NÁRODNÁ BANKA SLOVENSKA
EUROSYSTÉM

INFLATION DRIVERS IN NEW EU MEMBERS

MARTINA ALEXOVÁ

WORKING PAPER

6/2012

www.nbs.sk
Imricha Karvaša 1
813 25 Bratislava

research@nbs.sk

December 2012

ISSN 1337-5830

Inflation drivers in new EU members[1]

Working paper NBS

Martina Alexová[2]

Abstract

This paper focuses on the determinants of inflation for new European Union members during the period from 1996 to 2011. Detecting the drivers of inflation can be essential in designing structural reforms aimed at complementing the main objectives of monetary policy pursued in these countries. We utilize a structural vector error correction model to estimate long run relationships between inflation, mark-up and economic activity incorporating structural factors such as openness of the economy and production and analyse dynamic properties of the models. We find that half of the countries can be characterized by cost-push inflation and the rest by demand side factors. An appropriate monetary strategy to control inflation should accompany ECB monetary strategy in countries belonging to the euro area. The strategy should also maintain a credible currency peg in Lithuania, Latvia and Bulgaria and meet inflation targets in inflation targeting countries in addition with appropriate structural adjustments in labour markets and production capacity.

JEL classification: E 31, C 22
Key words: inflation, long run structural VARs, subset VEC model, mark-up, output gap, deficit, and commodity prices

[1] We are grateful to the participants of the research seminar of the National bank of Slovakia for their comments. Improvements to an early version of the paper were made thanks to the valuable comments of two anonymous referees.

[2] Research Department of the NBS, martina.alexova@nbs.sk.

1. INTRODUCTION

Inflation has been one of the main issues in economic transition in ten countries from Central and Eastern Europe (CEE) over the past 20 years. High inflation can have a negative impact not only on the welfare of households and businesses but also on the international competitiveness of a country and its output and employment[3]. Detecting what drives inflation and what are the interactions and transmission process between the macroeconomic variables and prices can be essential in designing structural reforms to complement the main objectives of monetary policy pursued in these countries. An analysis of the determinants of inflation can elucidate country-specific sources of inflation and highlight countries where cost-push factors play a dominant role and where inflation is driven by excessive demand.

CEE countries experienced turbulent development during their transition. Inflation rates were high in the early 90s and volatile in almost all CEE countries. By the mid-90s all countries' inflation rates had decreased. Cross country variability also declined due to structural reforms and stabilisation policies. Lower external demand from the EU and Russia, alongside falling oil and food prices, contributed to further decreases in inflation rates by the end of the 90s (Nath and Tochkov, 2011). Bulgaria and Romania were an exception from this development due to their sluggishness in implementing structural reforms. As a result their inflation rates remained high during the late 90s. Bulgaria introduced a currency board after a financial and banking crisis in 1996-1997 and decreased inflation to single digits after 2000. Romania was unable to reduce its inflation rate below 10% until 2005. After accession to the EU, average inflation rates dropped in almost all countries (expect for Baltic countries) as shown in Table 1. However, in 2008, inflation rates jumped again. This spike was fuelled by high oil and food prices, which affected all countries, as well as by a regional credit boom before the global financial crisis (Nath and Tochkov, 2011). Even though the average inflation of CEE countries is higher compared to euro area levels, there is a noticeable declining trend.

Papers studying the causes of inflation in CEE countries are scarce. Kim (2001) models the determinants of inflation in Poland using the VEC model during 1991 – 1999. He finds that Polish inflation is affected by the labour sector and also by external or foreign sectors. Golinelli and Orsi (2002) analyse inflation in the Czech Republic, Hungary and Poland during 1991 – 2000 using the VEC model. They conclude that the output gap and exchange rate had significant influence over the inflation rates during the transition process in these countries. Hammermann (2007) looks at non-monetary determinants of inflation in CEE countries (jointly) and in Romania. He concludes that employment and structural reforms have a strong influence on inflation rates. Piontkivky et al. (2001) and Catao and Terrones (2001; 2003) point out in their studies an existence of a long run relationship between inflation and deficit. Piontkivsky et al. (2001) confirms this relationship in Ukrainian data using the VEC model. They found that an increase in budget deficit of 1% leads to a 0.38% increase in inflation over the next year. Catao and Terrones (2001; 2003) use the panel data

[3] In 2004 and 2007 CEE countries joined the European Union. All new European Union member countries are bound to introduce the euro in the future. Therefore monitoring price stability is one of their key objectives.

approach and identified a strong direct relationship between inflation and budget deficit in developing countries with higher rate of inflation.

In this paper we identify country-specific long run determinants and the short run dynamics of inflation in CEE countries and thus contribute to the scarce literature on this topic, especially since 2000. We apply a model by Boschi and Girardi (2007) who identify the causes of inflation for the euro area as a whole and for the ten EU countries (prior to euro adoption during 1984-1998 when some countries were characterized by similar development as in CEE). The basic model is built around a mark-up inflation relationship in an open economy model (Banerjee and Russel, 2002) and between inflation and economic activity (Boshi and Girardi, 2007). Furthermore structural factors such as openness of the economy and production are presented in the model. We employ the structural co-integrating VAR model which allows for structural long run analysis of inflation determinants together with the analysis of its short run dynamic. We also look at each country separately; country specific factors are therefore not overlooked. Further, an alternative model explores the relationship between inflation and budget deficit (Catao and Terrones, 2001). The long run relationship is estimated as suggested when using the structural cointegration VEC model theory.

Following this introduction, the paper is divided into the following sections: section 2 describes the theoretical framework for the long run relationship of inflation and its econometric modelling; Section 3 describes data and the construction of variables; section 4 includes the model's specifications and variables; Section 5 shows the estimates of long run relationships of the basic model and section 6 assesses inflation development and its short run dynamics. Section 7 presents the alternative models (in comparison with the basic one) with their long run relationships and short run structures. Section 8 concludes.

Table 1 – Rates of inflation in CEE countries: 1997-2011 (average annual percentage changes in CPI)

	SK	CZ	HU	PL	SI	EE	LV	LT	BG	RO	average
1997	6.0	8.0	18.5	15.0	8.3		10.3	8.1			
1998	6.7	9.7	14.2	11.8	7.9	8.8	5.4	4.3	18.7	59.1	
1999	10.4	1.8	10.0	7.2	6.1	3.1	1.5	2.1	2.6	45.8	9.1
2000	12.2	3.9	10.0	10.1	8.9	3.9	1.1	2.6	10.3	45.7	10.9
2001	7.2	4.5	9.1	5.3	8.6	5.6	1.6	2.5	7.4	34.5	8.6
2002	3.5	1.4	5.2	1.9	7.5	3.6	0.3	2.0	5.8	22.5	5.4
2003	8.4	-0.1	4.7	0.7	5.7	1.4	-1.1	2.9	2.3	15.3	4.0
2004	7.5	2.6	6.8	3.6	3.7	3.0	1.2	6.2	6.1	11.9	5.3
2005	2.8	1.6	3.5	2.2	2.5	4.1	2.7	6.9	6.0	9.1	4.1
2006	4.3	2.1	4.0	1.3	2.5	4.4	3.8	6.6	7.4	6.6	4.3
2007	1.9	3.0	7.9	2.6	3.8	6.7	5.8	10.1	7.6	4.9	5.4
2008	3.9	6.3	6.0	4.2	5.5	10.6	11.1	15.3	12.0	7.9	8.3
2009	0.9	0.6	4.0	4.0	0.9	0.2	4.2	3.3	2.5	5.6	2.6
2010	0.7	1.2	4.7	2.7	2.1	2.7	1.2	-1.2	3.0	6.1	2.3
2011	4.1	2.1	3.9	3.9	2.1	5.1	4.1	4.2	3.4	5.8	3.9
Average	5.4	3.2	7.5	5.1	5.1	4.2	3.5	5.1	6.8	20.1	
Average (post-accession period)	2.7	2.4	4.9	3.0	2.8	4.8	4.7	6.5	5.2	6.4	

Source: Eurostat and authors calculations. SK, CZ, HU, PL, SI, EE, LV, LT became EU members in 2004, BG and RO in 2007.

2. ECONOMIC RELATIONSHIPS AND MODELLING FRAMEWORK

THEORETICAL FRAMEWORK

In this paper we estimate the underlying causes of cost-push, excess demand and imported inflation. Demand-pull inflation or excess demand inflation occurs when the labour force of a country is near full-employment and the demand for goods and services in the economy exceeds the available supply which results in a rise in prices. Exchange rate depreciation leading to a reduction of export prices and an increase in import prices may also cause an increase in the level of aggregate demand. In cost-push inflation an increase in inflation is caused by an increase in the cost of production which could be the result of corporate taxes, rising cost of imports or rising wages. Imported inflation is caused by a fall in local currency against other world currencies and by an increase in the price of imports or foreign price increases. Due to an increase in import prices, the prices of domestic goods (manufactured using imported raw materials) also increase leading to an increase in the general prices of all goods and services.

We follow Boschi and Girardi (2007) who formulate a model with two dynamic steady-state relationships based on the causes of inflation. Their model is an extended version of Banejree et al. (2001) and Banerjee and Russsel (2002). The model is based on four economic relationships for mark-up (1), real wages (2), Phillips curve (3) and Okun's law (4)[4]. The authors incorporate a linear trend in order to capture the possible effects of taxation, unemployment benefits, and tax rates and other costs. Inflation is also present in the mark-up equation since it represents costs to firms in the long run due to difficulties of costs settings in an inflationary environment.

The starting point of Boschi and Girardi (2007) analysis consists of the following system of equations:

$$p_t - wage_t = -\omega_t OG_t - \omega_2 o_t - \omega_3 \Delta p_t - \omega_4 t \qquad (1)$$

$$wage_t - p_t = \gamma_1 U_t + \gamma_2 o_t + \gamma_3 t \qquad (2)$$

$$\Delta p_t = -\delta U_t \qquad (3)$$

$$U_t = -\psi OG_t \qquad (4)$$

where p_t is the logarithm of the price level, $wage_t$ the logarithm of nominal wages, OG_t an output gap measure, o_t the logarithm of productivity and U_t the unemployment rate.

[4] Exact model is borrowed from Boshi and Girardi (2007) and its full derivation is presented their paper.

COST PUSH INFLATION

The relationship for mark-up and inflation is obtained by substituting Okun's law equation (4) into the real wage equation (2). The left hand side of the equation defines the mark-up by prices and unit labour costs whereas the right hand side presents the relationships of inflation, productivity and possible effects of other costs on the formation of mark-up. Boschi and Girardi (2007) assume that the labour force and companies have stable income shares in the long run and therefore they restrict the coefficient for productivity to be unitary.

$$p_t - ulc_t = -\mu_1 \pi_t - \mu_0 t \qquad (5)$$

where p_t indicates the price level, π_t is the annual inflation, t is a time trend and ulc_t is the unit labour cost determined by nominal wages and productivity and μ_1 and μ_0 are non-negative parameters. When $\mu_1 = 0$, inflation does not represent a cost to firms. In an open economy this equation should also take into account import prices and their effect on mark-up. Following Boshi and Girardi (2007):

$$p_t - \delta ulc_t - (1-\delta) ip_t = -\mu_1 \pi_t - \mu_0 t \qquad (6)$$

where ip_t represents the import price level. When we substitute $ulc_t - p_t$ by logarithm of labour income share, w_t, and $ip_t - p_t$ by a competitiveness index, ci_t, measured by real exchange rate, and letting $\beta_0 = (1-\delta)/\delta$, $\beta_1 = \mu_1/\delta$ and $\alpha_0 = \mu_0/\delta$ we get:

$$-w_t - \beta_0 ci_t = -\beta_1 \pi_t - \alpha_0 t \qquad (7)$$

In the long run the residual of this relationship is supposed to be stationary, therefore:

$$-w_t - \beta_0 ci_t + \beta_1 \pi_t + \alpha_0 t = \varepsilon_{mr,t} \qquad (8)$$

DEMAND INFLATION

Demand inflation is formulated through the relationship between price changes and a cyclical indicator. The relationships obtained from the Philips curve (3) and Okun's law (4) in Boschi and Girardi (2007) are as follows:

$$\pi_t = \beta_2 OG_t \qquad (9)$$

where β_2 is a positive parameter and OG_t denotes the output gap. As in Binder and Pesaran (1999), potential output is defined by production. Furthermore, the long run path of productivity is determined by the technological progress; therefore the trend represents a proxy of GDP and employment growth associated with technological progress.

$$\pi_t = \beta_2 o_t - \alpha_1 t \qquad (10)$$

when o_t indicates productivity, t is a trend and output measure is $o_t - \mu_3 t$ and $\alpha_1 = \beta_2 \mu_3$, then the long run condition for demand inflation is:

$$\pi_t - \beta_2 o_t + \alpha_1 t = \varepsilon_{dr,t} \quad (11)$$

ALTERNATIVE INFLATION RELATIONSHIP

Another long run relationship can exist between inflation and government deficit. Government deficit has an impact on monetary aggregates and public expectations which in turn cause movements in prices. According to Piontkivky et al. (2001) a relationship between government deficit and inflation is mutual. Deficit influences inflation through its impact on money and through expectations creates inflationary pressure. On the other hand inflation pushes up the deficit. If the deficit is financed by printing money, it will cause high inflation in the future (Sachs and Larrain, 1993). According to the fiscal theory of price level[5] fiscal policy can have a higher influence on the determination of a price level than direct monetary growth. Catao and Terrones (2001; 2003) identify a direct relationship between government deficit and inflation. They conclude that a fiscally effective government can affect nominal money demand and therefore inflation. Furthermore, Santos (1992) finds a positive direct relationship in three out of six countries within the European Union.

In order to assess this relationship, we define a long run relationship between government deficit, l_t, and inflation as:

$$\pi_t = \beta_3 l_t \quad (12)$$

so that inflation will rise as the deficit widens. In the long run we expect this relationship to be stationary.

$$\pi_t - \beta_3 l_t = \varepsilon_l \quad (13)$$

MODELLING FRAMEWORK

Our modelling framework is based on a VEC methodology. With this approach we are able to describe the long run relationship and short run dynamics between variables. We use a two-stage estimation approach. In the first stage we assess the theoretical specification of the long run equilibrium paths. We use the over-identification method which allows us to identify relationships between variables based on explained economic theory using a simple two step estimation. In the second stage we specify the dynamic structure of the model according to the statistical properties of the parameters through generalized least squares (GLS) estimation.

---

[5] See Carzoneri, Cumby and Diba (1998), Komulainen and Pirttila (2000), Piontkivky et al. (2001), Woodford (1994).

The basic structure for the VEC model is the following:

$$\Delta y_t = a + \Pi\varepsilon_{t-1} + \sum_{j=1}^{m-1}\Gamma_j.\Delta y_{t-1} + \rho d_t + u_t \tag{14}$$

where y_t is the vector of explanatory variables, ε_t is a vector of residuals of cointegration relations, a is a constant, matrix Γ_j is the matrix of autoregression coefficients, d_t is a vector for dummy variables whose parameters are in the ρ matrix and u_t is a vector of residuals distributed according to $u_t \approx N(0, \sum_u)$. Matrix Π can be rewritten as $\Pi = AC'$ with C representing the cointegration vector and A the speed of adjustment coefficients of short run dynamics to long run equilibrium paths. The exact cointegration relation C has the form:

$$\alpha t + By_t' = \varepsilon_t \tag{15}$$

Variables in the vector y_t are collected as $y_t = [w_t, ci_t, \pi_t, o_t]'$ where B collects the parameters defined in previous economic relations (demand or mark-up inflation or both) and vector α contains the slope for linear deterministic trend. This trend belongs to cointegration space.

In this case the structural relationship provides the remaining restriction in order to obtain an over-identified model. This restriction can be verified through the Likelihood ratio (LR) test.

In the model with one cointegration relationship we are testing the following constraints:

$\alpha_0 t + \begin{bmatrix} -1 & -\beta_0 & \beta_1 & 0 \end{bmatrix}' y_t = \varepsilon_{mu,t}$ for mark-up inflation

$\alpha_1 t + \begin{bmatrix} 0 & 0 & 1 & -\beta_2 \end{bmatrix}' y_t = \varepsilon_{pc,t}$ for demand inflation

In the alternative model vector y_t is presented as $y_t = [w_t, ci_t, \pi_t, o_t, l_t]'$ and the constraints take the form:

$\alpha_0 t + \begin{bmatrix} -1 & -\beta_0 & \beta_1 & 0 & 0 \end{bmatrix}' y_t = \varepsilon_{mu,t}$ for mark-up inflation

$\alpha_1 t + \begin{bmatrix} 0 & 0 & 1 & -\beta_2 & 0 \end{bmatrix}' y_t = \varepsilon_{pc,t}$ for demand inflation

$\begin{bmatrix} 0 & 0 & 1 & 0 & -\beta_3 \end{bmatrix}' y_t = \varepsilon_{l,t}$ for deficit inflation

The short run dynamics are modelled with a subset of the VEC model by sequential elimination of the regressors testing procedure (SER/TP). This method is proposed by Bruggemann and Lauthepohl (2000). It runs through the model and deletes the variables of the matrices A, Γ_j and ρ with p-values lower than a threshold. According to Boschi and Girardi (2007) significant parameters of A give useful information about the long run path movement in the economy. Clements and Hendry (1999) point out that dropping a statistically insignificant variable from the model can improve the quality of forecasts generated by the model. Furthermore, Bruggemann and Lutkepohl (2000) explain that the impulse response functions may differ from those estimated by an unrestricted model.

3. DATA SOURCES AND CONSTRUCTION OF VARIABLES

The model is estimated using quarterly data from the period 1996 – 2011 adjusted to specifications for particular countries. The data are taken from OECD Main Economic Indicators and where necessary from national sources. Additionally the European Commission, Eurostat and Ameco databases are used for constructing specific variables.

We use the following variables based on the model proposed by Boschi and Girardi (2007),: π_t is the annual inflation constructed as a growth rate of consumer price index. w_t is the logarithm of labour compensation over productivity. Productivity, o_t, is measured as a logarithm of the ratio of output over the total number of employed workers.[6]

The impact of competitiveness on foreign markets, ci_t, is measured as a logarithm of $ci_t = e_t + p_t^* - p_t$ where e_t is the nominal effective exchange rate, p_t is the domestic price level and p^*_t represents the foreign price level constructed as

$$p_t^* = \sum_{i=1}^{38} m_i * p_{it}$$

where *i* denotes the i-th country in a broad group of countries in European Commission trade database. m_i is a measure for weight of the i-th country based on the trade weight of the country to the group of countries (same weight is used to construct nominal effective exchange rate).

Additional variables supplementing the basic model is the ratio of net lending to borrowing to GDP, l_t. The commodity price index, com_t, is selected as an exogenous variable,.

4. MODEL SPECIFICATION AND DUMMY VARIABLES

A brief description of each model is presented in Table 2. The sample period 1996q1 – 2011q1 is used for Slovakia, the Czech Republic, Hungary, Poland and Slovenia. For Estonia the sample period is 1998q1 – 2011q1, for Latvia 1997q1-2011q1 and for Bulgaria and Romania it is 1998q2 – 2011q1. For Lithuania the time period for estimation is 1999q1 – 2011q1. The number of lags is selected according to AIC and LR criteria. In order to obtain

[6] Where necessary, data are seasonally adjusted.

the best fit of the model the countries' dummies are introduced. The dummy is in a form dyyq where d is the abbreviation for dummy, yy is the year and q is the quarter.

Table 2 – Model specifications

Country	Lags	Sample period		Dummy variables
SK	4	1997q2-2011q1	d993	shock to inflation
CZ	5	1997q3-2011q1		
HU	2	1996q4-2011q1		
PL	5	1997q3-2011q1	d981	shock to exchange rate
SI	5	1997q1-2011q1		
EE	3	1999q1-2011q1	d094	shock to inflation
			d981	shock to exchange rate
LV	2	1998q4-2011q1	d004	shock to labour market
			d082	shock to inflation
LT	3	2000q1-2011q1		
BG	5	1999q4-2011q1		
RO	5	1999q4-2011q1	d022	shock to labour market
			d002	
			d991	shock to inflation

Note. Sample period represents the actual period estimated by the model based on lag specification.

UNIT ROOT TESTS

In the proposed modelling structure we expect the series to be non–stationary and integrated at an order no higher than 1. Furthermore, we check for the presence of I(2) variables. As Haldrup (1998) points out, the presence of I(2) variables in VEC models might produce poor results. We employ an ADF test for unit roots on each series, both in levels and for first differences. The optimal regression lag is determined according to the SIC criterion with a maximum lag of 10.

The results are reported in Table 3.[7] Almost all variables are integrated with an order of one with the exception of ci_t for Estonia and Latvia where the null hypothesis of a unit root is rejected and for the Czech Republic, Bulgaria and Poland, where the null hypothesis is rejected at 5 % and 10% levels of significance. For π_t in Lithuania and Slovenia the null hypothesis can be rejected at 1% and 10% significance levels. For variable Δw_t in Hungary and Bulgaria, the null hypothesis is rejected at a 5 % level of significance. For the first differences of ci_t in Lithuania and Latvia and $\Delta\pi_t$ in Bulgaria the null hypothesis is rejected at a 5% level of significance. We can reject the null hypothesis of a unit root for l_t in the Czech Republic, Estonia, Bulgaria and Romania. Unit root tests suggest that for some countries the cointegration relationship between all variables might be weak or non-existent (especially regarding l_t). Furthermore some variables might be restricted to 0 in a long run relationship. Since the negative results of the unit root tests might be due to small sample bias we decide to continue with an estimation of the model.

[7] Critical values were taken from Davidson and MacKinnon (1993).

Table 3 - ADF Unit root test

	SK	CZ	HU	PL	SI	EE	LV	LT	BG	RO
Level										
w_t	-2.05	-3.19	-2.56	-3.01	-0.06	-3.56	-1.51	-2.75*	-0.71	-2.52
ci_t	-0.83	-3.73**	-2.32	-3.29*	-0.95	-4.18***	-1.88	-4.62***	-3.64**	-2.32
π_t	-1.60	-1.40	-2.59	-2.04	-3.26*	-2.17	-3.89***	-2.15	-2.32	-1.32
o_t	0.42	-2.52	-0.65	-0.92	-2.50	-0.95	-1.99	-2.75	-1.97	-1.39
l_t	-2.45	-5.30***	-0.12	-1.47	-1.43	-3.98***	-1.56	-2.21	-5.06***	-3.49**
com_t	-0.06	-0.06	-0.06	-0.06	-0.06	-0.54	-0.14	-0.14	-0.54	-0.54
First differences										
Δw_t	-7.40	-9.40	-3.17***	-8.11	-5.52	-7.76	-8.15	-6.33	-2.66**	-7.96
Δci_t	-6.42	-5.76	-7.25	-6.06	-6.40	-4.78	-3.78**	-3.84**	-4.43	-5.63
$\Delta \pi_t$	-6.14	-6.89	-4.75	-5.18	-6.00	-6.43	-4.40	-5.11	-3.76	-5.12
Δo_t	-6.10	-4.96	-5.89	-8.25	-7.41	-7.21	-4.03	-7.39	-9.95	-7.36
Δl_t	-8.02	-7.66	-3.89	-12.99	-9.62	-9.94	-10.02	-9.32	-7.59	-6.35
Δcom_t	-6.00	-6.00	-6.00	-6.00	-6.00	-6.00	-5.84	-5.84	-6.00	-6.00

Note. Critical values for the ADF unit root tests with constant and trend: 1% 4.13, 5% 3.49, 10% 3.17 and for constant without trend: 1% 3.52, 5% 2.91, 10% 2.59. Variables subject to test including trend: w_t ci_t, π_t, o_t, expect for w_t for Bulgaria, Lithuania and Romania, ci_t for Poland and π_t for , Estonia, Latvia, Lithuania and Bulgaria. Variable tested for unit root without trend: lc_t.

COINTEGRATION RANK

When we are modelling the relationship between non–stationary variables we have to test whether there is a cointegration relationship among them. By using three different tests, the trace test, the maximum eigenvalue test and Saikkonen and Lutkepohl test, the cointegration rank r is determined. The number of cointegration vectors is presented in Table 4.

It is shown that the results may differ as a result of test methodology. The Trace test is a joint test, where the null hypothesis is that the number of cointegration vectors is less than or equal to r, against a general alternative hypothesis that there is more than an r cointegration relationship. The Maximal Eigenvalue test conducts separate tests on each Eigenvalue. The null hypothesis is that there are r cointegration vectors present against the alternative that there are (r + 1) present. When we compare these two tests no major differences are detected (see Lutkepohl, Saikkonen and Trekler, 2001). The Saikkonen and Lutkepohl test is built on the Trace test, where the deterministic trend is subtracted from observation and then the trace test is applied to the adjusted series.

We followed the results by Saikkonen and Lutkepohl (S&L) test which according to Holmes et al. (2011) is superior to the trace and eigenvalue test. The S&L test implies one cointegration vector for all countries. The only exception is for the Czech Republic, where only one cointegration vector is selected.[8]

[8] The model with two cointegration relationships do not perform well therefore we decided to continue with results from Eigenvalue test.

Table 4 – Cointegration tests

Country	Trace test	Eigenvalue test	S&L test
SK	1	1	1
CZ	2	1	2
HU	2	1	1
PL	2	2	1
SI	1	1	1
EE	2	2	1
LV	1	1	1
LT	1	0	1
BG	1	2	1
RO	3	1	1

Note. The tests are performed in Eviews 7 and in JMulti 4.23. The critical values are taken from MacKinnon – Houg – Michellis (1999) for trace and eigenvalue tests and from Lutkepohl, Saikkonen and Trekler (2001) for the S&L tests.

5. SPECIFICATION OF THE LONG RUN STRUCTURE

In line with the theory summarized in the previous section we proceed with estimating the long run relationships.[9] For all countries one relationship is confirmed and selected in line with statistical theory which implies negative factor loadings for inflation equation and accept restrictions on cointegration space. Depending on which relationship is supported in a particular country, Table 5 presents results for cost–push inflation countries and Table 9 for demand side inflation countries. All models are tested by recursive Eigenvalue stability tests which do not indicate systemic instability in any of the models.[10] The model for a particular country is shown in columns with the estimated coefficients and their t–statistics. Slovakia, the Czech Republic, Hungary, Poland and Bulgaria are characterized by cost–push inflation, whereas demand side factors are more characteristics for Slovenia, Estonia, Latvia, Lithuania and Romania.

COST PUSH INFLATION COUNTRIES

The results of estimation for these countries are significant and cointegration restriction is accepted in all countries. In comparison with the proposed theory, a negative trend is present which implies that structural adjustments tend to decrease inflation. When inflation is plotted for these countries, a decreasing trend is apparent to some extent. Therefore, the sign is not surprising.

[9] As in Boschi and Girardi (2006) either one or both long run relationship can be supported by data.
[10] All recursive eigenvalues appear stable and the values of the tau statistic are considerably smaller than the critical value for 1% test. Hansen and Johansen (1999) recommend using recursive eigenvalue stability tests for VEC models.

What is more surprising is the sign of the competitiveness index, ci, for Poland and Hungary. Whereas for Hungary it is not statistically significant and close to zero, for Poland it is significantly different from zero and positive. An increase in competitiveness index causes an appreciation of exchange rate in relative terms and therefore it should decrease inflation. However, for Poland this effect seems to be the opposite. We can only conclude that ci_t is behaving very ambiguously in Poland.

Table 5 – Estimates of long run equation

		SK	CZ	PL	HU	BG
α		-0.010	-0.007	-0.012	-0.015	-0.003
		(-17.098)	(-3.797)	(-8.134)	(-11.978)	(-2.458)
B	w_t	-1	-1	-1	-1	-1
	ci_t	-0.381	-0.009	0.575	0.062	-0.980
		(-5.073)	(-0.063)	(2.553)	(0.397)	(-10.361)
	π_t	1.614	2.149	2.984	2.266	2.103
		(4.690)	(5.585)	(4.711)	(8.118)	(3.746)
	o_t	0	0	0	0	0
No. of coint. vectors		1	1	1	1	1
Over identification χ2		0.581	0.673	0.278	0.331	0.090

Note. The model for particular country is in columns. The cointegration relationship as stated in equation 4 is in the first column. The numbers in brackets are the particular t statistics. The probability statistics of LR test for the over identifying restriction with χ2 distribution with a one degree of freedom associated with the statistic's realizations is stated in the last row.

Using Slovakia as an example, the long run estimates from Table 5 are illustrated below:

$-0.010t - w_t - 0.381ci_t + 1.614\pi_t = \varepsilon_{mr,t}$ and for inflation:

$$\pi_t = 0.6196w_t + 0.2361ci_t + 0.0062t$$

The equation above indicates that long-term inflation is explained by labour income and by foreign prices adjusted by exchange rates. The trend also has an explanatory role. An increase in inflation would lead to pressures for higher wages (increase labour income) and lower the competitiveness of companies in foreign markets.

Table 6 presents the mark-up relationship for selected countries. Price changes in Slovakia are 70% attributable to unit labour cost fluctuations and almost 30% is related to import price. For the Czech Republic and Hungary, the significance of the competitiveness index is low and almost zero and therefore price levels are influenced mainly by developments in the labour market. Although foreign trade is not significant, in the long run, we can observe its influence on the short run dynamics. In Bulgaria, the price level is equally influenced by unit labour costs and import price levels. Around 60% of price level variation in Poland is due to labour costs and the remaining 40 % is determined by import price levels.

Table 6 – Mark-up relationship

	SK	CZ	HU	PL	BG
p	1	1	1	1	1
ulc	-0.724	-0.991	-0.942	-0.635	-0.505
ip	-0.276	-0.009	-0.058	-0.365	-0.495

Note. p_t represents price level, ulc_t is unit labour costs, ipl_t is import price level. Coefficients are based on equations in Section 2.

Table 7 shows the influence of exogenous components captured by the slope of the linear time trend. It seems that if everything else is constant, inflation would decrease in the long run. The extra costs represent the cost for companies as a result of a change in the price level due to structural (or exogenous) factors. This development is completely the opposite of Boshi and Girardi (2007). If we take into account the turbulent market development of Central and Eastern European countries and their transformation process, the decrease in inflation is not surprising.

Table 7 – Time trend and extra costs

	SK	CZ	HU	PL	BG
Coint. Eq	-0.010	-0.007	-0.015	-0.012	-0.003
	0.0072	0.0069	0.0141	0.0076	0.0015
Extra costs	-0.724%	-0.694%	-1.412%	-0.762%	-0.152%

Now we can rewrite the estimation of an open economy for Slovakia according to equation (2):

$$p_t - 0.724ulc_t - 0.276ipl_t = -1.169\pi_t + 0.007t$$

Based on equation (2) we can expect a negative relationship between inflation and mark-up. Therefore, we expect that an increase in inflation would cause the contraction of mark-up. This would decrease the profit margins for firms due to an increase in unit labour costs or import price levels (or both at the same time). To sum up, an increase in inflation would cause a cost increase for firms due to a loss of competitiveness in all models. These costs are higher in countries where the price level is mostly determined by domestic market factors, such as in the Czech Republic, Hungary and partially in Slovakia. A significant domestic market influence can be seen in Poland. However, one should bear in mind the difficulty in explaining the behaviour of import price levels in Poland. The variation of the mark-up associated with rise in annual inflation is calculated in the last row of Table 8. In other words, a 1% rise in inflation in Slovakia would increase the cost for firms by 1.17% due to worsening conditions mainly in the domestic market (ulc).

Table 8 – Mark-up/Inflation relationship

	SK	CZ	HU	PL	BG
Inflation	1.614	2.149	2.266	2.984	2.103
Mark-up/Inflation	-1.169	-2.130	-1.895	-2.134	-1.062
Contraction	1.17%	2.13%	1.90%	2.13%	1.06%

DEMAND SIDE INFLATION

Table 9 shows the estimates for demand side inflation. In comparison with the economic theory, coefficient for competitiveness, ci_t, cannot be restricted and it is highly significant. We conclude that the competitiveness index (and its items, especially the real exchange rate) plays an important role in determining the long run productivity path. Except for Romania, the trend's influence is very close to zero and insignificant.

Table 9 Estimates of long run equation

		SI	EE	LV	LT	RO
α		0.003 (1.170)	0.000 (1.044)	0.003 (1.617)	-0.002 (-1.473)	-0.032 (-10.232)
B	w_t	0	0	0	0	0
	ci_t	-0.020 (-0.235)	0.312 (5.274)	0.121 (3.443)	0.267 (5.840)	-0.534 (-14.070)
	π_t	1	1	1	1	1
	o_t	-0.211 (-0.603)	-0.071 (-1.923)	-0.100 (-1.577)	-0.067 (-1.233)	0.594 (11.398)
No. of coint. vectors		1	1	1	1	1
Over identification χ2		0.145	0.636	0.679	0.646	0.464

Note. The model for particular country is in columns. The cointegration relationship as stated in equation 7 is in the first column. The numbers in brackets are the particular t statistics. The probability statistics of LR test for the over identifying restriction with χ2 distribution with a one degree of freedom (expect for Estonia) associated with the statistic's realizations is stated in the last row.

For better illustration, the long run relationship from Table 9 can be rewritten. Using Slovenia as an example, this can be shown as:

$$0.003t_t - 0.020ci_t + \pi_t - 0.211o_t = \varepsilon_{pc,t}$$

$\pi_t = 0.211OG_t + 0.020ci_t$ where OG_t estimate is $o_t - 0.0142t$

The result for Slovenia indicates an increase in productivity relative to trends and increase in competitiveness index (meaning a loss of competitiveness in foreign markets) increases annual inflation. For Romania the relationship is not consistent with the economic theory from Section 2. The coefficient for productivity has the opposite sign indicating that the potential output does not behave according to the trend. Furthermore there is a significant influence of the competitiveness index on inflation. An increase in productivity would decrease inflation on one hand, but on the other hand loss of competitiveness on foreign markets (increase in index) would push inflation down. Looking at Estonia, Latvia and Lithuania we confirm the relationship between inflation and production as explained in Section 2. Furthermore, the competitiveness index is significant but positive. It seems an increase in inflation would not affect a country's competitiveness or competitiveness would not influence inflation in the long run.

6. INFLATION DEVELOPMENT AND SHORT RUN STRUCTURE

In the previous section we modelled the long run relationship of inflation based on the mark-up theory and business cycle inflation. Section six aims to identify factors responsible for creating short run dynamics. We use the SER/TP procedure by Bruggemann and Lutkepohl (2000) to eliminate the statistically insignificant short run coefficients. For the estimation of all models we use a GLS procedure. A threshold significance level for short run parameters with a value of t=1.60 is set based on a HC criterion.[11] Diagnostic properties for the inflation equation for all models are shown in Table B.1 in the Appendix.

Some factors such as the Balassa-Samuelson effect, the monetary policy regime and the credibility of monetary policy may influence our results. Recent studies show that Balassa-Samuelson effect is not an important (Egert, 2010) or strong (Palic, 2010) determinant of inflation in the CEE as detected by some earlier studies and explains about one percentage points of total domestic inflation on average. Based on the country exchange rate regime we created three groups of countries where we deal with different monetary policy regimes and the credibility of monetary policy. The first group consists of Slovakia, Slovenia and Estonia which have adopted the euro. The second group is defined by countries in ERM II or with a currency board: Lithuania, Latvia and Bulgaria. The last group consists of free floaters: the Czech Republic, Hungary, Poland and Romania.

EURO AREA MEMBERS – SLOVAKIA, SLOVENIA AND ESTONIA

Slovakia, Slovenia and Estonia used a different monetary policy strategy to adopt the euro as a currency. Slovenia used base money and M1 and M3 targeting and later on two pillar strategy before participation in the ERM II. Slovakia relied on an exchange rate targeting during 1994-1998 which was switched to informal inflation targeting. On the other hand Estonia established a currency board. Looking at the inflation criterion for euro adoption, Slovenia was on track since 2005. After euro adoption the country experienced a period of high inflation. Only towards the end of 2008 did inflation decrease again and approached average euro area figures. Although Slovakia followed informal inflation targeting, which in general should help keep inflation under control, the country fulfilled the criterion in 2007 for the first time. Estonia managed to fulfil the criterion in 2009. In all countries, the inflation rate jumped in 2008, most notably in Estonia which followed a fixed exchange rate policy strategy at the time.

Factors driving inflation in the long run are domestic and foreign demand in Slovenia and Estonia and production factors in Slovakia. The short run dynamic of inflation is different for Euro area members. The effect of an unanticipated increase of inflation is translated into the rise in inflation in all countries. In Slovakia, half of the inflation shock is absorbed within three quarters whereas in Estonia within two quarters. Inflation is more persistent in

[11] As in Boschi and Girardi (2007) the choice of threshold value is set in order to maintain the coefficients with uncertain significance rather than deleting them. Similar choice is made by Krolzing and Hendry (2001).

Slovenia where half of the inflation shock is absorbed only after a year. This rise in inflation is only temporal which suggests a "learning" behaviour by economic agents and thus reduces the possible costs of excessive inflation uncertainty. In both Slovenia and Estonia, shocks to production increases inflation and an unexpected increase of the competitiveness index would decrease inflation in all three countries. Table 10 shows the dynamic development of inflation and impulse responses to the inflation equation which can be found in Appendix C. From the results below we can see that the determinants of inflation differ in the three countries belonging to the Euro Area.

Table 10 - Inflation dynamics for Slovakia, Slovenia and Estonia

Dependent variable: π_t

	Slovakia		Slovenia		Estonia	
Variable	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**
$coint(A)_{t-1}$	-0.263	-8.216	-0.138	-2.378	-0.338	-5.624
Δw_{t-1}			-0.104	-3.469		
Δw_{t-2}			0.087	2.452		
Δw_{t-3}	0.145	1.93	-0.139	-3.088	0.044	1.611
Δw_{t-4}			-0.070	-1.991		
Δci_{t-3}	-0.184	-2.24				
Δci_{t-4}	0.369	4.73				
$\Delta \pi_{t-1}$	0.147	1.642	0.433	3.732	0.540	4.934
$\Delta \pi_{t-2}$	0.184	2.164			0.188	1.945
$\Delta \pi_{t-4}$			-0.280	-2.656		
$\Delta \pi_{t-5}$			0.172	1.676		
Δo_{t-1}	-0.16	-2.274				
Δo_{t-2}			0.142	2.753		
Δo_{t-3}			-0.240	-3.214	-0.058	-2.359
a	-0.176	-8.279	-0.246	-2.374	0.311	5.638
s1			0.015	2.944		
s2			0.006	1.675		
d993	0.046	6.297				
d094					-0.018	-2.102

Note. a presents a constant in equation, coint (A) is the error correction coefficient of the system. Δ are the differences of endogenous variables with their particular lags. d993 and d094 are dummies introduced in Table 2 in Section 4. s1 and s2 are seasonal dummies.

The best way to deal with cost-push and demand-pull inflation is to pursue a tight monetary policy. However, restrictive monetary policy might lead to a reduction in economic activity in countries where inflation is mainly driven by cost-push factors. Since all three countries shared a common monetary policy from the European Central Bank (ECB) the best way of keeping inflation under control is to maintain a credible price stability policy and anchor inflation expectations. The specific country policy should accompany the ECB's monetary strategy by maintaining the growth of aggregate demand consistent with the productive capacity in Slovenia and Estonia and by adjusting the labour market in Slovakia. In line with this specific policy it is necessary to monitor labour market developments as its past development has an influence on current inflation in Slovakia and it might affect inflation expectations. Slovenia and Estonia should focus on domestic market conditions such as the development of domestic prices and changes in domestic production. All countries should also monitor changes in export and import prices since these can affect current prices.

FIXED EXCHANGE RATE COUNTRIES – LITHUANIA, LATVIA AND BULGARIA

The exchange rate strategy in these countries can be defined by the fixed exchange rate mechanism pegged to the euro. Lithuania introduced a currency board to the US dollar in 1995 which was changed to the euro in 2002. The country is currently in the ERM II system without a fixed date for euro adoption. Latvia also pegged its currency to the US dollar and later to the euro. Together with Lithuania it participates in the ERM II system. On the other hand Bulgaria is not a ERM II member. In 1997 the country established a currency board. The consistency, predictability and clarity of monetary strategy in these countries created an anchor in the economy and stabilised inflationary expectation, mainly in Bulgaria. However, during the crisis, central banks had to react to exchange rate pressures to maintain credibility which was reflected in a high inflation rate. Keeping inflation in line with the ECB criterion[12] is a major challenge, especially for Bulgaria. Until recently the country was not able to fulfil the criterion of low and stable inflation. On the other hand inflation in Lithuania was not more than 1.5% higher than the ECB target, except from the end of 2006 until 2009. Maintaining inflation close to the Eurozone inflation target has been an issue for Latvia. Nowadays, all three countries have their inflation rate within the ECB target +1.5% and also in line with Maastricht inflation criterion.

What are the drivers of inflation in these countries? Long run determinants are on the demand side for Lithuania and Latvia. Increased domestic and foreign demands represent a potential risk for price rises. On the other hand production factors, for example increased raw materials and commodity prices, created a potential risk to price stability in Bulgaria. An unanticipated inflation shock would cause an increase in inflation rate. Inflation has decreased following the initial rise. In Bulgaria the initial shock would eventually stabilize at a higher level than the previous inflation rate. In the short run unexpected changes in productivity would lead to a rise in inflation in Lithuania and Latvia and an increase in the competitiveness index would result in a decrease in inflation rate in all countries (Table 11 and impulse responses in Appendix C).

The main monetary strategy for countries under a fixed exchange rate is to maintain a credible peg which in turn helps to stabilize inflation. Appropriate structural reforms which help to keep demand in line with production capacity would prevent inflationary pressures in Lithuania and Latvia. Close monitoring of labour market developments, export and import prices as well as changes in production activity would be necessarily in order to avoid hikes in current inflation. Adjustments in labour market conditions and an increase in production would help to mitigate cost-push inflation in Bulgaria. Focusing policy on external trade would help to alleviate inflation pressures from a shorter term perspective. Since Bulgaria's economy is vulnerable to commodity price shocks appropriate buffers need to be built in this direction.

[12] The ECB commits itself to keep inflation rates below, but close to, 2% over the medium term.

Table 11 - Inflation dynamics for Lithuania, Latvia and Bulgaria

Dependent variable: π_t

	Lithuania		Latvia		Bulgaria	
Variable	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**
$coint(A)_{t-1}$	-0.164	-3.564	-0.177	-5.292	-0.208	-6.653
Δw_{t-1}	0.079	2.405	0.067	3.485		
Δw_{t-2}					0.481	5.211
Δw_{t-3}	0.065	1.866				
Δci_{t-1}	-0.183	-3.012				
Δci_{t-3}	0.111	1.995			-0.197	-1.889
Δci_{t-4}					0.196	2.143
$\Delta \pi_{t-1}$	0.456	4.234	0.807	10.335	0.476	5.400
$\Delta \pi_{t-2}$					0.185	2.466
$\Delta \pi_{t-3}$					0.186	2.275
$\Delta \pi_{t-4}$					-0.186	-2.488
Δo_{t-1}	0.076	2.178	0.047	2.280	-0.269	-5.504
Δo_{t-2}					0.227	3.181
Δo_{t-3}	0.070	1.936			-0.186	-3.983
a	0.113	3.532	-0.023	-5.321	0.552	6.621
s1					0.058	4.201

Note. a presents a constant in equation, coint (A) is the error correction coefficient of the system. Δ are the differences of endogenous variables with their particular lags. s1 is a seasonal dummy.

INFLATION TARGETING COUNTRIES – THE CZECH REPUBLIC, HUNGARY, POLAND AND ROMANIA

The three Central European countries share a similar monetary policy. At first, the Czech Republic, Hungary and Poland pegged their currencies in order to achieve price stability. Around 2000 they switched to inflation targeting. Romania did not commit itself to any monetary policy strategy until 2005 when the central bank introduced inflation targeting. During the crisis inflation targets served as a good anchor of inflation expectations. The Czech Republic's inflation rate has been in line with the ECB's medium target (as well as with Maastricht inflation criterion), except for in 2008. Poland's inflation rate remained around the target value only during 2008-2010 and recently.[13] In both Hungary and Romania inflation rates have been more than 1.5% above the ECB target since their accession to the EU[14].

In Central Europe factors of productions such as labour and capital influence price changes. In Romania, households, corporations, governments and foreign buyers have an impact on

[13] Target value is EBC medium target rate + 1.5%. Poland has not fulfilled Maastricht inflation criterion since October 2008.

[14] Only since May 2012 Romania fulfilled Maastricht inflation criterion.

demand and consequently on prices. An unanticipated shock to the inflation rate is translated into a rise in inflation. In Hungary and Poland, inflation even stays at higher levels for subsequent quarters. For the Czech Republic and Hungary the rise in inflation is only temporal which suggest a "learning" behaviour by economic agents and thus reduces the possible costs of excessive inflation uncertainty. For Poland and Romania, the initial shock would eventually stabilise at a higher level than the previous inflation rate. Short-term inflation dynamics are influenced by changes in productivity, competitiveness and labour income in all countries (Table 12 and Appendix C). Interestingly, an unexpected production shock would increase inflation in Poland and decrease inflation in Romania. In addition, past lagged values of inflation impact the dynamics of current inflation.

Table 12 - Inflation dynamics for the Czech Republic, Hungary, Poland and Romania

Dependent variable: π_t

	Czech Republic		Hungary		Poland		Romania	
Variable	Coefficient	t-stat	Coefficient	t-stat	Coefficient	t-stat	Coefficient	t-stat
$coint(A)_{t-1}$	-0.171	-8.447	-0.094	-4.665	-0.039	-5.743	-0.300	-8.755
Δw_{t-1}			0.080	2.402	0.125	4.281	0.131	6.280
Δw_{t-2}	0.075	2.232	-0.084	-2.045			-0.105	-4.296
Δw_{t-3}	0.094	3.852			0.112	3.604	0.161	7.011
Δw_{t-4}					-0.075	-2.001	-0.090	-3.791
Δw_{t-5}	0.149	6.692					0.086	5.059
Δci_{t-1}					-0.045	-2.470	-0.127	-4.010
Δci_{t-2}	0.083	2.603	-0.059	-2.080	-0.051	-3.015		
Δci_{t-3}	-0.134	-4.177						
Δci_{t-4}	0.082	2.318					0.065	1.799
Δci_{t-5}	-0.098	-2.851						
$\Delta\pi_{t-1}$	0.435	6.135	0.595	7.491	0.384	4.431	0.506	7.032
$\Delta\pi_{t-2}$	0.319	4.384					0.363	6.483
$\Delta\pi_{t-3}$					0.177	2.155		
$\Delta\pi_{t-4}$	-0.370	-4.974			-0.200	-2.243		
$\Delta\pi_{t-5}$					0.284	3.511	0.262	4.607
Δo_{t-1}	-0.427	-5.132			0.296	5.871	0.183	6.483
Δo_{t-2}			-0.238	-3.167	0.210	5.086	-0.079	-2.852
Δo_{t-3}					0.324	6.917	0.153	5.732
Δo_{t-4}					0.171	3.186	-0.142	-5.474
Δo_{t-5}	0.342	4.462					0.120	4.370
a	-0.389	-8.488	-0.266	-4.625	-0.198	-5.861	0.475	8.810
s1			-0.021	-3.584				
s3			-0.041	-2.697				

Note. a presents a constant in equation, coint (A) is the error correction coefficient of the system. Δ are the differences of endogenous variables with their particular lags. s1 and s3 are seasonal dummies.

Inflation targeting countries have more flexibility in monetary policy responses towards higher inflation. The main priority should be to maintain price stability and avoid overheating pressures. In order to meet inflation targets, central banks might pursue restrictive policies. However, this type of policy might lead to a fall in GDP growth, especially in countries where inflation is driven by production factors. If inflation is not caused by temporarily factors, a proper response for the Czech Republic, Hungary and Poland would be an appropriate adjustment in the labour market. In Poland, monitoring changes in production is also necessary. In Romania a restrictive monetary policy should be accompanied by an adjustment in aggregate demand. The main focus should be put on domestic market development such as labour market income, production possibilities and changes and exchange rate changes since Romania's economy is vulnerable to commodity price shocks and appropriate buffers need to be built in this direction.

7. ALTERNATIVE MODELS

In this section alternative models are presented. The first alternative model shows an unrestricted model where the cointegration relationship is estimated using the Johansen procedure. In the second type of model we added an exogenous variable, commodity price - com_t, and observe its effects on the short run dynamic. The third alternative takes into account government deficit as an endogenous variable and its possible effect on the inflation from the long-run perspective as well as its effect on short run dynamics.

UNRESTRICTED MODEL

In this type of model no restrictions are placed on a) cointegration vector; and b) short run dynamics. Long run relationships without restriction on the cointegration vector are shown in Table 13 for cost-push inflation countries and in Table 14 for demand inflation countries and tables for short run dynamics are shown in Appendix D.

Table 13 Estimates of long run equation unrestricted

		SK	CZ	PL	HU	BG
α		-0.006 (-1.240)	-0.001 (-0.410)	-0.005 (-0.750)	-0.029 (-3.217)	0.024 (2.350)
B	w_t	1	-1	-1	-1	-1
	ci_t	-0.328 (-2.888)	0.335 (2.046)	0.765 (3.507)	0.967 (1.610)	-0.533 (-0.077)
	π_t	2.717 (5.769)	1.949 (4.318)	2.545 (2.427)	5.644 (7.101)	7.148 (6.646)
	o_t	-0.304 (-0.551)	-0.124 (-0.422)	-1.047 (-0.904)	0.951 (0.973)	-0.818 (-1.697)
No. of coint. vectors		1	1	1	1	1

Note. The model for particular country is in columns. The cointegration relationship is in the first column. The numbers in brackets are the particular t statistics.

Table 14 Estimates of long run equation – unrestricted

		SI	EE	LV	LT	RO
α		0.343 (3.671)	-0.002 (-1.264)	0.002 (1.135)	-0.014 (-5.480)	-0.070 (-8.461)
B	w_t	-15.341 (-1.456)	-0.033 (-0.474)	-0.033 (-0.414)	-0.020 (-0.460)	-0.160 (-0.732)
	ci_t	-0.848 (-0.453)	-0.295 (-2.520)	0.124 (2.419)	0.847 (11.068)	-0.936 (-9.069)
	π_t	1	1	1	1	1
	o_t	-35.465 (-4.914)	0.294 (4.284)	-0.070 (-0.966)	0.275 (2.805)	1.311 (9.652)
No. of coint. vectors		1	1	1	1	1

Note. The model for particular country is in columns. The cointegration relationship is in the first column. The numbers in brackets are the particular t statistics.

The results above confirm the acceptance of over-identified restrictions on cointegration space and restrictions on the dynamics. Overall, models without both a restriction of cointegration relationship and dynamics perform worse. The models for Slovakia, Hungary and Poland are robust and there is no significant change compared to unrestricted models. In the Czech Republic, foreign prices gained some importance also in the long run; however, the direction of this effect is ambiguous. Although productivity is allowed in the cointegration equation it is statistically insignificant in all of the cointegration relations. A less robust model is indicated for Bulgaria where the competitiveness index is no longer a significant determinant of mark-up relation which results in higher extra costs and variation of mark-up.

The results we obtain from models with restrictions for Slovenia, Lithuania and Romania are robust. The coefficients for labour income are insignificant in all models. Although the estimates for coefficients for competitiveness index and production are higher, the directions of influence of these coefficients remain the same as in original model. In the less robust model for Estonia the competitiveness index (loss of competitiveness on foreign markets) gains a significant role in explaining an increase in inflation. Less robust results were obtained for Lithuania where lifting the restrictions changes the productivity variable's behaviour. This coefficient is, however, relatively small.

Results from original models of inflation dynamics are robust without using restrictions. From a short run perspective, inflation returns to its equilibrium level more slowly. However, the statistical properties of the models' residuals are worse than in models with restrictions, especially the autocorrelation.

The models without cointegration restrictions and with restrictions on dynamics perform better. The residuals are not highly correlated as in previous case. Furthermore, restrictions on dynamics bring more statistically significant variables into inflation equations.

EXOGENOUS COMMODITY PRICE SHOCK

In this type of model, the commodity price index is allowed to influence the short run dynamics of inflation equation in original estimation. Tables for short run dynamics are shown in Appendix E.

For these models, adding another variable brings almost no visible change. The long run relationships remain the same as in the original model; only the short run dynamic is influenced. In models for the Czech Republic and Latvia the commodity price index appears to have no influence on the short run dynamics of inflation. In Slovakia, Poland, Hungary, Bulgaria, Estonia, Lithuania and Romania the adjustment coefficients have a lower value than in originally estimated model and therefore inflation is more persistent. Residuals of the models for almost all countries have the same statistical characteristics as the ones in original estimations expect for Romania and Estonia. For these two countries the models show more autocorrelation.

Even though the models do not seem to be much affected by additional commodity shocks, the policymaker should be aware of prolonged inflationary effect. Bulgaria and Romania are, in particular, more likely to suffer from sudden commodity price changes.

GOVERNMENT DEFICIT

In line with the theoretical foundation, no long run relationship between inflation and government deficit could be confirmed for any of the models. The cointegration tests also do not confirm another long run relationship between variables.[15]

8. CONCLUSION

In this paper the determinants of inflation for recent members of the European Union are studied. Detecting what drives inflation can be essential in designing structural reforms which complement the main objectives of monetary policy pursued in these countries. The sample period ranged from first quarter of 1996 to the first quarter of 2011 and differs due to the data availability for particular countries. This time period covers the transformation of these countries to market economies, trade liberalisation and their successful accession to the European Union and the recent global financial crisis.

We utilize a structural vector error correction model to estimate long run relationships between inflation, mark-up and economic activity incorporating structural factors such as openness of the economy and production and the analyse dynamic properties of the models. We find that Slovakia, the Czech Republic, Hungary, Poland and Bulgaria can be characterized by cost-push inflation. In the Czech Republic and Hungary, prices are mainly determined by developments in domestic markets, mostly by developments in unit labour costs. Price changes in Slovakia are 70% attributable to unit labour cost fluctuations and almost 30% is related to import prices. For Poland and Bulgaria the ratio is almost equal. For these countries the net mark-up is calculated and indicates that inflation represents a cost to firms due to the loss of competitiveness. In countries where the impact of import price levels is low, the above mentioned loss is higher. In Slovenia, Estonia, Latvia, Lithuania and Romania, inflation is determined by demand side factors. Contrary to economic theory, competitiveness in foreign markets plays an important role. However, the influence of this index does not have the same direction in all countries. For Slovenia and Romania, an increase in this index would cause a loss of competitiveness on foreign markets and an

[15] Results are not shown in paper but are available upon request.

increase in inflation whereas for Latvia, Lithuania and Estonia an increase in inflation would not affect a country's competitiveness or competitiveness would not influence inflation in the long run. In the short run, inflation dynamics are influenced by inflation inertia, labour costs, foreign market competitiveness, production as well as some exogenous shocks. In all models inflation moves back to its long run equilibrium. The speed of adjustments differs. In Poland and Hungary inflation adjusts very slowly whereas in Estonia the speed of adjustment is very quick.

As for policy implication, the best way to deal with cost-push and demand-pull inflation is to pursue a tight monetary policy. However, restrictive monetary policy might lead to a reduction of economic activity in countries where inflation is mainly driven by cost-push factors. For countries belonging to the euro area, maintaining a credible price stability policy and anchoring inflation expectations are the best way to control inflation. The specific country policy should accompany ECB monetary strategy by keeping aggregate demand growth consistent with production capacity in Slovenia and Estonia and adjustments in the Slovak labour market. In line with this specific policy it is necessary to monitor labour market developments as its past development influences current inflation in Slovakia and it might affect inflation expectation. Slovenia and Estonia should focus on domestic market conditions such as the development of domestic prices and changes in domestic production. The main monetary strategy for countries under a fixed exchange rate is to maintain a credible peg which in turn helps to stabilize inflation. Appropriate structural reforms which help to keep demand in line with production capacity would prevent inflationary pressures in Lithuania and Latvia. Close monitoring of developments in the labour market, export and import prices as well as changes in production activity would be necessary in order to avoid jumps in current inflation. Adjustment in labour market conditions and an increase in production would help to mitigate cost-push inflation in Bulgaria. Focusing policy on external trade would help to alleviate inflation pressures from shorter perspective. Since Bulgaria's economy is vulnerable to commodity price shocks, appropriate buffers need to be built in this direction. Inflation targeting countries have more flexibility in monetary policy response towards higher inflation. The main priority should be to maintain price stability and avoid overheating pressures. In order to meet inflation targets, central banks might pursue restrictive policies. However, this type of policy might lead to a fall in GDP growth, especially in countries where inflation is driven by production factors. If inflation is not caused by temporary factors, a proper response for the Czech Republic, Hungary and Poland would be appropriate adjustment in the labour market. In Romania a restrictive monetary policy should be accompanied by adjustment in aggregate demand. The main focus should be put on domestic market development such as labour market income, production possibilities and changes and exchange rate changes since Romania's economy vulnerable to commodity price shocks appropriate buffers need to be built in this direction.

REFERENCES

Aisen, A. and Veiga, F. J. (2005) *Does Political Instability Lead to Higher Inflation? A Panel Data Analysis.* IMF Working Paper No. 05/49.

Bagliano, F., Golinelli, R. and Morana, C. (2002) *Inflation Modelling in the Euro Area.* NBER Working Paper Series No. 11473.

Banerjee, A., Cockerell, L. and Russell, B. (2001) *An I(2) Analysis of Inflation and the Markup.* Journal of Applied Econometrics, vol. 16, pages 221-40.

Banerjee, A. and Russell, B. (2002) *A Markup Model for Forecasting Inflation for the Euro Area.* Available at: http://www.eui.eu/Personal/Banerjee/EuroPaper2002-16.pdf (Accessed 25 July 2011).
Binder, M. and Pesaran, H. M. (1999) *Stochastic Growth Models and Their Econometrics Implications.* Journal of Economic Growth, vol.4, pages 139-83.
Boschi, M. and Girardi, A. (2006) Does One Monetary Policy Fit All? The Determinants Of Inflation in EMU Countries. European University Institute Working Paper 2002/16.
Boschi, M. and Girardi, A. (2007) *Euro Area inflation: long-run determinants and short-run dynamics.* Applied Financial Economics, Taylor and Francis Journals, vol. 17(1), pages 9-24.
Bruggemann, R. and Lutkepohl. H. (2000) *Lag selection in subset VAR models with an application to a U.S. monetary system.* Available at: http://ideas.repec.org/p/ecm/wc2000/0821.html (Accessed 20 July 2011).
Calderón, C. and Schmidt-Hebbel, K. (2008) *What Drives Inflation in The World?.* Central Bank of Chile, Working Papers No. 491.
Catao, L. and Terrones, M. (2001) *Fiscal Deficit and Inflation: A New Look at the Emerging Market Evidence.* IMF Working Paper No. 01/74.
Catao, L. and Terrones, M. (2003) *Fiscal Deficit and Inflation.* IMF Working Paper No. 03/65.
Clements, M.C. and Hendry, D.F. (1999) *Forecasting Non – Stationary Economic Time Series.* MIT Press, London.
Cottarelli, C., Griffiths, M. and Moghadam, R. (1998) *Non - Monetary Determinants of Inflation: A Panel Data Study*. IMF Working Paper No. 98/23.
Egert, B. (2010) *Catching-up Inflation in Europe:Balassa-Samuelson, Engel's Law and Other Culprits.* OECD Economics Department Working Papers No. 792
Gali, J. (2005) 'Inflation Pressures and Monetary Policy in a Global Economy'. Prepared for the *IJCB-Banque de France conference on Monetary Policy Challenges in a Global Economy*. 24–25 September 2009. Paris, France.
Golinelli, R. and Orsi, R. (2002) *Modelling Inflation in EU Accession Countries: The Case of the Czech Republic, Hungary and Poland.* Ezoneplus Working Paper No. 9.
Haldrup, N. (1998) *An Econometrics Analysis of I(2) Variables*. Journal of Economic Surveys, Vol. 12 No. 5, pp. 595-650
Hansen, H. and Johansen, S. (1999) *Some tests for parameter constancy in cointegrated VAR-models.* Econometrics Journal, vol.2, pages 306-33.
Hammermann. F. (2007) *Nonmonetary Determinants of Inflation in Romania: A Decomposition.* Kiel Working Paper No. 1322.
Holmes, M., Panagiotidis, T. and Sharma, A. (2011) *The Sustainability of India's Current Account.* Taylor and Francis Journals, vol. 43(2), pages 219-29.
Kim, B. (2001) *Determinants of Inflation in Poland: A Structural Cointegration Approach.* BOFIT Discussion Paper No. 16.
Lutkepohl, H. and Kratzig, M. (2004). Applied TIme Series Econometrics, Cambridge University Press, UK.
Lutkepohl, H., Saikkonen, P. and Trenkler, C. (2001) ‚Maximum Eigenvalue Versus Trace Tests for the Cointegrating Rank of a VAR Process', *Econometrics Journal*, Royal Economic Society, Vol. 4 No. 2, pp. 8
Nath, H.K. and Tochkov, K. (2011) *Relative Inflation Dynamics in the EU Accession Countries of Central and Eastern Europe*. Available at: http://ideas.repec.org/p/shs/wpaper/1005.html (Accessed 15 March 2012).
Palic, M. (2010) *Estimating the Impact of the Balassa-Samuelson in Central and South Eastern European Countries: revised analysis.* National Bank of Serbia Working Paper 2010.
Piontkivsky, R, Bakun, A., Kryshko, M. and Sytnyk, T. (2001) *The Impact of the Budget Deficit on Inflation in Ukraine*. Available at: http://www.icps.com.ua/files/articles/33/40/bdi_eng.doc (Accessed 26 January 2012).
Sachs, J. and Larrain, F. (1993) *Macroeconomics in the Global Economy*, Englewood Cliffs: Prentice Hall, 1993.
Santos, J. (1992) *Budget Deficits and Inflation: Portugal and the other EC High Debt Countries.* Estudos de Economia, vol. 12(3), pages 245-53.

APPENDICES

APPENDIX A – DESCRIPTIVE STATISTICS

Table A.1 – Descriptive statistics of used variables for Slovakia

	w	ci	π	o	l	com
Mean	-2.28	4.82	0.06	8.44	-5.71	4.42
Maximum	-1.99	5.03	0.16	8.83	-0.85	5.31
Minimum	-2.66	4.69	0.00	8.13	-14.77	3.77
Std. Dev.	0.17	0.11	0.03	0.17	3.20	0.44
Jarque-Bera	4.05	7.64	15.64	2.82	2.79	5.10
Probability	0.13	0.02	0.00	0.24	0.25	0.08
Observations	61	61	61	61	61	61

Table A.2 – Descriptive statistics of used variables for the Czech Republic

	W	ci	π	o	l	com
Mean	-2.20	4.79	0.04	11.79	-4.21	4.42
Maximum	-1.97	5.07	0.13	12.00	0.41	5.31
Minimum	-2.67	4.48	0.00	11.59	-11.41	3.77
Std. Dev.	0.18	0.18	0.03	0.14	2.57	0.44
Jarque-Bera	9.62	4.39	11.26	5.78	13.49	5.10
Probability	0.01	0.11	0.00	0.06	0.00	0.08
Observations	61	61	61	61	61	61

Table A.3 – Descriptive statistics of used variables for Hungary

	W	ci	π	o	l	com
Mean	-2.26	4.67	0.09	13.92	-5.09	4.42
Maximum	-1.75	5.03	0.28	14.08	34.82	5.31
Minimum	-3.08	4.37	0.03	13.74	-15.00	3.77
Std. Dev.	0.35	0.15	0.06	0.11	5.78	0.44
Jarque-Bera	4.17	0.46	26.09	6.42	3521.12	5.10
Probability	0.12	0.80	0.00	0.04	0.00	0.08
Observations	61	61	61	61	61	61

Table A.4 – Descriptive statistics of used variables for Poland

	W	ci	π	o	l	com
Mean	-1.93	4.71	0.06	9.54	-4.61	4.42
Maximum	-1.64	4.94	0.21	9.75	-0.64	5.31
Minimum	-2.57	4.54	0.00	9.22	-10.01	3.77
Std. Dev.	0.23	0.08	0.06	0.16	1.82	0.44
Jarque-Bera	13.74	3.23	16.67	5.86	5.42	5.10
Probability	0.00	0.20	0.00	0.05	0.07	0.08
Observations	61	61	61	61	61	61

Table A.5 – Descriptive statistics of used variables for Slovenia

	W	ci	π	o	l	com
Mean	-1.84	4.82	0.05	8.74	-2.92	4.42
Maximum	-1.49	5.03	0.11	8.95	0.05	5.31
Minimum	-1.99	4.69	0.00	8.51	-8.67	3.77
Std. Dev.	0.10	0.11	0.03	0.13	1.96	0.44
Jarque-Bera	19.91	7.64	4.46	3.93	12.39	5.10
Probability	0.00	0.02	0.11	0.14	0.00	0.08
Observations	61	61	61	61	61	61

Table A.7 – Descriptive statistics of used variables for Latvia

	W	ci	π	o	l	com
Mean	-2.57	4.51	0.05	7.95	-2.27	4.44
Maximum	-2.30	4.74	0.18	8.55	1.70	5.31
Minimum	-3.12	4.23	-0.04	7.12	-10.82	3.77
Std. Dev.	0.19	0.17	0.04	0.43	3.24	0.44
Jarque-Bera	10.97	4.81	9.00	3.22	10.81	4.44
Probability	0.00	0.09	0.01	0.20	0.00	0.11
Observations	57	57	57	57	57	57

Table A.8 – Descriptive statistics of used variables for Lithuania

	W	ci	π	o	l	com
Mean	0.21	4.69	0.03	8.35	-3.76	4.44
Maximum	0.54	4.95	0.13	9.05	3.49	5.31
Minimum	-0.07	3.85	-0.02	7.52	-11.99	3.77
Std. Dev.	0.17	0.34	0.04	0.40	3.54	0.44
Jarque-Bera	4.15	22.16	8.71	2.90	3.85	4.44
Probability	0.13	0.00	0.01	0.23	0.15	0.11
Observations	57	57	57	57	57	57

Table A.9 – Descriptive statistics of used variables for Bulgaria

	W	ci	π	o	l	com
Mean	-2.03	4.71	0.06	7.83	0.24	4.47
Maximum	-1.81	4.82	0.18	8.38	6.47	5.31
Minimum	-2.18	4.46	-0.01	7.25	-9.54	3.77
Std. Dev.	0.10	0.07	0.04	0.31	3.57	0.45
Jarque-Bera	6.78	7.95	4.23	2.53	3.23	3.60
Probability	0.03	0.02	0.12	0.28	0.20	0.17
Observations	52	52	52	52	52	52

Table A.10 – Descriptive statistics of used variables for Romania

	W	ci	π	o	l	com
Mean	-2.02	4.10	0.20	7.48	-3.45	4.47
Maximum	-1.71	5.40	0.57	8.25	3.43	5.31
Minimum	-2.27	3.00	0.04	6.61	-10.31	3.77
Std. Dev.	0.13	0.62	0.17	0.55	3.20	0.45
Jarque-Bera	2.82	1.68	8.18	4.97	0.54	3.60
Probability	0.24	0.43	0.02	0.08	0.76	0.17
Observations	52	52	52	52	52	52

APPENDIX B – DIAGNOSTIC TESTS

Table B.1 – Diagnostic tests for inflation equation

	Log likelihood	ARCH test	Normality test	Joint Normality	Portmanteau test (16)	LM test (1)	LM test (2)	LM test (3)
SK	662.69	24.13	0.21	6.89	0.99	11.25	26.00	48.48
CZ	710.68	11.22	1.66	6.75	0.91	4.47	22.59	40.98
HU	666.88	8.24	1.41	*22.49*	0.91	12.96	22.52	38.75
PL	608.93	13.60	0.38	*938.07*	0.93	15.80	25.55	37.51
BG	559.66	24.17	0.37	5.81	0.73	11.69	42.18	*67.12*
SI	646.72	4.52	1.87	15.06	0.99	10.91	19.98	42.10
EE	563.16	13.01	0.04	3.79	0.94	16.58	24.58	56.39
LV	447.12	17.60	1.26	*559.46*	0.39	14.13	35.48	51.54
LT	414.63	13.05	1.36	4.25	0.99	*26.02*	*42.89*	56.08
RO	421.44	6.77	*10.49*	*32.96*	*0.00*	20.52	38.52	*66.34*

Critical values for χ^2 distributions are 23.542, 42.585 and 60.907 for 16, 32 and 48 degrees of freedom, respectively. In Portmanteau tests p value is shown and ARCH test, Normality test and Joint Normality tests particular test statistics is presented. Tests which cannot confirm null hypothesis are in italics.

Table B.2 – Diagnostic tests for inflation equation without cointegration restrictions and restrictions for dynamics

	Log likelihood	ARCH test	Normality test	Joint Normality	Portmanteau	LM test (1)	LM test (2)	LM test (3)
SK	672.93	13.42	0.40	9.38	0.45	*35.84*	*57.95*	*85.36*
CZ	728.75	14.32	0.95	1.69	*0.01*	*25.72*	*64.36*	*87.90*
HU	682.37	15.41	1.49	*17.66*	0.73	19.92	*44.96*	*78.45*
PL	629.69	21.47	0.18	*715.97*	0.44	18.00	*46.67*	*102.18*
BG	579.63	20.64	0.49	12.65	*0.00*	*40.06*	*79.09*	*115.87*
SI	679.25	10.55	1.25	7.99	0.44	11.93	42.02	*64.07*
EE	575.71	17.19	0.46	5.99	0.78	*45.33*	*59.57*	*78.73*
LV	457.22	15.98	1.01	*528.41*	*0.01*	*45.99*	*76.66*	*111.08*
LT	446.35	12.72	1.61	12.22	0.94	*33.69*	*50.50*	*73.70*
RO	442.19	16.01	*6.15*	*29.43*	*0.00*	*39.18*	*66.19*	*114.74*

Critical values for χ^2 distributions are 23.542, 42.585 and 60.907 for 16, 32 and 48 degrees of freedom, respectively. In Portmanteau tests p value is shown and ARCH test, Normality test and Joint Normality tests particular test statistics is presented. Tests which cannot confirm null hypothesis are in italics.

Table B.3 – Diagnostic tests for inflation equation without cointegration restrictions

	Log likelihood	ARCH test	Normality test	Joint Normality	Portmanteau	LM test (1)	LM test (2)	LM test (3)
SK	658.81	12.87	0.99	5.43	0.99	19.32	34.34	53.67
CZ	712.59	13.86	2.05	2.97	0.21	10.61	26.87	54.73
HU	674.31	11.38	1.66	*28.04*	0.93	18.25	32.70	*61.56*
PL	609.86	10.19	*5.64*	*1013.54*	0.94	16.93	30.26	45.51
BG	571.70	15.57	0.84	*14.25*	*0.04*	18.59	*53.76*	*77.63*
SI	658.30	7.94	1.81	*17.58*	0.89	11.14	17.85	41.77
EE	568.31	16.27	1.96	5.46	0.93	*28.46*	44.54	*62.87*
LV	447.83	18.46	1.73	*514.94*	0.41	13.39	37.13	46.49
LT	435.06	9.42	*6.39*	8.83	0.99	*23.74*	35.57	*61.36*
RO	435.35	13.03	0.56	*20.17*	*0.01*	16.36	39.33	*77.47*

Critical values for χ^2 distributions are 23.542, 42.585 and 60.907 for 16, 32 and 48 degrees of freedom, respectively. In Portmanteau tests p value is shown and ARCH test, Normality test and Joint Normality tests particular test statistics is presented. Tests which cannot confirm null hypothesis are in italics.

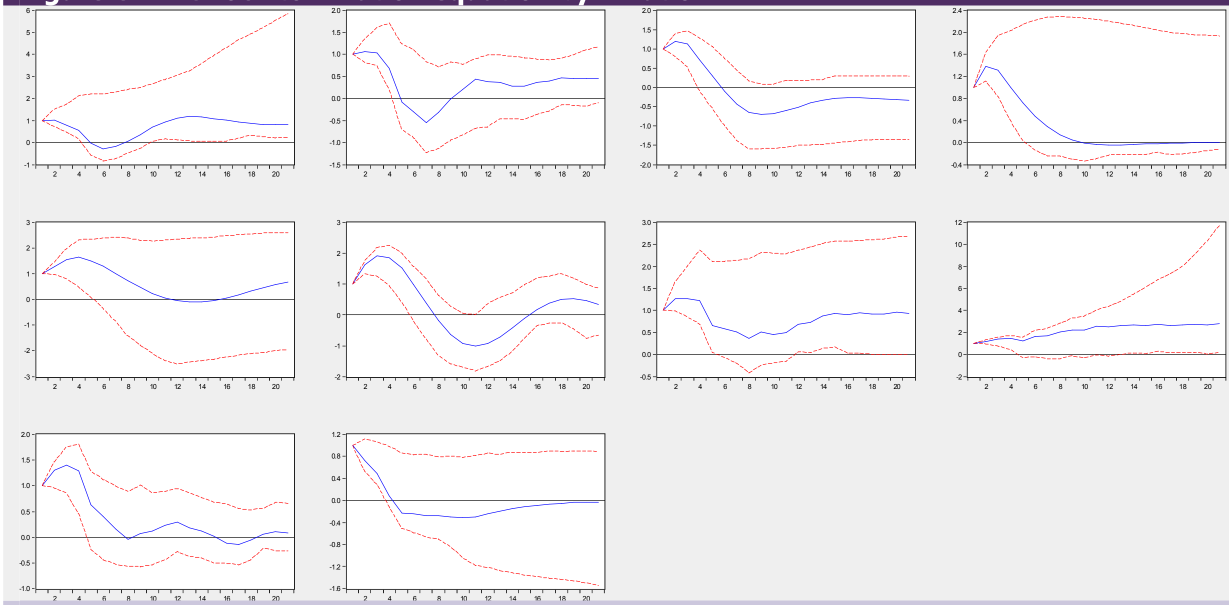
Table B.4 – Diagnostic tests for inflation equation for model with exogenous variable

	Log likelihood	ARCH test	Normality test	Joint Normality	LM test (1)	LM test (2)	LM test (3)
SK	676.67	21.04	0.40	11.00	15.61	25.00	44.72
CZ	730.74	11.70	0.62	5.06	14.79	30.89	50.54
HU	686.35	18.93	1.29	1.99	14.10	20.87	42.02
PL	628.83	9.54	0.28	*815.77*	7.13	29.24	41.49
BG	578.10	19.13	0.82	5.61	12.14	*61.98*	*88.44*
SI	661.23	12.33	0.68	6.31	9.95	17.19	29.85
EE	577.30	10.20	2.79	14.24	23.05	36.17	*62.87*
LV	448.74	17.81	1.25	*532.00*	14.82	34.73	49.83
LT	420.40	12.70	1.51	8.38	23.18	33.69	45.76
RO	430.00	5.80	*14.75*	*20.97*	18.20	41.39	*67.56*

Critical values for χ^2 distributions are 23.542, 42.585 and 60.907 for 16, 32 and 48 degrees of freedom, respectively. In Portmanteau tests p value is shown and ARCH test, Normality test and Joint Normality tests particular test statistics is presented. Tests which cannot confirm null hypothesis are in italics.

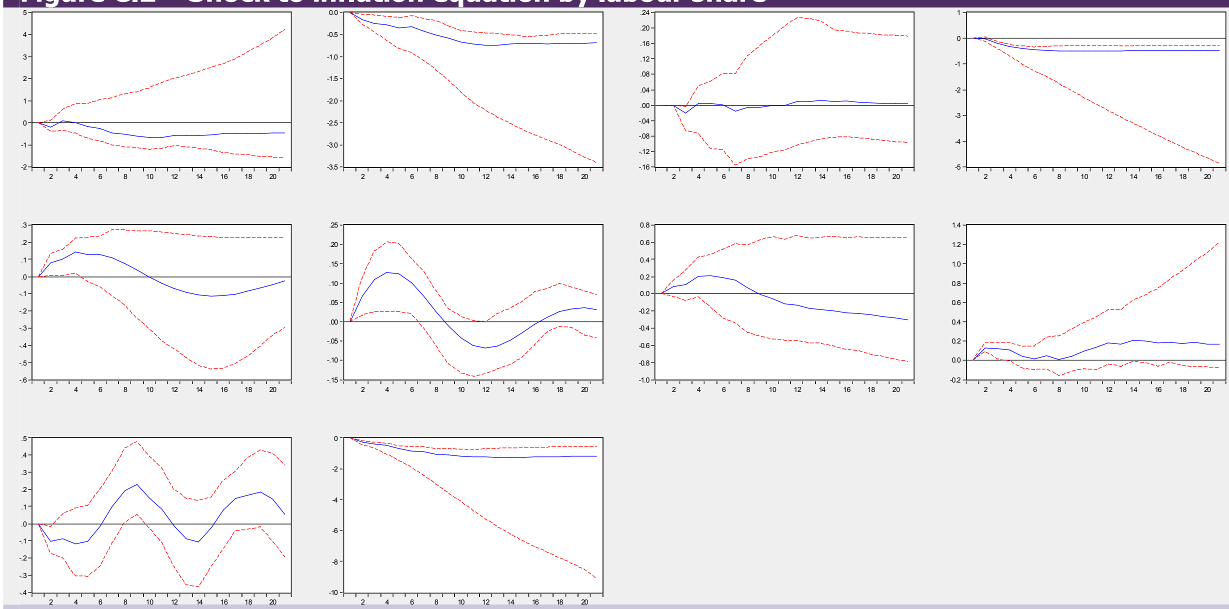
APPENDIX C – IMPULSE RESPONSES OF VARIOUS SHOCKS TO INFLATION EQUATION

Figure C.1 – Shock to inflation equation by inflation



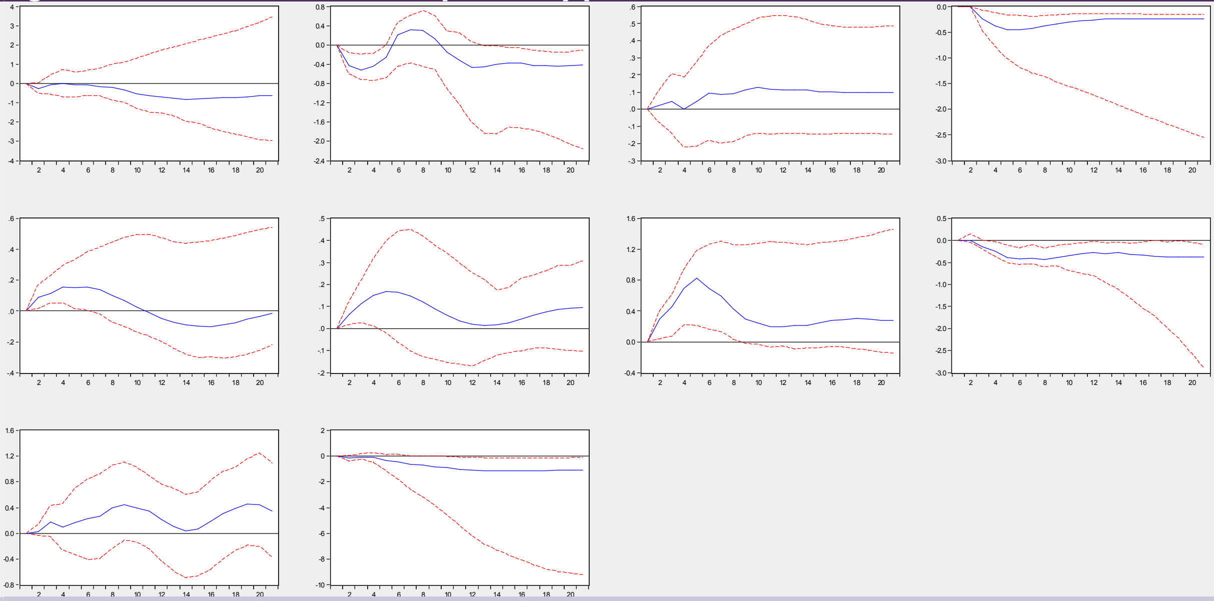
Note. Blue line represents the response of inflation to unexpected inflation shock. Red lines are relevant 95% Efron confidence bands. Ordering of the countries, from top left, is following: Bulgaria, the Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Romania, Slovenia, and Slovakia.

Figure C.2 – Shock to inflation equation by labour share



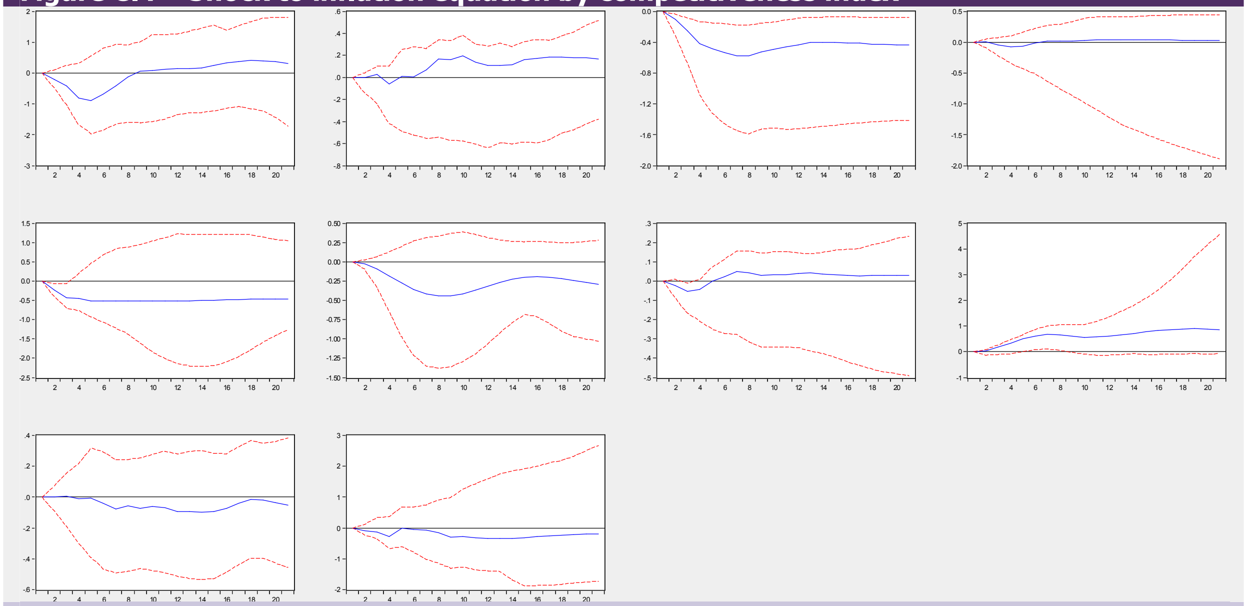
Note. Blue line represents the response of inflation to unexpected labour income share shock. Red lines are relevant 95% Efron confidence bands. Ordering of the countries, from top left, is following: Bulgaria, the Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Romania, Slovenia, and Slovakia.

Figure C.3 – Shock to inflation equation by production



Note. Blue line represents the response of inflation to unexpected production shock. Red lines are relevant 95% Efron confidence bands. Ordering of the countries, from top left, is following: Bulgaria, the Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Romania, Slovenia, and Slovakia.

Figure C.4 – Shock to inflation equation by competitiveness index



Note. Blue line represents the response of inflation to unexpected competitiveness shock. Red lines are relevant 95% Efron confidence bands. Ordering of the countries, from top left, is following: Bulgaria, the Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Romania, Slovenia, and Slovakia.

APPENDIX D - SHORT RUN DYNAMICS – UNRESTRICTED MODELS

Table D.1 – Slovakia

Dependent variable: π_t

Variable	Without restriction on dynamic		With restriction on dynamic	
	Coefficient	t-stat	Coefficient	t-stat
$coint(A)_{t-1}$	-0.163	-4.823	-0.157	-7.783
Δci_{t-3}	-0.183	-1.808	-0.190	-2.363
Δci_{t-4}	0.196	1.891	0.205	2.678
$\Delta \pi_{t-2}$	0.219	2.279	0.205	2.348
Δo_{t-1}			-0.126	-1.838
a	-0.513	-4.867	-0.519	-7.820
d993	0.042	5.144	0.045	6.155

Note. a presents a constant in equation, coint (A) is the error correction coefficient of the system. Δ are the differences of endogenous variables with their particular lags. d993 is a dummy introduced in Table 2 in Section 4.

Table D.2 – Slovenia

Dependent variable: π_t

Variable	Without restriction on dynamic		With restriction on dynamic	
	Coefficient	t-stat	Coefficient	t-stat
$coint(A)_{t-1}$	0.005	2.293	0.000	1.187
Δw_{t-1}	-0.101	-2.439	-0.093	-3.620
Δw_{t-2}	0.165	3.427	0.111	3.335
Δw_{t-3}	-0.103	-1.701	-0.130	-3.091
Δw_{t-5}	0.163	2.022		
Δci_{t-3}	0.093	2.095		
$\Delta \pi_{t-1}$	0.425	3.490	0.342	3.202
$\Delta \pi_{t-4}$	-0.374	-2.839	-0.420	-4.119
Δo_{t-2}	0.275	3.425	0.151	3.061
Δo_{t-3}				
Δo_{t-4}	0.218	2.073	-0.200	-2.674
Δo_{t-5}	0.300	2.672	0.128	3.240
a	1.324	2.290		
s1			0.012	2.550

Note. a presents a constant in equation, coint (A) is the error correction coefficient of the system. Δ are the differences of endogenous variables with their particular lags. s1 is a seasonal dummy.

Table D.3 – Estonia

Dependent variable: π_t

Variable	Without restriction on dynamic		With restriction on dynamic	
	Coefficient	t-stat	Coefficient	t-stat
$coint(A)_{t-1}$	-0.254	-3.892	-0.226	-4.489
Δw_{t-1}			0.083	2.485
Δw_{t-2}	0.104	1.667	0.059	1.726
Δw_{t-3}			0.105	2.629
Δci_{t-3}			-0.070	-1.803
$\Delta \pi_{t-1}$	0.603	3.722	0.605	5.024
Δo_{t-1}			0.080	1.724
Δo_{t-2}	0.162	2.051	0.145	3.190
a	0.273	3.849	0.243	4.441
d094			-0.020	-2.124

Note. a presents a constant in equation, coint (A) is the error correction coefficient of the system. Δ are the differences of endogenous variables with their particular lags. d094 is a dummy introduced in Table 2 in Section 4.

Table D.4 – Lithuania

Dependent variable: π_t

Variable	Without restriction on dynamic		With restriction on dynamic	
	Coefficient	t-stat	Coefficient	t-stat
$coint(A)_{t-1}$	-0.071	-2.416	-0.056	-2.340
Δw_{t-1}	0.098	2.749	0.101	2.811
Δw_{t-3}	0.066	1.634		
Δci_{t-1}	-0.158	-2.153	-0.156	-2.366
Δci_{t-3}	0.117	1.924	0.125	2.173
$\Delta \pi_{t-1}$	0.405	2.952	0.490	4.382
Δo_{t-1}	0.108	2.747	0.109	2.792
Δo_{t-3}	0.072	1.672		
a	0.333	2.257	0.250	2.075

Note. a presents a constant in equation, coint (A) is the error correction coefficient of the system. Δ are the differences of endogenous variables with their particular lags.

Table D.5 – Latvia

Dependent variable: π_t

Variable	Without restriction on dynamic		With restriction on dynamic	
	Coefficient	t-stat	Coefficient	t-stat
$coint(A)_{t-1}$	-0.191	-4.140	-0.154	-4.621
Δw_{t-1}	0.059	2.795	0.067	3.531
$\Delta \pi_{t-1}$	0.731	5.865	0.805	10.372
Δo_{t-1}	0.052	2.062	0.052	2.561
a	0.038	3.960	0.031	4.400

Note. a presents a constant in equation, coint (A) is the error correction coefficient of the system. Δ are the differences of endogenous variables with their particular lags.

Table D.6 – Bulgaria

Dependent variable: π_t

Variable	Without restriction on dynamic		With restriction on dynamic	
	Coefficient	t-stat	Coefficient	t-stat
$coint(A)_{t-1}$	-0.076	-2.514	-0.067	-5.478
Δw_{t-2}	0.564	4.861	0.467	4.912
Δw_{t-4}			0.192	2.333
Δci_{t-1}			-0.177	-1.755
Δci_{t-3}	-0.361	-2.339	-0.311	-3.587
Δci_{t-4}			0.184	1.943
Δci_{t-5}	-0.314	-2.145	-0.281	-3.948
$\Delta \pi_{t-1}$	0.594	3.111	0.526	5.136
$\Delta \pi_{t-2}$			0.184	2.491
$\Delta \pi_{t-3}$			0.150	1.671
$\Delta \pi_{t-4}$	-0.273	-1.595	-0.259	-2.546
Δo_{t-1}			-0.160	-3.821
Δo_{t-2}	0.509	3.579	0.398	3.529
Δo_{t-3}			-0.099	-2.095
Δo_{t-4}	0.287	2.821	0.249	2.603
a	-0.380	-2.497	-0.335	-5.500
s1	0.060	2.042	0.056	3.422
s3			0.034	2.779

Note. a presents a constant in equation, coint (A) is the error correction coefficient of the system. Δ are the differences of endogenous variables with their particular lags. s1 and s3 are seasonal dummies.

Table D.7 - The Czech Republic

Dependent variable: π_t

Variable	Without restriction on dynamic Coefficient	t-stat	With restriction on dynamic Coefficient	t-stat
$coint(A)_{t-1}$	-0.169	-6.050	-0.169	-7.993
Δw_{t-4}	-0.113	-1.997	-0.085	-4.570
Δci_{t-3}	-0.153	-3.681	-0.124	-4.018
Δci_{t-4}	0.064	1.688	0.063	1.860
Δci_{t-5}	-0.105	-2.676	-0.114	-3.234
$\Delta \pi_{t-1}$	0.385	3.472	0.304	4.359
$\Delta \pi_{t-2}$	0.290	3.328	0.275	3.933
$\Delta \pi_{t-3}$	0.145	1.689	0.141	1.944
$\Delta \pi_{t-4}$	-0.360	-4.359	-0.365	-5.063
Δo_{t-1}	-0.417	-2.846	-0.385	-5.066
Δo_{t-4}	-0.302	-2.210	-0.232	-2.750
Δo_{t-5}	0.339	2.258	0.279	3.720
a	-0.877	-6.039	-0.875	-7.995
s2			0.012	1.684

Note. a presents a constant in equation, coint (A) is the error correction coefficient of the system. Δ are the differences of endogenous variables with their particular lags. s2 is a seasonal dummy.

Table D.8 – Hungary

Dependent variable: π_t

Variable	Without restriction on dynamic Coefficient	t-stat	With restriction on dynamic Coefficient	t-stat
$coint(A)_{t-1}$	-0.020	-2.673	-0.023	-4.626
Δw_{t-1}			0.113	2.183
Δci_{t-2}	-0.091	-2.575	-0.100	-3.539
$\Delta \pi_{t-1}$	0.489	3.964	0.455	5.295
Δo_{t-1}			0.107	2.376
Δo_{t-2}			-0.155	-2.077
a	0.115	2.717	0.135	4.571
s1	-0.022	-1.884	-0.023	-2.481
s3	-0.042	-1.697	-0.041	-2.118

Note. a presents a constant in equation, coint (A) is the error correction coefficient of the system. Δ are the differences of endogenous variables with their particular lags. s1 and s3 are seasonal dummies.

Table D.9 – Poland

Dependent variable: π_t

Variable	Without restriction on dynamic Coefficient	t-stat	With restriction on dynamic Coefficient	t-stat
$coint(A)_{t-1}$	-0.033	-3.798	-0.052	-10.174
Δw_{t-1}	0.162	5.065	0.127	4.427
Δw_{t-2}			0.079	2.658
Δw_{t-3}	0.102	3.005	0.132	4.271
Δw_{t-4}	-0.069	-1.643		
Δw_{t-5}			-0.081	-2.892
Δci_{t-1}	-0.049	-2.585	-0.035	-2.047
Δci_{t-2}	-0.051	-2.284	-0.084	-5.024
Δci_{t-3}	-0.035	-1.795	-0.038	-2.348
$\Delta \pi_{t-1}$	0.352	2.909		
$\Delta \pi_{t-3}$	0.285	2.655	0.132	4.271
$\Delta \pi_{t-4}$	-0.298	-2.771		
$\Delta \pi_{t-5}$	0.227	2.156	0.186	2.374
Δo_{t-1}	0.280	4.447	0.302	6.239
Δo_{t-2}	0.187	2.394	0.353	7.386
Δo_{t-3}	0.268	3.547	0.443	9.226
Δo_{t-4}	0.214	2.576	0.357	8.354
a	-0.531	-3.810	-0.827	-10.255
s2	0.013	1.731		

Note. a presents a constant in equation, coint (A) is the error correction coefficient of the system. Δ are the differences of endogenous variables with their particular lags. s2 is a seasonal dummy.

Table D.10 – Romania

Dependent variable: π_t

Variable	Without restriction on dynamic		With restriction on dynamic	
	Coefficient	t-stat	Coefficient	t-stat
$coint(A)_{t-1}$	-0.009	-0.376	0.010	0.620
Δw_{t-1}	0.085	2.488	0.052	2.802
Δw_{t-2}	-0.093	-2.042	-0.098	-4.209
Δw_{t-3}			0.033	1.625
Δw_{t-4}	-0.083	-2.092	-0.083	-4.025
Δw_{t-5}	0.053	1.760	0.047	3.378
Δci_{t-2}	0.166	4.582	0.178	5.743
Δci_{t-3}	0.123	2.411	0.123	3.037
Δci_{t-4}	0.134	2.860	0.149	3.541
Δci_{t-5}			0.098	2.881
$\Delta \pi_{t-1}$			0.126	1.594
$\Delta \pi_{t-2}$	0.338	4.306	0.277	5.181
$\Delta \pi_{t-3}$			-0.155	-2.877
$\Delta \pi_{t-4}$	-0.227	-2.476	-0.268	-5.209
$\Delta \pi_{t-5}$	0.154	1.925	0.141	2.127
Δo_{t-2}	-0.188	-4.445	-0.208	-6.817
Δo_{t-3}			-0.064	-3.332
Δo_{t-4}	-0.171	-4.175	-0.175	-6.520
a			-0.016	-0.215

Note. a presents a constant in equation, coint (A) is the error correction coefficient of the system. Δ are the differences of endogenous variables with their particular lags.

APPENDIX E - SHORT RUN DYNAMICS – MODEL WITH EXOGENOUS VARIABLE

Table E.1 - Slovakia, Slovenia and Estonia

Dependent variable: π_t

	Slovakia		Slovenia		Estonia	
Variable	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**
$coint(A)_{t-1}$	-0.278	-8.455	-0.138	-2.432	-0.319	-3.613
Δw_{t-1}			-0.146	-4.401	0.043	1.642
Δw_{t-2}			0.066	2.866	0.086	2.142
Δw_{t-3}	0.128	1.685	-0.172	-4.335	0.109	3.160
Δci_{t-3}	-0.156	-1.912				
Δci_{t-4}	0.389	4.914				
$\Delta \pi_{t-1}$	0.157	1.817	0.313	2.949	0.336	3.360
$\Delta \pi_{t-2}$	0.202	2.476				
$\Delta \pi_{t-3}$			0.352	3.532		
$\Delta \pi_{t-4}$			-0.306	-3.177		
$\Delta \pi_{t-5}$			0.232	2.550		
Δo_{t-1}	-0.147	-2.161	-0.130	-3.015	0.085	1.665
Δo_{t-2}			0.138	3.428	0.196	4.233
Δo_{t-3}			-0.199	-4.079		
a	-0.166	-6.786	-0.251	-2.436	0.235	3.019
com_t	-0.027	-2.007	0.038	4.743	0.056	5.677
com_{t-1}	0.023	1.651	-0.037	-4.497	-0.045	-4.394
d993	0.048	6.589				
d094					-0.017	-2.292
s1					0.009	1.907

Note. a presents a constant in equation, coint (A) is the error correction coefficient of the system. Δ are the differences of endogenous variables with their particular lags. d993 and d094 are dummies introduced in Table 2 in Section 4. com is an exogenous variable with its particular lag. s1 is a seasonal dummy.

Table E.2 - Lithuania, Latvia and Bulgaria

Dependent variable: π_t

	Lithuania		Latvia		Bulgaria	
Variable	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**
$coint(A)_{t-1}$	-0.141	-3.077	-0.175	-5.240	-0.027	-2.613
Δw_{t-1}	0.080	2.488	0.066	3.449	-0.171	-1.929
Δw_{t-2}					0.325	3.351
Δw_{t-3}	0.062	1.861				
Δw_{t-5}					-0.302	-3.468
Δci_{t-1}	-0.201	-2.952				
Δci_{t-2}					0.249	2.510
Δci_{t-3}	0.122	2.038				
Δci_{t-4}					0.320	2.983
$\Delta \pi_{t-1}$	0.420	4.005	0.807	10.309	0.230	2.694
$\Delta \pi_{t-2}$					0.254	2.875
$\Delta \pi_{t-3}$					0.268	3.674
$\Delta \pi_{t-4}$					-0.425	-3.497
$\Delta \pi_{t-5}$					0.146	2.296
Δo_{t-1}	0.082	2.403	0.046	2.256	-0.313	-2.905
Δo_{t-2}					0.285	3.071
Δo_{t-3}	0.061	1.762				
Δo_{t-4}					0.120	2.313
Δo_{t-5}					-0.289	-2.825
a	0.095	2.723	-0.023	-5.261		
com_t	0.022	2.024			0.050	3.766
com_{t-1}	-0.022	-1.898			-0.033	-2.453
s1					0.038	2.147
s2					-0.052	-2.448

Note. a presents a constant in equation, coint (A) is the error correction coefficient of the system. Δ are the differences of endogenous variables with their particular lags. com is an exogenous variable with its particular lag. s1 and s2 are seasonal dummies.

Table E.3 - Czech Republic, Hungary, Poland and Romania

Dependent variable: π_t

	Czech Republic		Hungary		Poland		Romania	
Variable	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**	**Coefficient**	**t-stat**
coint(A)$_{t-1}$	-0.215	-9.036	-0.086	-4.190	-0.032	-3.344	0.116	6.244
Δw_{t-1}			0.072	2.156	0.120	4.043	0.07	3.201
Δw_{t-2}	0.126	3.572	-0.096	-2.254			-0.192	-7.918
Δw_{t-3}	0.130	4.286			0.112	3.633	0.114	5.698
Δw_{t-4}					-0.080	-2.133	-0.159	-8.605
Δw_{t-5}	0.125	3.940						
Δci_{t-1}					-0.054	-2.986		
Δci_{t-2}	0.085	4.691	-0.054	-1.894	-0.038	-2.206	0.135	4.309
Δci_{t-3}	-0.122	-3.936						
Δci_{t-4}	-0.137	-2.079			0.026	1.603	0.174	4.388
Δci_{t-5}	-0.074	-2.195					0.067	2.26
$\Delta \pi_{t-1}$	0.446	6.215	0.581	6.872	0.337	3.667		
$\Delta \pi_{t-2}$	0.315	4.691					0.328	6.158
$\Delta \pi_{t-3}$	0.178	2.524			0.245	2.895	-0.093	-1.896
$\Delta \pi_{t-4}$	-0.319	-4.549			-0.252	-2.805		
$\Delta \pi_{t-5}$					0.247	2.811		
Δo_{t-1}	-0.441	-5.478			0.292	5.789	0.052	1.798
Δo_{t-2}			-0.237	-2.908	0.201	4.915	-0.142	-3.739
Δo_{t-3}					0.313	6.963	0.188	5.259
Δo_{t-4}	-0.137	-2.079			0.165	3.100	-0.272	-8.034
Δo_{t-5}	0.305	3.932						
a	-0.488	-9.098	-0.229	-3.939	-0.173	-4.620	0.204	5.126
com$_t$			0.019	1.968	0.023	3.095	0.016	3.921
com$_{t-1}$			-0.021	-2.230	-0.021	-2.804		
s1			-0.021	-3.513			-0.09	-5.873
s2							-0.095	-5.283
s3			-0.040	-2.465			-0.035	-1.789

Note. a presents a constant in equation, coint (A) is the error correction coefficient of the system. Δ are the differences of endogenous variables with their particular lags. com is an exogenous variable with its particular lag. s1, s2 and s3 are seasonal dummies.

APPENDIX F

Table F.1 – Matrix of trade weights

	AU	AT	BE/LU	BG	CA	CZ	DK	EE	FI	FR	DE	EL	HU	IE	IT	JP	KR	LV	LT
BG	0.38%	1.98%	3.19%	0.00%	0.71%	0.71%	0.77%	0.08%	0.54%	6.53%	14.05%	7.21%	0.85%	0.53%	12.96%	2.39%	1.11%	0.12%	0.26%
CZ	0.32%	5.24%	2.94%	0.28%	0.38%	0.00%	0.98%	0.07%	0.69%	5.84%	32.87%	0.48%	1.74%	0.52%	6.08%	1.79%	0.78%	0.11%	0.25%
EE	0.23%	0.86%	2.21%	0.15%	0.49%	0.52%	3.42%	0.00%	15.52%	2.92%	11.17%	0.26%	0.72%	0.50%	2.65%	1.62%	0.87%	4.59%	2.88%
LV	0.21%	1.08%	2.41%	0.20%	0.44%	0.72%	3.97%	1.95%	3.51%	3.66%	15.65%	0.28%	0.66%	0.76%	3.58%	1.71%	0.64%	0.00%	4.72%
LT	0.16%	1.12%	2.37%	0.32%	0.65%	0.77%	3.61%	1.45%	2.20%	5.22%	15.38%	0.41%	0.70%	0.61%	4.54%	1.50%	0.74%	5.80%	0.00%
HU	0.31%	6.42%	3.02%	0.32%	0.39%	1.73%	0.91%	0.08%	0.83%	6.52%	30.27%	0.60%	0.00%	0.57%	8.01%	1.93%	0.79%	0.11%	0.21%
PL	0.28%	2.37%	3.21%	0.25%	0.52%	2.38%	2.45%	0.17%	1.20%	6.95%	30.60%	0.51%	1.37%	0.58%	7.27%	1.81%	0.77%	0.36%	0.90%
RO	0.39%	2.52%	3.26%	1.11%	0.56%	0.71%	0.58%	0.04%	0.40%	8.48%	18.24%	2.16%	1.79%	0.48%	18.60%	2.65%	1.21%	0.04%	0.10%
SI	0.31%	5.71%	2.42%	0.48%	0.44%	1.61%	1.12%	0.09%	0.56%	8.16%	26.20%	0.61%	1.65%	0.45%	13.83%	1.39%	0.72%	0.11%	0.32%
SK	0.21%	6.05%	2.61%	0.24%	0.36%	11.13%	0.85%	0.06%	0.70%	5.49%	27.91%	0.47%	2.79%	0.43%	8.04%	1.45%	0.54%	0.11%	0.19%

	MX	NL	NZ	NO	PL	PT	RO	SK	SI	ES	SE	CH	TR	UK	US	BR	CN	RU
BG	0.32%	3.09%	0.10%	0.47%	1.45%	0.37%	2.17%	0.35%	0.77%	3.18%	1.17%	1.18%	7.94%	4.39%	6.88%	0.69%	2.47%	8.66%
CZ	0.18%	3.80%	0.05%	0.69%	4.60%	0.38%	0.67%	5.28%	0.66%	2.22%	1.47%	1.64%	0.85%	5.16%	4.36%	0.42%	1.76%	4.44%
EE	0.14%	3.34%	0.06%	2.62%	1.68%	0.26%	0.16%	0.21%	0.25%	1.06%	10.82%	0.93%	0.86%	4.81%	4.70%	0.42%	1.74%	14.38%
LV	0.12%	3.45%	0.08%	1.76%	2.91%	0.28%	0.19%	0.30%	0.40%	1.37%	7.41%	0.98%	0.66%	11.28%	4.58%	0.32%	1.57%	16.20%
LT	0.15%	3.86%	0.09%	1.62%	4.58%	0.32%	0.29%	0.30%	0.49%	2.07%	4.01%	1.74%	1.56%	6.93%	4.97%	0.31%	1.61%	17.57%
HU	0.25%	4.01%	0.07%	0.58%	2.70%	0.49%	2.17%	0.94%	0.91%	2.56%	1.67%	1.62%	1.21%	5.33%	5.66%	0.45%	1.64%	4.72%
PL	0.23%	4.64%	0.07%	1.54%	0.00%	0.47%	0.67%	0.83%	0.42%	2.34%	2.82%	1.27%	1.01%	5.89%	4.86%	0.65%	1.78%	6.55%
RO	0.24%	3.54%	0.08%	0.78%	1.38%	0.30%	0.00%	0.35%	0.47%	2.30%	1.07%	1.29%	5.25%	5.93%	6.36%	0.63%	3.03%	3.70%
SI	0.19%	2.95%	0.10%	0.56%	2.79%	0.29%	0.86%	0.74%	0.00%	1.95%	1.37%	1.46%	1.38%	3.67%	4.84%	0.39%	1.80%	8.50%
SK	0.17%	3.51%	0.05%	0.54%	4.82%	0.27%	0.90%	0.00%	0.73%	1.97%	1.27%	1.49%	0.92%	3.71%	3.89%	0.29%	1.45%	4.40%

Note. Partner countries are reported in the columns. The weights are averages over the period 1994 – 2008. The weights sum to 100% by row. Each country's own trade is set to zero. Source: European Commission.