

Modelling Determinants of Inflation in CESEE Countries: Global Vector Autoregressive Approach

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Abstract: After a prolonged period of relatively stable price levels, the beginning of the third decade of the 21st century has brought inflation once again into the spotlight. This paper focuses on the inflation dynamics in a set of post-communist countries that eventually became members of the European Union. Due to EU accession augmented by the globalization process and involvement in global value chains (GVC), the international impacts are becoming progressively important for the domestic inflation dynamics and domestic variables are not sufficient to fully describe the domestic inflation dynamics. The employed methodology, Global Vector Autoregressive (GVAR) approach, allows modelling interactions and spillovers among countries, making the most of its advantages over the usual VAR models that model each economy separately and panel models, where countries are often treated as independent units. The results of the empirical analysis confirm that the globalisation process has led to increasing the importance of international impacts on the domestic inflation dynamics. On the other hand, the results also indicate that accounting for a larger set of countries decreases the severity of the commodity price shocks and makes them less persistent. Furthermore, monetary policy acts as a buffer against adverse shocks, especially in the countries that are still not members of the euro-zone. The findings of the paper show that the analysed countries are pronouncedly heterogeneous. Hence, each of the analysed economies has its own set of country-specific factors which, from country to country, play a more important or a less significant role in explaining national inflation dynamics. Thus, the paper should contribute to a more comprehensive understanding of the inflation dynamics in the policy-making context.

Key words: CESEE, food prices, generalized forecast error variance decomposition, generalized impulse response functions, Global VAR, inflation, monetary policy, oil prices, real exchange rate

JEL Classification: C30, C50, E31, E37, P24

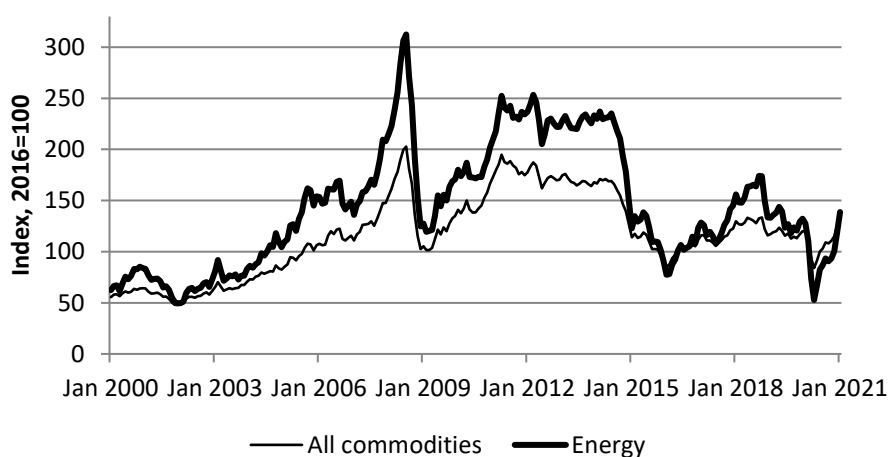
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Introduction

Price stability is usually the declared monetary policy goal of most modern economies. A central bank as the institution responsible for conducting monetary policy has a plethora of instruments for achieving price stability. Notwithstanding the instruments central banks have on their hands, the sources of inflation are numerous. Hence, it is safe to say that various factors could potentially mitigate the efforts of central banks, making their influence on price stability limited. For that reason, economic subjects keep their eyes closely on price movements. Entering the third decade of the 21st century, the world economy is faced with all sorts of turbulences: disruptions of global supply chains, lockdowns and armed conflicts, just to name a few. Naturally, these events were reflected in price movements. Amidst the COVID-19 crisis, the world economy first experienced deflation in times of lockdown and then inflation when economies started to open up and recover.

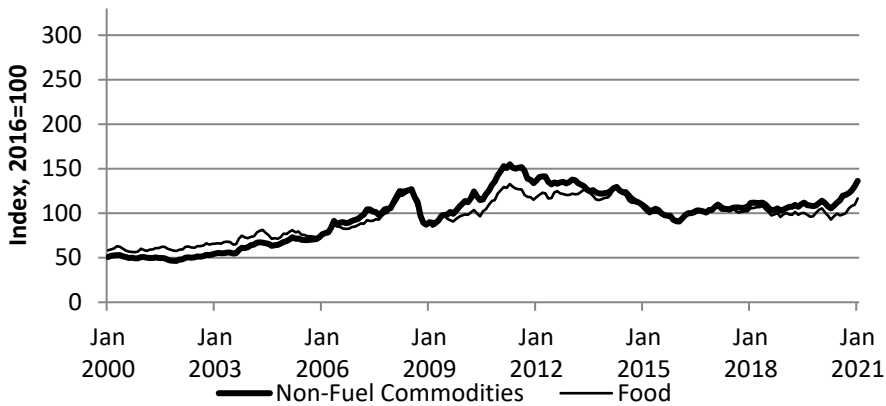
Figure 1. Prices (all commodities and Energy) from 2000 to 2021



Source: International Monetary Fund (IMF)

Figure 1 and Figure 2 depict the price movements from 2000 onwards. Entering the 21st century, prices were relatively stable (Figure 1). However, one can notice that this was an exception and occasional price hikes were established as a stylized fact of the modern economies. Not surprisingly, among the commodities, energy prices are the most volatile. They contribute the most to general price movements, thus proving the high energy dependence of the world economy.

When looking solely at the movement of prices of non-fuel commodities (Figure 2), they are pronouncedly less volatile in comparison to energy prices. However, occasional price hikes can also be noticed now and then.

Figure 2. Prices (non-fuel commodities and food) from 2000 to 2021

Source: International Monetary Fund (IMF)

Although rising inflation rates are perceived as bad news as they increase the cost of living and spark up uncertainty, this issue is not equally delicate in every country. Any sign of accelerating price levels brings in bad memories for a group of Central, Eastern and Southeastern European (CESEE) countries, which, upon entering the process of transition from centrally planned towards market-oriented economies, experienced either hyperinflation or very high inflation rates. Initially, the root cause of such price movements was the monetization of fiscal deficits augmented by backward-looking wage indexation inherited from the socialist system (Botrić and Cota, 2006). However, although carrying a similar legacy and being in close proximity to each other, the patterns were quite diverse, which can be seen in Figure 3 in the Appendix.

Hence, the question is: what is the explanation for such diverse patterns? To tackle the question, this article aims at capturing the main sources of inflation dynamics in CESEE countries. To achieve this, the employed methodology must be appropriate in the sense that it accounts for all possible factors that impact domestic inflation. Due to EU accession augmented by the globalization process, domestic variables are not sufficient to fully describe the domestic inflation dynamics. As the countries are becoming more and more involved in global value chains (GVC), the international impacts are becoming progressively important for the domestic inflation dynamics (Auer et al., 2017). Ciccarelli and Mojon (2010) showed that inflation in industrialized countries is largely a global phenomenon. Hence, Jordan (2016) emphasises that international spillovers will make it more difficult for small open economies (SOE) to control inflation. Therefore, besides domestic impacts, an appropriate model describing inflation dynamics should also include international factors. Moreover, due to increasing globalization and involvement in GVCs, the model should also include possible spillovers and interactions among neighbouring countries. On top of that, considering the importance of the German economy, an adequate model should also account for its impact on the economies of the CESEE countries.

Consequently, a GVAR approach (Pesaran et al., 2004) is employed as an appropriate modelling framework in this paper. The GVAR approach has advantages over the usual unrestricted VAR models that model each economy separately (neglecting possible interactions between economies and leading to distorted conclusions). On the contrary, the GVAR approach enables joint modelling of all CESEE countries in a single model, thus accounting for possible spillovers among their economies. Considering increasing globalization, as well as the economic and financial integration of the analysed economies under study, such a framework should provide better insight into the key determinants of domestic inflation dynamics. The GVAR approach can also be viewed as a better modelling solution than panel models, where countries are often treated as independent units which could lead to neglect of important spillovers among countries.

To assess the inflation dynamics appropriately, the empirical model should include various domestic and foreign macroeconomic variables. The domestic economy affects the national inflation rate dynamics through economic activity. Previous research (Kalimeris, 2011) found unemployment as an important determinant of inflation dynamics and it is also included in the model. A relative price indicator (real effective exchange rate) should also be included in the model, as well as a monetary policy proxy. As for foreign factors that influence national inflation dynamics, the empirical analysis accounted for the movement of commodity prices (oil prices and food prices), and various other foreign factors such as foreign output. In particular, previous research (Roeger, 2005) highlighted oil prices as an important determinant as they affect households, production and transportation, and thus price movements both directly (through consumer and producer prices) and indirectly (via monetary policy, wages and exchange rates).

Moreover, one should also account for one of the main features of the modern economy: rapid transmission of shocks and the necessity of economic policy-makers to quickly adapt to new and rapidly changing conditions. In other words, data frequency choice should prefer higher-frequency data (monthly) to lower-frequency data (yearly or quarterly) which are unable to capture this sort of dynamics.

The starting point of the analysis is also important in the model preparation stage. For most countries, data on all variables were available from the beginning of 2000. Although data on some variables were available before 2000, it did not make much sense to have a longer series for some of the variables at the expense of excluding some of the variables, or some countries. This is not just from a technical point of view but also based on the pattern and causes of inflation dynamics at the beginning of the transition period. Namely, CESEE countries' inflation rates exhibited considerable variation at the start of the transition period as the econometric relationship between economic fundamentals (prices, money, wages and exchange rates) have been unstable during this period (Golinelli and Orsi, 2002) and most of these countries were forced to take significant disinflation measures.

Hence, using monthly data for the period from January 2000 to June 2021, the employed GVAR model focuses on eleven CESEE countries that became EU member states in the analysed period in one of the three enlargement waves: 2004 enlargement (Czech Republic, Hungary, Poland, Slovak Republic, Slovenia, Latvia, Estonia and Lithuania), 2007 enlargement (Bulgaria and Romania) and 2013 enlargement which involved only Croatia.

Apart from CESEE countries, the analysed model also includes Germany, as the largest EU economy and the main trading partner of most of the analysed countries.

Considering that the previous research (Feldkircher, 2015; Backe et al., 2013; Sun et al., 2013) showed significant spillovers from Western Europe (especially Germany) to CESEE countries, the article assesses the impact of various shocks, such as oil price and food price shocks, using a dynamic analysis to make the most of the employed methodology (taking into account the interlinkages among analysed economies). Moreover, the paper analyses the importance of domestic and foreign variables as well as commodity prices (food and oil prices) in determining the dynamics of the CESEE countries' inflation, distinguishing between differences in the short-run and long-run effects. Previous research (Globan et al., 2016) has shown that the foreign factors are crucial for inflation dynamics in the long run, while the short-run dynamics is primarily driven by domestic factors. This article adds to the previous research by assessing the importance of particular factors (like monetary policy) for a particular country. Namely, CESEE countries are quite heterogeneous and it is expected that each country has its own set of country-specific contributing factors. The advantage of the applied GVAR approach is that it provides the setting for addressing the main determinants in a particular country.

Knowledge of the determinants of inflation dynamics, as well as the differences in responses and relative importance of factors, is of great importance for the policy-makers in making projections and selecting appropriate economic policy measures. Hence, this article and proposed methodology should contribute to a more comprehensive analysis in policymaking accounting for all possible influences in an appropriate model setting. The provided insight should be particularly valuable in the context of the price stability goal and the convergence criteria for the European monetary union (EMU) entrance.

The structure of the paper is following. The second section provides a literature review on inflation determinants in the CESEE countries. The third section presents the dataset and the methodology applied in the paper. The next section presents the results of the empirical analysis and the last section wraps up with a conclusion.

Literature review

Due to the EU accession process and convergence (Maastricht) criteria involving European monetary union (EMU) entrance, the CESEE countries are obliged to achieve price stability, i.e. to keep their inflation rates below a certain benchmark. This resulted in low inflation rates in the CESEE countries from the 2000 period onwards. Notwithstanding relatively stable price dynamics, in most CESEE countries, the 'ghosts of inflation past' are still present. On top of that, empirical research has carefully scrutinized the CESEE countries' abilities to conform to Maastricht criteria. Hence, the literature on inflation determinants is quite extensive.

In describing the determinants of inflation, the dynamics plays a prominent role. Therefore, most papers employ time series analysis and vector autoregression (VAR) models. Using individual countries' structural VAR (SVAR) models, Globan et al. (2016) found that in new EU member states (NMS), foreign shocks are a major factor in explaining inflation dynamics in the medium run, while the short-run inflation dynamics is mainly influenced by domestic shocks. The domestic variables are proxied by the output gap,

inflation expectations, money supply and the nominal effective exchange rate, while external inflation determinants are represented by the eurozone output gap, crude oil spot price and the eurozone three-month money market interest rate. Halka and Kotłowski (2017) also employed SVAR models and found that the fluctuations of inflation in Poland and the Czech Republic are to a large extent determined by the cyclical movements of the domestic output gap. The commodity shock also contributes strongly to inflation variability. The authors choose three variables: the growth of world imports, the index of commodity prices and the global CPI inflation.

As opposed to previously mentioned papers, Živkov et al. (2019) investigate the impact of only one foreign factor, oil price changes, on consumer price inflation in eleven CESEE countries. The authors use a wavelet-based Markov switching approach and find that the transmission of oil price changes to inflation is relatively low. The strongest impact of rising oil prices on inflation is found in longer time horizons for most countries, which means that the indirect spillover effect is more intensive than the direct one. Also, the results indicate that the exchange rate is not a significant factor when oil shocks are transmitted towards inflation, except for the occasions when high depreciation occurs. Slovakia and Bulgaria are the countries that experience the highest and most consistent pass-through effect throughout the observed sample, which may be due to higher oil import/GDP ratios.

Besides the time dimension, some papers also account for the spatial component by employing a panel data framework. Papers dealing with the early stages of transition (Hammermann, 2007) found that the structural differences are the main factor driving inflation, while the revenue, the balance of payments, and the financial stability motive are less important. Masso and Staehr (2005) employed a panel data model to explain the inflationary dynamics in the Baltic countries since the mid-1990s and found that the observed gradual disinflation can to a large extent be explained by the adjustment to international prices. Stringent fixed exchange rate systems exhibited downward pressure on inflation both directly and indirectly through the expectations of future inflation. Real oil price shocks have an immediate but short-lived impact on inflation. Panel data methodology was also applied by Staehr (2010) to identify factors driving consumer price inflation in the NMS. Convergence-related factors are important drivers of inflation. Import inflation and exchange rate developments have an important impact, while the exchange rate regime is unimportant. Higher government debt and larger revenues are associated with higher inflation. The cyclical position as measured by unemployment, employment changes or the current account balance is found to affect inflation. Food price shocks have large but short-lived effects, while energy price shocks have longer-lasting effects on the inflation rate. Using the dynamic panel methodology, Čaklovica and Efendic (2020) found that economic openness, unemployment, real wages, institutional effects, as well as external factors, such as prices of food and oil, determine the short-run inflationary dynamics in these countries. The obtained results also indicate that the inflation rate is autoregressive in the observed period (2005-2015), confirming that the contemporaneous inflation rate is determined by the entire history of these determinants. Employing the generalized method of moments (GMM), Mihailov et al. (2011) found that the inflation process is dominated by domestic variables in the larger countries of the sample, whereas external variables are most relevant in the smaller countries.

There are also papers dealing with only one CESEE economy. Again, these are mostly VAR models. For Croatia, notwithstanding the analysed period, all papers reach a similar conclusion. Botrić and Cota (2006) employed the SVAR model and found that the external sector is a key segment of the inflation generating process in Croatia. Jovičić and Kunovac (2017) employed a small open economy Bayesian VAR model and found that foreign shocks account for around 50% of the variation in inflation in Croatia. Krznar and Kunovac (2010) use the VAR model with block-exogenous restrictions and point to external factors as the main determinants of domestic inflation, while domestic shocks only slightly influence the movements and fluctuations of domestic inflation.

Szafranek and Hałka (2019) analyze the sources of low inflation in Poland using a structural Bayesian VAR. The authors found that excessive disinflation has been caused by deteriorating domestic conditions, while deflation has resulted from declining global demand and plummeting oil prices.

Using Bayesian SVAR and principal component analysis, Nagy and Tengely (2018) analyzed the impact of external and domestic drivers of Hungarian inflation. The authors found that the role of external factors in domestic inflation developments strengthened in the past period, and especially after 2012, the changes in inflation in Hungary were mainly influenced by external effects.

For Romania, Pop and Murărașu (2018) used a Bayesian VAR model and found that both domestic and global shocks have played important roles in shaping the dynamics of inflation. However, in the context of the increasingly significant presence of global value chains in the local market and the higher contribution of imported goods in covering domestic consumption, the low inflation rates observed since the mid-2013 seem to be to a larger extent driven by global factors. Similarly, using a frequency-domain framework, Albulescu et al. (2017) found that the oil price–inflation pass-through can be observed only for those components of inflation which include volatile prices and only in the medium run.

To sum up, the existing studies mostly focus on distinguishing between the importance of domestic and foreign determinants of inflation. One can notice the predominance of two approaches: SVAR and panel models. Although some of the SVAR papers study a subset of CESEE countries, they estimate individual country models, without interaction between the countries, thus neglecting possible spillovers. On the contrary, the GVAR approach enables joint modelling of all CESEE countries in a single model and accounting for possible spillovers among their economies, which is particularly convenient considering increasing globalization as well as economic and financial integration of the economies under study and should provide better insight into the key determinants of the domestic inflation dynamics.

The other prevalent modelling solution, the panel model, includes more countries within a single panel model but treats individual countries as independent units. However, panel models are based on yearly data and are thus unable to capture the within-year variation that is likely to occur when analysing inflation dynamics. This paper employs monthly data and in that way accounts for one of the main features of the modern economy: rapid transmission of shocks and the necessity of economic policy-makers to quickly adapt to new and rapidly changing conditions.

Moreover, instead of using a general proxy to capture foreign impacts, this paper defines foreign specific variables that account for possible spillovers from Germany, as the main trading partner, and neighbouring countries. Instead of modelling the foreign impacts as a strongly exogenous variable, the GVAR approach models it as a weakly exogenous variable.

Data and methodology

The empirical analysis of inflation dynamics in a set of countries accounting for possible interlinkages and spillovers is a challenging task. Due to increasing globalization and participation in GVCs, analysing national inflation dynamics inevitably brings in a multilateral aspect. As an adequate modelling framework for assessing the importance of various factors in explaining the inflation dynamics of CESEE countries in a multi-country setting, Lombardi and Galesi (2009) proposed the GVAR approach (Pesaran et al., 2004; Pesaran et al., 2006; Pesaran et al., 2007; Dees et al., 2007). The GVAR approach consists of two steps. Estimation of individual country VARX* models is performed in the first step. Each country model consists of domestic macroeconomic variables $y_{i,t}$ which are related to its lagged values, deterministic variables $D_{i,t}$ (trend and/or dummy variables), foreign-specific variables $y_{i,t}^*$ and global variables $d_{i,t}$. For country i , $VARX^*(p_i, q_i)$ is defined as

$$y_{i,t} = a_{i,0} + a_{i,1}D_{i,t} + \sum_{j=1}^{p_i} a_{i,j}y_{i,t-j} + \sum_{j=0}^{q_i} \beta_{i,j}y_{i,t-j}^* + \sum_{j=0}^{p_i} \gamma_{i,j}d_{i,t-j} + u_{i,t} \quad (1)$$

for $t = 1, 2, \dots, T$ and $i = 0, 1, 2, \dots, N$, p_i and q_i are the lag orders for the endogenous variables and foreign-specific variables, while $u_{i,t}$ is the error term for country-specific models. Individual country models are estimated separately. However, they are connected using foreign-specific variables, which are defined as weighted averages of the corresponding domestic variables for the remaining countries.

$$y_{i,t}^* = \sum_{j=0}^N w_{ij}y_{j,t} \quad (2)$$

Foreign-specific variables proxy for common unobserved factors. They are modelled as weakly exogenous variables. The weak exogeneity assumption is a usual SOE literature assumption (Fleming, 1962; Mundell, 1963), which is applicable in the context of CESEE countries. Fixed trade weights w_{ij} , calculated as average bilateral trade flows from the last nine years, are used for defining foreign-specific variables. Data on bilateral trade flows for defining trade weights were obtained from the Direction of Trade Statistics database (DOTS) of the International Monetary Fund (IMF). In addition to defining foreign-specific variables, weights are a very important segment of the GVAR approach as they are also used in linking country-specific models in the second step of the GVAR approach. Namely, individual country models are stacked together and solved in a global VAR model. That way, the GVAR approach enables modelling interlinkages on multiple levels: national (the connection between domestic variables) and international (interaction with foreign-specific variables). The GVAR approach is based on a modified and generalized version of Johansen's (1988, 1991, 1995) maximum likelihood approach. Under the weak

exogeneity assumption, coefficients of the country-specific models are estimated based on the reduced-rank approach developed by Johansen. Originally, Johansen's approach is based on the assumption that all variables are endogenous. However, Harbo et al. (1998) and Pesaran et al. (2000) modified the methodology to allow for weakly exogenous variables.

This paper models the effects of various macroeconomic indicators on the domestic inflation dynamics. The focus is on a group of CESEE countries that have become EU members in one of the three enlargement waves in the 21st century. These countries alone constitute a heterogeneous group of countries. However, the accession process ensured the existence and comparability of the data sets employed in the paper. The inclusion of other European transition economies would lead to either a shorter data set or the exclusion of certain variables. In addition to the eleven CESEE countries, Germany, as a reference country, is also included due to its importance as an important trading partner and as a country through which global shocks transmit to the CESEE countries.

To assess the determinants of inflation in selected CESEE countries, data selection regarding the frequency of the variables is of particular importance. Observing price movements using lower-frequency data (yearly or quarterly) is not adequate as it neglects potential and likely turbulences within a certain year. Moreover, for the analysis in a globalized setting where shocks tend to transmit at a faster pace across economies, higher-frequency data are more suitable. Hence, monthly data for the period from January 2000 to June 2021 are employed in the study, i.e. 258 observations.

Besides the choice of an adequate modelling framework, data frequency and data span, special care should be also exercised in selecting variables. Selected variables should reflect possible influences on inflation such as economy overheating, labour market and the movement of commodity prices (fuel and food prices). The central variable of the empirical model is the inflation rate, measured as year-on-year (y-o-y) changes in the Harmonised Indices of Consumer Prices (HICP), i.e. percentage changes of the HICP value in comparison with the corresponding period of the previous year.

The real effective exchange rate and real output (in 2015 prices) are added to proxy for relative prices and domestic demand, respectively. The unemployment rate represents the labour market. Interest rates are added as a monetary policy indicator in the countries that are not members of the Euro area. For the Euro area member states, to avoid the zero lower bound (ZLB), Wu-Xia (2016) ECB shadow rates are added as a monetary policy indicator. Food and oil prices are included in the model to proxy for the movement of commodity prices. Additionally, foreign-specific variables are included in the model to capture possible unobserved common factors influencing the CESEE countries' inflation dynamics. When diagnostic tests indicated the presence of seasonal components, series were seasonally adjusted using the TRAMO/SEATS method within JDEMETER+ statistical program. A detailed overview of variables and their sources is in Table 1 in the Appendix. The composition of endogenous and foreign specific variables is in Table 2 in the Appendix. Global variables (Food prices, oil prices and ECB shadow rates) are included in all of the individual country models.

Figure 3 depicts the inflation rates, while the descriptive statistics for the inflation rates and other variables employed in the model are reported in Table 3 and Table 4. When looking at the figures for the analysed period, the highest median values were reported in

Romania, which struggled with high inflation rates throughout almost the whole period from the beginning of the '90s until the start of the 21st century. Among four countries with the lowest median inflation rate, three are members of the EMU (Lithuania, Czech Republic and Slovenia). However, the country with the lowest median inflation rate is Croatia. Although the price stability goal is usually justified on the ground of viewing stability as a precondition for sustainable economic growth, Croatia was one of the worst-performing EU countries, with a recession period stretching from the 2008 crisis up until the end of 2014 – thus, confirming that price stability itself is not sufficient to ensure macroeconomic stability (White, 2006), or economic growth.

Empirical results

The empirical results are obtained using the GVAR Toolbox interface 2.0 (Smith and Galesi, 2014) which is based on MATLAB code. Country-specific models are connected via foreign-specific variables. The performed tests indicate that weak exogeneity assumption was rejected in 5 out of 41 conducted tests (12%) at the 5% level. Furthermore, at the 1% level, the weak exogeneity assumption was rejected only in one test (2.4%). Results of the weak exogeneity tests are not reported due to their extensiveness but are available upon request. Therefore, individual country models were estimated under the assumption that the foreign-specific variables are weakly exogenous (Harbo et al., 1998; Pesaran et al., 2000). Lag orders for the endogenous variables (p_i), foreign-specific (q_i) and global variables were selected using the Akaike information criterion (AIC) after which the cointegrating VARX* models were estimated. The rank of the cointegrating space was selected using trace statistics due to its better small sample performance compared to maximum eigenvalue statistics, which is also less robust to departures from normal errors (Cheung and Lai, 1993).

Table 5 in the Appendix summarizes selected lag orders for endogenous variables (p_i) and foreign-specific variables (q_i) as well as the rank of cointegrating space. The final selection was made in accordance with the AIC information criterion as well as the GVAR model diagnostics (Figure 4 and Figure 5).

The corresponding vector error correction model (VECMX*) had a restricted trend and unrestricted intercept. Individual country models were then estimated subject to reduced rank restrictions and the corresponding error-correcting terms (used for conducting weak exogeneity tests) were derived. Estimated VARX* and VECMX* models, model diagnostics and other empirical results not reported in the paper are available upon request.

Another important prerequisite for the application of the GVAR approach is that the cross-sectional dependence of the country residuals is generally weak. Figure 4 illustrates that 96% of the pairwise correlations across the country residuals are below the correlation of 0.1, pointing to weak cross-sectional dependence (Burriel and Galesi, 2018). Hence, the main prerequisites for linking the country-specific models are satisfied.

So far, all the prerequisites for the validity of the GVAR approach have been satisfied. The final precondition is the dynamic stability of the model which is also achieved. Namely, all the eigenvalues of the estimated GVAR model are on or inside the unit circle (Figure 5). Out of 220 eigenvalues, 38 are on the unit circle, suggesting a permanent effect

of some shocks on the levels of endogenous variables. Furthermore, 112 eigenvalues are complex, implicating a cyclical pattern of impulse responses.

Therefore, as all the prerequisites of the GVAR approach are satisfied, a dynamic analysis was performed using generalized forecast error variance decomposition (GFEVD) and generalized impulse response functions (GIRF). In a high-dimensional multi-country setting, any attempt in deriving a robust structural factorisation of the contemporaneous matrix would be challenging and hard to justify. Hence, the order-invariance of the generalized approach to dynamic analysis is one of the advantages of the GVAR approach (Greenwood-Nimmo et al., 2012).

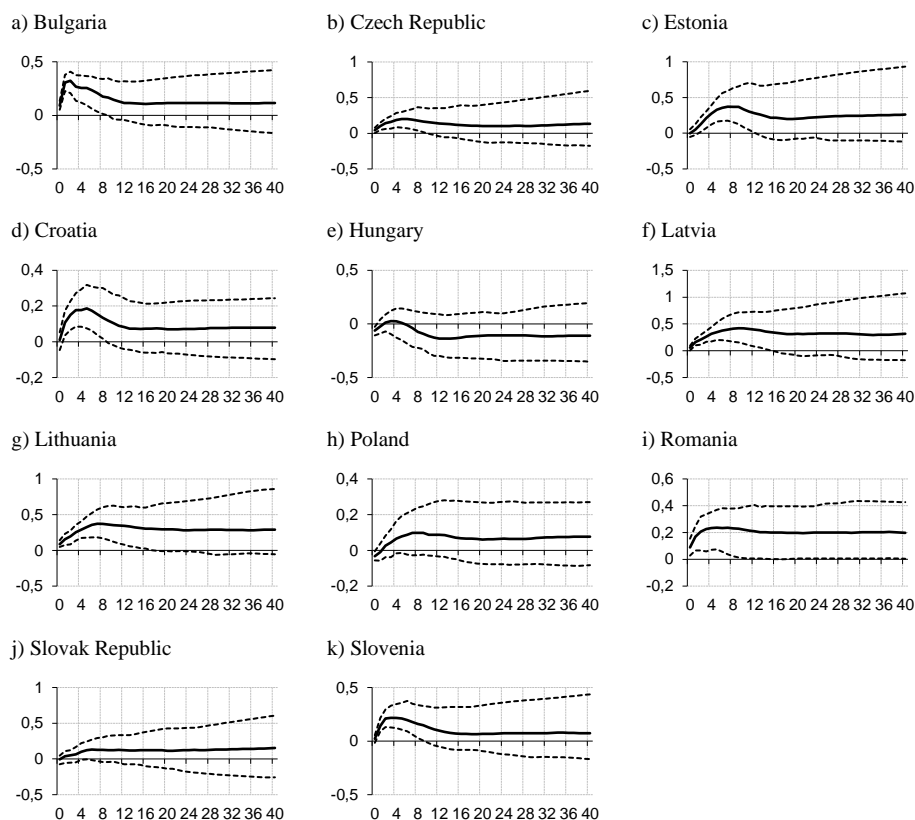
To assess the potential reaction of CESEE countries' inflation to commodity shocks, generalized impulse response functions (GIRFs) are presented in Figure 6 and Figure 7, i.e., median estimates and 90 percent bootstrap confidence bands. GIRFs indicate how the effects of a one standard error shock in commodity prices on the future states of all the variables in the system change in time.

As expected, Figure 6 and Figure 7 indicate that a one standard error shock in food prices and a one standard error shock in oil prices both lead to an increase in CESEE countries' inflation. The effect of the shock in food prices is the largest in the Baltic countries and Bulgaria. On the other hand, the effect of the shock in food prices is not statistically significant in Hungary, the Slovak Republic and, not surprisingly, Poland, which is one of the largest EU agricultural and meat producers. That way, Poland has more capacity to absorb food price shocks. However, even in the countries in which the food price shock is statistically significant, it is not that persistent and becomes statistically insignificant within a year. This means that either the countries can tackle the shocks after applying certain policy measures or it could be that these shocks were not that intensive in the analysed period.

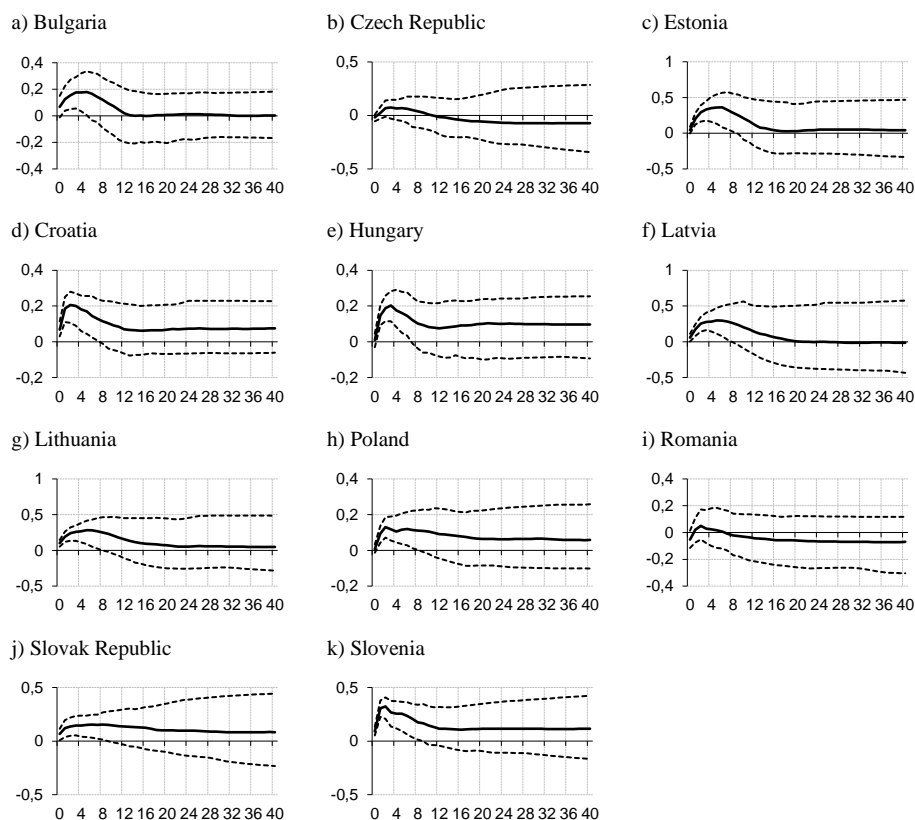
Similar to food prices, the effect of a one standard error shock in oil prices (Figure 7) is again the largest in the Baltic countries and Slovenia. The oil price shock is not statistically significant in Romania and the Czech Republic.

It can be concluded that in most CESEE countries, both commodity price shocks lead to an increase in inflation. Nevertheless, the effect becomes statistically insignificant within a year. Furthermore, the food price shock has a slightly larger effect.

Figure 6. Impact of a one standard error shock in food prices on CESEE countries' inflation



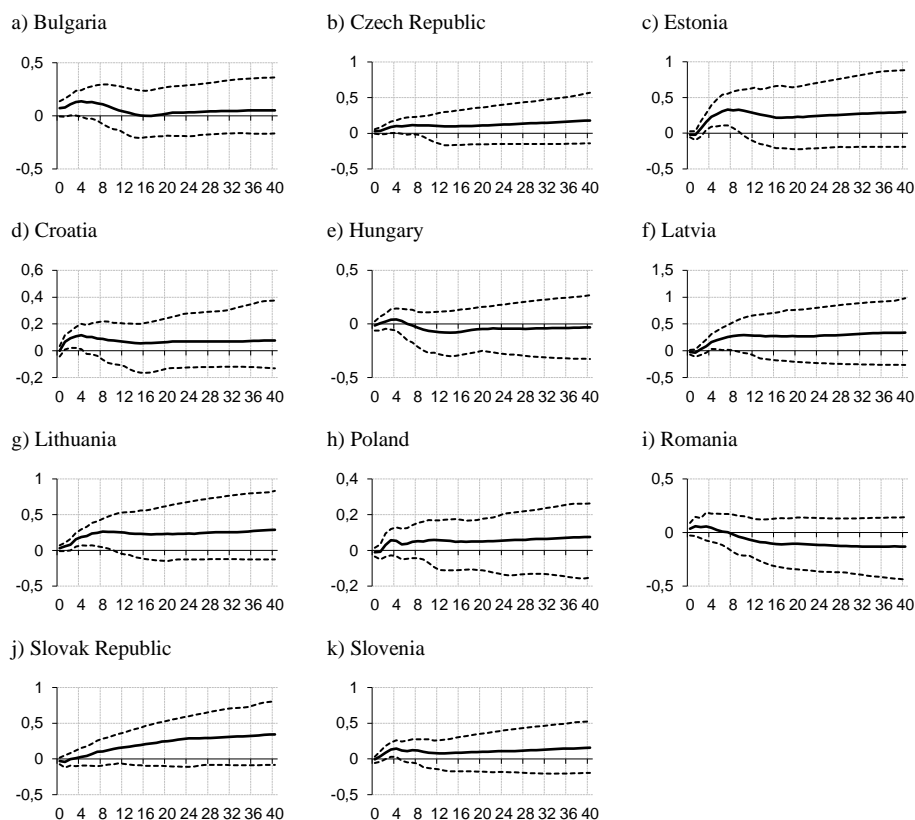
Source: Author's calculation

Figure 7. Impact of a one standard error shock in oil prices on CESEE countries' inflation

Source: Author's calculation

Considering monetary policy, the impact of two shocks is assessed. For the Euro area member states, a one standard error shock in shadow rates (Figure 8), while for other countries, a one standard error shock in the three months interest rates (Figure 9).

In most countries, the impact of a one standard error shock in shadow rates is not statistically significant. On the other hand, in countries in which this shock is statistically significant, it is significant with a lag (hence not on impact), i.e. after 3 to 4 months. Furthermore, quite soon, within 3 to 4 months, it becomes statistically insignificant. Moreover, it does not lead to a decrease in inflation, but quite the opposite, to an increase.

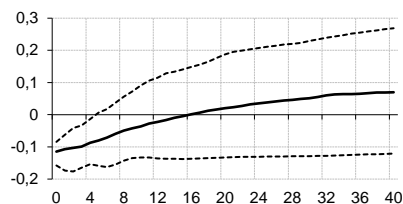
Figure 8. Impact of a one standard error shock in shadow rates on CESEE countries' inflation

Source: Author's calculation

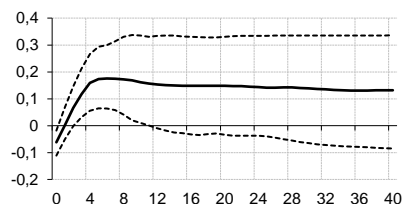
As opposed to the common monetary policy, a monetary policy shock in the countries outside the Euro area leads to a statistically significant decrease in inflation on impact, with the exception of Romania. Furthermore, its effect is only short-lived in the Czech Republic, while in Hungary, it becomes positive after three months, and then statistically insignificant within a year. However, in Poland, it has a permanent effect on decreasing inflation.

Figure 9. Impact of a one standard error shock in interest rates on CESEE countries' inflation

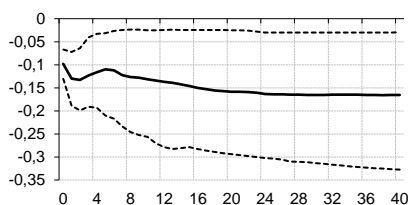
a) Czech Republic



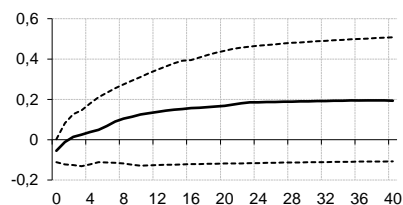
b) Hungary



c) Poland



d) Romania



Source: Author's calculation

Although the effects of a shock in the monetary policy variable are not statistically significant in some countries, it should be noted that in the model without monetary policy variables, the effects of oil price and food price shocks are persistent (Figure 10 and Figure 11 in the Appendix). Hence, monetary policy acts as a buffer against adverse shocks

As a robustness check, three separate models were estimated for three country groupings: Visegrád 4 (the Czech Republic, Hungary, Poland and the Slovak Republic), Baltic countries (Estonia, Latvia and Lithuania) and South-Eastern Europe (SEE) countries (Bulgaria, Croatia and Romania). Of course, each of these separate models also includes Germany as the main trading partner.

The results for the effect of the shock in shadow rates on inflation are not reported because they are almost the same as in the benchmark model. Results for other shocks (oil price and food price) are also very similar to the benchmark model with few small differences.

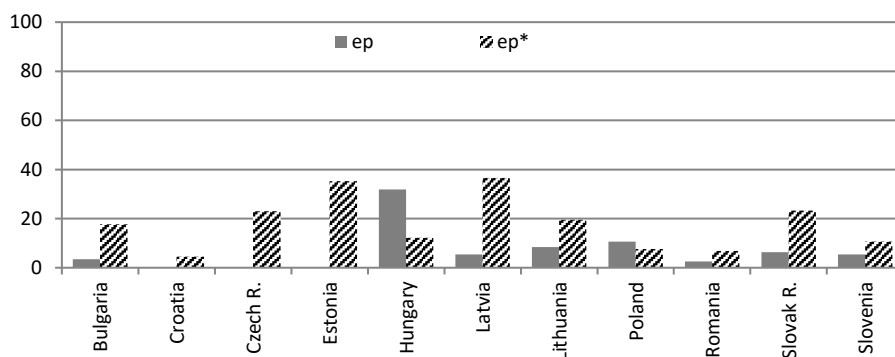
Regarding the food price shock (Figure 13, Figure 15 and Figure 17) in the Baltic countries, its effects are slightly stronger and more persistent. The same conclusion holds for the effect of the oil price shock in the Baltic countries (Figure 16). Additionally, the oil price shock has a bit larger and more persistent effect in Poland and the Czech Republic (Figure 14). Hence, it can be concluded that accounting for a larger set of countries helps diminish the effects of price shocks in these countries.

Furthermore, there is also one difference regarding the interest rate shock in the V4 countries (Figure 12). It seems that in the Czech Republic, while accounting for more countries, monetary policy becomes more efficient, while the opposite holds for Poland. To tackle this issue further, GFEVD is also analysed to assess the relative importance of various factors in CESEE countries' inflation dynamics. GFEVD estimates the proportion of the

variance of the h -step ahead forecast errors of each variable that is explained by conditioning on contemporaneous and future values of the generalized shocks of the system.

Figure 19 illustrates the importance of real exchange rate dynamics in explaining domestic inflation. The share of countries' real exchange is the highest in Hungary, a country with a fixed exchange rate regime, and Poland, which has a floating exchange rate regime. Furthermore, the dynamics of real exchange rates in neighbouring countries (ep^*) is also important. In particular, its share is the largest for members of the eurozone (Slovak R. and the Baltic countries) but also for countries outside the eurozone (Czech Republic).

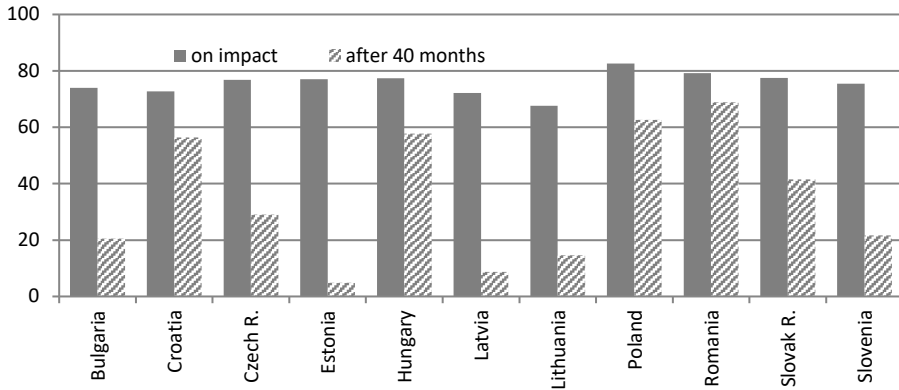
Figure 19. Share of the forecast error variance of CESEE countries' inflation explained by exchange rate dynamics (after 40 months)



Source: Author's calculation

Figure 20 confirms the conclusions from the previous research that in the CESEE countries, the domestic variables explain most of the inflation dynamics in the short run, while in the long run, foreign variables have a dominant role. However, this conclusion does not equally apply to all the analysed countries. For instance, in Estonia, after 40 months, virtually all (95%) of the forecast error variance of the historical shock is explained by the foreign variables. Similar high shares are recorded in other Baltic countries. However, it is interesting to notice that the relevance of the domestic factors in Poland, Romania, Hungary and Croatia is, besides in the short run, sustained in the long run as well.

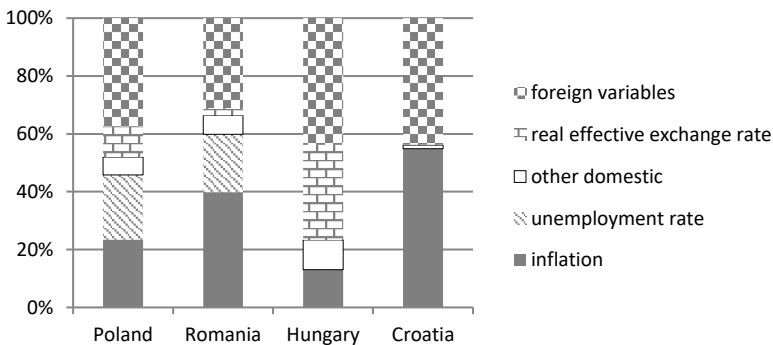
Figure 20. Share of the forecast error variance of CESEE countries' inflation explained by domestic variables



Source: Author's calculation

Figure 21 gives a closer look at the domestic sources of variability in CESEE countries in which domestic factors have a more pronounced role. Of the domestic factors in Poland, the domestic inflation, the unemployment rate and the real effective exchange rate drive the domestic inflation in the long run. On the other hand, in Romania, the results confirm the high persistence of the domestic inflation found in the previous research (Hammermann, 2007). Higher inflation persistence is exhibited even in Croatia. Additionally, in Romania, the labour market also plays an important role in the long run, while in Hungary, it is the real effective exchange rate that has the dominant impact on the inflation dynamics.

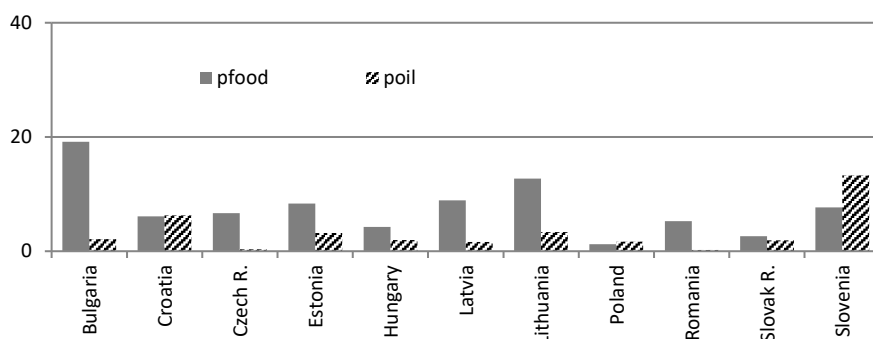
Figure 21. Generalized forecast error variance of inflation in selected CESEE countries



Source: Author's calculation

Regarding the commodity prices (Figure 22), in the long run, the impact of food prices is more pronounced in comparison to oil prices. In the long run, oil prices have the largest influence in Slovenia (13.3%), while the largest effect of the shock in food prices is in Bulgaria (19%) and Lithuania (12.7%).

Figure 22. Share of the forecast error variance of CESEE countries' inflation explained by oil prices (poil) and food prices (pfood) after 40 months

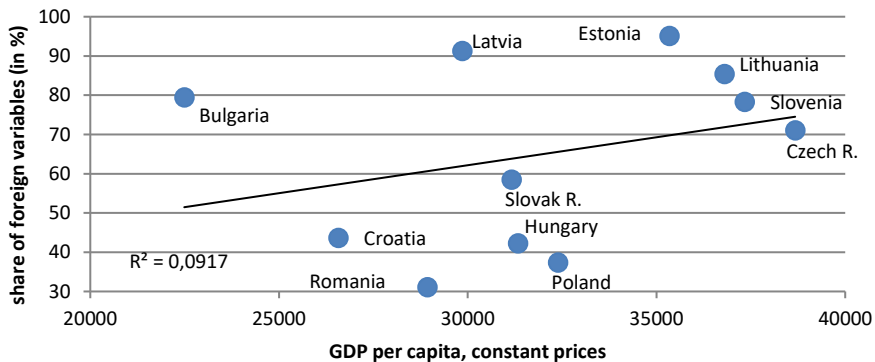


Source: Author's calculation

Following the results of the estimated model, it can be concluded that the analysed countries are pronouncedly heterogeneous and it is very difficult to spot a clear and distinguishing pattern. Exceptionally, the Baltic countries' inflation dynamics mostly tends to react similarly and the importance of factors is also similar. This is as close as there is to a common pattern.

Some findings of the analysis correspond to the previous research, like the relevance of the domestic variables for explaining inflation dynamics in the short run, and vice versa regarding the foreign variables in the long run. Nevertheless, the findings mostly point to the necessity of analysing inflation dynamics in a modelling framework that accounts for interlinkages and spillovers. For instance, Parker (2017) found that the influence of global inflation on national inflation rates is much lower for less developed countries. However, the scatter plot of GDP per capita, constant prices (Purchasing power parity; 2017 international dollar) against the share of foreign variables in explaining national inflation dynamics (after 40 months) indicates that the relationship between income and the relevance of foreign factors cannot be described as a clear pattern (Figure 23).

Figure 23. Scatter plot of GDP per capita, constant prices (Purchasing power parity; 2017 international dollar) against the share of foreign variables in explaining national inflation dynamics (after 40 months)

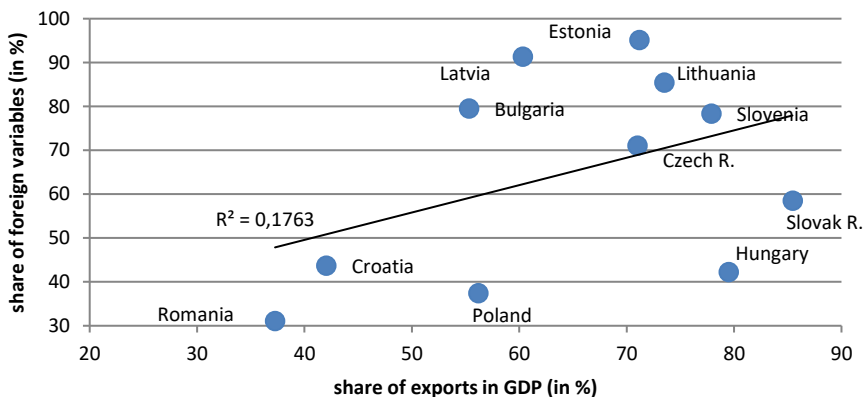


Source: Author's calculation and IMF

Many authors experienced difficulties in finding a common pattern, and, eventually, pointed to the size of a country. Mihailov et al. (2011) found that the inflation process is dominated by domestic variables in larger countries, while external variables are most relevant in smaller countries. However, the results of this research do not go in line with this conclusion, as Figure 23 demonstrates that there are large countries with smaller relevance of the foreign variables (Romania and Poland) but there are also large countries with larger relevance of foreign variables (Bulgaria). The same conclusion can be drawn for small countries (Estonia at one end and the Slovak Republic at the other).

Additionally, the scatter plot of the share of exports in GDP against the share of foreign variables in explaining national inflation dynamics (after 40 months), Figure 24, illustrates that the openness of the economy is also not helpful in finding a common pattern.

Figure 24. Scatter plot of share of exports in GDP against the share of foreign variables in explaining national inflation dynamics (after 40 months)



Source: Author's calculation and World Bank

Furthermore, five out of eleven CESEE countries are the EMU members; Slovenia (from 2007), Slovakia (from 2009), Estonia (from 2011) and, more recently, Latvia (from 2014) and Lithuania (from 2015). Although it can also be concluded that the adoption of the euro as a national currency is not decisive for the importance of foreign factors, countries mostly adopted the euro later in the sample, so it is more likely that the effects, should there be any, are yet to be seen.

Additionally, Furceri et al. (2016) found that, due to the smaller share of food in the consumption baskets in advanced economies, food price shocks have a larger effect in lower-income countries. Again, when accounting for spillovers and country linkages, such a pattern cannot be found. Furthermore, the empirical study in this paper confirms that the effects of oil price shocks tend to be less persistent when accounting for monetary policy variables (Choi et al., 2018).

Conclusion

After a prolonged period of relatively stable price levels, at the beginning of the third decade of the 21st century, inflation is once again in the spotlight. Hence, this paper analyses the main sources of inflation dynamics in CESEE countries. Due to EU accession augmented by the globalization process and involvement in GVCs, the international impacts are becoming progressively important for the domestic inflation dynamics and domestic variables are not sufficient to fully describe the domestic inflation dynamics. Consequently, the GVAR approach (Pesaran et al., 2004) is employed as an appropriate modelling framework. The GVAR approach has advantages over the usual unrestricted VAR models that model each economy separately (neglecting possible interactions between economies and leading to distorted conclusions) as the GVAR approach enables modelling of the international linkages. The GVAR approach can also be viewed as a better modelling solution than panel models, where countries are often treated as independent units which could lead to neglect of important spillovers among countries.

Although the CESEE countries are often analysed as a group, the findings of the paper show that these countries are pronouncedly heterogeneous and, hence, the ‘one size fits all’ approach is not appropriate. Each of the analysed economies has its own set of country-specific factors which, from country to country, play a more important or a less significant role in explaining national inflation dynamics. Therefore, each country should be addressed individually instead of a joint conclusion that usually stems from panel data models.

Using dynamic analysis (generalized forecast error variance decomposition and generalized impulse response functions), the results of the empirical analysis partly confirm the results of the previous research that in the CESEE countries, the domestic variables explain most of the inflation dynamics in the short run, while in the long run, foreign variables have a dominant role. However, there are a few exceptions. Namely, the relevance of the domestic factors in Poland, Romania, Hungary and Croatia is, besides in the short run, sustained in the long run as well. Of the domestic factors in Poland, the unemployment rate and the real effective exchange rate drive domestic inflation in the long run. In Romania, the results confirm the high persistence of the domestic inflation found in the previous research (Hammermann, 2007). Higher inflation persistence is exhibited even

in Croatia. In Hungary, real exchange rate movements are the predominant inflation driver.

Both commodity price shocks have the largest effect in the Baltic countries. Moreover, the food price shock has a slightly larger effect. However, the effects of both shocks are not persistent. The performed analysis indicates the important role of monetary policy as well as fostering trade integration in reducing the adverse effects of commodity shocks.

The results of the performed empirical analysis point to the importance of addressing the determinants of inflation in CESEE countries using a global macroeconomic model with particular emphasis on the ability to address country-specific factors. As such, the findings of the paper should contribute to a more comprehensive understanding of the inflation dynamics in the policy-making context.

Overall, the findings confirm the narrative of maintaining the price stability and that, ultimately, in a relatively stable macroeconomic setting, notwithstanding the 2008 economic crisis and occasional price hikes, monetary policy is able to act as a buffer against commodity price shocks.

The analysis performed in this paper, covering the period prior to the 2022 turmoil, makes it a 'requiem' for the inflation dynamics determinants in a stable macroeconomic surrounding, i.e. the inflation dynamics 'as it once was'. However, it seems that the turmoil brought upon at the start of 2022, i.e. changes in the macroeconomic setting and the departure from stability, will probably bring changes to the pattern of the inflation dynamics and it is more than likely that both food prices and energy prices will have a larger impact. Although the future outlook looks quite grim, hopefully, the 2022 events will remain a temporary turmoil and will not develop into Armageddon.

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Appendix

Figure 3. Selected CESEE countries' inflation rates for the period from 2000 to 2021

Source: Eurostat

Table 1. Data sources and data preparation procedures

Variable	Description	Source
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Inflation	Measured as year-on-year (y-o-y) changes of the Harmonised Indices of Consumer Prices (HICP), i.e. percentage changes of the HICP value in comparison with the corresponding period of the previous year. HICP (2015=100) was also applied to obtain real GDP.	Eurostat
Real output	Quarterly data series on the gross domestic product at market prices in million euros was seasonally adjusted using TRAMO/SEATS procedure within JDemetra+ software. Seasonally adjusted quarterly GDP series was disaggregated to monthly frequency using Chow-Lin's (1971) procedure, using seasonally adjusted series on industrial production indices (2015=100) as a high-frequency indicator. Expressed in logarithms.	Eurostat
Real effective exchange rates	Real effective exchange rate index (deflator: consumer price index - 42 trading partners - industrial countries), 2010=100. Expressed in logarithms.	Eurostat
Interest rates	Three-month interest rates. Calculated as real interest rates using data on inflation. Expressed in %.	ECB, Macrobond
Unemployment	Seasonally adjusted using TRAMO/SEATS procedure within JDemetra+ software. Expressed in %.	Eurostat
Oil prices	Monthly averages of Europe Brent Spot Price FOB (Dollars per Barrel). Measured as year-on-year (y-o-y) changes.	Thomson Reuters
Food prices	FAO Monthly Real Food Price Indices (2014-2016=100). Measured as year-on-year (y-o-y) changes.	IMF
ECB shadow rate	Data prior to September 2004 were backward extrapolated using data on EONIA (Euro OverNight Index Average).	ECB, Cynthia Wu web page

Table 2. Composition of endogenous and foreign specific variables in the individual country models of the GVAR model

Variables	Number of countries	
Endogenous		
Inflation (dp)	12	Czech R., Hungary, Poland and Romania
Real output (y)	12	
Real effective exchange rate (ep)	12	
Unemployment (ur)	12	
Interest rate (ir)	4	
Exogenous		
Inflation (dp^*)	12	Excluding: Germany Excluding: Germany
Real GDP (y^*)	12	
Real effective exchange rate (ep^*)	11	
Interest rate (ir^*)	11	

Table 3. Descriptive statistics: Endogenous variables

Country	Minimum	Median	Maximum		Country	Minimum	Median	Maximum
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Inflation								
Romania	-3,00	4,59	44,93		Poland	-1,30	2,29	10,93
Hungary	-1,38	3,86	10,19		Slovenia	-1,38	2,23	9,50
Estonia	-2,16	3,41	10,96		Czech R.	-0,77	2,09	7,57
Bulgaria	-2,58	3,02	13,75		Lithuania	-1,91	2,00	11,93
Latvia	-4,44	2,64	16,30		Croatia	-1,47	1,98	7,70
Slovak R.	-0,86	2,63	15,53					
Unemployment								
Slovak R.	5,68	13,49	19,86		Estonia	4,10	7,90	17,80
Croatia	6,10	13,21	17,70		Romania	3,56	6,83	8,84
Latvia	5,24	10,83	20,55		Czech R.	1,49	6,64	9,37
Lithuania	3,97	9,99	18,09		Hungary	2,87	6,58	11,36
Bulgaria	3,88	9,87	20,30		Slovenia	3,92	6,44	10,89
Poland	2,78	9,62	20,40					
Output								
Poland	5,31	5,78	6,08		Bulgaria	3,06	3,52	3,93
Czech R.	4,28	4,92	5,18		Slovenia	3,34	3,47	3,69
Romania	4,34	4,81	5,18		Lithuania	2,64	3,34	3,67
Hungary	4,38	4,59	4,75		Latvia	2,50	2,95	3,22
Slovak R.	3,36	4,12	4,31		Estonia	2,14	2,75	3,08
Croatia	3,29	3,66	3,82					
Real exchange rate								
Estonia	4,38	4,62	4,77		Croatia	4,48	4,57	4,65
Slovak R.	4,05	4,61	4,67		Bulgaria	4,22	4,57	4,65
Latvia	4,43	4,60	4,72		Poland	4,39	4,56	4,78
Slovenia	4,55	4,60	4,64		Czech R.	4,20	4,54	4,69
Lithuania	4,43	4,60	4,75		Hungary	4,30	4,53	4,73
Romania	4,35	4,59	4,77			4,48	4,57	4,65
Interest rate								
Romania	0,19	6,05	78,46		Poland	-0,70	3,94	19,47
Hungary	-0,73	5,84	12,59		Czech R.	-0,98	1,53	6,17

Source: Author's calculation.

Table 4. Descriptive statistics: Global variables

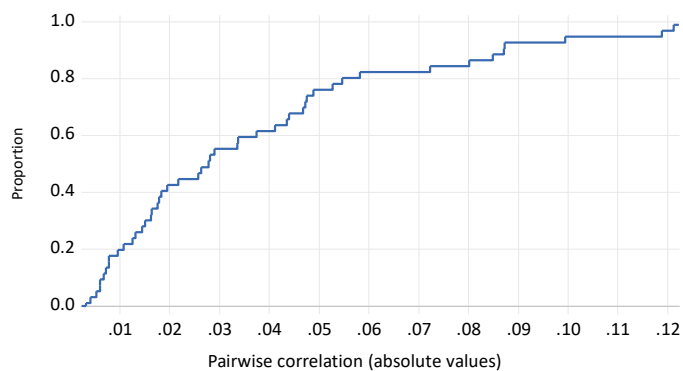
Variable	Minimum	Median	Maximum	Variable	Minimum	Median	Maximum
Oil prices	-135,47	6,12	126,02	Shadow rate	-7,82	0,31	5,14
Food prices	-38,84	1,44	41,69				

Source: Author's calculation.

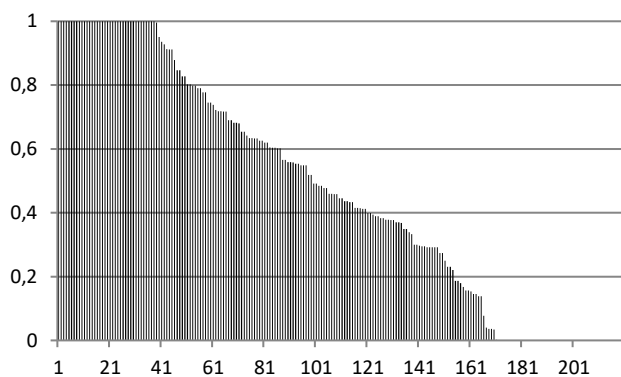
Table 5. VARX* order and number of cointegrating relationships in the country-specific models

Country	p_i	q_i	Number of cointegrating relations	Country	p_i	q_i	Number of cointegrating relations
Bulgaria	4	1	2	Latvia	3	2	2
Czech R.	3	2	1	Lithuania	4	2	1
Estonia	2	2	2	Poland	3	2	1
Croatia	3	2	2	Romania	2	2	1
Germany	4	2	1	Slovak R.	2	2	1
Hungary	3	2	2	Slovenia	4	2	1

Source: Author's calculation.

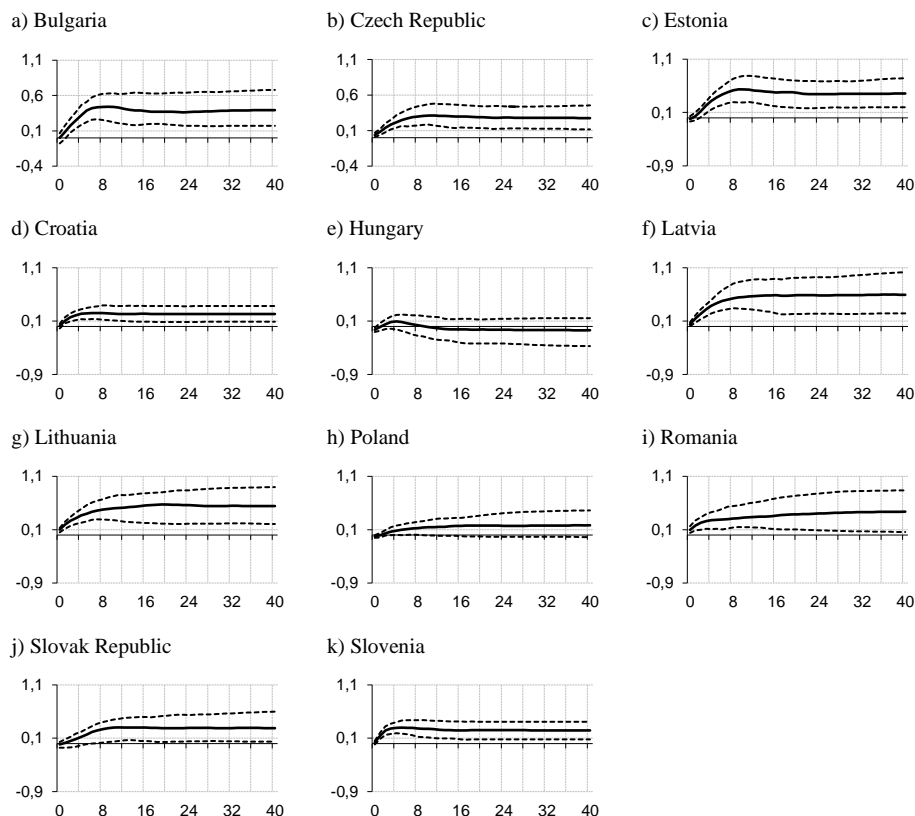
Figure 4. Residual cross-sectional dependence

Source: Author's calculation

Figure 5. Eigenvalues of the GVAR model

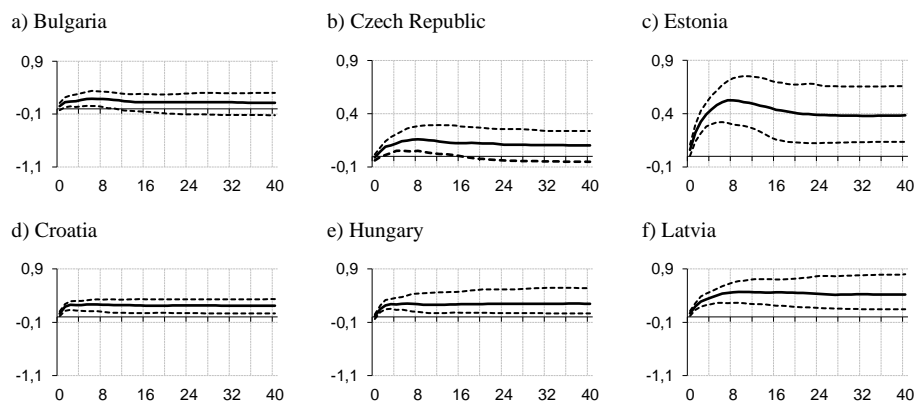
Source: Author's calculation

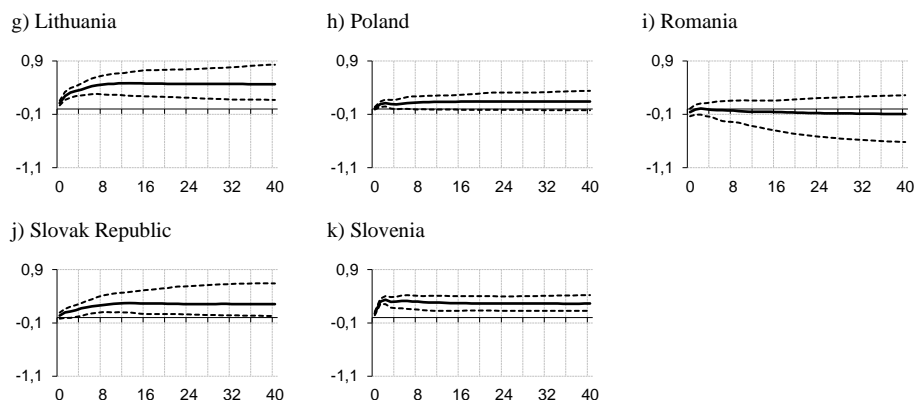
Figure 10. Impact of a one standard error shock in food prices on CESEE countries' inflation (model without monetary policy variables)



Source: Author's calculation

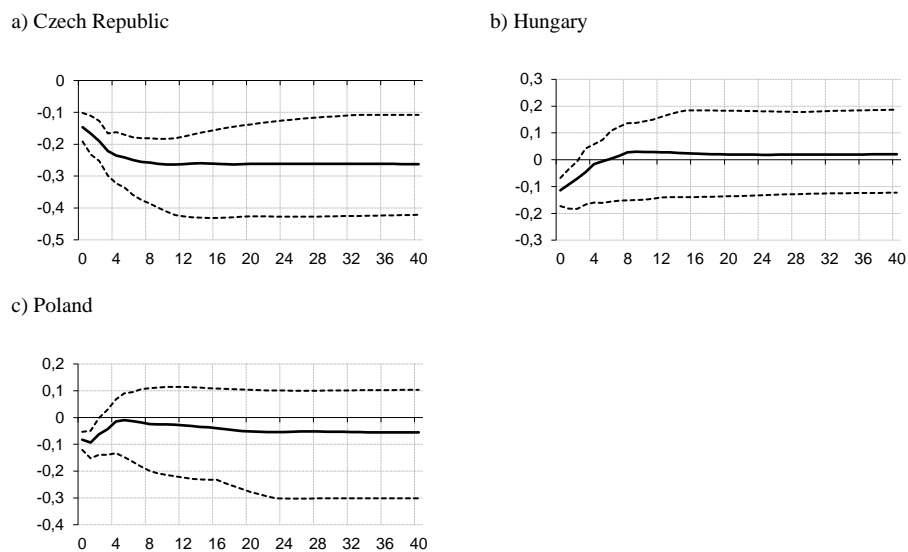
Figure 11. Impact of a one standard error shock in oil prices on CESEE countries' inflation (model without monetary policy variables)





Source: Author's calculation

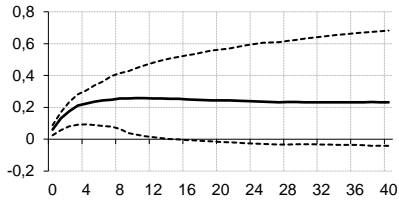
Figure 12. Impact of a one standard error shock in interest rates on CESEE countries' inflation (Visegrád 4 countries model)



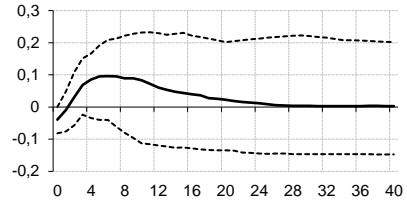
Source: Author's calculation

Figure 13. Impact of a one standard error shock in food prices on CESEE countries' inflation (Visegrád 4 countries model)

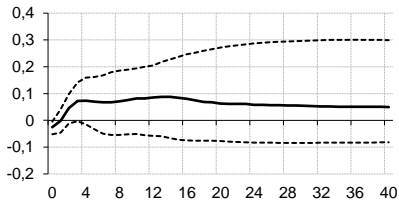
a) Czech Republic



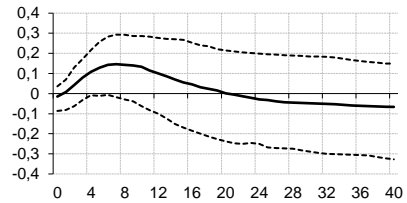
b) Hungary



c) Poland



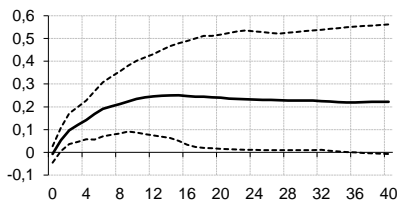
d) Slovak Republic



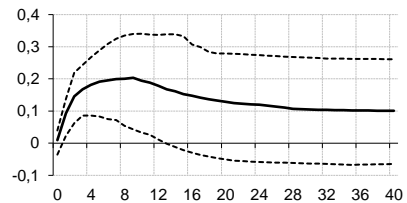
Source: Author's calculation

Figure 14. Impact of a one standard error shock in oil prices on CESEE countries' inflation (Visegrád 4 countries model)

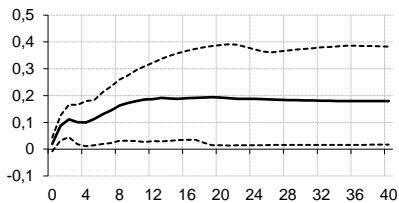
a) Czech Republic



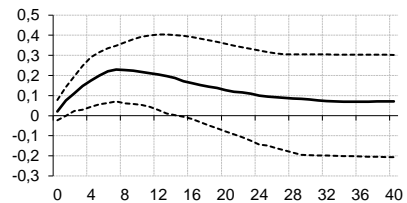
b) Hungary



c) Poland



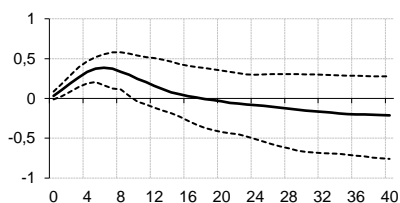
d) Slovak Republic



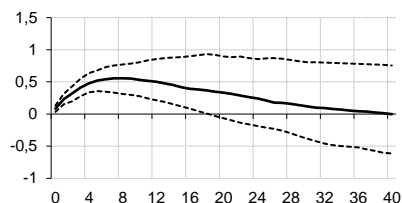
Source: Author's calculation

Figure 15. Impact of a one standard error shock in food prices on CESEE countries' inflation (Baltic countries model)

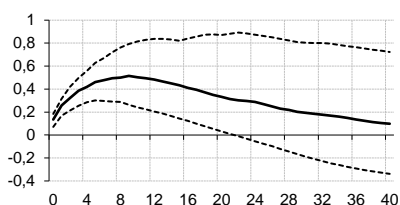
a) Estonia



b) Latvia



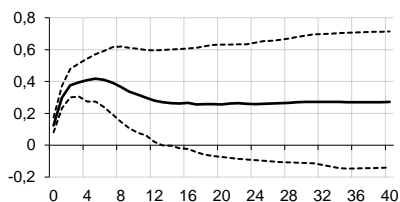
c) Lithuania



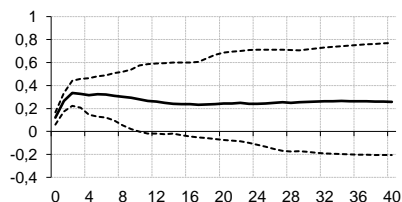
Source: Author's calculation

Figure 16. Impact of a one standard error shock in oil prices on CESEE countries' inflation (Baltic countries model)

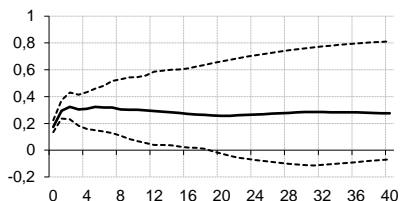
a) Estonia



b) Latvia



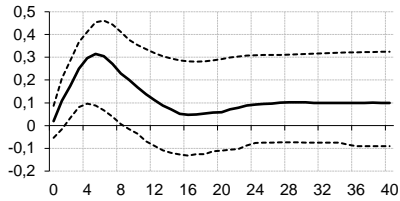
c) Lithuania



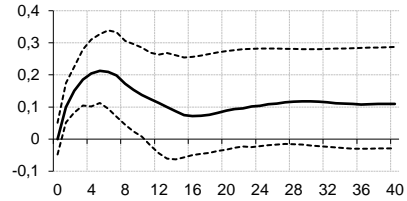
Source: Author's calculation

Figure 17. Impact of a one standard error shock in food prices on CESEE countries' inflation (SEE countries model)

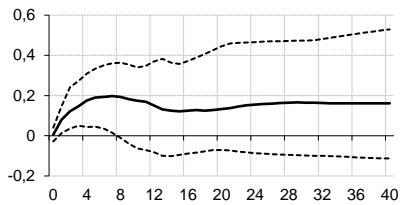
a) Bulgaria



b) Croatia



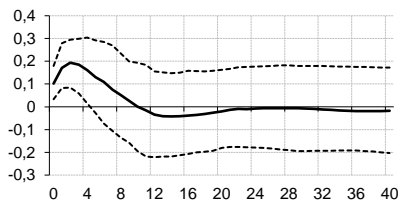
c) Romania



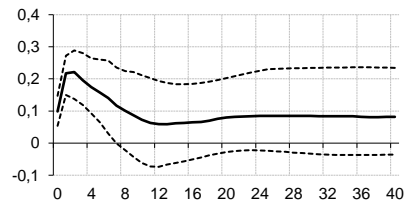
Source: Author's calculation

Figure 18. Impact of a one standard error shock in oil prices on CESEE countries' inflation (SEE countries model)

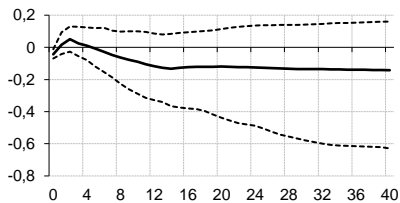
a) Bulgaria



b) Croatia



c) Romania



Source: Author's calculation