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Transmission of euro area shocks to Central and Eastern European countries. Implications for monetary autonomy problem and business cycles synchronization.

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ABSTRACT

This paper uses the VAR methodology to analyse the effects of European Central Bank monetary policy shocks and euro area output and inflation shocks on the European Union member states from Central and Eastern Europe. First, we look at the strength of effects of identified euro area monetary policy shocks and compare the influence with the one of the domestic policy shocks. Next, we turn to analysis of output and inflation responses to euro area output and inflation shocks relative to aggregate euro area reaction. We provide implications for each country monetary policy decision process and draw conclusions concerning readiness for euro adoption, both from monetary and real economy point of view.

Keywords: monetary policy shocks, VAR, international transmission, business cycles, EMU enlargement

JEL Classification: E52, F42, F36

1. Introduction

In the globalizing world where effects of policy and economic changes in one country increasingly affect other countries, the international transmission of monetary policy shocks, especially from US, has drawn attention of many economists. However, it seems plausible that European Central Bank's (ECB) policy influence also goes beyond euro area borders. Especially, the neighbouring countries from Central and Eastern Europe (CEE) seem to be susceptible to such spill-overs due to factors such as their close trade and financial ties with the euro area, relative small size and relatively high openness of these economies.

Based on this background, the main aim of this paper is to investigate the effects of euro area monetary policy shocks on CEE economies and to determine the strength of ECB's policy impact as compared to domestic policy one. Additionally, we study also the effects of euro area output and inflation shocks. In order to present that, we estimate a VAR models for chosen CEE countries which have not adopted the common currency yet.[1]

Studying the effects of both monetary and real economy shocks has important implications. First, the effects of euro area shocks on CEE economies provide information to the countries' central banks. While analysing domestic economic situation and making decisions on the monetary policy, central banks have to take into consideration all variables plausible for the task. Showing the effects of foreign variables and monetary policy on the domestic economy says how useful developments in euro area can be for domestic economy analysis and policy making.

By studying countries of both floating and flexible exchange rate regimes, we are also able to bring new evidence on a theory of monetary autonomy. The impossible trinity theorem states that monetary autonomy can supposedly be only achieved when country resigns from controlling its exchange rate. However, there also exist studies implying that, outside few largest economies, countries do not have much monetary freedom regardless of exchange rate regime (see, for instance, Frankel et al., 2004). We want to re-examine that problem.

What's more, the extent to which CEE countries are affected by euro area shocks is important for future euro adoptions.[2] When it comes to monetary policy, the more a country is affected by ECB's monetary policy decisions now, before euro adoption, the lower should be a cost of giving up its own monetary policy when it joins the monetary union. What's more, dissimilar reactions of output and inflation to the common monetary policy make the central bank the cause of asymmetric shocks and thus, the monetary policy works against instead of in favour of the existence of monetary union. Such situation would also nullify the benefit of monetary union in form of elimination of domestic monetary policies as sources of country idiosyncratic shocks.

The reactions of domestic variables to euro area output and inflation shocks, on the other hand, inform us about business cycle synchronization, the problem underlined by OCA theory. For monetary union to be sustainable, countries should not be affected by asymmetrical shocks which make carrying out of monetary policy difficult since it cannot fit well countries with divergent business cycles. Therefore, we consider responses to euro area output and inflation shocks that are consistent with aggregate euro area reactions as important condition for future success of enlarged euro area.

The main advantage of the paper approach, when compared with enormous literature on monetary union sustainability, is that its estimation is not just about OCA theory and business cycles synchronization, but that it also studies the monetary shock transmission. We believe that both issues are important in the context of euro adoption, making up two sides of the same coin. Moreover, the paper includes rarely seen comparison between influences of ECB monetary shocks and domestic monetary shocks, thanks to which it is possible to check the scope of ECB's control over the economy as compared to domestic central banks.

This analysis is especially interesting in the light of recent euro adoption in Latvia (January 2014) and Lithuania (January 2015) well as discussions on the subject in Poland, Czech Republic and Hungary. Even though the outbreak of euro area crisis halted the prospects of prompt euro adoption, the talks on the subject did not disappear completely and are recursively coming back in many countries.

The rest of the paper is structured as follows. Section 2 presents the literature review. Section 3 contains empirical model description. Section 4 describes data and sample periods. Section 5 reports empirical analysis results. Section 6 concludes and provides policy implications.

2. Literature review

Our study on the euro area monetary policy and macroeconomic shocks effects bases largely on the Optimal Currency Area (OCA) theory on the costs and benefits of common currency, started with Mundell (1961), McKinnon (1963), and Kenen (1969). The European

Commission publication from 1990 evaluates these benefits and costs of forming economic and monetary union in the context of the European countries. Using various methodologies, many empirical studies in this field concentrate mainly on the problem of business cycles synchronization and speed of shock adjustment, to name Bayoumi and Eichengreen (1994) as example.

Our research bases on the large literature using Vector Autoregression models to study macroeconomic effects of unexpected changes in interest rates. The use of VAR to study monetary policy, which started from the seminal work of Sims (1980), concentrated first on the US economy. Christiano et al. (1998) constitute for a review of research on what happens after exogenous shock to monetary policy in the US and research methodology.

There are also many studies analysing the monetary policy effects in the euro area as a whole or its individual countries. Most of them encompass a period prior to euro introduction. Peersman and Smets (2001) construct synthetic data for euro area in order to derive impulse-response functions for the monetary union as a whole. They also estimate responses of various real and financial variables as well as individual countries' output and prices to the identified euro area monetary policy shock. Mojon and Peersman (2001) analyse individual countries for the period 1980-1998. They divide countries in respect to their monetary integration with Germany and study responses to either domestic or German monetary policy shock. Peersman (2004) looks at the impact of common monetary policy shock on chosen euro area member states, taking into consideration spill-over effects across countries.

Another strand of the literature we base on concerns international transmission of monetary policy shocks. Such studies concentrate almost solely on transmission of US interest rate shocks on different groups of countries. Kim (2001) takes the non-US, G-6 countries and presents detailed evidence of the effects of US monetary policy and the transmission mechanism behind them. The main results show that while US expansionary monetary policy leads to booms in other countries, the main role in the transmission is played not by changes in the trade balance but rather by the decrease in the world interest rate. Kim and Yang (2012) study the transmission of US monetary policy shocks to the East Asian countries while taking into consideration their exchange rate regimes and eventual capital controls. Their results contradict expectations in that they find strong responses of domestic interest rates of the countries with floating exchange rate regime while these responses in fixed exchange rate regimes are much weaker. As the possible reasons, they state fear of floating in the former group of countries and capital controls in the latter.

For the connected topic of monetary autonomy and exchange rate regimes, one must mention Frankel et al. (2004). They construct Hendry's general unrestricted model to examine whether the exchange rate regime choice influences sensitivity of local interest rates to the changes in international one, taking for the international rate US money market rate and also German money market rate in some cases. They find that even in countries with floating exchange rate regimes, the full transmission cannot be rejected in the long run. They find evidence for monetary autonomy only in few biggest industrial economies.

There exists also some literature using VAR models for transmission of euro area shocks to Central and Eastern European countries. However, it concentrates mainly on business cycle shocks. Fidrmuc and Korhonen (2003) as well as Horvath and Rátfai (2004) use Blanchard and Quah (1989) identification strategy to identify euro area output and demand shocks in order to study shock correlations across chosen euro area countries and New Member States (NMS).

In the field of the transmission of monetary policy shocks, Eickmeier and Breitung (2006) construct structural factor model and identify euro area supply shock, euro area real demand shock, and a common monetary policy shock to study cyclical synchronization of euro area and NMS.

There exists also a group of research about domestic monetary policy transmission in Central and Eastern European countries. Ganev et al. (2002) is one of the first to carry out a cross-country comparison of reactions to domestic interest rates and exchange rates shocks in ten CEE countries. They carry out Granger causality tests and impulse-response analysis and state that in most countries exchange rate channel is stronger and more stable than interest rate channel.

3. Empirical methodology

We use VAR framework to analyse the effects of European Central Bank's monetary policy shocks and euro area output and demand shocks in chosen European Union countries from Central and Eastern Europe.

The basis of our identification strategy is an assumption that euro area variables are not influenced by any variables of a single country from Central and Eastern Europe. We think that such an assumption is plausible since most of the countries of the region are relatively small compared to the euro area as a whole.[3] While the situation in some non-euro Central European countries might affect macroeconomic variables of neighbouring small euro area countries, like Estonia or Slovakia, it is hard to believe it can have any influence on the average euro area data.

Based on such assumptions, we construct structural block-exogenous VAR model of the representation:

$$G(L)y_t = e_t$$

where: $G(L) = \begin{bmatrix} G_{11}(L) & 0 \\ G_{21}(L) & G_{22}(L) \end{bmatrix}$, $y_t = \begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix}$, $e_t = \begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix}$,

G(L) is matrix polynomial in lag operator L. Vector y_t constitutes of endogenous variables: y_{1t} is vector of euro area variables, y_{2t} is vector of CEE countries variables. e_t is vector of structural disturbances. $G_{12}(L) = 0$ is a restriction of block-exogeneity which means that y_{1t} is not affected by current as well as lagged values of y_{2t}.

The reduced-form of our VAR model has the representation:

$$y_t = B(L)y_{t-1} + u_t$$

where: $B(L) = \begin{bmatrix} B_{11}(L) & 0 \\ B_{21}(L) & B_{22}(L) \end{bmatrix}$, $y_t = \begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix}$, $u_t = \begin{bmatrix} u_{1t} \\ u_{2t} \end{bmatrix}$

B(L) is matrix polynomial in lag operator L. Vector y_t constitutes for endogenous variables: y_{1t} is vector of euro area variables, y_{2t} is vector of CEE countries variables. u_t is a vector of serially uncorrelated reduced-form disturbances with a mean zero and a covariance matrix Σ_u. We use Choleksy decomposition of the reduced-form covariance matrix to identify structural innovations.

Because explanatory variables differ in some equations of the VAR equation system, OLS estimations provide inefficient estimates. Thus, we use seemingly unrelated regressions (SUR) method to estimate the reduced form block-exogenous model.

Thanks to such identification method, the identified euro area shocks are identical for all the countries under consideration which greatly facilitates cross-country comparison. It also has an advantage of saving degrees of freedom as compared to the full two-country model.

First, we construct a block of euro area variables which we use to identify the euro area shocks. We follow Peersman and Smets (2001) and include in the block data for euro area aggregate output, inflation, money market short term interest rate and real effective exchange rate. We also add one more variable to the system – economic sentiment survey data – in order to control for market sentiments. The market sentiments tell not only about present situation but also about future expectations of market players towards economic situation. As central banks are supposed to look not only at past variables but also at their forecasts, we believe that including market economic sentiment data helps in controlling for these future values. What's more, according to European Central Bank's institutional framework, it looks at various economic variables while deciding on its policy stance. Since it would be impossible to include in our VAR specification all the variables that ECB might be taking into consideration, we assume that economic sentiment data account for good summary of all these data. Therefore, we have a five-variable euro area block with the ordering being: output, inflation, economic sentiment indicator, short term interest rate and real effective exchange rate to identify the euro area structural monetary policy and macroeconomic shocks.

In the next step, we construct very similar block for each CEE country. Our block for each CEE consists of domestic output, inflation, money market short term interest rate and exchange rate to euro.

In each VAR specification we also include additional variables exogenous to both euro area and domestic blocks: world commodity price index and US short-term nominal interest rate. Inclusion of exogenous variables is practice in many VAR specifications and is justified by the literature with a need of controlling for changes in world demand and inflation. This necessity comes from the "price puzzle" problem, i.e. the situation in which after positive interest rate shock, the VAR model results point at price level increase. Sims (1992) argues that such a problem may stem from the fact that central bank has more information about predicted future inflation than is included in simple VAR and proposes inclusion of exogenous variables (commodity price index in his case) as a means to at least partially solve this problem. Many euro area VARs include also US output and federal funds rate (e.g. Peersman & Smets, 2001) as well. Introducing federal funds rate as exogenous variables has one more important implication – it helps us to control for changes in US monetary policy, which affect both euro area and CEE countries, and thus concentrate on the transmission of the pure ECB shocks.

4. Data and sample periods

This section describes data we use in the empirical analysis as well as sample periods for the analysed countries.

4.1. Data

We use data of monthly frequency. The indicator of output is industrial production index excluding construction. Inflation is measured with harmonized index of consumer prices (HICP), all-items index. Interest rate used in case of euro area is average monthly observations of EONIA. For CEE countries we use monthly averages of day-to-day money market interest rates provided by Eurostat. The real effective exchange rate of euro area is based on consumer price indices of 42 trading partners as deflator. The exchange rate towards euro is formed as price in national currency for 1 euro. The economic sentiment in euro area is measured with Economic Sentiment Indicator, being a weighted average of the components of the confidence indicators for industry, services, consumers, construction, and retail trade provided by European Commission DG ECFIN. The data for euro area are taken from ECB databases, while the data for CEE countries are taken from Eurostat. Only data on industrial production for Czech Republic are taken from IMF IFS database. For world variables we use All Commodity Price Index including both fuel and non-fuel price indices from IMF and US federal funds effective rate taken from Datastream.

All data are seasonally adjusted and in their logarithms (except for interest rates) and in levels. Therefore, we allow for implicit co-integration relationships in the data. However, as Sims, Stock, and Watson (1990) state, we still achieve consistent estimates of the parameters.

We estimate all VAR models with 4 lags. The value was chosen based on Akaike statistic run for the euro area block specification. Admittedly, the theory points at longer lag order, as central banks are supposed to take into consideration data from the period longer than only last four months. However, some of our sample periods are quite short and there is a large number of coefficients to be estimated in each equation, so with the choice of longer lag order we would run out of degrees of freedom fast.

4.2. Sample periods

Sample period varies for each country and its length depends on the starting day for the latest exchange rate regime. In many CEE countries we can observe changes in the exchange rate regimes after system transformation in the beginning of 1990s, as many of the countries were using exchange rate as means for stabilization of internal economic situation and were looking for regime best suited to their needs and economic conditions.

Table 1. The exchange rate regimes in Central and Eastern European countries from 1990s and starting point for estimation periods.

Country	Dates	Regime	Sample period
Bulgaria	Feb 1991-Jul 1997 July 1997	Floating Currency board - first to DM, then to euro	From Jan 2000 (due to data availability)
Czech Republic	May 1993-Feb 1996 Feb 1996-May 1997 From May 1997	Hard peg Peg with fluctuation margins +/- 7% (basket DM 65%, USD 35%) Managed float and inflation targeting (from Dec 1997)	From July 1997[4]
Hungary	Until Jun 2001 Jun 2001-Feb 2008 From Feb 2008	Narrow band peg (ecu/euro 70%; only euro from January 2002) Flexible peg to euro with wide fluctuation band and inflation targeting Managed/free float and inflation targeting	From Jun 2001[5]
Latvia	Feb 1994-Dec 2004 From Jan 2005	Peg to SDR Peg to euro with +/- 1% bands	From Jan 2005
Lithuania	Apr 1994-Feb 2002 From Feb 2002	Fixed peg to USD Currency board towards euro	From Feb 2002
Poland	Until May 1995 May 1995-Apr 2000 From Apr 2000	Fixed exchange rate: crawling basket peg with decreasing crawl Crawling peg with widening corridor (basket: USD 45%, DM 35%) Free float and inflation targeting	From Apr 2000

On the whole, we can observe two patterns of exchange rate regime setting and changes in Central and Eastern Europe. For the first group of countries that operate now under floating exchange rate regime (Czech Republic, Hungary, Poland), the first choice of the regime after transition was usually some type of a hard peg. Then, they gradually eased exchange rate controls, achieving managed float or free float regime. The second group of countries (Bulgaria, Latvia, Lithuania) operates now under fixed exchange rate regime. In case of Baltic countries, that was the choice made soon after gaining independence and only base currency changed later. In Bulgaria, the government first opted for floating exchange rate regime which was then replaced with a currency board. The more detailed history of exchange rate regimes in CEE is showed in Table 1 together with the starting days of our estimation samples for each country.

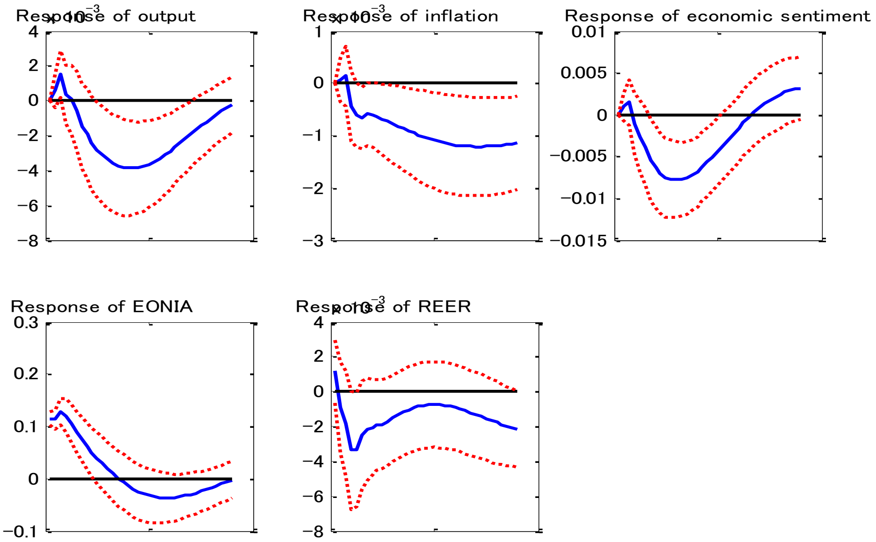
5. Results

This section presents results of our empirical study. First, the responses of countries' output, inflation, and interest rate to euro area and domestic monetary policy shocks are presented. Next, we analyse again the relative strength of both of the shocks based on variance-covariance decomposition analysis. After that, euro area output and inflation shocks' effects are examined. All the studied impulse-response functions present reactions up to 36th month after the shock.

5.1. Monetary policy shocks

First, we present the reactions of euro area aggregate variables to common monetary policy shock. As we can see at Figure 1, impulse response functions in most cases follow expectations and results from the previous research. The output starts falling with few months lag, with the negative impact deepening for the next year, then recovering slowly and almost reaching zero at the end of considered period. It also takes inflation 2-3 months to react, after which it falls with the impact staying persistent. We also observe fall in economic sentiment after interest rate increase but it recovers quicker and becomes positive after around 25 months. Only for the

Figure 1. Responses of euro area aggregate variables to euro area monetary policy shock



Note: Solid lines: impulse response functions; dotted lines: bootstrapped 90% confidence bands

exchange rate the results are not consistent with the previous research and expectations that after the positive interest rate shock the appreciation of a currency takes place. In our case we have small appreciation at the impact but soon after that the index starts falling, and the depreciation of the currency takes place.

Next, we report the impulse response functions of CEE countries variables to the EONIA shock identified with the block-exogenous model. Blue lines at Figure 2 present impulse response functions of CEE countries' output, inflation, and interest rate to euro area monetary policy shocks. Because the character of exchange rate regime can potentially have big influence on the monetary policy transmission, while reporting the results we take into consideration whether country has fixed or floating exchange rate regime. We compare the countries within and between the groups.

Looking at the results for the six Central and Eastern European countries while taking into consideration their exchange rate regime, we can observe high similarity of impulse responses for the countries with fixed exchange rate regime. The group of countries with floating exchange rate is more diversified. For all the countries, from both groups, the most similar is the reaction of the output. In all cases the output starts falling few months after the shock and the reaction stays negative for most of or the whole period under consideration.

Figure 2. Responses of CEE countries' output, inflation and interest rate to euro area and domestic monetary policy shocks

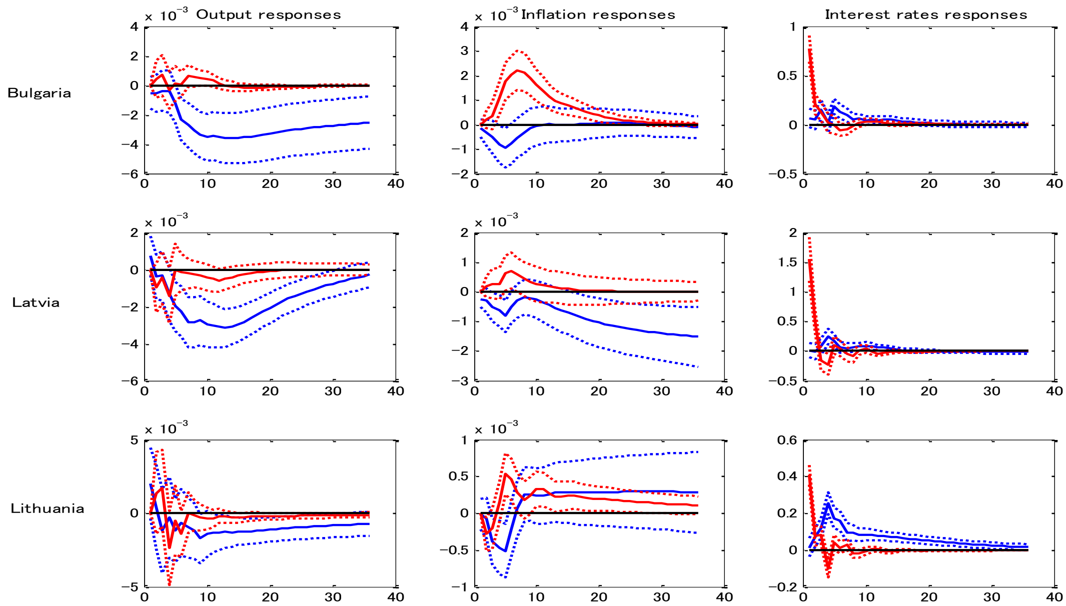
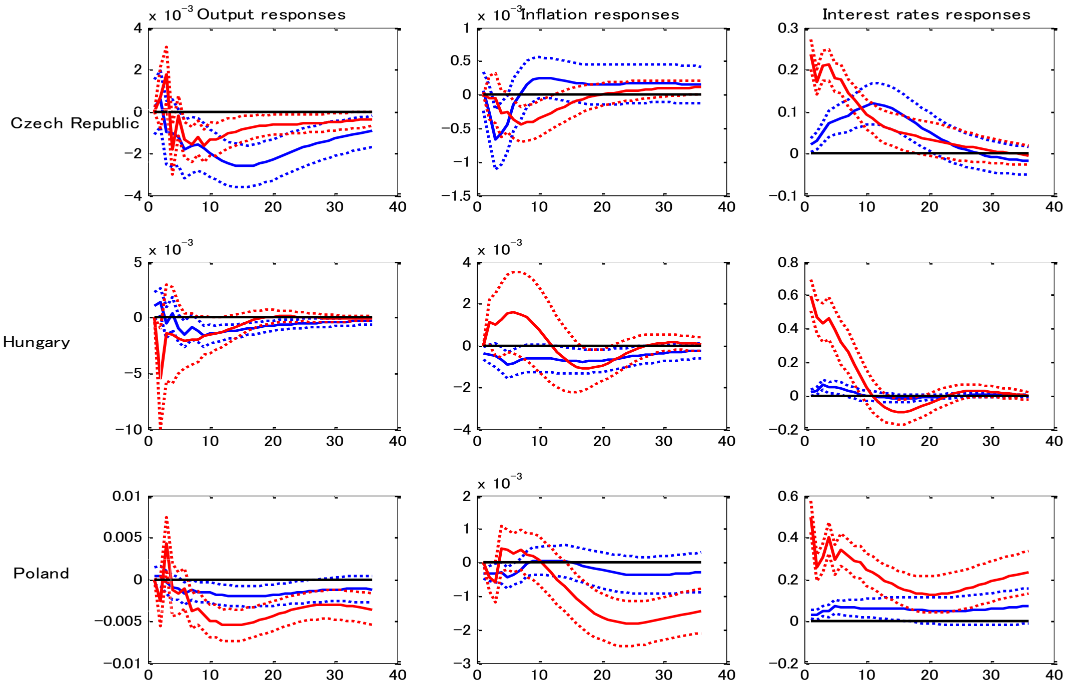


Figure 2 (continued)



Note: Solid lines: impulse response functions (blue – reaction to euro area monetary policy shock; red – reaction to domestic monetary policy shock); dotted lines: bootstrapped 90% confidence bands

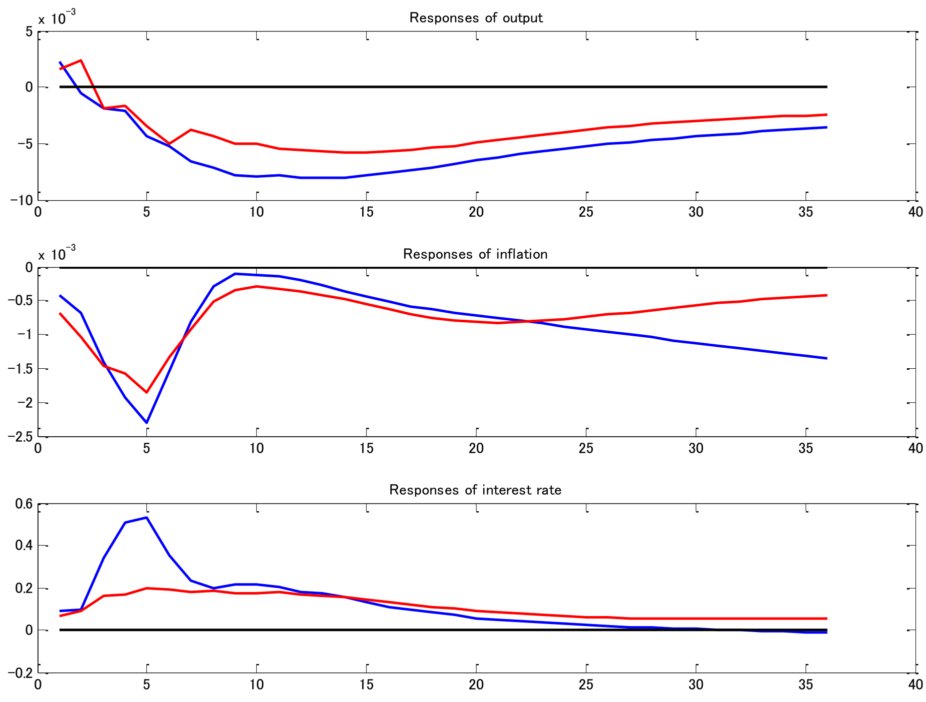
While the output responses are quite uniform for all the countries, there are bigger differences in the responses of inflation. Only in case of Hungary, Latvia, and Poland the reaction stays negative for the whole period. In the remaining countries, after few months of declining inflation rate, it starts rising or the reaction becomes zero.

In all countries with fixed exchange rate as well as in Hungary we can observe quick rise in the interest rate after the shock with most of the effect disappearing in just few months. Only in Czech Republic we have slower growth at first and the effect disappearing much slower. Poland stands out even more with the positive effect on the interest rate not fading down for the whole considered period. That result may seem a bit surprising as according to the impossible trinity theorem we would rather expect more significant and larger rise of interest rate in countries with fixed exchange rate and small and/or insignificant increase for floaters. Therefore, these results confirm the previous research conclusions that even the countries with floating exchange rate regime are not characterized with much monetary autonomy.

In order to have a better outlook at the scale of differences in foreign monetary shocks transmission between flexible and fixed exchange rate regime countries, we study the average responses for each group of countries. Figure 3 presents average impulse response functions to EONIA shocks for the two groups. We can observe that on the whole, results show similar patterns between the fixed and floating exchange rate regimes. There is mainly the difference in the magnitude of the reactions. The output falls deeper for fixed exchange rate regimes. Inflation fall is similar for both groups. Interest rate shows higher increase for fixed exchange rate regimes but the reaction is slightly more persistent in the floating countries.

The results follow the expectations that transmission of foreign monetary policy shocks is stronger in fixed exchange regime countries though one might have expected higher differences. However, with the exchange rate reacting freely to foreign shocks, the shocks' effects on the economy should be not only weaker but also slower. In our case, there is no evidence on the reactions in floating countries being more sluggish, as also shown for instance by Canova (2005).

Figure 3. Average responses to euro area monetary policy shocks for fixed and floating exchange rate groups of countries



Note: Average impulse response functions; blue line: fixed exchange rate regime countries, red line: floating exchange rate regime countries

The analysis up till now shows us that euro area monetary policy shocks have high influence on the domestic variables of CEE countries. Thus, the question arises how this influence compares with the effects of domestic monetary policy. In order to check this, we go back to Figure 2 where we plot responses to EONIA shocks (blue lines) against responses to domestic monetary policy shocks (red lines). In order to carry out comparisons of the two effects, we normalize both shocks so that they have equal magnitude of one. The analysis of the impulse-response functions with their confidence bands shows us that there are many significant differences between effects of EONIA and monetary policy shocks. This is especially the case for the output variable which usually falls deeper after euro area monetary policy shock. The biggest exceptions would be Hungary where the responses to both shocks are very similar and Poland where domestic policy effects are stronger. Inflation is falling more after EONIA shock in Bulgaria, Latvia, and Hungary but differences are usually not statistically significant. One of the reasons for this is placed in the very wide confidence bands on most of inflation responses. When it comes to the interest rate, the initial response is naturally higher after domestic interest rate shocks but EONIA shocks have often more persistent effects. However, especially in Poland, but also in Hungary and Czech Republic to some extent, we observe considerably stronger effects of domestic shocks.

These results imply that euro area monetary policy shocks not only have an important influence on CEE countries' macroeconomic variables but also that in many cases this influence seems to be stronger than influence of domestic monetary policy. This shows what a difficult situation the central banks of these countries face when it comes to carrying out their monetary policy and deciding on their policy stance. What's more, these results do not clearly depend on whether the country functions under fixed or flexible exchange rate.

5.2. Variance-covariance decomposition

After looking at impulse response functions which show the direction of responses to the shocks, we again study the relative strength of euro area and domestic monetary policy effects using at variance-covariance decompositions of the domestic variables due to mentioned shocks. Table 2 shows the percentage of the variance in each variable explained by EONIA shocks as compared to domestic interest rate shocks 12, 24, 36 months after the shock as well as the maximum values reached within 36-month period.

For most of the countries, EONIA is responsible for much larger part of output variance than domestic interest rate. Only for Poland we observe close values. What's more, the influence of EONIA is usually increasing with the time, reaching maximum in the third year after the shock, while domestic interest rate's impact is usually highest in the first year after the shock and then the impact gradually falls. Only in case of Poland the maximum of domestic influence is reached much later – in 25th month.

The situation in case of inflation is more diverse. While only for Bulgaria we observe higher influence of domestic interest rate, the differences between EONIA and domestic rate shocks are divergent across countries. In Czech Republic, Lithuania, and Poland, the EONIA rate influence is only slightly higher. Hungary and Latvia (to some extent) show much higher percentage of inflation variance explained by EONIA in comparison to domestic interest rate.

The maximum values for domestic interest rate shocks are naturally much higher in case of its own shock than EONIA one. Therefore, we concentrate on the variance decompositions estimated for 12th, 24th and 36th month after the shock only. The results imply that in Bulgaria, Hungary and Latvia it is domestic interest rate shocks that influence most of interest rate variance. The EONIA shocks have only small, additional impact. Also in Poland domestic interest rate impact is higher but the difference is not as decisive as in aforementioned countries. In Lithuania EONIA's impact is higher. However, in here both euro area and domestic interest rate play very important role, explaining together over 70% of domestic interest rate variance. Only in case of Czech Republic in the longer run EONIA's shocks start explaining slightly higher variance than domestic interest rate shocks.

Based on the results of variance decomposition analysis, we can confirm that euro area monetary policy shocks have important influence on domestic variables and that this influence is often higher than the one of domestic monetary policy. There are, however, some differences across the analysed countries. It is also hard to observe any patterns connected to exchange rate regime and relative strength of euro area and domestic monetary policy shocks.

Table 2. Variance-covariance decompositions of CEE countries' output, inflation and interest rate due to euro area and domestic monetary policy shocks

Output	Bulgaria		Czech Republic		Hungary		Latvia		Lithuania		Poland	
Shocks	Euro area	domestic	Euro area	domestic	Euro area	domestic	Euro area	domestic	Euro area	domestic	Euro area	domestic
12	8.20	0.25	4.11	1.25	6.50	1.42	9.47	0.36	2.40	1.39	6.07	5.09
24	11.75	0.14	9.38	1.18	9.06	1.34	15.64	0.32	4.01	1.38	13.03	9.24
36	12.56	0.11	9.75	1.12	9.29	1.28	15.07	0.29	4.79	1.37	12.99	9.07
max	12.56	0.34	9.78	1.27	9.29	1.66	15.72	0.69	4.79	1.49	13.30	9.25

Note: Percentage of variables' variance explained by the shocks 12, 24 and 36 months after the shock as well as the maximum value reached within 36 months period.

Table 2 (continued)

Inflation	Bulgaria		Czech Republic		Hungary		Latvia		Lithuania		Poland	
Shocks	Euro area	domestic	Euro area	domestic	Euro area	domestic	Euro area	domestic	Euro area	domestic	Euro area	domestic
12	1.98	19.22	3.17	1.22	8.40	1.46	2.68	0.85	3.57	3.58	3.18	0.45
24	1.53	16.83	2.72	0.92	10.49	1.41	4.63	0.30	4.05	3.13	2.31	4.06
36	1.45	15.83	2.44	0.75	10.41	1.23	6.81	0.16	5.14	2.98	3.72	7.22
max	3.07	19.41	3.81	1.23	10.60	1.80	6.81	1.35	5.14	3.74	8.09	7.22

Interest rate	Bulgaria		Czech Republic		Hungary		Latvia		Lithuania		Poland	
Shocks	Euro area	domestic	Euro area	domestic	Euro area	domestic	Euro area	domestic	Euro area	domestic	Euro area	domestic
12	8.05	58.18	14.78	21.45	6.41	49.99	5.73	65.85	41.16	40.09	11.64	35.44
24	7.82	52.38	13.82	12.70	6.44	46.01	5.54	60.89	42.85	34.28	8.43	16.53
36	7.49	50.11	12.95	11.82	6.34	45.35	5.42	57.95	41.37	32.04	8.79	14.43
max	8.22	95.20	15.12	91.26	8.12	90.52	5.83	96.01	43.09	91.96	12.98	84.23

5.3. Euro area output and inflation shocks

Until now our analysis concentrated solely on transmission of monetary policy shocks. However, the close economic ties of CEE countries with euro area let us think that not only monetary but also other shocks might have significant impact on these economies. Therefore, in this section we present the impulse response functions of CEE domestic variables to euro area output and inflation shocks. That will let us draw further conclusions regarding dependence of these small open economies on economic developments in their neighbouring area.

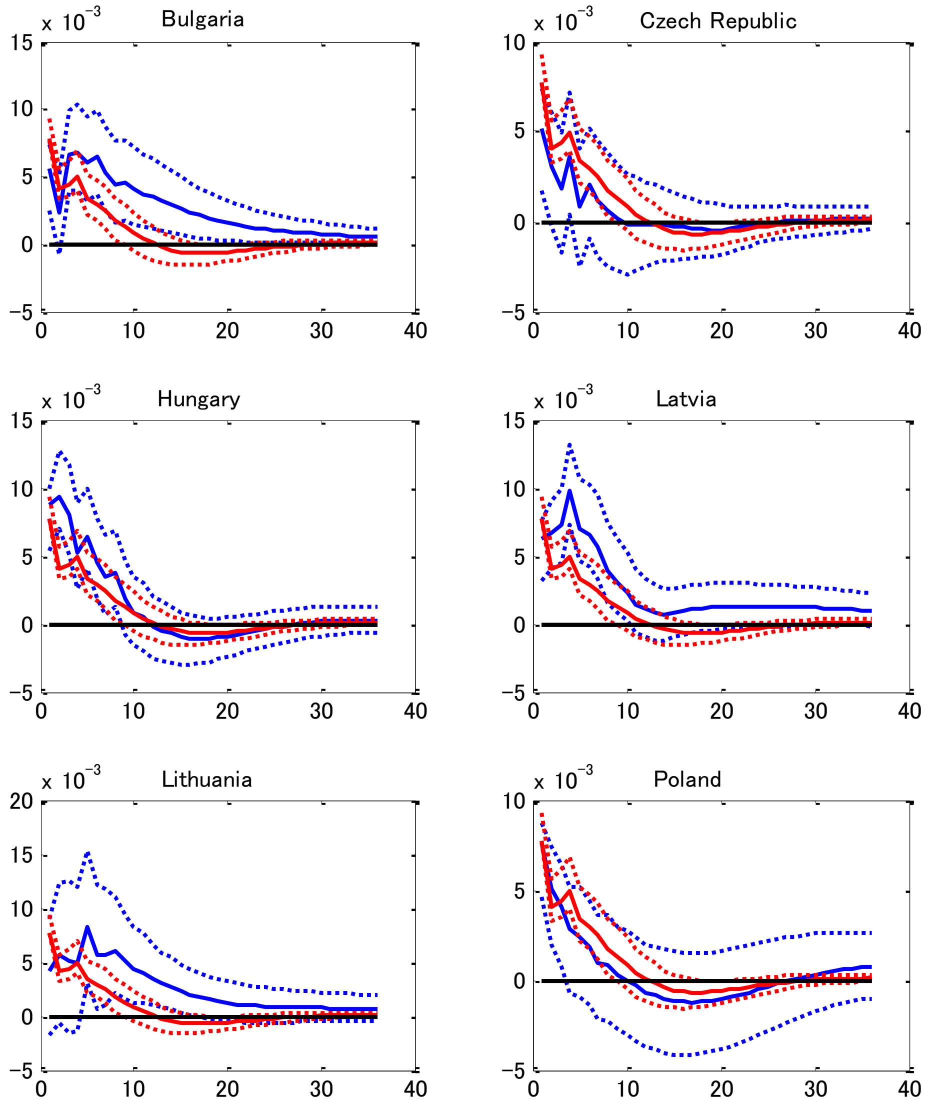
Figures 4a-d present responses of each country output and inflation to euro area output and inflation shocks as compared to aggregate euro area reactions. In order to facilitate comparisons, all estimations are based on equal sample periods which start in February 2002. After euro area positive output shock we observe instant increase in output in all CEE countries. The exact size and persistence of that increase differ across the countries but it usually is not significantly different from the aggregate euro area reaction. Output increase is higher than euro area output rise especially in case of Bulgaria and Lithuania and rather similar or lower in other countries.

After euro area positive output shock euro area inflation increases for around two years. On the other hand, in most of CEE countries inflation shows movements in opposite direction. The differences between each country response and aggregate euro area response are, however, usually not significant (with short exception in Bulgaria). The main reason for that are the very wide confidence bands on CEE countries' inflation responses, showing that it is hard to predict how the inflation really changes after euro area output shocks.

The euro area inflation shock causes slight fall in aggregate output. CEE countries react differently. In all the countries increase in output can be observed and in many cases the difference with euro area response is statistically significant. What's more, the responses of CEE countries are largely similar across the countries. Though, naturally there are slight differences in exact strength of reaction.

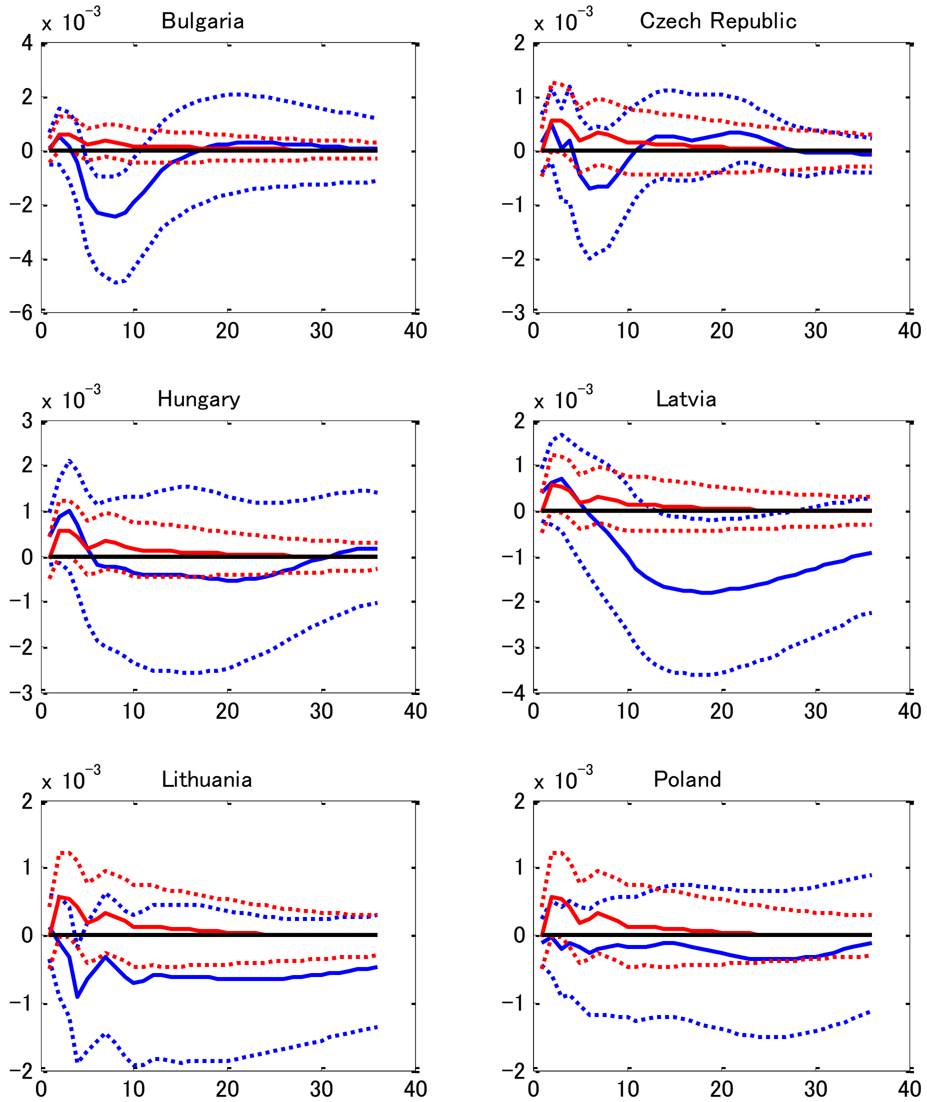
After positive inflation shock in euro area we also observe increase in inflation in CEE countries. In Czech Republic, Latvia, and Lithuania the reactions are especially similar to the aggregate euro area one. Hungary and Poland show significantly stronger inflation hikes, at least for some period after the shock. In Bulgaria, after initial fall in inflation, the response becomes similar to aggregate euro area one in the second year after the shock.

Figure 4a. Responses of CEE countries' output to euro area output shock



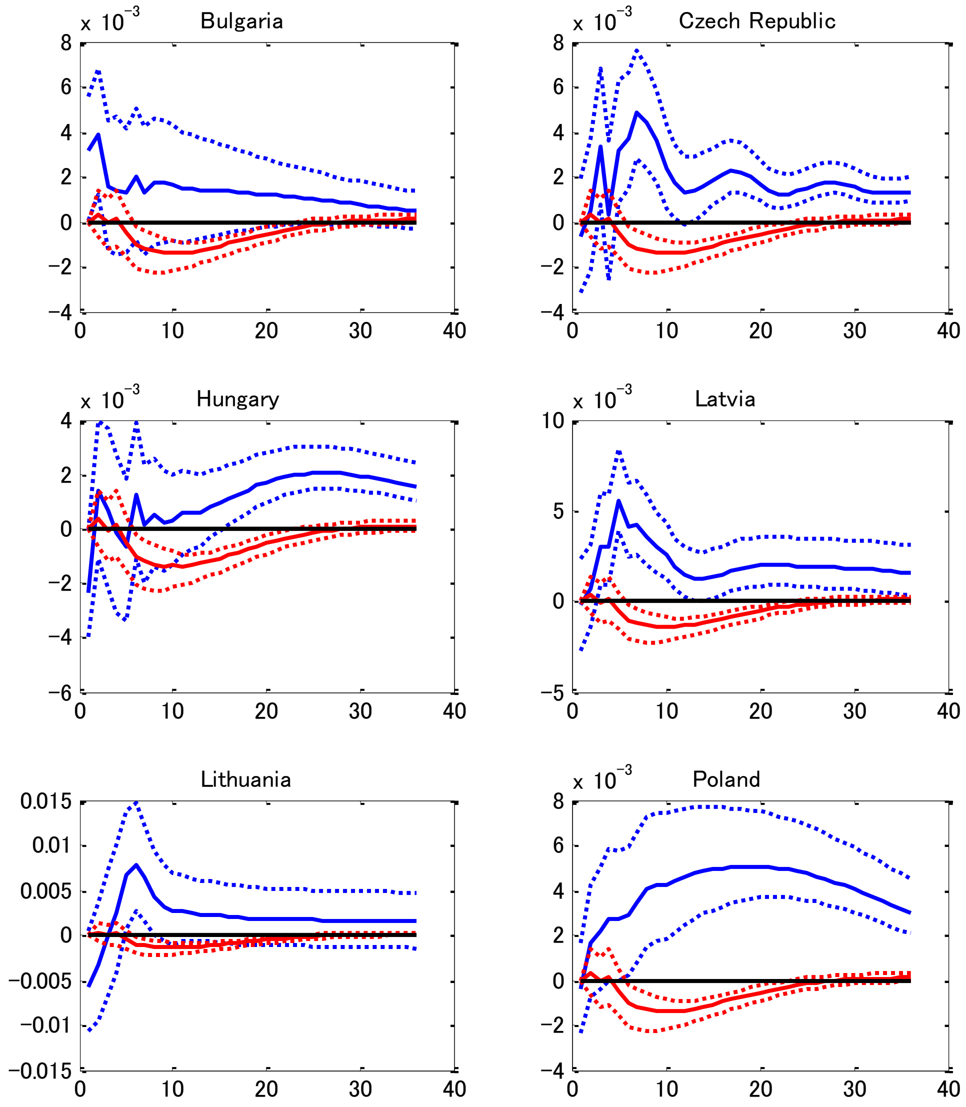
Note: Solid lines: impulse response functions (blue – responses of each CEE country variable; red – response of aggregate euro area variable); dotted lines: bootstrapped 90% confidence bands

Figure 4b. Responses of CEE countries' inflation to euro area output shock



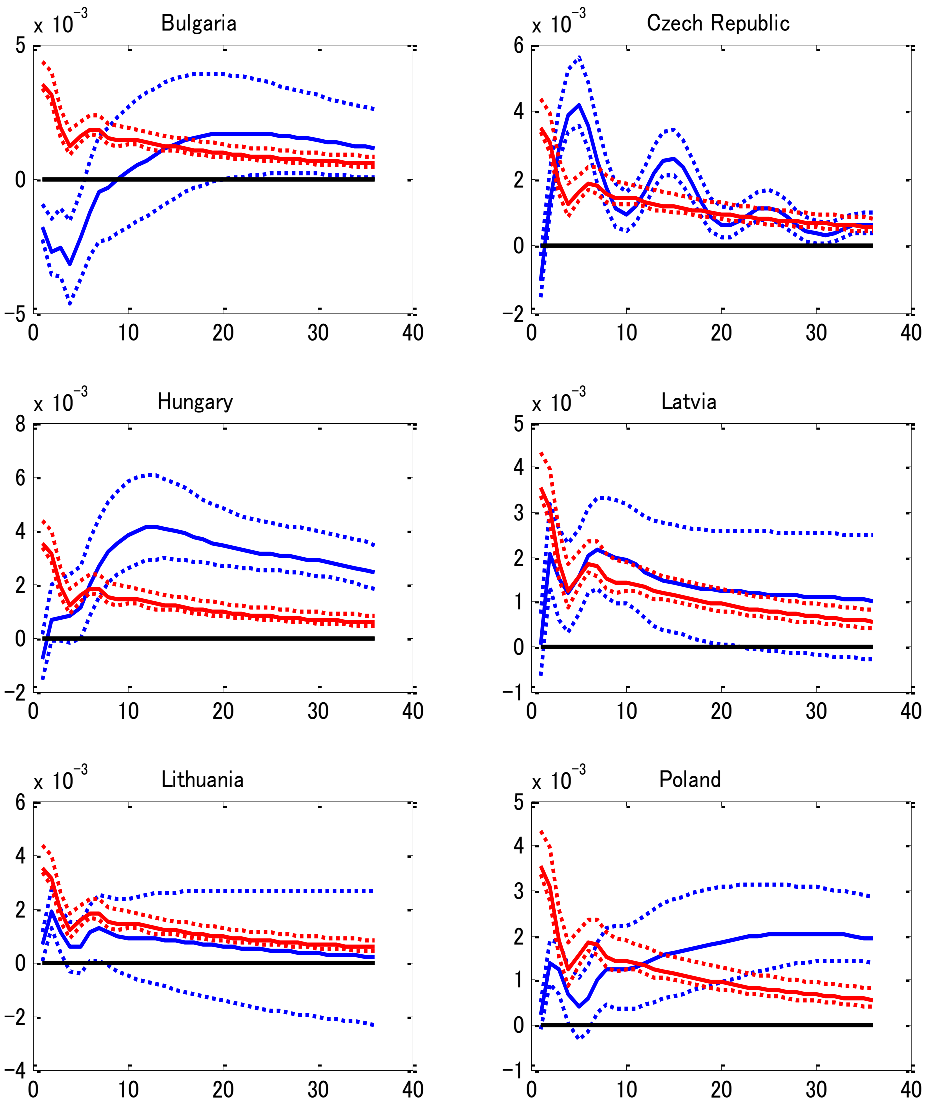
Note: As Figure 4a

Figure 4c. Responses of CEE countries' output to euro area inflation shock



Note: As Figure 4a

Figure 4d. Responses of CEE countries' inflation to euro area inflation shock



Note: As Figure 4a

Summing up, euro area output and inflation shocks have an important, often statistically significant influence on output and inflation in CEE countries. While comparing countries' responses with the average euro area one, we observe mixed results. The euro area responses of output and inflation after their own respective shocks are placed somewhere in the middle of the CEE countries responses. In the remaining cases, we observe opposite reactions in euro area and CEE countries. In case of response of output to euro area inflation shock, the euro area variable's reaction is negative and CEEs' output response is positive. While the average euro area reaction is slightly positive after euro area output shock, in most CEE countries inflation reacts negatively.

5.4. Robustness results

In order to assure the robustness of our results, we also carry out additional estimations checking two main assumptions of our model. Table 3 contains chosen results of that exercise – 12th and 24th period responses of output and inflation to the considered shocks[6].

First, we estimate the models using variables in differences instead of levels. Even though many studies follow opinion of Sims, Stock, and Watson (1990) and use data in levels even if they are non-stationary, there also exist arguments for and cases of using differenced data (e.g. Miyao, 2000). The first observation we make on the results is a fact that the impulse responses estimated with variables in differences do not die out to zero, with the possible reason being the fact that this specification might not be stationary VAR model due to inability to impose possible co-integrating relations. Aside of that, we can observe some sign and results' significance differences as compared to benchmark specification. However, even in this situation, the main observations and conclusions do not change significantly.

Second, we check the influence of the chosen order of variables on the results. In order to do that, we estimate generalized impulse response functions (GIRFs) which do not depend on the order of variables in VAR model. The results, and thus main conclusions, are very close to benchmark specification. What's more, we confirm benchmark results with, not reported in here, model estimations using Cholesky decomposition but for few different orderings of variables.

Table 3. Responses to euro area shocks. Benchmark and alternative specifications.

Shock/ specification		Country						
EONIA shock	Output	EA	Bul.	Czech Rep.	Hung.	Lat.	Lith.	Pol.
	12	**-0.0016**	**-0.0035**	**-0.0024**	**-0.0013**	**-0.0031**	**-0.0013**	**-0.0019**
benchmark	24	**-0.0008**	**-0.0030**	**-0.0018**	**-0.0006**	**-0.0014**	**-0.0010**	**-0.0016**
	12	0.0343	-0.0011	-0.0087	-0.0089	0.0062	-0.0259	0.0094
differences	24	0.0645	0.0051	-0.0038	-0.0015	0.0213	-0.0163	0.0114
	12	**-0.0146**	**-0.0515**	**-0.0366**	**-0.0313**	**-0.0663**	**-0.0118**	-0.0160
GIRFs	24	**-0.0095**	**-0.0547**	**-0.0251**	**-0.0176**	**-0.0368**	**-0.0082**	**-0.0199**

EONIA shock	Infla-tion	EA	Bul.	Czech Rep.	Hung.	Lat.	Lith.	Pol.
	12	**-0.0002**	0.0000	0.0002	**-0.0007**	-0.0005	0.0003	0.0001
benchmark	24	**-0.0001**	0.0001	0.0002	**-0.0006**	**-0.0012**	0.0003	-0.0004
	12	**-0.0088**	**-0.0220**	**-0.0120**	-0.0064	-0.0146	**-0.0403**	-0.0136
differences	24	**-0.0085**	**-0.0226**	-0.0107	-0.0098	-0.0204	**-0.0407**	-0.0183
	12	-0.0016	0.0215	-0.0024	-0.0246	0.0171	**0.0238**	0.0162
GIRFs	24	-0.0007	0.0038	0.0034	**-0.0392**	**-0.0674**	**0.0244**	-0.0329
EA output shock	**Output**	**EA**	**Bul.**	**Czech Rep.**	**Hung.**	**Lat.**	**Lith.**	**Pol.**
	12	0.0065	**0.3524**	-0.0197	-0.0240	0.1075	**0.3473**	-0.0708
benchmark	24	**-0.0314**	**0.1134**	-0.0136	-0.0384	0.1250	0.0897	-0.0519
	12	**1.0598**	**1.2210**	**0.9940**	**1.5285**	**1.4565**	**0.9364**	**1.0041**
differences	24	**1.0040**	**1.1520**	**0.9280**	**1.4804**	**1.2530**	**0.9202**	**0.9731**
	12	0.0410	**0.1588**	0.0554	-0.0420	**0.0932**	0.0797	-0.0627
GIRFs	24	-0.0199	**0.0473**	-0.0060	-0.0128	**0.0897**	0.0244	-0.0005
EA output shock	**Infla-tion**	**EA**	**Bul.**	**Czech Rep.**	**Hung.**	**Lat.**	**Lith.**	**Pol.**
benchmark	12	0.0126	-0.1142	0.0138	-0.0417	-0.1469	-0.0606	-0.0166
	24	0.0012	0.0252	0.0228	-0.0456	**-0.1626**	-0.0655	-0.0358
differences	12	**0.0928**	**0.3219**	0.1267	0.1448	0.1835	0.0103	-0.0416
	24	**0.0970**	**0.3570**	0.1260	0.1698	0.2221	0.0238	-0.0253
	12	0.0126	-0.1848	0.0146	-0.0881	**-0.2726**	**-0.2094**	-0.1246
GIRFs	24	-0.0107	0.0847	0.0377	-0.1131	**-0.3269**	**-0.1796**	-0.1999
EA inflation shock	**Output**	**EA**	**Bul.**	**Czech Rep.**	**Hung.**	**Lat.**	**Lith.**	**Pol.**
	12	**-0.1335**	0.1465	0.1325	0.0610	**0.1436**	0.2454	**0.4606**
benchmark	24	-0.0214	0.1035	**0.1334**	**0.2013**	**0.1944**	0.1688	**0.4828**
	12	-0.0678	0.1069	0.0789	-0.3316	0.0411	-0.3630	0.0128
differences	24	-0.0811	0.1122	0.0559	-0.3339	0.0435	-0.4212	0.0518
	12	**-0.0943**	0.0221	0.0230	**0.0410**	**0.0522**	**0.0394**	**0.1597**
GIRFs	24	**-0.0524**	0.0074	**0.0349**	**0.0686**	**0.0605**	**0.0330**	**0.1620**
EA inflation shock	**Infla-tion**	**EA**	**Bul.**	**Czech Rep.**	**Hung.**	**Lat.**	**Lith.**	**Pol.**
	12	**0.1311**	0.0683	**0.1626**	**0.4080**	**0.1677**	0.0899	**0.1376**
benchmark	24	**0.0813**	**0.1659**	**0.1084**	**0.3127**	0.1182	0.0477	**0.1981**
	12	**0.1875**	-0.0200	0.0831	0.0084	-0.0070	0.1395	-0.0734
differences	24	**0.1991**	-0.0192	0.0641	0.0349	-0.0397	0.1394	-0.0501
	12	**0.1146**	**0.1300**	**0.1762**	**0.3435**	**0.1331**	**0.1377**	**0.1884**
GIRFs	24	**0.0917**	**0.1864**	**0.1276**	**0.2514**	**0.0803**	0.0796	**0.3233**

Note: Point estimates of impulse responses for output and inflation in 12th and 24th month after the shock; values in bold indicate responses significantly different from zero based on the bootstrapped 90% confidence intervals

6. Conclusions and implications

In this paper we employ VAR methodology in order to study empirically the dependence of CEE economies on changes in euro area monetary policy as well as macroeconomic conditions. The results point at strong influence of euro area money market interest rate shocks on the economies under consideration which is also often higher and more prolonged than domestic interest rate shocks' influence. What's more, euro area output and inflation shocks are important drivers of changes in domestic variables. Though, some reactions of CEEs variables to these shocks are dissimilar to the aggregate euro area responses.

The results of the analysis let us draw few important conclusions and implications. First, there is the importance of the exchange rate regime in keeping monetary autonomy. Strong interest rate reactions even in the countries with floating exchange rate regimes confirm the results of previous research stating that even floaters do not have much monetary autonomy. Moreover, the reactions of macroeconomic variables after ECB's monetary policy shock show very similar patterns for both fixed and floating exchange rate countries. These results confirm low importance of exchange rate regime in foreign shock transmission and therefore the need to use other criteria for the choice of exchange rate regime.

The results we achieve imply that central banks of floating exchange rate regime Central and Eastern European countries should take into consideration European Central Bank's monetary policy as well as euro area output and inflation shocks while deciding their own policy stance. Also in fixed exchange rate countries, where monetary policy rule is more automatic, it is important to estimate detailed influence of changes in economic and monetary conditions in euro area on each country. In all the countries euro area variables seem useful indicators in forecasting future changes of domestic policy goals as well as macroeconomic conditions - the information that central banks should not ignore. Additionally, in floating countries this is to avoid the situation when the economy is depressed or stimulated too much through simultaneous ECB's and national central bank's policy changes.

Our analysis lets us also draw some implications regarding the future euro adoptions in Central and Eastern European countries. Most of them are common for both floating and fixed exchange rate countries. Quite high, on average, influence of euro area shocks, dependence of domestic interest rate on changes in EONIA as well as strong response of macroeconomic variables to euro area output and inflation shocks can serve as argument for euro adoption in most CEE countries.

On the other hand, however, divergent inflation responses and large standard deviations for inflation reactions can pose potential problems after euro adoption. The reason is the fact that ECB's main objective lies in inflation and not output stabilization. Therefore, uncertain and divergent changes in inflation rate can make implementation of common monetary policy extremely difficult, if not impossible. As de Grauwe (2009) points out, different economic conditions in monetary union countries can bring the situation where ECB has no reason for interest rate changes because the average rate of inflation in euro area will always be between actual inflation rates in individual countries.

This situation, however, might also be more harmful to CEE countries than ECB policy making process. ECB might not change its policy even after the countries adopt euro due to relatively small size of these economies.[7] That means ECB's monetary policy decisions often not fitting economic situation in the countries, leading to further destabilization of the economy. Especially, divergent inflation rates together with common nominal interest rate lead to differences in real interest rates across countries. Too high real rates might excessively depress the economy, while too low might lead to unsustainable booms at asset markets. Recent years have already given us examples on these cases, proving the danger to be more than just theoretical deliberation. Therefore, there exists a need for detailed country-specific study on risks of euro adoption connected to the role of real interest rate in the economy.

There exist also some implications connected to euro adoption decision depending on country's exchange rate regime. While in case of fixed exchange rate regime the shock transmission after euro adoption might not change significantly, loss of floating exchange rate regime might constitute for important structural break in transmission mechanism. That means the need for further analysis of the role of floating exchange rate and the effects of euro adoptions in these countries, which however exceeds the scope of this paper.

NOTES

1. As the data we use end in year 2013, we include to our non-euro CEE countries Latvia which adopted euro in January 2014 as well as Lithuania which adopted euro in January 2015.
2. Guiso et al. (1999) state three main conditions for common monetary policy to be successful. First, the countries should have common goals, which in case of EMU are guaranteed by treaties and ECB status. Second, countries should have similar business cycles to minimize possibility of asymmetric shocks. And third, the monetary transmission mechanism in each country should work in the similar way.

3. The only possible exception, we believe, might be Poland, being the largest economy in Central and Eastern Europe and population-wise the 6th largest country in the European Union. However, for the sake of uniformity of our identification strategy for all the countries and, therefore, also the easiness of comparisons, we maintain our basic assumption also for this country.
4. In May 1997 a currency crisis occurred in Czech Republic, being one of most important reasons for implementation of floating regime. Due to the crisis the interest rates grew to unusually high levels with the effects still visible in June 1997. Therefore, we exclude these two months from our sample period.
5. We argue that the change to managed float regime in February 2008 does not constitute a break due to the fact that already from June 2001 Hungary pursued inflation targeting, and its peg to euro was very flexible.
6. Due to space restrictions, the results of robustness tests in form of derived impulse response functions are not included into the paper but are available from the author upon request.
7. ECB makes policy decisions based on aggregate euro area data computed as weighted averages of the data on euro area individual member states. Therefore, in case of small country adopting euro the weighted average of aggregate euro area data do not change considerably.

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