Filter

Further, the authors apply the Kalman filter procedure as in Babetski (2004) to calculate the time varying correlation coefficients of supply and demand shocks between the Baltic States and the EU represented by Germany and Russia as alternative points of reference. The main benefit from applying this method is the possibility of estimating the robustness of correlation between macroeconomic shocks of different countries in the presence of structural changes, which is one of the aims of this study.

To start with, the Kalman filter consists of two types of equations: the measurement equation, which estimates the relationship between the variables and transition equations, describing time-varying coefficients.

Measurement equation:

$$(X_t^j - X_t^i) = a_t^{ijk} + b_t^{ijk}(X_t^j - X_t^k) + \mu_t \qquad (2.0)$$

Transition equations:

$$a_t^{ijk} = a_{t-1}^{ijk} + v_t^a \qquad (2.1)$$

$$b_t^{ijk} = b_{t-1}^{ijk} + v_t^b \qquad (2.2)$$

X is a vector of recovered structural shocks, where i denotes a Baltic country, j denotes Germany or Russia and k denotes the USA. Error terms (μ and υ) are white noise processes in this setting. Coefficients a_t and b_t are time varying (see equations 2.1 and 2.2).

In case of convergence it is expected that a_t and b_t will decrease to zero. A stable and close to zero a_t coefficient implies the absence of idiosyncratic shocks for a particular country. Moreover, a significant and non-zero b_t implies that the United States (world) affects country *i* shocks more than the reference country *j* (Germany/Russia). Consequently, if the right hand side of the equation 2.0 is equal to zero, there is no difference in the shocks between the individual country and the reference country.

The Kalman filter represents a recursive algorithm for optimally (by minimizing the mean square error (MSE)) estimating the unknown parameters a_t and b_t. To do this, one needs to maximize a likelihood function given the information available at time t.

To be able to estimate the model the equations need to be specified in matrix form:

Measurement equation:

$Y_t=A_tZ_t+\varepsilon_t$ (2.3)

Transition equations: (2.4)

$A_t=T_tA_{t-1}+\eta_t$,

where $Y_t = X_{jt} - X_{it}, Z_t = \begin{pmatrix} 1 \\ X_t^j X_t^k \end{pmatrix}, A_t = (\alpha_t \; \beta_t), T = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$ *and* $\eta_t = (\eta_{1t} \eta_{2t})$ (2.5)

Moreover, the following assumptions are needed:

- The normal error term ε_t has a mean of 0 and variance V_t; the error term η_t is also normal and has a mean of 0 and a variance/covariance matrix Q_t;
- The error terms in the measurement and transition equations should be independent of each other;
- A_{t-1} should be uncorrelated with ε_t and independent of the error term η_t

(see Boone, 1997).

Knowing V_t and Q_t allows us to calculate A's initial covariance matrix. Having the starting estimate of A_0 optimal forecasts of the unobserved A_t (t=1,...T) are computed using the MSE criterion. Further, based on the assumption of normality of the distributions, the ML estimator of A can be obtained.

After values A_{t-1} and P_{t-1} (and V_t and Q_t) are obtained, a prediction about the value of A at time t can be made (2.6-2.7).

$$A_{t/t-1} = T_tA_{t-1} \quad (2.6)$$

$$P_{t/t-1} = T_tP_{t-1}T_t + Q_t \quad (2.7)$$

Afterwards, the forecast is compared with the true value. The difference will be the usual one-step-ahead forecast prediction error (2.8) with the covariance matrix (2.9)

$$\upsilon_t = Y_t - Y_{t/t-1} = Y_t - Z_t A_{t/t-1} \tag{2.8}$$

$$F_t = Z_t P_{t/t-1} Z_t + V_t \tag{2.9}$$

After one more period has passed it is possible to update the prediction. The Kalman filter works by such updating equations after each subsequent period in all sample (3.0-3.1).

$$A_t = A_{t/t-1} - P_{t/t-1} Z_t' F_t^{-1} Z_t (y_t - Z_t A_{t/t-1}) \tag{3.0}$$

$$P_t = P_{t/t-1} - P_{t/t-1} Z_t' F_t^{-1} Z_t P_{t/t-1} \tag{3.1}$$

In practice the values of V_t and Q_t are usually ignored at the beginning and some initial proposed values are used to derive recursive values of A_t, P_t and ν_t. Then the obtained estimates are plugged into the maximum likelihood function, which, in turn, gives out the initial estimates for the Kalman filter. This process is also recursive until convergence is achieved giving us the ML estimate of parameters (Boone, 1997).

4 Empirical Findings

The empirical findings are divided into two parts. The first part describes the sequence of the estimation process. This includes the analysis of data, the specifications of the SVAR model, the process of recovering shocks and the application of the Kalman filter, concluded with the model robustness subsection. In the second part the authors describe the findings, the investigation of which is later continued in the discussion part.

Data Analysis

First the authors determine three periods of data which the dataset is split into for further investigation. The first period stretches from the first quarter of 1995 up until the second quarter of 2004 (inclusively), just before the Baltic States joined the European Union. The second period is called the pre-crisis period. The authors have chosen data from the first quarter of 1995 to the third quarter of 2007 as the last in the pre-crisis period. The choice is based on the fact that in the fourth quarter the first signs of the recession started to appear for the majority of countries, with inflation and the real GDP growth rates becoming negative. The third period is the whole time span of the dataset. The time periods are cumulative due to the small number of observations available. Such a split allows us to make a judgement about the effect of structural economic changes on the correlations between shocks.

The authors have checked for the stationarity of the variables across different time periods. Blanchard and Quah (1989) emphasize stationarity as the required condition for disturbances to have no long term effect on the rate of change in macroeconomic variables. Besides classical ADF (Augmented Dickey-Fuller) test the authors have employed Dickey-Fuller GSL and KPSS (Kwiatkowski-Phillips-Schmidt-Shin) tests as the former despite its popularity has very low power in small samples (please see the results in tables below). The tests are specified with intercept, but no time trend as the data is already differentiated.

Table 2 *Stationarity tests (full time period)*

Full period	*Stationary at 5% sign. level*			*Full period*	*Stationary at 5% sign. level*		
	ADF	*DF-GLS*	*KPSS*		*ADF*	*DF-GLS*	*KPSS*
cpi_de	Yes	Yes	Yes	gdp_de	No	Yes	Yes
cpi_ee	No	No	No*	gdp_ee	No	No	Yes
cpi_lv	Yes	No	Yes	gdp_lv	No	No	Yes
cpi_lt	Yes	No	Yes	gdp_lt	No	No	Yes
cpi_ru	Yes	No	No*	gdp_ru	No**	Yes	Yes
cpi_usa	No	Yes	Yes	gdp_usa	No	No	No*

Note. *Stationarity hypothesis is not rejected at 1% sign. level **Unit root hypothesis is rejected at 10%, but not 5% sign. level

Table 3 *Stationarity tests (pre-crisis time period)*

Pre-crisis period	*Stationary at 5% sign. level*			*Pre-crisis period*	*Stationary at 5% sign. level*		
	ADF	*DF-GLS*	*KPSS*		*ADF*	*DF-GLS*	*KPSS*
cpi_de	Yes	Yes	Yes	gdp_de	No	Yes	Yes
cpi_ee	Yes	No	No*	gdp_ee	Yes	No**	Yes
cpi_lv	Yes	No	No*	gdp_lv	Yes	No	No*
cpi_lt	Yes	No	Yes	gdp_lt	Yes	No	No
cpi_ru	Yes	No	No*	gdp_ru	Yes	Yes	No*
cpi_usa	Yes	Yes	Yes	gdp_usa	No	No**	Yes

Note. *Stationarity hypothesis is not rejected at 1% sign. level **Unit root hypothesis is rejected at 10%, but not 5% sign. level

Table 4 *Stationarity tests (pre-EU time period)*

Pre-EU period	*Stationary at 5% sign. level*			*Pre-EU period*	*Stationary at 5% sign. level*		
	ADF	*DF-GLS*	*KPSS*		*ADF*	*DF-GLS*	*KPSS*
cpi_de	No**	Yes	Yes	gdp_de	No	No**	Yes
cpi_ee	No	No	No*	gdp_ee	Yes	Yes	Yes
cpi_lv	Yes	No	No*	gdp_lv	Yes	Yes	Yes
cpi_lt	Yes	No	No*	gdp_lt	Yes	No	Yes
cpi_ru	Yes	No	Yes	gdp_ru	Yes	Yes	Yes
cpi_usa	No	Yes	Yes	gdp_usa	No	No	Yes

Note. *Stationarity hypothesis is not rejected at 1% sign. level **Unit root hypothesis is rejected at 10%, but not 5% sign. level

The results are inconclusive as tests often contradict each other. However there is no variable which stationarity is rejected by all tests at the highest significance level implying that we do not have a perfect unit root condition. Moreover, even if the variables are non-stationary, the estimation of SVAR is possible and coefficients obtained are consistent and have standard asymptotic distributions (Sims, Stock and Watson 1990). The same can be said about the consistency of impulse response functions in the short and medium term (Phillips, 1996). Thus the authors proceed with the further analysis precautionary taking this as the limitation imposed by our data sample.

The SVAR model for each particular country is estimated to obtain the residuals as well as coefficient matrix to recover the shocks. The number of lags is determined using information criteria (subsequential modified LR test statistic (at 5% significance level), Final prediction error, Akaike information criteria, Schwarz information criteria, Hannan-Quinn information criteria)[2]. The authors have chosen the lag length which is selected by the largest number of information criteria. The number of lags for each country is summarized in Table 5 below. The individual specification of lags for each country is found to provide the results which correspond to reality better and which do not have heteregoneity bias attributable to the models with uniform responses (Partridge & Rickman, 2006).

[2] We have chosen the common number of lags for all time periods to ensure comparability across them. Usually countries had higher number of lags for the pre-EU period and lower for the two other periods. We believe that this peculiarity comes from the short time series in the first period so we applied the number of lags selected in longer time periods as it should be able to capture the long term structure of an economy better. Details are available on the request.

Table 5 *Lag selection for SVAR models*

Country	Number of lags	Country	Number of lags
Germany	2	Estonia	6
Russia	5	Latvia	2
The USA	1	Lithuania	2

Alternatively, the authors also estimate the model with a uniform number of lags, as suggested by Eichengreen and Bayomi (1992). The authors choose two lags as proposed by Horvath and Ratfai in their previous research (2004). Also, despite the fact that, according to information criteria, two lags are the best choice only for the half of countries, namely Germany, Latvia and Lithuania, a higher number of uniform lags leads to unstable SVARs for one to four countries depending on the specification and time period chosen. The stability of SVARs is assessed evaluating the moduli of eigenvalues. To satisfy condition for stability eigenvalues have to lie inside the unit circle.

After estimating the SVAR model the authors obtain the residuals and apply structural defactorization to estimate the matrix of coefficients which would allow us to recover shocks from the estimated residuals. Additionally, this allows us to estimate the impulse response function, which shows the speed of adjustment to shocks.

The difference between the specifications is in the way the shocks are defined. The specification of the model with individual number of lags implies a non-synchronous definition of shocks. This means that at any point in time the countries compared are affected by preceding shocks from different periods. The uniform number of lags in turn implies synchronous shocks, meaning that the timing of shocks and the adjustment periods across individual economies are the same. The authors have chosen the individual number of lags as main specification because this would provide a more realistic picture about the economies investigated, as the countries differ in their macroeconomic processes. In the results section, the authors also discuss correlation coefficients from the uniform number of lags specification to see the robustness of the model and to examine the impact the definition of shocks has on the correlations between countries.

As a next step in studying the shocks the auhors apply the Kalman filter to estimate the dynamics of shock convergence. The authors also check lagged coefficients for independent variable (expressed as the excess of world shocks over the countries of reference) in case shocks react with some time lag. The Kalman filter model lag length is selected based on Akaike information criteria, setting the maximum length of the independent variable in the measurement equation equal to five. In the selection procedure the authors have identified zero lag length of the independent variable for all three Baltic States. Moreover, neither the supply nor the demand shock coefficients have proven to be significant in any of the three periods we have the dataset is split in.

Model Robustness

The aim of this short section is to compare the results from different model specifications to be able to judge how strongly the change in the shock definition affects the result.

Overall, it can be said that the estimated models perform robustly. Regardless of the specification, most of the coefficients retain their sign and approximate magnitude. Moreover, the change in the sign is present only for highly insignificant coefficients, once more emphasizing the stability of the models.

However, the significance of the coefficients changes for some countries depending on the specification chosen. This can be explained by the fact that despite the shocks, countries experience in a given time period, generally are of the same direction, the exact time when the shock hit the economy as well as the adjustment time might differ across countries. Using a uniform number of lags implies automatically imposing initial symmetry in shocks as in Bayomi and Eichengreen, 1992. It makes the results easier to compare, but the authors believe that this restriction can be loosened in order to make the estimation correspond to reality better.

Additionally the model with individual numbers of lags varying both across countries and periods was estimated; however, this model also did not yield significantly different results from the two above. The results of the model are available from the authors on request.

5 Results

In this section the authors proceed with the empirical findings. First, the impulse response functions are described; next the authors turn to the shocks correlation coefficients themselves and make a comparison between the findings from two specifications of lag length. Finally, the results for the Kalman filter coefficients are presented.

Impulse Response Functions

From looking at the impulse response functions (Appendix A), one can observe that countries have quite dissimilar adjustment processes in case of shocks.

Germany and the USA have very smooth and robust impulse response functions which have not changed much during all three time periods investigated. This can be seen as a sign of their strong and large economies. The impulse response function of Russia is robust as well, but it is more spontaneous than the German or American ones. This proves that the Russian economy, despite being large and strong, is more volatile in case of a shock. As it was pointed by Brunat and Richet in 2008 this stems from the fact that the Russian GDP is highly dependent on trade of natural resources leading to instability in public financing and structural misalignments.

Our main countries of interest are the Baltic States. Looking at their impulse response functions we see that they exhibit changing pattern implying that economies are not as stable as the large countries presented above. This is logical, as the Baltic States are very young and open economies which have just recently (20 years) separated from the USSR. Estonia and Latvia have a very strong change in their impulse response functions if we add the crisis period to the estimation period. Especially noticeable was the change in the impact of inflation shocks.[3] The response of Latvian inflation to a demand shock became especially vulnerable and even not converging. This is not surprising due to the soaring growth of inflation Latvia started to experience as a result of economy overheating which continued for some months also in the recession time and the following sharp decline in it.

An interesting observation is that Lithuania experiences only a modest change in the impulse response function pattern if we include the crisis period. The possible explanation for this might be the fact that Lithuania was the last among the three Baltic countries to enter the crisis. Moreover, from our data one can see that Lithuanian real GDP growth (year-on-year change) became negative only in the fourth quarter of 2008. So our data series might include too few observations in crisis period to see what the effect they had on Lithuania.

To conclude, the economies of Latvia, Lithuania and Estonia remain quite sensitive and unstable in response to the shocks, which implies that even if the shocks in the Baltics are symmetric with the EMU, it will take a different path and time for every country to respond,

[3] The authors believe that this stems from the change in inflationary expectations and also the fact that real GDP declined more than inflation when the crisis hit.

especially if we compare the Baltic States with some large strong economies.

Correlations

After the authors have recovered the structural shocks from the model the correlation coefficients between them are estimated. First, the correlation coefficients are calculated between the Baltic States and Germany and Russia which allows us to judge whether young economies are better aligned with the EU than with Russia, and how this alignment changed over time. Secondly, the authors estimate the correlation coefficients among the Baltic States themselves to see how well they form a homogenous group of economies. As already mentioned, the authors perform the analysis using two specifications: one with the number of lags tailored to the macroeconomic patterns of the individual country to give more realistic picture and the second with the uniform number of lags to impose the symmetry of shocks. The results can be seen in Table Appendix B.

The Baltic States vis-à-vis Germany.

First, the authors analyze the demand shocks in the specification with the individual number of lags. Overall, most of the demand shock correlation coefficients are of positive sign (seven if the individual number of lags is applied, six if the uniform number of lags is chosen).

However it should be noted that only Estonia exhibits significant positive correlation of demand shocks with Germany (30%) and it happens only in the period which includes the participation of the Baltic States in the EU. Furthermore, when the crisis is included in the estimation period, this relationship disappears and the coefficient becomes highly insignificant.

Lithuania instead shows a borderline significant negative correlation of 29 % (at 10% significance level) with German demand before the Baltic States joined the EU. Later the negative correlation with Lithuania also decreases slightly and becomes insignificant (p-value of 12 percent)

If we look at the specification with the uniform number of lags the correlation of Estonia with Germany becomes smaller and insignificant. The Lithuania is not affected as it has the same number of lags in both specifications. Latvia has the correlation coefficients of positive sign; however they are also of small magnitude and highly insignificant.

Turning to the supply shock correlation, again, only Estonia has a significant positive shock correlation with Germany. In case of the specification with the individual number of lags, the correlation holds for both the pre-crisis (27%) and the full time periods (increasing to 41%). In case of the uniform number of lags the correlation of 27% is significant only in the full time period. However, all three states in all periods have positive supply shock correlation coefficients with Germany independently of specification; this indicates that the Baltic States are trying to adjust their production to correspond to European structure.

The Baltic States vis-à-vis Russia.

Next, the authors analyze the demand correlation coefficients with Russia. In the specification with the individually selected lags only Lithuania shows a highly significant positive (40%) correlation with Russia in the full time period. Estonia shows a 23% correlation at a significance level just above 10%. If we impose the uniform number of lags this strong correlation still remains and both Latvia and Estonia have relatively high (25-26%) correlation with Russian demand shocks (at 10% significance level), while Lithuania has even higher correlation of 35% (at the 5% significance level). A noticeable observation is that the demand shock correlation of the Baltic States with Russia is positive in all periods (eight coefficients are positive in specification with the individual number of lags and all coefficients are positive if the uniform number of lags is applied). The Baltic States still actively trade with Russia and are dependent on imported Russian energy, and this has synchronized the demand shocks.

One should not be surprised about the trade importance for shock correlation as the CPI measure already includes also import prices, consequently, contributing to higher correlation of estimated demand shocks in case countries have important trading relationships (Fidrmuc, and Korhonen, 2006).

Further the authors look at the supply shock correlation with Russia. The supply shock correlation with Russia is negative almost for all countries and all periods (six coefficients are negative in the specification with the individual numbers of lags specification and all are negative if the uniform number of lags is chosen) which is contrary to the situation with demand shock correlation. Despite this consistency in sign, the majority of the correlation coefficients are insignificant. The negative sign of the coefficients indicates that after the fall of the USSR the Baltic States have been reorienting their production from the requirements of Russia to the needs of the EU.

The coefficients are significantly negative for Latvia and Lithuania of (both -32% at the 10% significance level) only in the period before the Baltic States joined the European Union (a specification with the individual number of lags). In turn, if the uniform number of lags is applied the correlation with Lithuania decreases and becomes insignificant. The significant negative correlation of Latvia with Russia holds longer in this case, and it also continues at a value of -28% in the period when the Baltic States had already become members of the EU.

The Baltic States as a group.

The results for the Baltic States are presented in Table 2b Appendix B. Findings show that the countries form quite a homogeneous area, Estonia being slightly separated from the other two states.

Considering demand shocks, Latvia and Lithuania show highly significant positive correlation of 42-45%. The evidence with respect to Estonia is diverse. In case of the individual number of lags Estonia is highly significantly correlated with the other Baltic States, with coefficients in the 30-46% range, depending on the time period. However, if the authors choose the uniform number of lags the correlation (with both Latvia and Lithuania) is high and significant only in the time period when the crisis is included.

Looking at the supply shocks the situation is very similar to that presented above. Lithuania and Latvia are highly and significantly correlated. Correlation coefficients for these two countries are in the range of 44-48% depending on the time period and specification chosen. Estonia shows significantly high supply shock correlation (25-35%) with the other two Baltic States only in the full time period. In case of the individual number of lags selected Estonia correlates only with Latvia in full time period.

Kalman filter

Finally the authors describe the results for the Kalman filter. The results are shown Appendix C. None of the coefficients are significant, implying that the Baltic economies are still very volatile and unstable and convergence processes are not robust.

Latvia has larger coefficients in all time periods. This fact is not surprising, given the development of inflation in Latvia. The Kalman filter coefficients become especially large for Latvian and Lithuanian demand shocks during the crisis. Estonia has big coefficient for impact of all other world over Russia in full time period as well. This shows that the Baltic countries have large idiosyncratic fluctuations which cannot be explained by the impact of the German or Russian economies. No exceptional coefficients are observed that would be related to supply shocks. Only Estonia has quite high coefficient describing the impact of all over the world over Russia on Estonian domestic supply shocks; but this country also was the fastest to reallocate its production towards exporting to Finland and the EU. The graphs of the time varying coefficients also do not show presence of clear convergence process (due to the limited length of this paper the graphs are available from the authors on request).

6 Discussion

In this section, the authors discuss the findings on correlations with Germany for each Baltic country and compare them with the previous research while also introducing the impulse response functions and findings from the Kalman filter into the analysis. In parallel, the authors present the conclusions about the impact of Russia on the Baltics to see whether the countries were able to reorient themselves towards the economies of the eurozone. Additionally, the authors discuss the effect the current crisis had on the shock correlations between the Baltic States and the countries of reference.

Estonia

Based on the results, the authors propose that Estonia is most prepared for adoption of the euro. This is consistent with the majority of previous findings, for example, Nabil (2008), Eickmeier and Breitung (2006), Artis et al. (2004), Berger et al. (2004), Traistaru (2004), Korhonen (2003). Estonia is the only country which exhibits positive and mostly high supply and demand shock correlation with Germany in all periods and specifications.

Estonia was the fastest to build trading links with the EU, with Finland being its major trading partner. Estonia was also able to develop a strong banking system with an independent Central Bank and a currency board exchange rate regime earlier than the other two Baltic States (Lainela & Sutela, 1994). There is a widespread belief that Estonia was able to build better institutions and therefore also introduce more certainty and attract more foreign direct investment into the country (Bø, 2008). All of these factors played a large role in making Estonia a front-runner among the Baltic countries and making it more aligned with the EU. Furthermore, both historically and culturally Estonia has been a more distinct entity compared to the other two Baltic States and this had an effect when the Baltics stopped being a part of one large country. Thus, it is also not unanticipated that Estonia has imperfect business cycle allocation with the two other Baltic States which have very strong correlation of macroeconomic shocks between themselves in all time periods.

Turning to Russia, Estonia does not show any strong robust relation with that country. It has the highest supply shock correlation with Russia in pre-crisis period; however, in no specification was it significant (in the specification with the uniform number of lags it actually was slightly negative). Whereas there is some evidence that demand shocks start to be correlated during the crisis, this borderline significance appears only in the specification which assumes symmetric shocks. This relationship completely disappears in individual specifications.

Although there are strong signs of real convergence towards the EU levels, the authors would argue that one should still be cautious in the Estonian case. First of all, demand correlation disappears during the crisis time, implying that the effect of joining the EU was not strong enough to hold in times of recession. Moreover, insignificance of time varying coefficients obtained from the Kalman filter only amplifies our concerns as it proves that the correlation was also not robust enough before the crisis. The same is related to the change in the impulse response functions, signifying that the crisis had an important effect on the way the Estonian economy responds to the shocks, and that this might affect the future structure of the Estonian business cycle and its correlation with the business cycles of other countries.

Latvia

Latvia has shown very idiosyncratic behaviour as a most unstable economy of the Baltic States. This can be seen both from the large and insignificant coefficients obtained from the Kalman filter and also from the extremely vulnerable impulse response function in the full time period (especially for inflation). Also, looking at reality, Latvia has experienced huge fluctuations in its main macroeconomic indicators during the last years: be it GDP growth, inflation or current account balance.

The correlation of shocks for Latvia does not show any robust positive or negative correlation with Germany in any of the time periods studied, pointing once more at Latvian instability from a macroeconomic point of view. As for Russia, Latvia shows significant negative supply shock correlation until the Baltic States joined the EU (in case of the specification with the uniform number of lags this relationship last until the crisis); however, this correlation later diminishes and becomes insignificant. The Latvian correlation of demand shocks with Russia behaves in the same way as for Estonia: it becomes significantly positive only if we consider the whole data period and use the specification with the uniform number of lags. This shows that there is still some impact coming from trade with Russia, but it is not as strong as for Lithuania as the other two Baltic States trade significantly less with Russia and more with the EU.

Previous research also is not unanimous about Latvian case. Depending on the time period studied and approach chosen the country is found to be integrated with the euro area to a different extent. So, Lättemäe (2003) and to some degree Babetski, Boone, Maurel (2002) propose that Latvia follows Estonia on its way towards the eurozone, whereas Błaszkiewicz and Wozniak (2003) actually do not witness convergence between Latvia and the EU.

Overall the authors conclude that Latvian economy has not stabilized yet to painlessly join the euro area. However if it is able to learn from the past and pursue balanced economic growth in the future Latvia has all chances to be the next candidate for the euro adoption.

Lithuania

Lithuania has appeared to be better aligned with Russia rather than Germany. It actually shows mostly negative demand shock correlation with Germany (which is also significant in the time period before the Baltic States joined the EU), whereas the demand correlation with Russia is highly significant and positive independent on the specification chosen. This is easily explained by the fact that Lithuania is more dependent on the trade with Russia. In 2008 Russia constituted 30.1% of Lithuanian imports whereas for other Baltic States trade with Russia amounted to only around 10% of their trade volumes (The Investment and Development Agency of Latvia, n.d.; The Lithuanian Development Agency, n.d.; the U.S. State Department, n.d.). Our conclusion is similar to the previous findings by Eickmeier and Breitung (2006), Korhonen (2003), Traistaru (2004), and Lättemäe (2003) who also discussed that Lithuania is least prepared for the eurozone.

Despite the observations presented above, one should be careful to say that Lithuania might diverge from the other two Baltic States in the future. Firstly, the strong positive correlation with Russia appears only when the crisis period is included. Secondly, the coefficients obtained from the Kalman filter are highly insignificant and large also for the relationship between Lithuania and Russia.

Moreover, Lithuania has a negative supply shock correlation with Russia, but a positive relation with Germany. Neither of them is strong enough to be significant over time but the signs of the correlation coefficients remain the same in all time periods, suggesting that the Lithuanian economy is gradually becoming better aligned with the eurozone.

7 Conclusion

The main finding of this study is that Estonia, contrary to widespread belief, is not that well prepared for joining the eurozone in an Optimum Currency Area context. This is an important warning, since the good alignment of economies is the key prerequisite for a country wishing to participate in a monetary union and avoid a costly adjustment process in case of asymmetric shocks.

In this paper, the authors have investigated the readiness of the Baltic States to join the eurozone by analyzing the correlation of macroeconomic shocks between the Baltics and Germany obtained from SVAR structural decomposition. To assess whether the shocks are indeed converging the Kalman filter procedure is used, describing a time varying shock interdependency. In parallel, the authors have performed the same analysis for Russia, which has been the determinant of Baltic economic development for several decades in the past. Below, brief results on each country are summarized.

Estonia has been the front runner of the Baltic States, being best prepared for the eurozone among the three countries. It mostly has a large positive and significant correlation with Germany of both demand and supply shocks. Despite this fact, a deeper analysis has shown that Estonia is still a very unstable and rapidly developing economy, and it is also subject to macroeconomic vulnerability, though to a lesser extent than the two other Baltic States. Importantly, the authors are not able to identify any robust trend of Estonian convergence with Germany over time, implying that the estimated correlation is not yet stable enough to ensure sustainable performance in the monetary union.

In turn, the Latvian economy has behaved in the most idiosyncratic way and has faced large imbalances. Due to this fact, it is impossible to identify any stable relationship with either of the reference countries. However, the signs of the reorientation of Latvian production from Russia towards the eurozone are already present. This implies that if Latvia succeeds in stabilizing its economy it has a potential to become the next prospective candidate for joining the EMU.

Lithuania had asymmetric demand shocks with Germany in the past, which continue also as the country joined the EU. Lithuanian aggregate demand is still influenced by Russia, its largest trade partner. Nevertheless, the authors verify realignment of Lithuanian supply shocks towards the shocks that German production experiences. This makes the processes in the Lithuanian economy similar to the Latvian situation and implies that Lithuania also has good chances of becoming more interrelated with European economies to painlessly join the eurozone in the future.

The study provides clear evidence that none of the Baltic States are completely ready for the euro yet. The authors have proven that connections with Russia continue to play an important role for the Baltic economies, especially for Lithuania, – mainly through trade and energy dependence. However, the Baltic countries have already done a considerable job in rebuilding their economies after the disintegration of the USSR, and the obvious signs of this process are presented in this paper. To conclude, the authors would like to emphasize that the convergence process with Germany has started for all three Baltic States, Estonia being the leader; but the findings show that there is still a way to go to achieve stable macroeconomic alignment with the eurozone for each country.

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Appendix A

Impulse Response Functions

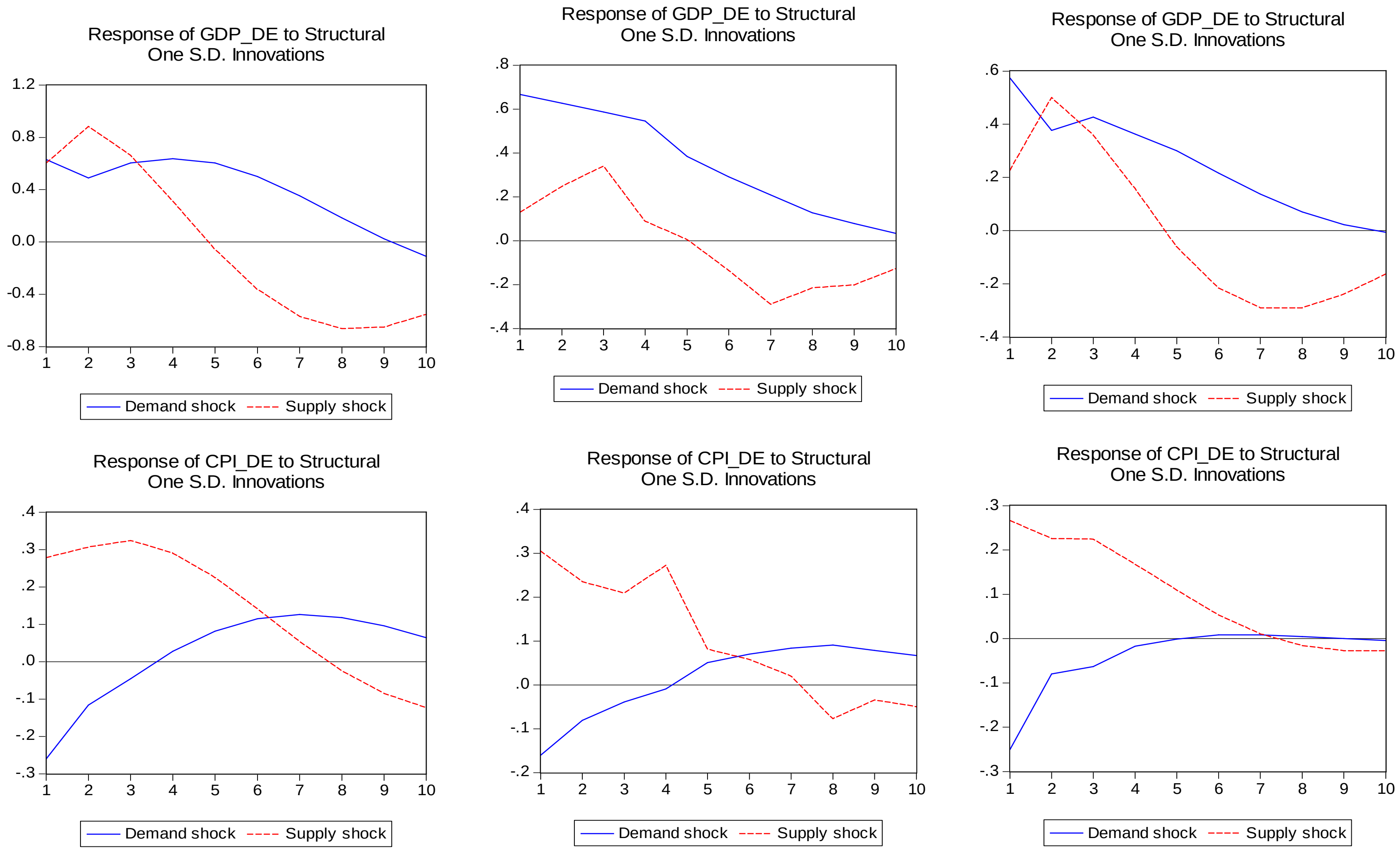

Figure 1a Impulse response functions for Germany (from left to right: full time period, pre-crisis period, pre-EU period).

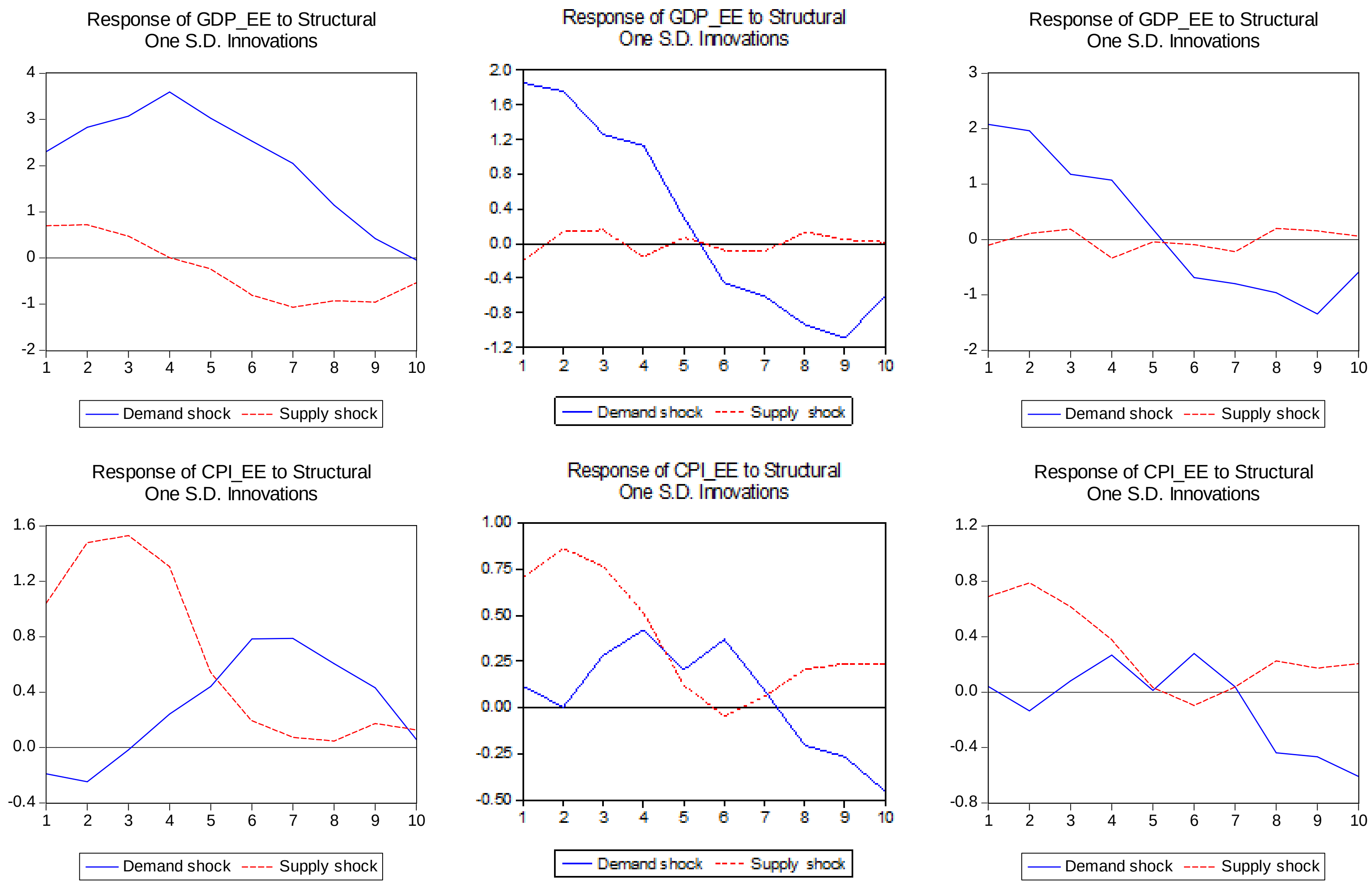

Figure 2a Impulse response functions for Estonia (from left to right: full time period, pre-crisis period, pre-EU period).

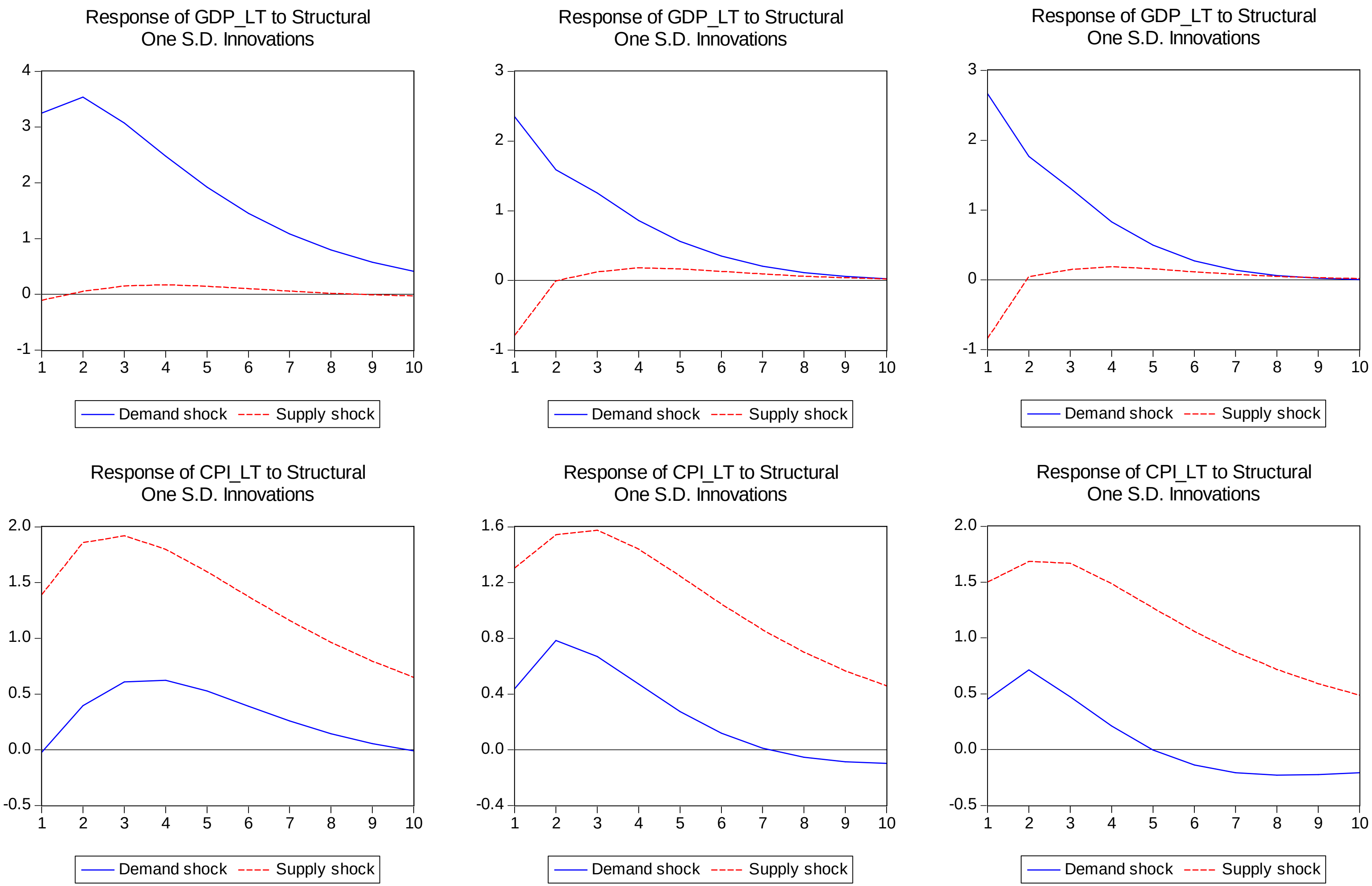

Figure 3a Impulse response functions for Lithuania (from left to right: full time period, pre-crisis period, pre-EU period).

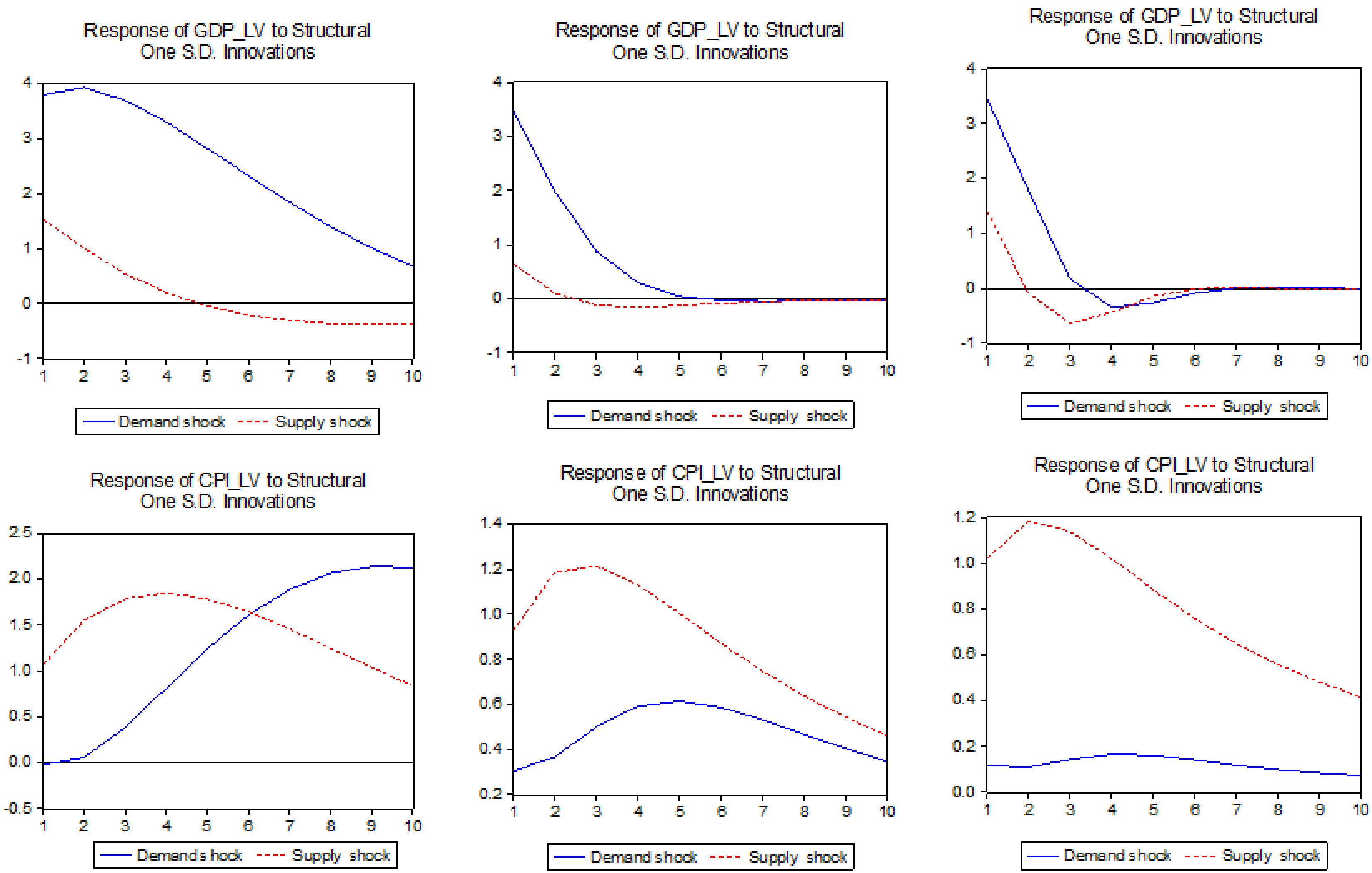

Figure 4a Impulse response functions for Latvia (from left to right: full time period, pre-crisis period, pre-EU period).

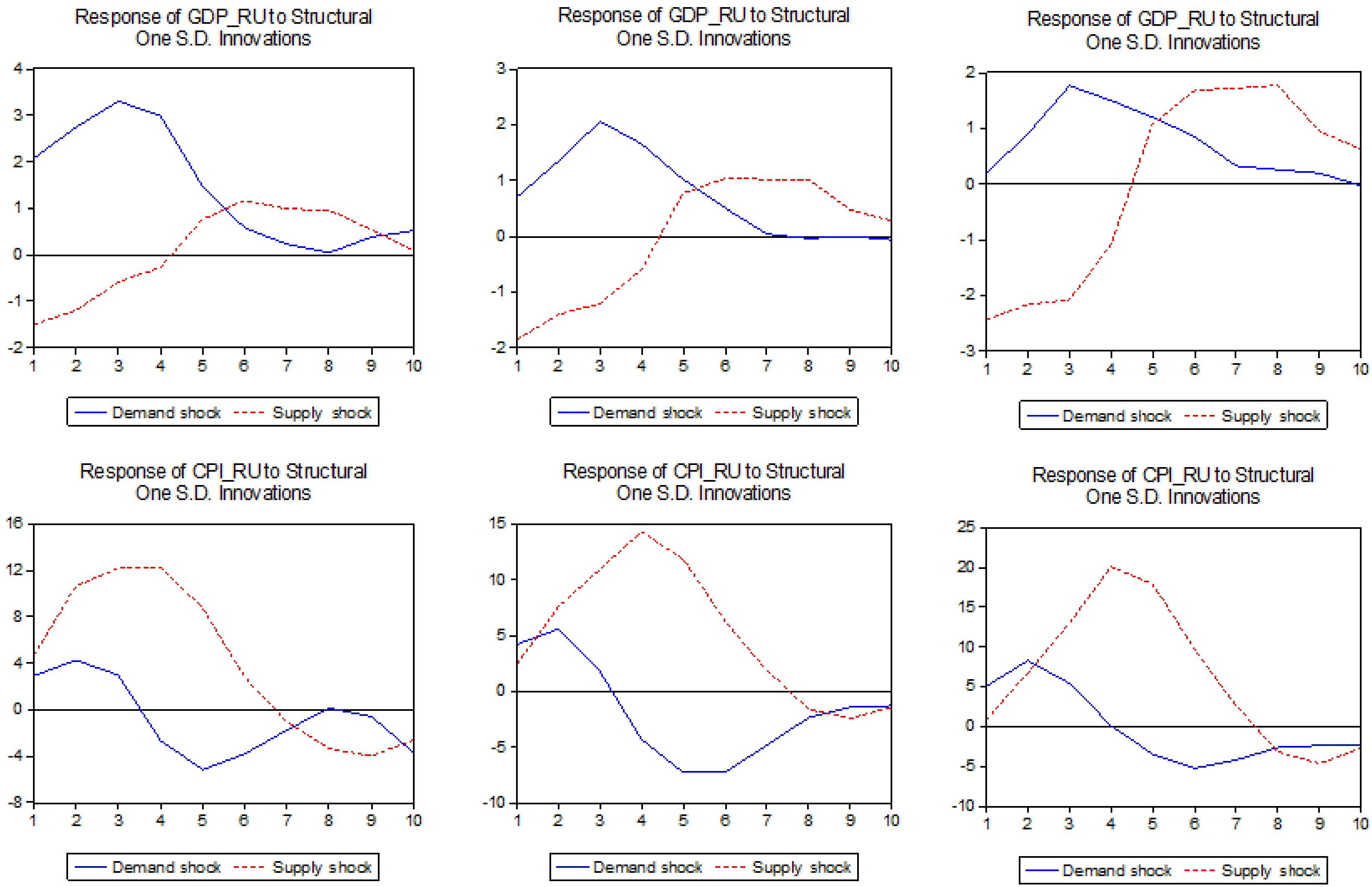

Figure 5a Impulse response functions for Russia (from left to right: full time period, pre-crisis period, pre-EU period).

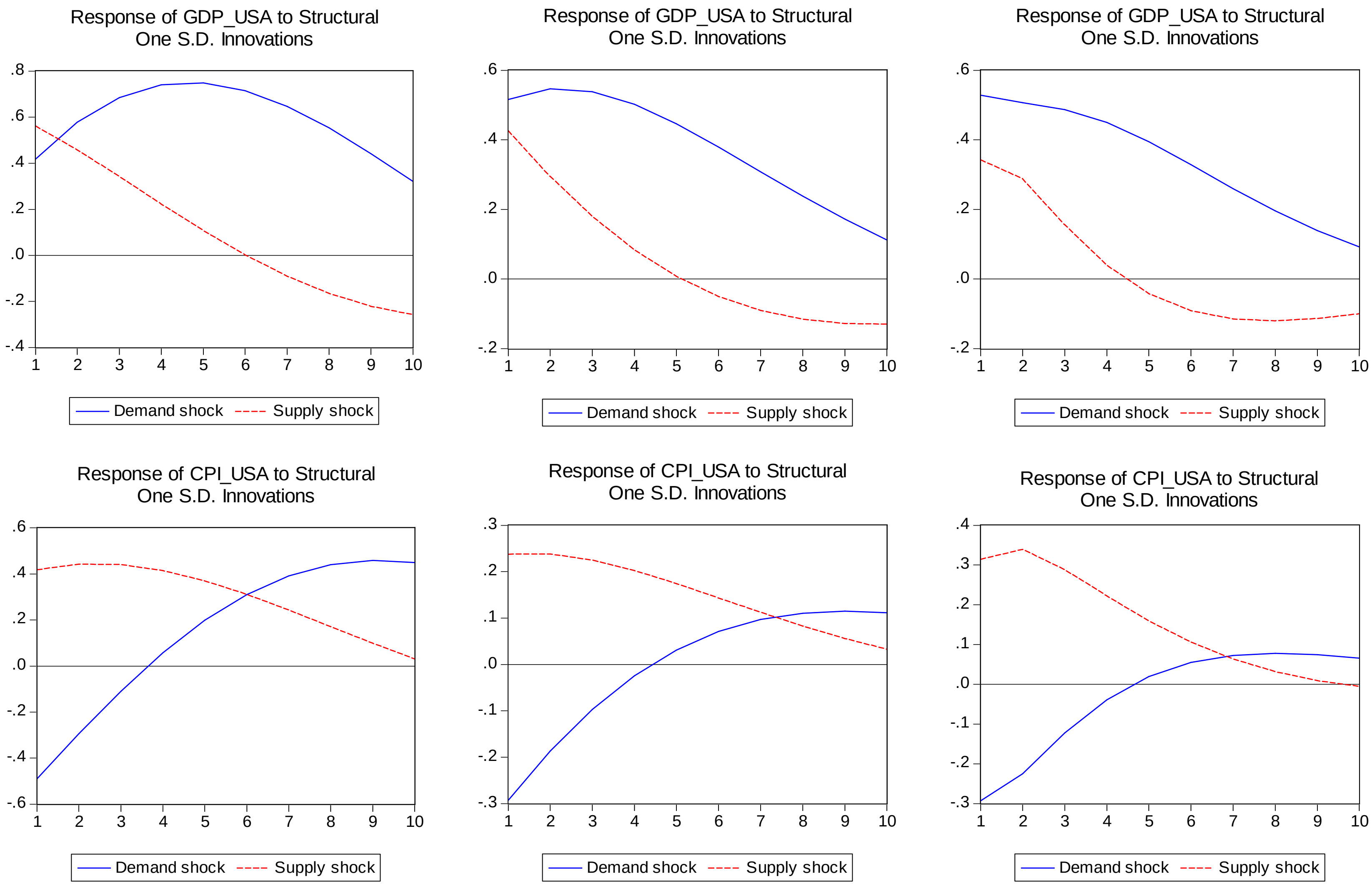

Figure 6a Impulse response functions for the USA (from left to right: full time period, pre-crisis period, pre-EU period).

Appendix B

Shock Correlation

Table 1b *Supply and demand shock correlation table between the Baltic States and Germany/Russia*

Individual number of lags	Germany			Russia		
Demand	full time	pre-crisis	pre-EU	full time	pre-crisis	pre-EU
	0.1867	0.0293	-0.0399	0.1807	0.1198	0.0810
LV	(0.1642)	(0.8417)	(0.8171)	(0.2093)	(0.4500)	(0.6761)
	0.0536	-0.2223	-0.2869*	0.4006***	0.0625	0.3090
LT	(0.6919)	(0.1248)	(0.0898)	(0.0039)	(0.6942)	(0.8735)
	0.1028	0.2989**	0.0666	0.2343	0.0028	-0.0155
EE	(0.4637)	(0.0461)	(0.7173)	(0.1015)	(0.9857)	(0.9364)
Uniform number of lags - 2	Germany			Russia		
Demand	full time	pre-crisis	pre-EU	full time	pre-crisis	pre-EU
	0.1867	0.0293	-0.0399	0.2566*	0.0814	0.0079
LV	(0.1642)	(0.8417)	(0.8171)	(0.0636)	(0.5984)	(0.9656)
	0.0536	-0.2223	-0.2869*	0.3449**	0.0086	0.0717
LT	(0.6919)	(0.1248)	(0.0898)	(0.0114)	(0.5627)	(0.6965)
	0.0584	0.1816	0.0424	0.2477*	0.0712	0.0727
EE	(0.6854)	(0.2118)	(0.8060)	(0.0737)	(0.6419)	(0.6925)
Individual number of lags	Germany			Russia		
Supply	full time	pre-crisis	pre-EU	full time	pre-crisis	pre-EU
	0.0486	0.1303	0.0343	0.0686	-0.2082	-0.3199*
LV	(0.7194)	(0.3720)	(0.8427)	(0.6120)	(0.1857)	(0.0907)
	0.1485	0.2038	0.2028	-0.0446	-0.2321	-0.3170*
LT	(0.2702)	(0.1601)	(0.2355)	(0.7584)	(0.1391)	(0.0938)
	0.4110***	0.2703*	0.1537	-0.0597	0.1822	0.1961
EE	(0.0022)	(0.0725)	(0.4009)	(0.6804)	(0.2481)	(0.3080)
Uniform number of lags - 2	Germany			Russia		
Supply	full time	pre-crisis	pre-EU	full time	pre-crisis	pre-EU
	0.0486	0.1303	0.0343	-0.1781	-0.2832*	-0.3003*
LV	(0.7194)	(0.3720)	(0.8427)	(0.2020)	(0.0594)	(0.0949)
	0.1485	0.2083	0.2028	-0.1507	-0.2079	-0.2118
LT	(0.2702)	(0.1601)	(0.2355)	(0.2814)	(0.1705)	(0.2446)
	0.2665**	0.2073	0.1345	-0.1768	-0.0249	-0.0460
EE	(0.0451)	(0.1529)	(0.4343)	(0.2054)	(0.8711)	(0.8025)

Note. *p<0.1, **p<0.05, ***p<0.01

Table 2b *Supply and Demand shock correlation table among the Baltic States for all periods*

Individual number of lags	full time		pre-crisis		pre-EU	
Demand shocks	LV	LT	LV	LT	LV	LT
LT	0.4484***		0.4236***		0.4235**	
	(0.0005)		(0.0024)		(0.0101)	
EE	0.4295***	0.3012**	0.3787**	0.3655**	0.4114**	0.4573***
	(0.0013)	(0.0284)	(0.0103)	(0.0136)	(0.0193)	(0.0085)
Uniform number of lags – 2	full time		pre-crisis		pre-EU	
Demand shocks	LV	LT	LV	\LT	LV	LT
LT	0.4484***		0.4236***		0.4235**	
	(0.0005)		(0.0024)		(0.0101)	
EE	0.2489*	0.2797**	0.0232	0.0950	0.1494	0.1773
	(0.0619)	(0.0351)	(0.8743)	(0.5163)	(0.3845)	(0.3009)
Individual number of lags	full time		pre-crisis		pre-EU	
Supply shocks	LV	LT	LV	LT	LV	LT
LT	0.4822***		0.4361***		0.4402***	
	(0.0001)		(0.0017)		(0.0072)	
EE	0.2861**	0.1539	0.1547	0.2158	-0.0522	0.2319
	(0.0378)	(0.2713)	(0.3102)	(0.1546)	(0.7767)	(0.2017)
Uniform number of lags – 2	full time		pre-crisis		pre-EU	
Supply shocks	LV	LT	LV	LT	LV	LT
LT	0.4822***		0.4361***		0.4402***	
	(0.0001)		(0.0017)		(0.0072)	
EE	0.3457***	0.2486*	0.1058	0.1307	0.2063	0.1663
	(0.0084)	(0.0623)	(0.4693)	(0.3703)	(0.2274)	(0.3324)

Note. *p<0.1, **p<0.05, ***p<0.01

Appendix C

Kalman filter

Table 1c Kalman filter coefficients table

	Supply shocks							Demand shocks					
	Reference country: Germany							Reference country: Germany					
	full time period		pre-crisis period		pre-EU period			full time period		pre-crisis period		pre-EU period	
	a	B	A	b	a	b		a	b	a	b	a	b
LV	0.2928	1.7236	0.7151	-0.5195	0.9844	1.4674	LV	-3.5632	-4.2781	1.1154	2.8025	0.8598	-2.3601
	(0.9325)	(0.7672)	(0.8306)	(0.9401)	(0.7529)	(0.9056)		(0.2607)	(0.5139)	(0.7517)	(0.6967)	(0.8027)	(0.7267)
LT	0.0684	1.1103	0.2462	0.1698	1.1929	-0.1061	LT	0.5879	5.9633	1.5857	1.2425	0.2746	1.1427
	(0.9842)	(0.8488)	(0.9413)	(0.9804)	(0.7028)	(0.9932)		(0.8528)	(0.3628)	(0.6528)	(0.8628)	(0.9364)	(0.8656)
EE	0.1893	0.8952	0.4762	0.4778	0.5281	-2.0819	EE	-0.9357	-0.9693	0.0931	-1.5681	0.5361	0.7165
	(0.9563)	(0.8778)	(0.8867)	(0.9449)	(0.8659)	(0.8664)		(0.7677)	(0.8824)	(0.9789)	(0.8273)	(0.8762)	(0.9155)

	Supply shocks							Demand shocks					
	Reference country: Russia							Reference country: Russia					
	full time period		pre-crisis period		pre-EU period			full time period		pre-crisis period		pre-EU period	
	a	B	A	b	a	b		a	b	a	b	a	b
LV	-0.1394	1.1298	1.2031	0.6065	0.7754	1.2787	LV	-1.5575	3.5838	1.6929	1.9299	0.4423	1.3331
	(0.9832)	(0.8064)	(0.7080)	(0.9277)	(0.8580)	(0.8332)		(0.6974)	(0.4908)	(0.5890)	(0.7916)	(0.9049)	(0.8096)
LT	0.3076	0.9365	0.5835	0.6542	0.3877	2.2029	LT	-1.6854	-3.1354	1.7662	-0.3959	0.0329	-2.0278
	(0.9629)	(0.8390)	(0.8559)	(0.9220)	(0.9287)	(0.7168)		(0.6740)	(0.5466)	(0.5729)	(0.9568)	(0.9929)	(0.7140)
EE	0.2860	1.0111	0.6301	0.8775	-0.7195	2.8504	EE	-0.1237	2.0043	-0.7427	0.1552	0.6591	1.0291
	(0.9655)	(0.8264)	(0.8445)	(0.8955)	(0.8682)	(0.6388)		(0.9746)	(0.7000)	(0.8126)	(0.9830)	(0.8587)	(0.8525)

Note. P-values in parentheses.