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Inflation in New EU Member States: A Domestically or Externally Driven Phenomenon?

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Abstract

This paper analyzes the domestic and external inflation determinants for eight non-eurozone new EU member states (NMS). The empirical literature has been rather silent on the comparison of the relative importance of domestic vs. foreign inflation determinants. This paper aims to fill this gap and add to the literature by several methodological and empirical contributions. Empirical analysis is based on the structural vector autoregression (SVAR) model. It enables the authors to decompose inflation into its domestic and foreign component via historical decomposition analysis. Results indicate that 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. Moreover, the importance of the foreign inflation component has had a rising trend in the pre-crisis period in all NMS, while the start of that trend mostly coincided with their accession to the EU. The global financial crisis seems to have decreased the importance of the foreign inflation component, although the results vary across countries. Since foreign shocks proved to be a very important determinant of inflation in NMS, the main policy implication of this study is the need to augment the classical Taylor rule with foreign factors in case of small open economies.

Key words

domestic and external inflation determinants, historical decomposition, inflation, new EU member states, consumer surveys

JEL classification

C22, E31, E52, F41

1. Introduction

During the Great Moderation period, inflation was rather stable in the vast majority of developed countries. At the same time, the emerging economies of Central and Eastern Europe (CEE) frequently recorded even double-digit inflation figures (see e.g. Hammermann and Flanagan (2009) for an overview of inflation differentials in CEE countries). The necessity of thorough inflation analysis in those countries has been even more accentuated with regards to recent economic developments.

Namely, Vašíček (2009) as well as Franta, Saxa and Šmídková (2010) provide fresh evidence that inflation persistence in some New EU Member States (NMS) is much higher than in the eurozone economies. As they suggest, this may lead to severe problems with fulfilling the Maastricht criterion on inflation. Additionally, almost all NMS have witnessed a growth in total external trade relative to GDP during the crisis period. This has made their economies more vulnerable to external shocks in the global economic conditions (demand-pull inflation) or in commodity prices (cost-push inflation).

However, the empirical literature has been rather silent on the comparison of the relative importance of domestic vs. foreign factors driving inflation. One of the rare empirical studies of that kind is Mihailov, Rumler and Scharler (2011a), who make an effort to estimate the New Keynesian Phillips curve (NKPC) for 10 OECD countries using the Generalized Method of Moments (GMM). The authors start from the Galí and Monacelli (2005) open-economy NKPC model (comprising inflation expectations, output gap and the effective terms of trade vis-à-vis the rest of the world), and consider several alternative model specifications. For the majority of the observed countries, the external factors (terms of trade) turned out to be more important for inflation than the domestic one (output gap).

To the best of the authors' knowledge, the only study formally comparing the relevance of domestic and external inflation drivers in the CEE economies is the one by Mihailov, Rumler and Scharler (2011b). They estimate the NKPC for 12 NMS (within the 2004 and 2007 enlargements), repeating the exact same empirical exercise as in Mihailov, Rumler and Scharler (2011a). Their results strongly point out the superiority of the original Galí and Monacelli (2005) model, which also enables the comparison of the relative importance of domestic factors (output gap) and foreign determinants (terms of trade) in explaining the inflation generating process. The authors obtain rather diverse results, explicating them by the size effect. Namely, the domestic inflation component is found to be dominant in the four largest sample countries (Poland, Hungary, the Czech Republic and Bulgaria). On the other hand, the majority of the remaining (mostly smaller) countries exhibit a mainly externally-driven inflation generating process.

This paper analyzes the domestic and external inflation determinants for eight non-eurozone NMS: Bulgaria, Croatia, the Czech Republic, Hungary, Latvia, Lithuania, Poland, and Romania. It aims to shed some light on the underexplored phenomenon of NMS inflation and contribute to "revealing" inflation either as a dominantly domestically or externally driven phenomenon in small open economies.

This study adds to the literature by several methodological and empirical contributions. First of all, it comprises a much wider set of explanatory variables than the NKPC framework of Mihailov, Rumler and Scharler (2011b). To be specific, several domestic variables (inflation expectations, output gap, M1, and the nominal effective exchange rate) and external factors (eurozone output gap, EURIBOR and Brent Crude oil price) are considered. Second, Mihailov, Rumler and Scharler (2011b) base their analysis on a static NKPC regression, inspecting the importance of domestic and external inflation determinants by mere comparison of their estimated regression coefficients. Contrary to that, this paper bases its empirical analysis on the structural vector autoregression (SVAR) model, enabling the authors to examine the temporal interdependence of the observed variables. The aggregate domestic and external inflation components are extracted through the forecast error variance decomposition. The link between each of the two components and actual inflation is examined through the historical decomposition and rolling-window correlations.

The existing studies of the inflation generating process in NMS have been criticized due to short macroeconomic time series, which poses the question of their results' robustness (Benkovskis 2008).

The robustness issue has been even more scrutinized due to exogenous shocks such as the EU accession or the recent Great Recession. It is precisely the rolling-window correlation analysis within the SVAR model which enables the researcher to investigate the possible effect of the above mentioned extreme events on the relevance of domestic/external inflation components. Additionally, it enables the researcher to analyze whether the relative importance of the two inflation components is stable in the analyzed period, or has the relationship been altered by the process of economic integration with the EU, trade openness and international competition.

Results of this analysis indicate that foreign shocks are a major factor in explaining inflation dynamics in the medium run in the majority of the analyzed NMS, while the short run inflation dynamics is mainly under the influence of domestic shocks. Moreover, the importance of the foreign inflation component in most NMS started to rise in the mid-2000s, coinciding with the time those countries joined the EU. The global financial crisis seems to have decreased the importance of the foreign inflation component, although the results vary across countries. Since foreign shocks proved to be very important in driving inflation in NMS, the main policy implication of this study is the need to augment the classical Taylor rule with foreign factors in case of small open economies.

The paper is conceptualized as follows. Section 2 offers a brief review of the prevailing inflation theories and the main inflation determinants they point to. Section 3 presents the analyzed dataset and the applied SVAR methodology, thoroughly explaining the identified structural relationships between the observed variables. Section 4 reveals the obtained empirical results. Finally, section 5 provides concluding remarks.

2. Theoretical aspects and literature review

Modern macroeconomic models almost unavoidably employ the NKPC as the workhorse model for any kind of inflation analysis. Therefore this study also starts from the following NKPC specification:

$$\pi_t = \lambda\kappa\tilde{y}_t + \beta E_t \pi_{t+1} \tag{1}$$

where π_t is the actual inflation rate, $\tilde{y}_t$ is the output gap, κ is the output elasticity to marginal cost, $E_t\pi_{t+1}$ stands for inflation expectations, while λ and β are the model parameters.[1]

The above NKPC model has often been augmented in the literature by several domestic and external variables. The following section offers an overview on the main theoretical underpinnings and the relevant empirical findings regarding the "geographical" segregation of inflation sources.

2.1. The global output gap hypothesis

The traditional approach to modeling inflation is country-centric. It postulates that the actual inflation rate is a derivative of the domestic economic conditions (excess demand/economic slack), while the external influences are modeled solely by the exchange rate or import prices (Borio and Filardo 2007). However, the empirical literature in the last decade has altered the prevailing paradigm to a globe-centric one, fully acknowledging the inflation sensitivity to global economic conditions. Borio and Filardo (2007) augment the Phillips curve by global output gap for as many as 15 industrialized countries and find strong evidence in favor of the globalization effect. This finding is not firmly corroborated by other studies. For instance, Calza (2009), inter alia, reviews the voluminous literature on this topic. The author stresses that the global output gap has mostly not been found significant for the US inflation, just as for the OECD countries (Pain et al. 2006; Ihrig et al. 2007).

[1] Technical details and the full derivation of NKPC can be found in e.g. Galí and Gertler (1999).

However, the impact of global output gap on inflation in emerging economies (particularly the CEE ones analyzed in this study) is still an underexplored phenomenon. This paper aims to fill that niche.

2.2. Exchange rate pass-through effect

The exchange rate pass-through (ERPT) is defined as the exchange rate influence on domestic inflation. The mechanism itself is rather straightforward: exchange rate appreciation directly causes the import prices to fall and export prices to rise. The final effect on the aggregate domestic price level depends on various factors. For example, Takhtamanova (2010) pinpoints four main factors determining the ERPT extent: the degree of openness of the economy, the fraction of flexible-price firms, central bank credibility, and the degree of ERPT at the microeconomic (company) level.

ERPT is particularly interesting in the case of CEE countries, like the ones analyzed in this study.[2] Namely, several authors empirically confirm that the ERPT is much stronger in the emerging economies than it is in the developed ones. For instance, Calvo (2001) finds that the ERPT effect is as much as four times stronger in emerging economies. Ca' Zorzi, Hahn and Sánchez (2007) elaborate that premise further, proving that the ERPT is more accentuated in those emerging economies which record higher inflation rates.

2.3. Oil price pass-through effect

The large impact of commodity prices on inflation was firstly recognized during the 1970s stagflation period, which seriously undermined the *Phillips curve* as the then prevailing theoretical inflation specification model. However, the addressed relationship has weakened over time.

For instance, Chen (2009) observes the oil price pass-through for 19 industrialized economies and finds that, almost without exception, the oil price-inflation link is weaker today than it was in the 1970s.

The oil price shocks are passed-through into inflation in a direct and indirect manner. The direct effect refers to a price change of refined oil products (e.g. fuel) that are regularly bought by consumers. The indirect impact is inherent through a change in production costs due to an oil price shock. Álvarez et al. (2011) add another dimension to the pass-through process: a second-round effect characterized by a shift in inflation expectations, which ultimately feeds into actual inflation developments. The above authors analyze all three effects for the euro area and Spain. They find that the direct impact has gained significance over the last decade due to the rising demand for refined oil products. On the other hand, the indirect and second-round effects have diminished.

Post-transition economies are much more energy intensive than the developed ones. To corroborate this claim, Stavrev (2006) and Égert (2011) analyze the CPI weight of energy consumption and find that the NMS consume 40 to 100 percent more energy than the core EU member states. This finding is in line with Petrović, Mladenović and Nojković (2011), who find that the transition process in European countries has altered in a way that the demand shocks lose their significance, while the supply shocks such as the oil prices begin to dominate. With that in mind, it would be expected that the commodity price shocks have a strong impact on inflation dynamics in NMS. This firmly substantiates the necessity of including oil price shocks in the inflation specification model for the countries analyzed in this study.

2.4. Inflation as a monetary phenomenon

One of the pivotal monetary models of inflation is the “excess money” model (Juselius 1992), establishing the aggregate money demand relation. To be specific, Juselius (1992) finds a stationary cointegration relationship between real money holdings, aggregate domestic demand, Danish bond rate, and Danish deposit rate. Her empirical findings point out to a small, but significant effect of excess money on Danish inflation. She also considers several external inflation determinants (German

[2] For instance, see Tica and Posedel (2009) for a nonlinear examination of the ERPT in Croatia.

inflation and German 3-month Treasury bill interest rate), finding strong evidence of their dominance in comparison to any domestic factor.

In the context of NMS economies, it is worthwhile mentioning the study of Vizek and Broz (2007), who apply an analogous model for Croatia and find that excess money significantly feeds into inflation. Again, its relative importance in comparison to supply side factors and exchange rate is rather weak.

Apart from the "excess money" model, one should certainly consult the "P-star" when modelling the monetary determinants of inflation. The P-star model (Hallman et al. 1991) defines the price gap (the difference between the equilibrium and actual price level) as a function of real money holdings, money velocity and equilibrium output.[3]

3. Data and methodology

This section covers the dataset description, as well as the main methodological specificities.

3.1. Data

The dataset analyzed in this paper comprises the following variables for each of the eight NMS: yearly HICP inflation rate, π_t; four domestic inflation determinants (output gap, $\tilde{y}_t$; inflation expectations based on consumer surveys, π_t^e, $M1$ monetary aggregate in natural logarithms, M_t; and the nominal effective exchange rate (17 trading partners)[4], E_t); and three external inflation determinants (the eurozone output gap, $\tilde{y}_t^*$; crude oil spot price in dollars per barrel, oil_t; and the eurozone 3-month money market interest rate, i_t^*). All the observed variables are of monthly frequencies, spanning from 2001M05 to 2013M06, subject to data availability (for details see appendix 1). All variables are seasonally adjusted using TRAMO/SEATS method. The data sources and descriptive statistics for all the observed variables are also given in appendix 1.

3.1.1. Output gap calculation

Output gaps for both the eurozone and NMS have been calculated using GDP data. However, GDP for all analyzed countries is available only on the quarterly basis. To deal with this issue, GDP data has been interpolated, based on a state-space algorithm with the Kalman smoothing procedure. Industrial production (ind) and retail (ret) have been used as regressors.

In order to calculate the output gaps, the Baxter-King (BK) filter (Baxter and King 1999) was employed on the interpolated GDP.[5] Therefore, in measuring the output gap, all fluctuations higher than six and lower than 96 months were eliminated. The original BK filter has missing data at the beginning and the end of the sample. To deal with this problem, the missing data was backcasted and forecasted with an AR(12) model, as proposed by Stock and Watson (1999).

[3] There is a voluminous body of literature on the P-star model. The reader may consult e.g. Belke and Polleit (2006), Ozdemir and Saygili (2009) or Czudaj (2011) or for empirical verifications of the model.
[4] Nominal effective exchange rate is obtained as a weighted geometric average of the bilateral exchange rates against the currencies of 17 competing countries.
[5] Besides the Baxter-King, the Hodrick-Prescott (HP) filter was also used for robustness check. However, qualitatively, the results are very similar. The only difference is that the HP filter-based output gap is more volatile, so results are not as smooth as with the BK filter. To conserve space, only the results estimated with the BK filter are presented in the paper. However, the results with the HP filter are available upon request.

3.1.2. Extracting inflation expectations

Consumer surveys (CS) represent qualitative examinations of consumers' views on the relevant micro- and macroeconomic variables. The CS question of particular interest here is the one targeting consumers' expectations regarding inflation dynamics in the following year.

Q6 By comparison with the past 12 months, how do you expect that consumer prices will develop in the next 12 months? They will …

> *a) increase more rapidly, b) increase at the same rate, c) increase at a slower rate, d) stay about the same, e) fall, f) don't know.*

Let a, b, c, d, and e be the fractions of respondents declaring that prices in the following year will increase more rapidly, increase at the same rate, stay about the same, increase at a slower rate, and fall, respectively. Having these data at hand, the researchers have several alternative routines for obtaining numerical indicators of the expected inflation.

The most commonly used quantification method is established by Carlson and Parkin (CP) (1975), who assume that a, b, c, d, and e can be represented by the corresponding areas under the standardized normal density curve. Another viable route would be to employ the Pesaran (1987) and Smith and McAleer (1995) approach, which does not model expected inflation as a function of consumers' subjective probability distribution. On the contrary, it sees inflation expectations as a function of a specific nonlinear regression model. Nardo (2003) highlights several major pitfalls of both mentioned procedures, so this paper chooses a less restrictive route and follows an approach introduced by Theil (1952) and Batchelor (1986). They extract the difference between the fraction of consumers who expect growing prices ($U_t = a_t + b_t + c_t$) and the percentage of those anticipating a price decline ($D_t = e_t$). Batchelor (1986) additionally scales the stated difference in order to obtain inflation expectations.

$$E_t \pi_{t+12} = \theta \left(U_t - D_t \right), \tag{2}$$

where θ is the scaling factor obtained by assuming the long-term unbiasedness of expectations.

$$\sum_t E_t \pi_{t+12} = \sum_t \pi_t \ , \tag{3}$$

where π_t is the actual inflation rate in time t. Thus the final expression for the economy-wide inflation expectations is given by:

$$E_t \pi_{t+12} = \frac{\sum_t \pi_t}{\sum_t \left(U_t - D_t \right)} \left(U_t - D_t \right). \tag{4}$$

Since CS questions are conceptualized to reflect consumers' economic attitudes at the 12 months' time horizon (see Q6), π_t is also analyzed as the year-on-year rate of change.

3.2. Methodology

In order to measure the importance of foreign and domestic shocks to inflation, a structural vector autoregression (SVAR) model with long run restrictions was applied. Firstly, the following reduced VAR model was estimated:

$$Y_t = \varphi_0 + \sum_{i=1}^{p} \varphi_i Y_{t-i} + e_t \tag{5}$$

where φ_0 is a vector of constants, $\varphi_1, \varphi_2, \dots, \varphi_p$ are the estimated matrices of coefficients, e_t is a vector of iid error terms, and Y_t is a vector of variables, which in this specific case comprises the following variables in this order:

$$Y_t = [oil_t, \tilde{y}_t^*, i_t^*, \tilde{y}_t, E_t, M_t, \pi_t^e, \pi_t]' \tag{6}$$

where oil_t are oil prices, $\tilde{y}_t^*$ is the eurozone output gap, i_t^* is the eurozone interest rate, $\tilde{y}_t$ is the domestic output gap, E_t is the nominal effective exchange rate, M_t is the M1 monetary aggregate, π_t^e is the survey-based expected inflation and π_t is the actual inflation. The justification for all the included variables is given in section 2. The SVAR model was estimated using long run restrictions such as in Blanchard and Quah (1989). However, most authors define only aggregate shocks in small scale SVAR models with two or three variables (Blanchard and Quah 1989, Clarida and Galí 1994, Galí 1999). Contrary to this approach, De Vita and Kyaw (2008) and Ying and Kim (2001) use larger VAR systems to identify foreign and domestic determinants of capital flows. Building on these assumptions, one can represent inflation as a function of a larger number of shocks, which can be written as:

$$\pi_t = f(\varepsilon_{s,t}^*, \varepsilon_{d,t}^*, \varepsilon_{m,t}^*, DOMESTIC_t) \tag{7}$$

where the first three variables represent the foreign supply, demand and monetary shock, respectively. The last variable is a composite domestic shock represented by $DOMESTIC_t$. The structural shocks are unobservable, so additional identifying assumptions are needed to uncover structural shocks from the data. Equation (8) presents the SVAR model in the matrix form along with the imposed long run restrictions to identify foreign and domestic shocks:

$$\begin{bmatrix} oil_t \\ \tilde{y}_t^* \\ i_t^* \\ \tilde{y}_t \\ E_t \\ M_t \\ \pi_t^e \\ \pi_t \end{bmatrix} = \begin{bmatrix} C_{11} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ C_{21} & C_{22} & 0 & 0 & 0 & 0 & 0 & 0 \\ C_{31} & C_{32} & C_{33} & 0 & 0 & 0 & 0 & 0 \\ C_{41} & C_{42} & C_{43} & C_{44} & 0 & 0 & 0 & 0 \\ C_{51} & C_{52} & C_{53} & C_{54} & C_{55} & 0 & 0 & 0 \\ C_{61} & C_{62} & C_{63} & C_{64} & C_{65} & C_{66} & 0 & 0 \\ C_{71} & C_{72} & C_{73} & C_{74} & C_{75} & C_{76} & C_{77} & 0 \\ C_{81} & C_{82} & C_{83} & C_{84} & C_{85} & C_{86} & C_{87} & C_{88} \end{bmatrix} \begin{bmatrix} \varepsilon_{s,t}^* \\ \varepsilon_{d,t}^* \\ \varepsilon_{m,t}^* \\ \varepsilon_t^{h1} \\ \varepsilon_t^{h2} \\ \varepsilon_t^{h3} \\ \varepsilon_t^{h4} \\ \varepsilon_t^{h5} \end{bmatrix} \tag{8}$$

Three foreign shocks in the model (supply, demand and monetary shock) are identified using the following assumptions:

1. Oil prices are determined by the supply and demand on the world market. Therefore, they are exogenous to both eurozone shocks (output gap and interest rate), as well as to all domestic shocks in the long run. Thus, $C_{12} = C_{13} = \cdots = C_{18} = 0$. This restriction identifies the supply shock.

2. Foreign variables are unaffected by domestic shocks in the long run, which is a valid assumption in the case of small open economies. This assumption implies that $C_{i4} = C_{i5} = C_{i6} = C_{i7} = C_{i8} = 0$, for $i = 2,3$. This restriction separates foreign from domestic shocks.

3. Real variables are unaffected by monetary shocks in the long run. This means that the eurozone output gap does not react to a shock in the eurozone nominal interest rate in the long run, thus $C_{23} = 0$. This restriction identifies the foreign demand and monetary shock.

4. Since foreign shocks are well identified, all other shocks are domestic. Five remaining domestic shocks $\varepsilon_t^{h1}, \varepsilon_t^{h2}, \varepsilon_t^{h3}, \varepsilon_t^{h4}, \varepsilon_t^{h5}$ are not individually identified, but they comprise the composite

domestic shock which is a sum of all five remaining shocks. Restrictions on the domestic shocks are placed in the form of a lower triangular matrix in order to obtain a just identified system. Examples for this approach can be found in the literature, e.g. Galí (1999) or Francis and Ramey (2005).[6]

Given that the foreign shocks have been identified, while the domestic shocks have not, the analysis is conducted on composite foreign and domestic shocks. Specifically, inflation can be written as a sum of all eight shocks:

$$\pi_t = \varepsilon_{s,t}^* + \varepsilon_{d,t}^* + \varepsilon_{m,t}^* + \varepsilon_t^{h1} + \varepsilon_t^{h2} + \varepsilon_t^{h3} + \varepsilon_t^{h4} + \varepsilon_t^{h5} \tag{9}$$

The composite foreign shock contains the foreign supply, demand and monetary shock, while the composite domestic shock contains five remaining unidentified shocks. Inflation can therefore be written as:

$$\pi_t = FOREIGN_t + DOMESTIC_t \tag{10}$$

where $FOREIGN_t = \varepsilon_{s,t}^* + \varepsilon_{d,t}^* + \varepsilon_{m,t}^*$, and $DOMESTIC_t = \varepsilon_t^{h1} + \varepsilon_t^{h2} + \varepsilon_t^{h3} + \varepsilon_t^{h4} + \varepsilon_t^{h5}$.

Two separate models have been estimated for each analyzed country: DVAR as the benchmark model and LVAR for the purpose of robustness check. In the DVAR models all $I(1)$ variables were differenced to satisfy the stationarity condition. Since macroeconomic time series in CEE countries of interest are rather volatile (see appendix 2 for graphical presentations of all the analyzed variables), it is often very hard to detect the true order of integration. In order to tackle this issue, four different unit root tests have been applied to determine the degree of integration of each variable: the Augmented Dickey-Fuller (ADF) test, Kwiatkowski-Phillips-Schimdt-Shin (KPSS), Phillips-Perron (PP) test and the Ng-Perron (NP) test. The obtained results are summarized in Table 1.
However, the LVAR models have been estimated with all the variables in levels. This model serves as a robustness check and as an indicator of the DVAR's appropriateness. The number of lags in each VAR was chosen according to the Akaike information criterion.[7]

The importance of foreign and domestic shocks is analyzed by the forecast error variance decomposition and historical decomposition of foreign and domestic shocks.[8] Forecast error variance decomposition shows the relative importance of each shock in the model. Historical decomposition presents similar information, but in a different manner. It reveals the dynamics of inflation in absence of all the shocks but one. Therefore, historical decomposition reproduces the time series of inflation, which is only under the influence of foreign shocks, while the domestic ones are abstracted and vice versa.

4. Results

The ADF test is conducted utilizing the Dolado, Jenkinson and Sosvilla-Rivero (1990) general-to-specific approach, as well as the KPSS and Phillips-Perron tests. The results are summarized in Table 1. Since the obtained results obviously differ to some extent, the following estimation strategy was pursued: a prevailing conclusion for each analyzed variable was drawn. E.g., if three out of four tests indicated that the series is $I(1)$, it was treated as such (i.e., it was differenced in the DVAR analysis). If there was a tie (two $I(0)$ vs. two $I(1)$ decisions), the analyzed variable was also differenced in order not to obtain spurious results.

[6] In both papers authors estimate the augmented SVAR which only identifies a technology shock. All other shocks are assumed to be non-technology shocks, which are not explicitly identified.
[7] After estimating the reduced VAR, multivariate portmanteau (Q) autocorrelation test for 12 lags was applied. In several cases, the number of lags in the VAR proposed by Akaike information criterion was insufficient to resolve the autocorrelation issues. In those cases one additional lag was included in the model, which completely resolved the autocorrelation problems.
[8] Since the direction of the relationship between variables is not of a primary interest for this study, the impulse response functions are not reported, but are available upon request.

A glimpse at Table 1 reveals that π_t^e and M_t can be treated as nonstationary for all observed countries, while $\tilde{y}_t$ is uniformly stationary**.** The remaining variables exhibit rather mixed trending properties. In some countries they are $I(0)$, while in some they are $I(1)$.[9] The analysis is continued through a structural DVAR model, where all the $I(1)$ time series are first-differenced.

4.1. Benchmark model

Figure 1 displays the forecast error variance decomposition of inflation in eight non-eurozone NMS in order to measure the relative importance of two respective components (*DOMESTIC* and *FOREIGN*) in determining the inflation variance.[10]

[9] All the analyzed variables are stationary in first differences. The obtained unit root test results for differenced data are left out here for brevity purposes but can easily be obtained from the authors upon request.
[10] The period of analysis for every individual conutry corresponds to the data availability of monetary aggregate M1 (given in Appendix 2).

Table 1. Unit root test results

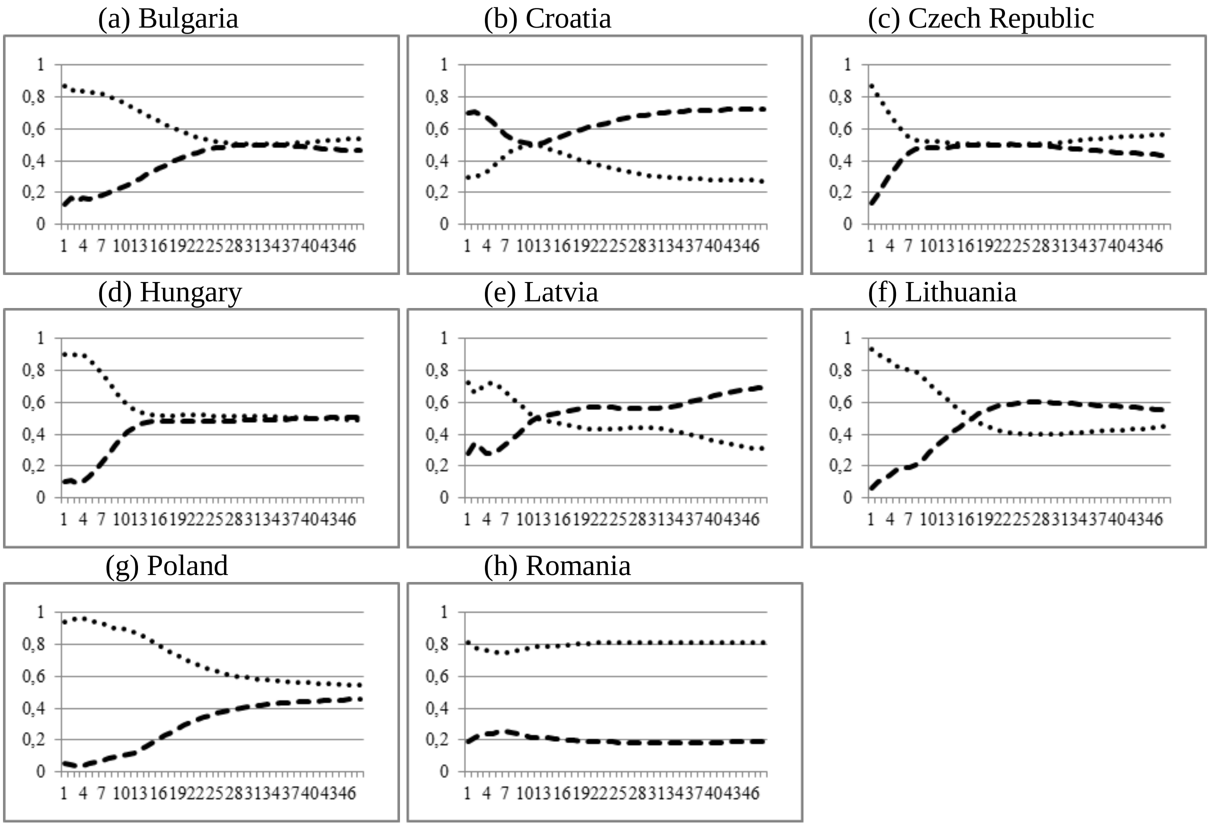
Country	π_t				π_t^e				E_t				$\tilde{y}_t$				M_t			
	ADF	**KPSS**	**PP**	**NP**	**ADF**	**KPSS**	**PP**	**NP**	**ADF**	**KPSS**	**PP**	**NP**	**ADF**	**KPSS**	**PP**	**NP**	**ADF**	**KPSS**	**PP**	**NP**
Bulgaria	1	1	1	1	0	0	1	1	1	0	1	1	0	0	0	0	1	1	1	1
Croatia	0	0	0	1	1	0	0	1	1	1	1	0	0	0	0	0	0	1	0	1
Czech Rep.	1	0	0	1	0	0	1	1	1	1	1	1	0	0	1	0	1	1	1	1
Hungary	0	0	0	1	0	0	1	1	0	0	1	1	0	0	0	1	1	1	1	1
Latvia	1	1	0	1	1	1	0	0	0	0	1	1	0	0	0	0	1	1	1	1
Lithuania	1	1	1	0	1	1	1	1	0	0	0	1	0	0	0	0	1	1	0	1
Poland	1	0	0	1	0	0	1	1	0	0	0	1	0	0	1	0	0	1	1	1
Romania	0	0	1	1	0	0	1	1	0	0	0	1	0	0	0	0	0	1	1	1

External variables	i_t^*				oil_t				$\tilde{y}_t^*$			
	ADF	**KPSS**	**PP**	**NP**	**ADF**	**KPSS**	**PP**	**NP**	**ADF**	**KPSS**	**PP**	**NP**
	1	0	1	1	0	0	1	0	0	0	0	0

Note: Table entries represent the order of integration for each variable, as indicated by each individual unit root test. Grey cells indicate variables which were first-differenced in the DVAR analysis.

It is evident that the initial share of domestic shocks in the forecast error variance is greater than the share of foreign shocks (with the exception of Croatia), but then it consistently declines across all countries except Romania. Simultaneously, the share of foreign shocks in the forecast error variance consistently rises in the analyzed countries, eventually becoming the dominant component of inflation (e.g. in Croatia, Latvia and Lithuania) or at least roughly as important as the domestic component (e.g. in Bulgaria, Czech Republic, Hungary and Poland). The only exception is, again, Romania in which the domestic component dominates both in the short and medium run.[11]

Figure 1. Variance decomposition of inflation rates in NMS – benchmark model



Note: The dotted line displays the share of component *DOMESTIC* in the variance decomposition of inflation, while the dashed line displays the share of component *FOREIGN*.

Results indicate that in the majority of NMS inflation has been significantly influenced by external factors, in some countries even more than it has reflected the situation in domestic economies of NMS. Therefore, the short run inflation dynamics is under the dominant influence of domestic shocks, but in the medium run foreign shocks significantly gain in importance.

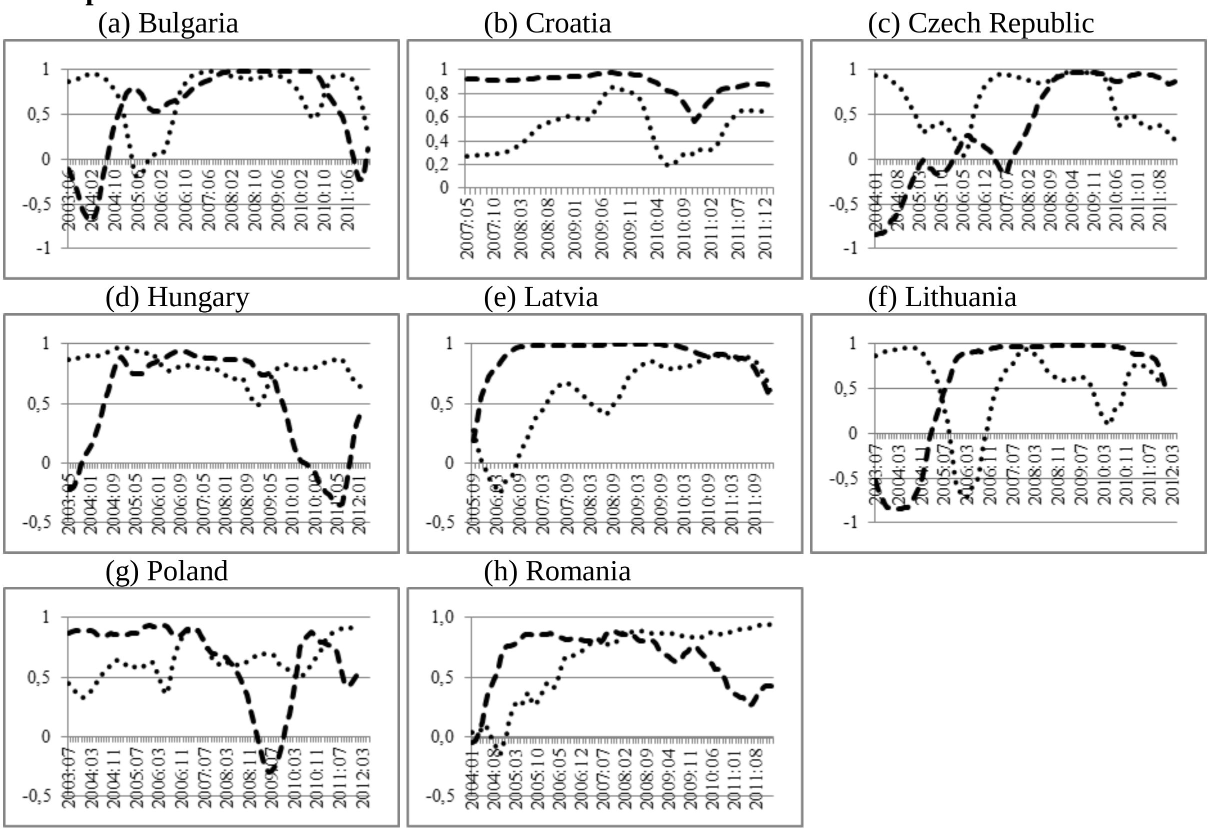
Historical decomposition was used to examine the dynamics of the relative importance of domestic and foreign shocks on inflation in NMS. Centered 3-year rolling window correlations (36 observations) have been calculated in order to gain insight into both the dynamics and importance of

[11] The possible explanation for the pronounced significance of the domestic component of inflation in Romania could be the high inflation rates at the beginning of the sample period, occurring in the aftermath of a domestically-driven hyperinflation episode. Furthermore, Mihailov, Rumler and Scharler (2011b) argue that the importance of domestic vis-à-vis foreign factors is usually more pronounced in larger economies in the sample due to the so-called size effects, which seems to be the case here. The domestic component seems to be the most pronounced in two largest countries – Poland and Romania, while it is the least important in three smallest economies – Latvia, Lithuania and Croatia.

domestic and foreign components of inflation. It has been calculated for *FOREIGN* and π_t, as well as for *DOMESTIC* and π_t.

Figure 2 reveals an upward trend in the correlation of *FOREIGN* and observed inflation rates throughout most of the last decade. The rising trend started in mid-2000s and reached a peak on the eve and during the financial crisis when it caught up with or exceeded the correlation of *DOMESTIC* in all the countries. The start of the noticeable increase in correlations between *FOREIGN* and inflation rates in most countries preceded or even quite accurately coincided with the time of their accession to the European Union[12], reflecting the rising levels of integration of NMS with core EU and eurozone countries. However, the increase in the impact of external factors on inflation has not been the same across all countries. For instance, the correlation increase in Poland has not been as strong as in Bulgaria, Latvia and Lithuania, likely reflecting the differences in levels of economic and trade openness of the respective countries.

Figure 2. Rolling window correlation between inflation rates and components from the historical decomposition – benchmark model



Note: The dotted line displays the correlations between the inflation rate and component *DOMESTIC*, while the dashed line displays the correlations between the inflation rate and component *FOREIGN*.

The rising levels of importance of the foreign inflation component suggest that the considerable increase in pre-crisis inflation rates amongst NMS happened primarily due to external factors, on which local governments had little or no impact. This fact, in combination with the previous evidence on greater importance of foreign components of inflation imposes serious concerns for proper monetary policy rules. Most central banks follow some sort of the Taylor rule (Taylor 1993).

[12] Namely, the rise in correlations coincides with the May 2004 EU accession for Latvia, Lithuania, Hungary, Czech Republic, while it precedes the January 2007 accession for Bulgaria and Romania. In these two countries the rise in the significance of foreign factors began jointly with the 2004 accession countries. Croatia joined the EU in July 2013, the period which has not been covered by the data.

Typically, the Taylor rule sets the optimal interest rate as a function of inflation, real interest rate and the output gap. For example, Galí (2009) proposes the following Taylor rule for the open economy:

$$i_t = r_t^n + \varphi_\pi \pi_{h,t} + \varphi_y \tilde{y}_t \tag{11}$$

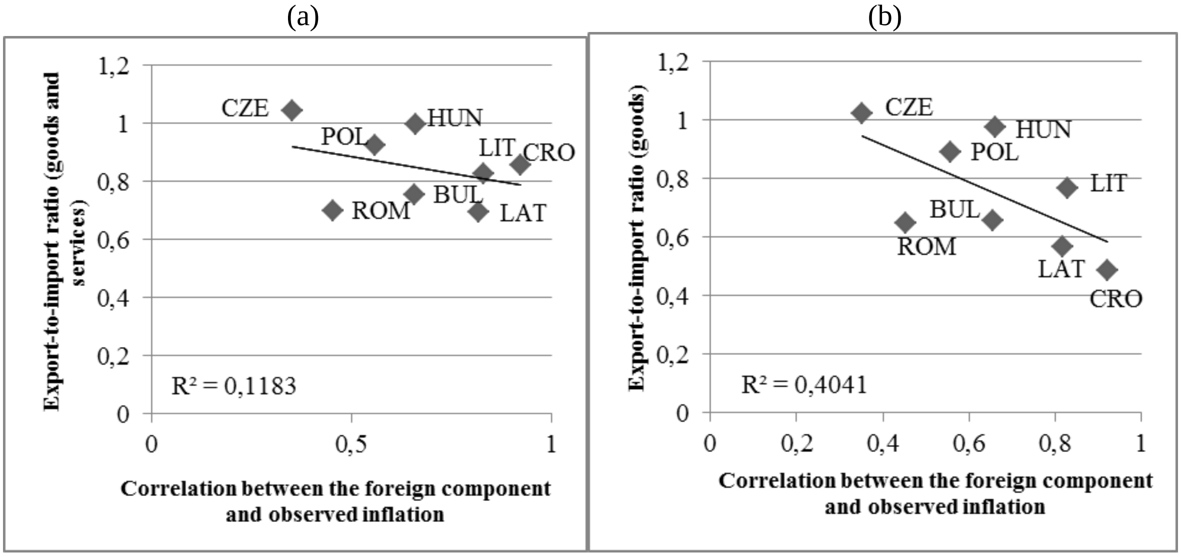
where r_t^n is the equilibrium real interest rate, $\pi_{h,t}$ is domestic inflation and $\tilde{y}_t$ represents the output gap. Following the Taylor rule, φ_π and φ_y are non-negative coefficients. Full stabilization of domestic prices requires the following condition:

$$\tilde{y}_t = \pi_{h,t} = 0. \tag{12}$$

However, this rule stabilizes domestic prices, such as the GDP deflator. For open economies, imported prices are also important; therefore HICP would be a more reasonable policy target. The findings of greater importance of foreign in comparison to domestic shocks suggest that in case of small open economies the Taylor rule should be augmented by foreign determinants of domestic inflation. In the model in this study, all the three foreign shocks (supply, demand and nominal) proved to be important in explaining domestic inflation.

The foreign component's significance seems to be correlated to the import orientation of the country (measured by the export-to-import ratio). Figure 3 reveals that inflation has on average been less influenced by foreign factors in countries that had been least import-oriented prior to the crisis, e.g. Czech Republic, Poland and Hungary. The link between the two variables increases significantly if the export-to-import ratio is limited only to goods, i.e. if services are excluded.

Figure 3. Correlation between the foreign component and observed inflation vs. export-to-import ratio



Note: The vertical axis displays the average export-to-import ratio in the 2006-2008 period for goods and services (Panel a) and goods only (Panel b). The horizontal axis displays the correlation coefficient between the foreign component and actual inflation for the entire period of the analysis (both panels).

It is interesting to note that the correlation of the foreign inflation component decreased during the 2009 – 2011 period in all countries. This likely reflects the rapid drop in imports prompted by the global financial crisis, thus limiting the external influence on domestic inflation. However, the intensity of the decrease has not been homogeneous across countries. In some countries, e.g. in the Czech Republic, the correlation decreased only slightly before it quickly returned to the pre-crisis levels, while in the others, e.g. in Bulgaria and Romania, the decrease was more intensive and permanent.[13] The behavior of inflation components could also be linked to domestic policy decisions. For instance, in Poland, the decrease in the significance of the foreign component coincided with the onset of the global financial crisis, to which the Polish authorities responded with a fiscal and monetary expansion, accompanied by the 15 percent depreciation of the domestic currency (zloty). This shifted the demand away from imports towards domestic products (Blanchard, Amighini and Giavazzi 2010).

4.2. Robustness checks

In order to test the robustness of results obtained by the benchmark model, LVAR models have been estimated. There is an obvious need for such robustness check for at least two reasons. First, the results in the literature often differ depending on the use of DVAR or LVAR.[14] However, Fernald (2007) argues that both models should yield the same results. Opposite results occur in the presence of structural breaks in the data, which generate false low frequency correlations. The second reason for the use of LVAR is purely statistical. As was already mentioned, some variables in the DVAR model were differenced although the unit root test results were not entirely conclusive.[15] To check whether this approach is reasonable, LVAR has been estimated. If both DVAR and LVAR yield similar results, then the obtained inferences are robust across specifications, meaning that applying first differences in several disputable cases was reasonable.

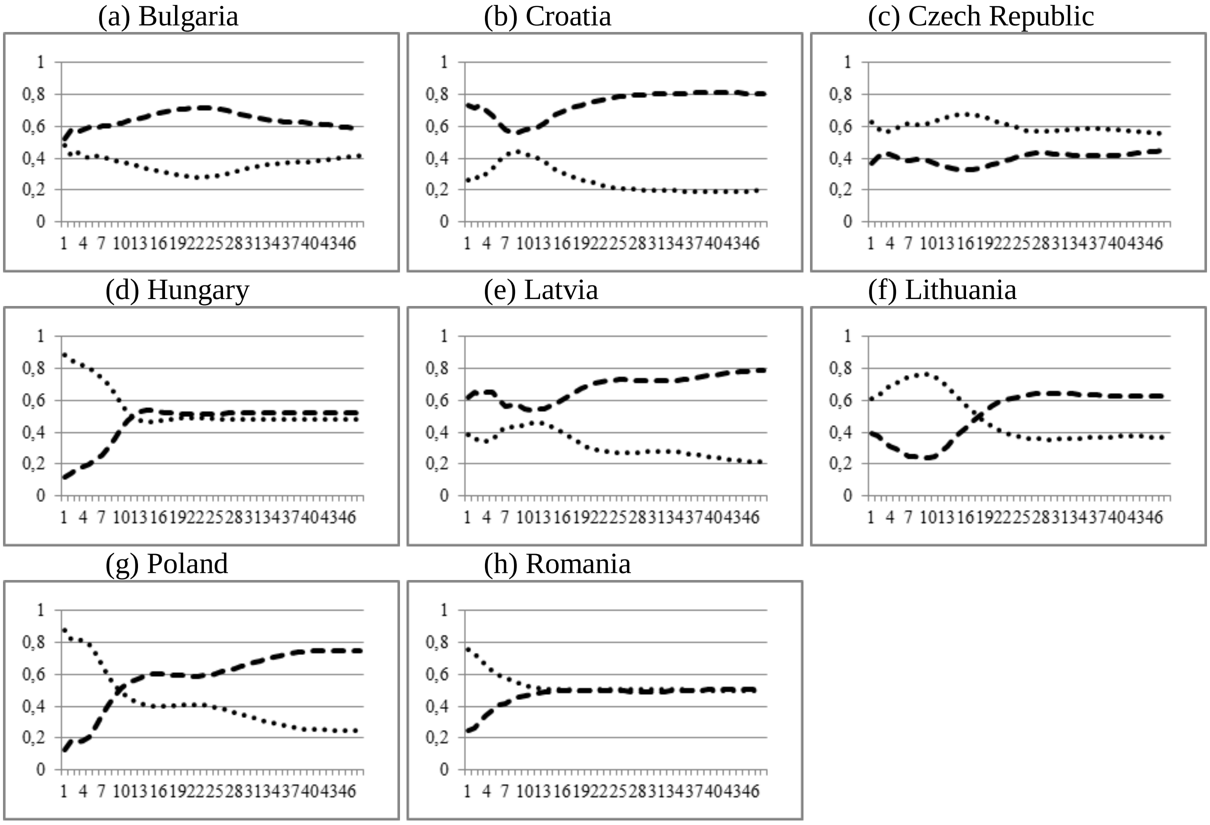
Figure 4 displays the variance decomposition of inflation in the analyzed countries. It is evident that the two components of inflation behave rather similarly to those from the benchmark model. The significance of the foreign component rises over time, while the significance of the domestic component decreases. In the end, *FOREIGN* is more important, or at least roughly as important as *DOMESTIC* in all NMS, even in Romania. However, an obvious difference between the two models is that LVAR points out to even greater importance of the foreign component. For example, DVAR estimates that the foreign component explains on average around 50 percent of variation in inflation four years after the shock. On the other hand, in LVAR, the foreign component on average explains around 63 percent of variation in inflation four years after the shock. Nevertheless, those differences are not resounding and the conclusions do not significantly change regardless of SVAR specification.

[13] This can be linked to the study of Hammermann (2007), who finds that the most important contributor to the Romanian inflation differential with respect to the eurozone is the share of agriculture in GDP. Namely, the agricultural sector is strongly dependent on the external factors such as the world oil price or the prevailing cost of borrowing money.

[14] For example, one could consult papers by Francis and Ramey (2005) who use DVAR, and Christiano et al. (2003) who use LVAR on the same topic and same data, but get opposite results.

[15] For three π_t series, six π_t^e, two E_t and one M_t series, the results were ambiguous: two unit root tests indicated that the variables of interest are stationary, while two tests contradicted that.

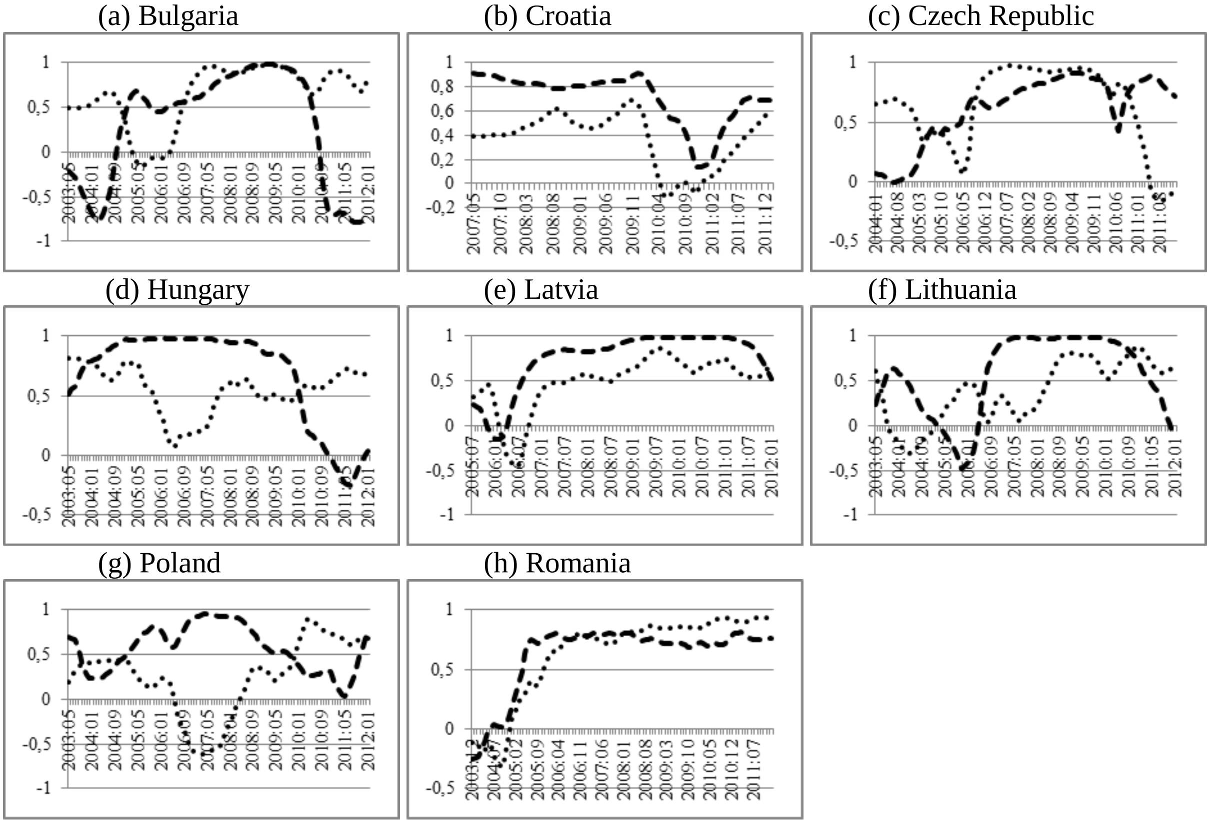
Figure 4. Variance decomposition of inflation rates in NMS – LVAR model



Note: The dotted line displays the share of component *DOMESTIC* in the variance decomposition of inflation, while the dashed line displays the share of component *FOREIGN*.

Figure 5 displays the rolling window correlations between the two components and inflation rates. Again, the results do not differ much from the benchmark model, except for Romania where the foreign component does not display the same amount of volatility and remains relatively stable throughout the analyzed period. The foreign components again display higher levels of correlation with the observed inflation rates than the domestic components throughout the larger part of the sample period in the majority of countries.

Figure 5. Rolling window correlation between inflation rates and components from the historical decomposition – LVAR model



Note: The dotted line displays the correlations between the inflation rate and component *DOMESTIC*, while the dashed line displays the correlations between the inflation rate and component *FOREIGN*.

5. Conclusion

This paper analyzed the importance of foreign and domestic determinants of inflation in case of the New EU Member States. The empirical and theoretical approach taken in this paper is innovative in several ways. First, it takes into account a much wider set of explanatory variables than the typical new Keynesian Phillips curve framework. Second, inflation determinants are observed in a dynamic SVAR framework. Finally, conclusions on the impact of structural changes such as the EU enlargement and global financial crisis can be drawn using historical decomposition and rolling window correlation.

The obtained results indicate that foreign shocks are either dominant or of similar importance as domestic factors in explaining inflation dynamics in the medium run for the majority of the NMS. The increasing importance of foreign shocks is clearly evident in all the NMS, and this conclusion is robust across specifications. This means that, throughout the analyzed period, inflation in NMS has been influenced severely by external factors, in some countries even more than by the situation in domestic economies. However, the short run inflation dynamics is better explained by domestic factors.

The importance of foreign shocks started to increase in mid-2000s, which coincided with the time when most of the analyzed countries joined the EU. On the other hand, the global financial crisis has had an inverse impact. It caused a significant decline in importance of foreign shocks between 2009 and 2011 in most NMS. At the same time, domestic factors became more important in explaining inflation. A possible explanation for this phenomenon is the relative openness of the analyzed countries measured by their export to import ratio. More open countries experienced a rapid growth in the foreign component of inflation after their EU accession, while less open countries recorded a more stable structure of both foreign and domestic components of inflation.

Finally, taking into account the fact that the foreign component proved to be very important in explaining inflation, it could be concluded that the classical Taylor rule for conducting monetary policy should be augmented by foreign determinants in case of small open economies, such as the NMS.

Based on these conclusions, two promising areas of further research arise. The first one concerns building an acceptable monetary policy rule for small open economies. As it is shown in this paper, foreign driving factors of inflation should also be incorporated into such a policy rule. The second fruitful area of research would be to extend the conclusions from this paper on measuring economic costs of joining EMU in the case of the analyzed NMS. Namely, since foreign factors dominantly drive domestic inflation, giving up monetary independence should not deviate much from the main goal of central banks – price stability.

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Appendix 1. Data

Country	Bulgaria	Croatia	Czech Republic	Euro area	Hungary	Latvia	Lithuania	Poland	Romania
Variable:	π_t								
min	0.5331	0.6480	-0.6547		1.8518	-4.2711	-1.7936	0.1773	1.5089
max	13.0046	7.9868	7.8432		10.8635	17.7108	12.7127	7.1012	37.0630
mean	5.2531	2.8675	2.3235		5.2120	4.9963	3.1923	2.8211	10.1383
st. dev.	2.9520	1.3868	1.8252		1.8251	4.5425	3.2454	1.4177	7.6795
Time span	2001M05 - 2013M06								
Source	Eurostat								
Variable:	π_t^e								
min	4.6506	2.2575	1.0136		7.1725	-0.4078	0.1045	1.9345	9.6304
max	9.5246	4.1617	5.3942		13.2941	6.7559	3.5924	6.8214	37.3097
mean	5.9897	3.2820	2.3061		9.1289	4.2284	2.0706	2.8682	17.1465
st. dev.	0.8607	0.3343	0.8863		1.6158	1.4842	1.1287	0.8069	7.1959
Time span	2001M05 - 2013M06	2005M05 - 2013M06	2001M05 - 2013M06		2001M05 - 2013M06	2001M05 - 2013M06	2001M05 - 2013M06	2001M05 - 2013M06	2001M05 - 2013M06
Source	European Commission, authors' calculation								
Variable:	E_t								
min	99.6996	96.2360	86.9707		80.1323	97.5381	94.8776	83.1281	80.1009
max	100.4267	103.4403	124.7937		105.6924	128.4205	100.7516	122.4494	146.9271
mean	99.9782	99.7501	106.5773		94.3849	103.4857	99.7048	100.0086	97.0217
st. dev.	0.2436	1.5140	10.4808		6.3966	8.1994	0.7801	8.1408	14.3768
Time span	2001M05 - 2013M06								
Source	Eurostat								

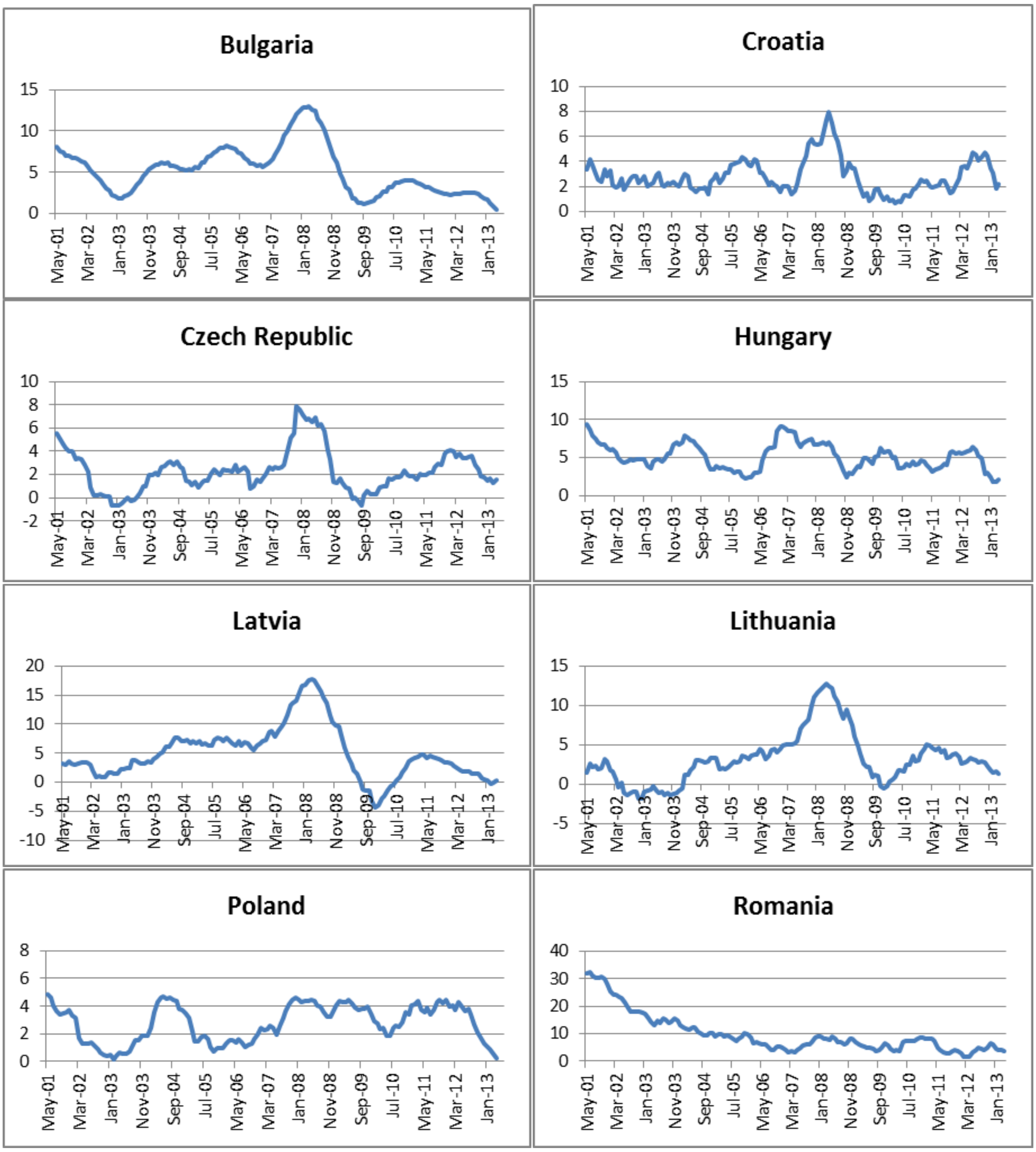
Country	Bulgaria	Croatia	Czech Republic	Euro area	Hungary	Latvia	Lithuania	Poland	Romania
Variable:	ret_t								
min	49.33174	69.96153	69.00416	94.24464	81.25486	66.28084	67.91497	62.00722	45.42162
max	118.5874	112.8867	104.9165	104.1299	113.4341	154.1188	141.6434	106.5306	123.8721
mean	88.07239	96.9303	90.32469	99.15881	101.1748	107.5462	104.121	84.25699	83.9768
st. dev.	21.73866	10.02415	11.73084	2.435811	7.523321	22.62794	18.99072	13.63176	24.88299
Time span	2001M05 - 2013M06								
Source	Eurostat								
Variable:	ind_t								
min	62.8534	83.3325	65.8849	90.2952	64.5060	75.9402	59.9562	49.7306	72.4697
max	131.3408	119.4993	117.4995	116.4309	121.6673	128.9068	129.3751	114.6011	126.4161
mean	99.7323	100.2088	93.5002	103.1395	94.3194	101.6629	95.8938	82.6995	92.3981
st. dev.	17.2579	8.3703	14.1362	5.6555	13.7299	13.4609	16.5007	19.8532	13.1876
Time span	2001M05 - 2013M06								
Source	Eurostat								
Variable:	$\tilde{y}_t$								
min	-2.6808	-2.2955	-2.8654		-3.9597	-10.4738	-9.1222	-2.2299	-3.2600
max	7.8759	5.8520	5.2897		4.1697	12.4460	10.2121	2.7698	7.7494
mean	0.1396	0.2959	0.2980		0.0453	0.0341	0.0826	-0.1308	0.1139
st. dev.	2.1462	2.0438	1.9148		1.9463	5.6506	4.4321	1.2440	2.4899
Time span	2001M05 - 2013M06								
Source	Eurostat, authors' calculation								

Country	Bulgaria	Croatia	Czech Republic	Euro area	Hungary	Latvia	Lithuania	Poland	Romania
Variable:	M_t								
min	22.3561	23.6465	27.2851		28.5862	21.1055	22.3938	25.3598	22.4023
max	23.9524	24.7537	28.5057		29.6846	22.3306	24.3154	26.9705	25.2587
mean	23.2976	24.4295	27.9714		29.2488	21.8702	23.6101	26.2864	24.3057
st. dev.	0.4889	0.2778	0.3518		0.2952	0.3286	0.5416	0.4852	0.9741
Time span	2001M05 - 2013M06	2001M05 - 2013M06	2002M01- 2013M06	2001M05 - 2013M06	2001M05 - 2013M06	2003M07- 2013M06	2001M05 - 2013M06	2001M05 - 2013M06	2001M12- 2013M06
Source	IMF's International Financial Statistics database								
Variable	$\tilde{y}_t^*$								
min				0.0750					
max				4.9750					
mean				2.3618					
st. dev.				1.3924					
Time span	2001M05 - 2013M06								
Source	Eurostat, authors' calculation								
Variable:	i_t^*								
min				0.0750					
max				4.9750					
mean				2.3618					
st. dev.				1.3876					
Time span	2001M05 - 2013M06								
Source	Eurostat								
Variable:	oil_t								
min				21.0927					
max				132.5610					
mean				64.6431					

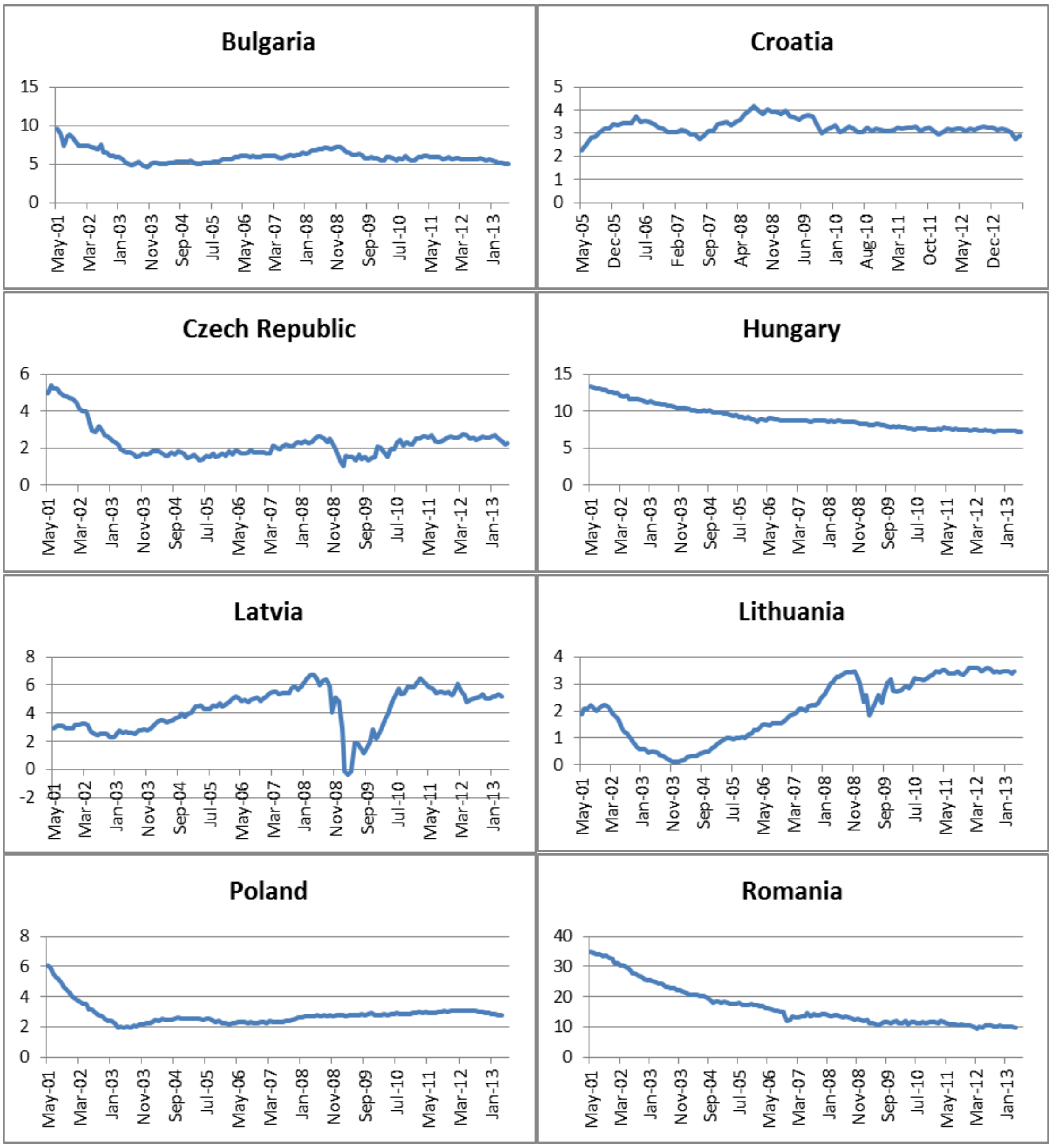
st. dev.		27.6711	
Time span	2001M05 - 2013M06		
Source	US Energy Information Administration		

Appendix 2. Graphical presentations of the analyzed variables

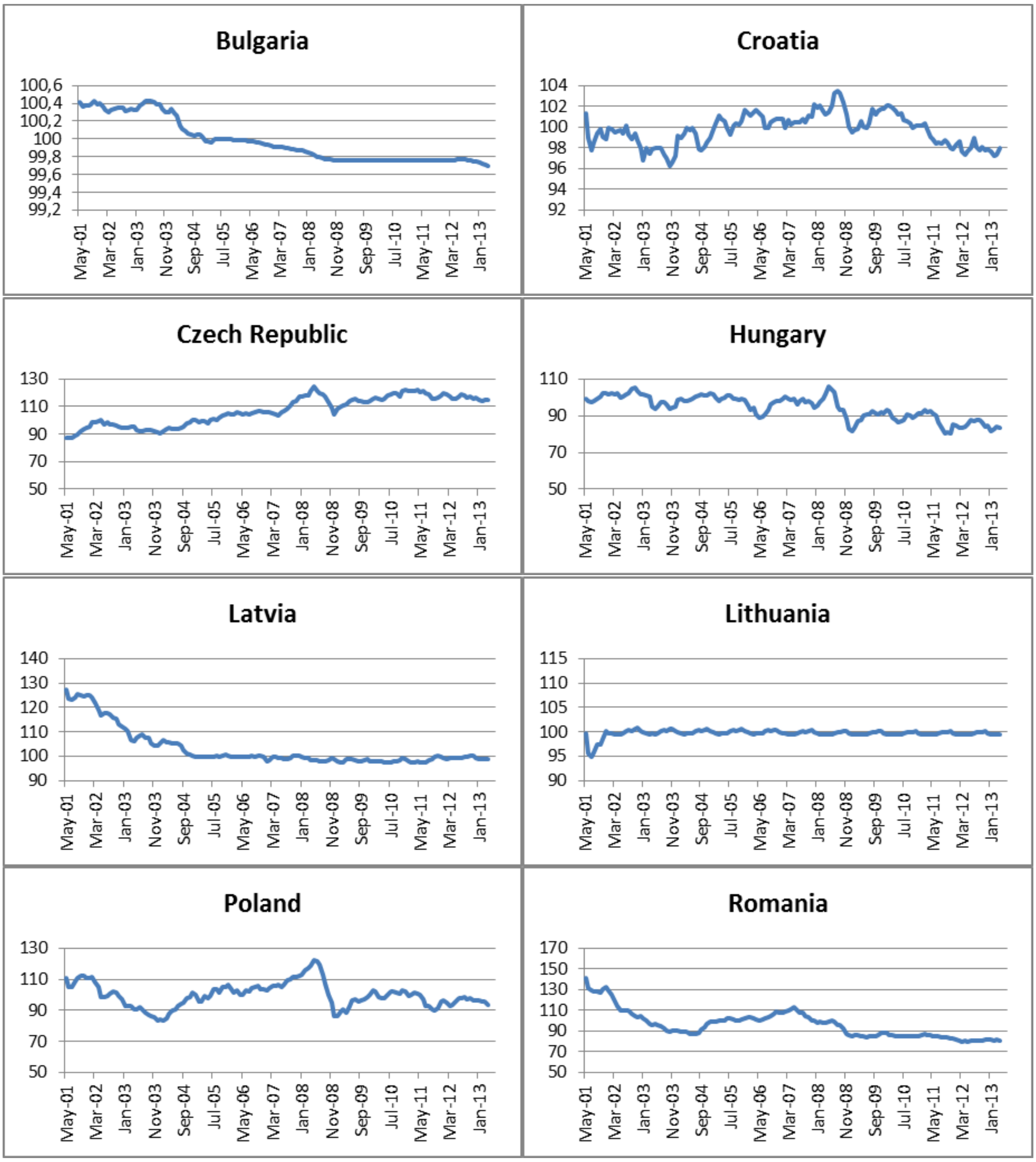
2.a inflation (π_t)



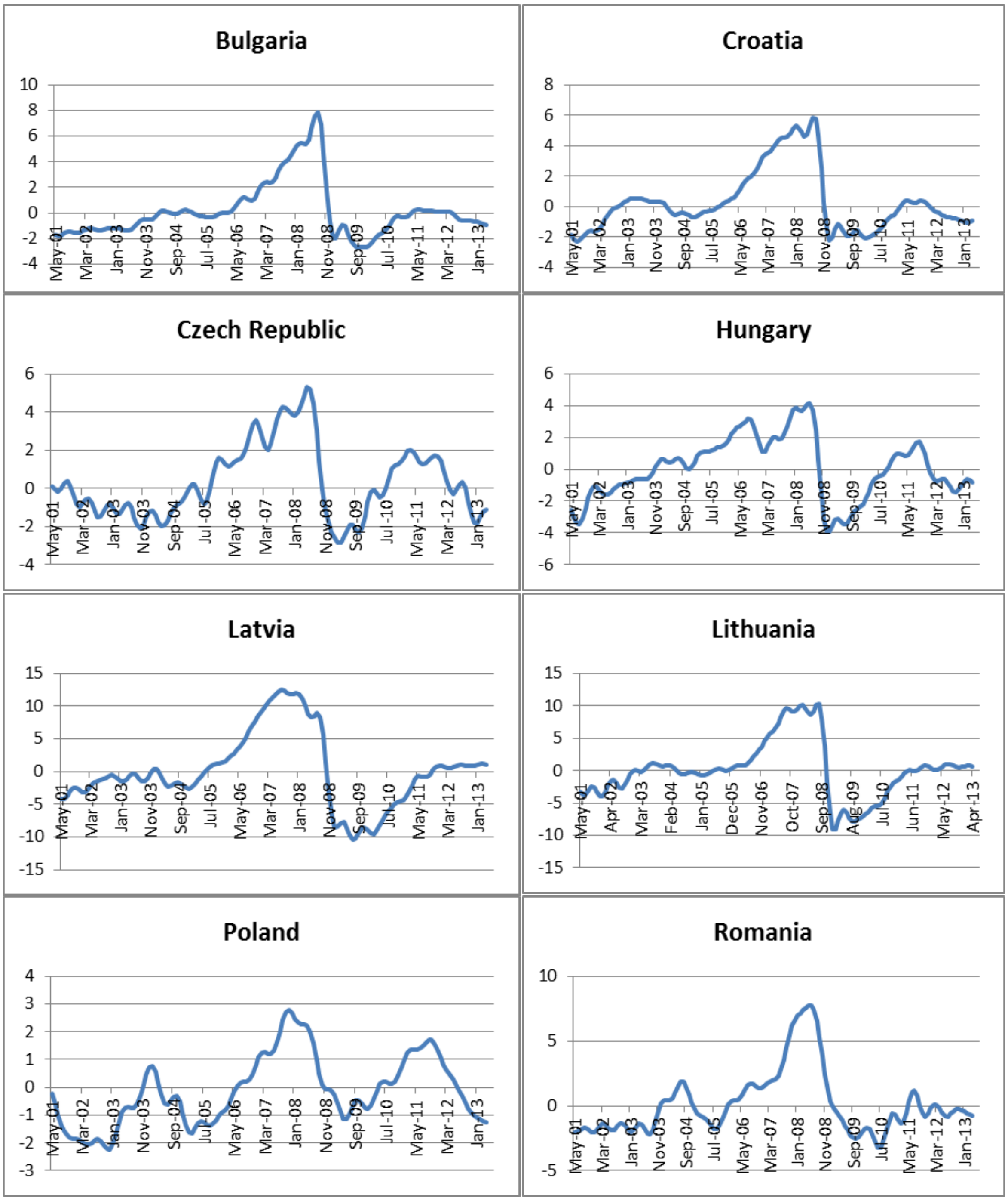
2.b Inflation expectations (π_t^e)



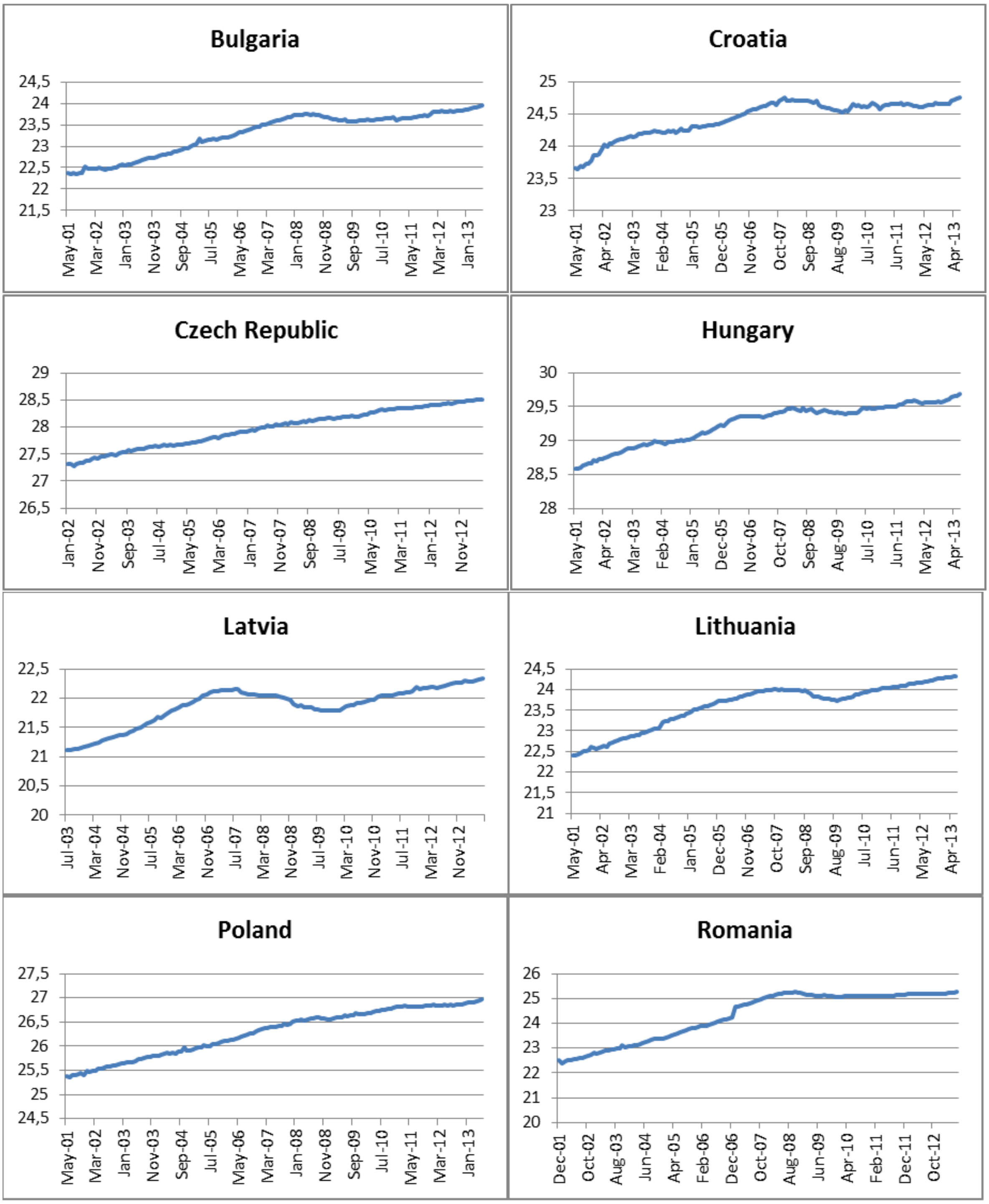
2.c. Exchange rate (E_t)



2.d. Output gap ($\tilde{y}_t$)



2.e Money supply (M_t)



2.f Foreign variables