Evaluation of the Transmission of the Euro Area, Japan and US Monetary Shocks to the Baltic States

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Signed

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Abstract

This paper studies the international monetary transmission mechanisms in the Baltic region, for all three Baltic countries separately and in comparison with the Euro Area. The model for the empirical estimation is the Global VAR, which allows capturing both, direct and indirect cross-border monetary transmission. The authors generate several shocks to the short-term interest rates of US, Japan and the Euro Area over the estimation period 2000-2013 and observe the impact on the following macroeconomic variables: real GDP, inflation, short-term interest rates. The main conclusions are that the Baltic countries have the strongest reaction to Euro Area monetary shocks, while the effect from US and Japan is transmitted to the Baltics through the link with the Euro Area. Out of the three Baltic countries, Latvia has the most pronounced reaction to Euro Area, US and Japan monetary shocks. These results are driven by strong trade relationships, as well as the amount of debt denominated in foreign currency. The fact that the Baltic States are small and open economies also explains bigger volatility of the Baltic economies as a result of monetary shocks. The conclusions formulated about the response of the macroeconomic variables are in line with the ones drawn from previous researches.

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Introduction

Some of the changes in the monetary policy of central banks are expected by economic agents and therefore are already incorporated into current macro variables. Another part of changes are unexpected. These unpredicted changes are defined as monetary policy shocks that pass the effect to the economy through various monetary transmission mechanisms. The functioning of the particular transmission mechanisms largely depends on the characteristics of the country.

In the recent years, due to the continuous globalization process, the transmission of monetary shocks involves the cross-border effect more intensively and is affecting virtually all countries engaged in world economics. Being small and open economies the Baltic States are especially affected by various monetary measures implemented in the rest of the world. Obviously, close integration with European countries implies a strong reaction of Baltic economies to the monetary policy of the European Central Bank (ECB). In addition, the effect from big non-European economies is transmitted to the Baltics indirectly, mostly through its link with the Euro Area (EA). One should also take into account that Euro Area membership increases the integration of the Baltic States into the European economic system, and the Baltic countries will have a greater influence from the monetary policy of ECB as well as of other big economies due to a tighter link with EA. The Baltic States are transition economies and countries with currency boards or hard pegs; therefore, it is impossible to draw perfectly relevant conclusions about the functioning of monetary transmission in the Baltic States from the experience of other countries. One needs to analyse monetary transmission relying on Baltic data, taking into account both, direct and indirect transmission effects. The aim of the work is to view transmission of monetary shocks to the Baltics in the global context and to consider spillover effects among the EA and the three Baltic countries. Only very few studies have estimated all the three Baltic countries together, which is an important advantage of this thesis.

For the empirical analysis the authors will apply the Global VAR (GVAR) model, which offers a suitable evaluation of the policy shocks and how these were transmitted to other country blocks. The model is new and, to our best knowledge, has never been applied to the Baltic States before. The GVAR model is perfectly suited for such type of economy as that of the Baltic States and has many advantages over the previous methods used for these purposes. Conclusions from this work are very relevant to the central banks of the Baltics in

order to adapt for the potential unexpected changes in short-term rates of other countries that could occur.

Thus this paper will try to answer the following question: *"How monetary shocks of the Euro Area, US and Japan are transmitted to the main macroeconomic variables in the Baltic States?"*

Due to the specifics of monetary transmission mechanisms in each country the effect of monetary shocks could be different, even though, all the countries were affected by the same shock. Such things as difference in economic development, financial systems and geographical location can cause asymmetry of reactions to monetary shocks. Furthermore, to obtain a more in depth analysis the authors will also take into consideration the following sub-questions:

1. What is the effect of Euro Area-wide monetary policy shocks on the main macroeconomic variables in the Baltic States?
2. What are the spillover effects of US and Japan monetary policy shocks on the main macroeconomic variables in the Baltics and the Euro Area?
3. What are the differences in impulse responses between the Euro Area and the Baltic States, and among the three Baltic countries?

The paper is structured as follows: section two will cover the review on the existing literature about international transmission mechanisms; section three will be dedicated to the derivation of the used methodology, as well as, describe the dataset; the fourth section will be devoted to the empirical estimations of the research and the discussion of the results, and, finally, the fifth section will contain the main conclusions.

Literature review

Theoretical review

First, the authors decided to pay attention to the theoretical issues behind the classical domestic monetary transmission mechanisms. It is usually claimed in the literature that one transmission channel is more important than others, thus the authors decided to describe in more details the three transmission channels that are discussed the most.

Interest rate mechanism

The interest rate mechanism is widely known from the IS-LM framework, initially proposed by Keynes and later described by J.R. Hicks (Hicks, 1937). If the central bank

decides to ease the monetary policy of the country, they should lower the interest rates. That leads to lower costs of borrowing and therefore more attractive conditions for investment. An increase in aggregate demand will cause a rise in inflation. Although, originally Keynes introduced this channel with an emphasis on investment decision of businesses, investment equally applies to businesses and consumer spending decisions (for example, durable expenditure and housing) in the current version of the model. An important feature of the interest rate channel is that it works through the real long-term interest rates. Despite the fact that expansionary monetary policy can also lead to lower short-term interest rates and in consequence the same result, it still goes through the same interest rate mechanism because expectation theory states that long-term interest rates are the average of short-term interest rates (Hicks, 1937).

Wealth effect

The wealth effect was described by Modigliani (1971) based on the principles of consumption, which by definition is a spending on non-durable goods and services. That depends on the resources the consumer possesses and not only on his current income. Keeping in mind the inverse relationship between interest rates and prices, it can be concluded that a monetary easing in a country (decrease in interest rates) causes an increase in the stock price. Common stock is assumed to be a component of the resources consumers possess and, therefore, an increase in the stock price corresponds to an increase in the financial wealth that leads to a rise in consumption and aggregate demand (Modigliani, 1971).

Bank lending channel

Monetary transmission can also be explained from another perspective, the credit channel (or bank lending channel). Expansionary monetary policy, which is aimed at boosting the economy, increases reserves in the banks and the amount of bank deposits. Due to that commercial banks have a bigger amount of money they can distribute, therefore, the supply of loans increases. Bank loans are the most important source of external financing for small and medium sized firms and, the amount of investment certainly increases for these firms. An increase in investment always leads to a rise in aggregate demand. The bank lending channel works mostly through small and medium sized businesses, as these are exactly the types of firms dependent on bank loans, in contrast to big, well-known corporations (Bernanke & Blinder, 1988; Bernanke & Gertler, 1995).

Cross-border monetary transmission

However, the main body of this thesis will be dedicated to the cross-border spillover mechanisms, which define how monetary shocks are transmitted internationally. Speaking about *interest rates*, there is a positive relationship between one country's interest rates and another. Keeping in mind that big countries have an influence over small countries by determining global rates, one can draw a conclusion that big foreign countries have a direct influence over small countries' interest rates. One more channel of interest rate transmission could be through domestic borrowing in foreign currency. That could be of particular importance for the Baltic States in relation to the Euro Area.

International shocks can also be transmitted through the *demand channel*, where one country's increase in demand causes the same effect for another country. Consequently, restrictive monetary policies causing a decrease in demand in a foreign country also causes a decrease for the domestic products.

Further, the *exchange rate channel* is also relevant when speaking about cross-border effects. The final outcome of shift in money supply and change in interest rates is dependent upon the fact whether the exchange rate is floating or fixed. Changes in the monetary policy causes the real output of both countries to move in different directions under floating exchange rate conditions (Kim, 2000). This mechanism can be explained using the Mundell-Fleming framework, which is an expansion of the IS-LM model in an open economy. An increase in the money supply leads to a decrease in interest rates, which causes capital outflow as domestic interest rates are lower than the global ones. As a result domestic currency depreciates under a floating exchange rate regime which makes local goods cheaper in comparison to foreign goods and net exports for the domestic country increase. Therefore, the demand is shifted from foreign to domestic products (Young & Darity, 2004). Basically, the domestic country becomes more competitive due to currency depreciation on the expense of foreign currency, which is known as the beggar-thy-neighbour's policy. If the exchange rate is fixed, the transmission channel would be as follows: a decrease of the interest rates causes capital outflow that puts pressure on the exchange rate. However, as the exchange rate is fixed, the central bank needs to defend its exchange rate and does so by purchasing the home currency. Decreasing money supply shifts the economy back to its original level. Therefore, there is no long-term effect of expansionary monetary policy under the fixed exchange rate (Koźluk & Mehrotra, 2008). *Financial markets* also play a role in transmitting

monetary shocks as foreign monetary growth can foster capital flows and improve the liquidity position in the domestic markets.

As a result, several shocks could lead to different effects, depending on the relative importance of the transmission channels. The uncertainty concerning the final outcome is only relevant when speaking about international transmission as there are no different sign effects in the monetary policy transmission within one country. Easing of foreign monetary policy can have a positive effect on domestic demand if interest rate and demand channels are more pronounced, or have a negative impact if exchange rate channel is the leading one. Thus, the net result depends upon the fact which of the mechanisms is stronger. Such factors as the size of a country, loans in foreign currency, international trade openness, monetary and exchange rate regimes determine the sign and the size of a cross-border transmission (Benkovskis, Bessonovs, Feldkircher, & Wörz, 2011).

Empirical puzzles

There are certain puzzles which frequently occur in many empirical works investigating transmission mechanisms in both closed and open economies. Liquidity puzzle means that monetary shocks coming from innovations in money aggregates lead to an increase and not a decrease in interest rates (Leeper & Gordon, 1991). The price puzzle addresses the issue that the reaction of the output and money supply to interest rate changes is consistent with the predictions, while the price reaction does not correspond to the real life situation. As a result of a tightening monetary policy, money supply and real output should fall, while prices rise despite the predicted fall in price level (Sims, 1992). The exchange rate puzzle suggests a different reaction of exchange rate to a similar monetary shock. An increase in interest rates in the US is followed by the appreciation of the US dollar relative to the non-US G-7 (Germany, Japan, UK, France, Italy, and Canada) currencies, which serve as a proxy for the rest of the world. While, if one looks at a monetary contraction among G-7 countries, the effect of depreciation of their home currencies is found (Sims, 1992). The forward discount bias puzzle occurs when positive interest rate differentials lead to the appreciation of the domestic currency. This reality contradicts the theoretical predictions, based on the uncovered interest rate parity condition, which state that positive interest rate differentials should lead to currency depreciation in the long-run (Kim & Roubini, 2000).

Methodological review

The importance and significance of cross border effects among others was researched using empirical methods such as Structural Vector Autoregression (SVAR), Near-VAR,

Structural Dynamic Factor Model, Factor Augmented Vector Autoregression (FAVAR) and Global Vector Autoregression (GVAR).

Structural VAR

The most frequently used method for such purposes is the structural VAR. SVAR is a linear representation of a vector of variables on both domestic and possibly foreign variables, which was first introduced in 1980 by Sims. The SVAR model aims to determine the true empirical model by taking into consideration the shocks that affect the model. In order to derive this model identifying restrictions are imposed, so that it is possible to use impulse response functions and bypass the theoretical model created for this purpose. Thus, by using the SVAR model it is possible to create and identify dynamic connections between left-hand side variables and further on being able to interpret the results obtained (Sims, 1980).

One of the classical papers of structural VAR as a way of studying cross-border channels is in the work of Kim (2000). The paper studied the transmission mechanisms of US to other countries with flexible exchange rate regimes. An expansionary monetary policy in the US was found to lead to boom in the US and other G-7 countries. Based on the research done, it was concluded that the interest rate channel was the most pronounced in this transmission, while changes in the trade balance did not to affect the situation too much (Kim, 2001).

Kim and Roubini (2000) also investigated a similar problem using the structural VAR approach and came to slightly different conclusions. The output response to positive US interest rate shock was distinct for different non-US G-7 countries despite the fact that the short–term interest rate response was similar. On the one hand, exchange rate depreciated and that caused an increase in domestic demand and real output. On the other hand, demand decreased due to higher interest rates. Speaking about small economies of the G7, such as Canada, for example, interest rate reacted strongly and second effects were the leading ones, therefore, Canada's output decreased significantly. When looking at bigger economies, such as Germany and Japan, real output response was positive due to the exchange rate depreciating more (Kim & Roubini, 2000).

Aarle, Garretsen and Gobbin (2003) studied monetary and fiscal policy transmission in the Euro Area from adjustments in the European Monetary Union (EMU) fiscal policies and identified that the transmission effects of various structural shocks in the Euro Area could be compared to those in the US and Japan, especially in regards to demand shocks. The empirical analysis showed that for the Euro Area the impact on output from demand shocks

was more pronounced and lasted for a much longer time period than for Japan or the US. Also, changes in prices were more significant for the EA than they were for the other two countries. Moreover, the effect on interest rates was negative in the case of monetary policy shocks only for Japan. Furthermore, if countries from the EMU were analyzed individually, the impact of these shocks varied significantly depending on the affected country (Aarle, Garretsen, & Gobbin, 2003).

Errit and Uusküla (2013) in their research about Estonia concluded that for this economy, the trade channel was the weakest transmission channel for Euro Area monetary policy shocks. The main reason behind this was a lower decrease of the exports of the country in comparison to its imports, as a percentage of GDP. Also, even though foreign demand had a strong impact, the effect created by the domestic demand was much stronger (Errit & Uusküla, 2013).

The structural VAR approach can also be used to find the spillover effects inside the block of countries, such as the Euro Area, for example. Peersman (2004) identified that in the Euro Area the effect of monetary shocks was relatively even distributed. The impact on interest rates was more pronounced in Germany, while the effect on prices was stronger in Italy and Spain than in Austria and the Netherlands (Peersman, 2004).

Sousa and Zaghini (2004) were also studying monetary policy shocks in the Euro Area and global liquidity spillovers. They found that a positive shock to foreign liquidity generated a permanent rise in Euro Area prices, as well as in real money demand, output, and an appreciation of the euro real exchange rate (Sousa & Zaghini, 2004).

Neri and Nobili (2006) worked on the transmission of monetary policy shocks from the US to the Euro Area and have identified that an increase in the US Federal rates led to an immediate depreciation of the EUR and afterwards the European currency experienced a slow appreciation as predicted by the purchasing power parity (PPP) condition. Furthermore, a positive effect on the real output in the Euro Area was observed. However, this was valid only for the short run, while for the long run there was a negative effect. Also, the authors showed that the exchange rate channel had a small impact on price changes in the short run, while it was insignificant in the medium and long run (Neri & Nobili, 2006).

There are certain disadvantages of using the SVAR model. First of all, quite a limited number of variables is allowed, because if a higher number of variables is taken the model will experience substantial loss of degrees of freedom. Due to the limited number of variables, the model could suffer from omitted variable bias. What is more important, the small number

of variables is a substantial drawback for studying cross-border spillover effects where long time series and many variables are essential. Moreover, in the structural VAR model it is possible to obtain impulse response functions only for those variables that are included in the model, while many variables, which could be of interest, are not represented. It is also quite usual for this type of researches using a VAR methodology to face price puzzles in the empirical results. Sims (1992) attempted to explain this problem with the fact that price puzzles could have resulted from the lack of control for information the central banks have. If the central bank tightens the monetary policy while anticipating for future inflation and if these policies are not captured by the data in a correct manner, the VAR approach results into a price puzzle. In the VAR interpretation this represents a policy shock, while in reality that was a response of the central bank to the anticipated inflation (Bernanke, Boivin, & Eliasz, 2004).

Despite the above mentioned drawbacks, the SVAR methodology is still widely used to investigate the importance of interest rate versus exchange rate channel in terms of its impact on the work of spillover monetary mechanisms. Depending on its relevant importance in different countries, the reaction of real output is different as a result of a specific monetary policy. While most VAR models find a real GDP increase as a result of monetary expansion, others acknowledge this relationship in several cases, while providing proof for the contrary relation as well, meaning a decrease in real output. However, all the researches using the SVAR model are restricted to a limited number of variables and cannot get rid of the price puzzle.

Near-VAR

The Near-VAR model is also used to determine the dynamic linkages between variables. Near-VAR is a Structural VAR with the exogenous variables included into the model. The main difference between Near-VAR and the other mentioned models, is that by using Near-VAR it is possible to incorporate structural breaks in it. Firstly, these breaks are identified and accounted for in the theoretical model created for this purpose. Secondly, the Near-VAR model is derived and regressed so that the effect of the shocks can be observed. One of the differences between Near-VAR and many other VAR specifications is that Near-VAR allows for different lag lengths (Jiménez-Rodriguez, Morales-Zumaquero, & Egert, 2010).

Jiménez-Rodriguez, Morales-Zumaquero, and Egert (2010) studied the impact of international shocks of interest rate, commodity price and industrial production shocks on

macroeconomic variables of Central and Eastern Europe (CEE) countries (Bulgaria, Estonia, Hungary, Czech Republic, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia). The researched period was 1990-2009 and the model used was Near-VAR. The authors identified several structural breaks in the period from 2007 to 2008 and considered it to be a valuable addition to the previous researches done. Euro Area economies experienced a more pronounced effect from foreign industrial production shocks. The authors identified that the reaction to global commodity price shocks was influenced by the monetary policy used and the economic situation of the country. Also, because of the strong production link identified between CEE countries and the Euro Area, the authors touched upon the subject of these countries adopting the Euro as their currency in the future (Jiménez-Rodriguez, Morales-Zumaquero, & Egert, 2010).

Structural Dynamic Factor Model

Another method is the Structural Dynamic Factor Model which is used mainly for large databases. It allows for incorporating more variables into the model and the large data sets deal with the non-fundamentals problem and reduce the high degree of variation of the parameters from their true values. Also, there is no need to create a theoretical model in the first place. It is possible to impose the necessary identifying restrictions directly on the impulse response functions and then derive the true empirical model and estimate the effects of the shocks on its variables (Barigozzi, Conti, & Lucian, 2011).

Barigozzi, Contiand, and Lucian (2011) used this method to evaluate the effect of common monetary policy on Euro Area countries, both on aggregate and individual levels. The main conclusions obtained are that the monetary policy had an effect on the real output, while the impact on prices was quite small. In general, no asymmetries in terms of GDP reaction were found, while Spain and Italy experienced an asymmetric reaction in respect to consumption, investment and unemployment. According to the results of the research the introduction of a single currency decreased asymmetry in terms of price reaction, while it had no effect on consumption and investment (Barigozzi, Conti, & Lucian, 2011).

The same method was used for the evaluation of US monetary policy by Forni and Gambetti (2010). The authors considered that this approach had several advantages over the VAR approach. Firstly, it is possible to investigate how many shocks there are in total. When using the VAR method, the number of shocks is equal to the number of variables, therefore, the factor model could be a good ground for building a macroeconomic model for the

analysis. Secondly, the factor model can work with a bigger amount of information (Forni & Gambetti, 2010).

The dynamic factor model does not take the trade structure into account and is purely "data-driven" (Kryshko, 2011). This is an important drawback compared to the SVAR, FAVAR and GVAR models, which have a more solid theoretical background.

Factor Augmented VAR

The idea behind the FAVAR model is to look at the dynamic linkages between latent factors that affect the variables tested and observe how they influence the overall economy. The main advantage of this model is that it allows working with a large set of variables and, therefore, is considered a "data-rich" model. Also, it is possible to deal with the omitted variable problem identified in simple VAR models. Bernanke, Boivin, and Eliasz (2004) suggested using a large dataset where the variables were taken as the sum of a common and an idiosyncratic factor. The factors follow a simple VAR process and can be obtained from the sum of a few common components and a variable-specific factor. Also, with the help of the FAVAR model it is possible to study and interpret dynamic effects of monetary shocks (Mumtaz & Surico, 2009).

The FAVAR approach was first used by Bernanke, Boivin, and Eliasz (2004) for the purpose of researching cross-border monetary transmission mechanisms. There are several advantages the FAVAR model has over the VAR method. Central banks usually have much more information at their disposal, which they would like to include in the model than it is possible to do in the VAR model. The FAVAR approach allows for more variables, which is closer to real life decision-making analysis. The FAVAR methodology also is better to use for policy-makers, as this analysis allows generating impulse responses for a variety of factors. As a proof that FAVAR gives a better representation of the reality, Bernanke, Boivin, and Eliasz (2004) described that the price puzzle, which was present when the VAR approach was applied, was solved by the FAVAR model. As well as, more information included in the framework and an increased number of factors led to conclusions being more in line with theoretical predictions (Bernanke, Boivin, & Eliasz, 2004).

An example of the FAVAR approach used to study international transmission mechanisms was in the work of Mumtaz and Surico (2009). The authors used a dataset of 17 countries and concluded that foreign expansionary monetary policy led to UK nominal exchange rate appreciation. The authors found an evidence of temporary but significant growth rate of real output and consumption. In the third year after the shock occurred CPI and

GDP deflator reached their maximum levels. While there was evidence of a puzzle in monetary shocks originated from foreign countries, there was no puzzle in UK monetary shock effects, which is a substantial advantage over VAR approach, where this problem is usually present (Mumtaz & Surico, 2009).

Blaes (2009) provided a good comparison of the VAR and FAVAR methods when examining the two methodologies over the reaction of monetary aggregates to a monetary policy shock, observed in the Euro Area. Results from both models were in line with the theoretical predictions regarding the reaction to restrictive monetary policy. Meaning, in the long term restricted money growth was foreseen because of the impact on credit growth. While in the short run money growth increased due to the rise of short-term interest rates. The authors concluded that in general the results were the same, while if one wants to look at a bigger set of variables, it is better to use the FAVAR model (Blaes, 2009).

Benkovskis, Bessonovs, Feldkircher, and Wörz (2011) studied cross-border transmission of Euro Area monetary shocks to Eastern-European countries, such as the Czech Republic, Poland and Hungary using the FAVAR approach. It was concluded that contractionary monetary policy led to a reduction of GDP through increased interest rates and decreased foreign demand. Overall, the effect in these countries was found to be big enough comparing to the Euro Area (Benkovskis, Bessonovs, Feldkircher, & Wörz, 2011).

In general, most of the researchers studying contarctionary or expansionary monetary policy effects agree on the fact that using the FAVAR methodology leads to the results being consistent with the theoretical predictions and no puzzles are present in these cases. However, this methodology has some important drawbacks. Firstly, this model does not capture indirect cross-border effects of monetary policy shocks. Secondly, it looks only at unexpected changes in the monetary policy and does not take into account the choice of the policy rule or the effects of the systemic part of a monetary policy (Iiboshi, 2012).

Global VAR

The first mention of GVAR was in 1997, when it was applied for credit risk analysis after the Asian crisis. Moreover, it soon gained a much wider application and was particularly well suited for analysing transmission mechanisms between different countries and regions.

The first research where the GVAR model was mentioned in regards to transmission mechanisms was about modelling regional interdependencies by Pesaran, Schuermann, and Weiner (2002). The authors took 26 countries, grouped them into 11 regions and estimated for the time period 1979-1999. The estimated variables for these countries were GDP, CPI,

nominal money supply, nominal equity index, exchange rate, nominal rate of interest and oil price. First, the authors derived individual country models, which were later combined in a global model and used to forecast the behaviour of several variables. A big part of the work was dedicated to the derivation of the GVAR model, the overview of the key assumption, which is weak exogeneity of foreign variables, the description of the advantages of this model over the similar ones, as well as, several applications of the GVAR model. In the empirical part of the paper several shocks were generated, such as a negative shock to US equity prices, a positive shock to German output and a negative shock to equity markets in south Asia. Based on this, the authors draw several conclusions about the linkages between selected countries. Additionally, the authors generated a loss distribution function for a credit portfolio in their research. However, the main body was still dedicated to the theoretical issues of the GVAR approach and its application (Pesaran, Schuermann, & Weiner, 2004).

The work about international linkages of the Euro Area by Dées, di Mauro, Pesaran, and Smith (2005) is an extension of Pesaran, Schuermann, and Weiner's (2002) work. First, the authors extended both the geographical coverage and the estimation period. In this work, 33 countries were grouped into 25 regions plus the Euro Area, taken as a single economy, which were studied over the period 1979-2003. Additionally, both short-term and long-term interest rates were included in the study. Despite the fact that Pesaran, Schuermann, and Weiner (2002) already included oil price in their work, current researchers included oil prices as dependent on the US economy and not as a global exogenous variable as it was done before. All these factors allowed for more transmission mechanisms and better representation of the interaction of variables between different economies. The novelty of the work was also in the development of the bootstrap procedure which helped to check for the stability of the coefficients and error variances obtained. As well, the bootstrap procedure helped to build confidence intervals for the impulse responses. The work also complemented the previous research by applying the GVAR for a "structural" impulse response analysis. In its empirical part, the research focused on the shocks from US to Euro Area economy. Structural breaks were affecting the results insignificantly. In their work, Dees, di Mauro, Pesaran, and Smith (2005), have identified that the financial shocks were often amplified as they were carried from the US to the Euro Area; however, the transmission effects of changes in the US monetary policy were quite limited and did not have any significant impact on the Euro Area. Furthermore, the authors have concluded that second round effects were statistically significant and important. There were several reasons for that. Firstly, the shock taking place

in the US was magnified because of the long run effects of inflation and output in the rest of the world. Secondly, the Euro Area experienced not only an immediate direct effect but also an indirect one, which comes mostly from the impact of the US shock on Euro Area's trading partners (Dées, Mauro, Pesaran, & Smith, 2005).

Due to the increasing integration processes between countries, the co-movement of macroeconomic variables became more pronounced and that effectively influenced monetary policy spillovers. The GVAR methodology accounts for this co-movement and, therefore, provides a more explicit framework for policy analysis of international transmission of monetary shocks (Dées, Mauro, Pesaran, & Smith, 2005).

Methodology

The GVAR model

The Global Vector Autoregression (GVAR) model combines individual error-correcting models for a selected set of countries or regions and estimates them in one model. An important feature of this approach is the existence of a domestic, foreign and global variable in each individual country model (Smith, 2012). Due to the fact that individual country VARX* are linked with each other, where foreign variable vector X* is also entering domestic VAR, it is possible to track international linkages of all included countries and transmission of monetary shocks worldwide through a single model (Bettendorf, 2012).

In more details, the GVAR model can be completed in three steps. Firstly, it is necessary to derivate the country specific models that are constructed from the domestic and foreign variables by using a simple VAR structure. The foreign variables used in these models are weighted averages of the domestic variables for all the other countries. For example, if in the model the interest rate (r_{it}) of the domestic country is used, then the foreign interest rate (r_{it}^{*}) is composed of the weighted average of all other countries' interests rates. The choice of weights is based upon the trade or financial relationship between the regions employed in the model. Secondly, from this extended simple VAR model, it is possible to derive individual country models using specific lag choices for each particular country. In the third step, the respective models are grouped together and with the help of a global VAR model the cross country shock effects can be analyzed. Furthermore, with the GVAR methodology it is possible to unite different countries in a single region and estimate the transmission effects of the monetary shocks for them.

Let us assume that N countries are considered for the GVAR model, with i = 0, 1, …, N, where 0 is the reference country. For any country *i* chosen from the sample, the following VARX (p_i,q_i) structure is constructed, where p_i represents the domestic lag order and q_i the foreign lag order, which are chosen using the Akaike Information Criterion (AIC) or the Schwarz Bayesian Criterion (SBC):

$$x_{i,t} = a_{i,0} + a_{i,1}t + \Phi_{i,1}x_{i,t-1} + \ldots + \Phi_{i,p_i}x_{i,t-p_i} + \Lambda_{i,0}x^*_{i,t} + \Lambda_{i,1}x^*_{i,t-1} + \ldots + \Lambda_{i,q_i}x^*_{i,t-q_i} + e_{i,t}, \quad (1)$$

where x_{it} represents a $k_i \times 1$ vector of domestic variables and x^*_{it} is a $k^*_i \times 1$ vector of foreign variables, Φ is a $k_i \times k_i$ matrix of domestic lagged coefficients, while Λ is a $k_i \times k^*_i$ matrix of coefficient of foreign specific variables, and $x^*_{it} = \sum_{j=0}^{N} w_{ij} * x_{ij}$, w_{ij} stands for the share of country *j* in the trade of country *i*, taking into account both imports and exports. Moreover, $e_{i,t}$ represents a $k_i \times 1$ vector of country-specific residuals, which are assumed to be serially uncorrelated and have a mean of zero and a non-singular covariance matrix:

$e_{it} \sim i.i.d.(0, \sum_{ii}), \sum_{ii} = \delta_{ls} = cov(e_{i,l}, e_{i,s})$

For any country *i*, the variables used in the VAR model can be described as follows:

$$x_{it} = \begin{pmatrix} y_{it} \\ r_{it} \\ p_{it} \end{pmatrix}, x^*_{it} = \begin{pmatrix} y^*_{it} \\ r^*_{it} \\ p^*_{it} \end{pmatrix}, \text{ and}$$

$y^*_{it} = \sum_{j=0}^{N} w_{ij} * y_{jt}$, $\Delta p^*_{it} = \sum_{j=0}^{N} w_{ij} * \Delta p_{jt}$, $r^*_{it} = \sum_{j=0}^{N} w_{ij} * r_{jt}$

(Pesaran, Schuermann, & Weiner, 2002).

In this case, $w_{ii} = 0$ and w_{ij} $(j = 0, 1, \ldots, N)$ represents the set of weights of the foreign variables so that it satisfies the following granularity condition: $\sum_{j=0}^{N} w_{ij} = 1$, where granularity condition means that no country weight is dominated by the cross section units (Chudik, Pesaran, & Tosetti, 2009). In this work, fixed weights will be applied for the GVAR model. These weights used for the computation correspond to the average amount of trade between the countries in the period 2000-2012. The trade shares are obtained by calculating the total trade of each country *i* and dividing it by the amount of trade with country *j*, as a result the i^{th} column should sum to one, for all *i* (Pesaran, Schuermann, & Weiner, 2002).

An error correction model (ECM) represents several time series models that estimate the speed at which the dependent variable can return to its equilibrium as a result of a change in the independent variable (Davidson, Hendry, Srba, & Yeo, 1978).

In order to obtain this form, equation (1) can be rewritten as follows:

$$\Delta x_{i,t} = a_{i,0} + a_{i,1}t + \left(\Phi_{i,1} + \cdots + \Phi_{i,p_i} - I_{k_i}\right)x_{i,t-1} + \left(\Lambda_{i,0} + \cdots + \Lambda_{i,q_i}\right)x^*_{i,t-1} -$$
$$\left(\Phi_{i,2} + \cdots + \Phi_{i,p_i}\right)\Delta x_{i,t-1} \ldots - \Phi_{i,p_i}\Delta x_{i,t-p_i+1} + \Lambda_{i,0}\Delta x^*_{i,t} - \left(\Lambda_{i,2} + \cdots + \Lambda_{i,p_i}\right)\Delta x^*_{i,t-1} \ldots -$$
$$\Lambda_{i,q_i}x^*_{i,t-q_i+1} + e_{i,t}, \quad (2)$$

which can further be reduced to:

$$\Delta x_{i,t} = a_{i,0} + a_{i,1}t + \gamma_i\beta_i{}'z_{i,t-1} - \left(\Phi_{i,2}+\ldots+\Phi_{i,p_i}\right)\Delta x_{i,t-1}\ldots-\Phi_{i,p_i}\Delta x_{i,t-p_i+1} + \Lambda_{i,0}\Delta x^*_{i,t} -$$
$$\left(\Lambda_{i,2}+\ldots+\Lambda_{i,p_i}\right)\Delta x^*_{i,t-1}\ldots-\Lambda_{i,q_i}x^*_{i,t-q_i+1} + e_{i,t} \quad (3)$$

In this case, $z_{i,t}$ is a $(\mathrm{k_i} + \mathrm{k_i^*}) \times 1$ vector and is defined as $z_{i,t} = \left(x_{i,t}{}', x^*_{i,t}{}'\right)'$, a_i represents a $\mathrm{k_i} \times r_i$ full column rank loading matrix, β_i is a $(\mathrm{k_i} + \mathrm{k_i^*}) \times r_i$ full column rank matrix of co-integration vectors, and $\gamma_i\beta_i^{'} = A_i - B_i$, where γ_i represents an $\mathrm{k_i} \times 1$ error correction vector, $A_i = \left(I_{k_i}, -\Lambda_{i,0}\right)$, I_{k_i} is an identity matrix of order $\mathrm{k_i}$, and $B_i = \left(\Phi_{i,1}+\ldots+\Phi_{i,p_i}, \Lambda_{i,1}+\ldots+\Lambda_{i,q_i}\right)$. For this term $(\gamma_i\beta_i^{'})$, its rank indicates the long run relationships between the domestic and foreign variables, namely x_{it} and x^*_{it} (Pesaran, Schuermann, & Weiner, 2002).

An important feature to mention is that the shocks in the model are orthogonalized using Cholesky decomposition, which makes them more applicable for the analysis. If there are, for instance, three VAR equations combined in the GVAR model together, there are three error terms, denominated: e_{1t}, e_{2t}, e_{3t}, which should be orthogonalized to be interpreted as shocks (ε_{it}).

Let's assume that: $\varepsilon_{1t} = e_{1t}$. Then the second shock can be written as: $\varepsilon_{2t} = c_{21}\varepsilon_{1t} + e_{2t}$. And correspondingly the third one: $\varepsilon_{3t} = c_{31}\varepsilon_{1t} + c_{32}\varepsilon_{2t} + e_{3t}$. After running an OLS regression on the two latter reduced-form shocks, a matrix $G\varepsilon_t = e_t$ is obtained. After inverting, $\varepsilon_t = Ce_t$. Therefore, these shocks are uncorrelated with each other because the right-hand-side variables of the VAR equations are uncorrelated with the error terms in the OLS equations (Whelan, 2014).

One of the main assumptions is that x^*_{it} is treated as a weakly exogenous variable. This assumption implies that every country including US is treated as a small open economy, which cannot be true for all the countries included in the model. Meaning there is a risk that this assumption could be violated in practice, for example, for EA variables, as it is quite a big union and it is not only affected by other countries, but certainly has an influence over other countries as well. Whether weak exogeneity assumption will hold in practice is highly affected by the size of the country and the degree of cross-country dependence (Dées, Mauro, Pesaran, & Smith, 2005). Therefore, this assumption could be violated for Euro Area and US variables. However, in the researches of Dées, Mauro, Pesaran, and Smith, (2005), Pesaran,

Schuermann, and Weiner, (2002), where aggregation of Euro Area countries and US variables were tested, such problem was not identified.

The distinctive feature of GVAR methodology is based on several channels through which the interaction between the economies happens. The first one is that domestic variables are dependent on the foreign variables and their lagged values. Secondly, the interaction channel is that all the domestic variables are dependent on a global variable, which in this case is oil price. Thirdly, cross-country covariance allows for shocks in one country to be dependent on the shocks in another country (Pesaran, Schuermann, & Weiner, 2002). The GVAR model is a superior tool to use for studying monetary transmission as it takes into account both long-term theory predicted relationships and indirect links between the variables, and, also, short-term relationships consistent with the data (Smith, 2012).

Data

The chosen set of countries and regions is US, Japan, Euro Area (12 countries: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain), and the Baltic States. Japan, the United States and the Euro Area are chosen for the analysis because they represent the biggest regions in terms of international trade of goods. According to the estimates from 2012, EA 18 countries is on the first place (392,6 billion of USD) followed by the US (318,42 billion of USD) and Japan (140,37 billion of USD) (OECD statistics, 2014). Despite the fact that the authors analyze EA 12 and not EA 18 countries in their work, EA 12 still has a high share in world merchandise, because such countries as Cyprus, Estonia, Latvia, Malta, Slovakia and Slovenia, which were added to EA after 2006 (at that time EA 12 countries), have a negligible part in total EA merchandise trade (European Commission, 2014; World Trade Organization, 2014). Even though, China has a higher share in the trade of goods it is not taken because of the inconsistency in the data. As it is a fast developing economy and in the last ten years there has been a number of structural reforms that have taken place and influenced its economy that would have resulted in biased results during the analysis (Morrison, 2014).

Euro Area 12 (EA12) countries is chosen on purpose as in this case the authors have a full set of Baltic countries in their research. Taking the Euro Area with 17 countries as at 2013 (final year of estimated sample period), which includes Estonia, would eliminate this possibility as one and the same country cannot be included in different country sets simultaneously. Taking the Euro Area with flexible country composition would result into

misleading results. If the set of countries change, such variables as real GDP, for example, would change their values significantly rather than develop gradually over time.

The authors build the model using four variables. All the taken variables are the core ones in every GVAR model aimed at studying transmission mechanisms and, therefore, are included in all the researches reviewed, such as Pesaran, Schuermann, and Weiner (2002) and di Mauro, Pesaran, and Smith (2005), to name the most prominent ones. The quarterly data are downloaded over the period 2000Q1-2013Q3 in order to obtain a full business cycle. The definitions of the initially obtained variables and the sources are presented in Appendix 1.

In order to account for the real output of the economy, the authors use real gross domestic product (GDP). The authors obtain the real GDP indices seasonally adjusted and adjusted by working days, with a reference year 2005 from Eurostat:

$y_{it} = 100 * \ln(GDP_{it})$.

Multiplying the natural logarithm of GDP by 100, enables the authors to describe the percentage change of the index later in the analysis section.

The general price level in each country is accounted for using price indices, which are later recalculated to inflation. Inflation is of exceptional importance as sometimes this variable is targeted by central banks on a country level and, therefore, it is important to follow its response to monetary shocks that might occur (Mayes, 2004). The price indices for all the countries, except for Japan are downloaded from Eurostat, while Japan's index is obtained from OECD statistics:

$p_{it} = 400 * \ln(HICP_{it}/HICP_{it-1})$.

As HICP indices for all the countries except Japan are monthly, the authors take the arithmetical mean of the monthly HICP for three corresponding months, which results in quarterly data. In order to compute the inflation, the authors apply the formula $HICP_t$ / $HICP_{t-1}$ to the price indices. In the work of Pesaran, Schuermann, and Weiner (2002) it is argued that price inflation is better to use compared to the current price level. That was concluded due to the fact that the usage of current price level results into variables being I(2) and makes it impossible to use in the particular model. The price index for Japan is downloaded with 2010 as a base year, and the authors recalculate it themselves to 2005 as a base year. Due to the fact that information on EA12 price index is officially unavailable, the authors compute this variable by themselves, using the chain-linked volume method utilizing the twelve countries' price indices and their HICP weights in EA12. After all modifications, the inflation is seasonally adjusted using the program X12-ARIMA, which was developed by

the US Census Bureau (The X-12-ARIMA Seasonal Adjustment Program, 2013). By multiplying the final result by 400, the authors get the annualized inflation in percentage terms.

Monetary policy works through the changes in nominal short-term interest rates, which is the third variable included in the model. Three month short-term interest rates are obtained from Eurostat. Despite the fact that the ECB or Federal Reserve System (FRS) does not determine or affect directly the three-month EURIBOR and LIBOR rates, but rather the refinancing rate, the money market rate is an even better tool for analyzing monetary policy nowadays. For example, ECB used additional non-standard measures to provide additional liquidity for the existing volatile market during the 2008 financial crisis. In their work Lenza, Pill, and Reichlin (2010) discuss the main three interest rate channels, through which the effect on real economy was passed. First, the short-term rates were influenced. Second, the spreads in the money market were affected. And third, as expectations were affected as well, the money market yield curve changed. As a result non-standard measures increased the monetary base significantly. Due to the fact that three-month EURIBOR takes into account both standard and non-standard measures it can be used as a good approximation of ECB monetary policy changes (Benkovskis, Bessonovs, Feldkircher, & Wörz, 2011):

$r_{it} = 100 * \ln(1 + R_{it}/100)$.

The result from the calculation above, allows the authors to insert the annual interest rate reported quarterly in the model.

Oil prices are included in the model as an approximation of the global price variable. Although, there could be other possibilities of a common variable for all countries, such as prices for food, for example, the majority of researches use oil prices as they are correlated with food prices. Oil prices are downloaded from the US Energy Information Administration:

$p_t^o = 100 * \ln(p_t^o)$.

The oil prices taken in USD currency are included in the model as a natural logarithm. Oil prices are assumed to be determined by the US macroeconomic conditions and therefore are included in the US model as an endogenous variable, while for all other countries oil price is an exogenous variable. In order to make oil prices connected to the macroeconomic fluctuation in the world, the global variable should be tightly linked to the other countries. Out of the existing countries in the particular model, it is most reasonable to assume that the US is closer to determining the oil price compared to any other country present in the model. It is argued that in the last decade there is a strong correlation between oil prices and the USD

dollar fluctuations. In the short-term it is believed that the USD dollar is a good predictor of oil price movements (Hassey, 2013).

The justification for the use of the particular data for the model is present in Appendix 2, where all the tests on variables are defined and the results are described.

Foreign variables and weight matrix

Corresponding foreign variablesy_{it}^{*}, π_{it}^{*}, r_{it}^{*}, are constructed using trade weights. The data for the purpose of identifying trading relationships among the countries is taken from UN Comtrade. In order to construct a trading matrix, the authors obtain the data for all the trade flows between the corresponding countries. The figures for the Euro Area countries are downloaded separately and are later summarized for one region.

Table 1. Weight Matrix (based on fixed weights) of 6 country sets

Country	Estonia	Japan	Latvia	Lithuania	Euro Area	United States
Estonia	0	0.0006	0.1706	0.0983	0.0138	0.0011
Japan	0.0428	0	0.0061	0.0073	0.2197	0.3344
Latvia	0.1235	0.0003	0	0.1779	0.0091	0.0010
Lithuania	0.1056	0.0003	0.2749	0	0.0167	0.0018
Euro Area	0.6568	0.3582	0.5238	0.6633	0	0.6617
United States	0.0713	0.6406	0.0246	0.0532	0.7407	0

Source: created by authors using data from United Nations Commodity Trade Statistics Database (2013)

A program-built weight matrix for six separate country sets can be seen in the Table 1. The fixed weight matrix is constructed based on the 2000-2012 period averages of both imports and exports flows between the countries. All trade shares for every country in a column sum to one. After studying this matrix it is possible to draw conclusions in terms of which countries will most probably have more pronounced transmission of monetary shocks based only on the trade relationships they have. In respect to the three Baltic countries, each of them separately has a negligible part of trade with Japan and the US and, therefore, the direct effects cannot be expected to be strong; however, there will be an indirect effect via the EA and other links. Out of the three Baltic countries, Lithuania has the biggest amount of trade with EA12. The monetary effects coming from the EA should have the most pronounced direct effects in the US. The United States has the biggest share of trade with the EA. Moreover, if looking at Japan's trading relationships, its share of trade with US is bigger than with the EA. Therefore, shocks generated in the US should be more pronounced in the EA, while shocks generated in Japan should have stronger effects in the US. Latvia, Lithuania and Estonia are closely dependent on each other, which can also be observed from the trade

matrix. Therefore, it is vital to include all three Baltic countries in the model as in this way it gives a better picture of the work of cross-border transmission in each of the countries.

Table 2. Weight Matrix (based on fixed weights) of 4 country sets

Country	Baltics	Euro Area	Japan	United States
Baltics	0	0.0396	0.0011	0.0039
Euro Area	0.9005	0	0.3582	0.6617
Japan	0.0257	0.2197	0	0.3344
United States	0.0738	0.7407	0.6406	0

Source: created by authors using data from United Nations Commodity Trade Statistics Database (2013)

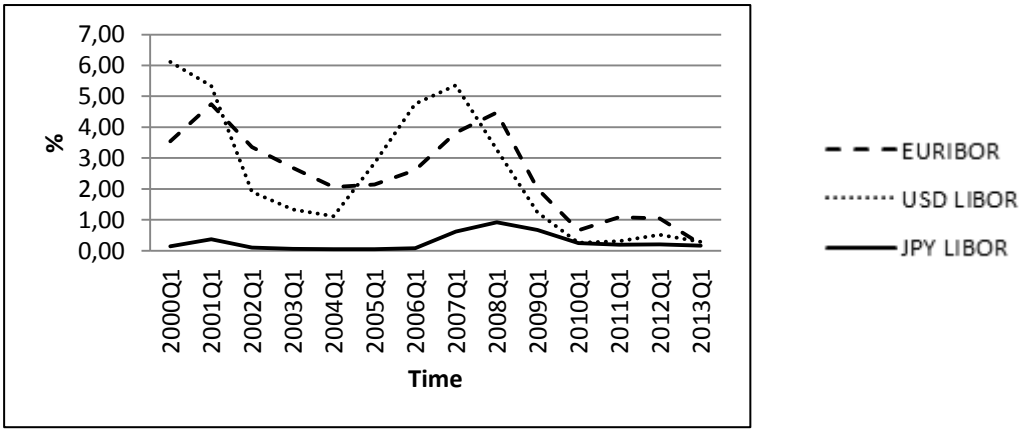
The weight matrix for US, EA, Japan and the Baltic states as one region can be seen in Table 2. When Latvia, Estonia and Lithuania are aggregated under the Baltic region, the main patterns of trade relationships do not change dramatically. The dominant Baltic trade partner is the Euro Area and as the Baltics does not have strong enough trade relationships with other countries, the monetary shocks from other countries should be transmitted to the Baltics through its link with the EA.

For answering the different sub-questions, the three Baltic countries are either grouped into one region or viewed separately. In this case regional variables are constructed from country-specific variables using PPP-GDP weights, which are not the same weights as those used for the computation of the foreign variables.

Monetary policy in EA, US and Japan over 2000-2013

General description of the monetary policy carried out in the EA, US and Japan helps to get an overview of the changes in short-term rates made, based on the macroeconomic situation in the country.

Figure 1. Three-month USD LIBOR, JPY LIBOR and EURIBOR development over 2000-2013



Source: created by authors using data from Eurostat (2014c)

In US in 2001, the high interest rates were due to the burst of the dotcom bubble and the 9/11 attacks. From 2005-2008, an increase in short term interest rates was accompanied by a decrease in the US inflation. During the financial crisis, from 2007-2008, this effect was observed the most, as the country faced liquidity problems, the burst of the housing bubble and the sub-prime crisis (Financial Crisis Inquiry Commission, 2011). Currently the level of short-term interest rates in US is quite low, which is comparable to the situation in EA and Japan.

The main aim of the Euro Area monetary policy is to have price stability and to keep the inflation at a level that is around two percent over the medium term (European Central Bank, 2014). Over the last 13 years, there were three main interventions in the monetary policy by the European Central Bank, which happened on the 14th and 22nd of September and 3rd of November 2000. The ECB together with the United States and Japan intervened in order to increase the market value of the EUR, which at that time was at an all-time low of below 85 cents, since its introduction into the market in January 1999. During the financial crisis in 2007-2008, there can be seen an increase in short term interest rates, as an expansionary monetary policy was implemented in order to deal with the liquidity problems. Furthermore, during the sovereign debt crisis 2009-2011, severe austerity measures and bailout programs were enforced in order to deal with the countries in recession (Greece, Italy, Spain, Portugal, Ireland) (International Monetary Fund, 2012).

For the past 15 years Japan has been dealing with deflation. Its central bank implemented an expansionary monetary policy and intervened only during the sovereign debt crisis. The main reason was that the economy was affected by the situation in the United States and Europe, which led to a worsening in the price stability of the country. During this period (2007-2008) the inflation was declining and interest rates were increasing; however, after 2009, the interest rates returned to their previous level (Bank of Japan, 2008; Bank of Japan, 2014).

Model specification

As most of the variables are justified according to the test results (see Appendix 2 for detailed description), the authors find a single set of model specifications to obtain fitting results for both models. The choice of lags (p, q) for the parameters is done based on the Akaike Information Criterion (AIC), with a lag order of two for all domestic variables and a lag order of one for the foreign ones in both models. Moreover, for the VECMX (country-

specific vector error correcting model with foreign variables) estimation, the model with an unrestricted intercept and no trends identified in the co-integration space is chosen (case III). Rank order being equal to one is applied in both cases, as it gives the results with most realistic convergence properties of the model. The summary of specification of both models is in Appendix 3.

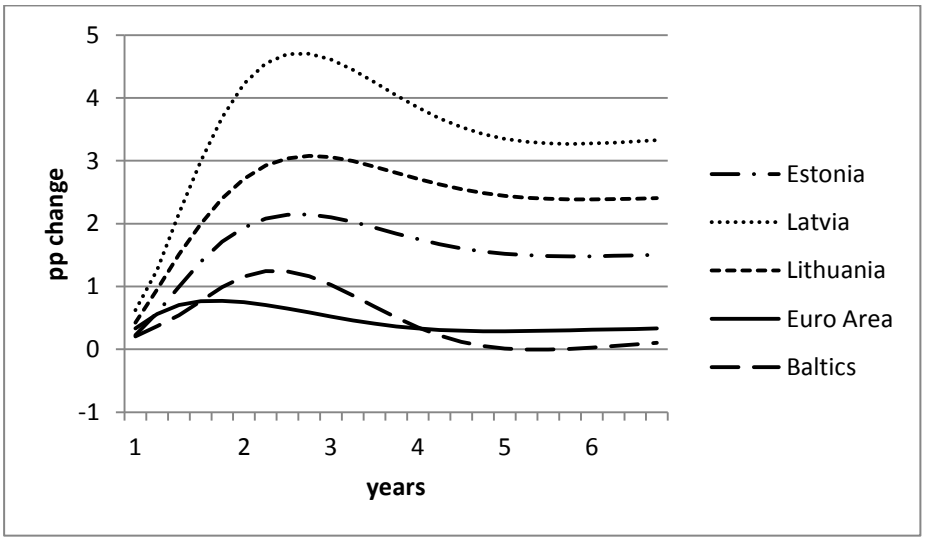
Analysis and discussion of results

A monetary shock in this work is defined as an unexpected change in short-term interest rates. For the easiness of comparison the authors equalize all the shocks to 25 basis points, which is a standard move of the central bank.

In order to interpret the results correctly, it is crucially important to distinguish between expected versus unexpected changes in interest rates. In the case of monetary shocks, the only thing, which matters is the unexpected change as expected changes are already incorporated into the interest rates structure, according to the expectations theory (Woelfel, 1993). Monetary policy shocks are analyzed using Generalized Impulse Response Functions (GIRF), which plot the response to an unexpected change in the monetary policy at different points in time for all the variables in the model. In this work, the authors analyze only monetary policy shocks generated in one particular country block and their response over a six year time horizon. Such time horizon is chosen in order to analyze both short-term effects and also convergence properties.

EA generated shock

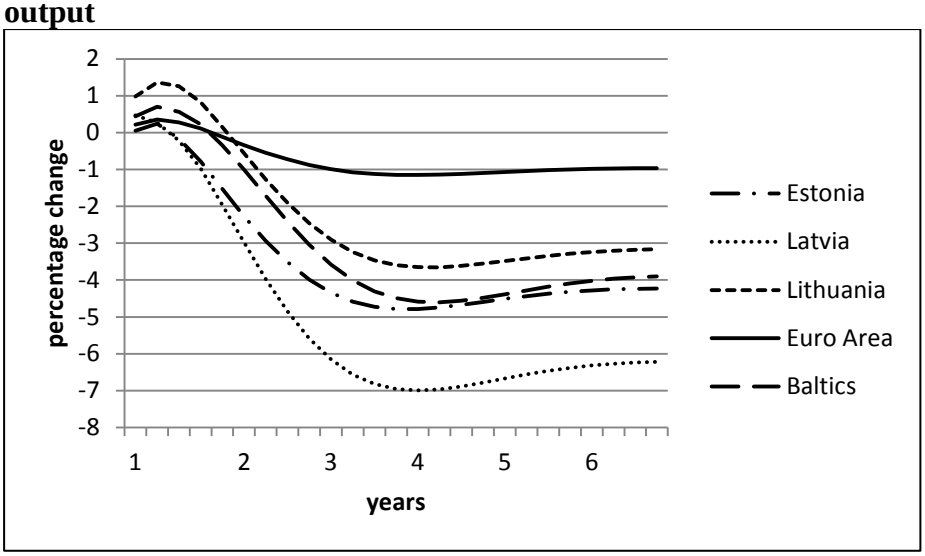
Figure 2. GIRFs of an unpredicted 25 bp positive shock to EA short-term rates on interest rates



Source: created by authors

Contractionary monetary policy in the EA causes all the short-term interest rates of the studied countries to increase, with the sharpest increase observed in Latvia. An unusual phenomenon observed in this graph is that the interest rate growth for the Baltics as a region is much smaller than for each country taken separately. In order to explain this occurrence it is important to remember how foreign variables are constructed in the GVAR model. All the variables are dependent on their own lagged variables and foreign lagged variables included in the model. It is quite important to note that the weights used for the computation of the foreign variables are the same for all the variables. Meaning that the weights calculated based on the trade patterns are used for the computation of foreign GDP, as well as, inflation and interest rates. Therefore, for example, in the case of Latvia, Lithuania and Estonia have a big influence over Latvian variables. That is perfectly justified in the case of GDP, as spillover effects in terms of GDP between the Baltic countries are quite important. However, it is not adequate to state that Latvian interest rates are by 27 percent determined by Lithuanian interest rates and by 17 percent by Estonian interest rates (numbers according to the estimated weight matrix, Table 1). Interest rates of any of the Baltic countries are mostly determined by the EA. The same goes for inflation, although to a smaller extent, as price growth is largely dependent on global prices. Therefore, it is reasonable to compare regional and each country's separate response to monetary shocks in quantitative terms only in the case of GDP. If inflation and short-term rates are analyzed it makes sense to compare only qualitative information as the values for the separate Baltic countries are exaggerated.

Figure 3. GIRFs of an unpredicted 25 bp positive shock to EA short-term rates on real output

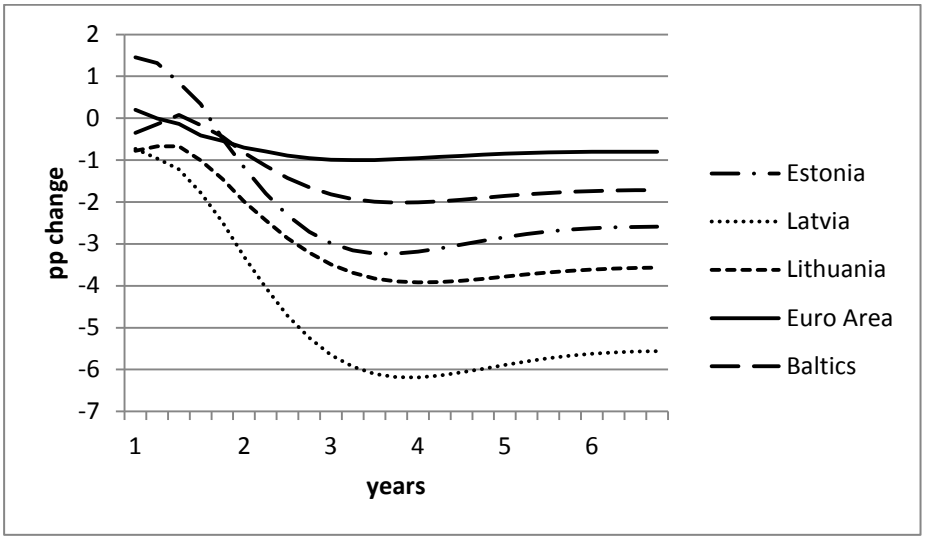


Source: created by authors

One positive EA short-term interest rate shock is equivalent to a one percentage drop of EA GDP over the long-term. The effect on the Latvian GDP is most pronounced, as in the long-term it is predicted to drop by 6.3 percent, while in Lithuania only by 3.2 percent. Real output in the Baltics stabilizes after 3 years. When shocks are transmitted from the EA to the Baltic countries, both interest rate and foreign demand channel are working well.

Speaking about the differences between the three Baltic countries, the effect for Latvia is the strongest one. The interest rate and demand channels are working stronger in the case of Latvia. It is possible to make an assumption about which of these channels adds more to the total effect. The interest rate channel could be more pronounced if a certain country had more credits denominated in the currency of the country where the shock comes from. From the three Baltic countries, Latvia has the biggest amount of its government debt denominated in EUR. In 2012, in Latvia 62.5 percent of the total debt was denominated in EUR and in Lithuania 42.1 percent (Eurostat, 2014g). That implies that any unexpected changes of the interest rates imposed by the ECB have a bigger direct impact on Latvian macroeconomic variables. In order to investigate the foreign demand channel it is insufficient to view only overall trade flows. Foreign demand channel works through the change in the domestic demand, which affects both consumption of domestic goods and exports. For example, the foreign demand channel for Latvia works as follows: changes in the ECB monetary policy affect consumption of EA domestic production and consumption of goods exported to the EA, including exports from the Baltics as well. Therefore, it is important to consider exports to the country where the shock originated from and the authors decided to view export statistics of the Baltic countries. As the goal is to investigate how important foreign EA demand is for the Baltics it is important to consider what share of exports of each of the Baltic countries goes to the EA. For that purpose the authors have extracted additional data from the UN Comtrade website related to export flows from the Baltic countries. According to the data in Appendix 4, Estonia exports the biggest part of its production to the EA, while Latvia and Lithuania have a smaller share of total exports sent to EA countries. However, it should be mentioned that the composition of other export partners also plays an important role. For instance, Estonia exports a big part of its production also to Sweden, which stabilizes their overall export flow. The same is true for Lithuania, which has Poland among its trading partners, a country that had quite a stable performance during the crisis years. While for Latvia all the other export partners, such as Russia, for example, expose the country to big fluctuations (United Nations Commodity Trade Statistics Database, 2013).

Figure 4. GIRFs of an unpredicted 25 bp positive shock to EA short-term rates on inflation



Source: created by authors

Higher interest rates lead to a decrease in inflation in all the studied countries. For the case of Estonia, it can be observed that during the first year prices are predicted to increase, which represents a price puzzle as described in the theoretical review. This particular issue is addressed in the further research part. Overall, it can be seen that the EA interest rate shock has a stronger effect on the GDP of the Baltic countries than on its own inflation.

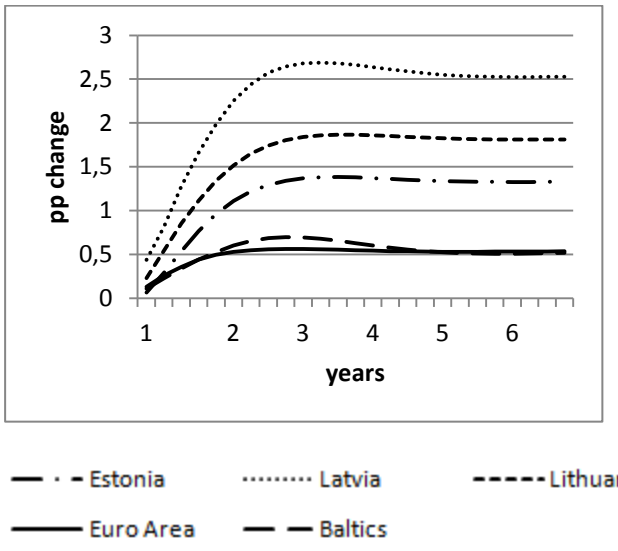
According to the theoretical prediction if inflation decreases over the long-term, foreign demand is dominating over the exchange rate appreciation effect. That is absolutely in line with the real situation in the Baltics. Both Latvian and Lithuanian national currencies during the observed period have been fixed to EUR and Estonia has been fixed to EUR before 2011 and later adopted this currency. Thus there is no exchange rate channel between the Baltic countries and the EA, which eliminates the negative effect of monetary policy on foreign inflation. Foreign demand channel is working strong enough according to the empirical results. As a result of increased interest rates in ECB, investment opportunities become less attractive and the investment decreases, which inevitably reduces the real output of the economy. As a result, consumption of imported goods decreases in the EA, which means that the demand for exports from Latvia to EA declines as well, which forces Latvian prices to drop.

For this type of shock the authors construct bootstrap mean estimates with a 70% confidence interval as it was done in the works of Blaes (2009) and Benkovskis, Bessonovs, Feldkircher, and Wörz (2011). The results for EA and the three Baltic countries are present in

Appendix 5. Bootstrap is carried out with 5000 replications. Except for the EA short-term rates reaction, all the other responses are statistically significant, which implies that the obtained results of this model are credible.

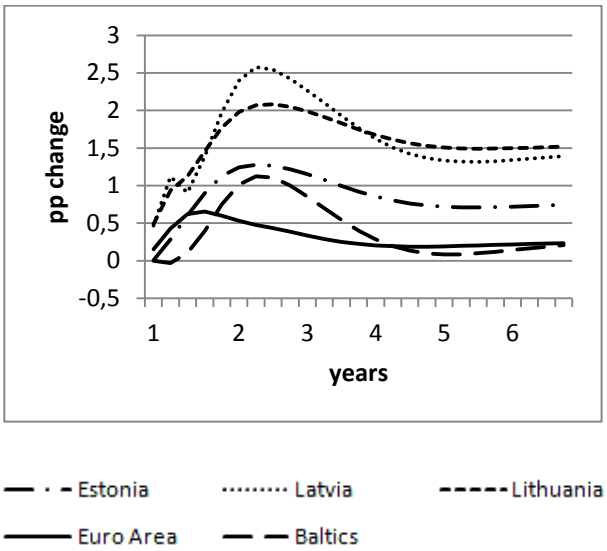
Japan and US generated shocks

Figure 5. GIRFs of an unexpected 25 bp shock to US short-term rates on interest rates



Source: created by authors

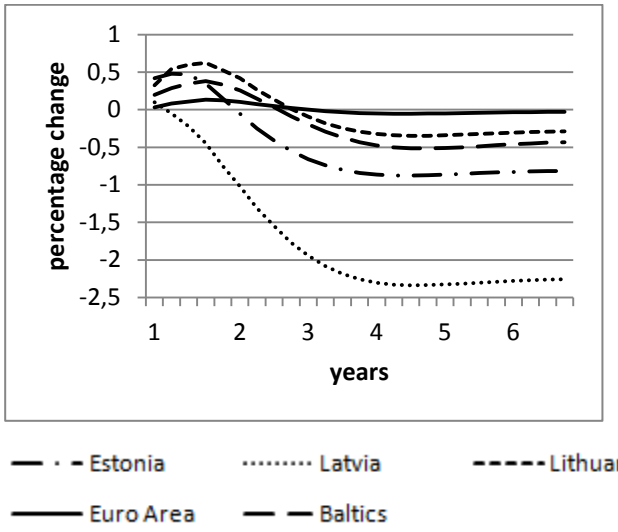
Figure 6. GIRFs of an unexpected 25 bp shock to Japan short-term rates on interest rates



Source: created by authors

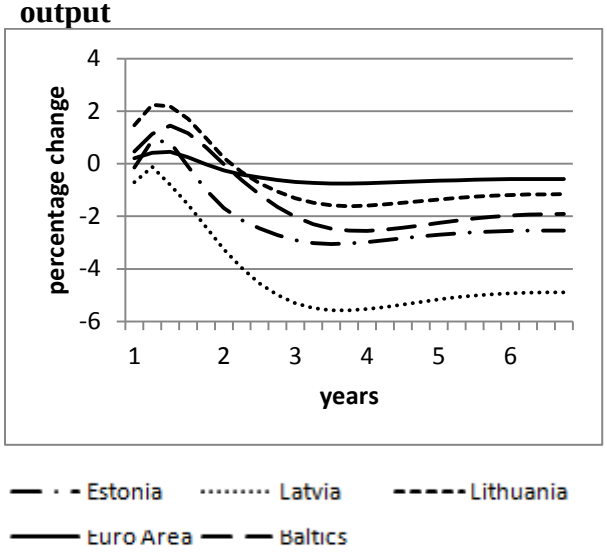
Both shocks cause the interest rates of other countries to shift in the upward direction. Keeping in mind that the Baltic countries have much more trade relationships with the EA than with Japan and US, it can be explained why the increase is not so big compared to the monetary shock coming from the EA. Speaking about the differences in effects, US generated shocks result into much more gradual change comparing to Japanese shock. In case of Japanese shock the stabilization for EA happens much faster than for the Baltic region. That could be due to the fact that the Baltics receive this effect not directly, but rather through its link with the EA and, therefore, the effect takes more time to occur. In general long-term changes for all the studied countries are smaller in the case of monetary shock coming from Japan. Meaning a 25 basis point shock to Japan short-term rates causes short-term rates of EA to rise by 22 basis points and Baltics by 20, while a 25 basis point shock to US results into long-term increase of short-term rates of EA by 53 and for Baltics as a region by 51 basis points. That is in line with the conclusions from the weight matrix constructed, as both EA and Baltics have more trade with US than with Japan.

Figure 7. GIRFs of an unexpected 25 bp shock to US short-term rates on real output



Source: created by authors

Figure 8. GIRFs of an unexpected 25 bp shock to Japan short-term rates on real output



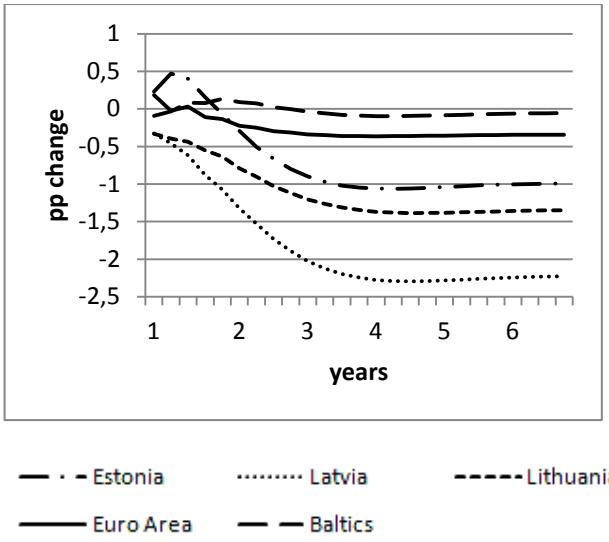
Source: created by authors

Despite the fact that the effect on interest rates was smaller when the shock was generated in Japan, the real output reaction is stronger in the case of the shock coming from Japan. As a result of a 25 basis point shock to Japan short-term rates, the GDP of the EA drops by 0.58 percent over the long-run, while the drop for the Baltics is predicted to be 1.9 percent. No major changes are expected in terms of the EA real output reaction to US short-term interest fluctuations. Despite the small increase during the first two years after the shock, the GDP stabilizes after a decrease of 0.03 percent. The effect is considerably stronger for the Baltic countries, a decline by 0.4 percent for the region as a whole.

When interpreting monetary policy shocks coming from Japan it is crucial to remember three-month JPY LIBOR development over 2000-2013. The performance of short-term interest rates in Japan was vey stable, at a low level and varied only slightly, therefore, any unexpected changes in JPY LIBOR result into a big effect on other macro variables. Comparing with the three-month USD LIBOR development the difference becomes even more pronounced, as short-term rates in US were very volatile and at a comparatively high level; therefore, the same amount of unexpected shock does not have such a big impact in US as it has in Japan. The impact the shock has on its own domestic variables translates into a similar effect on other foreign countries as well. Japan interest rate is close to the zero-lower-bound, which may create some nonlinear effects not captured by our model.

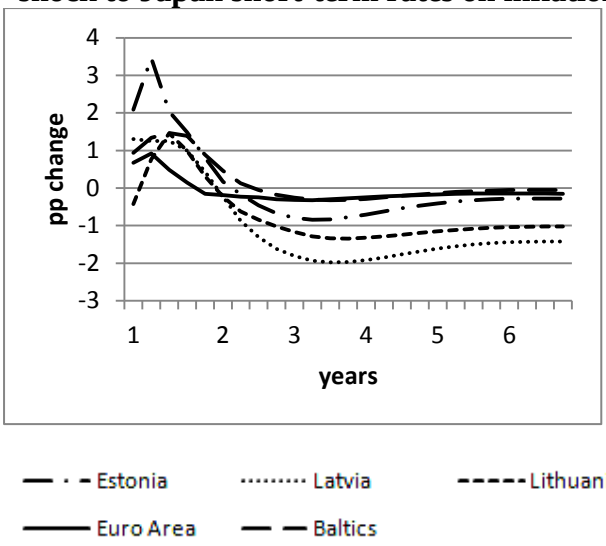
According to Kim (2000), US monetary contraction should have translated into quite a substantial decrease of GDP for other countries due to the fact that US interest rate changes affect world interest rates substantially. As current goods become more expensive compared to future consumption, world demand should have decreased both in US and non-US countries. Although, recent studies argue that China is getting more influence over global rates (Feldkircher & Korhonen, 2012).

Figure 9. GIRFs of an unexpected 25 bp shock to US short-term rates on inflation



Source: created by authors

Figure 10. GIRFs of an unexpected 25 bp shock to Japan short-term rates on inflation



Source: created by authors

Comparing the reaction on inflation of different origin shocks, the authors can conclude that a 25 basis point shock to Japan short-term rates causes EA inflation to drop by 15 basis points and the inflation of the Baltics by 5 basis points. In this case, the price puzzle is present for all countries. The potential solution to this problem is addressed in the section further research. Same amount of shock from US results into drop of EA inflation by 35 and for Baltics by 6 basis points. That is quite a unique case when the reaction for the Baltics in general is smaller than for EA. The results for the Baltics are quite similar, while the reaction on EA, in terms of inflation, is stronger in the case of a US originated shock.

Based on that, several conclusions can be drawn on the work of transmission mechanisms between these countries. The interest rate channel is rather weak in the case of US shocks transmitted to the EA, while the exchange rate channel is strong. According to Mayes (2004), the exchange rate channel is relatively more important for open and small economies. Although, we cannot claim that EA is a small economy it is certainly quite open

compared to Japan and US. According to ECB estimates, in 2012 EA exports of goods and services were equal to 26.8 percent as a share of GDP, which is more than in Japan and twice as much as in the US (European Central Bank, n.d.). US is among the biggest EA export trading partners, which means that the exchange rate channel is crucial for the transmission of monetary shocks from US to EA (Eurostat, 2014h).

Generally, the Baltics does not have its own transmission mechanisms with such countries as US and Japan, but shocks are transmitted through its channels with EA. Interest rate changes for the Baltics and the EA are quite similar, while the spillover effects in terms of GDP and inflation reaction for the Baltics are almost always bigger, which is a proof of high spillover effects that the Baltic countries are exposed to.

Further research

Such problem as the price puzzle is not expected to arise in the model where so many transmission channels are taken into consideration; although, in this particular case this problem could have appeared due to omitted variable bias. Possibly, the addition of such variable as exchange rate could align changes in the price levels of different countries.

A potential solution for the problem of inadequate weights used for the computation of foreign inflation and interest rate variables would be to use different kind of weights for different variables, but this opportunity is not provided by the GVAR_Toolbox 1.1 used for the empirical estimation. Additional programming is needed for this purpose, which could be a further improvement of this work.

The model is certainly lacking several important trading partners for the Baltic countries, such as Russia, Poland, Belarus and Sweden. Adding these countries would certainly benefit the research and obtained results as it would allow for more monetary transmission channels to be taken into account.

Conclusion

The conclusions are structured so as to answer the three research sub-questions stated in the beginning of the work.

1. What is the effect of Euro Area-wide monetary policy shocks on the main macroeconomic variables in the Baltic States?

Comparing the three different origin shocks it can be concluded that the Baltics have the strongest effect from EA shocks, which is perfectly in line with the expectations and results of previous researches. An unexpected 25 basis point increase in the short-term interest rates of the EA results into one percent drop in the GDP of EA, 3.2 percent for Lithuania, 6.3 percent for Latvia and 4.2 percent for Estonia. The same amount of shock translates into a 0.9 percentage point drop for EA inflation and 1.7 for the Baltics. There are lots of reasons for the Baltics having the most pronounced reaction from EA short-term interest rate shocks. Firstly, the biggest part of the Baltics exports goes to EA countries, which strengthens the foreign demand channel. Secondly, all three Baltic countries have quite a big amount of both government and household loans denominated in EUR. Thirdly, the Baltic countries are open economies and, therefore, are easily affected not only directly, but also indirectly through strong links with other countries.

When shocks are transmitted from the EA to the Baltics there is no exchange rate channel, as all the Baltic countries are either fixed to EUR or have already adopted this currency, therefore, only the interest rate and the foreign demand channels are working. Both inflation and real output are predicted to decrease over the long-term as a result of contractionary monetary policy in the EA.

2. What are the spillover effects of US and Japan monetary policy shocks on the main macroeconomic variables in the Baltics and the Euro Area?

The results of both shocks are very much in line with the predictions drawn from the trade relationships the countries and regions have among themselves. As the Baltics does not have a substantial amount of trade with Japan and US, the effect from these countries is indirectly passed to the Baltics through its link with the EA. US generated shocks are transmitted to the EA economy mostly through the exchange rate channel and, therefore, the reaction for EA and, consequently, the Baltic inflation is quite strong.

3. What are the differences in impulse responses between the Euro Area and the Baltic States, and among the three Baltic countries?

Considering the EA shocks separately, for Latvia the effect is always more pronounced than for the other two Baltic countries. This is mostly due to the interest rate

channel, which works through the big amount of debt denominated in EUR. As well as, the composition of exporting partners of Latvia adds volatility to its macroeconomic performance, compared to Lithuania and Estonia.

Currently, the ECB monetary policy effects are important for the Baltics. Generally, after joining a currency union, countries are expected to increase their openness and, therefore, the importance of ECB monetary decisions for the Baltic States could increase even more.

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Appendices

Appendix 1: Summary of the description and sources of the variables

Variable Name	Definition	List of countries	Source
Inflation (π_{it})	The economic indicator (HICPs) which measures the change in prices over a certain time period (reference year 2005)	Belgium, Germany, Ireland, Greece, Spain, France, Italy, Luxembourg, Austria, Netherlands, Portugal, Finland, Estonia, Latvia, Lithuania, US	Eurostat
		Japan	OECD stat.
Interest rate (r_{it})	The 3-month short term interest rates	EA12,Estonia, Latvia, Lithuania, US, Japan	Eurostat
GDP (y_{it})	The value added from domestically produced goods recorded at constant price indices (reference year 2005). Adjusted seasonally and by working days	EA12,Estonia, Latvia, Lithuania, US, Japan	Eurostat
Oil price (p_t^o)	Petroleum (crude oil) price in US Dollars per barrel.	US	US Energy Information Administration
HICP weights	The aggregate spending on any goods or services, expressed as a percentage of the total spending on all HICP covered goods and services. The country weights are denoted in Euros and derived from the Household Final Monetary Consumption Expenditure (HFMCE)	Belgium, Germany, Ireland, Greece, Spain, France, Italy, Luxembourg, Austria, Netherlands, Portugal, Finland	Eurostat
Trade flows	The import/export flows of the reporter and partner countries (annual data)	Belgium, Germany, Ireland, Greece, Spain, France, Italy, Luxembourg, Austria, Netherlands, Portugal, Finland, Estonia, Latvia, Lithuania, US, Japan	UN Comtrade
GDP-PPP	The GDP converted to US Dollars using the Purchasing Power Parity (PPP) conditions, by adding taxes on goods and services and subtracting subsidies not related to the product value.	EA12,Estonia, Latvia, Lithuania, US, Japan	Eurostat

Source: created by the authors using data from Eurostat (2014a, 2014b, 2014c, 2014d, 2014e, 2014f), OECD statistics (2013), United Nations Commodity Trade Statistics Database (2013) and US Energy Information Administration (2014).

Appendix 2: Testing variables

The chosen variables are tested according to several parameters in order to be justified for the inclusion in the model.

Unit root test

The unit root test is used to check for the stationarity of the parameters as all the variables should be integrated around order 1. The zero hypothesis is that there exist a unit root and, therefore, the variable is non-stationary. The aim is to check whether variables are stationary if one difference is taken, meaning I(1). Rejecting the hypothesis for the first difference would give the authors an opportunity to consider the long-term relationship between the variables as co-integrating. According to Pantula, Gonzalez-Farias, and Fuller, (1994) the weight statistics (WS) give more reliable results compared to ADF results because the main criteria for selection is the Akaike Information Criterion (AIC) used with the standard ADF estimations (Dées, Mauro, Pesaran, & Smith, 2005).

According to the results obtained for the country model for the domestic variables, the real GDP (*dy*) based on WS estimations is I(1) in most of the cases, except for the Baltics as a region which is I(2). Inflation (*dp*) is I(1) for the Baltics, United States, Japan and the Euro Area. The short-term interest rate (*dr*) for Japan is I(2) and I(1) for US, the Baltics and the Euro Area. Looking at the country model with the foreign variables, the situation is mostly the same. The real GDP, inflation and short-term interest rate is I(1) for all regions. As for the global variables (oil price) based on WS test it is I(1) as well.

In the case of Baltic countries separately, the results for the unit root test for the domestic country model are fairly similar to those mentioned above for Baltics as a region. The slight differences lie in the fact that for the GDP the three Baltic countries are I(1). The short-term interest rate for Japan is I(2), while all the other countries are I(1). For the foreign variable country model there are no deviations observed from the results obtained in the region specific model described above. In this case the oil price is also I(1) as in the previous case.

Weak exogeneity

The main assumption of the model is weak exogeneity of foreign variables, which implies that domestic variables will not affect foreign variables in the long-run. Such kind of test was first described by Johansen (1992) and Harbo, Johansen, Nielsen, and Rahbek (1998). The test of joint significance of the estimated error correction term in each country specific model is run both for foreign and global variables. It is an F-test on joint hypothesis,

where the zero hypothesis stands for weak exogeneity and joint coefficient being equal to zero.

$$\Delta x^{*}_{1t,l} = \mu_{1l} + \sum_{j=1}^{r_1} \gamma_{1j,l} * ECM^{j}_{1,t-1} + \varphi_{1,l} * \Delta x^{*}_{1,t-1} + \vartheta_{1,l} * \Delta x_{1,t-1} + \epsilon_{1t,l}$$

$$\Delta x_{0t,l} = \mu_{1l} + \sum_{j=1}^{r_1} \gamma_{1j,l} * ECM^{j}_{1,t-1} + \varphi_{1,l} * \Delta x^{*}_{0,t-1} + \vartheta_{1,l} * \Delta x_{1,t-1} + \epsilon_{1t,l}$$

The null hypothesis for the F test is: $\gamma_{1j,l} = 0$, j = 1, 2, 3, …, r_1
(Mauro & Pesaran, 2013).

The test results show that for the case with the regions all variables are exogenous. However, in the situation when the Baltics are included as separate states, the short-term interest rate for Latvia and GDP for the Euro Area are the only variables which do not satisfy the exogeneity condition.

Serial correlation

The F-statistic used for the evaluation of residual serial correlation is the F-version of Lagrange Multiplier (LM) statistic. The zero hypothesis stands for no serial correlation and, therefore, it is desirable not to reject the zero hypothesis for the majority of cases (Smith, 2012). Serial correlation could be reduced if more domestic lags are chosen.

For testing for the residual serial correlation it is necessary to take into consideration the l^{th} equation of the estimated model for the i^{th} country:

$$\Delta x_{it,l} = \hat{\mu}_{il} + \sum_{j=1}^{\widehat{r_1}} \hat{\gamma}_{ij,l} * \widehat{ECM}_{ij,t-1} + \sum_{n=1}^{\widehat{p_i}-1} \hat{\varphi}'_{in,l} * \Delta x_{i,t-n} + \sum_{s=0}^{\widehat{q_i}-1} \widehat{\vartheta'_{is,l}} * \Delta x_{i,t-s} + e_{it},$$

which can be re-written as:

$$\gamma_{it,l} = \widehat{\theta'_{il}} * z_{it} + e_{it,l} \ ,$$

where $\gamma_{it,l} = \Delta x_{it,l}$ and $z_{it} = \left(1, \widehat{ECM}'_{ij,t-1}, \Delta x'_{i,t-n}, \Delta x'^{*}_{i,t-s}\right)', \widehat{ECM}_{ij,t-1}$, j = 1, 2, 3, …, r_i represent the estimated error correction terms for the $r_i$co-integration relation of the model and

$$\hat{\theta}_{il} = \left(\hat{\mu}_{il}, \hat{\gamma}_{ij,l}, \hat{\varphi}'_{in,l}, \hat{\vartheta}'_{is,l}\right).$$

For the F-test, the result obtained for the F-actual are be compared to the F-critical ($F_{p_{ei},T-k_i-p_{ei}}$), where *T* represents the sample size, p_{ei} is the number of lagged error terms from the regression and k_i is the total number of regressors of the model (Mauro & Pesaran, 2013).

In the case of regions, serial correlation is detected for the inflation rate in the Baltics, the Euro Area and the United States and for the short-term interest rate for the Baltics and the

US. In the other cases, serial correlation is identified for GDP in Estonia, short-term interest rate in the US and for the inflation across Latvia, the Euro Area and the United States.

Co-integration tests

Further on it is important to determine the number of co-integrating relations for each country specific model. Critical values for determining these parameters are taken from MacKinnon, Haug, and Michelis (1999). There are several theoretical long–term relations that could be found with the particular set of variables: purchasing power parity, output convergence, the Balassa-Samuelson effect. The choice of different co-integrating vectors for each country could severely affect the results, meaning the impulse response functions and the persistence profiles. Therefore, different number of co-integrating relations will be tested with different number of lags (Bussière, Chudik, & Sestier, 2009).

Appendix 3: Model specifications

VARX Order of Individual Models (p: lag order of domestic variables, q: lag order of foreign variables)

	p	q	Intercept and trend	Rank orders
Baltics	2	1	3	1
Euro Area	2	1	3	1
Japan	2	1	3	1
US	2	1	3	1

Source: Created by the authors

VARX Order of Individual Models (p: lag order of domestic variables, q: lag order of foreign variables)

	p	q	Intercept and trend	Rank orders
Estonia	2	1	3	1
Japan	2	1	3	1
Latvia	2	1	3	1
Lithuania	2	1	3	1
Euro Area	2	1	3	1
US	2	1	3	1

Source: Created by the authors

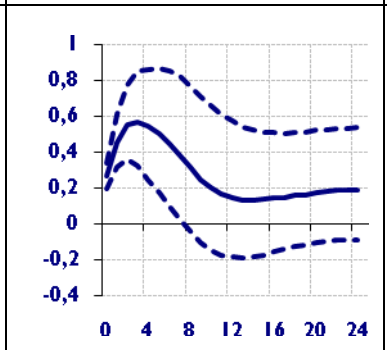
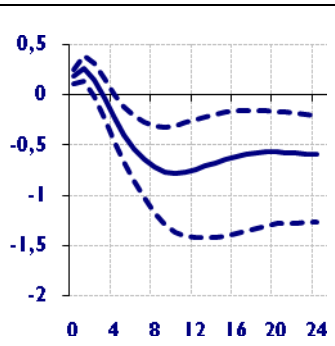
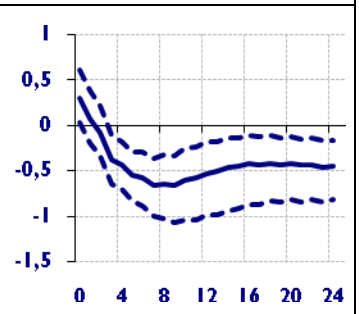
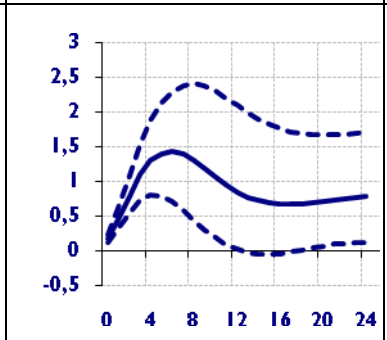
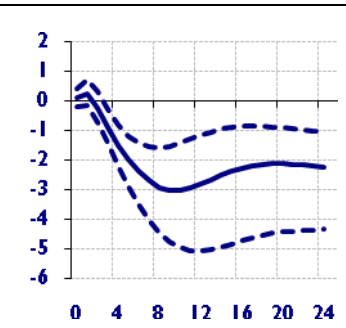
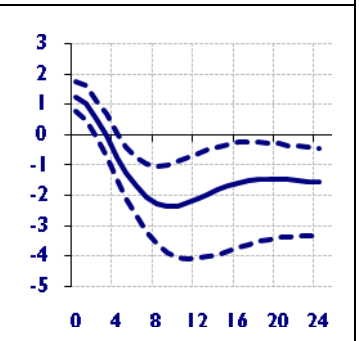
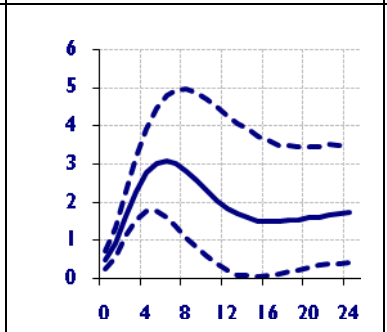
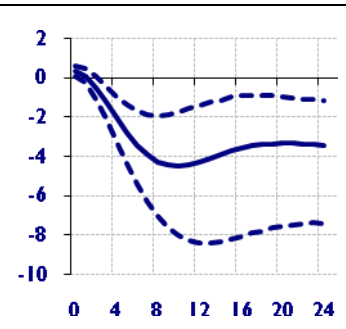
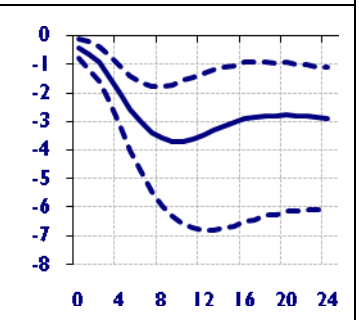
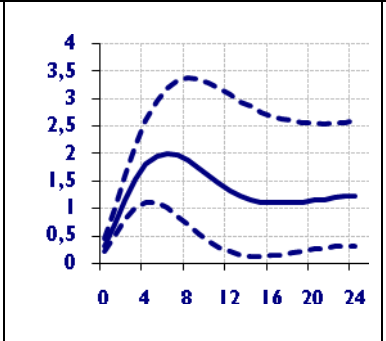
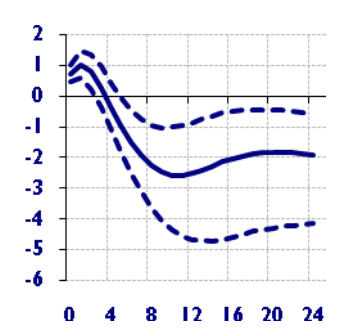
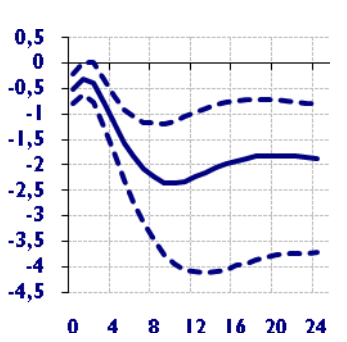
Appendix 4: Export of Baltic countries to the EA

	Share of exports to EA in total exports		
	Lithuania	Latvia	Estonia
2000	30.83	30.60	44.32
2001	25.80	30.23	41.42
2002	25.70	29.57	36.65
2003	26.97	29.70	39.04
2004	30.38	24.94	35.74
2005	27.81	23.23	37.56
2006	24.89	23.92	29.28
2007	25.15	21.57	29.00
2008	22.75	21.31	28.35
2009	26.24	21.29	29.38
2010	25.65	21.00	27.66
2011	25.65	19.19	27.07
2012	22.24	18.45	24.58
Average 2000-2012	26.16	24.23	33.08

Source: created by the authors using data from United Nations Commodity Trade Statistics Database (2013)

Appendix 5: Results of the bootstrap procedure

GIRF of 25 bp shock to EA short-term rates (bootstrap mean, upper and lower bound 70% estimates)

	Interest rate	GDP	Inflation
EA			
Estonia			
Latvia			
Lithuania			

Source: created by the authors