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Exchange Rate Dynamics and its Effect on Macroeconomic Volatility in Selected CEE Countries

Volha Audzei and František Brázdik *

Abstract

To understand the potential for forming an optimum currency area it is important to investigate the origins of macroeconomic volatility. We focus on the contribution of exchange rate shocks to macroeconomic volatility in selected Central and Eastern European countries. The contribution of the exchange rate shock relative to other shocks allows us to evaluate whether the exchange rate is a source of volatility or a buffer against shocks as the theory suggests. The identification of the contributions is based on variance decomposition in two-country structural VAR models, which are identified by the sign restriction method. We identify countries where shocks are predominantly symmetric relative to the effective counterpart and countries where the contribution of real exchange rate shocks is strong. In general, for all the countries considered the results are consistent with the real exchange rate having a shock-absorbing nature. Finally, a significant role of symmetric monetary policy shocks in movements in real exchange rates is found for some of the countries.

Abstrakt

Chceme-li pochopit potenciál pro vytváření optimálních měnových oblastí, je důležité zkoumat původ makroekonomické volatility. V této práci se zaměřujeme na příspěvek kurzových šoků k makroekonomické volatilitě ve vybraných zemích střední a východní Evropy. Relativní příspěvek kurzového šoku vzhledem k příspěvku ostatních šoků nám umožňuje vyhodnotit, zda-li je kurz zdrojem volatility, nebo v souladu s teorií působení šoků tlumí. Rozklady volatility chyby predikce jsou založeny na strukturálním modelu VAR pro dvě země, který je identifikován pomocí znaménkových restrikcí. Pomocí těchto rozkladů identifikujeme skupiny zemí s převažujícím příspěvkem symetrických šoků a s výrazným příspěvkem šoků do reálného kurzu. Obecně platí, že výsledky pro všechny zkoumané země ukazují, že reálný kurz tlumí šoky. V některých zemích zjišťujeme významný vliv symetrických měnověpolitických šoků na vývoj reálného kurzu.

JEL Codes: C32, E32, F31, F41.
Keywords: Asymmetric shocks, Central and Eastern Europe, monetary union, real exchange rates, sign restrictions method, structural vector autoregression.

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Nontechnical Summary

The motivation of this study originates in the theoretical role of the real exchange rate as an important adjustment mechanism available in the presence of asymmetric (individual) shocks. The sample of countries examined covers those which have adopted a common currency and those which have retained an independent currency. However, in both cases the real exchange rate can simultaneously serve as an adjustment mechanism that absorbs volatility and as a generator of business cycle volatility.

Whether real exchange rates are shock absorbers or shock generators has long been discussed in the empirical literature. Theoretically, when an asymmetric shock hits an open economy, real exchange rate adjustment should accommodate the shock and dampen its propagation further into the economy. The exchange rate channel may thus be beneficial for an economy with an independent monetary policy in pursuing its goals. When a common currency is adopted or the exchange rate is fixed, the loss of the exchange rate adjustment mechanism might be considered undesirable for monetary policy performance. However, for economies that are close in terms of industrial structure, labor market flexibility and so on, such that they face symmetric shocks, the importance of the real exchange rate as an adjustment mechanism diminishes.

The goal of our work is to assess what role dominates for the exchange rate in selected Central and Eastern European (CEE) countries vis-á-vis the Eurozone. A number of authors have used alternative approaches and identified cases where the exchange rate takes the role of generator of business cycle volatility. The wide spectrum of results in previous studies motivates us to assess the role of the exchange rate in absorbing economic shocks for a group of CEE countries.

Structural VAR models have become one of the most widely used tools for identifying structural shocks. Earlier studies, e.g. Clarida and Gali (1994), Thomas (1997) and Farrant and Peersman (2006), set their two-country models in the form of ratios of domestic to foreign variables (relative terms). This form imposes a strong implicit assumption that the transmission of a symmetric/common shock is the same in both countries and any deviation is regarded as a response to an asymmetric shock. Hence, these models are only able to identify the contributions of asymmetric shocks to relative macroeconomic volatility and are not able to judge the relative importance of symmetric versus asymmetric shocks for the business cycle. This drawback may lead to the contribution of asymmetric shocks being overrated when the overall volatility is mostly generated by symmetric shocks.

Therefore, our work uses a model that is able to distinguish between symmetric and asymmetric shocks. We use the SVAR approach and rely on the sign restriction identification method. This method was introduced by Uhlig (2005) and has become a standard analytical tool of modern macroeconomics. Recently, Peersman (2011) employed this methodology to analyze the contribution of nominal shocks to macroeconomic volatility.

In our sign restriction identification scheme, we modify the approach sketched by Peersman (2011) and define the sign restrictions so that the contribution of symmetric and asymmetric shocks can be identified, while keeping consistency with the scheme used in the relative models. Our modification is based on Fry and Pagan (2011), who criticize the popular approach of reporting the median response at each horizon separately for each variable, which makes the responses of such models inconsistent across all variables. Therefore, we employ the closest-to-median approach applied over all variables simultaneously and we are able to identify the sole model.

Our results are consistent with the conclusion that the real exchange rate is a shock absorber rather than a shock generator, as we are not able to find a country where the majority of business cycle volatility originates in the real exchange rate shock. The results suggest that the CEE region is formed of heterogeneous countries. This heterogeneity can be attributed to differences in monetary policy and exchange rate regimes, as well as to structural differences. Shock contribution analysis allows us to conclude that for prices and interest rates, symmetric shocks prevail and countries can be clustered with respect to the extent of the contribution of symmetric shocks. The most distinct clusters can be identified when one considers the contributions to output volatility. For Romania the asymmetric shock prevails, while for Bulgaria, Latvia, and Slovakia the symmetric and asymmetric shocks contribute with almost equal weights. For the rest of the countries the symmetric shock prevails. We further decompose the historical movements in the model variables to check for the historical contribution of each shock to each country's business cycle. Among other things, two interesting results emerge from this analysis.

In the case of Bulgaria, we identify a substantial role of real exchange rate shocks. This finding is consistent with Bulgaria's currency board policy. The exchange rate shock dominated output and price volatility in both the pre-crisis and crisis periods, with a declining role after 2009. A similar pattern is observed for Romania, but with a stronger influence of the exchange rate shock. This is a result of explicit exchange rate targeting in the Bulgarian case.

The role of monetary policy in the Czech Republic in the evolution of output over the period 2005–2011 should also be noted. In the initial stage, the symmetric policy shock contributes positively to growth. However, as the output deviation becomes too large (early 2007) it turns restrictive. After a slowdown hit the economy (in early 2009), policy was eased again to support the recovery. A similar pattern is observed for domestic prices. Analogous behavior of domestic output within this group is found for Poland and Latvia.

1. Introduction

There is a tradition in theoretical models to consider the real exchange rate a buffer against shocks. According to this view, if a shock hits an economy, the real exchange rate responds and helps re-establish equilibrium. However, support for this view from the empirical literature is mixed, as countries differ in many respects. In some economies, the real exchange rate could itself be a source of shocks that drives macroeconomic volatility. The question of the role of the exchange rate is closely related to the study of asymmetries between countries. The debate on the role of the real exchange rate becomes especially relevant when one considers a common currency area. The real exchange rate could be an important adjustment mechanism for countries within the area.

When two economies differ in economic structure, labor market flexibility, or fiscal or monetary policy, their response even to a common shock can be asymmetric, meaning that it has the opposite sign in the home and foreign country. If such asymmetries prevail, there is room for shock absorption via the exchange rate for establishing equilibrium. However, when shocks with a symmetric response prevail, there is little need for shock absorption.

In this paper, we assess importance of symmetric and asymmetric shocks for the business cycles of CEE countries and address the role of real exchange rate shocks in volatility. Some of the countries considered are already members of the Eurozone, while others are obliged to enter it in the near future and the question of entry has become a hot political and economic topic there. In this work, we study the following European Union member states: the Czech Republic, Slovakia, Poland, Hungary, Lithuania, Latvia, Estonia, Slovenia, Bulgaria, and Romania.

Our analysis is based on structural two-country models identified by the sign restriction method. The advantage of this method is that the signs of the impulse responses are restricted, so we are able to distinguish between symmetric and asymmetric responses. The sign restriction method was introduced by Uhlig (2005) and since then has become a popular analytical tool. Recently, Scholl and Uhlig (2008), Mallick and Rafiq (2008), and Peersman (2011) have employed this methodology to analyze the contribution of shocks to macroeconomic volatility. A thorough discussion of this method and its shortcomings is presented in Fry and Pagan (2011) and we implement their suggestions in our analysis.

We identify countries with a significant long-run relative contribution of asymmetric shocks to exchange rate volatility: in Romania, Lithuania, Bulgaria, Slovakia, and the Czech Republic this contribution is over 40 percent, and for the rest of the group it is around 30 percent. Our findings also show that economies in the region exhibit heterogeneous monetary policy responses due to asymmetries present both within the region and vis-á-vis the rest of the countries considered. These asymmetries are partially due to different monetary policy and exchange rate regimes (for non-member countries) and to structural differences (for example, TFP levels and levels of nominal prices). At the same time, our results are consistent with the real exchange rate having a shock absorption role in CEE countries.

We start our paper by addressing the theoretical role of the real exchange rate as a shock absorber and reviewing the relevant literature in Section 2. Section 3 describes the sign restriction method and its implementation. In Section 4, we present our data preparation procedure. The estimation and identification of the structural VAR model setup is presented in Section 5, where we also discuss the restrictions we use. Section 6 considers the relative importance of asymmetric shocks and the role of the exchange rate in absorbing or generating shocks. Finally, Section 7 concludes and describes the relevance of our findings to the debate on optimal currency areas and acknowledges the limitations of our study.

2. Exchange Rates as a Source of Shocks or a Shock Absorber

The theoretical discussion of whether the real exchange rate can act as a buffer against shocks goes back to a paper by Obstfeld et al. (1985) featuring the Mundell-Fleming-Dornbusch model. In this model, output, prices, and interest rates are affected by supply, demand, and nominal shocks. The equation for the real exchange rate reflects its response to shocks and whether it is helpful in restoring equilibrium. This theory underpins the framework considering the real exchange rate a shock absorber. At the same time, exchange rates themselves exhibit large deviations from equilibrium, implying that they could be influenced by idiosyncratic shocks. These deviations, in turn, can affect output and prices. In this regard, the question is whether these exchange rate shocks propagate further into the economy, and whether the real exchange rate is itself a source of volatility. This question is of particular interest when considering the choice of exchange rate regime and optimal currency areas.

There is a strand of empirical literature assessing whether real exchange rates are shock absorbers or sources of shocks. Clarida and Gali (1994) state that demand shocks explain most of the variance in the real exchange rate. Nominal shocks, including exchange rate shocks, were found to be unimportant. The study concluded, therefore, that the real exchange rate acts as a shock absorber. Recent work by Juvenal (2011) supports the finding that demand shocks are important for generating real exchange rate fluctuations in the US vis-á-vis the rest of the world. Farrant and Peersman (2006), using a different methodology, come to a different conclusion for a similar set of countries considered. They show that real exchange rate shocks are important determinants of exchange rate fluctuations, suggesting that the exchange rate is a source of volatility. On the other side of the ocean, there are studies inspired by European economic integration focusing on whether the real exchange rate against the euro insulates a country from shocks or whether it is an undesirable source of volatility. Peersman (2011) studies the UK vis-á-vis the euro, Amisano et al. (2009) examine Italy vis-á-vis the euro, and Artis and Ehrmann (2006) study the UK, Denmark, and Sweden vis-á-vis the euro, and Canada vis-á-vis the US. These studies did not find the real exchange rate to be a shock absorber; fluctuations on foreign exchange markets were important sources of volatility for some countries. In contrast, Thomas (1997) found that 60 percent of fluctuations in the real Sweden-euro exchange rate are explained by real shocks, suggesting there is potential for the real exchange rate to play a shock-absorbing role. The paper uses the identification methodology described in Clarida and Gali (1994), which was criticized by Farrant and Peersman (2006) as too restrictive.

An important aspect to consider when studying exchange rate absorption properties is whether shocks in the region are mostly symmetric or mostly asymmetric. By asymmetric we mean a shock causing the variables to respond with the opposite signs in the home and foreign country. The nature of the opposite responses lies in structural differences or differences in labor market flexibility or fiscal policy between countries. When countries are closely related in terms of their economic structure, shocks are likely to cause symmetric responses. In such case, the two economies are moving in the same direction and a strong reaction of the exchange rate is not expected. If, however, there are important asymmetries between the countries and shocks cause predominantly asymmetric responses, the exchange rate can respond to the shock and dampen its propagation further into the economy. Therefore, in this paper we address the relative importance of symmetric and asymmetric shocks to analyze the potential role of the real exchange rate as a shock absorber.

In addition to absorbing shocks, exchange rates can themselves be a source of volatility. High volatility in the exchange rate market translates into volatility of prices and, potentially, output. In this regard, we study how much of the real exchange rate variation is due to an idiosyncratic shock. If this contribution is high, it suggests that the exchange rate breeds its own shock. We then assess the contribution of the idiosyncratic shock to the volatility of output and prices.

3. Implementing Sign Restrictions

In this study, we estimate a structural VAR (SVAR) model of a small open economy. The common approaches to identifying SVAR models impose various short or long-term restrictions on the responses of the variables to shocks or impose contemporaneous restrictions via recursive ordering. As Uhlig (2005) summarizes, the ordering approach often leads to the emergence of anomalies such as the price puzzle or delayed overshooting puzzles. Also, Farrant and Peersman (2006) show that long-term zero response restrictions can deliver biased results.

Therefore, we employ the sign restrictions identification method pioneered by Faust (1998) and further developed by Uhlig (2005). In the sign restriction approach, shocks are identified by imposing restrictions on the signs of the impulse responses to structural shocks. These restrictions are usually imposed in the short to medium term to represent the effects of the structural shocks. The restrictions applied to the impulse responses can avoid the different puzzles that can occur when alternative estimation procedures are employed.

A structural VAR model of order p with n variables, where X is a vector of endogenous variables, can be stated as:

$$BX_t \quad = \quad A(p)X_{t-1} + \varepsilon_t. \tag{1}$$

Here, $A(p)$ is a polynomial of order p of matrices of size $n \times n$; B is a matrix of size $n \times n$; and ε_t is an $n \times 1$ vector of normally i.i.d. shock disturbances with zero mean and diagonal variance matrix Σ. The reduced-form VAR can then be written as:

$$X_t \quad = \quad \Pi(p)X_{t-1} + e_t, \tag{2}$$

where $\Pi(L) = B^{-1}A(L)$ and e_t is an $n \times 1$ vector of normally i.i.d. shock disturbances with zero mean and variance-covariance matrix V. The general-form shocks are related to the structural representation of the model in the following manner:

$$e_t = B^{-1}\varepsilon_t \qquad V = E(e_t e_t') = HH'. \tag{3}$$

The impulse responses of the structural representation are characterized by impulse matrix B^{-1}. The identification problem arises if there are not enough restrictions to pin down V as $HH' = B^{-1}\Sigma B^{-1'}$. The multiplicity originates from the orthonormal property of matrices, as for any orthonormal matrix Q, $V = (HQ)(HQ)'$. Thus e_t has the same variance matrix but is associated with different impulse responses generated by impulse matrix $B^{-1}Q$.

As Berg (2010) claims, the ability to generate multiple impulse responses makes the sign restriction approach more advantageous than recursive identification schemes. The large number of factorizations available, together with the choice of restrictions, allows us to avoid counterintuitive results. The IRIS toolbox used in our paper implements the following algorithm based on the procedure by Berg (2010), which was originated by Rubio-Ramírez et al. (2005).

First, the reduced-form VAR model is estimated to obtain matrix V. Second, the lower triangular factor of V is computed. Third, a random $n \times n$ matrix W is drawn from the multivariate standard normal distribution. Further, W can be factorized $W = QR$, so that $QQ' = QQ' = I$ and R is the upper triangular matrix. Fourth, the impulse response matrix $B^{-1}Q$ is created and the responses are calculated. Finally, the restrictions are checked and if all are fulfilled the draw is kept; otherwise it is discarded. This procedure is repeated until the targeted number of successful draws is collected.

Theoretically, there can be an infinite number of parameters in the admissible set. The popular approach is to report the median response at each horizon for each variable separately. This approach suffers from the fact that these separate median responses originate in different models (different parameterizations). For consistency in reporting the results, we use the closest-to-median approach proposed by Fry and Pagan (2011). The representative model is parameterized by solution to the following problem given by:

$$\min_j M(j) = \sum_{i=1}^{q} (\overline{\phi_i} - \phi_j)(\overline{\phi_i} - \phi_j)', \tag{4}$$

where the search runs over all successful draws j, and $\overline{\phi_i}$ is the median impulse for each period i over all successful draws ϕ_j. Here, $\overline{\phi_i}$ and ϕ_js are $n \times n$ matrices.

In order to analyze the role of the exchange rate in generating economic volatility, we decompose the variance of the model variables. The forecast error variance decomposition indicates how much of the forecast error variance of each of the variables can be explained by exogenous shocks to the other variables. In accordance with the Fry and Pagan (2011) critique of the multiplicity of parameterizations, the variance decomposition of the closest-to-median model is analyzed.

4. Data

We consider the following ten countries as the domestic country in our two-country model: Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia. For each of these countries, the foreign counterpart is the effective foreign aggregate of the remaining European Union countries. These effective indicators are constructed as weighted averages from the corresponding series for Eurozone countries. The weights correspond to the shares of domestic exports for each country under consideration.

The time series used in this study are taken from the Eurostat database, and for each country we have to take into account the specific data available. For most of the countries, the sample period covers the period from the first quarter of 1998 to the fourth quarter of 2013, so there are 63 observations. All the series used in the analysis are seasonally adjusted and converted to quarterly frequency.

For each of the countries considered, and for the construction of the foreign aggregates, real gross domestic product (GDP) is constructed by deflating nominal GDP by its deflator. The harmonized index of consumer prices (HICP) is used as the price index.

Short-term interest rates are described by the three-month money market rates that apply to interbank deposits or loans with an original maturity of three months. As Slovenia adopted the euro in 2007, followed by Slovakia in 2009 and Estonia in 2011, their three-month interbank rate is represented by the euro interbank offered rate (Euribor) after adoption. Latvia joined the euro in 2014, but as our sample ends with the fourth quarter of 2013, this does not affect our data.

As the measure of the real exchange rate, the effective real exchange rate of the domestic currency against the currencies of the other European countries is used. The real effective exchange rate aims to assess a country's (or currency area's) price or cost competitiveness relative to its principal competitors in international markets. Changes in the real exchange rate depend not only on exchange rate movements, but also on cost and price trends. The series from Eurostat use export weights to calculate the real exchange rate, reflecting not only competition in the home markets of the various competitors, but also competition in export markets elsewhere. A rise in the real exchange rate means a loss of competitiveness.

Table 1 presents a summary of the recent monetary policy settings in the countries considered over 1998–2013. Although the CEE accession countries aim to adopt the euro in the medium-term future, their experience with exchange rate regimes is quite diverse. The countries in the sample experienced transition from centrally planned to market driven economies in the early 1990s and are now converging to the common market of the European Union. This summary shows that inflation targeting has gained popularity in many CEE countries over the period, while exchange rate-focused monetary policy is still very popular.

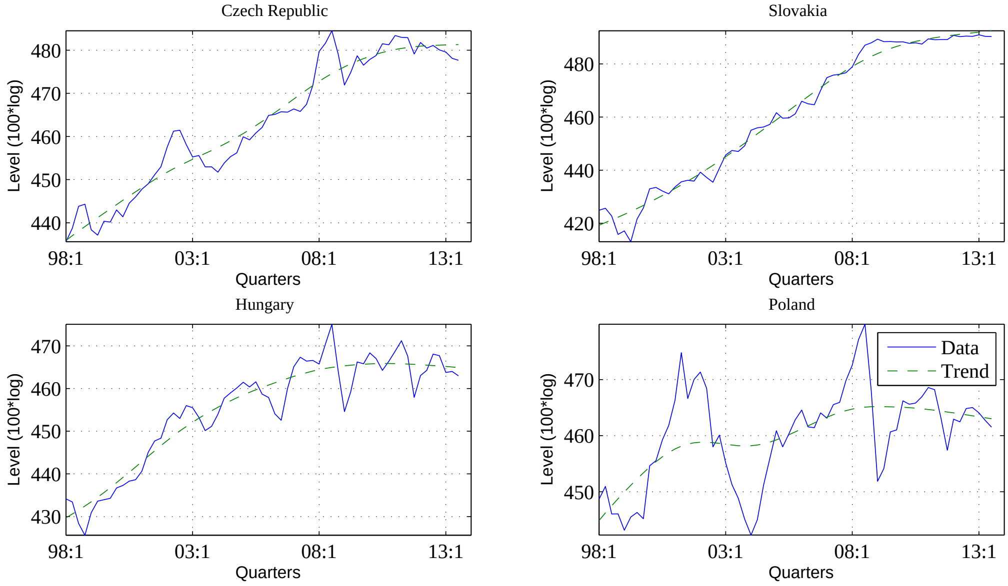
Table 1: Monetary Policy Strategies

Country	Exchange Rate Regime	Monetary Policy	Note
Bulgaria	Peg to euro	Exchange rate targeting	Currency board
Czech Republic	Free float	Inflation targeting	
Estonia	Peg to euro	Exchange rate targeting	Euro – 2011
Hungary	Managed/free float	Ex. rate+Inflation targeting	Free float from 2008
Latvia	Conventional fixed peg	Exchange rate targeting	Euro – 2014
Lithuania	Managed float	Exchange rate targeting	Euro – 2015
Poland	Managed/free float	Inflation targeting	Free float from 2000
Romania	Managed float	Ex. rate+Inflation targeting	
Slovakia	Managed float	Inflation targeting	Euro – 2009
Slovenia	Managed float	Ex. rate+Inflation targeting	Euro – 2007

Figure 1 documents the presence of trends in the real exchange rate for countries with diverse characteristics and choices of monetary policy. The transformation and convergence processes are fueled mainly by faster productivity growth in the countries considered as compared to the core countries of the European Union. Also, as many CEE economies use inflation targeting, trends are also present in the price level data. Therefore, trend-cycle transformation of the data is needed to handle the presence of these trends. However, the convergence trajectories of the countries differ significantly, as they have had to cope with changes in their economic structures and policies and differences in the initial conditions of the convergence process. This figure also suggests that these trends vary over the period considered, so we assume that there are no common trends in the convergence process.

To remove time-varying trends under the assumption of the absence of common trend components, we consider univariate trend-cycle decomposition for all variables in the model. To do this, we detrend the data with the HP filter by setting $\lambda = 1600$ after taking logs and rescaling the series by a factor of 100. We believe that this approach is flexible enough to remove time-varying trends

Figure 1: Real Exchange Rates: Data and Trends



and handle the presence of unit roots in the data and anchored expectations in developed countries. An advantageous product of the transformation procedure is the transformation of all the data into percentage deviations from the trend, which makes the results easier to interpret.

5. Imposing Identification Restrictions

The origins of the sign restrictions used to examine the relationship between the real exchange rate and the business cycle can be traced to the two-country model with sticky prices derived by Obstfeld et al. (1985). Based on the two-country model, Clarida and Gali (1994) presented a parsimonious model where the variables under consideration are in the form of ratios of domestic to foreign variables. This approach was adopted by a stream of structural VAR studies, such as Thomas (1997), Artis and Ehrmann (2006), and Amisano et al. (2009). This approach is based on the reasoning that the real exchange rate itself is a relative variable and that only relative or asymmetric shocks are interesting, as symmetric shocks do not require any adjustment of the real exchange rate. These models feature four variables: relative GDP (domestic to foreign), the relative price, and the relative interest rate, together with the real exchange rate.

Models in relative terms are not able to identify symmetric shocks and thus do not provide information on the comparative importance of asymmetric shocks with respect to symmetric shocks. As Peersman (2011) points out, it is possible that asymmetric shocks are not a major source of volatility. In such case, the relative model focuses only on a small proportion of the variance. Nevertheless, due to an inability to judge the comparative importance of symmetric and asymmetric shocks, the relative form of variables implies that the strong restriction of the transmission of symmetric (common) shocks in the economies under comparison is the same in amplitude and timing. As in relative models any deviation from one-to-one propagation of a common shock is regarded as asymmetric, it is also necessary to consider differences in transmission mechanisms before judging the importance of asymmetric shocks.

Following Peersman (2011), we apply an extended version of the VAR model that is able to separate symmetric and asymmetric shocks. In contrast to relative models, our identification scheme takes into account not only the presence of symmetric supply, demand, and policy shocks, but also their asymmetric counterparts. Recall that asymmetric shocks are identified as those calling for opposite movements in model variables. The interpretation of the shocks identified is the standard one used in the literature. A positive supply shock increases output and reduces prices, and a positive demand shock is characterized by increasing prices and output, while restrictive monetary policy leads to a reduction of output and prices. The exchange rate shock is identified so that exchange rate appreciation (loss of competitiveness) leads to a restrictive influence on the domestic economy. As shocks are identified by their effects on economies, this scheme abstracts from a one-to-one form of symmetry.

The variables used in the VAR model set up the following vector: $X_t = \{y_t, p_t, i_t, q_t, y_t^*, p_t^*, i_t^*\}$, where y_t is the real GDP gap, p_t is the consumer price index gap, i_t is the interest rate gap, and q_t is the gap in the real exchange rate (and an increasing value reflects a loss of competitiveness of the domestic economy), while y_t^* is the effective foreign real GDP gap, p_t is the gap in the effective foreign consumer price index, and i_t is the effective foreign interest rate gap.

In the structural VAR model, we identify seven structural shocks: a symmetric supply shock, a symmetric demand shock, and a symmetric monetary policy shock, three corresponding asymmetric shocks, and a real exchange rate shock. The restrictions presented in Table 2 are consistent with the responses of the two-country theoretical model presented in Clarida and Gali (1994), Farrant and Peersman (2006), and Peersman (2011).[1] This complex set of restrictions focuses on identification of the symmetric and asymmetric shocks and the real exchange rate shock.

Table 2: Sign Restrictions – Individual Shocks

Variable Structural shock	y_t	p_t	i_t	y_t^*	p_t^*	i_t^*	q_t
Symmetric supply	≥ 0	≤ 0	≤ 0	≥ 0	≤ 0	≤ 0	
Symmetric demand	≥ 0	≥ 0	≥ 0	≥ 0	≥ 0	≥ 0	
Symmetric monetary policy	≤ 0	≤ 0	≥ 0	≤ 0	≤ 0	≥ 0	
Asymmetric supply	≥ 0	≤ 0	≤ 0	≤ 0	≥ 0	≥ 0	
Asymmetric demand	≥ 0	≥ 0	≥ 0	≤ 0	≤ 0	≤ 0	≥ 0
Asymmetric monetary policy	≤ 0	≤ 0	≥ 0	≥ 0	≥ 0	≤ 0	≥ 0
Exchange rate	≤ 0	≤ 0	≤ 0	≥ 0	≥ 0	≥ 0	≥ 0

The first step in the sign restrictions method is to estimate the reduced-form VAR model as given by equation 2. The lag length is determined by the Akaike information criterion (AIC) and we set the lag at two for each country in our study.

5.1 Data and Restrictions

We consider countries at different stages of transformation, with different structures, and under various policy regimes, so some of our restrictions may be rarely supported by the data. Therefore, our first exercise is focused on analyzing the support for our restrictions on the shocks. To run this analysis, we identify seven models for each country. Each of these models is very simple and

[1] The change in notation stems from the data definition, as in our notation, an increase in the real exchange rate q_t means a loss of competitiveness.

identifies only one specific shock as given by the restrictions in Table 2. In our search for shocks, we impose restrictions in the first period only.

Table 3: Numbers of Draws: Summary

	Countries									
Shock	CZ	SK	HU	PL	EE	LT	LV	RO	BG	SI
S. supply	17	12	28	20	10	15	17	22	32	11
S. demand	10	11	15	12	13	11	15	12	12	6
S. policy	17	17	27	46	13	30	20	35	21	12
A. supply	69	401	42	41	94	130	119	75	101	379
A. demand	160	130	166	98	228	380	182	237	78	416
A. policy	415	850	168	69	2938	504	261	338	8683	3778
Ex. rate	265	319	127	102	5273	485	179	90	10915	2409

We target 1000 accepted parameterizations. We calculate the average number of draws to get a successful draw using the total number of draws needed. Table 3 reports these averages. Similar to Peersman and Straub (2006), we use this number as a measure of the compatibility of the data and our restrictions. The larger is the number, the less support for the restriction is found in the data. The high average number of draws needed for Bulgaria, Estonia, and Slovenia when considering the asymmetric monetary policy and real exchange rate shock signals that parameterizations compatible with the shock response definition are very rare. This observation stems from the fact that for countries with fixed exchange rates, the monetary policy response avoids actions that can be regarded as asymmetric policy shocks.

Table 4: Ratio of Draws: Omitting Recent Slowdown

	Countries									
Shock	CZ	SK	HU	PL	EE	LT	LV	RO	BG	SI
S. supply	0.7	0.5	1.0	1.6	0.8	0.5	1.5	0.9	1.0	0.8
S. demand	0.7	0.6	0.6	0.8	0.6	0.3	0.4	1.3	0.2	0.2
S. policy	0.6	0.5	1.8	1.4	0.4	1.0	1.3	2.1	1.7	0.3
A. supply	1.8	4.5	0.4	1.1	2.1	2.5	2.7	1.2	1.6	6.9
A. demand	1.4	2.8	0.8	1.0	1.2	4.5	0.6	0.3	0.7	2.0
A. policy	0.9	1.2	0.2	0.3	1.8	0.7	1.5	0.7	1.9	4.8
Ex. rate	1.2	1.9	0.8	0.2	2.3	4.9	0.6	0.2	1.2	3.1

It could be argued that the recent recession might have amplified the structural differences between countries so it will be easier to find parameterizations compatible with responses to asymmetric shocks. As a robustness check, we shortened our sample by omitting data after the third quarter of 2008. Table 4 presents the results of this robustness check as a ratio of the average number of draws needed in the full sample to the average number of draws needed in the short sample. In this relative metric, if the ratio is close to unity, the restriction support was not affected by the crisis and the recession. If the ratio is greater than unity, the restriction is less compatible with the data over the pre-crisis period. A ratio smaller than unity indicates that the supporting parameterization for such restriction is easier to find over the pre-crisis period.

The simple average ratio for symmetric shocks is 0.9. This means that the number of draws needed is similar for the symmetric shocks in the full and short data set. However, the value of 1.8 for asymmetric shocks indicates that the number of draws needed for the identification of asymmetric shocks decreases when the 2008–2013 period is omitted. The inclusion of the recent recession delivers more compatibility between the data and our identification scheme for the asymmetric shocks. As only ten out of the thirty (three shocks and ten countries) ratios are below unity, it seems easier to support our restrictions on asymmetric shocks during the recent recession.

When analyzing the data support for individual asymmetric shocks, the largest ratio of draws is needed for the asymmetric supply shock. This is consistent with a situation of higher flexibility of suppliers in the countries in the study and lower flexibility of suppliers in their trading partners. Even for the countries with a peg or exchange rate targeting (Bulgaria, Romania, Hungary, and Latvia) we observe that it is harder to find support for asymmetric demand restriction over the pre-crisis period.

Also, to assess the effects of adoption of the euro for Estonia, Slovakia, and Slovenia, we cut the sample at the euro adoption date to exclude data covering Eurozone membership. The ratios of the average parameterization draws needed are in the range of 0.9–1.1. When breaking down the ratio into individual shocks, we find that more parameterizations support restriction on the asymmetric supply shock for all three countries. In our view, this is due to continuation of the convergence process. As the ratio does not differ noticeably from unity in this check, the following analysis will be done on the full sample for all the countries considered.

As regards the effect of sample length for the real exchange rate shock identification, Table 4 reports an average ratio of 1.6. This result suggests that parameterizations supporting restrictions on exchange rate shocks are more frequent when the underlying VAR model is estimated on the full data set.

The low support for restrictions on asymmetric shocks for most of the countries leads us to relax the restrictions on individual asymmetric shocks. However, the restrictions on symmetric shocks as presented in Table 2 ensure that none of the symmetric shocks could be confused with an asymmetric shock. Therefore, it is possible to apply an identification scheme that distinguishes symmetric shocks from asymmetric ones, even though asymmetric shocks are not explicitly restricted individually.

The discussion in the previous section suggests that restrictions on asymmetric responses are rarely supported by the data and the model with restrictions on individual asymmetric shocks is hard to identify. However, this does not necessary imply that shocks causing asymmetric responses have only a minor impact. Therefore, in the following section we employ a model where asymmetric shocks are not identified individually, but remain as "other shocks" in the residuals. With this model we study the impulse responses and variance decomposition. We also address the relative importance of symmetric and asymmetric shocks, as they contribute to each country's business cycle, with asymmetric shocks identified as residuals. We aware of the fact that, in addition to asymmetric shocks, the residuals may contain noise and potential data errors. This could potentially lead to overestimation of the importance of asymmetries. Therefore, we take our estimates with caution and treat them as indicative rather than solid proved results. As in Peersman (2011), we conduct historical decomposition of the contribution of shocks to the business cycle, with the focus on each symmetric and asymmetric shock as a group of "other shocks."

As we aggregate the asymmetric shocks, the number of individual restrictions is reduced, as described in Table 5. It resembles Table 2, but without the implicit restrictions on the asymmetric shocks. However, the set of restrictions kept distinguishes each symmetric shock from any of the asymmetric shocks as restricted in Table 2. All the restrictions are applied to the responses in the first period only. The asymmetric shocks mentioned in the previous identification schemes are not individually identified and are referred to in the following analysis as "Asymmetric shocks.”

Table 5: Baseline Model Identification Scheme

Variable Structural shock	y_t	p_t	i_t	y_t^*	p_t^*	i_t^*	q_t
Symmetric supply	≥ 0	≤ 0		≥ 0	≤ 0		
Symmetric demand	≥ 0	≥ 0	≥ 0	≥ 0	≥ 0	≥ 0	
Symmetric monetary policy	≤ 0	≤ 0	≥ 0	≤ 0	≤ 0	≥ 0	
Exchange rate	≤ 0	≤ 0		≥ 0		≥ 0	≥ 0

With the set of restrictions presented in Table 5, we collect the parameterizations of the structural VAR models and use the median criterion to select a representative model. Further, we present the impulse response analysis and examine sources of volatility by variance decomposition. This also allows discussion of the relative importance of symmetric and asymmetric shocks. Finally, we are able to identify their historical contributions to the business cycle.

5.2 Impulse Responses

Impulse responses for individual countries are reported in Figures A1–A10 as percentage deviations from the variables’ trend value. As the asymmetric shocks are not identified individually, only the responses to symmetric and real exchange rate shocks are presented. The countries in the study are small open economies, so our presentation focuses on domestic variables. The figures also show bands representing the 90^{th} and 95^{th} percentiles across the models.

Generally, in response to a symmetric supply shock, a persistent increase in domestic output can be observed for all countries. Domestic inflation is restricted to a decline in the first period, though it reverts rather quickly. The policy response is not restricted, so it varies across countries. However, patterns are observed, as monetary policy eases in the Visegrad countries (the Czech Republic, Hungary, Poland, and Slovakia), tightens in Bulgaria, Romania, and Lithuania, and tightens a little in Estonia and Latvia. Slovenia responds with the tightening in the next period. As policy eases for the inflation-targeting countries, the initial response of the exchange rate is depreciation. However, as output continues to grow, appreciation occurs. Generally, real exchange rate depreciation follows a symmetric supply shock, meaning that export-oriented countries profit from lower prices and their exports become cheaper.

In response to the symmetric demand shock, output, prices, and interest rates rise. Depending on the strength of the monetary policy response, the positive response of output and inflation is eliminated. After the initial periods of tightened policy, inflation and output start to contract. Then the policy is eased to restore equilibrium. For all countries except Lithuania and Romania, the exchange rate appreciates in response to the initial tightening of monetary policy. For Lithuania, delayed exchange rate appreciation is observed and can be explained by the lagging nature of the currency board. The impulse responses suggest that there are differences across the exchange rate responses to the demand shock (depreciation in Romania and Latvia). These differences could be driven by monetary policy regimes or could be structural, but the prevailing appreciation is consistent with growth in the net exports of the countries in the study.

Romania's response to the symmetric demand shock is a large and persistent depreciation of the real exchange rate. Despite the increase in competitiveness, Romania experiences the largest and longest decline in output of all the countries in the study. We believe that this is due to structural problems in its economy and its monetary policy as regards managing the exchange rate. A conflict may exist between exchange rate and inflation rate targeting, as one can see monetary policy tightening to fight the inflation, which stays long above equilibrium, partially due to a fall in the exchange rate.

Symmetric monetary policy tightening is restricted to reduce output and inflation. The exchange rate depreciates for most of the countries, with the exception of Latvia, where it rises first and falls after a few periods. This response suggests the presence of asymmetries in transmission channels, with both the domestic and foreign economies raising interest rates while the domestic monetary authority avoids appreciation. This prevents too large a slowdown in output growth and fosters a recovery in price level dynamics.

The restrictions on the exchange rate appreciation shock require a reduction of domestic output and prices, increasing foreign output and the foreign interest rate. However, in the following periods output rises very quickly above the steady state (except for Hungary), as does inflation, despite mostly tightening responses of domestic monetary policy.

The differences identified in the countries' responses are consistent with their heterogeneous economic structures and monetary policy regimes. Some similarities can be found within the groups (the Visegrad countries and the Baltic countries). In the following section, we analyze the differences in the contributions of the shocks to economic volatility and the historical decomposition of the shocks.

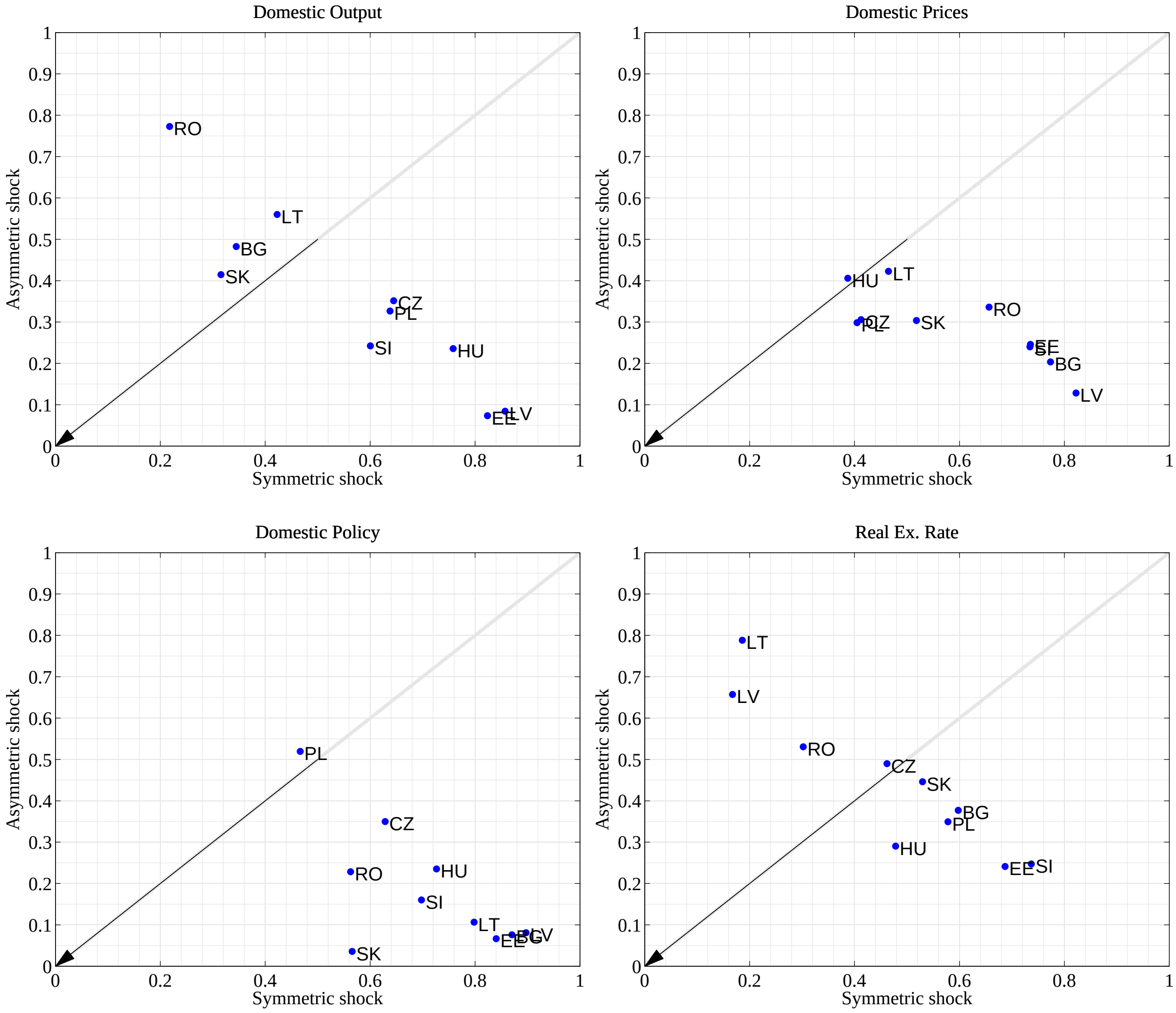
5.3 Relative Importance of Symmetric and Asymmetric Shocks

A major concern of the optimal currency area literature when assessing the application of a single monetary policy stance is the similarity of the business cycles of the participating countries. Some degree of synchronization of shocks and cycles is required to have a single monetary policy stance that is acceptable to the individual countries. As our shocks are defined via their impact on the economy irrespective of their common or idiosyncratic origin, our assessment of the relative importance of symmetric and asymmetric shocks provides guidelines on the costs of the dissimilarities present.

As the relative importance varies over the periods after shocks, we consider it from the short-run and business cycle perspectives. The average contribution of the symmetric and asymmetric shocks for the model closest to the median over the first six periods describes the short run and is presented in Figure 2. The relative importance for the business cycle is assessed by taking the average from the 6^{th} to the 32^{nd} period after the shock and is presented in Figure 2. A detailed evaluation of the shock contributions is presented in Figures B1–B10. As we study small open economies, each figure shows the decomposition for the domestic variables only.

Aggregating the contributions of symmetric and asymmetric shocks allows us to assess their relative importance. For countries with a relatively high contribution of symmetric shocks, synchronization of business cycles with trading partners is high. So, the costs to a small open economy of adopting a common monetary policy with its trading partners are considered to be rather small. However, if asymmetric shocks have a relatively high contribution, the required monetary policy response is the opposite in the two countries, and giving up independent monetary policy can be very costly. As a result, to form a currency union, it is important that the contribution of asymmetric shocks to the business cycle is small.

Figure 2: Short Run: Symmetric vs Asymmetric Shock Contributions

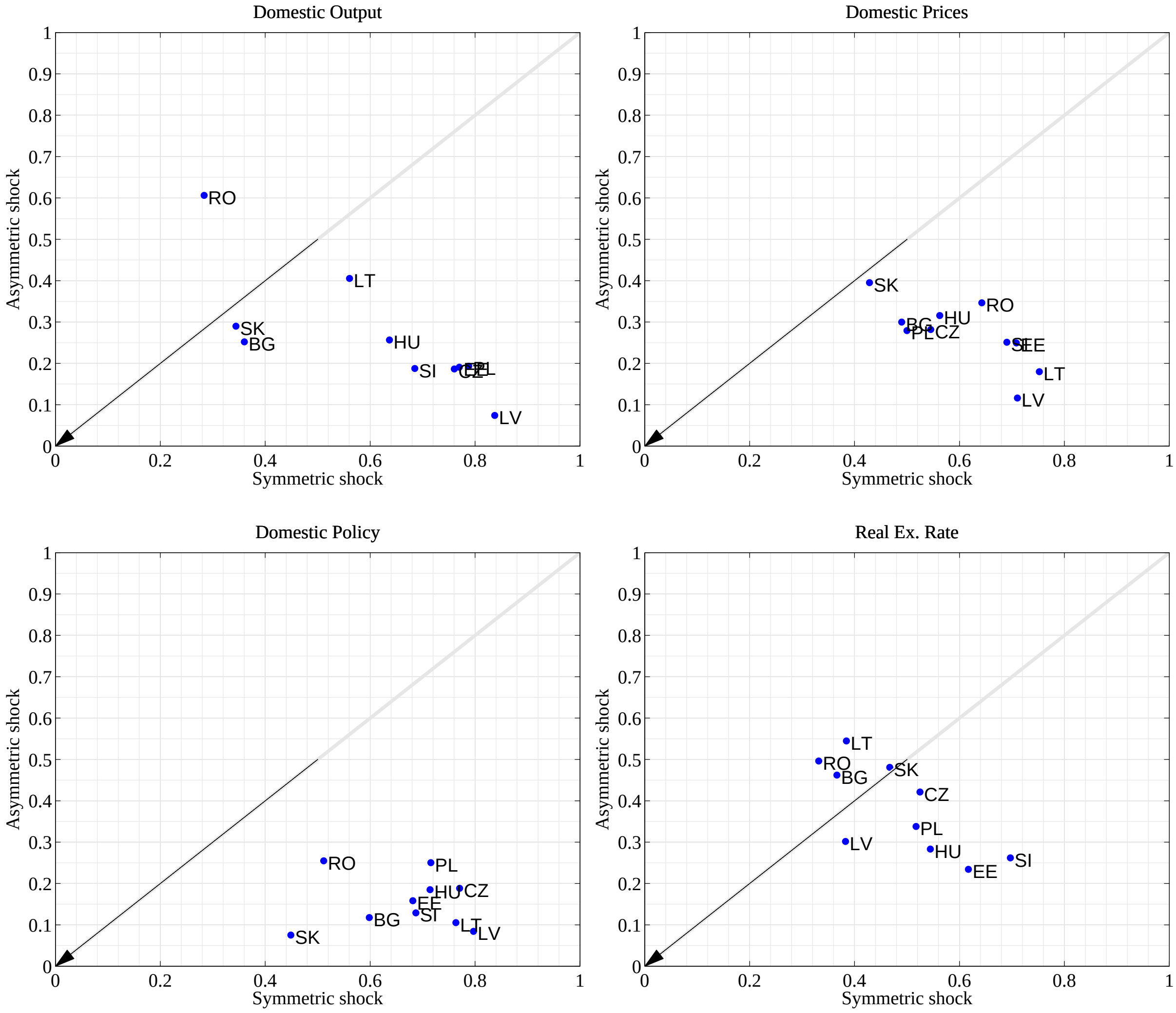


Countries with a substantial contribution of asymmetric shocks to output volatility in the short run include Romania, Lithuania, Slovakia, and Bulgaria, where this contribution can reach up to 80 percent in the initial period (see Figure B9 for Bulgaria). The contribution of asymmetric shocks to output volatility is also high in the long run for these countries, with contributions in the 20–60 percent interval. For the rest of the countries in the study, the long-run contribution of asymmetric shocks is below 20 percent.

The set of countries with the strongest short-run contribution of asymmetric shocks to domestic price volatility contains the Czech Republic, Hungary, Poland, Lithuania, Romania, and Slovakia, where the contributions range from 25 to 40 percent. As our sample includes transition countries, there is a high percentage of administered prices present in these economies. The adjustment of these prices often follows schemes that are not correlated with the business cycles of other countries, so it can result in asymmetries.

The countries with a prevailing contribution of asymmetric over symmetric shocks to the real exchange rate in the long run are Bulgaria, Lithuania, Romania, and Slovakia. If we consider short-run contributions, the Czech Republic and Latvia join this group, while the contribution of asymmet-

Figure 3: Business Cycle: Symmetric vs Asymmetric Shock Contributions



ric shocks for Bulgaria decreases. Most of the relatively high contribution (almost 80 percent) for Latvia can be explained by the choice of an exchange rate peg as policy, with the prevailing regime for this group being either exchange rate targeting or an exchange rate peg. The substantial contribution of asymmetric shocks is consistent with the real exchange rate having a shock-absorbing nature.

The countries with a small contribution of asymmetric shocks to domestic prices are Bulgaria, Estonia, and Latvia. For these countries, symmetric shocks account for about 80 percent of the volatility of prices. The variance decompositions for domestic output, prices, and policy presented in Figures B9, B5, and B7 are dominated by the contribution of symmetric shocks at almost all horizons. This group of countries is also characterized by pegging and fixation of their currencies to the euro. This choice of monetary policy sets up a strong link between domestic and foreign prices and interest rates, resulting in limitation of the presence of asymmetric shocks.

The variance decompositions show a large influence of asymmetric shocks on specific groups of economies. Even though asymmetric responses are not frequent in the data, together they account for a significant portion of output and price volatility. Due to their relative importance for the volatilities of the variables considered, the frequency of occurrence must be offset by their amplitude. The presence of substantial asymmetry stems from asymmetries across the countries considered in terms of productivity and monetary and exchange rate policies. There are striking differences in the relative contributions of asymmetric shocks across countries – the contributions to output volatility range from 10 to 80 percent.

The results are important for the formation of an OCA within the region and the Eurozone. The large relative influence of asymmetric shocks suggests low synchronization of the countries' business cycles and complicates common monetary and exchange rate policy implementation.

5.4 Role of the Real Exchange Rate

In theory, the role of the real exchange rate is to act as a mechanism which reacts to structural shocks and helps stabilize output and inflation variability. However, there is empirical evidence suggesting that real exchange rates are very volatile, further fueling macroeconomic volatility and causing economic disturbances. Therefore, the crucial question is what proportion of the exchange rate volatility stems from idiosyncratic real exchange rate shocks and what is the influence of these shocks on the volatility of output, prices, and monetary policy. Assessing how much volatility the real exchange rate generates or absorbs is not a straightforward exercise and could be subject to debate.

In this paper we pursue the approach developed in the literature (Peersman, 2011; Clarida and Gali, 1994; Farrant and Peersman, 2006), where studies consider what fraction of the exchange rate volatility is driven by the exchange rate shock. The intuition behind this approach is the following. If exchange rate volatility is driven mostly by, for example, the supply shock, it is a sign that the exchange rate largely reacts to the supply shock. This could be interpreted as the exchange rate absorbing the supply shock. If, however, the exchange rate is driven mostly by the idiosyncratic shock, it could be interpreted as having little role as a shock absorber. Another question related to the analysis is what to consider a "large" reaction to a shock. Generally in the literature, and in line with common sense, less than 10 percent is not considered to be an important source of volatility, while more than 20 percent is an important source of volatility.[2]

Figures B1–B10 present decompositions of the real exchange rate, highlighting the contribution of the real exchange rate shock. If this contribution is high, the exchange rate absorbs little volatility from the remaining structural shocks and thus does not serve as an important stabilization mechanism. However, if one aims to judge whether the real exchange rate is itself a source of volatility, its impact on the volatility of output, prices or monetary policy is more important. If the contribution of the real exchange rate is low, idiosyncratic exchange rate fluctuations are not harmful for the rest of the economy.

The short-run contribution of the idiosyncratic real exchange rate shock to real exchange rate volatility ranges from a tiny 1 percent in the case of Slovenia to approximately 5 percent for Bulgaria, the Czech Republic, and Slovakia, and up to 20 percent for Hungary and Latvia. This is far below the 45 percent of sterling-euro fluctuations explained by the idiosyncratic shock in the short run as identified by Peersman (2011). In the long run, the idiosyncratic shock fuels Latvia's real exchange rate volatility by 30 percent. Meanwhile, most of the countries form two distinct groups, one with

[2] Clarida and Gali (1994) consider 35–41 percent of the exchange rate variance explained by a nominal shock a "substantial amount," Peersman (2011) considers more than 30 percent "significant," while Uhlig (2005) refers to 5–15 percent of the explained variation as a "small" fraction.

a contribution of approximately of 15 percent and the other at 5 percent. The latter values are in line with the findings of Clarida and Gali (1994) and Farrant and Peersman (2006). On the other hand, the contributions of exchange rate shocks in the former group are still markedly lower than the results obtained by Artis and Ehrmann (2000) for Denmark, Germany, and the United Kingdom, where the contributions range from 50 to 90 percent.

Studies such as Clarida and Gali (1994) and Eichenbaum and Evans (1995) that attempt to identify the contribution of various shocks to the real exchange rate often find that monetary policy shocks are unimportant. However, our results suggest that symmetric monetary policy shocks deliver an important part of the real exchange rate volatility for the Czech Republic, Hungary, Poland, and Slovenia. Thus, we can support the conclusion reached by Rogers (1999) that monetary policy shocks matter and that the focus on monetary shocks in the recent dynamic general equilibrium literature is empirically well-founded.

When we consider the transition of real exchange rate shocks to domestic output in the short run, the countries can be split into three groups. Slovakia's output is significantly driven by the exchange rate shock, as its contribution is 25 percent. For Bulgaria, Estonia, and Slovenia the short-run contribution is 12 percent on average, while for the rest of the countries either there is no effect (the Czech Republic) or the effects are less than 5 percent. In the long run, a large contribution of 35 percent is present for Bulgaria and Slovakia and a rather high contribution of approximately 15 percent is observed for Slovenia, while the rest of the countries are characterized by contributions of less than 10 percent. Most of the countries in the study exhibit an interesting pattern in which the contribution of the exchange rate shock is almost nil or very low in the initial periods after the shock but starts to increase over time. This behavior reflects the speed of pass-through of the exchange rate to output.

In the short run, the exchange rate shock substantially contributes to the volatility of domestic prices in the Czech Republic, Poland, Hungary, and Slovakia (15–30 percent). There is another distinct group, containing Bulgaria, Estonia, Latvia, Romania, and Slovenia, where the short-run pass-through is low (below 5 percent). Poland is characterized by largest long-run contribution of the real exchange rate shock to domestic prices (30 percent). The group close to the average contribution of 15 percent is dominated by inflation-targeting countries – the Czech Republic, Slovakia, Latvia, and Hungary. Surprisingly, Bulgaria also belongs to this group, while the countries with pegged exchange rates and early euro adopters such as Estonia, Latvia, and Slovenia are in the group with a long-run contribution of less than 8 percent.

The monetary policy volatility decomposition in the long run shows an exceptionally high contribution of the exchange rate shock for Slovakia, where it reaches 45 percent. Clearly, Slovakia's monetary policy is highly responsive to movements in the exchange rate. As a large effect of the exchange rate shock is found for domestic output, the large contribution of the exchange rate shock to domestic monetary policy stems from the use of the Taylor rule with inflation and output gap components. The Czech Republic and Poland have a low (below 5 percent) monetary response to exchange rate shocks. The remaining countries evenly cover a range of contributions running from 8 to 22 percent. As there are many rigidities present, the short-run contributions to volatility are lower than the long-run ones. However, the ordering of countries does not change much when short-run effects are considered.

For most of the countries in the study (Bulgaria, Poland, and Slovakia being the exceptions) the results illustrate that the real exchange rate shock does not significantly contribute to the volatility of domestic variables. Generally, the most significant effect of the exchange rate shock is identified for domestic prices. This is not surprising given that most of the countries are small and open (to their foreign counterparts in the study); movements in the real exchange rate pass into prices, as these are more responsive than output. For most of the countries, the transmission of the real exchange rate shock is lagged and reaches its long-term contribution value only slowly.

When considering the potential of the real exchange rate to act as a shock absorber, attention should be paid to the variance decomposition of the real exchange rate. When the contribution of shocks other than idiosyncratic shocks is large, this could be interpreted as a sign of shock absorption. Figures B1–B10 show that for most of the countries, real exchange rate volatility is mostly due to asymmetric shocks. Their long-term contribution is about 50 percent for the Czech Republic, Slovakia, Latvia, Lithuania, Romania, and Bulgaria, with a short-term contribution close to 100 percent for Lithuania and Latvia. For the rest of the countries in our sample, asymmetric shocks cause between 20 and 30 percent of the variation in the real exchange rate. We interpret such an impact as a sign of absorption of asymmetric shocks. Hungary, Poland, and Slovenia exhibit a large impact of the monetary policy shock on real exchange rate volatility (up to 40 percent). In Slovakia, Estonia, and Lithuania, the real exchange rate acts as a supply shock absorber, accounting for up to 30-40 percent of the variance.

To conclude, in the selected countries exchange rate volatility is mostly driven by symmetric and asymmetric shocks rather than by real exchange rate shocks. The low contribution of idiosyncratic shocks to the exchange rate variance indicates that the exchange rate does not generate much volatility on its own, but rather responds to domestic and foreign shocks. For countries with a very low impact of exchange rate shocks on other domestic variables, this may imply that the exchange rate is not a source of volatility. At the same time, the real exchange rate volatility is fueled by shocks other than idiosyncratic shocks. This finding is interpreted as a shock-absorbing property of the real exchange rate.

5.5 Estimation of Historical Shocks

The identification of structural shocks is often a controversial issue, so to support our choice of technique and identifying restrictions, we present the results of a historical shock estimation over the sample considered. As in the previous analysis, this identification is based on the closest-to-median model, which is fitted to the data. The result of this estimation provides the overall contribution of the symmetric, asymmetric, and real exchange rate shocks to the observed business cycles.[3]

Figures C1–C10 show the period of economic boom preceding the most recent economic slowdown linked to the financial crisis of 2008. The results suggest that there is a group of countries whose business cycles were dominantly driven by symmetric supply and demand shocks. This group contains the Czech Republic, Poland, Estonia, Lithuania, and Latvia, and these shocks explain a substantial amount of the output and price movements and monetary policy responses.

The asymmetric and real exchange rate shocks were important for output in Romania and Slovakia, as they together explain a substantial amount of the output fluctuations. The asymmetric shocks also significantly contributed to the evolution of domestic prices. However, the main driver for Romanian prices was the symmetric price shock, while this is not the case in Slovakia.

[3] Here, the asymmetric shocks also include the effects of the initial state. The general pattern for the contribution of the initial state is a significant contribution in the initial few periods (the start of the dataset) and a negligible contribution in recent periods. As the initial state also reflects some asymmetry in the setup, we aggregate its contribution with the asymmetric shocks.

In the case of Bulgaria, we identify a substantial role of real exchange rate shocks, consistent with its currency board policy. The idiosyncratic real exchange rate shocks are also the most influential driver of domestic variables. In Bulgaria, the exchange rate shock dominated output and price volatility in both the pre-crisis and crisis periods, with a declining role after 2009. A similar pattern is observed for Romania, but with a stronger influence of the exchange rate shock. This is a result of explicit exchange rate targeting in the case of Bulgaria.

As in the previous sections, we examine the role of monetary policy in output, and find an ample role of the symmetric policy shock for Slovenia in domestic variables. These results are consistent with the adoption of the euro and common monetary policy in 2007. However, such behavior is not observed for Slovakia, which also adopted the euro.

The role of monetary policy in the Czech Republic in the evolution of output over the period 2005–2011 should also be noted. In the initial stage, the symmetric policy shock contributed positively to growth. However, as the output deviation became large (in 2007) the policy became restrictive. After a slowdown hit the economy (in early 2009), policy was eased again to support the recovery. A similar pattern is observed for domestic prices. Such patterns are also seen for domestic output in the case of Poland and Latvia. However, in the case of Latvia, the expansionary policy contribution occurred with a lag, since the Latvian economy was severely hit by a slowdown in the foreign environment.

This historical analysis supports our findings in the previous section that asymmetric and idiosyncratic shocks prevail for a group of countries, while for the rest of the countries symmetric shocks drive the business cycle. These findings are consistent with the countries' past experience and monetary policy settings. Generally, a common feature of the economies under consideration is a relatively low contribution of the real exchange rate to cyclical movements. With the exception of Bulgaria and Latvia, the real exchange rate has been driven by shocks other than the idiosyncratic one. Such an outcome for the real exchange rate is consistent with the real exchange rate having a shock-absorbing role.

6. Conclusion

For countries in the CEE region, being a part of the currency area is a very topical discussion, as some of them are recent Eurozone entrants while others are actively considering joining in the future. This paper tackles important OCA-literature issues such as the role of the real exchange rate and the importance of asymmetric and symmetric shocks. We identify countries with a relatively large importance of asymmetric shocks (up to 80 percent) and others with a very low impact (around 10 percent). We find differences in terms of impulse responses to shocks. These differences stem from varying economic structures and monetary policy and exchange rate regimes.

Some similarities, however, are observed. For most of the countries (the exceptions being Bulgaria, Poland, and Slovakia), the results illustrate that the real exchange rate shock does not generate significant volatility in macroeconomic variables. We interpret this as indicating that the exchange rate is not a source of additional volatility. The largest contribution of the idiosyncratic exchange rate shock is to volatility in prices. This is interpreted as being a result of the countries being small open economies with close trading links with the Eurozone. Therefore, movements in the real exchange rate are transmitted to prices, with a rather small effect on output. We also find that the reaction to the idiosyncratic shock is lagged, reflecting the speed of exchange rate pass-through.

The results of the variance decomposition also suggest that the real exchange rate acts as a shock absorber.

The results of the study are relevant to academics and policy-makers considering the question of a common currency area. When asymmetries in the response to shocks prevail, it implies that forming a currency union is not desirable. Also, if countries need to respond to a shock with the opposite monetary policy action, a common monetary policy is not optimal for them.

Another policy-related question is whether the real exchange rate can act as a shock absorber when the nominal exchange rate is fixed to a currency union. For the countries analyzed, the real exchange rate behavior is consistent with a shock-absorbing role. We also find little evidence of a shock-generating role for the real exchange rate.

We acknowledge that our results should be taken with caution. First of all, the countries considered have data starting from the late 1990s, leaving us with only 63 quarterly observations. Also, the impact of asymmetric shocks could be biased toward a larger impact, as asymmetric shocks are identified as “the rest of the shocks” and could be contaminated with other unidentified shocks and data errors. However, we believe that our study provides useful guidance for both academics and policy-makers when considering currency unions in the CEE region.

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Appendix A: Impulse Response Functions

Figure A1: Impulse Response Functions – Czech Republic

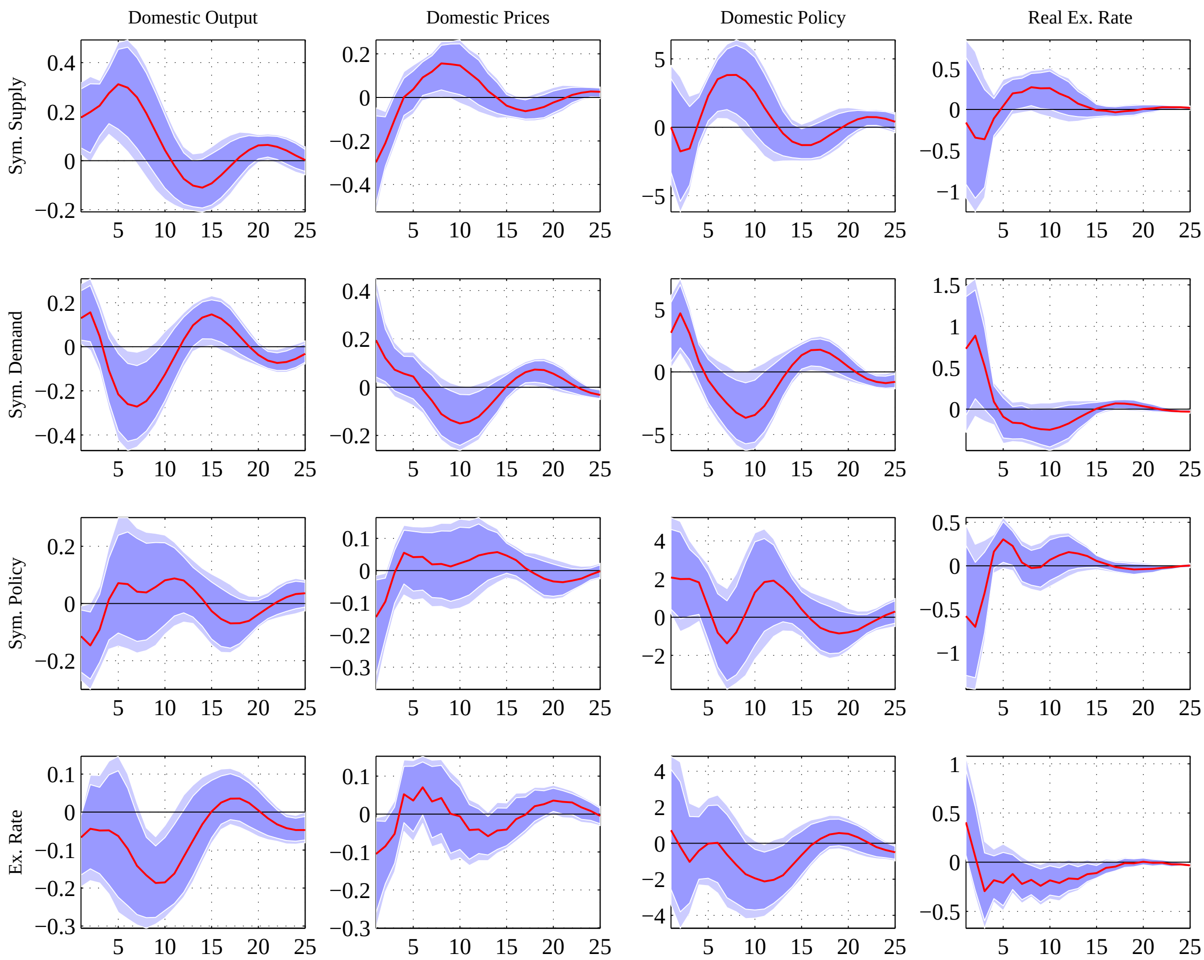


Figure A2: Impulse Response Functions – Slovakia

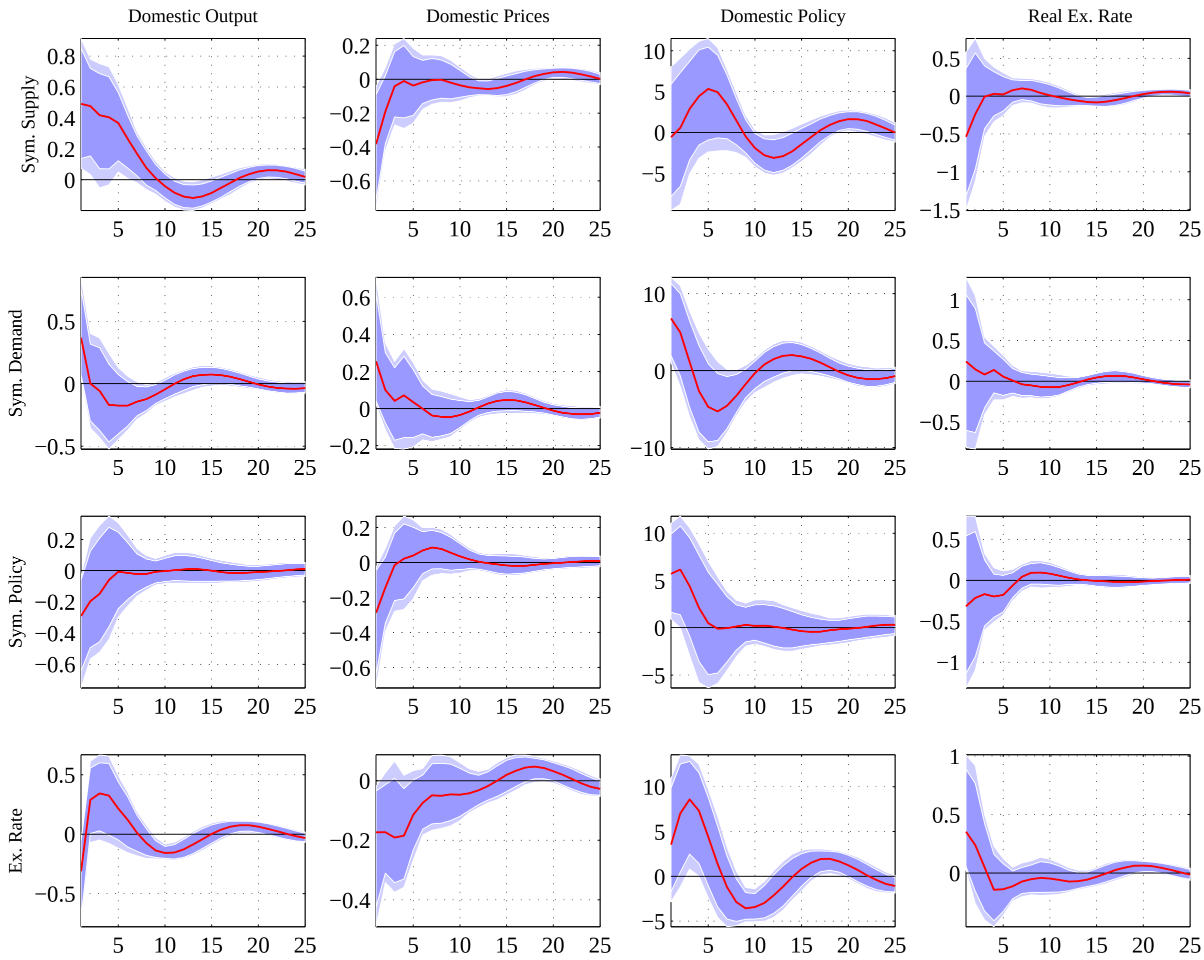


Figure A3: Impulse Response Functions – Hungary

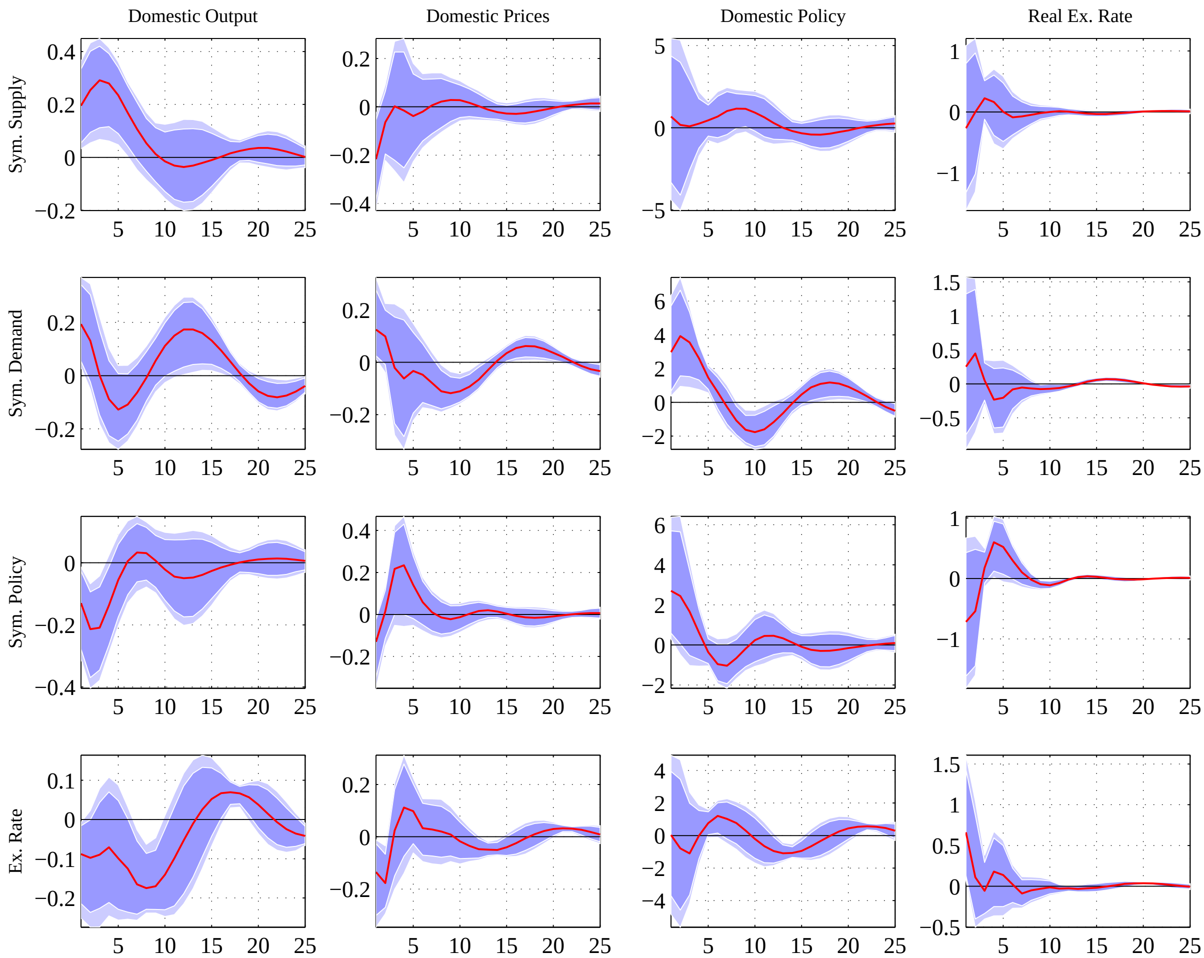


Figure A4: Impulse Response Functions – Poland

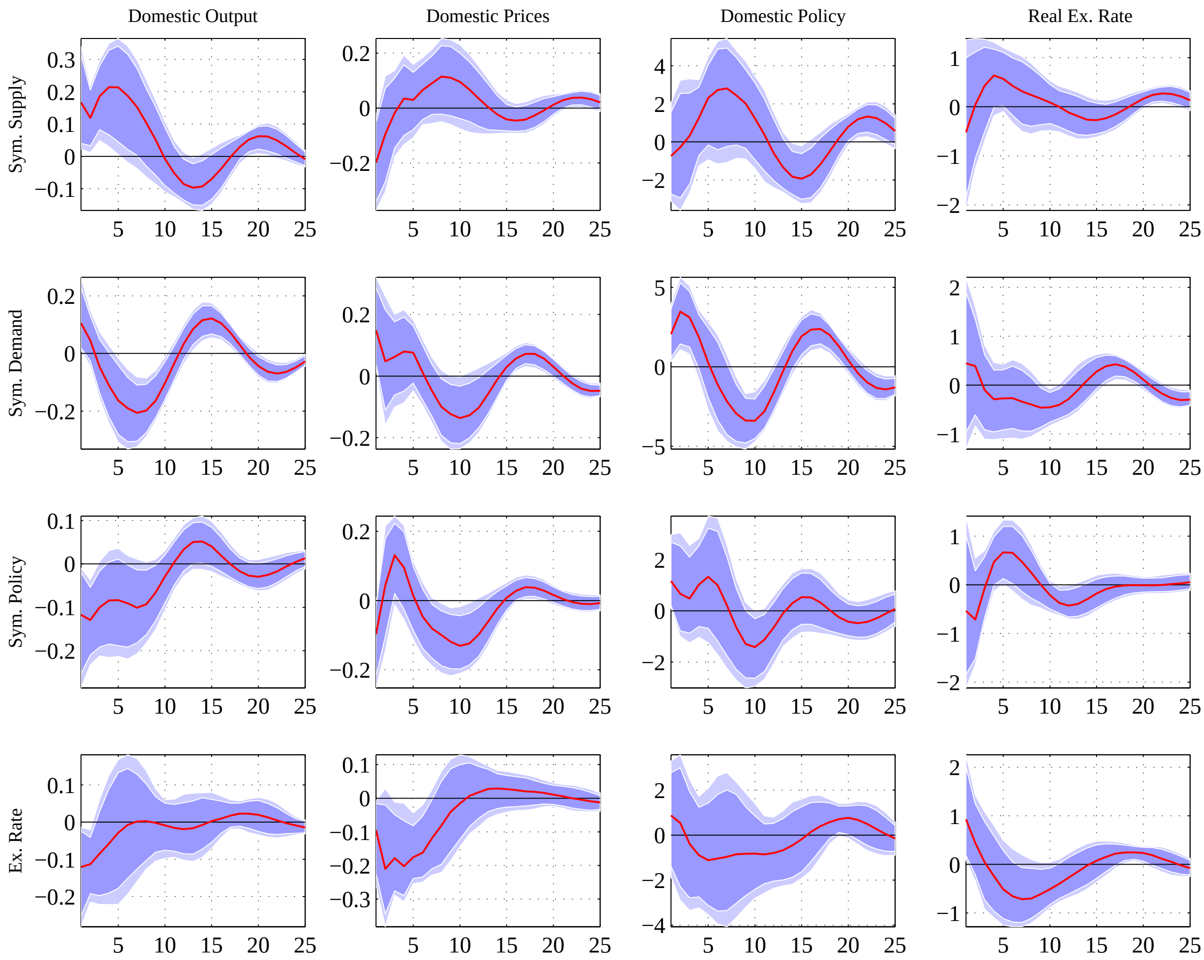


Figure A5: Impulse Response Functions – Estonia

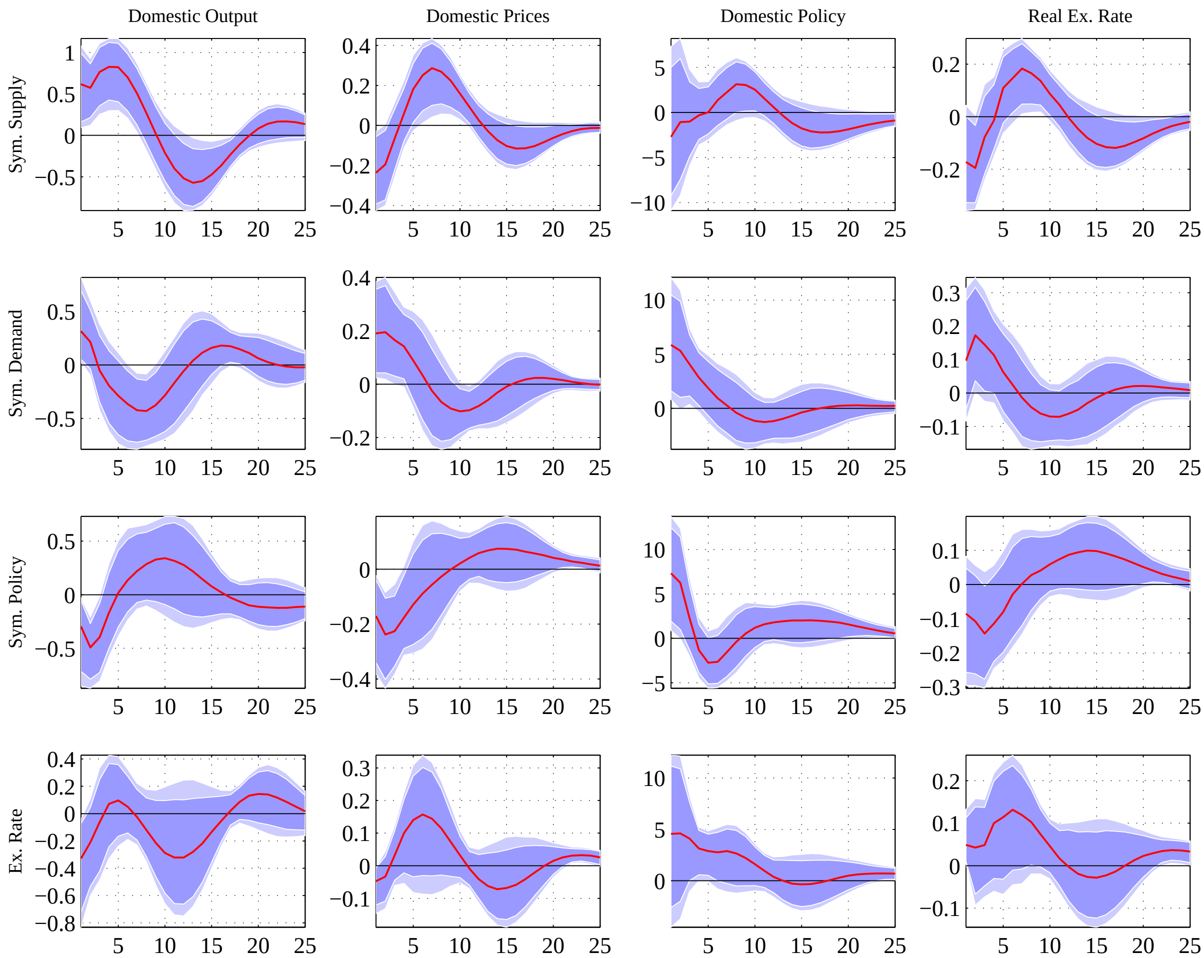


Figure A6: Impulse Response Functions – Lithuania

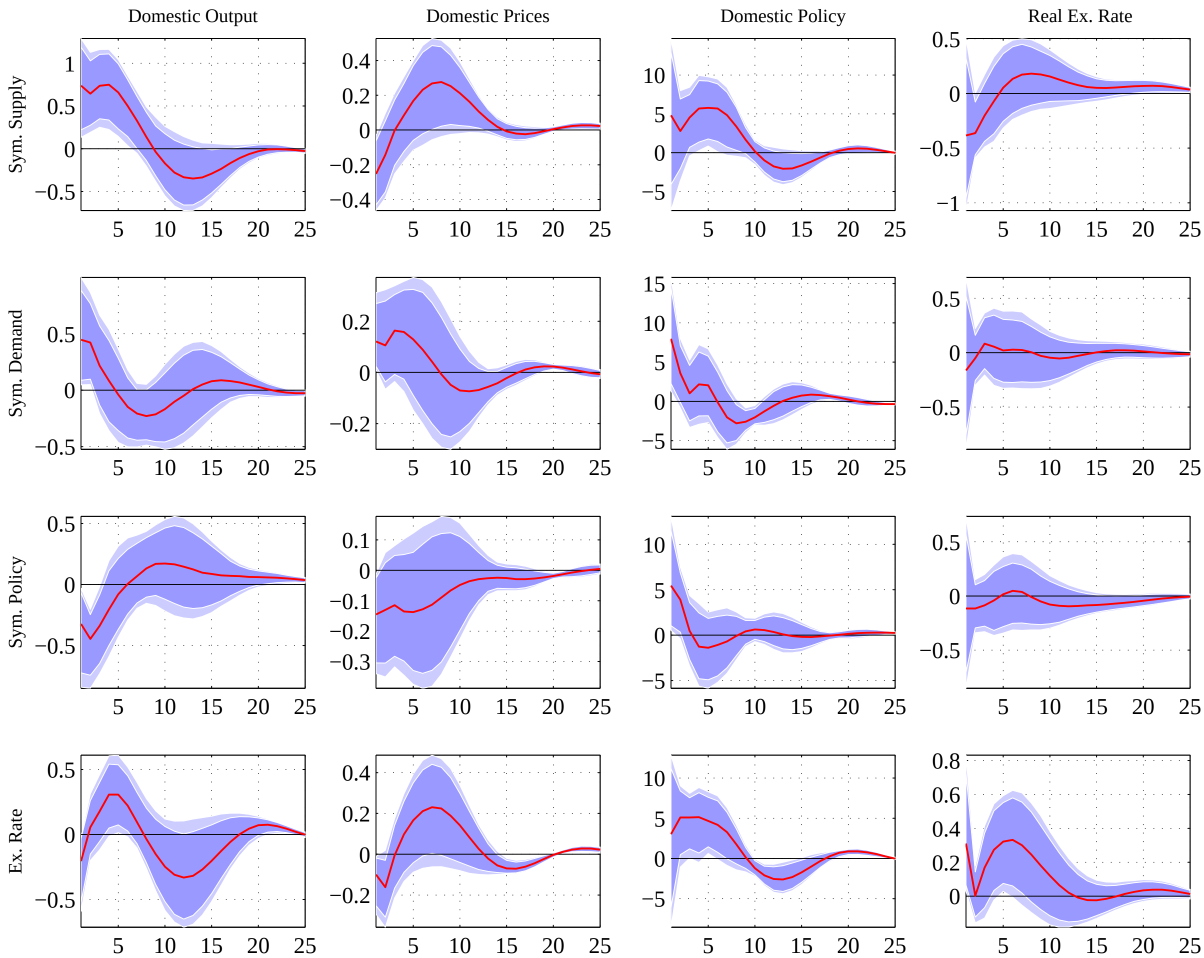


Figure A7: Impulse Response Functions – Latvia

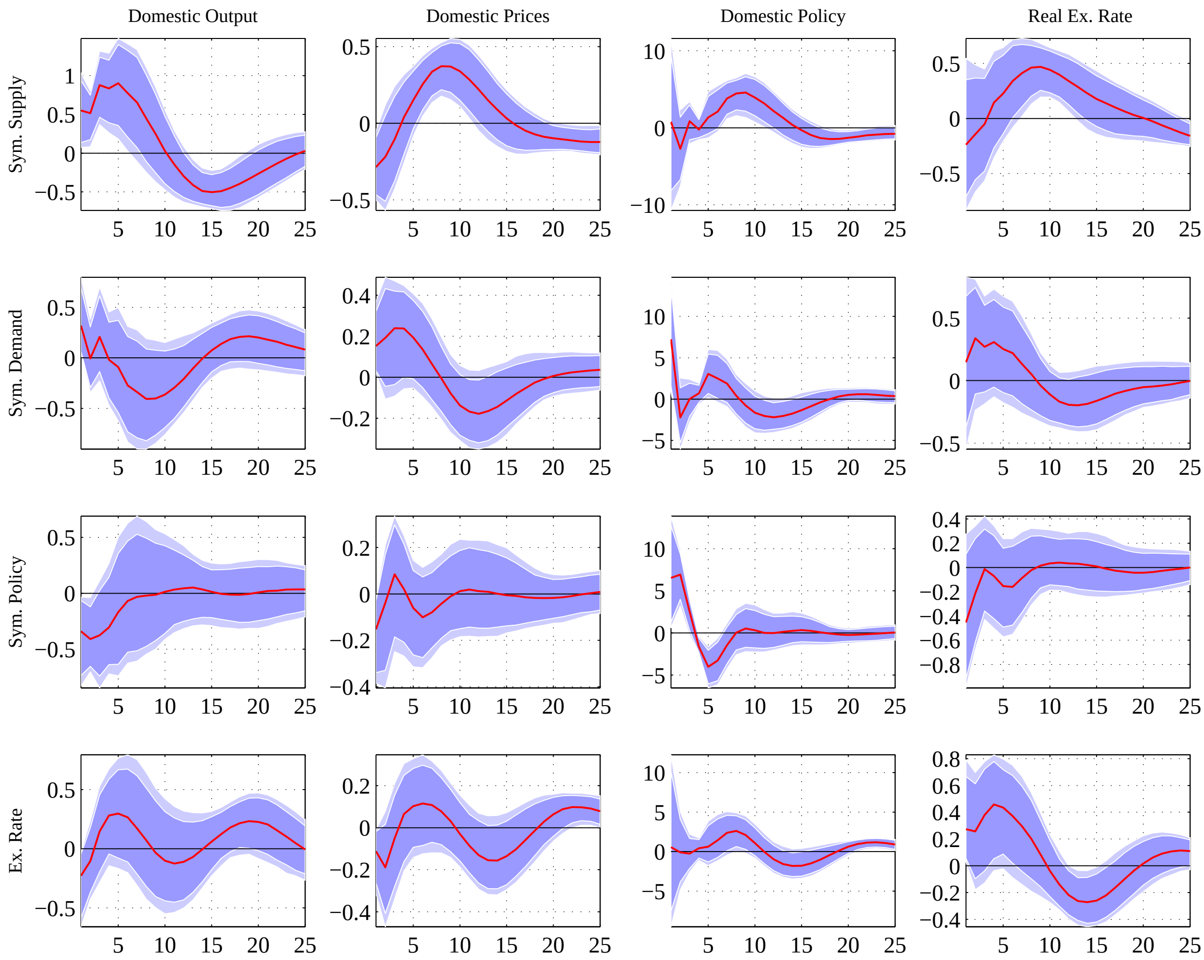


Figure A8: Impulse Response Functions – Romania

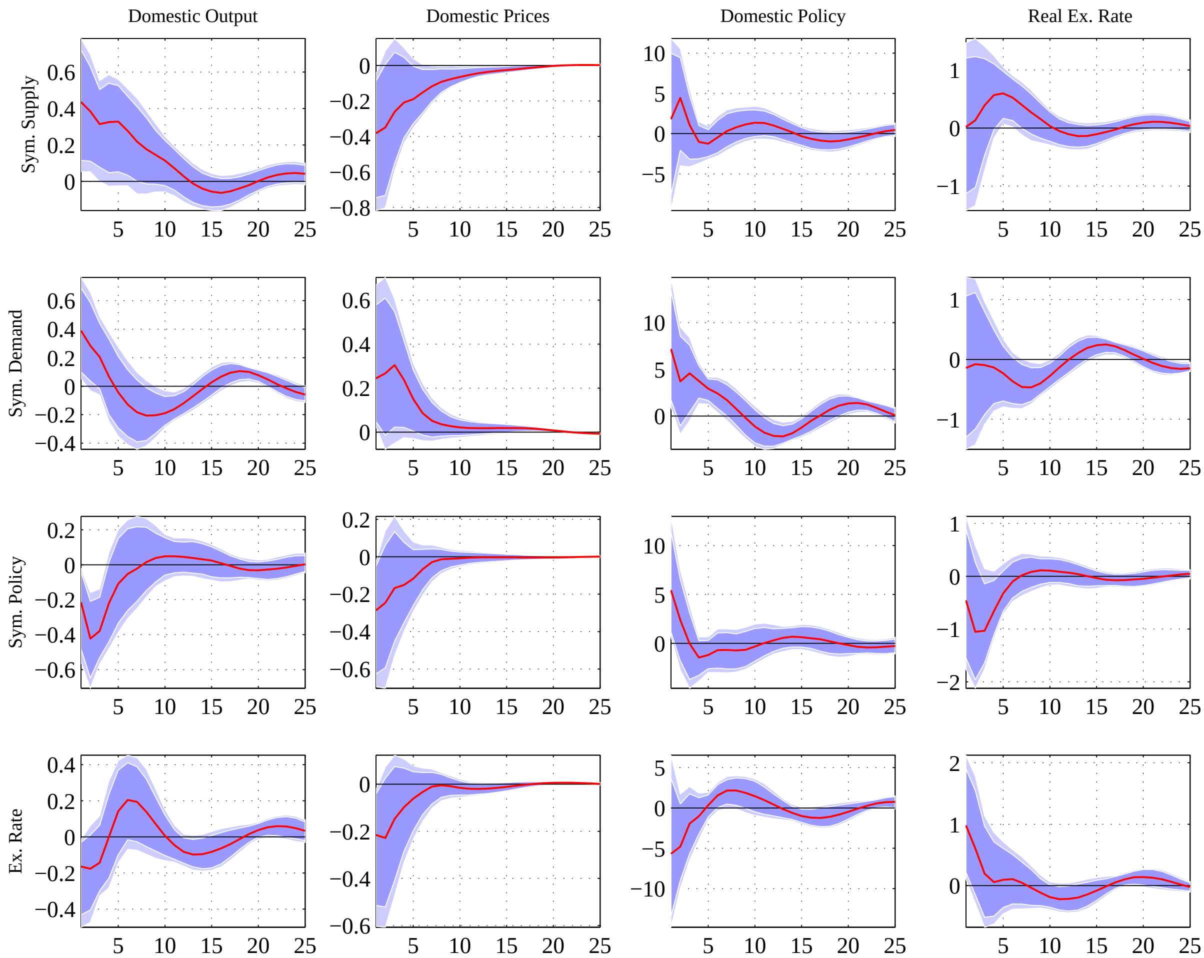


Figure A9: Impulse Response Functions – Bulgaria

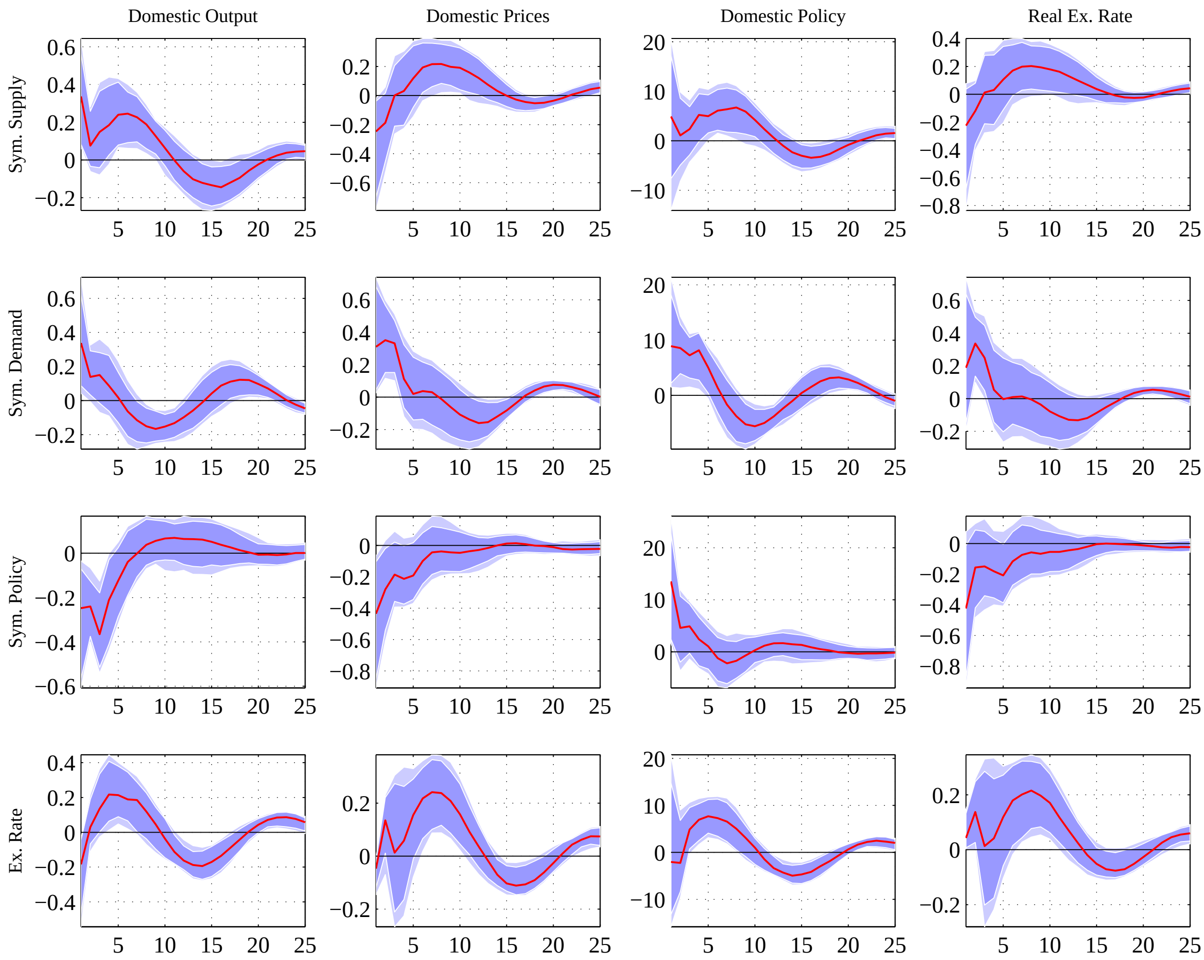
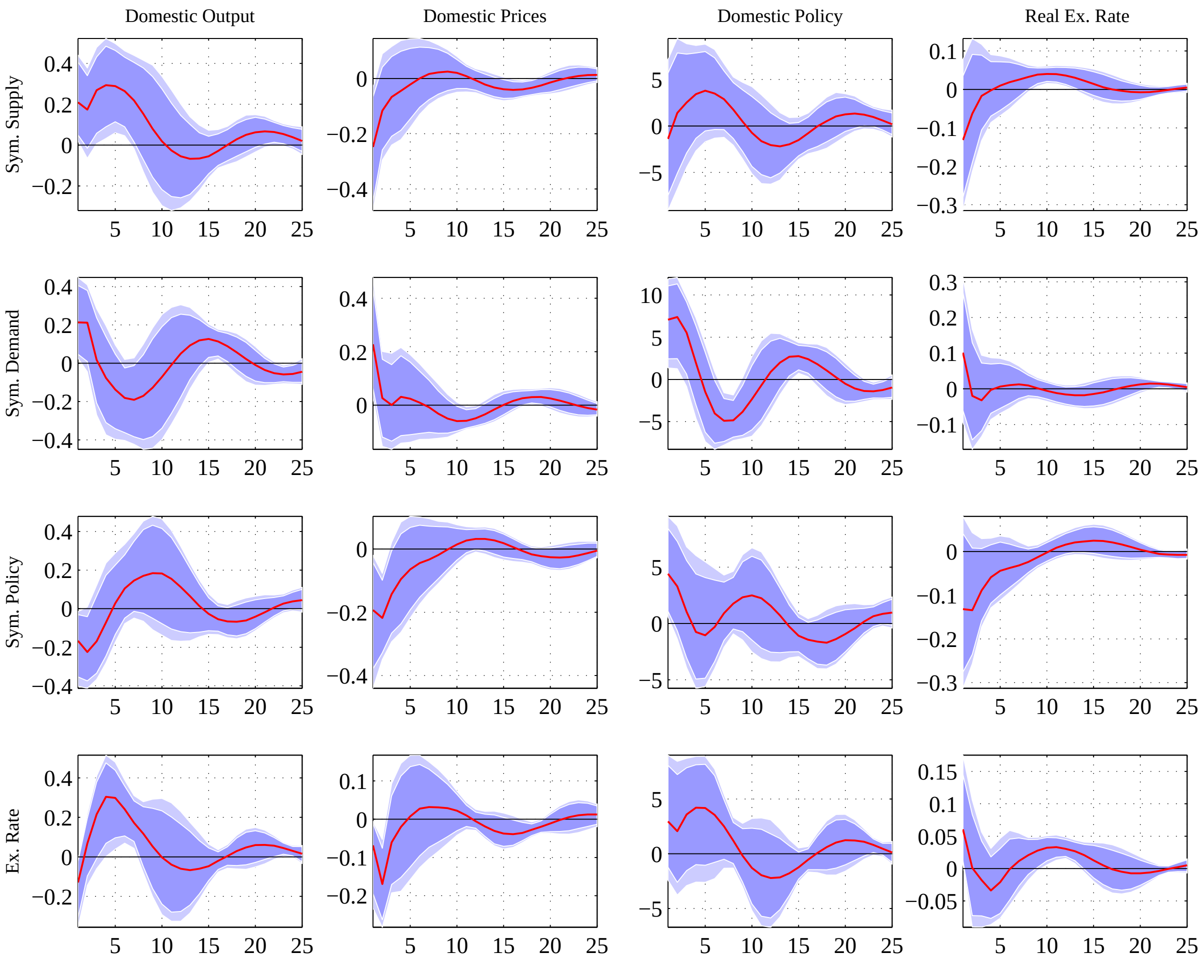


Figure A10: Impulse Response Functions – Slovenia



Appendix B: Variance Decomposition

Figure B1: Variance Decomposition: Czech Republic

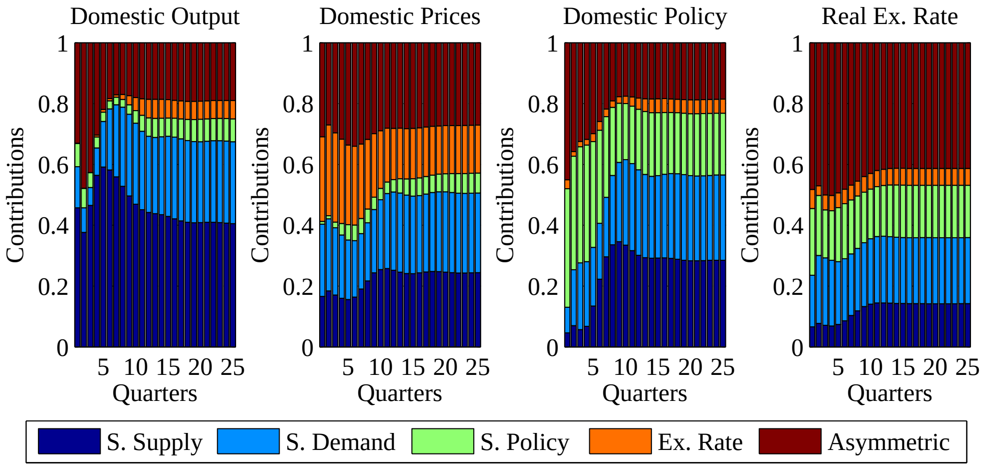


Figure B2: Variance Decomposition: Slovakia

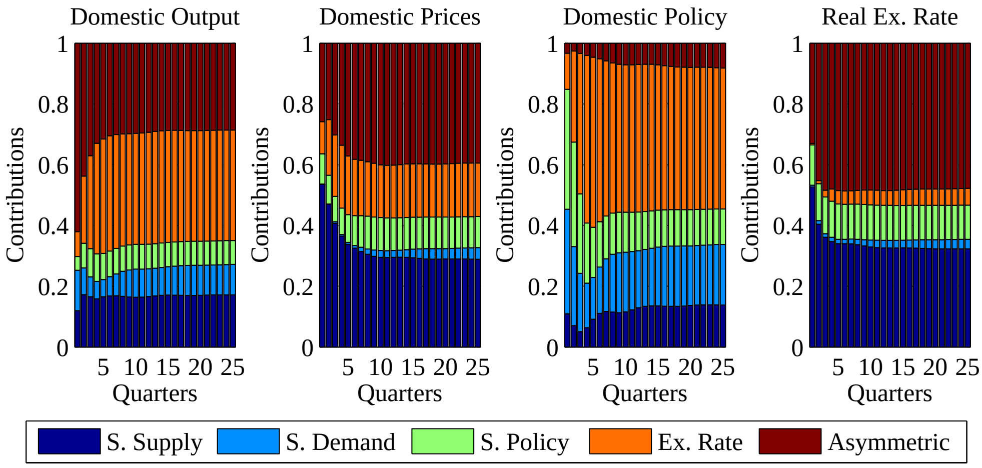


Figure B3: Variance Decomposition: Hungary

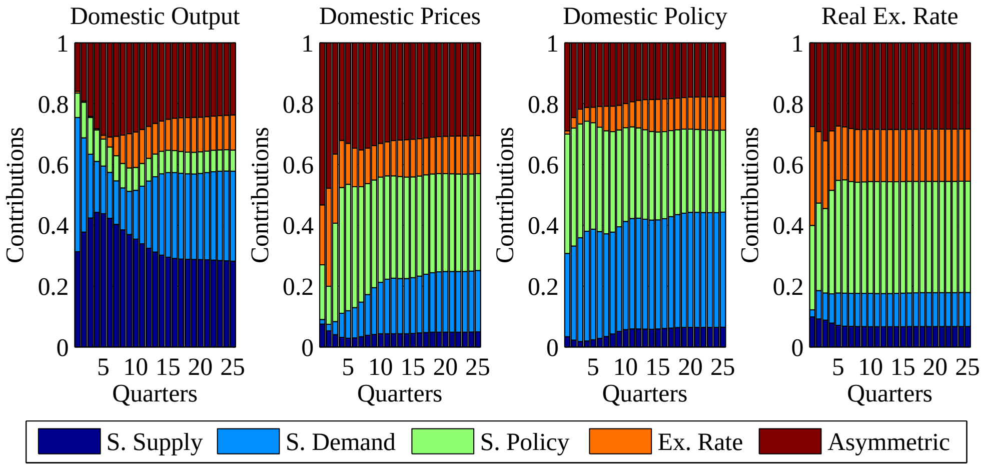


Figure B4: Variance Decomposition: Poland

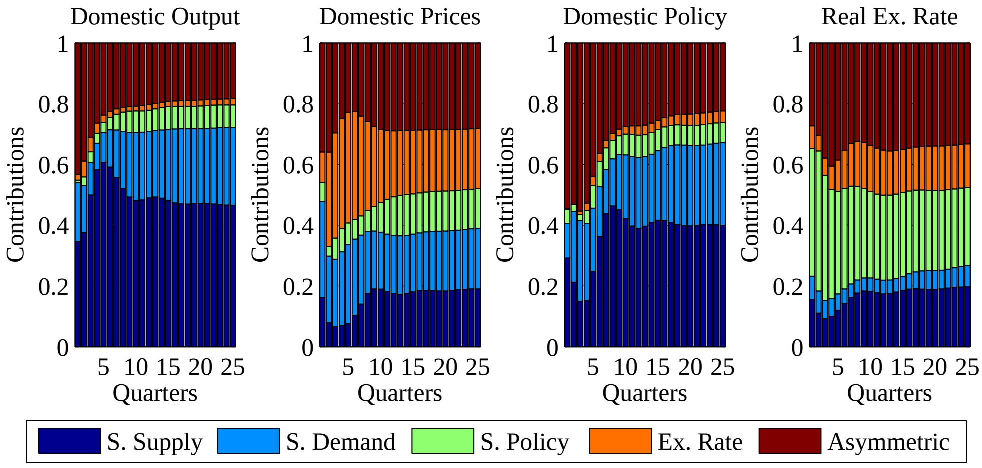


Figure B5: Variance Decomposition: Estonia

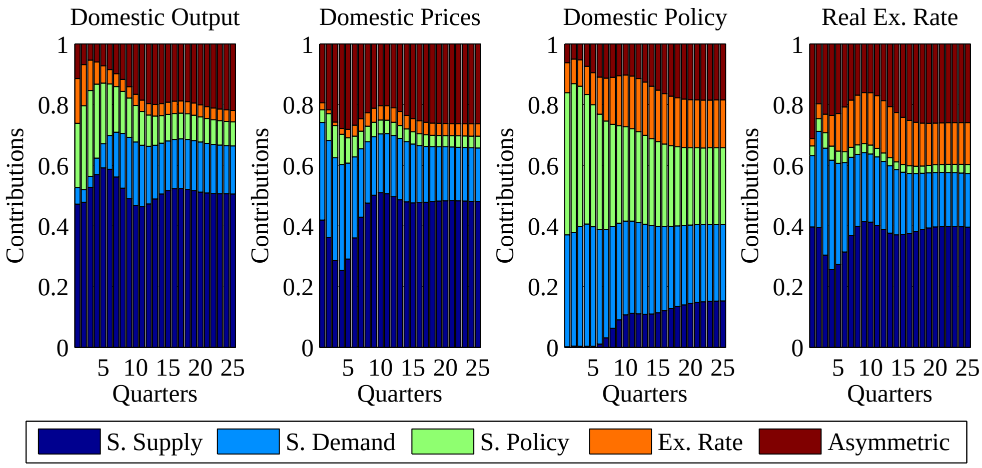


Figure B6: Variance Decomposition: Lithuania

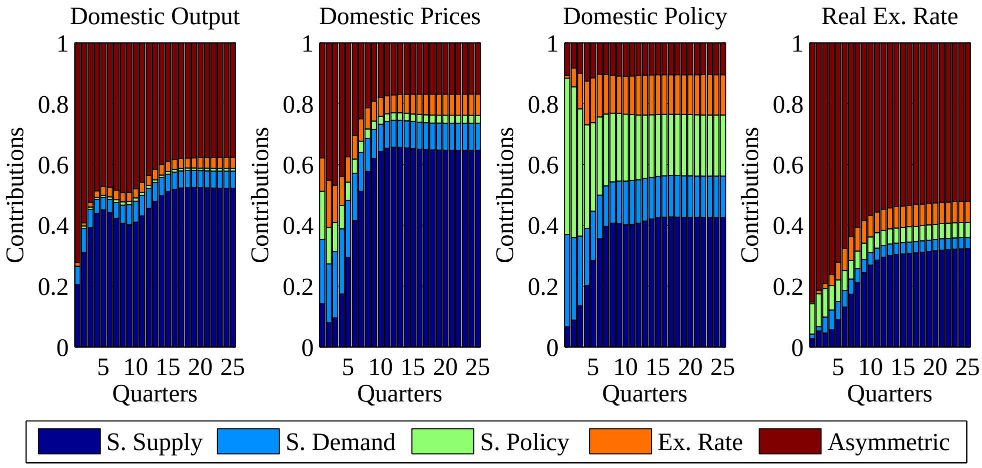


Figure B7: Variance Decomposition: Latvia

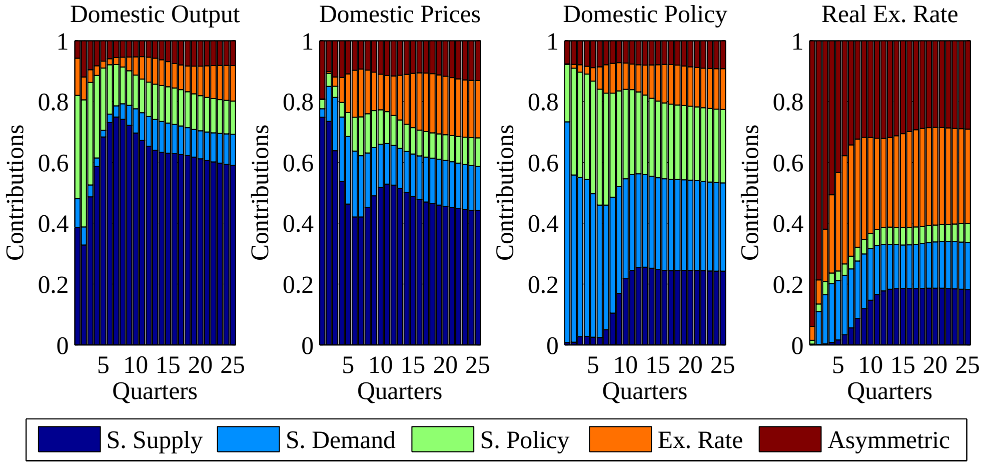


Figure B8: Variance Decomposition: Romania

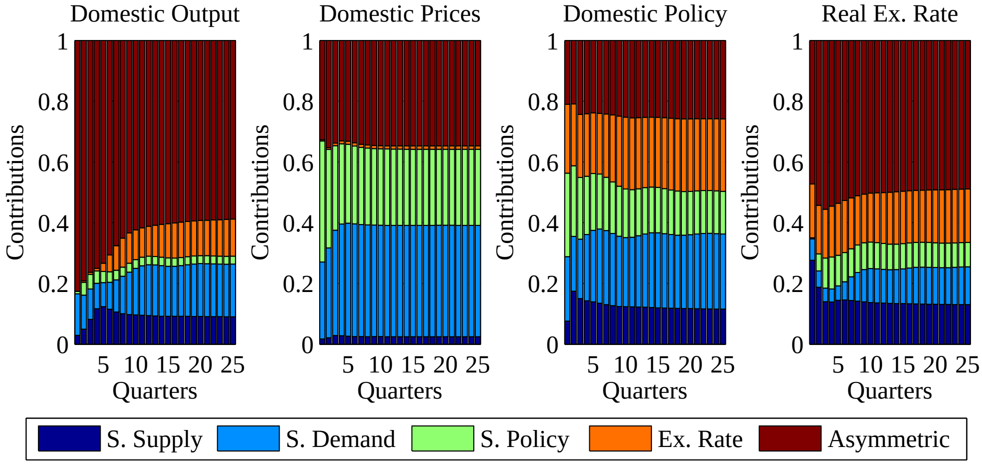


Figure B9: Variance Decomposition: Bulgaria

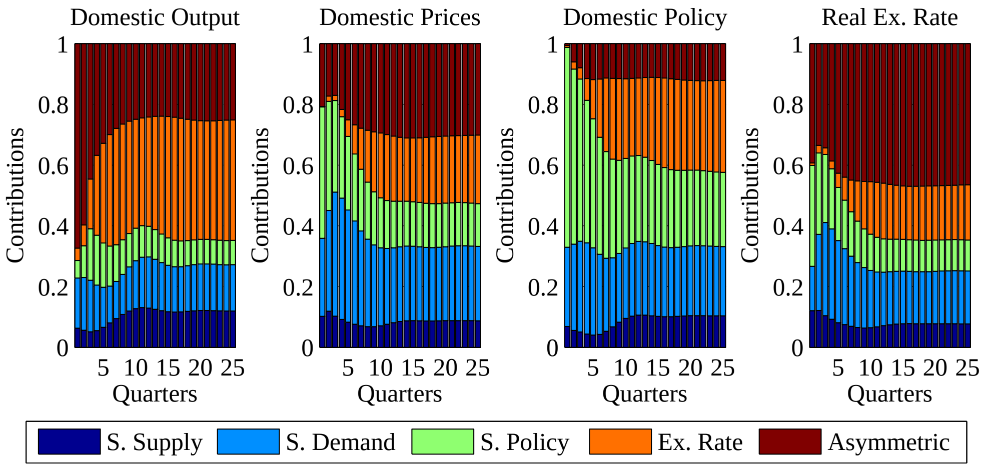
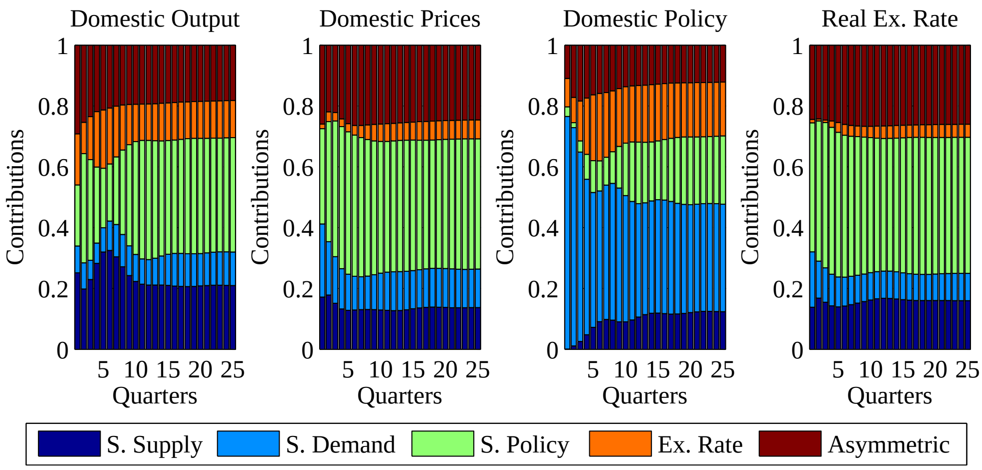


Figure B10: Variance Decomposition: Slovenia



Appendix C: Identified Shocks

Figure C1: Shocks Contributions – Czech Republic

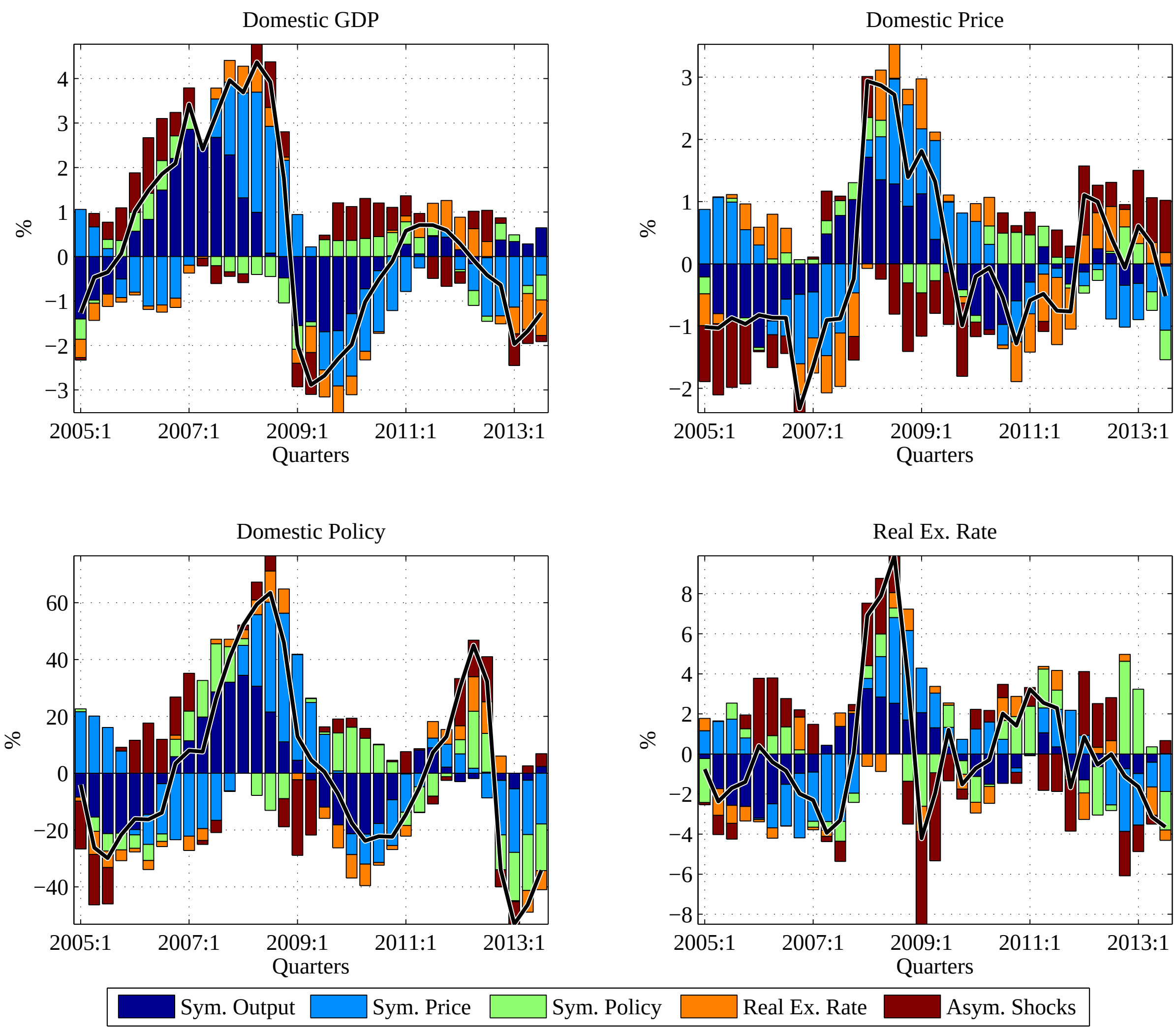


Figure C2: Shocks Contributions – Slovakia

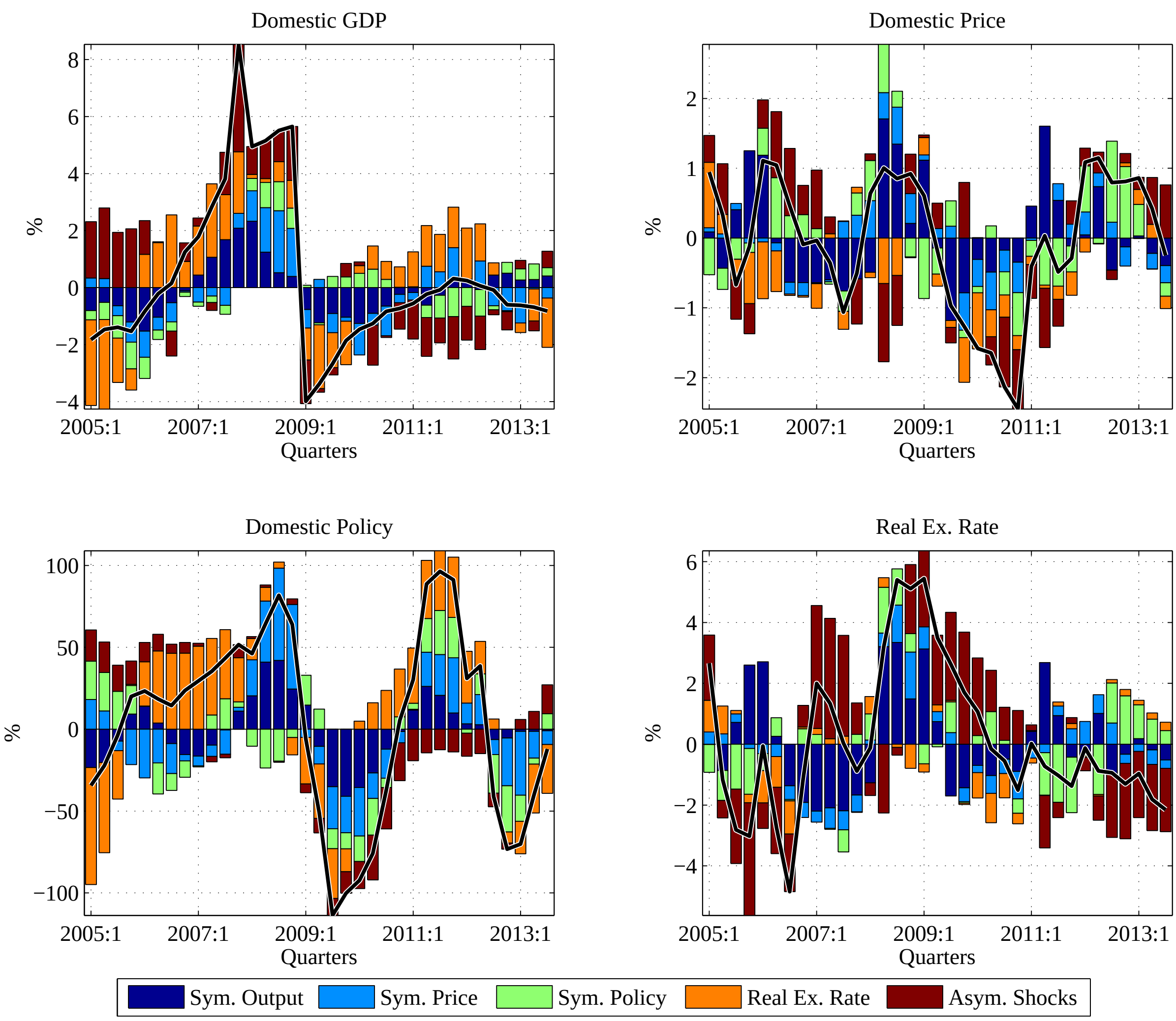


Figure C3: Shocks Contributions – Hungary

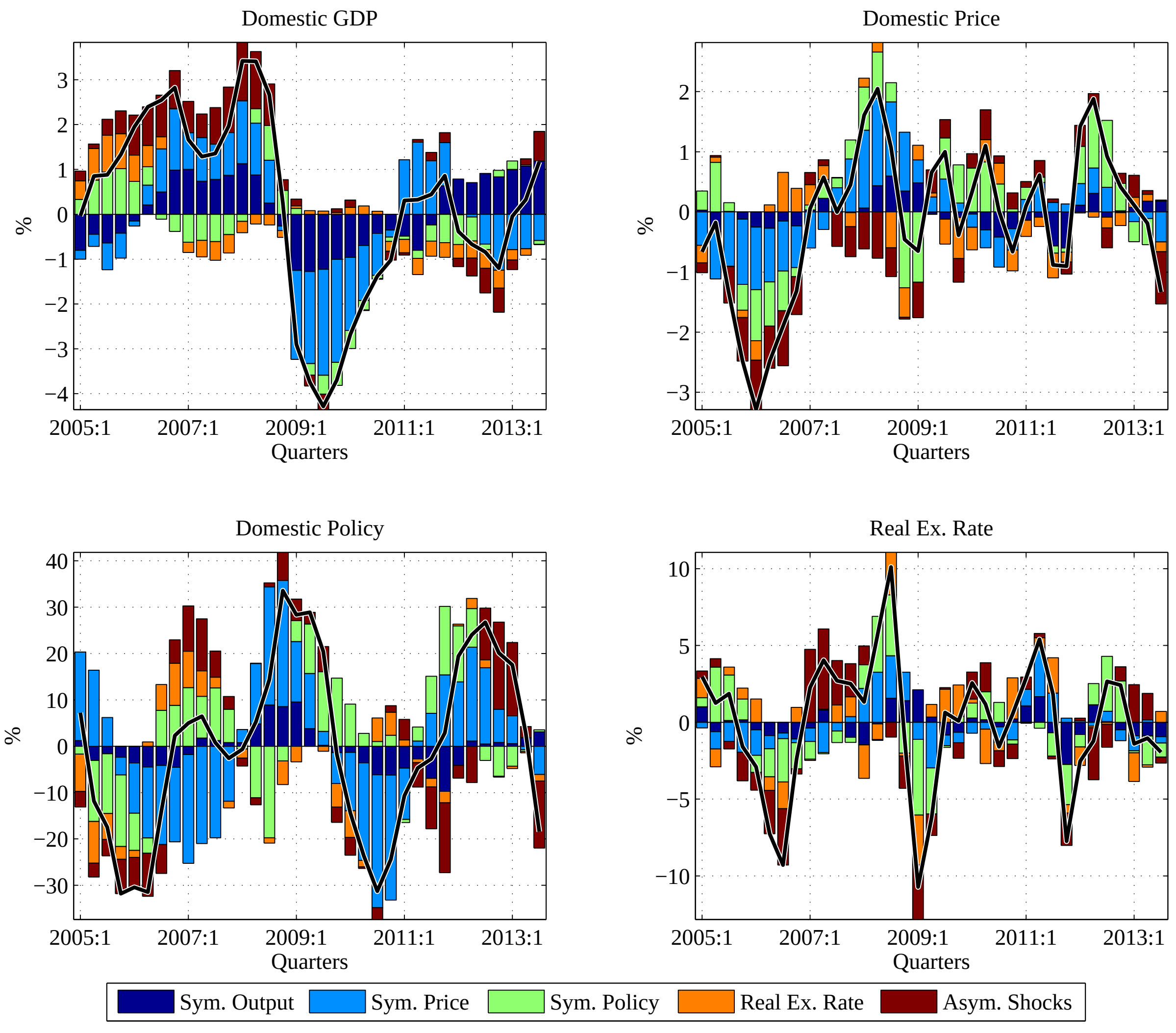


Figure C4: Shocks Contributions – Poland

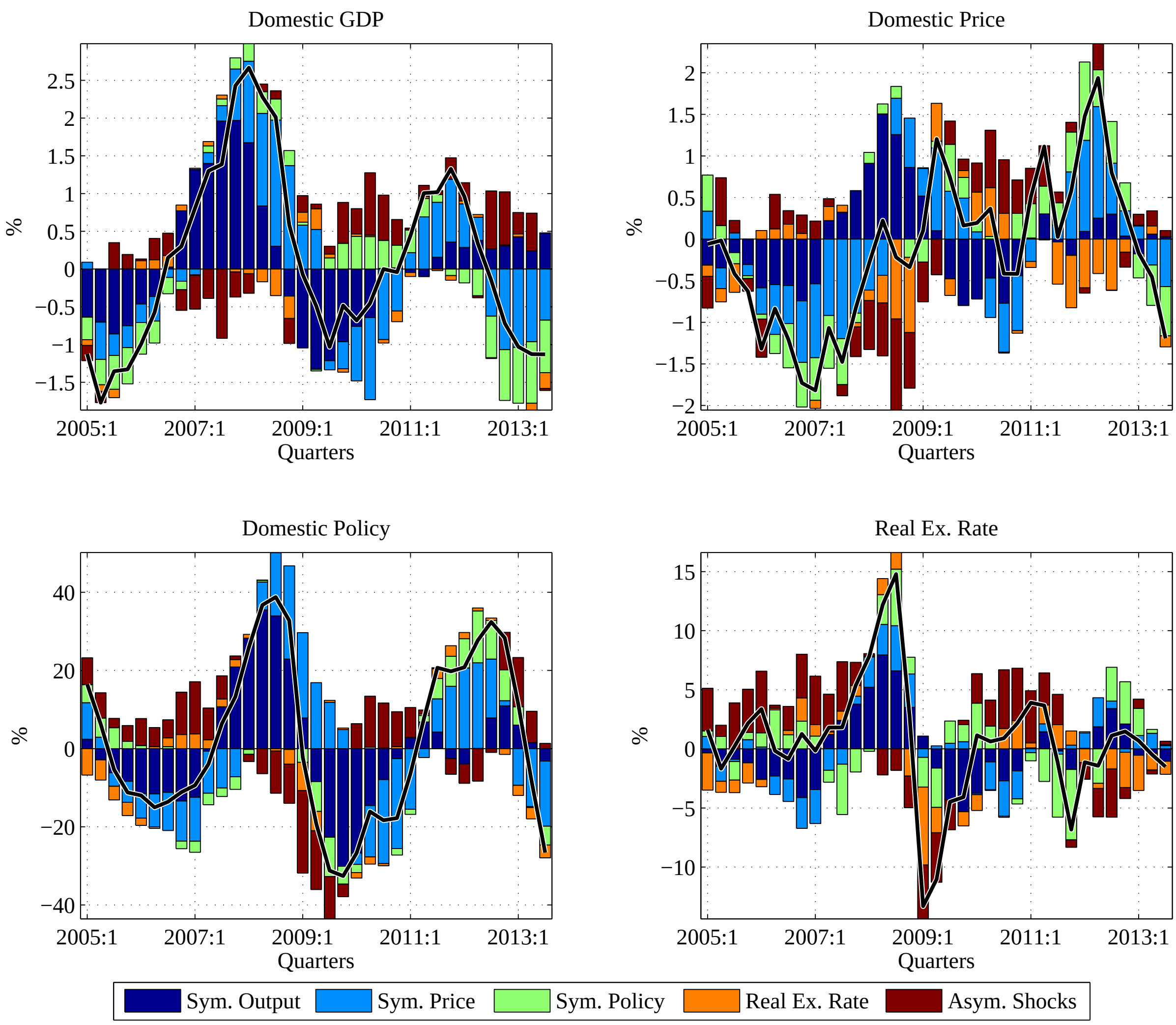


Figure C5: Shocks Contributions – Estonia

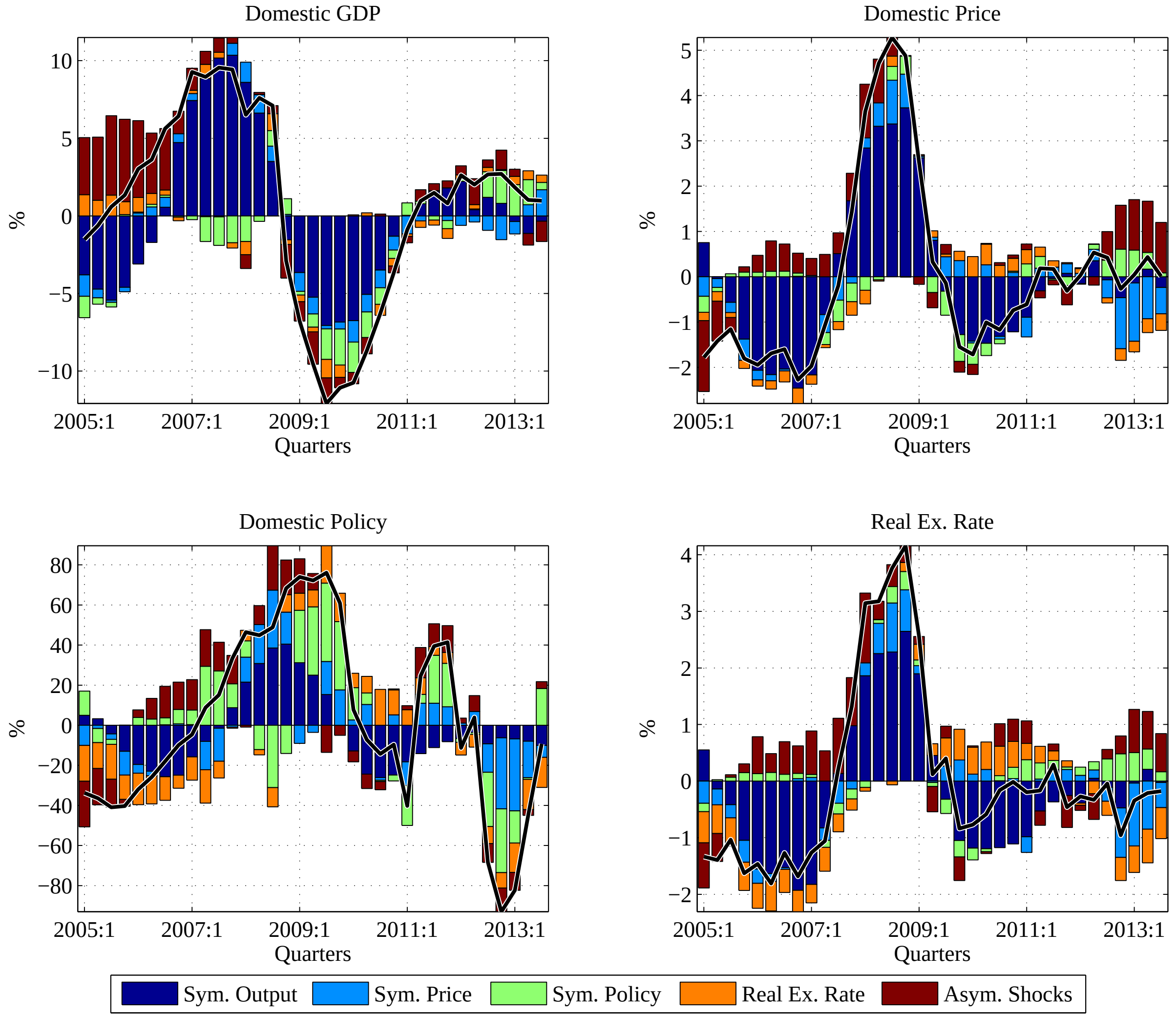


Figure C6: Shocks Contributions – Lithuania

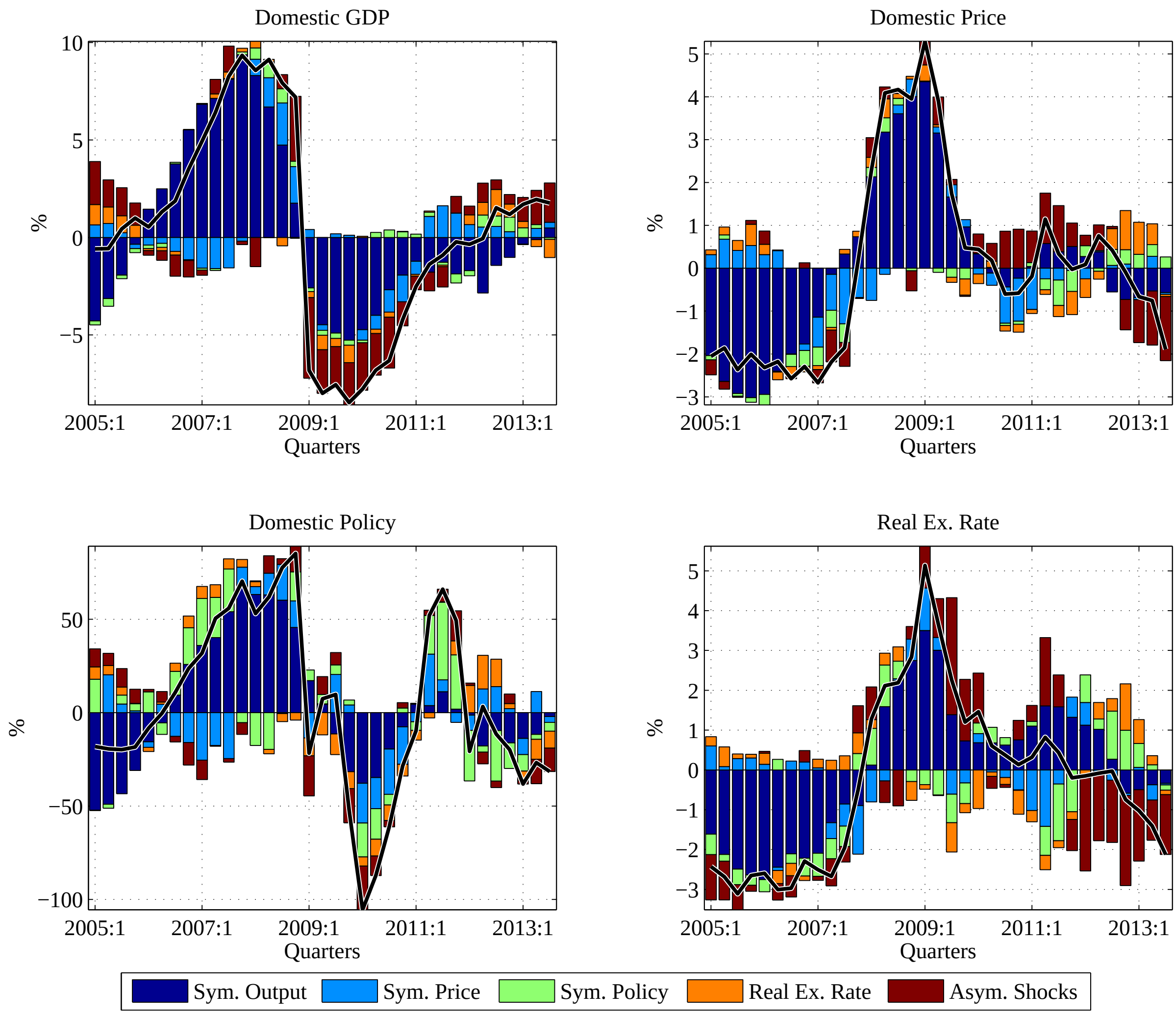


Figure C7: Shocks Contributions – Latvia

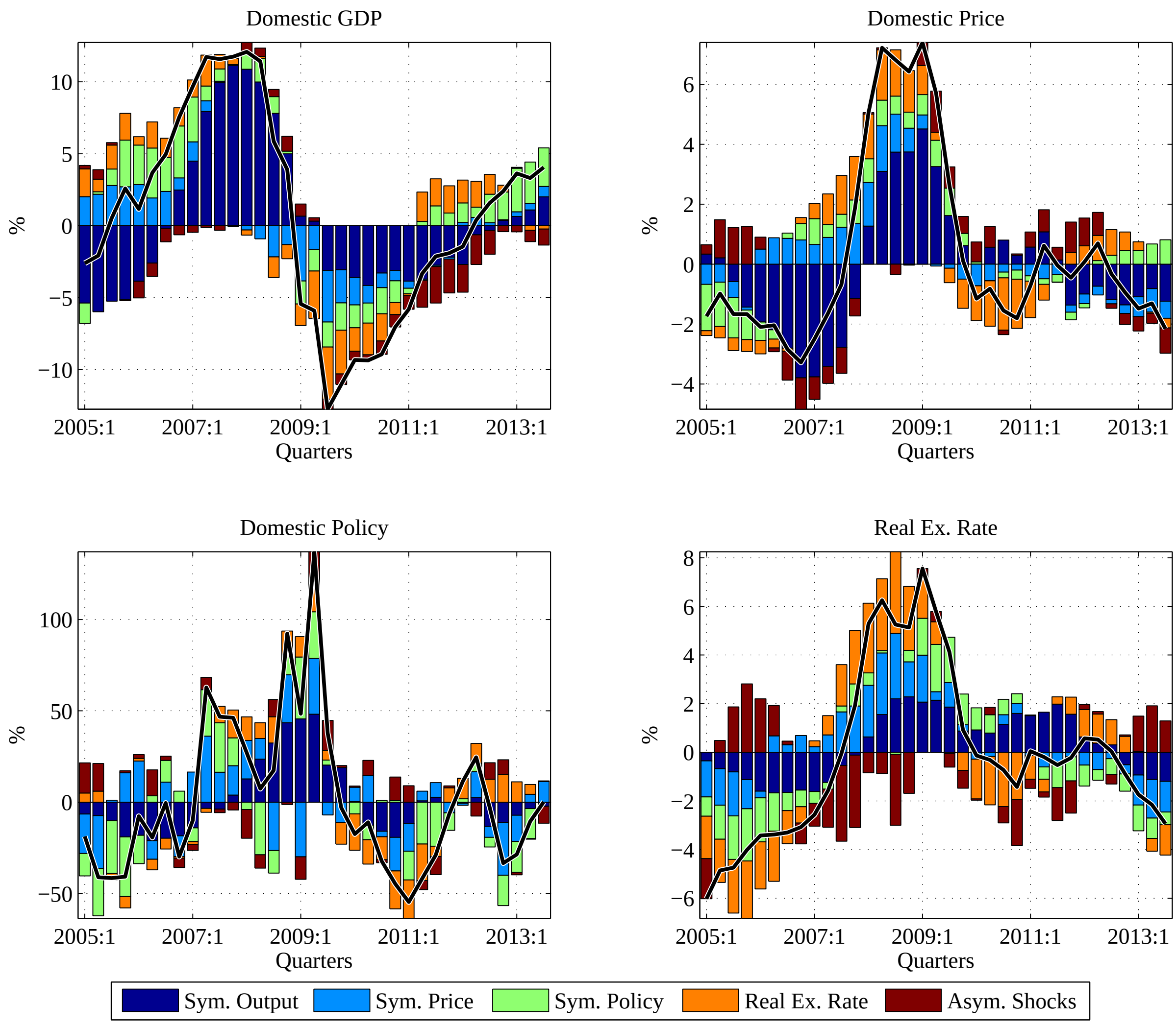


Figure C8: Shocks Contributions – Romania

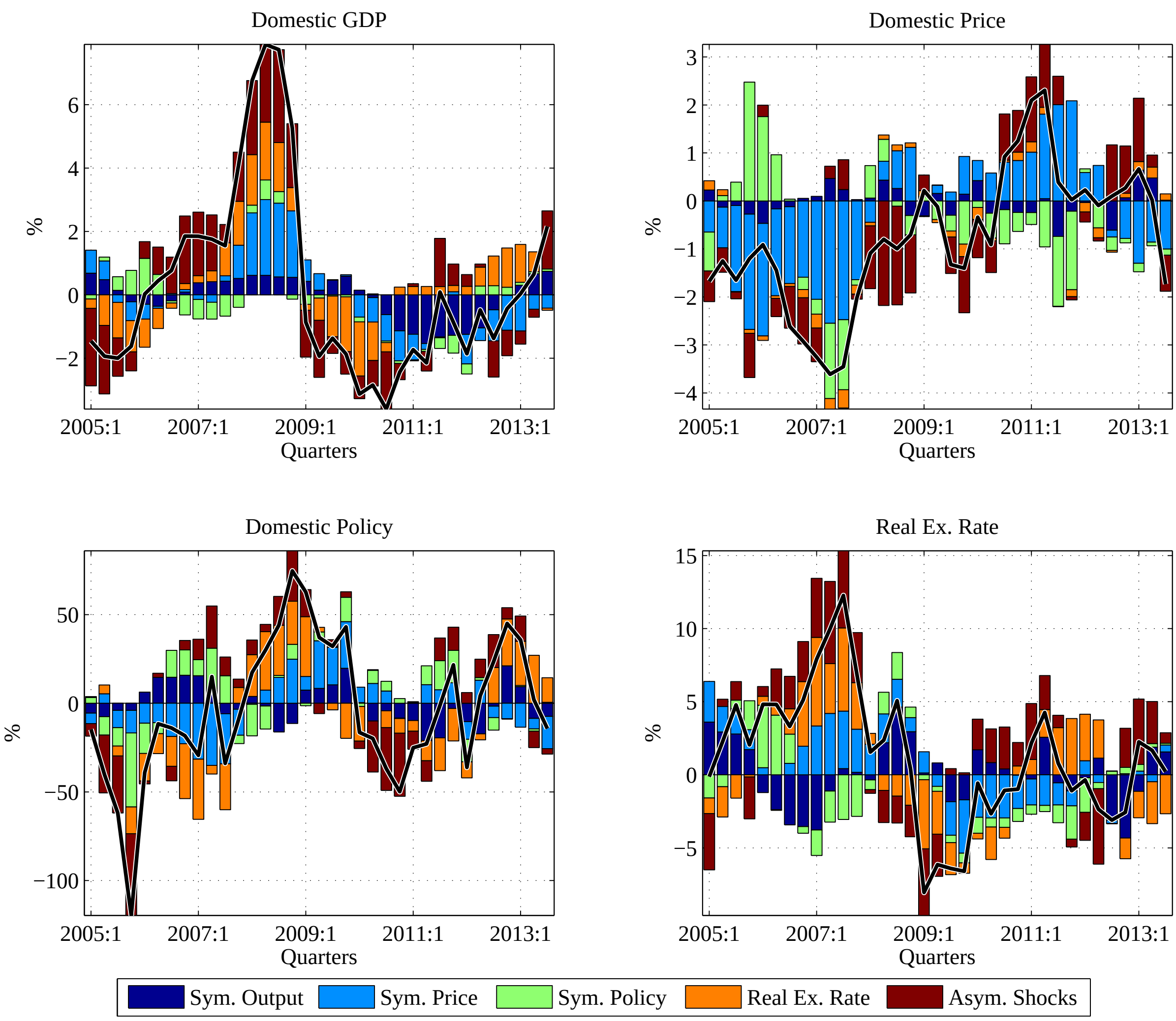


Figure C9: Shocks Contributions – Bulgaria

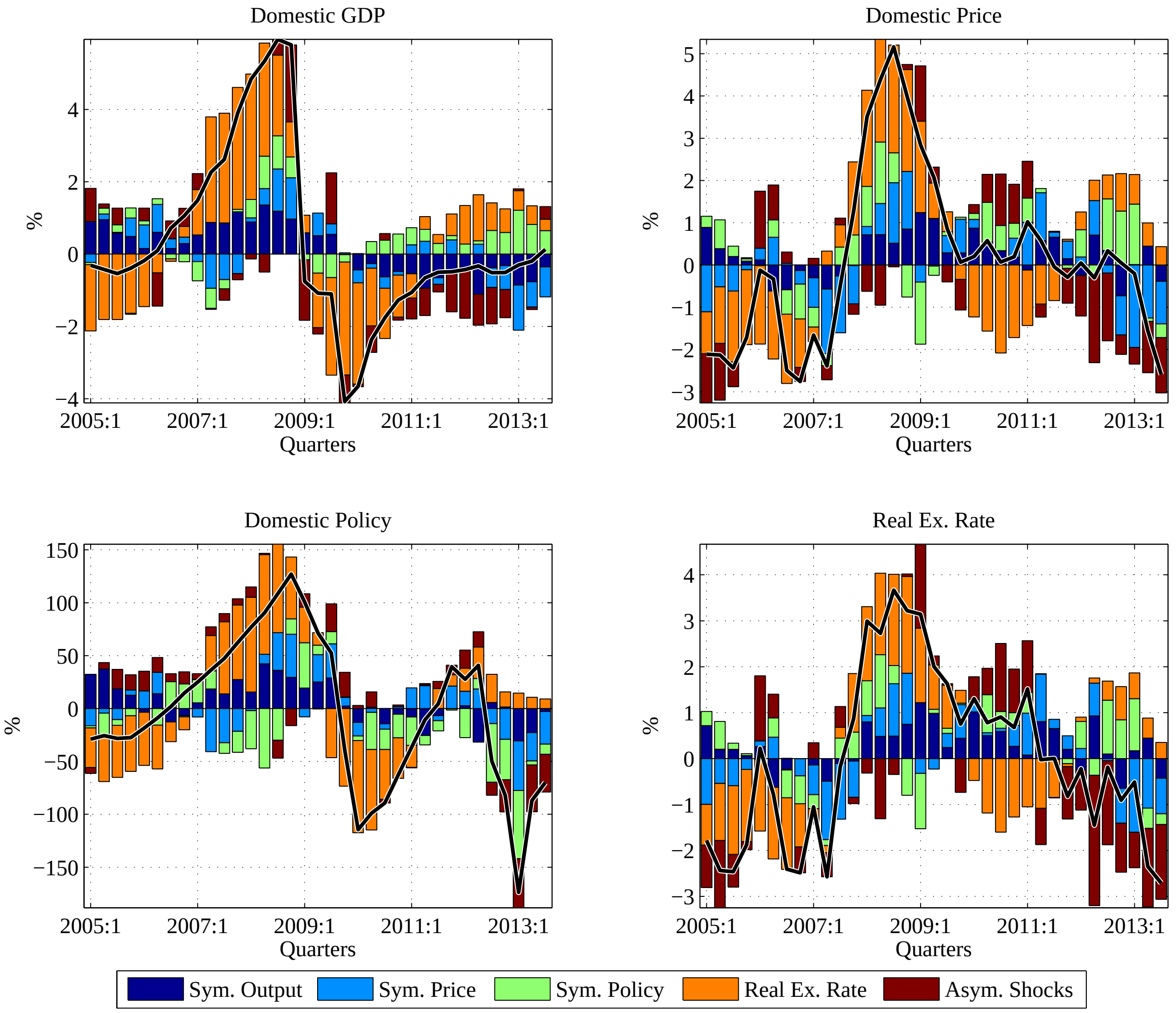
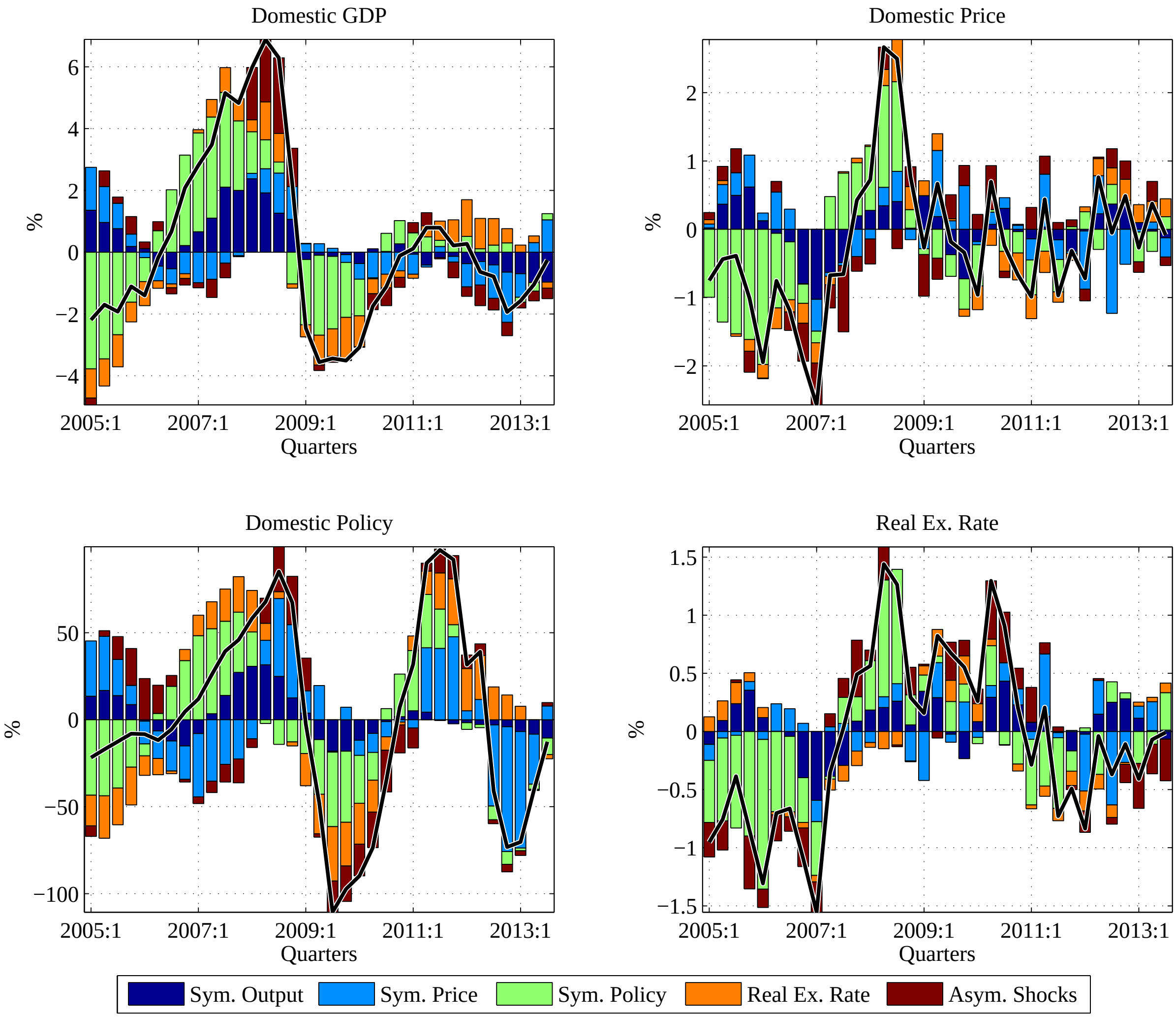


Figure C10: Shocks Contributions – Slovenia



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