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The Impact of the USD/EUR Exchange rate on Inflation in CEE Countries

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Croatian National Bank

June 14, 2007

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1 Introduction

During the last few years there are has been a growing empirical support for the idea that external factors might have a leading role in explaining business cycle in small open economies[1]. In particular, import prices and exchange rates were in the focus of empirical studies trying to determine main sources of inflation in small open economies. This paper suggests that the USD/EUR exchange rate might be considered as an additional important source of inflation in the Central and East European countries (CEEC) that was not explicitly analyzed in previous studies.

Despite different monetary and exchange rate regimes in the CEEC, it seems that there are some similarities in their inflation paths[2] that might be accounted for by the USD/EUR exchange rate fluctuations (as the Figure 1 shows). The figure shows a strong correlation between the first principal component[3] of CEEC annual consumer price inflation rates and the annual change in the USD/EUR exchange rate. This analysis is undertaken in order to better understand this empirical finding.

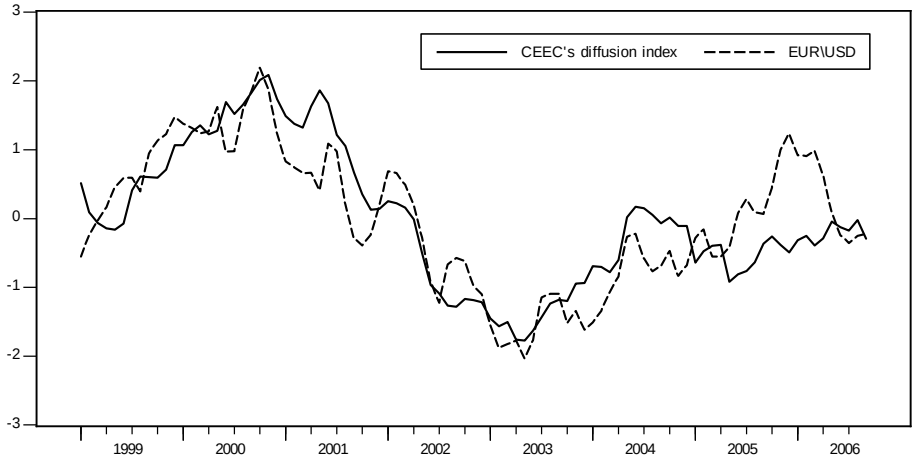

Figure 1: EUR/USD exchange rate and the principal component constructed as a maximum variance weighted average of 9 CEEC (Romania and Slovenia not included) annual inflation rates. Both series are standardised i.e. demeaned and divided by its standard deviation.

Our result might be important in the context of price stability requirement of Maas-

[1]See for example Canova (2003), Cushman and Zha (1995), Jones and Kutan (2004),Mackowiak (2005),Mackowiak (2006). Most of the empirical research on this topis was a reaction to *Old* Keynesian literature that was (unsuccesfully) explaining inflation solely as a domestic phenomenon (using a famous concept of natural rate of unemployment) in a closed economy environment. Before mentioned empirical research supports a microfounded new Keynesian theory of small open economy that takes into account external factors, in addition to domestic factors, in explaining determinants of prices. SeeObstfeld and Rogoff (1999) for a basic model of small open economy where the overall price index depends on domestic prices, import prices and the exchange rates.

[2]See Figure 7 in appendix.

[3]Principal component of a group of variables is maximum variance weighted average of those variables with weights coresponding to highest value eigenvector of group's correlation matrix.

tricht Criteria - in addition to internal challenges to keep the inflation low and dealing with the difficulties of price convergence process, the applicant countries could face problems out of their influence. Given that most of the CEEC peg their currency to Euro[4], either because of the conditions of the Exchange Rate Mechanism II (ERM-II) or because of their domestic issues (eurozation in particular), and taking into account a high volatility of USD/EUR exchange rate, our findings suggest that a high degree of price stability in the CEEC might be difficult to achieve. The problem is especially acute for the economies under a fixed or heavily managed exchange rate.

The decision to include USD/EUR exchange rate as a separate external factor is motivated by monetary and exchange rate regimes in the CEEC. Those countries are primarily concerned with the fluctuations of their exchange rate against euro: while all countries have to participate in the ERM-II, some countries use the exchange rate against euro (previously Deutsche Marks) to reduce imported inflation and anchor inflation expectations. Since the USD/EUR exchange rate is determined on global financial markets, individual country is not able to influence it (nor the world prices) - hence, it can not simultaneously *manage* both its bilateral exchange rate against euro and against the U.S. dollar. For this reason, we restrain from using the effective exchange rate which combines the managed exchange rate against euro and the exchange rate against dollar, that an individual country can not simultaneously influence[5]. Therefore, for countries with heavily managed exchange rate against euro, the USD/EUR exchange rate in fact represents an external shock. By focusing on stability of their local currency against euro, the CEEC effectively reduce the exchange rate pass-trough of the goods priced in euros to domestic inflation. However, since some commodities are priced in dollars there is still a pass-trough present from USD/EUR exchange rate and is amplified by the USD/EUR fluctuations.

Most previous studies of pass-through in CEEC focus on the effective exchange rates and assume that the individual country can influence it (for the survey of empirical studies of the pass-trough in the transition countries see Égert and MacDonald (2006)). Contrary to previous studies, we distinguish between local currency to euro exchange rate and USD/EUR rate and analyze what part of the variation in inflation in CEEC can be attributed to the USD/EUR exchange rate, as an external shock. In addition, we study to what extent does the USD/EUR exchange rate shocks influence inflation. Finally, we attribute the different impact of USD/EUR exchange rate on inflation among the CEEC to the different exchange rate regimes.

To measure the impact of USD/EUR exchange rate on domestic producer and consumer inflation across countries we employ an empirical model of pricing along a distribution chain, as in McCarthy (2000). The advantage of this model is that it has a Vector Autoregression (VAR) representation that allows us to trace the impact of exchange rate

[4]Exchange Rate Mechanism II (ERM-II) imposes +/- 15% fluctuations while some countries can adopt smaller bands. Crawling pegs and pegs to currencies other than the Euro are inconsistent with the ERM-II.

[5]Given that the CEEC primarily control their exchange rate against euro, most of the variation of their effective exchange rate comes from the impact of more volatile exchange rate against U.S. dollar rather than more stable price of euro. For that reason results implied by the regression analysis using effective exchange rate might be misleading.

fluctuations on inflation at each stage along the distribution chain (importers, producers, consumers). In comparison to McCarthy (2000) who studies a big open economy that can influence external factors, we adopt a small country assumption where domestic variables cannot influence external factors. In other words, we represent the model of pricing along the distribution chain in the CEEC by the VAR model with block exogenous restrictions (for external variables) in the spirit of Cushman and Zha (1995) [6]. The imposition of block exogeneity seems a reasonable way to identify foreign shocks from the point of view of the small open economies.

The paper is organized as follows. The second part illustrates the model of pricing along the distribution chain applied to the CEEC. The third part describes the VAR methodology with block exogenous restrictions. The fourth part describes data used, together with basic description of monetary and exchange rate regimes in the CEEC. Results, presented in the fifth chapter, are set up in such a way that first there is an in-depth analysis of the data for a case study- Croatia - in order to describe components of inflation (in a distribution) chain in more details. Results for other countries are then presented in more condensed form. The final chapter concludes.

2 The model of pricing along the distribution chain

Following McCarthy (2000), we set up a model of pricing along the distribution chain to examine the impact of external factors, in particular the USD/EUR exchange rate, on inflation in the CEEC. Due to unavailability of import prices data for many CEEC, our distribution chain consists of two stages[7]. Each stage corresponds to a particular type of inflation: producer prices inflation and consumer prices inflation, each comprised of several components. Each type of inflation is a function of previous period conditional expectation of inflation and contemporaneous shocks: supply shock, demand shock, exchange rate shock (either USD/EUR exchange rate shock in case of heavily managed exchange rate of local currency against euro or both USD/EUR exchange rate shock and the shock to exchange rate of local currency against euro in case of looser exchange rate regime[8]), the shock to inflation at previous stage of the distribution chain as well as its own shock.

Supply shock is identified from the world primary commodity prices expressed in U.S. dollars[9]. The USD/EUR exchange rate shock is identified from the behavior of

[6] Our approach is similar to Mackowiak (2005) who measured the impact of external shocks on some of the CEEC. He found that most of the volatility in main macro variables comes from abroad.

[7] Instead of 3 as in McCarthy (2000).

[8] The value of a country's currency can be expressed bilaterally against any other currency. Thus we could include in the VAR both exchange rate of national currency against USD and against EUR. Both bilateral rates would in this case be a part of the domestic VAR block. However, although a country can influence any bilateral rate, the ratio of such bilateral rates is exogenously given by the USD/EUR exchange rate which is set on the international financial market ($\frac{DC}{EUR}/\frac{DC}{USD} = \frac{USD}{EUR}$). Since all CEEC are pegged to euro either directly or throught the ERM-II, we focus on the bilateral exchage rate against EUR, and take echange rate of USD/EUR as given.

[9] Despite the growing international role of the euro, prices of most tradables, especially commodities, are formed in U.S. dollars. Actual transaction may take place in any currency even though the price is set in U.S. dollars, which limits the potential use of the information about the invoicing currency

the USD/EUR exchange rate after taking into account the supply shock. These two shocks make the exogenous block that is unaffected by the domestic business cycle[10]. In comparison to the previous studies that combine the two external shocks (to save some degrees of freedom, see for example Mackowiak (2005)) our intention is to analyze the impact of each external factor separately to see which of the two has the dominant role. Demand shock is identified from the dynamics of the output gap after taking into account the supply shock and the exchange rate shock. The shock to the exchange rate of local currency against euro (in cases of *looser* exchange rate regime) is identified from the behavior of the exchange rate of local currency against euro after taking into account the supply shock, the USD/EUR exchange rate shock and the demand shock. Last two shocks (demand shock and local currency against euro shock), together with the dynamics of producers and consumers inflation will be the part the domestic block, that can be affected by the exogenous block.

The structure of the model suggests that the model can be cast into a recursive VAR model. Hence it can be estimated to explore the impact of external factors, in particular the impact of the USD/EUR exchange rate, on inflation rates in CEEC.

3 Methodology - Vector Autoregression Analysis with block exogeneity restrictions

Here we describe a simple VAR model constructed to identify properly foreign shocks and their impact on domestic fluctuations in a small open economy environment.

Let y_1 be an n_1 dimensional vector of external variables. Let y_2 be an n_2 dimensional vector of domestic (small open economy) variables. We combine both vectors in $y = [y_1, y_2]'$. Now consider a dynamic system of equations:

$$\sum_{s=0}^{p} A_s y_{t-s} = \varepsilon_t, \tag{1}$$

where A_0 is (regular) contemporaneous matrix of coefficients, $\{\varepsilon_t\}_{t=0}^{\infty}$ are i.i.d. random vectors with multivariate normal distribution $MVN(0, I)$, and A_j are block lower triangular matrices of dimension $(n_1 + n_2) \times (n_1 + n_2)$, that have the following form:

$$A_j = \begin{bmatrix} A_{11}^j & 0 \\ A_{21}^j & A_{22}^j \end{bmatrix}, \ j = 0, \ldots, p.$$

for determining the role of foreign currencies in country's trade. For that reason, and in the absence information about individual countries' import prices, we use the world commodity prices (IMF) expressed in U.S. dollars in order to model the import price inflation.

[10] Due to shortness of data and unavailability of some of the series we were forced to adopt more parsimonious approach by reducing the number of external variables. By focusing on the (indirect) exchange rate pass-trough as a model for describing inflation dynamics, we dismiss a number of other potential external shocks which could also affect a country (for example foreign interest rates or foreing demand shock). However, it seems that a number of shocks are mutually correlated (for example GDP gap in Germany, interest rate in Euro zone and the USD/EUR exchange rate) and the model could be reduced to save degrees of freedom from already short series for countries under the investigation.

Submatrices A_{lk}^{j} are of $n_l \times n_k$ dimension for $l, k = 1, 2$ and $j = 1, \ldots, p$.

The form of A_j assumes block exogeneity restrictions which represent the underlaying idea that foreign shocks can affect a small open economy, but not the other way around.

After multiplication by A_0^{-1}, equation (1) yields corresponding reduced form VAR model:

$$y_t = \sum_{s=1}^{p} B_s y_{t-s} + \eta_{t,} \tag{2}$$

where $A_0^{-1}\varepsilon_t = \eta_t \sim MVN(0, \Sigma_\eta)$ and $B_j = A_0^{-1}A_j$ for $j = 0, \ldots, p$. It can be shown (see Lütkepohl (2005)) that matrices of coefficients B_t inherits[11] block exogeneity form so that:

$$B_j = \begin{bmatrix} B_{11}^{j} & 0 \\ B_{21}^{j} & B_{22}^{j} \end{bmatrix}, \; j = 1, \ldots, p.$$

Note that this is equivalent to the statement that domestic block does not Granger cause foreign block variables, i.e. that domestic block does not help to forecast (in MSE sense) values for variables in the foreign block. This is a standard and testable assumption when modelling small open economy's reaction to foreign shocks.

Given the autoregressive representations (1) and (2), we can derive corresponding moving average representations:

$$\begin{aligned} y_t &= (A_0 - A_1 L + \ldots + A_p L^p)^{-1}\varepsilon_t = & (3)\\ &= (D_0 + D_1 L + D_2 L^2 + \ldots +)\varepsilon_t = & (4)\\ &= D(L)\varepsilon_t & (5) \end{aligned}$$

and

$$\begin{aligned} y_t &= (I - B_1 L - \ldots - B_p L^p)^{-1}\eta_t = & (6)\\ &= (I + C_1 L + C_2 L^2 + \ldots +)\eta_t = & (7)\\ &= C(L)\eta_t & (8) \end{aligned}$$

Given reduced form residuals η_t with corresponding estimate Σ_η (having $\frac{n(n+1)}{2}$ unique elements) and coefficient matrices B_i and C_i, one needs to recover impulse responses - $D_{i,}$ subject to normalization condition - $\Sigma_\eta = A_0^{-1}A_0^{'-1}$. In order to identify A_0, we need to impose at least $\frac{n(n-1)}{2}$ additional restrictions. For that purpose, let us define $\varepsilon_t = A_0\eta_{t,}$ where A_0 is a lower triangular Cholesky factor[12] of noise covariance matrix Σ_η. It follows that $E[\varepsilon_t\varepsilon_t^{'}] = E[A_0\eta_t\eta_t^{'}A_0^{'}] = A_0E[\eta_t\eta_t^{'}]A_0^{'} = A_0\Sigma_\eta A_0^{'} = I$ and orthogonality holds. For alternative types of identification see Cushman and Zha (1995) and Mackowiak (2005).

[11] Lower triangularity is also inherited in $MA(\infty)$ representation of VAR procces which implies no response of foreign variables to small open economy's shocks. See Lütkepohl (2005) for details.

[12] A_0 is a lower triangular matrix such that $A_0^{-1}(A_0^{-1})^{'} = \Sigma\eta$. Such a decomposition allways exists for a symmetric and positive-definite matrix. It can be shown that every covariance matrix is a symmetric and positive-definite.

Pursuing this type of identification, the ordering in y becomes crucial, and accordingly robustness needs to be investigated. Reduced form VAR model was estimated applying the feasible least squares estimator (FLSE) using jMulti. Details concerning the estimation and structural analysis of VAR processes with parameter constraints (restrictions) and the type of (2) models can be found in Lütkepohl (2005).

4 Data

The data was taken from the IMF's International Financial Statistics (IFS) database. For the external block, which is the same for all countries, we use IMF's Primary Commodity Price Index (WP_t) as a measure of world prices and the USD/EUR exchange rate (USD/EUR_t)[13]. Domestic block consists of output gap, defined as the deviation of GDP (in constant prices) from its trend (Gap_t)[14], exchange rate of local currency against euro (ER_t) , producers price index (PPI_t) and consumer price index (CPI_t) for each country. ER_t was calculated as a product of the local currency to U.S. dollar rate and USD/EUR rate[15]. All the data are logged quarterly averages (prices, exchange rate) of the time period 1998 (first quarter)-2006 (third quarter). We take the first differences of looged data to remove the unit root present in the series.

Table 1. Monetary and exchange rate regimes and inflation in CEECs

	Monetary regime	Changes in monetary regime since 1998
Bulgaria	Currency board	
Croatia	Managed float	
Estonia	Currency board	
Latvia	Peg to euro ± 1%	2004: Re-pegged its currency from SDR to EUR
Lithuania	Currency board	2002: Re-pegged its currency from USD to EUR
Slovenia	Euro	2007: Adopted euro; previously: managed floating:
Czech Republic	Inflation targeting	
Hungary	Inflation targeting	
Poland	Inflation targeting	2001 changed from managed to independent floating
Romania	Inflation targeting	2001 changed from managed float to crawling bands
Slovak Rep.	Inflation targeting	previously: managed floating

The most serious problem with the CEEC data are structural breaks. The first kind of structural breaks pertains to the undergoing transition process that can affect parameter stability. In our analysis, we dismiss this type of structural breaks as we are looking at the late phase of transition. However, the second kind of structural breaks - changes in monetary and exchange rate regimes - present much more serious problems since they might affect the price formation process that we analyze. As shown in the Table 1, a regime change occurred in most countries under the investigation. Due to lack of data, we do not model the structural breaks; instead, we will not consider the result of those

[13]Prior to introduction of euro, we used DEM/USD exchange rate and transform it into EUR using the DEM/UEUR conversion rate, sinced the DEM was the single most important currency for the CEEC.

[14]Real GDP data are not available for Bulgaria and Romania- industrial production was used instead.

[15]For countries with fixed exchange rate the calculated rate needed to be adjusted to remove the calculation mistakes.

countries that experienced the most serious regime change during the period under the examination.

We group countries according to different monetary and exchange rate regimes in two ways: by type of regime currently in place and by the severity of the regime change those countries undertook during the period under the investigation.

From the point of the existing monetary regime, we distinguish between exchange rate targeters and inflation targeters. Exchange rate targeters include countries with fixed exchange rate to euro or the ones with small oscillations vis-a-vis euro. The extreme example is Slovenia which adopted euro at the beginning of 2007. There are two currency boards (Bulgaria and Estonia), a fixer (Lithuania), one country with a tight (1%) exchange rate band (Latvia), and a managed floater (Croatia). Those countries seem as perfect candidates for this type of analysis since the USD/EUR exchange rate corresponds to their exchange rate against U.S. dollar. The other group consists of inflation targeters: Czech Republic, Hungary, Poland, Romania and Slovak Republic. However, there are significant differences among them in terms of exchange rate stability vis-a-vis euro (see table 2)

Table 2. Consumer price index/Exchange rates correlations and coefficients of variation (standard deviation divided by mean)

	Bu	Ee	Cz	Cr	Hu	La	Li	Pl	Ro	Sk	Sl
Correlations											
CPI-DC./EUR	-0.10	0.03	-0.26	-0.13	-0.04	-0.01	-0.08	-0.17	0.66	0.00	0.62
CPI-EUR/USD	0.38	0.40	0.07	0.58	0.29	0.11	0.29	0.52	0.41	0.03	0.25
Coeff. of variation											
LC/EUR	0.00	0.00	0.08	0.02	0.03	0.09	0.10	0.07	0.34	0.06	0.09
LC/USD	0.14	0.14	0.18	0.14	0.14	0.05	0.17	0.11	0.13	0.18	0.13

LC = local currency.

Bulgaria (Bu), Croatia (Cr), Czech Republic (Cz), Estonia (Ee), Hungary (Hu), Latvia (La), Lithuania (Li), Poland (Pl), Romania (Ro), Slovak Republic (Sk), Slovenia (Sl)

Unfortunately, some of the countries undertook the significant regime change which creates a significant difficulty in interpreting the results form the estimated VAR model. On one extremes are Slovenia and Romania that tried to achieve real exchange rate stability and have gone through gradual disinflation and depreciation before achieving price stability. A serious policy change from the perspective of our analysis occurred in two Baltic countries which changed the currency peg to euro. The most interesting case is Lithuania which repegged from U.S. dollar to euro in February 2002. This shift should lead to a change of sign in the estimated USD/EUR exchange rate pass-trough coefficients. A similar case is Latvia which repegged from SDR to euro in February 2004. Because of the estimation problems in case of Slovenia and Romania as a result of regime shifts we exclude those two countries from our analysis[16]. Furthermore, due to the short

[16]Slovenia and Romania experienced gradual disinflation, and their prices and the exchange rate are integrated of second order - I(2). Those series were differentiated twice to achieve stationarity, but this produces some difficulties in interpreting the results.

sample, we are unable to model the regime in Latvia and Lithuania, so we also exclude them from our analysis.

The most interesting for our analysis are countries with fixed (or managed) exchange rate to DEM prior to 1999 and EUR afterwards (Bulgaria, Croatia and Estonia). We compare their results with countries that moved from more managed to less managed regime - usually in the form of inflation targeting (Czech Republic, Hungary, Poland, Slovak Republic) - before or during the period under the investigation.

Prior to the estimation, we test the block exogeneity restrictions on constrained VAR specifications in order to find out whether such constraints are supported by actual CEEC's data. We have already mentioned that block exogeneity is equivalent to the fact that domestic block does not Granger cause foreign block. Given Wald test's p-values from table 3, we conclude that a priory exogenous restrictions in VAR specification have been well chosen. Details on multivariate Granger causality can be found in Lütkepohl (2005).

Table 3: Null hypothesis: domestic block does not Granger-cause foreign block

	Bu	Cr	Cz	Ee	Hu	Po	Sk
p-value	0.071	0.915	0.221	0.116	0.182	0.492	0.404

Bulgaria (Bu), Croatia (Cr), Czech Republic (Cz), Estonia (Ee), Hungary (Hu), Poland (Po), Slovak Republic (Sk)

5 Country Case Study: Croatia

Monetary policy in Croatia uses the exchange rate against euro to anchor both import prices and inflation expectations. This policy was implemented during the successful Stabilization Program of 1993 which ended hyperinflation and brought inflation to single digits ever since. In addition to stabilizing inflation, this policy helps to ensure the stability of largely eurolized financial system. The exchange rate is not fixed: the Croatian National Bank (CNB) intervenes to prevent large and sudden oscillation in exchange rate. As the result, the exchange rate against euro has been very stable with small oscillations from 12-year average. During the last 6 years, exchange rate volatility decreased further.

Given the prominent role of the exchange rate, there has been a lot of interest in examining the exchange rate pass-trough in Croatia. Most studies (Billmeier and Bonato (2002), Gattin-Turkalj and Pufnik (2002) and Maoduš (2006)) used a VAR approach (without block restrictions) in order to measure the EUR/HRK (DEM/HRK) exchange rate pass-trough. This however, did not yield any significant result due to EUR/HRK exchange rate stability[17].

[17] Either the exchange rate volatility has been to low to give statistically significant result, or fixing the exchange rate to euro reduced inflation expectations to the point that existing volatility was lower than the costs of changing prices.

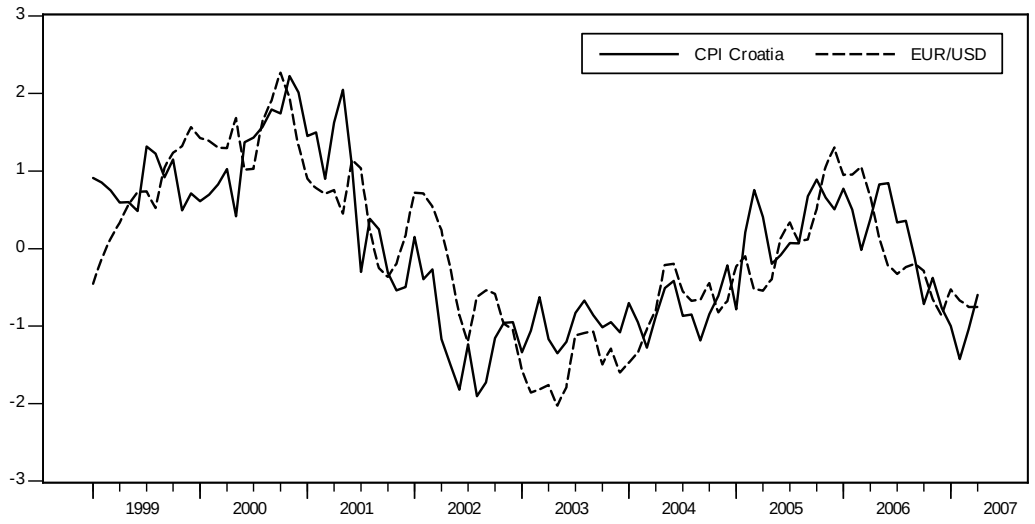

Figure 2: EUR/USD exchange rate (annual changes) and Croatia's annual CPI inflation. Both series are normalized.

Table 4: Studies of pass-trough for Croatia

	Methodology	Period
Billmeier and Bonato (2002)	$VAR(\pi^{\text{WP}}, Output\ gap, \Delta dem/hrk, \pi^{\text{PPI}}, \pi^{\text{RPI}}, \Delta m4)$	1994/1-2001/1
Turkalj and Pufnik (2002)	$VAR(\pi^{\text{WP}}, Output\ gap, \Delta dem/hrk, \pi^{\text{PPI}}, \pi^{\text{RPI}}, \Delta m1)$	1994/1-2001/1
Maoduš (2006)	$VAR(\pi^{\text{WP}}, Output\ gap, \Delta dem/hrk, \pi^{\text{PPI}}, \pi^{\text{RPI}}, i, \Delta m4)$	1994/1-2005/12

Our motivation to include the USD/EUR exchange rate stems from the high correlation between the CPI inflation in Croatia and the annual change of the USD/EUR exchange rate (Figure 2). By including the USD/EUR exchange rate, we manage to account for the USD/EUR exchange rate pass-through in which the prices change due to the volatility of the USD/EUR exchange rate. This might suggest that through the stable HRK/EUR exchange rate policy, the Croatian National Bank reduced the inflation to the level that external shocks (USD/EUR volatility in particular) became almost solely responsible for the inflation variations.

When estimating the VAR, we looked into a few different setups. Most importantly, we tried to estimate the VAR with and without the exchange rate of the local currency against euro. The reason for this is that the oscillations in the HRK/EUR exchange rate were too small to have any material impact on inflation. Although the VAR model with the HRK/EUR exchange rate produces impulse responses of expected signs, results are not statistically significant. In order to save some degrees of freedom, we completely remove the HRK/EUR from the VAR model[18]. The VAR lag length of two quarters is a compromise between the length of the series (number of data) and the time of the full impact of

[18]Removing the local currency exchange rate from the model in effect assumes exchange rate stability, which corresponds to the CNB's policy. A similar reduction of variables was done in the case of two other countries with fixed exchange rate vis-a-vis EUR (Bulgaria and Estonia).

the exchange rate shock to manifest itself on prices. After checking for all the necessary diagnostics (see Table 10. in Appendix) we estimate (2) for Croatia with the exogenous block $y_{1t} = [WP_t, USD/EUR_t]'$ and the domestic block $y_{2t} = [Gap_t, PPI_t, CPI_t]'$.

The variance decomposition of the specified VAR model shows that external shocks have large impact on the variation of domestic variables: output gap and prices (PPI and CPI). With a two year horizon, (8 quarters ahead), shocks in the world commodity prices and the USD/EUR exchange rate account for more than a half of variation of all domestic variables: output gap (54%), PPI (60%) and CPI (65%). In addition, the USD/EUR seems to give rise to more variation of consumer inflation rate than the world commodity prices[19] and for PPI the world commodity prices seem to have more prominent role.

Table 5: Variance decomposition for Croatia

	Qtr's ahead	Wpc	USD/EUR	Ex. shocks	Gap	PPI	CPI
Output Gap	t+1	0.02	0.27	0.29	0.71	0	0
	t+8	0.1	0.44	0.54	0.4	0.06	0
PPI	t+1	0.21	0.17	0.38	0.01	0.61	0.00
	t+8	0.41	0.19	0.60	0.03	0.35	0.01
CPI	t+1	0.24	0.42	0.66	0	0.01	0.32
	t+8	0.32	0.33	0.65	0.06	0.13	0.15

Impulse responses show that the world commodity prices shock affects domestic variables through a few different channels. Producer costs (PPI), and to some extent also consumer prices, are immediately affected. With a time lag, producer prices shock is then further transmitted to consumers prices in form of higher costs. A similar channel also works for the USD/EUR exchange rate shock: euro appreciation against dollar (appreciation of kuna) instantly reduces the producer costs[20] and to a slightly less extent also consumer prices which suggests that prices of goods that represent a significant share of the consumer basket strongly react to world market movements, which is also confirmed from the disaggregated data (see next section). Here an important channel goes from producer costs to prices of consumer goods, which is in line with theory and the logic that the USD/EUR exchange rate to a large extent works as an important cost factor. Since we use quarterly frequency, it is possible that there is an immediate effect of PPI to CPI.

Given that the share of Croatian import goods priced in U.S. dollars is about 20% can we really trust our results of the USD/EUR exchange rate having an important influence on both the extent and volatility of inflation in Croatia? In other words, taking into

[19] We have also estimated a similar VAR (as in Mackowiak (2005)) with world prices denominated in EUR and therefore USD/EUR rate has been excluded from this specification. Results were similar as in table 5. For example, variance decomposition exercise suggested that for 8 quarters ahead 18% of output gap variance is due to external shock (world prices in EUR) which is signifficantly less then in table 5 (54%). In addition, 58% PPI's variance is due to external shock (60% in table 5.) and 48% for CPI (65% in table 5.). These results were considered as a further justification for the inclusion of EUR/USD exchange rate in our analysis.

[20] Notice that with the 95% confidence interval of bootstrapp bands the impulse response of PPI to the USD/EUR exchange rate in not significantly different from zero. However, this is not true if we consider 68% intervals, as proposed in Sims and Zha (1999).

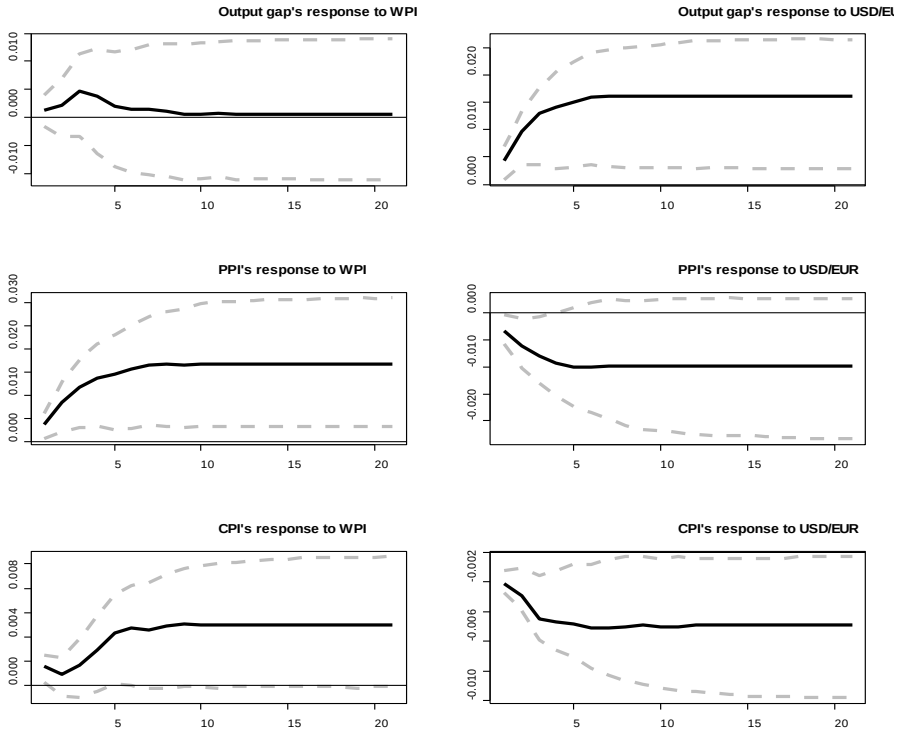

Figure 3: Accumulated responses to one standard deviation foreign shocks (Efron-type error bands based on 1500 bootstrap replications)

account that Croatian imports are largely prices in euros (about 80%) one might expect that the imported inflation should correspond to a large extent to the inflation in Euro zone and fluctuations of the HRK/EUR exchange rate. However, inflation in Euro zone was very low for many years whereas the HRK/EUR exchange rate was quite stable. On the other hand, fluctuations of world prices expressed in dollar and especially the USD/EUR exchange rate *were on a spree* during the whole period under investigation. Then, the question is the following: is it possible that the fluctuation of the USD/EUR exchange rate (hence the HRK/USD exchange rate) were so much bigger than that of HRK/EUR exchange rate that the fluctuation of the value of overall imports (i.e. imports price inflation) was to a large extent influenced by a fluctuation of the USD/EUR exchange rate? Figure 5 gives some suggestive answer to this question. The figure shows the annual change of nominal effective exchange rate (with the weight on HRK/USD equal to 0.2 and that of HRK/EUR 0.8), annual change of the HRK/USD exchange rate and annual change of the HRK/EUR exchange rate. We see that the HRK/USD exchange rate, because of its large volatility, is an equally strong driving force of nominal effective exchange rate even tough its weight is four time smaller than that of HRK/EUR exchange rate.

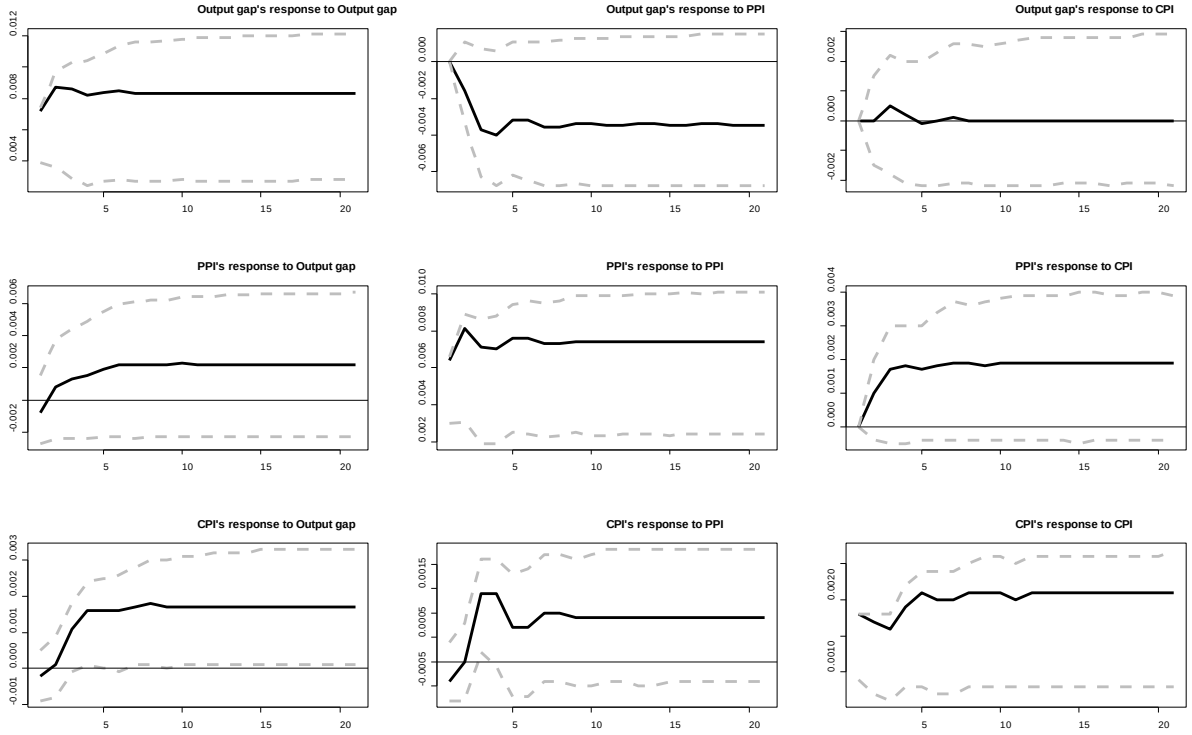

Figure 4: Accumulated responses to one standard deviation domestic shocks (Efron-type error based on 1500 bootstrap replications)

5.1 Evidence from micro data

In order to understand the impact of the USD/EUR exchange rate we need additional insight into the price formation process. For that purpose we examine prices of individual items (categories) of the consumer basket[21]. The analysis is simple yet illustrative: we calculate simple correlations between annual rates of change of individual components of consumer basket and the USD/EUR exchange rate. Our hypothesis is that there should be a negative correlation between the USD/EUR rate and tradable products whose prices are expressed in dollars (and whose prices became cheaper when euro against dollar appreciates - and thus also kuna against dollar).

Table 11 in appendix shows that the largest correlations correspond to individual products mostly produced in Asia (and thus priced in U.S. dollars): household appliances (-0.73), glassware and tableware utensils (-0,69), clocks, watches and jewelry (-0,59), toys (-0,59), footwear (-0,52), garments (-0,50) etc.; and products with a large share of oil (also priced in U.S. dollars) in their total costs: passenger transport by road (-0,65), fuels and lubricants for personal transport equipment (-0,64), air-transport (-0,54) etc. On the other hand, most of the (non-travel) services, food and other non-tradables are not correlated with the USD/EUR exchange rate. This is in line with our hypothesis about

[21] Unfortunately, we do not have data on individual products, which are instead bundeled in 120 categories of consumption.

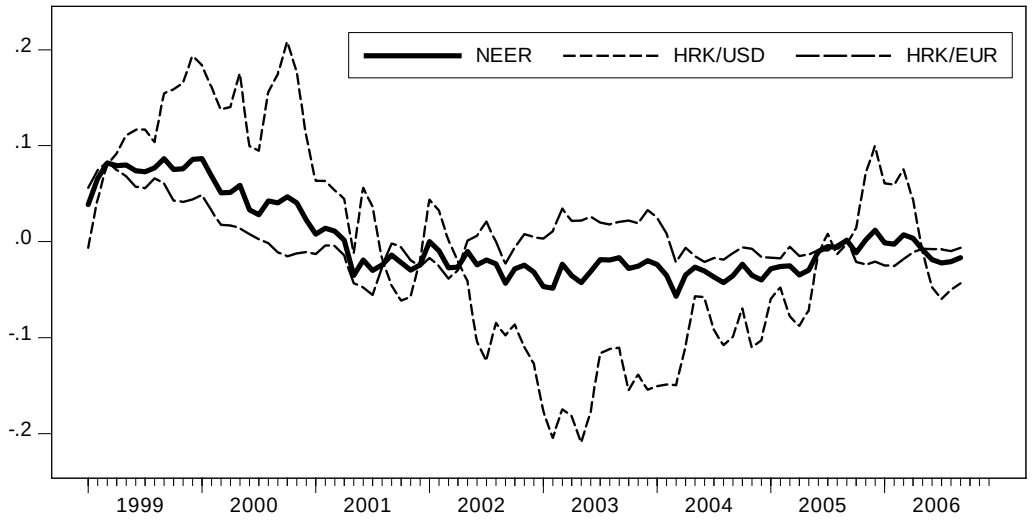

Figure 5: Y-o-y growth rates of Nominal effective exchange rate (NEER), HRK/USD and HRK/EUR exchange rates. Coefficent of correlation beetween NEER and HRK/USD is 0.85 and 0.65 between NEER and HRK/EUR exchange rate.

the way how the USD/EUR rate influences inflation[22].

6 Does the impact of USD/EUR exchange rate vary among CEEC?

Finding that the external shocks, especially the USD/EUR exchange rate, account for most of the inflation volatility in Croatia and given our logic of this influence suggest that the same might be the case in other similar countries (at least in countries with the similar exchange rate regime). In order to explore this issue further, we repeat the VAR analysis for other CEEC. We consider the same period for all countries (1998-2006) in order to expose them to the same external shocks. A similar VAR specification is used: quarterly VAR model with two lags. The only difference between countries is whether we include the exchange rate of the local currency against euro - in countries with stable exchange rate we exclude it from the model.

Variance decomposition shown in tables 6 and 7 indicates that external shocks account for a large share of price volatility (both PPI and CPI) in all countries regardless of the policy regime. This is, however, due to the movement of the world commodities prices. The impact of USD/EUR in explaining the inflation variance is greater in countries with

[22]The interesting result is that aggregated categories of consumption are often more correlated with the USD/EUR exchange rate than individual goods and services (with CPI aggregate more correlated with the exchange rate than any of its components). This could be due to the substitution effect in which consumers shift their consumption from products priced in the U.S. dollars when dollar appreciates and vice versa. This, however, has yet to be examined.

stable exchange rate against euro (Bulgaria and Estonia). Interestingly, the largest share of the price variance is explained by the USD/EUR exchange rate for Croatia.

Table 6. PPI's variance decomposition

	Qtr's ahead	Wpc	USD/EUR	Ex. shocks	Gap	Dom. curr./EUR	PPI	CPI
Croatia	t+1	0.21	0.17	0.38	0.01	/	0.61	0.00
	t+8	0.41	0.19	0.60	0.03	/	0.35	0.01
Estonia	t+1	0.07	0.14	0.21	0.02	/	0.77	0.00
	t+8	0.17	0.26	0.43	0.02	/	0.50	0.05
Bulgaria	t+1	0.70	0.00	0.70	0.00	/	0.30	0.00
	t+8	0.65	0.10	0.75	0.06	/	0.19	0.01
Czech	t+1	0.49	0.00	0.49	0.04	0.01	0.47	0.00
	t+8	0.68	0.02	0.70	0.12	0.05	0.09	0.04
Slovak	t+1	0.10	0.02	0.12	0.01	0.00	0.87	0.00
	t+8	0.16	0.20	0.36	0.04	0.04	0.56	0.01
Poland	t+1	0.36	0.00	0.36	0.01	0.27	0.35	0.00
	t+8	0.33	0.03	0.36	0.04	0.29	0.21	0.10
Hungary	t+1	0.00	0.04	0.04	0.03	0.37	0.56	0.00
	t+8	0.08	0.27	0.35	0.18	0.18	0.26	0.04

Table 7. CPI's variance decomposition

	Qtr's ahead	Wpc	USD/EUR	Ex. shocks	Gap	Dom. curr./EUR	PPI	CPI
Croatia	t+1	0.24	0.42	0.66	0	/	0.01	0.32
	t+8	0.32	0.33	0.65	0.06	/	0.13	0.15
Estonia	t+1	0.33	0.23	0.56	0.00	/	0.10	0.33
	t+8	0.23	0.29	0.52	0.06	/	0.24	0.19
Bulgaria	t+1	0.14	0.16	0.30	0.06	/	0.07	0.57
	t+8	0.17	0.23	0.40	0.06	/	0.09	0.45
Czech	t+1	0.03	0.06	0.09	0.07	0.03	0.02	0.80
	t+8	0.56	0.06	0.62	0.15	0.03	0.02	0.18
Slovak	t+1	0.00	0.06	0.06	0.01	0.00	0.69	0.23
	t+8	0.14	0.04	0.18	0.04	0.18	0.45	0.16
Poland	t+1	0.32	0.12	0.44	0.00	0.08	0.03	0.45
	t+8	0.27	0.04	0.31	0.01	0.21	0.07	0.39
Hungary	t+1	0.13	0.00	0.13	0.25	0.08	0.01	0.53
	t+8	0.08	0.19	0.27	0.24	0.21	0.11	0.18

The size of the impact of different shocks is measured using impulse responses for each country (Table 8). Directions of the impulses are as expected for most countries. Only one (Slovakia) shows *wrong* sign of the impact of the USD/EUR exchange rate shock on the CPI. In all other countries, euro appreciation against dollar leads to drop in prices. The size differs and 2 years after the shock ranges from -0.08 for Poland to -0.3 for Bulgaria. Again, larger effect is present in countries with stable exchange rate to euro.

This result is partially supported by the impact of the local currency (to euro) shock on inflation. Again, for all countries it has the expected direction and ranges from 0.10 for Czech R. to 0.56 for Hungary.

Table 8: CPI's response on one unit residual shock.

Impulse		Bu	Cr	Cz	Ee	Hu	Pl	Sk
wpc	t+1	0.05	0.01	0.04	0.06	0.03	0.07	0.06
	t+4	0.10	0.07	0.14	0.07	-0.01	0.15	-0.01
	t+8	0.15	0.08	0.30	0.11	0.02	0.20	-0.01
USD/EUR	t+1	-0.16	-0.08	-0.05	-0.12	0.02	-0.05	0.06
	t+4	-0.30	-0.13	-0.07	-0.22	-0.05	-0.07	0.08
	t+8	-0.32	-0.13	-0.14	-0.20	-0.18	-0.08	0.06
gap	t+1	-0.03	0.01	-0.55	0.00	0.57	0.05	0.13
	t+4	0.00	0.19	0.10	0.33	0.97	0.16	0.89
	t+8	-0.01	0.20	2.22	0.22	-0.34	0.16	1.55
DC/EUR	t+1	/	/	-0.01	/	0.19	0.10	0.16
	t+4	/	/	0.10	/	0.61	0.24	0.47
	t+8	/	/	0.10	/	0.56	0.35	0.49
ppi	t+1	0.33	0.00	0.16	0.50	0.21	0.34	0.71
	t+4	0.44	0.09	0.43	1.55	0.75	0.62	1.16
	t+8	0.43	0.11	0.43	1.39	0.23	0.83	1.03
cpi	t+1	0.52	0.53	1.09	0.56	1.06	0.95	0.59
	t+4	0.64	0.65	1.32	0.32	1.01	2.11	0.86
	t+8	0.58	0.65	1.41	0.06	0.49	3.17	0.74

Bulgaria (Bu), Croatia (Cr), Czech Republic (Cz), Estonia (Ee), Hungary (Hu), Poland (Po), Slovak Republic (Sk)

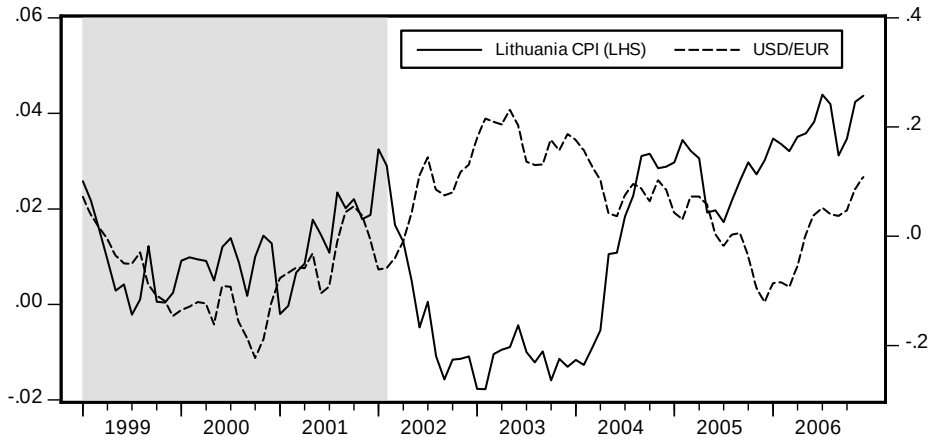

Figure 6: Correlation between CPI inflation in Lithuania and USD/EUR. Lithuania repegged from the USD to EUR in February 2002. As the result, the correlation between inflation and USD/EUR changed from 0.46 during the 1999-2002m1 (shaded area) to -0.69 from 2002m2-2006.

Although the lack of data may prevent it from conducting a proper econometric analysis, countries which changed their exchange rate policy represent a natural experiments for our hypothesis. The prime candidate is Lithuania that changed the peg from dollar to euro in February 2002. As it shown in the Figure 6, there has been the *expected* change in the direction (sign) of correlation between the USD/EUR exchange rate from positive to negative. The depreciation of dollar against euro seems to have contributed to deflation Lithuania faced after the policy shift. The euro appreciation in 2006, however, did not

have an immediate effect to the Lithuanian CPI due to domestic factors (liberalization of administrative prices in particular), and Lithuania barely missed the inflation criterion for joining the eurozone.

7 Conclusion

Our empirical analysis shows that in countries with stable exchange rate to euro, fluctuations of USD/EUR exchange rate might be one of the leading factors responsible for inflation variation. This might due to the fact that stable exchange rate managed to bring down the major external sources of inflation coming from price changes of euro-denominated goods (anchoring also domestic inflation expectations). Taking into account large fluctuations of USD/EUR exchange rate the policy of stable exchange rate of local currency against euro is leaving the external shock of dollar-denominated goods to dominate. Therefore, in the case of a significant appreciation of dollar in the run-up to the eurozone, our findings suggest that in such countries inflationary (external) shocks might need to be dealt with using other economic policies (instead of the monetary policy). The 1.5% buffer in the Maastricht criteria might not be enough to accommodate the rising inflation in the case of larger dollar appreciation.

A Appendix

Table 9. Output gap's variance decomposition

	Qtr's ahead	Wpc	USD/EUR	Ex. shocks	Gap	Dom. curr./EUR	PPI	CPI
Croatia	t+1	0.02	0.27	0.29	0.71	/	0	0
	t+8	0.1	0.44	0.54	0.4	/	0.06	0
Estonia	t+1	0.03	0.03	0.06	0.94	/	0.00	0.00
	t+8	0.09	0.04	0.13	0.52	/	0.30	0.04
Bulgaria	t+1	0.07	0.18	0.25	0.76	/	0.00	0.00
	t+8	0.16	0.16	0.32	0.54	/	0.01	0.13
Czech	t+1	0.00	0.04	0.04	0.96	0.00	0.00	0.00
	t+8	0.44	0.16	0.60	0.39	0.01	0.00	0.00
Slovak	t+1	0.13	0	0.13	0.87	0.00	0.00	0.00
	t+8	0.09	0.01	0.10	0.75	0.05	0.05	0.04
Poland	t+1	0.00	0.03	0.03	0.96	0.00	0.00	0.00
	t+8	0.26	0.20	0.46	0.44	0.02	0.04	0.04
Hungary	t+1	0.01	0.00	0.01	0.99	0.00	0.00	0.00
	t+8	0.04	0.23	0.27	0.63	0.02	0.06	0.02

Table 10. Portmanteau test for autocorrelation (lag=12) and stability conditions

	Bu	Cr	Cz	Ee	Hu	Po	Sk
Portmanteau test (p-values)	0.08	0.57	0.10	0.10	0.12	0.08	0.04
Root's modulus (minimum)	1.41	1.44	1.10	1.17	1.11	1.12	1.24

In table 10 we provide results from Portmanteau test for autocorrelation. In addition we report the minimum modulus root from determinantal polynomial $det(I - A_1 z - -A_p z^p)$, A_j denoting reduced form VAR coefficient matrices. The VAR process is stable if this polynomial has no roots in or on the complex unit circle (see Lütkepohl (2005))- sufficient condition for stability is that the minimal modulus is greater than unity.

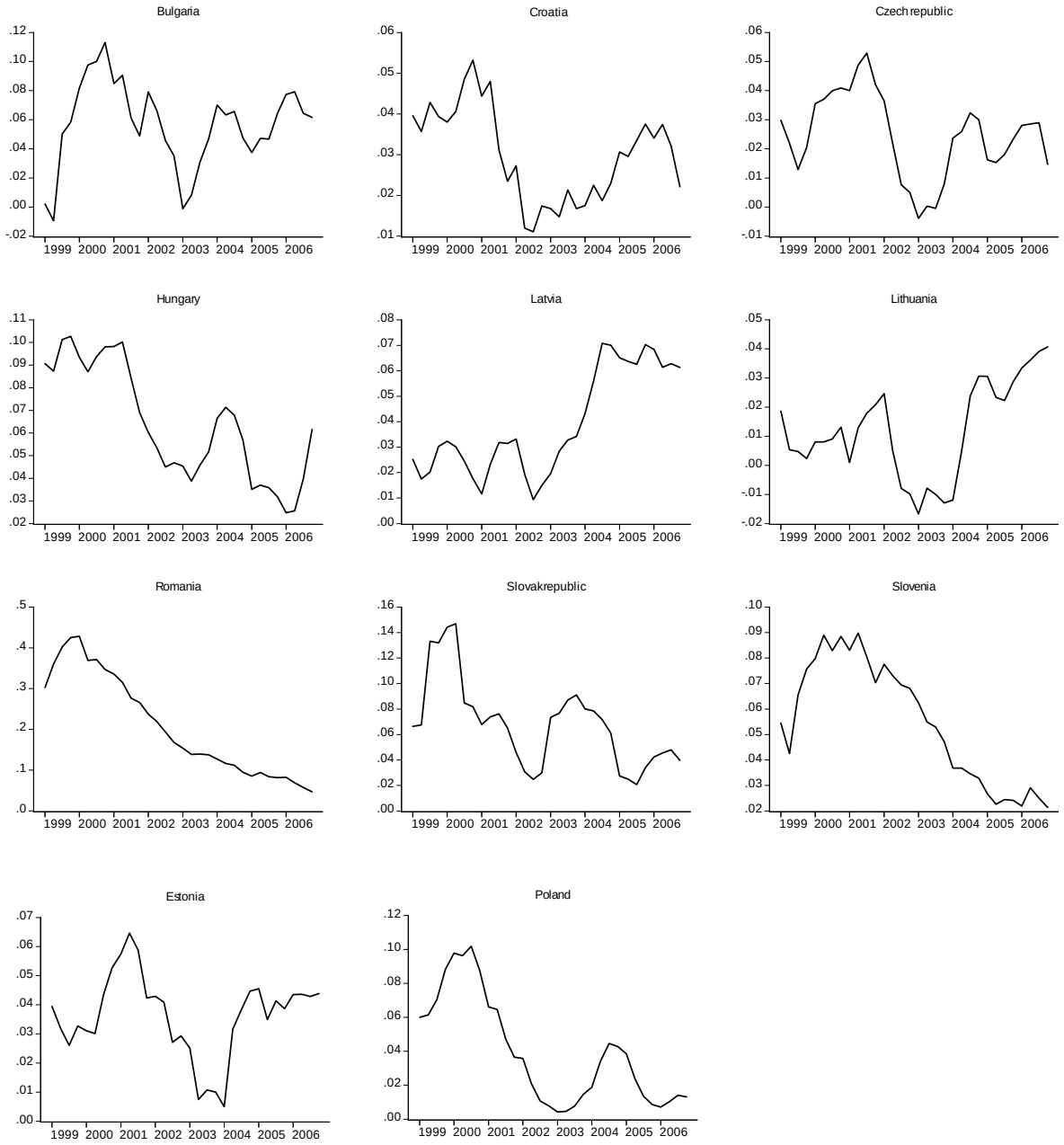

Figure 7: CEEC's y-o-y inflation rates.

Table 11: Correlation between USD/EUR exchange rate and 12 disaggregated CPI components

Consumer price indices – total	-0.78	6. Health	0.48
1. Food and non-alcoholic beverages	-0.02	Medical products, appliances and equipment	0.26
Food	-0.04	Pharmaceutical products	0.27
Bread and cereals	0.49	Other medical product, except appliances	-0.13
Meat	-0.31	Medical services, except hospital services	0.29
Fish	-0.49	Medical services	0.30
Milk, cheese and eggs	0.04	Dental services	0.23
Oils and fats	0.23	Hospital services	0.49
Fruit	-0.13	7. Transport	-0.63
Vegetables	0.03	Purchase of vehicles	0.00
Sugar, jam, honey, chocolate and confectionary	-0.03	Motor cars	0.07
Food products, n. e. c.	-0.08	Motor cycle and bicycles	-0.44
Non-alcoholic beverages	0.18	Operation of personal transport equipment	-0.64
Coffee, tea and cocoa	0.31	Spare parts and accessories	0.30
Mineral waters, soft drinks and juices	0.02	Fuels and lubricants for personal transport eq	-0.64
2. Alcoholic beverages and tobacco	-0.58	Maintenance and repair of personal transport eq.	-0.01
Alcoholic beverages	-0.26	Other services in respect of personal transport eq.	-0.13
Spirits	-0.49	Transport services	-0.60
Wine	0.47	Passenger transport by railway	-0.23
Beer	-0.25	Passenger transport by road	-0.65
Tobacco	-0.55	Passenger transport by air	-0.54
3. Clothing and footwear	-0.56	Passenger transport by sea and inland waterway	0.07
Clothing	-0.49	Combined passenger transport	-0.09
Clothing materials	-0.32	Other purchased transport services	-0.46
Garments	-0.50	8. Communication	-0.29
Other articles of clothing and accessories	-0.31	Postal services	0.23
Cleaning, repair and hire of clothing	0.23	Telephone and telefax equipment and services	-0.29
Footwear, including repairs	-0.51	9. Recreation and culture	-0.25
Footwear	-0.52	Audio-vis., phot. and information proc. eq.	-0.31
4. Housing, water, electricity, gas and other fuels	-0.14	Eqfor the reception, rec and rep. of sound and pic.	-0.29
Actual rentals for housing	-0.08	Photographic and recording equipment	-0.48
Maintenance and repair of dwelling	-0.17	Information processing equipment	-0.33
Materials for the maint. and repair of the dwelling	-0.25	Recording media for pictures and sound	0.47
Services for the maintenance and repair of the dwelling	-0.14	Other major durables for recreation and culture	-0.52
Water supply and miscellaneous services	0.05	Toys, games and hobbies	-0.59
Water supply	0.20	Equipment for sport, camping and open-air recreation	-0.12
Refuse collection	-0.54	Gardens, plants and flowers	-0.35
Electricity, gas and other fuels	-0.16	Pets and related prod. for pets incl. vet. serv. for pets	-0.45
Electricity	-0.10	Recreational and cultural services	0.01
Gas	0.09	Recreational and sporting services	-0.12
Liquid fuels	-0.36	Cultural services	0.12
Solid fuels	-0.04	Books, newspapers and stationery	-0.13
Heat energy	0.22	Books	-0.06
5. Furnishings, household eq. and routine m. of house	-0.45	Newspapers and periodicals	-0.31
Furniture and furnishings, carpets and other	-0.44	Misc. printed matter and stationary and drawing mat.	0.19
Furniture and furnishings	-0.40	Package holidays	0.22
Carpets and other floor coverings	-0.22	10. Education	-0.49
Repair of furniture, furnishings and floor coverings	-0.63	11. Catering and accommodation services	-0.11
Household textiles	-0.42	Catering services	-0.09
Household appliances	-0.73	Meals and drinks provided by restaurants, cafes...	-0.01
Major household appliances	-0.65	Canteens	-0.53
Small electric household appliances	-0.44	Accommodation services	0.04
Repair of household appliances	0.12	12. Miscellaneous goods and services	-0.60
Glassware and tableware utensils	-0.69	Personal care	-0.37
Tools and equipment for house and garden	-0.25	Services of hairdressing salons and grooming est.	-0.13
Major tools and equipment for house and garden	-0.08	Electrical appliances for personal care	-0.30
Small tools and accessories	-0.39	Other non-el. appliances and products for pers. care	-0.34
Goods and services for household maintenance	-0.14	Personal effects, n. e. c.	-0.54
Non-durable household goods	-0.14	Clocks, watches and jewellery	-0.59
Domestic services and household services	0.02	Other personal items	-0.40

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