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IN THE NEW EU MEMBER STATES

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The Exchange Rate Pass-Through in the New EU Member States*

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Résumé

Ce papier s'inscrit dans la réflexion sur la relation existante entre les changements des taux de change effectifs nominaux et les prix dans les nouveaux pays membre de l'Union européenne. A l'aide de données trimestrielles sur la période janvier 1996 - juin 2010, nous analysons le pass-through du taux de change pour les prix à l'importation, les prix à la production et les prix à la consommation dans le cas de dix pays d'Europe centrale et orientale. Dans une première étape, les estimateurs du pass-through moyen sont obtenus à partir d'un modèle en données de panel, par la méthode des moments généralisés. Nous trouvons un pass-through du taux de change statistiquement significatif uniquement dans le cas des prix à l'importation. En s'interrogeant sur le potentiel impact d'un changement de l'environnement inflationniste sur les pass-through, nous trouvons qu'un tel changement engendre une diminution du pass-through du taux de change, à la fois à court et à long terme, mais uniquement pour les prix à l'importation. Dans une deuxième étape, nous procédons à une analyse individuelle, pays par pays, et nous testons la stabilité des modèles estimés par des estimations glissantes. Nos résultats montrent une forte hétérogénéité des estimateurs du pass-through.

Mots-clés : inflation et prix ; pass-through du taux de change ; économie internationale
Code JEL : C33; E31; E42; E52; F31; O52

Abstract

This paper aims to complete our understanding of the relationship between changes in nominal effective exchange rates and prices in the new EU member states. We investigate the exchange rate pass-through to import, producer and consumer prices for ten Central and Eastern European countries with quarterly data from January 1996 to June 2010. In a first step, the pass-through estimates are derived from a dynamic panel data model, through the generalized method of moments. A statistically significant exchange rate pass-through to import prices is found, while no statistically significant exchange rate pass-through is estimated to consumer and producer prices. We further investigate whether exchange-rate pass-through estimates have declined in response to a change in inflation environment and find evidence of such decline only for import prices, both in the short run and the long run. In a second step, we proceed to an individual analysis, country by country, and find support for an increased heterogeneity in the exchange rate pass-through estimates. We equally test for the stability of the estimated models through rolling regressions and find support for some rather stable patterns.

Keywords: inflation and prices; exchange rate pass-through; GMM; international topics
JEL Classification: C33; E31; E42; E52; F31; O52

1 Introduction

The evolution of inflation in the new EU member states (NMS[1]), both before and after their entry in the Euro area, represents an issue of concern not only from the point of view of the economic policy but also from the political perspective of adopting the euro. Prior to the adoption of the common currency, a sufficient degree of real and nominal convergence with the existing EU members must be achieved. While the latter consists in the ability of a NMS to comply with the convergence criteria[2], the former is not evaluated through a specific criteria laid down in the Treaty and might be assesed on the basis of stuctural and cyclical developments in these economies. The real convergence process is closely related to the pressure of real exchange rate appreciation, phenomenon usually called the Balassa-Samuelson effect (Égert, 2007).

An issue of concern related to the participation in the euro area is the requirement of sound fiscal positions in the NMS, since several of these countries have considerable fiscal deficits of a structural nature. Another issue of concern is that of the inflationary developments after their EU accession. Complying with the convergence criteria means, besides other things, having an inflation rate close enough to that of the Euro area countries (i.e. on a sustainable basis). However, during the process of real convergence, the NMS face inflationary pressures caused both by demand factors (i.e. the reduction in interest rates, the credit growth, the property investments etc.) and supply factors (i.e. inter-sectoral differences in productivity that might determine a higher inflation in the non-tradable sectors).

In these circumstances, the exchange rate, an important economic indicator that affects the real economy in the NMS, is expected to become a significant monetary policy instrument, with an essential role in facilitating nominal and real convergence.

The exchange rate criteria, according to which new members must participate, without serious tensions, in the ERM II for at least two years before acceding to the Euro area, does not forbid the nominal exchange rate to appreciate. The main characteristics of ERM II include a central parity rate against euro and standard fluctuation bands of +/-15%. Generally, the fluctuation bands are large enough, leaving sufficient place for exchange rate appreciation and allowing, this way, the central banks to counterbalance (or at least reduce) the inflationary pressures that might occur before joining the EU. Moreover, the central parity against euro can adjust at any moment during the participation in the ERM II, supplying an additional tool that facilitates nominal convergence[3].

[1]Bulgaria, Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Romania, Slovenia and Slovakia.

[2]The convergence criteria (also known as the Maastricht criteria) are the criteria for European Union member states to enter the third stage of European Economic and Monetary Union (EMU) and adopt the euro as their currency. These criteria are based on Article 121(1) of the European Community Treaty and are related to: inflation rate (no more than 1.5 percentage points higher than the average of the three best performing (lowest inflation) member states of the EU); government finance (the ratio of the annual government deficit to gross domestic product (GDP) must not exceed 3% at the end of the preceding fiscal year, the ratio of gross government debt to GDP must not exceed 60% at the end of the preceding fiscal year); exchange rate (applicant countries should have joined the exchange-rate mechanism (ERM II) under the European Monetary System (EMS) for two consecutive years and should not have devalued its currency during the period); and long-term interest rates (the nominal long-term interest rate must not be more than 2 percentage points higher than in the three lowest inflation member states).

[3]The Slovak authorities have re-evaluated the central parity rate twice: in March 2007 (+8,5%) and in May 2008 (+17,6%). The size of the appreciation of the Slovak koruna was unique for an ERM II member state

The effectiveness of the exchange rate policies of the NMS within the ERM II largely depends on the relationship between exchange rate changes and inflation. For the exchange rate to be an effective tool that can be used to control inflation, changes in nominal exchange rate have to be transmitted into domestic prices relatively fast and the relationship between the two must be strong (Bîtans, 2004).

It is thus important to estimate, from a quantitative point of view, the relationship between the nominal exchange rate fluctuations and inflation, translated by the exchange rate pass-through to domestic prices. This estimation allows to asses to what extent the nominal appreciation would have caused a reduction in inflation, thus giving an idea about the inflation sustainability; a high pass-through associated to a strong appreciation before joining the EU might be the sign of a question mark on the sustainable nature of inflation. This issue was largely debated in the 2008 Convergence Report regarding Slovakia, when an empirical evidence of a limited size of slovak pass-through played a decisive role for supporting the inflation criteria' sustainability.

From a more theoretical point of view, it is interesting to analyze whether the degree of pass-through is related to the macroeconomic environment of a country or whether changes in pass-through can be associated to changes in political regimes (Bîtans, 2004). In that sense, Central and Eastern European Countries (CEECs) offer a rich evidence, allowing us to shed light on the influence of different economic and political regimes on the size of the pass-through.

Developments in nominal exchange rate play an important role. If the exchange regime is fixed, as it is the case for instance in a monetary union, the real appreciation passes exclusively through an inflation differential. On the contrary, in a flexible exchange regime with inflation targeting, we might observe a tendency of appreciation in nominal exchange rate, as the inflation target, if credible, makes less probable the existence of a sensible inflation differential. Moreover, in the special context of nominal convergence criteria, the exchange rate appreciation becomes an important instrument of economic policy, that might be used in order to facilitate the reduction in inflation (for instance the Slovak strategy).

Our study is focused on a sample formed by the new EU members states. The large majority of countries in the region commuted from a high inflation environment (at the begging of 90s) to a relatively moderate inflation rate (at the end of 90s). The analysis of the last ten years shows a diminishing tendency in inflation rate for the large majority of CEECs compared to the end of 90s. Nevertheless, inflation went up again in almost all these countries between 2003 and 2005, in particulary in Bulgaria, Estonia, Latvia and Lithuania. In Romania and Slovakia inflation continued to register a global descending trend compared to 2003, while the exchange rate was on an appreciation tendency, even though this trend got reversed lately due to the global financial crisis. Some of these countries encountered changes in exchange rate regimes during the 90s. The Czech Republic and Poland moved from rigid

and caused doubt on the sustainability of inflation, as indicated in the 2008 ECB Convergence Report: "In recent years inflation has been dampened, in particular, by the trend appreciation of the exchange rate of the Slovak koruna. Available assessments suggest that the appreciation of the koruna has reduced inflation over the past year". The quantitative effect is nevertheless uncertain and depends on the pass-through estimates; this makes important the precise and reliable estimation of the exchange rate pass-through for the countries entering the ERM II with a floating exchange rate (Hungary, Poland, Czech Republic and Romania).

pegs towards more flexible regimes. Bulgaria moved in the opposite direction. The Baltic countries maintained unchanged fixed exchange rate regimes over the period[4].

Thus, a rigorous quantitative analysis of the exchange rate pass-through in the NMS might answer both political economy questions (sustainable convergence) and theoretical questions (the impact of exchange rate regime on the magnitude of pass-through). We estimate the average exchange-rate pass-through, both in the short and long run, with the use of the generalized method of moments estimator for dynamic panel-data models, while considering the exchange rate pass-through to consumer, producer and import prices. We equally analyze whether a significant decline in exchange rate pass-through took place after the occurrence of a shift in inflation regime. In a second step, we complete the panel data analysis by an individual country specific analysis.

Our work differs from previous empirical work on CEECs in that we focus on identifying the inflation environment changes, thus allowing for potential multiple breaks[5]. This seems appropriate in the case of the NMS, given the substantial decrease in inflation in these countries, from two digits levels at the beginning of 90s to one digit level, nowadays.

We find evidence of a negative exchange rate pass-through to importer prices that seems to increase slightly in the long run. In other words, on average, the nominal exchange rate appreciation is followed by a decline in importer prices. Several structural breaks in inflation series are detected for each country in the sample; we find support of a decline in the exchange rate pass-through with a shift in inflation regime, both in the short run and the long run, but only for importer prices.

The paper is organized as follows. Section 2 reviews the macroeconomic conditions in our sample of countries. We present the theoretical framework in Section 3, while enumerating the factors that influence the exchange rate pass-through; in the same section, we present the methodology that can be employed for the pass-through estimation and what has been done in the previous studies. In Section 4 we present the data and then we focus on the econometric specification. Section 5 concludes.

2 Macroeconomic conditions in the NMS

The NMS have maintained different exchange systems over time. These regimes included currency boards, fixed pegs to a basket, crawling pegs, managed float and free float. Three countries are currently members of the ERM II[6]: Estonia and Lithuania with a currency board as a unilateral commitment and, respectively, Latvia with +/-1% fluctuation band as a unilateral commitment. Bulgaria has a currency board arrangement with the euro as an anchor currency. The Czech Republic, Hungary, Poland and Romania are under inflation targeting regimes with free floating exchange rates, while Hungary's inflation targeting is conducted in conjunction with an exchange rate band of +/-15% against the euro. Before

[4] The real effective exchange rate appreciation related to the real catching-up process is presented in Appendix 3 (Figure 4).

[5] A similar approach was followed by Bailliu and Fujii (2004) in the case of 11 industrialized countries.

[6] Estonia has joined the euro area the 1st of January 2011 and is no longer an ERM II member. Nevertheless, since the analysis is realized over the period 1996 to 2010, we can still talk about the existence of three members of the ERM II.

joining the euro area, Slovakia practiced inflation targeting with a standard fluctuation band of +/-15% and Slovenia practiced a managed float.

We present some key economic indicators in the NMS for the period 2000-2009 in Appendix 2 (Table 10).

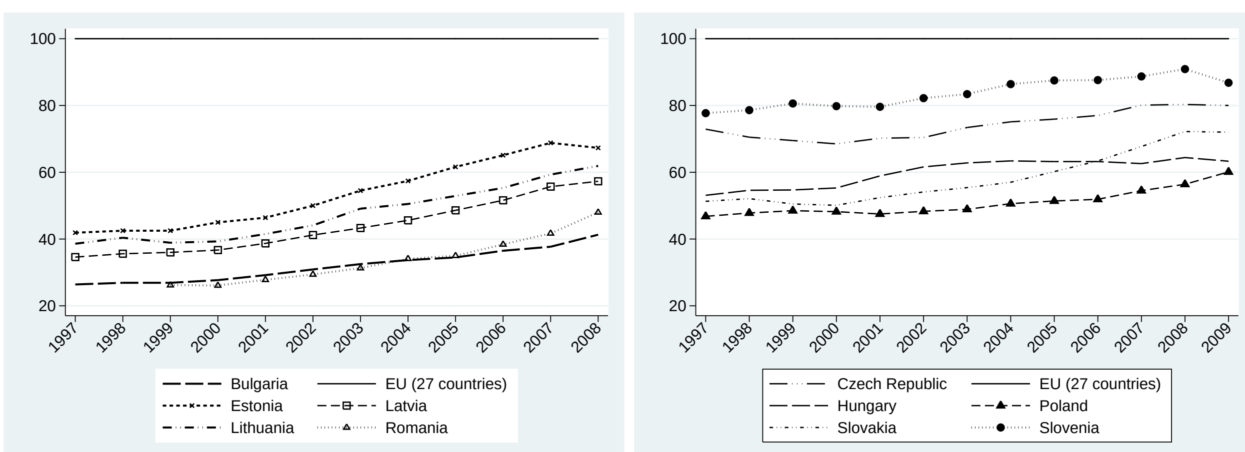
A first conclusion that emerges from this table is the existence of a heterogeneous macroeconomic situation in the NMS. The Baltic States, Bulgaria and Romania are the countries with the lowest relative per capita GDP (in PPS) in 2000 (left side of Figure 1). These countries recorded the fastest annual GDP growth rates (with an average growth rate between 4.3% and 4.9% for the period 2000-2009), the fastest credit growth, the largest current account deficits, the most rapid wage increases and the highest inflation rates. They had the lowest starting price level (except for Estonia) and the lowest ratios of domestic credit to private sector (in % of GDP). Among these countries, Romania is the only one having a floating exchange rate, while the others have a fixed exchange rate regime.

On the opposite side of the picture, we find the countries with the highest relative per capita GDP in 2000: the Czech Republic and Slovenia; they recorded lower output growth, slower credit expansion, smaller current account deficits, as well as lower wage growth and inflation in recent years. The Czech Republic had a floating rate, while Slovenia was under a tightly managed float before joining the euro area in 2007.

Hungary, Poland and Slovakia are situated in an intermediary position in terms of GDP per capita. They recorded slower output growth (except for Slovakia), smaller credit expansion, lower current account deficits and lower inflation (except for Hungary where inflation was boosted by tax increases and administrative price adjustments in order to deal with fiscal deficits). The three countries had floating exchange rates.

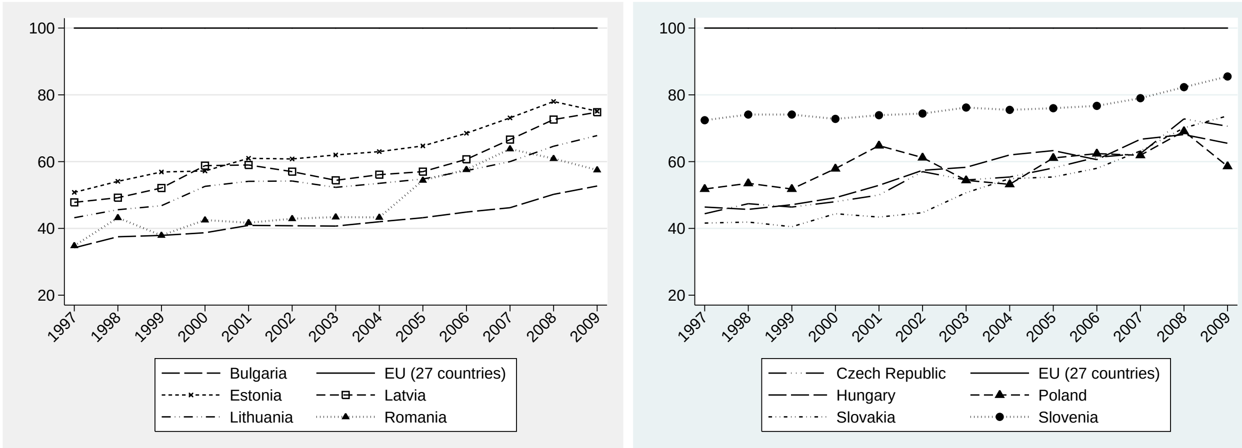
Despite the existing differences, the NMS share several similar structural characteristics.

Figure 1: GDP per capita in purchasing power standards (UE27=100), 1997-2009.



Source: Eurostat.

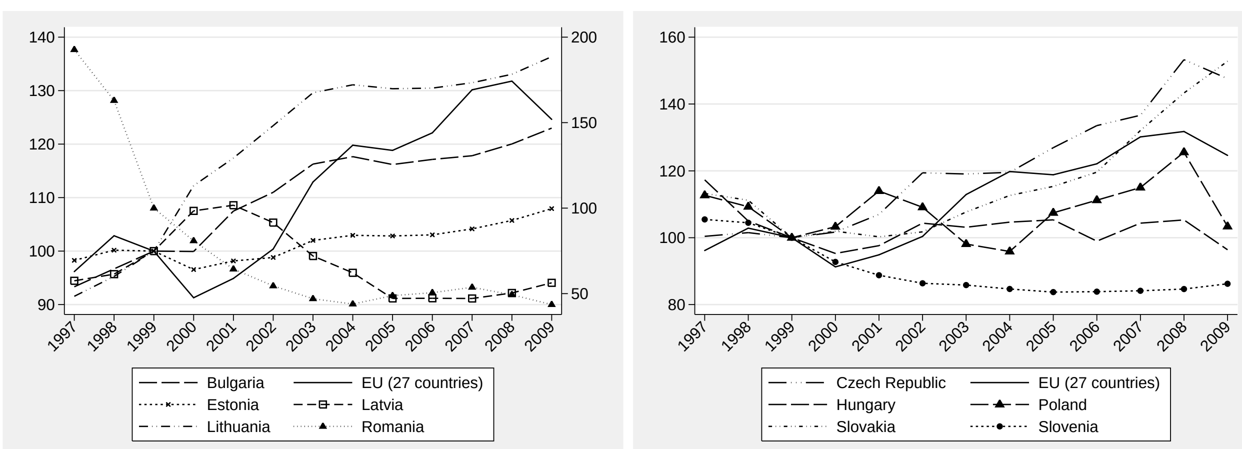
Figure 2: Price level of consumption (UE27=100), 1997-2009.



Source: Eurostat.
Note: values shown correspond to comparative price levels of final consumption by private households including indirect taxes (UE27=100).

First, a feature of the NMS' economic development is their catching up in terms of GDP per capita (Figure 1) and the associated price level convergence (Figure 2). One can notice the negative impact of the 2007-2009 global financial crisis on the convergence process, both in terms of GDP per capita and of the price level. Another indicator that assesses the price level convergence is the CPI based real effective exchange rate (Figure 5 in Appendix 3); it provides a similar picture to the comparative price levels shown in Figure 2 above. The unit labor cost (ULC) based real effective exchange rates exhibits similar trend to the CPI based real effective exchange rates (Figure 6 in Appendix 3).

Figure 3: Nominal effective exchange rate (1999=100), 1997-2009.



Source: Eurostat.
Note: a rise in the index means nominal appreciation. Right hand scale (RHS) for Romania.

The real effective exchange rate appreciated in all these countries, over a long period of time (Figure 4 in Appendix 3), irrespective of their exchange rate regime. Nevertheless, the evolution of nominal exchange rates (Figure 3) shows a mixed picture.

In Romania, the exchange rate depreciated sharply until 2004, then appreciated until 2007 and it slightly depreciated since 2007. Latvia is another country where the exchange rate depreciated between 2001 and 2005, then it stabilized until 2007 and it slightly appreciated since 2007. Nevertheless, the extent of fluctuations was higher in Romania. In Bulgaria, Estonia and Lithuania, the exchange rate appreciated slightly. In the Czech Republic and Slovakia, the nominal exchange rate has been on a relatively strong appreciating trend since 1997. Slovenia's exchange rate depreciated until 2004 and remained stable thereafter. In Hungary, the exchange rate depreciated until the adoption of inflation targeting (in May 2001) and has fluctuated since then, without any significant upward or downward trend. Poland's exchange rate is appreciating since 2004, after previous periods of both significant depreciations and appreciations.

Another feature is the rapid growth in private consumption; during the period 2000 - 2009, the average growth rate of private consumption was of 4.8% in Bulgaria, 5.1% in Estonia, 5.7% in Latvia, 5.9% in Lithuania and 7.5% in Romania (compared to 4% in EA 12, 3% in Czech Republic and Hungary, 3.6% in Poland, 2.5% in Slovenia and 4.4% in Slovakia). In the former group of countries, consumption was fueled by rapid increase in wages and substantial increase in loans to households; investment also expanded rapidly. Regarding exports and imports, there is not much difference between more and less developed countries. However, large current deficits accompanied the faster rate of growth in less developed countries, their catching up being largely realized at the cost of accumulating foreign debt.

We add to these features the low level of financial intermediation, reflected both by a low ratio of domestic credit to GDP and a low stock market capitalization. Regarding the first indicator, its level is still low in the NMS compared to the Euro area average; in 2008, this indicator ranged between 38.5% (in Romania) and, respectively, 97.4% (in Estonia), while the euro average was of 141.9%. Several factors affect the effectiveness of domestic monetary policy in these countries: (i) the large and growing share of foreign currency loans that contribute to increased macro financial vulnerability[7]; (ii) the high share of external financing (whose driver is the low level of development), explained by the borrowing by banks and firms from their mother companies abroad or from other sources of external lending.

After presenting the macroeconomic environment in the NMS, in the following section we present the theoretical framework underlying the pass-through estimations.

3 Theoretical framework

Both nominal and real exchange rates play an important role in the monetary policy transmission. There are two stages of the transmission mechanism: the first stage shows the

[7]The high share of foreign currency loans represents a substantial risk in the case of exchange rate depreciation. According to National Central Banks data, in September 2009, the share of domestic credit to private sector in foreign currency in total domestic credit to private sector ranged between 8.16% in Czech Republic, 33.4% in Poland, 57.7% in Bulgaria, 59.7% in Romania, 67% in Hungary, 69.8% in Lithuania, 87.1% in Estonia, and, respectively, 91.3% in Latvia.

way the monetary policy impacts on exchange rates, while the second stage consists in the pass-through from exchange rates to import and domestic prices, followed by adjustments in real variables (imports, exports, investment).

Nominal exchange rate movements caused by monetary policy actions can be translated into domestic inflation through changes in the prices of imported final goods, as well as through the upward or downward pressure of imported intermediate goods prices on domestic inflation via the price of domestically manufactured tradable and non-tradable goods.

The pricing behavior of importing firms has an important contribution in the way exchange rate affects domestic prices through imported prices. If the prices of imported goods are set in the importer's currency (producer currency pricing), any change in exchange rate will be automatically transmitted to the prices of the destination country and, thus, the pass-through is complete. On the other hand, if the prices of imported goods is set in local currency (local or consumer currency pricing), exchange rate movements are not reflected in domestic prices and the pass-through is zero.

Two general opinions emerge in the empirical literature related to the exchange rate pass-through. First, the exchange rate pass-through is generally higher in developing and emerging countries compared to developed economies (Campa and Goldberg, 2002); it declines over time with the catching-up in terms of living standards, both in the industrialized and the developing countries (Coricelli et al., 2006; Bitâns, 2004). These evolutions are related mainly to the role of macroeconomic variables (especially inflation) (Taylor, 2000; Choudhri and Hakura, 2001; Devereux and Yetman, 2003), as well as to the shift in imports from goods with higher pass-through elasticities to goods with lower ones (Frankel, Parsley and Wei, 2005). Second, the pass-through is highest for imported goods, lower for producer goods and lowest for consumer prices. Among the potential explanations, we mention the role of distribution costs for final imported goods[8] (Burstein, Eichenbaum and Rebelo, 2002) and the role of intermediate imported goods (Engel, 2002).

3.1 Factors influencing the size of the exchange rate pass-through

The pass-through of the exchange rate to prices is only partly due to monetary policy actions. Several other factors, both macroeconomic and microeconomic, might cause changes in exchange rates. Among these factors we mention: the inflation rate, the exchange rate regime, the output gap, the openness and the composition of trade and imports, as well as expectations.

A first strand of literature underlines the importance of the *rate of inflation* (Taylor, 2000). The higher the inflation rate, the larger the exchange rate pass-through since prices are adjusting more frequently in an inflationary environment. Moreover, as noted by Corsetti, Dedola and Leduc (2007), a more stable inflation environment reduced the incentive of producers to price discriminate across countries (implying lower pass-through). The need to account for the observed inertial behavior of inflation (inflation persistence) has been emphasized by the literature on inflation dynamics (Gali and Gertler, 1999). The more persistent inflation is,

[8] As noted by Égert and Mac Ronald (2009), imported goods reach consumer through wholesaling and retailing networks, so that their prices have a substantial local input, which serves as a buffer to soften the impact of exchange rate changes.

the less exchange rate movements are perceived to be transitory and the more firms might respond via price-adjustments. A reduction of inflation persistence would cause a decline in the long run effect that exchange rate fluctuations might have on inflation (Takhtamanova, 2008). According to the theory, the pass-through is positively related to the average inflation rate and negatively related to the inflation persistence (Bitâns, 2004).

Another key macroeconomic variable is the *exchange rate regime*. As noted by Bussière and Peltonen (2008), a more stable exchange rate regime is likely to induce more pricing-to-market from foreign exporters and to decrease pass-through to import prices. On the opposite, if the exchange rate is not used as an intermediate target, expectations are not strongly associated with the exchange rate, resulting in lower pass-through[9]. In a country with a crawling peg regime, the preannounced devaluation offers a nominal anchor for inflationary expectations. Any changes in exchange rate will be rapidly incorporated into expectations and thus into prices, both for tradable and non-tradable goods. This implies a high and relatively homogenous pass-through to consumer prices. The move towards a more flexible exchange regime, combined with inflation targeting, can break the link between exchange rate and prices, by disconnecting the level of non-tradable goods price from the exchange rate.

Égert and Mac Donald (2009) noted little interest in the literature in the role played by the exchange rate regime, despite the fact that the pass-through were thought to be higher for countries where the exchange rate served as a nominal anchor to inflationary expectations[10].

As outlined in previous studies, it may be argued that the adoption of the fixed exchange rate regime was appropriate in the environment of high inflation rates observed in many East European countries (see Bitâns, 2004). According to Bitâns (2004), the high exchange rate pass-through enhanced the effectiveness of exchange rate-based stabilization policies; it also implied that the level at which the exchange rate was fixed had little impact on the real economy. However, when inflation rates in these countries declined over time, the stabilizing role of the exchange rate diminished along with the decreasing pass-through effect. In the same time, the exchange rate role in the real economy gradually increased as shocks to nominal effective exchange rate produced increasingly persistent deviations of real exchange rate from the equilibrium level. In these circumstances, several countries opted for the abandonment of their fixed exchange rate regimes; the central banks in these countries became less concerned about the impact of exchange rate fluctuations on inflation and, instead, allowed their currencies to respond to various economic shocks. The move towards more flexible exchange rate regimes tended to reduce the degree of exchange rate pass-through even further. For countries which retained rigid exchange rate regimes either explicitly or implicitly, the decline in pass-through was relatively less pronounced. As a result, exchange rate fluctuations are relatively more important in determining inflation and relatively less important for the real exchange rate in these countries.

The business cycle is another determining factor. One measure of the country-specific business cycle stage is the *output gap*; it consists in the deviation of the actual real GDP from the "potential" real GDP. A positive gap signals that the economy is running above potential so domestic demand is expanding and a lower exchange rate pass-through may be observed

[9]In a floating regime, exchange rate changes have little influence on non-tradable prices.

[10]In these countries, any change in exchange rate will be rapidly incorporated into expectations and into prices (both tradable and non-tradable).

if export companies try to gain market share by absorbing the exchange rate fluctuations in their profit margins in order to quote competitive prices. This way, importing countries with growing output gaps may be perceived by exporting firms as an opportunistic incentive to reduce pass-through in terms of scale expansion.

Openness, measured as imports to GDP ratio, is equally an important determining factor. According to Dornbush (1987), higher import penetration should be associated to higher pass-through to import prices.

The importance of the *composition of trade and imports* (Campa and Goldberg, 2002) has to be considered. The pass-through is large for homogenous goods and reduced for differentiated goods, where the pricing-to-market practices are more frequently used. As a consequence, poor countries (with imports formed mainly by homogenous goods) face a higher pass-through compared to rich countries (where the share of manufactured goods in the total of imports is higher). The changing composition of imports (towards more differentiated goods), through the process of economic development, might equally explain the decrease in pass-through during the catching-up process.

Expectations represent another important factor that influences the pass-through. When exchange rate changes are perceived as permanent, the pass-through is generally larger compared to situations when exchange rate changes are temporary. Nevertheless, in transition economies, exchange rates represent nominal anchors for inflation expectations. If the exchange rate is a credible anchor in a crawling peg or a fixed-type regime, exchange rate changes are rapidly incorporated in expectations and, consequently, in prices. On the contrary, the inflation rate shouldn't be highly connected with the exchange rate in an inflation targeting environment, where the expectations are anchored by the announced inflation target and credible rules.

3.2 Methodology and previous studies

Two approaches are generally used for estimating the exchange rate pass-through. These are the structural VAR (Vector Auto Regressive) models introduced by McCarthy (1999) and the unique econometrical equation including variables in difference (Campa and Goldberg, 2002).

A large number of studies have used the VAR methodology for examining the impact of changes in monetary policy on the most important macroeconomic variables. They have equally analyzed the impact of short-term interest rate shocks on nominal exchange rate; their results are debatable, since positive interest rate shocks might determine both an appreciation or a depreciation of the exchange rate (i.e. the so-called "exchange rate puzzle"). The VAR methodology offers a comfortable way to analyze the impact of exchange rate on prices through the impulse response functions (IRF). It nevertheless presents a main drawback, since its effectiveness is lower during short period of analysis. Moreover, impulse response parameters are rather imprecisely measured for the long forecasting horizons.

3.2.1 The VAR analysis

One methodology frequently applied consists in the "distribution chain" model introduced by McCarthy in 1999. In this model the pass-through is evaluated in a recursive VAR framework which includes in addition to exchange rate, the import, producer and consumer prices, as well as an exogenous supply shock (proxied by oil prices) and a demand shock (proxied by the output gap), that might influence the response of prices to exchange rate movements[11].

Previous studies have focused on pass-through into a single price (e.g. import or consumer prices), without distinguishing between the types of underlying exchange rate shocks (permanent or transitory) that might be occurring. By examining the exchange rate pass-through into a set of prices along the pricing chain, the VAR analysis characterizes not only absolute but *relative* pass-through in upstream and downstream prices.

The distribution chain model is recursive by construction, as the ordering starts with a truly exogenous variable and ends with the consumer prices, on which all shocks are expected to have an impact.

Depending on the exchange rate regime, two different set-ups have been used in the existing literature :

- for the countries with strictly managed exchange rate regimes, the vector of endogenous variables is: $Y_1 = [\Delta s \Delta m \Delta w \Delta y \Delta pm \Delta py \Delta pc]'$, with s the nominal effective exchange rate relative to the euro, m the broad monetary aggregate[12], w the foreign exporters' unit labor cost[13], y the domestic demand conditions (output gap), pm the importer price index, py the producer price index and pc the consumer price index. This ordering implies a contemporaneous impact of nominal exchange rate shocks on all the other variables, with no contemporaneous impact from other shocks to the nominal exchange rate.

- for the countries with a flexible exchange rate regime, the vector of endogenous variables is: $Y_2 = [\Delta m \Delta w \Delta y \Delta s \Delta pm \Delta py \Delta pc]'$. The nominal exchange rate moved between the output gap (y) and the importer price index (pm), to account for the independent monetary policy and the possibility of contemporaneous impact of real and nominal shocks on the exchange rate.

The reduced-form $VAR(p)$ can be written as it follows:

$$Y_t = c + A(L)Y_{t-1} + \mu_t; \tag{1}$$

with $E[\mu_t \mu_t'] = \Omega$, where $Y = Y_1$ or $Y = Y_2$ depending on the type of exchange rate regime (see the two set-ups above). c is a vector of deterministic terms (i.e. quarterly time dummies), A is a matrix polynomial of degree p in the lag operator L, μ is the (7×1) vector of reduced-form residuals with variance-covariance matrix Ω.

To recover the underlying exchange rate shock, the Cholesky decomposition of the variance-covariance matrix Ω is used to produce orthogonalized innovations ε. These disturbances are

[11] McCarthy (2000) augments this model with a central bank reaction function (based on using interest rates as an instrument) and a money demand function.

[12] By including the money in the model, the inflation/hyperinflation caused by a rapid monetary expansion in several East European countries up to mid-1990s are taken into account.

[13] The oil price is usually used in order to reflect an exogenous supply shock. Nevertheless, both the oil price and the foreign exporters' unit labor cost can be used.

expressed in terms of the reduced-form VAR innovations as follows:

$$C\varepsilon_t = \mu_t \tag{2}$$

with C the lower triangular Cholesky matrix with ones along its principal diagonal. The recursive structure in equation (2) imposes the assumption that orthogonalized innovations to nominal exchange rate in the case of managed exchange rate regimes (and, respectively, to the broad monetary aggregate in the case of flexible exchange rate regimes) depend only on residuals from the nominal exchange rate (and respectively the broad monetary aggregate)' equation and not from the other equations. For prices, the corresponding disturbance term will represent a mix of shocks, including the structural exchange rate shock.

The implications of the identifying restriction can be further understood from the structural representation of the VAR:

$$F(L)Y_t = k + C\varepsilon_t \tag{3}$$

where $F(L)$ is a matrix polynomial of degree $p+1$, k is a transformation of the deterministic terms ($Ck = c$) and ε is the vector of structural shocks. The identification scheme based on the Cholesky decomposition introduces the following restriction: in the case of managed exchange rate regimes, in the first equation (i.e. for nominal exchange rate, Δs), the coefficients of contemporaneous changes in Δm, Δw, Δy, Δpm, Δpy and Δpc are equal to zero; in the case of flexible exchange rate regimes, in the first equation (i.e. for broad monetary aggregate, Δm), the coefficients of contemporaneous changes in Δw, Δy, Δs, Δpm, Δpy and Δpc are equal to zero.

In the reduced-form representation (equation 1), demand factors are identified by the output gap. The price series contain sequential shocks that can be attributed to different stages of the supply chain. The system allows to trace the dynamic effect of an exchange rate shock on prices along the supply chain, going from exchange rate to factor input prices then to wholesale producer prices (that contain a relatively high proportion of tradable goods) and, finally, to retail consumer prices (that contains a smaller proportion of tradable goods).

Generally, different ordering schemes are estimated to prove the robustness of the estimated degree of pass-through with respect to assumptions on the nature of structural shocks under the chosen decomposition method.

3.2.2 The dynamic panel data analysis

The earlier literature on pass-through focused on studying the behavior of import prices from a microeconomic perspective, based on the pricing behavior of exporting firms. In this context, it is useful to consider a simple static profit-maximization problem faced by a foreign exporting firm (this firm exports its products to the domestic country):

$$\max_q \pi = s^{-1}pq - C(q) \tag{4}$$

where π denotes profits (in foreign currency), s is the exchange rate measured in units of domestic currency per unit of foreign currency, p is the price of the good (in domestic currency),

$C(.)$ is the cost function (in foreign currency units) and q is the quantity demanded for the good.

The first condition obtained when solving equation (4) is:

$$p = sC_q\mu \quad (5)$$

with C_q the marginal cost and μ the markup of price over marginal cost. The markup is further detailed as $\mu \equiv \eta/(\eta - 1)$, where η is the price elasticity of demand for the good. According to equation (5), local currency price of the good can vary as a result of a change in exchange rate, a change in firm's marginal costs and/or a change in firm's markup. One should note that firm's marginal cost and markup may change independently of the exchange rate. To properly isolate the effects of exchange rate changes on import prices, it is thus important to take into account the movements in other price' determinants when estimating the pass-through.

A log-linear, reduced-form equation may be expressed as:

$$p_t = \alpha + \beta s_t + \lambda w_t + \tau y_t + \varepsilon_t \quad (6)$$

where w_t measures of the marginal cost of the exporter and, respectively, y_t measures the demand conditions in the importing country. In the above equation, β measures the exchange rate pass-through. Different versions of equation (6) are used in the pass-through literature (see Goldberg and Knetter, 1997).

As far as we are concerned, we develop a two step analysis. In a first step we estimate the average exchange-rate pass-through in the new EU member states, with the use of the generalized method of moments estimator for dynamic panel-data models. We apply the standard specification used in the pass-through literature for three price indexes: the consumer, the producer and the import price index[14]. This is completed by a country by country analysis in a second step. Our work complements the previous empirical work on CEECs in that we focus on identifying the changes in inflation environment and we allow for potential multiple breaks in the dynamic panel analysis. Before presenting the empirical work, we make a brief review of the previous studies on this issue.

3.2.3 Previous work

A limited number of empirical studies on the exchange rate pass-through in East European countries exist. These studies are considering individual countries or narrow groups of countries; a main drawback is that this does not allow for systematic cross-country comparisons. In addition, the degree of pass-through depends considerably on the applied estimation techniques.

In table (1) above we briefly resume the existing studies.

[14]Due to poor data availability, the analysis on import prices could not be carried on for Romania and Slovenia.

Table 1: Existing studies on exchange rate pass-through in Central and Eastern Europe.

Vector Auto Regressive (VAR) Models

Author	**Methodology**	**Sample of countries**	**Period of analysis**	**Results pass-through (PT)**
Kuijs (2002)	separate estimation of long-run relationships used as error correction terms	Slovakia	1993-2000	short-term PT: 40%, declining gradually with the appreciation
Gueorguiev (2003)	first-difference VAR	Romania	1997-2002	PT to CPI: 30%-40%, most of the impact within 12 months
Coricelli et al. (2004)	co-integrated VAR	Hungary, Czech Rep., Poland, Slovenia	1993-2002	full PT: Slovenia, Hungary 80%: Poland, 50%: Czech Rep.
Bitâns (2004)	recursive VAR in first differences	13 East European countries *	1993-2003	cross-country variation 50% PT decline over time

Dynamic panel data

Author	**Methodology**	**Sample**	**Period**	**Results pass-through (PT)**
Mihaljek, Klau (2001)	single equation estimation technique	13 emerging economies **	1993-2000	6%: Czech Rep. 45%: Poland 54%: Hungary
Darvas (2001)	time varying parameters framework, accounting for regime shifts during the 1990s	Hungary Czech Rep. Poland Slovenia	1993-2000	long-run PT: 15%: Czech Rep. 20%: Poland 40%: Hungary, Slovenia short run PT: 0 to 10%

* Bulgaria, Cyprus, Czech Republic, Croatia, Estonia, Hungary, Latvia, Lithuania, Macedonia (FYR), Poland, Romania, Slovak Republic, Slovenia.
** Brazil, Chile, Mexico, Peru, Czech Republic, Hungary, Poland, South Africa, Korea, Malaysia, Philippines, Thailand, Turkey.

The main conclusion that emerges from the previous studies is the existence of a large heterogeneity across countries regarding the pass-through to consumer price index (CPI), which is found to be higher in less developed countries. At the same time, the pass-through to producer prices (PPI) is higher than the pass-through to consumer prices (CPI).

4 Empirical framework and data

4.1 Data description

Our sample consists of quarterly data and covers the period January 1996 to June 2010. We use the Eurostat data for the consumer price index, the unit labor cost (ULC), the ULC-based real effective exchange rate, the nominal effective exchange rate, the GDP volume and the monetary aggregate M3. The International Financial Statistics (IFS, IMF) database is used for the producer price index. Data on the import prices comes from national sources. Information on the exchange rate regimes was taken from Ilzetzki, Reinhart and Rogoff (2008). See Table 8 in Appendix 1 for a description of data and further information on data availability.

4.2 Dynamic panel data analysis

We modify the standard pass-through specification (equation 6) in order to estimate the pass-through for three prices indexes (the consumer, the producer and the import price indexes):

$$\Delta p_{i,t} = \alpha_i + \eta_t + \sum_{j=1}^{2} \phi_j \Delta p_{i,t-j} + \beta \Delta s_{i,t} + \beta_{reg}(\Delta s_{i,t} * regime_{i,t}) + \lambda \Delta ulc_{i,t} + \tau gap_{i,t} + \varepsilon_{i,t} \quad (7)$$

with $\Delta p_{i,t}$ the rate of change in the relevant aggregate price index for country i in time period t, α_i a country-specific effect, η_t a time dummy, $\Delta s_{i,t}$ the rate of change in the nominal effective exchange rate for country i and time period t[15], $regime_{i,t}$ is a dummy variable that capture the exchange rate regime (it takes the value 1 for countries in a fixed-exchange rate regime and, respectively, 0 for flexible-exchange rate regimes)[16], $\Delta ulc_{i,t}$ and $gap_{i,t}$ control variables capturing changes in foreign producer cost and domestic demand conditions for country i and time period t, $\varepsilon_{i,t}$ an independent and identically distributed error term.

The inflation persistence is captured in our case by the autoregression on inflation[17], namely by the first two lags of inflation ($\Delta p_{i,t-1}$ and $\Delta p_{i,t-2}$)[18].

The aggregate pass-through may be a function of the exchange rate regime environment ($regime_{i,t}$). According to Darvas (2001), in an exchange rate targeting environment, a change in exchange rate might be regarded as more permanent than in a floating regime, implying higher pass-through.

Movements in the costs of foreign producers that export to domestic market are captured by a foreign exporters' unit labor cost (ULC), defined as $ulc_t = reerulc_t - s_t + ulcdom_t$ ($reerulc_t$ is the ULC-based real effective exchange rate, s_t is the nominal effective exchange rate and $ulcdom_t$ is the domestic country' ULC). Both nominal and real effective exchange rate series are trade weighted (since calculated against 36 trading partners), so that $\Delta ulc_{i,t}$ effectively measures the rate of change in ULC of exporters relative to the domestic country. The output gap is used as a proxy for changes in domestic demand conditions (i.e. it accounts for possible demand side shocks to inflation).

[15] Even though some countries have opted for a fixed exchange rate regime (thus limiting nominal exchange rate movements), there is still a considerable degree of variation in the effective nominal exchange rate that allows the exchange rate pass-through estimation for these countries.

[16] By including the interaction term between the change in nominal effective exchange rate and the exchange rate regime, we account for the potential influence of a change in exchange rate regime on prices.

[17] According to Fuhrer (2009), several measures of the reduced-form inflation persistence exists: conventional unit root tests; the autocorrelation function of inflation series; the first autocorrelation of inflation series; the dominant root of the univariate autoregressive inflation process; the sum of autoregressive coefficients for inflation; unobserved components decompositions of inflation that estimate the relative contributions of "permanent" and "transitory" components of inflation.

[18] The inflation persistence is measured by the sum of coefficients of the two lags of inflation.

In equation (7) above, there are two coefficients of interest: the coefficient of the rate of change in exchange rate (β)[19] and the coefficient of the interaction term between exchange rate changes and exchange rate regime (β_{reg}). The former captures the average rate of short run exchange rate pass-through (for each price index), while the latter captures the incremental effect due to a change in exchange rate regime over the period of analysis.

Before estimating the equation (7), several issues have to be considered, namely the non-stationarity and the measurement of the domestic demand conditions:

- The aggregate price level and the exchange rate follow non-stationary processes. The Fisher type unit root test for panel data[20] shows that both variables are best described as I(1) series; we consequently use the two variables in their first-difference form.
- The domestic demand conditions are proxied by the output gap, which is the difference between the actual and the estimated potential output[21]. We apply the Hodrick Prescott (HP) filter on seasonally adjusted GDP series. In order to mitigate the well-known *end-of-sample* problem of HP filtering procedure[22], we extend the output series by eight quarters by means of forecasts using ARIMA models (see Kaiser and Maravall, 1999). A brief overview of the method can be found in Appendix 4. For robustness checking, we use the OECD output gap series while bearing in mind the limitation due to data availability, since these series exist only for the OECD member states: Czech Republic, Estonia, Hungary, Poland, Slovenia and Slovakia.

4.2.1 Estimation technique and results

We apply the two-step System Generalized Method of Moments (GMM), designed by Arellano and Bover (1995) and fully developed by Blundell and Bond (1998). The use of this method is due to the inclusion of the lagged dependent variable as an explanatory variable[23] and to the potential endogeneity of some variables (as it is probably the case with the exchange rate term)[24]. The Arellano-Bond (1991) estimation starts by transforming all regressors, usually by differencing, and uses the Generalized Method of Moments (Hansen, 1982). The Arellano-Bover/Blundell-Bond estimator augments Arellano-Bond by making an additional assumption, i.e. that the first differences of instrument variables are uncorrelated with the

[19]A negative relationship is expected between exchange rate and inflation, since an appreciation of the currency should be followed by a decrease in inflation.

[20]The Fisher test combines the p-values from N independent unit root tests, as developed by Maddala and Wu (1999). Based on p-values of individual unit root tests, the Fisher test assumes that all series are non-stationary under the null hypothesis against the alternative that at least one series in the panel is stationary. Unlike the Im-Pesaran-Shin (1997) test, Fisher's test does not require a balanced panel.

[21]Conceptually, the potential output is the level of output achieved when prices and wages are fully flexible; it cannot be directly observed, so that any estimate of potential output is subject to considerable uncertainty.

[22]In the middle of the sample, the HP is a symmetric two-side filter as both leads and lags of output appear in the loss function. At the beginning or the end of the sample, some leads and lags will be unavailable, requiring either the transformation of the HP to a one-side filter towards the edges of the sample, or generating forecasts of output outside the sample of observations. See Guarda (2002) for further details.

[23]The presence of the lagged dependent variable among the regressors in a specification which considers the individual effect as well, brings about a correlation between the error term and the right-hand regressor. In such a case, the OLS estimation would be inconsistent and biased.

[24]The Kiviet estimator is suggested for estimating panel data models with small N and large T. It is in an efficient approximation of the bias of the Least Square Dummy Variable (LSDV) estimator for dynamic panel data models but, its main drawback is the fact the endogeneity of the explanatory variables is not resolved.

fixed-effects. This allows the introduction of a larger number of instruments and can improve the efficiency of estimators. We apply the Windmeijer (2005) finite-sample correction, without which the standard errors in two-step estimation tend to be significantly downward biased because of the large number of instruments. A crucial assumption for the validity of GMM is that the instruments are exogenous, tested by the Sargan/Hansen test (for the joint validity of instruments). The GMM validity also depends on the assumption that the model is not subject to serial correlation in ε_{it}.

The increased number of instruments is a common feature both of Arellano-Bond and Arellano-Bover/Blundell-Bond methodologies. According to Roodman (2008), in small-samples, numerous instruments can cause different kind of problems: the over-fitting of endogenous variables, imprecise estimates of the optimal weighting matrix, downward bias in two-step standard errors[25] and a weak Hansen test of instrument validity. We seek to avoid the proliferation of instruments by collapsing them[26] and limiting the lag depth.

Both the short run and the long run elasticities of the model are presented[27]. The short run pass-through is the immediate reaction of inflation to a change in exchange rate, while the long run pass-through is the overall response of inflation to an exchange rate shock. The collapsed instruments are: the third lags of the dependent variable, the first and second lags of the exchange rate term and the first lag of the output gap. The unit labor cost is considered to be exogenous.

We examine the results of the estimation of equation (7), first by abstracting away the effects of exchange rate regime on the average pass-through (columns 1, 3 and 5) and then by considering these potential effects (columns 2, 4 and 6). The pass-through estimates, both in the short and the long run, for the price indexes that we consider (i.e. the consumer price index (CPI), the producer price index (PPI) and the import price index (IPI)), are reported in Table 2. More complete estimation results can be found in Appendix 5 (Table 11). The results are broadly the same when using the OECD output gap series.

[25] Before the Windmeijer correction, researchers considered one-step results in making inferences (Roodman, 2008).

[26] One instrument is created for each variable and lag distance, rather than one for each time period, variable and lag distance. This reduces the statistical efficiency in large samples but, in small samples, it can avoid the bias that arises as the number of instruments increases with the number of observations (Roodman, 2008).

[27] The long-term coefficient of a variable is computed as the sum of its coefficients (of its lags and current values, where applicable) divided by one minus the sum of coefficients of the lags of the dependent variable. This way, the measure of the long run pass-through is $\beta / \left[1-\left(\sum_{j=1}^{2}\phi_j\right)\right]$; it is intended to capture the effects of an exchange rate change in period t on inflation over several subsequent periods.

Table 2: GMM estimates over 1996Q1-2010Q2.

Price Index	**CPI (1)**	**CPI (2)**	**PPI (3)**	**PPI (4)**	**IPI (5)**	**IPI (6)**
short run						
$\Delta s_{i,t}$	-0.012	-0.010	-0.136*	-0.095	-0.628***	-0.688*
	(0.058)	(0.065)	(0.074)	(0.092)	(0.064)	(0.327)
$\Delta s_{i,t} * regime_{i,t}$		0.002		-0.279		0.009
		(0.100)		(0.200)		(0.377)
Long-run						
$\Delta s_{i,t}$	-0.224	-0.121	-0.214	-0.140	-1.045***	-1.053
	(3.069)	(1.492)	(0.131)	(0.150)	(0.181)	(0.830)
$\Delta s_{i,t} * regime_{i,t}$		0.025		-0.414		0.014
		(1.327)		(0.258)		(0.582)

Notes:
1. Columns 2, 4 and 6 report the results obtained when including interaction terms to account for exchange rate regime shifts.
2. Two-step System GMM with the Windmeijer (2005) correction.
3. Standard errors in parenthesis. *,**,*** denotes significance at 10%, 5%, 1% level.

As shown in Table 2, the CPI pass-through estimates present the expected negative sign (i.e. an increase in nominal effective exchange rate translates an appreciation of the currency and it should normally be followed by a decrease in inflation), but are not statistically significant neither in the short nor in the long run. This applies both when we consider only the effects of exchange rate on the average pass-through (column 1) and when we distinguish between the fixed-exchange and the flexible-exchange rate regimes (column 2).

The PPI pass-through estimates: when estimating the equation (7) without distinguishing between the exchange rate regimes (column 3), the PPI pass-through presents a negative and statistically significant coefficient. A 1 per cent appreciation of nominal effective exchange rate leads to, on average, a 0.14 per cent decrease in producer prices. When we consider the different exchange rate regimes (columns 4), the PPI pass-through estimates are no longer statistically significant.

The IPI pass-through estimates: both the short run and the long run exchange rate pass-through are statistically significant and present the expected negative sign when we do not consider the potential effect of exchange rate regimes on the average pass-through (column 5). In the short run, a 1 per cent appreciation of nominal effective exchange rate leads to, on average, a 0.63 per cent decrease in import prices. In the long run, the decrease in IPI is more pronounced, of about 1.04 per cent. When we distinguish between the fixed and the flexible exchange rate regimes (column 6), the short run pass-through is still statistically significant and presents the expected negative sign; in this case, a 1 per cent increase in nominal effective exchange rate leads to, on average, a 0.69 per cent decrease in IPI. Moreover, the long run average pass-through is not statistically significant.

The interaction term between the rate of change in exchange rate and the dummy variables that capture the type of exchange rate arrangement ($\Delta s_{i,t} * regime_{i,t}$), is not statistically significant in any of the estimations. This implies that the effects of exchange rate movements on consumer, producer and/or import prices are not affected by the exchange rate regime.

4.2.2 Exchange rate pass-through in different inflation environments

During the last twenty years, most of East European countries have experienced changes in either the inflation rate, the exchange rate regime or both. We wonder whether the different inflation environments affect the exchange rate pass-through estimates.

We first test for structural breaks in HICP series, as these series might reflect the potential changes in domestic inflation environment[28]. We seek to detect the potential breaking points and, then, to estimate the exchange rate pass-through in different inflation environments. In this respect, we use the multiple break test developed by Clemente, Montanes and Reyes (1998), i.e. the double-break additive outlier AO model, and we detect, for each country in the sample, changes in inflation environment that are significant enough to appear in the data.

In a second step, we check whether the breaks identified in the first step are in line with changes in monetary policy regimes. We thus verify if changes in inflation environment identified through the Clemente, Montanes and Reyes (1998) structural break test are indeed the result of a change in monetary policy regime and not the result of some other factors.

The results of the Clemente, Montanes and Reyes test and the methodology are presented in Appendix 6; Figure 7 presents the CPI inflation series with the identified structural breaks (as indicated by the red vertical lines), country by country. As shown in these graphs, two breaks are identified for each country: the first one coincides with the 1997-1998 Asian crisis and the 1998 Russian crisis, while the second one corresponds to the more recent global financial crisis that began in the summer of 2007 (a year marked by rising tensions both in domestic and international markets).

In Table 3 we present the identified structural breaks, and the monetary policy strategies and the official exchange arrangements, country by country. As can be seen, most of the identified structural breaks in inflation series do not line up with a change in the monetary policy regime. The exceptions are formed by Bulgaria, Czech Republic and Poland[29]. Another exception is Romania, where the second break in inflation correspond to the adoption of an inflation targeting strategy.

To compare the pass-through estimates under alternative inflation environments when the shifts result from a change in monetary policy, we construct a dummy variable $regime\_97$ that captures a shift in the inflation environment in 1997, taking the value one starting with the period in which the country experienced the structural break (and for all subsequent years) and zero otherwise. We thus account for shifts in inflation resulting from a change in monetary policy in Bulgaria, Czech Republic and Poland. For the other countries the dummy variable takes the value zero all over the period. The dummy variable is then interacted with the exchange rate term and included as an explanatory variable in equation (7). The coefficient of this interaction term captures the change in pass-through that occurs as a result of a transition to a new inflation environment.

[28] The test for the existence of structural breaks was done both on the rate of inflation (i.e. the variation in price level) and on the variance of inflation. The identified breaks are mostly the same.

[29] In these countries, the first break correspond to a change in the monetary policy regime.

Table 3: Identified structural breaks in inflation and monetary policy changes.

Country	Identified breaks in inflation	Monetary Policy Strategies	Official Exchange Arrangements
Bulgaria	1997Q3 1998Q1		1994-1997 Managed float 1997- Currency board arrangement
Czech Rep.	1997Q3 2007Q3	1994-1997 Exchange rate and monetary targeting (credit volume and M2) 1998-2001 Net inflation targeting 2002- Headline inflation targeting with linear and declining target band	1994-1997 Basket peg May 1997 - Managed float
Estonia	1998Q1 2007Q1		Since 1992 - Currency board arrangement
Hungary	1998Q1 2005Q3	1994-2002 Exchange rate targeting 2002- Inflation targeting	1994-2001 Crawling peg Since 2001 Peg to euro Since Feb. 2008 Managed float
Latvia	2007Q2 2008Q3		Since 1994 Peg to SDR Since 2005 Peg to euro
Lithuania	1997Q1 2006Q4		Since 1994 Currency board arrangement
Poland	1997Q3 2007Q2	1994-1998 Exchange rate targeting 1998- Inflation targeting	1994-2000 Crawling peg 2000 - Free float
Romania	1997Q3 2005Q2	1994-2005 No official commitment to a monetary policy strategy Since Aug. 2005 Inflation targeting	Since 1994 managed float
Slovakia	1999Q1 2002Q3	1994-1998 Exchange rate targeting 1998-2005 Informal inflation targeting 2005-2008 ERM II with inflation targeting Since 2009 Euro system	1997-1998 Basket peg 1998-2005 Managed float 2005-2008 ERM II Since 2009 Official euro system member
Slovenia	2000Q4 2008Q1	1997-2000 M3 targeting 2001-2006 Two pillar strategy 2004-2006 ERM II Since 2007 Euro system	1994-2004 Managed float 2004-2006 ERM II Since 2007 Official euro system member

Sources: Ilzetzki, Reinhart and Rogoff (2008) for official exchange arrangements in Bulgaria, Estonia, Latvia and Lithuania; Frömmel, Garabedian and Schobert (2009) for monetary policy strategies and official exchange arrangements in the rest of the countries.

The results are presented in Table 4 below. More complete estimation results are presented in Appendix 5 (Table 12).

Table 4: GMM estimates over 1996Q1-2010Q2, while accounting for shifts in inflation regimes.

Price Index	**CPI**	**PPI**	**IPI**
short run			
$\Delta s_{i,t}$	-0.014	-0.126	-0.806***
	(0.078)	(0.161)	(0.095)
$\Delta s_{i,t} * regime\_97i, t$	0.036	0.027	0.265*
	(0.074)	(0.170)	(0.142)
Long-run			
$\Delta s_{i,t}$	0.158	-0.233	-1.190***
	(0.560)	(0.354)	(0.118)
$\Delta s_{i,t} * regime\_97i, t$	-0.406	0.050	0.392*
	(0.781)	(0.325)	(0.200)

Notes:
1. Two-step System GMM with the Windmeijer (2005) correction.
2. Standard errors in parenthesis. *,**,*** denotes significance at 10%, 5%, 1% level.

As shown in Table 4, the CPI pass-through estimates present the expected negative sign both in the short and the long run but are not statistically significant.

As far as the PPI pass-through estimates are concerned, these are non statistically significant neither in the short nor in the long run.

Regarding the IPI pass-through estimates, these are statistically significant and present the expected negative sign both in the short and the long run. In the short run, a 1 per cent increase in the nominal effective exchange rate leads to, on average, a decrease of 0.81 per cent in the IPI. In the long-run, a 1 per cent increase in the nominal effective exchange rate leads to, on average, a full pass-through to the IPI.

The interaction term between the rate of change in exchange rate and the dummy variable that capture the inflation regime shift, $\Delta s_{i,t} * regime\_97i, t$, presents a statistically significant coefficient both in the short and the long run in the case of the IPI. The average short run IPI pass-through is thus of 0.54 per cent for the three countries that have encountered shifts in their monetary policy regimes (i.e. Bulgaria, Czech Republic and Poland), as the more stable inflation environment in these countries determines a lower pass-through. In the same time, the average long-run IPI pass-through for the three countries is of 0.80 per cent. We can equally assert that the effects of exchange rate movements on producer and consumer prices were not affected by the shift in inflation environment that occurred in 1997 (i.e. for the countries that experienced such a shift: Bulgaria, Czech Republic and Poland).

We conclude by assessing the existence of a significant average pass-through to import price index (IPI), both when taking into account the break in inflation series and when ignoring the existence of such a break. As far as the average pass-through to consumer and producer price indexes (CPI and PPI) are concerned, the results of the dynamic panel data analysis are rather inconclusive and this might be explained by the increased heterogeneity in the sample of countries. The panel estimations are imposing the slope homogeneity across countries, hypothesis which is rather unrealistic in the case of our analysis. An individual analysis, at the level of each country, could provide us with some useful information on the differences in pass-through estimates; and we therefore proceed to it in the following subsection.

4.3 The country by country analysis

We estimate the exchange rate pass-through to CPI, PPI and IPI for each of the 10 countries in the sample, country by country. We use the same specification as in the dynamic panel data analysis:

$$\Delta p_t = \alpha + \eta_t + \sum_{j=1}^{2} \phi_j \Delta p_{t-j} + \beta \Delta s_t + \lambda \Delta ulc_t + \tau gap_t + \varepsilon_t \tag{8}$$

with Δp_t the rate of change in the relevant aggregate price index for each country at time period t, α a country-specific effect, η_t a time dummy, Δs_t the rate of change in nominal effective exchange rate for each country and time period t, Δulc_t and gap_t control variables capturing changes in foreign producer cost and domestic demand conditions for each country and time period t, ε_t an independent and identically distributed error term.

4.3.1 Statistical preliminaries

Before proceeding to the empirical estimations, several empirical tests are computed, in order to choose the right specification model.

We first compute the Dickey-Fuller unit root test, then test for the autocorrelation of residuals (the Box-Ljung Q test) and for the serial correlation (the Breusch-Godfrey or Lagrange Multiplier(LM) test). We equally compute the Breusch-Pagan / Cook-Weisberg heteroskedasticity test.

The results of these preliminary statistical tests are presented in Appendix 6, in Tables (13), (14) and (15). As shown in these tables: the nominal effective exchange rate, the CPI, the PPI and the IPI follow I(1) processes and their first-difference form follow I(0) processes; there are problems of serial correlation in 3 cases: for PPI and IPI in Czech Republic and for PPI in Slovenia; the aspects of autocorrelation and heteroskedasticity are taken into account.

Regarding the estimation technique, we apply the ordinary least squares (OLS) method, except for the cases where we detect the presence of serial correlation, in which case we adjust the linear model for serial correlation in the error term through the Cochrane-Orcutt (1949) estimation.

4.3.2 Estimates of the pass-through coefficients

In this subsection we summarize the results of the estimation of the exchange rate pass-through to consumer prices, producer prices and import prices.

In the case of consumer price regressions (Table 5), the estimation results show that the coefficients of the nominal exchange rate pass-through are statistically significant, with the expected negative sign only for Bulgaria, Estonia and Slovenia. The magnitudes are of 21 per cent in Bulgaria, 37 per cent in Estonia and 17 percent in Slovenia. We cannot compare these figures with the average short run exchange rate pass-through to CPI estimated in subsection

4.2 Table 2, since the coefficient of the average CPI pass-through estimated through the panel data analysis was not statistically significant. Our results are broadly in line with those of the previous studies.

Table 5: The exchange rate pass-through to consumer prices.

Country	ΔCPI_{t-1}	ΔCPI_{t-2}	$\Delta NEER$	**output gap**	$\Delta ulct$	**No. obs.**	R^2
Bulgaria	0.220**	-0.019	-0.207*	0.108	0.009	52	0.525
Czech Republic	0.353**	0.294*	-0.043	0.062	-0.005	55	0.369
Estonia	0.459***	-0.058	-0.336***	0.092***	-0.003	55	0.615
Hungary	0.784***	-0.020	-0.016	-0.035	0.001	55	0.662
Latvia	0.705***	-0.190	0.054	0.069**	0.019**	55	0.772
Lithuania	0.392***	0.145	0.075	0.076**	0.004	55	0.612
Poland	0.559***	0.231	-0.003	0.023	0.008	55	0.723
Romania	0.551**	0.321**	-0.022	-0.001	-0.0006	41	0.913
Slovakia	0.186**	0.369***	0.0009	0.021	-0.020	54	0.210
Slovenia	0.467***	0.187**	-0.166*	0.005	0.029	55	0.545

Notes: ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

The producer price regressions (Table 6) show a negative and statistically significant coefficient for the nominal effective exchange rate but only for Bulgaria, Estonia, Hungary, Latvia and Romania. The magnitudes are of 50 per cent in Bulgaria, 77 per cent in Estonia, 33 percent in Hungary, 16 percent in both Latvia and Romania. If we compare these figures with the average short run exchange rate pass-through to PPI estimated in subsection 4.2 Table 2 (of 13.6 per cent), we see that the figures obtained through the individual analysis are superior to the average obtained through the panel data analysis.

Table 6: The exchange rate pass-through to producer prices.

Country	ΔPPI_{t-1}	ΔPPI_{t-2}	$\Delta NEER$	**output gap**	$\Delta ulct$	**No. obs.**	R^2
Bulgaria	0.403***	-0.039	-0.500***	-0.089	-0.049**	52	0.463
Czech Republic	-0.022	0.108	0.033	0.033	-0.024*	54	0.099
Estonia	0.162	0.252	-0.768*	0.032	0.015	55	0.279
Hungary	0.275*	0.073	-0.327***	0.100	0.067*	55	0.549
Latvia	0.956***	-0.490***	-0.160**	0.052	0.039**	55	0.682
Lithuania	0.483***	-0.251	-0.041	-0.027	-0.019	55	0.206
Poland	-0.24	-0.891	0.007	0.534	0.110	55	0.204
Romania	0.539***	0.140	-0.156**	-0.091	-0.002	41	0.709
Slovakia	0.287*	-0.011	0.010	0.028	-0.014	54	0.093
Slovenia	0.645**	-0.327**	-0.194	0.063	-0.022	54	0.433

Notes: ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

The importer price regressions (Table 7) show a negative and statistically significant coefficient for the nominal effective exchange rate for all the countries, except for Lithuania (less Romania and Slovenia where there is no available data on IPI). The magnitudes are of 150 per cent in Bulgaria, 48 per cent in Czech Republic, 107 per cent in Estonia, 67 per cent in Hungary, 56 per cent in Latvia, 51 per cent in Poland and, respectively, 95 per cent in Slovakia. When we compare these figures with the average short run IPI pass-through estimated in subsection 4.2 Table 2 (of 63 per cent), we see that the figures obtained through the individual analysis are superior to these average obtained through the panel data analysis in Bulgaria, Estonia and Slovakia; they are close or slightly inferior in Hungary, Latvia and Poland.

Table 7: The exchange rate pass-through to importer prices.

Country	ΔIPI_{t-1}	ΔIPI_{t-2}	$\Delta NEER$	**output gap**	$\Delta ulct$	**No. obs.**	R^2
Bulgaria	0.127	-0.129	-1.498*	-0.140	-0.039	35	0.230
Czech Republic	0.143	-0.103	-0.475***	0.077	0.008	46	0.487
Estonia	0.358**	-0.426***	-1.074***	0.123**	-0.050*	47	0.632
Hungary	0.303*	-0.177	-0.666***	0.371	-0.168	27	.0574
Latvia	0.211	-0.032	-0.556**	0.037	0.059	47	0.269
Lithuania	0.547***	-0.160	-0.464	-0.148	0.001	51	0.295
Poland	0.032	0.010	-0.513***	-0.445	0.011	55	0.350
Slovakia	0.345**	0.016	-0.950**	-0.561	0.046	54	0.216

Notes: ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

The individual analysis confirms the heterogeneity in the estimated exchange rate pass-through to consumer, producer and importer prices. We wonder what are the factors that might explain the differences in the estimated exchange rate pass-through. We proceed here to a simple statistical analysis.

A first conclusion is that countries having the highest share of imports (as a % of GDP) are also the countries with the highest exchange rate pass-through to import prices. Over the period 1996Q1-2010Q2, the average share of imports in the total GDP is superior to 70% in the countries with the highest exchange rate pass-through to import prices (72.5% in Bulgaria, 78.2% in Estonia and 76.3% in Slovakia), and lower in the other countries (65% in Czech Republic, 55% in Hungary, 60% in Latvia, 68% in Lithuania and 35.4% in Poland).

The estimation of the determinants of cross-country differences in exchange rate pass-through is beyond the scope of this paper; it could nevertheless make the object of some future work.

4.3.3 Robustness tests and stability analysis

We investigate the possibility that the variables in equation (8) may co-integrate, as suggested by de Bandt et al. (2007) and Bussière and Peltonen (2008). We test for co-integration, through the two step process suggested by Engle and Granger (1987), the EG-ADF test. The results are presented in Appendix 6, Table (16). Overall, there is not much evidence for a co-integrating relation among variables, as the residuals of the long run relationships in level are not stationary.

We test de stability of the estimated models, by focusing on the coefficient of the exchange rate. As shown by Bussière and Peltonen (2008), the stability of parameters is not only an issue for the emerging markets but also for the advanced economies, where a structural fall in the degree of pass-through took place. We estimate the benchmark equation (8) using a rolling sample of 20 quarters, to verify whether a decrease in the exchange rate pas-through took place over time. The results are reported in Figures (8), (9) and (10) in Appendix 6. One should bear in mind that a decrease in pass-through means, in our case, an ascending trend on the graphs, since the relationship between prices and exchange rate is negative. Starting with the regression for consumer prices, a slight reduction in the degree of pass-through can be observed for Czech Republic and Latvia. Stable patterns are observed in Bulgaria, Hungary, Poland, Romania, Slovakia and Slovenia, while a slight increase in pass-through is found in Estonia and Lithuania. Turning to the producer price equation, a stable pattern is observed in Bulgaria, Estonia and Poland, while the pass-through decreases in Czech Republic, Romania and Slovenia and even increases in Latvia, Lithuania, Hungary and Slovakia. As far as the importer price regressions are concerned, stable patterns are observed in Estonia, Hungary, Latvia, Poland and Slovakia, and the pass-through decreases in Czech Republic and increases in Bulgaria and Lithuania.

Another question that arises are that of the factors explaining these evolutions in the estimated pass-through. As mentioned above, the analysis of the determinants of cross-country differences in the exchange rate pass-through could make the object of some further work.

5 Conclusions

This paper investigates the relationship between changes in nominal exchange rates and prices in the new EU member states, over the period 1996-2010.

In a first step, we examine whether the changes in exchange rates affect the consumer, the producer and the import prices through an analysis at the aggregate cross-country level, with quarterly data. We also investigate the potential effect of shifts in exchange regimes and in inflation regimes on the average exchange rate pass-through.

We find evidence of a significant exchange rate pass-through to import prices, both in the short and the long-run:

- when we do not consider the potential effects of changes in the exchange rate regime on the average pass-through (column 5 of Table 2), the short run pass-through for import prices is of 63 percent and increases to 104 per cent in the long-run.
- when we consider the potential effects of the exchange rate shifts on the average pass-through (column 6 of Table 2), the short run pass-through for import prices is of 69 percent.
- when we consider the inflation regime shifts (column 3 of Table 4), the short run pass-through for import prices is of 81 percent and increase to 119 percent in the long-run.

No statistically significant exchange rate pass-through was estimated at the aggregate level for consumer prices (measured by the HICP) and for producer prices (measured by total PPI).

We test for the existence of multiple structural breaks in CPI inflation series that might reflect a change in the monetary policy regime. We detect two such structural breaks for each country in the sample, corresponding more or less to the 1997/1998 Asian and 1998 Russian crises and, respectively, to the actual global financial crisis. We focus on changes in monetary policy regime that might have determined the shift in inflation; consequently, we take a further look at monetary policy strategies and official exchange arrangements in the sample of countries over the period of analysis. We find that the first structural break in CPI inflation series reflects a monetary policy regime change in Bulgaria, the Czech Republic and Poland. We estimate the exchange rate pass-through by taking into account the changes in monetary policy regimes and find evidence of an inflation regime shift' influence on the exchange-rate pass-through both in the short run and the long run, but only for the import prices (i.e. a decrease in the import price index pass-through estimates of about 26 percent in the short run and, respectively, of about 39 percent in the long run). This result is similar to Bailliu and Fujii (2004).

In a second step, we asses the exchange rate impact on import, producer and consumer prices at an individual level, country by country. The conclusions that emerges is that of an increase heterogeneity in the exchange rate pass-through estimates. We find evidence of a negative and statistically significant exchange rate pass-through to importer prices in Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Poland and Slovakia; its magnitude is higher compared to the average importer prices exchange rate pass-through estimated through the panel data analysis. The countries with the highest importer price exchange rate pass-through are also the countries having the highest average share of imports in the total GDP over the period of analysis. As regards the consumer price regressions, the estimated exchange rate pass-through is negative and statistically significant only in Bulgaria, Estonia and Slovenia. Turning to the producer price regressions, the estimated exchange rate pass-through is negative and statistically significant in Bulgaria, Estonia, Hungary, Latvia and Romania and its magnitude is larger than the average producer price exchange rate pass-through estimated through the panel data analysis.

We test for the stability of the estimated models, with a focus on the coefficient of the exchange rate. We thus estimate the benchmark equations using a rolling sample of 20 quarters, to verify in particular whether there has been a decrease in the degree of exchange rate pass-through over time. Overall, the results show some rather stable patterns.

Further work will focus on the determinants of the cross-country differences in the exchange rate pass-through estimates.

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Appendix

Appendix 1. Sources and data availability

Table 8: Variables definitions and sources.

Variable	Source	Definition
ULC	Eurostat	Nominal unit labor cost, index, 2000=100, NSA. Own calculations for Hungary, Poland and Romania, as a ratio of compensation on employee to labor productivity on employee.
NEER	Eurostat	Nominal effective exchange rate, 36 trading partners, average index, 1999=100.
REER ULC	Eurostat	Real effective exchange rate, deflator: ulc for the whole economy, 36 trading partners, average, index, 1999=100.
M	Eurostat	M3 monetary aggregate.
Output	Eurostat	GDP in volume.
PPI	IFS (IMF)	Producer price index or wholesale price index, index, 2005=100.
IPI	Datastream	Import price index.
HICP	Eurostat	Harmonized index of consumer price, overall index, monthly index, SA, not working day adjusted.
Exchange rate regime	Ilzetzki, Reinhart and Rogoff (IRR) 2008	Dummy variable (1 for fixed-exchange rate regime and 0 for flexible exchange rate regime), based on IRR (2008) database on exchange rate arrangements.

IFS - International Financial Statistics, IMF - International Monetary Fund.

Table 9: Sample period by country.

Country	CPI, PPI, NEER	IPI	GDP	ULC
Bulgaria	1996Q1 - 2010Q2	2001Q1 - 2010Q2	1996Q1 - 2010Q2	1996Q1 - 2010Q2
Czech Republic	1996Q1 - 2010Q2	1998Q1 - 2010Q2	1996Q1 - 2010Q2	1996Q1 - 2010Q2
Estonia	1996Q1 - 2010Q2	1998Q1 - 2010Q2	1996Q1 - 2010Q2	1996Q1 - 2010Q2
Hungary	1996Q1 - 2010Q2	2003Q1 - 2010Q2	1996Q1 - 2010Q2	1996Q1 - 2010Q2
Latvia	1996Q1 - 2010Q2	1998Q1 - 2010Q2	1996Q1 - 2010Q2	1996Q1 - 2010Q2
Lithuania	1996Q1 - 2010Q2	1997Q1 - 2010Q2	1996Q1 - 2010Q2	1996Q1 - 2010Q2
Poland	1996Q1 - 2010Q2	1996Q1 - 2010Q2	1996Q1 - 2010Q2	1996Q1 - 2010Q2
Romania	1996Q1 - 2010Q2	-	1998Q1 - 2010Q2	1999Q1 - 2010Q2
Slovakia	1996Q1 - 2010Q2	1996Q1 - 2010Q2	1996Q1 - 2010Q2	1996Q1 - 2010Q2
Slovenia	1996Q1 - 2010Q2	-	1996Q1 - 2010Q2	1996Q1 - 2010Q2

Note: All data are quarterly. One can notice the scarce data on the import price index (IPI) compared to the other price indexes (PPI et CPI).

Appendix 2. Key indicators

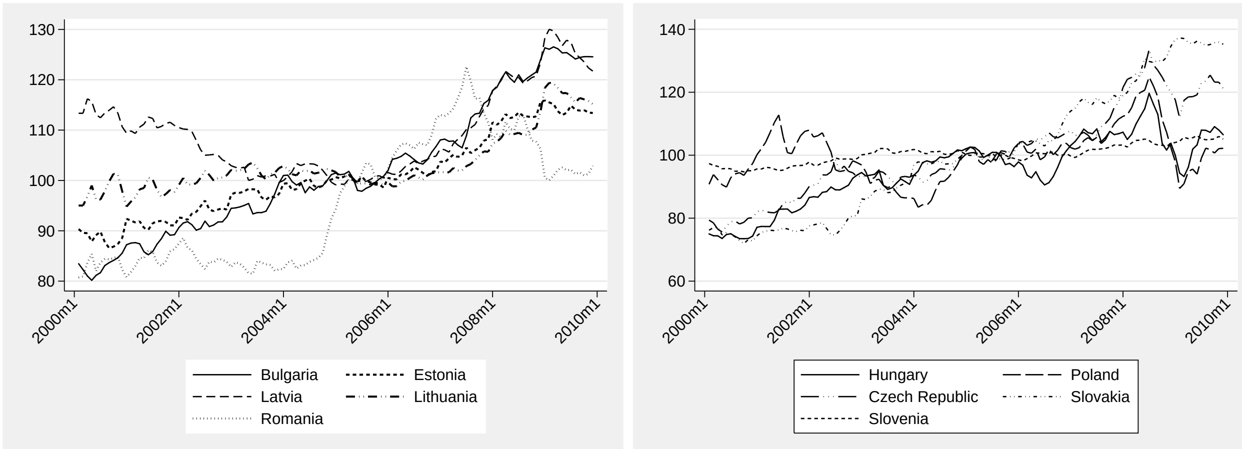
Table 10: Key macroeconomic indicators.

	GDP per capita in PPS UE27=100 2000	2009	Domestic credit to private sector (% GDP) 2008	Public debt (% GDP) 2009	External debt (% GDP) 2009	△GDP
Euro area 12	113.9	109.3	141.9	79.2	-	1.3
Bulgaria	27.7	41.3	74.5	14.8	111.3	4.7
Czech Republic	68.5	80	52.7	35.4	43.8	3.4
Estonia	45	60.7	97.4	7.2	126.7	4.9
Latvia	36.7	49.4	90.0	36.1	154.7	4.8
Lithuania	39.3	55.4	62.9	29.3	86	4.8
Hungary	55.3	63.3	69.8	78.3	140.5	2.5
Poland	48.2	60.1	49.7	51	66.4	4
Romania	26.1	46.8	38.5	23.7	49	4.3
Slovenia	79.8	86.8	85.6	35.9	105.6	3.1
Slovakia	50.1	72	44.6	35.7	103.1	4.7
	△Private consumption	**△Exports**	**△Imports**	**△Domestic demand**	**△Investment**	
Euro area 12	4	3.5	3.3	1.2	0.9	
Bulgaria	4.8	7.1	9	5.8	12.8	
Czech Republic	3	9.5	8.8	2.8	2.9	
Estonia	5.1	7.0	7.1	4.6	7.1	
Latvia	5.7	6.2	5.4	4.5	6.7	
Lithuania	5.9	9.2	8.7	4.9	5.2	
Hungary	3	9.6	7.9	1.4	3	
Poland	3.6	8.9	6.8	3.5	4	
Romania	7.5	10.5	15.0	6.7	10.1	
Slovenia	2.5	6.6	5.5	2.6	2.9	
Slovakia	4.4	7.6	6.7	4.0	3.3	
	△Current account (% GDP)	**△Domestic credit**	**△General government balances (% GDP)**	**△Wages**	**△HICP**	
Euro area 12	-0.2	8.5	-2.3	2.3	2.1	
Bulgaria	-11.7	37.9	0.4	9.8	6.7	
Czech Republic	-3.6	7.1	-4.1	6	2.6	
Estonia	-9.2	28.2	0.6	11.4	4.4	
Latvia	-10.1	41.7	-2.4	12.7	5.8	
Lithuania	-7.1	32.3	-2.6	7.8	3.1	
Hungary	-6.6	20.3	-6.0	8.8	6.1	
Poland	-3.4	16.2	-4.5	4.7	3.6	
Romania	7.4	53.6	-3.3	26.8	16.5	
Slovenia	-2.3	20.4	-2.5	7.4	4.9	
Slovakia	-6.5	8.9	-5.0	8.1	5.3	

Source. Eurostat. National Central Banks data for gross external debt (in % of GDP).
Note. △ indicates the growth rates of the indicators; we report their average over the period 2000-2009 (except for domestic credit to private sector, where the average over the period 2000-2008 is reported).

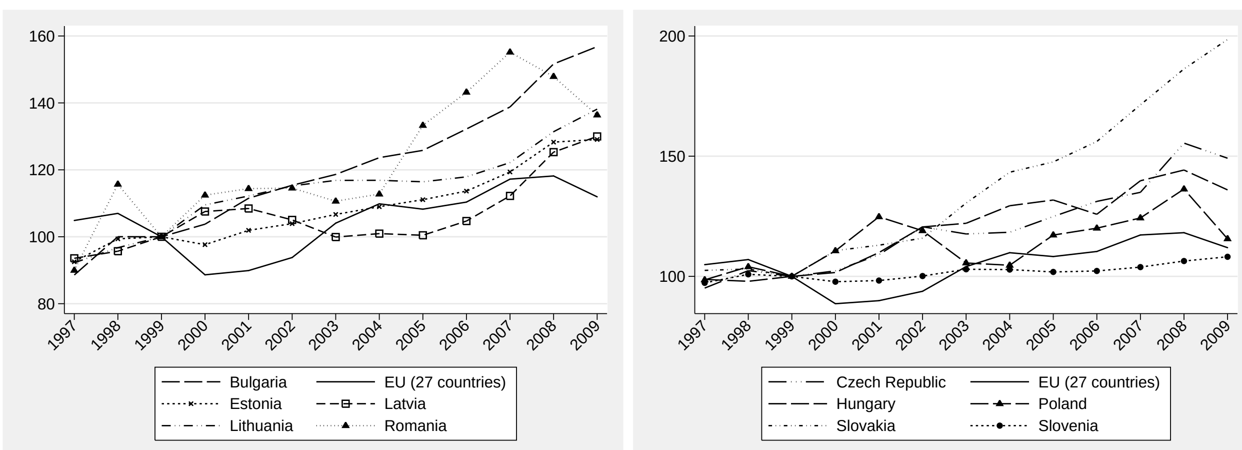
Appendix 3. Figures

Figure 4: Real effective exchange rate, CPI deflated (2005=100), 2000-2009.



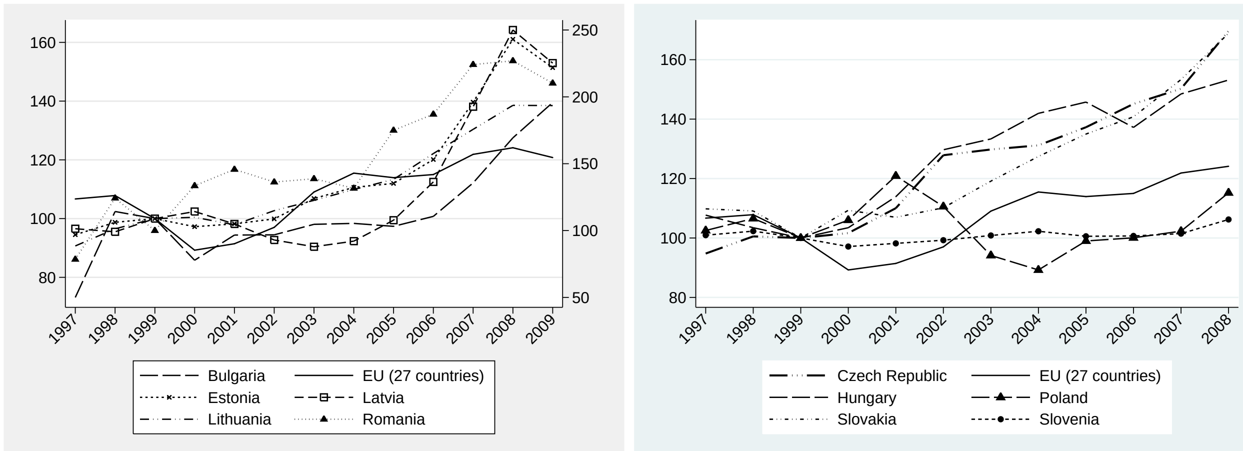
Source: BIS.
Note: A rise in the index means real appreciation.

Figure 5: CPI based real effective exchange rate (1999=100), 1997-2009.



Source: Eurostat.
Note: values shown correspond to CPI based real effective exchange rate (calculated against 36 trading partners). A rise in the index means real appreciation.

Figure 6: Total economy unit labor cost based real effective exchange rate (1999=100), 1997-2009.



Source: Eurostat.
Note: A rise in the index means real appreciation. RHS for Romania.

Appendix 4. Potential output - The Hodrick-Prescott filter

There exist two main approaches to measure the potential output: the *univariate methods*, essentially statistical, that identify the output gap solely from past behavior of output series without referring to any macroeconomic variables; they are based only on some (explicit or implicit) assumption about the dynamics of output series; and the *multivariate methods* that consider both the past behavior of output series and the evolution of other macroeconomic variables, and that exploit the relationships derived from the economic theory (such as the Phillips curve) for obtaining a measure of potential output closer to the notion of sustainable aggregate supply capacities of the economy.

Both approaches imply several measurement issues. Moreover, additional challenges appear when estimating the output gap of an emerging market economy, in which case, because of the lack of reliable data, the potential output is mostly measured through a statistical technique (Tanaka and Young, 2008).

The univariate filtering methods allow potential output growth to change smoothly through the time. The HP filter of Hodrick and Prescott (1997) has proved the most popular univariate filtering method. It is based on the assumption that a given time series y_t is the sum of a trend or growth component g_t and a cyclical component c_t.

$$y_t = g_t + c_t$$

for $t = 1, ..., T$. The measure of smoothness of $\{g_t\}$ path is chosen to be the sum of the squares of its second difference. c_t, the cyclical component, represents deviations from g_t; their average is assumed to be near zero over long time periods. The growth component g_t is extracted by minimizing the following loss function:

$$\underset{\{g_t\}_{t=-1}^{T}}{Min} \left\{ \sum_{t=1}^{T} c_t^2 + \lambda \sum_{t=1}^{T} \left[(g_t - g_{t-1}) - (g_{t-1} - g_{t-2}) \right]^2 \right\}$$

The parameter λ represents terms on which deviations from trend are traded off against variability in trend. The higher is λ the "stiffer" is the trend component[30]. The results can be sensitive to the choice of λ and no objective criterion of choosing this parameter exists. Hodrick and Prescott (1997) recommend a value of $\lambda = 100$ for yearly data and $\lambda = 1600$ for quarterly data[31].

Several pros and cons are associated to the use of this method. The pros consist in the fact that it extracts the relevant business-cycle frequencies of the spectrum and it closely approximates the cyclical component implied by reasonable time-series models of output. One attraction of the HP filter is that it may be applied to non-stationary time series (series containing one or more unit roots in their autoregressive representation), a relevant concern for many macroeconomic and financial time series. Nevertheless, several studies raised doubts about the above-mentioned affirmations and about the reliability of HP filter as a mean of extracting trend components (see Harvey and Jaeger, 1993; Cogley and Nason, 1995; Guay and St-Amant, 1996).

Appendix 5. Estimation results for equation (7)

Table 11: GMM estimates over 1996Q1-2010Q2.

Price Index	**CPI (1)**	**CPI (2)**	**PPI (3)**	**PPI (4)**	**IPI (5)**	**IPI (6)**
$\Delta p_{i,t-1}$	1.185	1.151	0.396*	0.367*	0.340**	0.248
	(0.720)	(0.666)	(0.189)	(0.197)	(0.133)	(0.266)
$\Delta p_{i,t-2}$	-0.242	-0.234	-0.032	-0.041	0.059	0.097
	(0.179)	(0.162)	(0.051)	(0.048)	(0.120)	(0.080)
$\Delta s_{i,t}$	-0.012	-0.010	-0.136*	-0.095	-0.628***	-0.688*
	(0.058)	(0.065)	(0.074)	(0.092)	(0.064)	(0.327)
$\Delta s_{i,t} * regime_{i,t}$		0.002		-0.279		0.009
		(0.100)		(0.200)		(0.377)
$\Delta ulc_{i,t}$	-0.004	-0.002	-0.016	-0.010	-0.048	0.0005
	(0.014)	(0.011)	(0.018)	(0.015)	(0.041)	(0.019)
$gap_{i,t}$	-0.0007	0.006	0.369**	0.320**	0.693	-0.073
	(0.054)	(0.061)	(0.153)	(0.121)	(0.394)	(0.157)
AR1 (p-value)	0.128	0.115	0.131	0.128	0.083	0.293
AR2 (p-value)	0.232	0.216	0.263	0.281	0.500	0.286
Hansen test(2nd step)(p-value)	0.143	0.116	0.388	0.359	0.313	0.685
No. of instruments	10	10	10	10	8	8
No. of observations	532	532	532	532	363	363

Notes:
1. Columns 2, 4 and 6 report the results obtained when including interaction terms to account for exchange rate regime shifts.
2. Two-step System GMM with the Windmeijer (2005) correction.
3. Standard errors in parenthesis. *,**,*** denotes significance at 10%, 5%, 1% level.

[30] When $\lambda \to \infty$ the trend becomes a straight line and the HP filter gives the same result as the linear time trend method.

[31] These values have become "standards", despite several attempts to determine endogenously the value of λ (see Ravn and Uhlig, 2002).

Table 12: GMM estimates over 1996Q1-2010Q2, accounting for inflation regime shifts.

Price Index	**CPI**	**PPI**	**IPI**
$\Delta p_{i,t-1}$	1.378***	0.349	0.188*
	(0.364)	(0.225)	(0.099)
$\Delta p_{i,t-2}$	-0.288***	-0.021	0.134
	(0.091)	(0.060)	(0.100)
$\Delta s_{i,t}$	-0.014	-0.161	-0.806***
	(0.078)	(0.115)	(0.095)
$\Delta s_{i,t} * regime\_97i, t$	0.036	0.103	0.265*
	(0.074)	(0.132)	(0.142)
$\Delta ulc_{i,t}$	-0.007	-0.001	0.023
	(0.009)	(0.013)	(0.020)
$gap_{i,t}$	-0.010	0.044	-0.056
	(0.052)	(0.026)	(0.078)
AR1 (p-value)	0.054	0.149	0.116
AR2 (p-value)	0.153	0.232	0.310
Sargan test(2nd step)(p-value)	0.256	0.499	0.412
No. of instruments	10	9	9
No. of observations	532	532	363

Notes:
1. Two-step System GMM with the Windmeijer (2005) correction.
2. Standard errors in parenthesis. *,**,*** denotes significance at 10%, 5%, 1% level.

Appendix 6.

Changes in Inflation Environments in the Sample of Countries.

A well known weakness of the Dickey Fuller style unit root test with I(1) as a null hypothesis is its potential confusion of structural breaks in the series as evidence of nonstationarity. Many econometricians have attempted to deal with this confusion by devising unit root tests that allow for some sort of structural instability in an otherwise deterministic model.

One test of this nature was devised by Andrews and Zivot (1992). This test allows for a single structural break in the intercept and/or the trend of the series, as determined by a grid search over possible breakpoints. Subsequently, the procedure conducts a Dickey-Fuller style unit root test conditional on the series inclusive of the estimated optimal breaks. One obvious weakness of the Zivot-Andrews strategy, relating as well to similar tests proposed by Perron and Vogelsang (1992), is the inability to deal with more than one break in a time series.

Addressing this problem, Clemente, Montanes and Reyes (1998) proposed tests that would allow for two events within the observed history of a time series, either additive outliers (the AO model, which captures a sudden change in a series) or innovational outliers (the IO model, allowing for a gradual shift in the mean of the series).

The double-break additive outlier AO model as employed in Baum, Barkoulas and Caglayan (1999) involves the estimation of:

$$y_t = \mu + \delta_1 DU_{1t} + \delta_2 DU_{2t} + \overline{y}_t$$

where $DU_{mt} = 1$ for $t > T_{bm}$ and 0 otherwise, for $m = 1, 2$. T_{b1} and T_{b2} are the breakpoints. The residuals from this regression, $\overline{y}_t$, are then the dependent variable in the equation to be estimated. They are regressed on their lagged value, a number of lagged differences, and a set of dummy variables needed to make the distribution of the test statistic tractable:

$$\overline{y}_t = \sum_{i=1}^{k} \omega_{1i} DT_{b1,t-i} + \sum_{i=1}^{k} \omega_{2i} DT_{b2,t-i} + \alpha \overline{y}_{t-i} + \sum_{i=1}^{k} \theta_i \Delta \overline{y}_{t-i} + e_t$$

where $DT_{bm,t} = 1$ for $t = T_{bm} + 1$ and 0 otherwise, for $m = 1, 2$. No intercept is necessary, as $\overline{y}_t$ is mean zero. This regression is then estimated over feasible pairs of T_{b1} and T_{b2}, searching for the minimal t-ratio for the hypothesis $\alpha = 1$; this is the strongest rejection of the unit root null hypothesis. The value of the minimal t-ratio is compared with critical values provided by Perron and Vogelsang (1992), as they do not follow the standard Dickey-Fuller distribution.

The equivalent model for the innovational outlier (gradual change) model expresses the shocks to the series (the effects of δ_1, δ_2 above) as having the same ARMA representation as other shocks to the model, leading to the formulation

$$y_t = \mu + \delta_1 DU_{1t} + \delta_2 DU_{2t} + \phi_1 DT_{b1,t} + \phi_2 DT_{b2,t} + \alpha y_{t-1} + \sum_{i=1}^{k} \theta_i y_{t-i} + e_t$$

where again an estimate of α significantly less than unity will provide evidence against the $I(1)$ null hypothesis.

In each of these models, the breakpoints T_{b1}, T_{b2} and the appropriate lag order k are unknown. The breakpoints are located by a two-dimensional grid search for the maximal (most negative) t-statistic for the unit-root hypothesis ($\alpha = 1$), while k is determined by a set of sequential F-tests.

Figure 7: Identified structural breaks in the variance of CPI Inflation Series, by Country

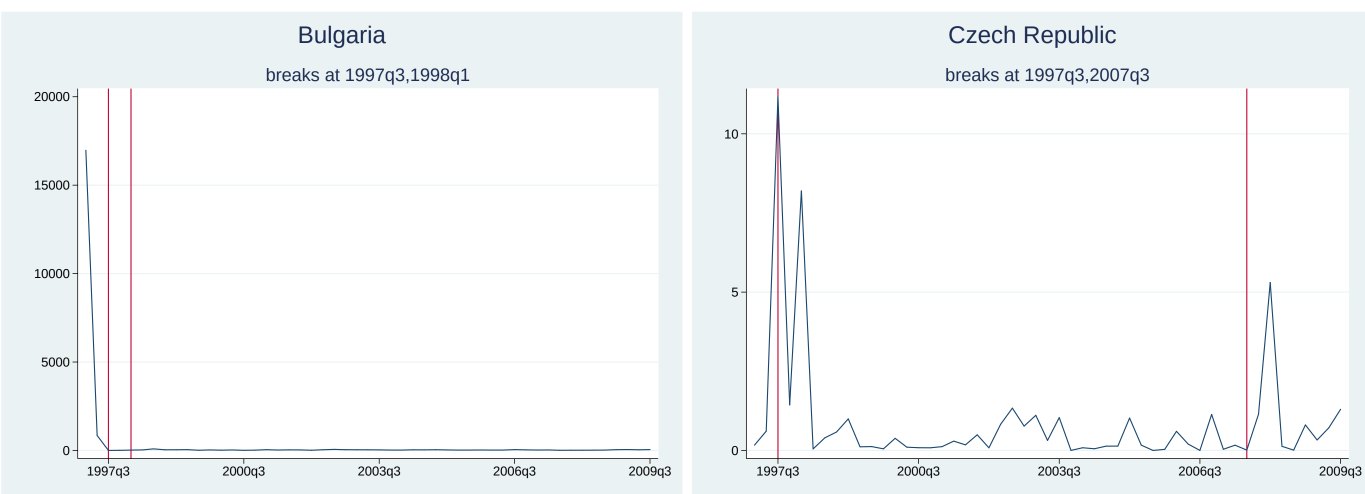


Figure 7: Identified structural breaks in the variance of the CPI Inflation Series, by Country (con't)

Figure 7: Identified structural breaks in the variance of the CPI Inflation Series, by Country (con't)

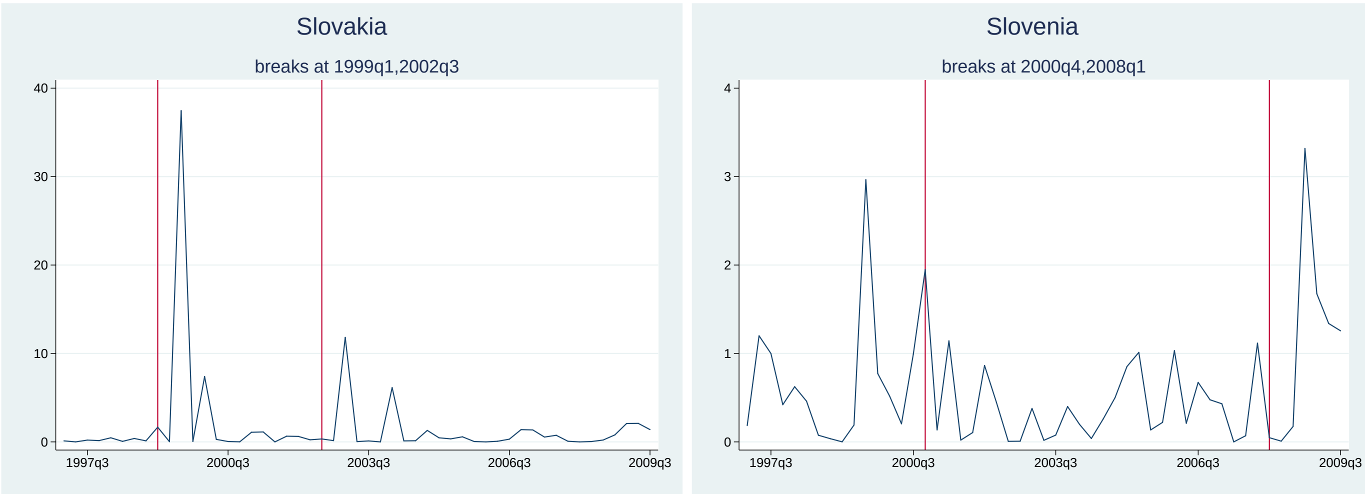


Table 13: Augmented Dickey-Fuller test for unit root.

Country	Variable	neer	CPI	PPI	IPI
Bulgaria	level	0.2902	0.9900	0.8809	0.5016
	difference	0.0004	0.0000	0.0000	0.0042
Czech Republic	level	0.9670	0.3962	0.7530	0.9670
	difference	0.0073	0.0037	0.0006	0.0073
Estonia	level	0.7919	0.9930	0.9988	0.9582
	difference	0.0048	0.0064	0.0454	0.0039
Hungary	level	0.1287	0.8713	0.8719	0.2450
	difference	0.0285	0.0497	0.0241	0.0563
Latvia	level	0.5766	0.9972	0.9936	0.9860
	difference	0.0155	0.0231	0.0754	0.0118
Lithuania	level	0.2322	0.9685	0.9207	0.3265
	difference	0.0047	0.0869	0.0002	0.0015
Poland	level	0.1923	0.4152	0.9924	0.1151
	difference	0.0108	0.0114	0.0329	0.0005
Romania	level	0.1933	0.6080	0.9847	-
	difference	0.0000	0.0263	0.0251	-
Slovakia	level	0.9551	0.2212	0.7568	0.1228
	difference	0.0945	0.04444	0.0226	0.0066
Slovenia	level	0.1858	0.3973	0.8220	-
	difference	0.0472	0.0541	0.000	-

Notes: ADF null hypothesis: the series has a unit root. *Observation*: P-values reported. No IPI data available for Romania and Slovenia. *neer* stands for nominal effective exchange rate.

Table 14: Autocorrelation and heteroscedasticity tests.

	Ljung-Box Q test			Breusch-Pagan test		
Country	**CPI**	**PPI**	**IPI**	**CPI**	**PPI**	**IPI**
Bulgaria	0.6468	0.9985	0.4334	0.0021	0.0638	0.0998
Czech Republic	0.8686	0.3111	0.9767	0.0002	0.0894	0.8714
Estonia	0.4701	0.9993	0.5283	0.8450	0.0000	0.2044
Hungary	0.2825	0.3588	0.4958	0.5997	0.0001	0.0447
Latvia	0.1728	0.0984	0.7791	0.2400	0.0107	0.3892
Lithuania	0.9848	0.8572	0.1884	0.1872	0.0270	0.6966
Poland	0.7545	0.9990	0.5740	0.0333	0.0000	0.0233
Romania	0.8136	0.8001	-	0.0015	0.0000	-
Slovakia	0.7847	0.8101	0.5360	0.0397	0.0013	0.8666
Slovenia	0.6794	0.0000	-	0.0057	0.2568	-

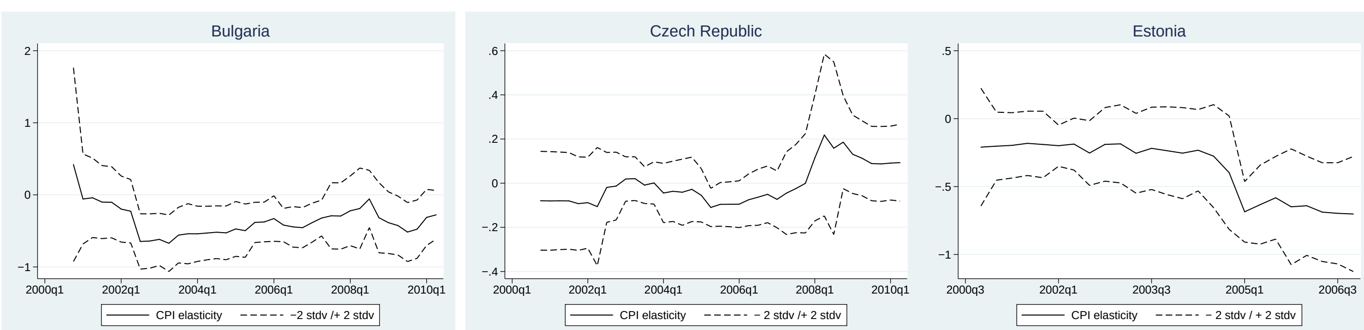
Notes: Ljung-Box Q test null hypothesis: the data are independently distributed (i.e. the correlations in the population from which the sample is taken are 0, so that any observed correlations in the data result from randomness of the sampling process). Alternative hypothesis: the data are not independently distributed. Breusch-Pagan test null hypothesis: the variance of residuals is homogenous. *Observation*: no IPI data available for Romania and Slovenia.

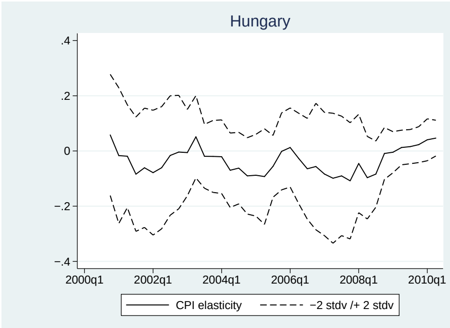
Table 15: Serial correlation test.

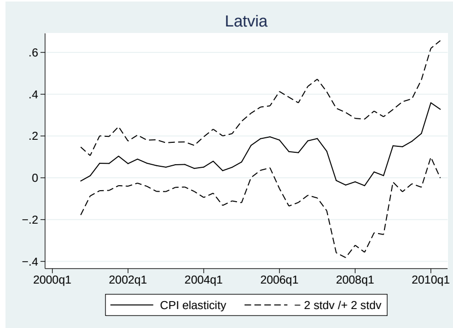
Country	**CPI**	**PPI**	**IPI**
Bulgaria	0.4812	0.7063	0.6736
Czech Republic	0.2587	0.0174	0.0723
Estonia	0.3313	0.7825	0.2410
Hungary	0.1417	0.2349	0.7127
Latvia	0.4064	0.8028	0.8693
Lithuania	0.9432	0.1234	0.3126
Poland	0.2837	0.1393	0.4981
Romania	0.2236	0.2545	-
Slovakia	0.8675	0.4373	0.6083
Slovenia	0.3345	0.0110	-

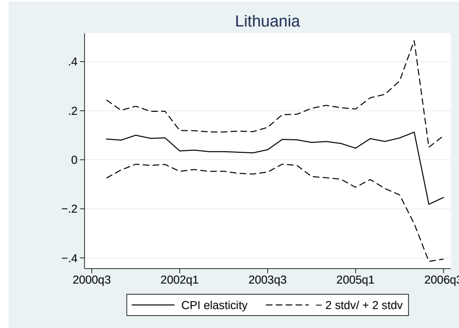
Notes: Null hypothesis of the Breusch-Godfrey LM test: no serial correlation. *Observation*: no IPI data available for Romania and Slovenia.

Figure 8: Estimated consumer price elasticities, rolling sample with a window size of 20 quarters (end Q2/2010)









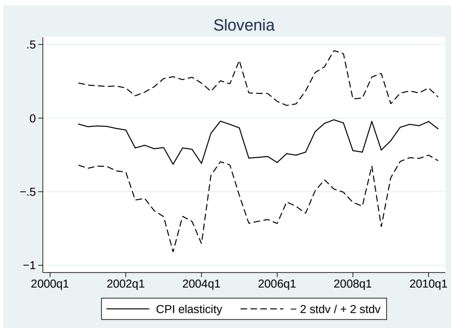


Table 16: EG-ADF test for co-integration.

Country	**CPI**	**PPI**	**IPI**
Bulgaria	0.2345	0.1901	0.8679
Czech Republic	0.1738	0.1417	0.1440
Estonia	0.1620	0.5390	0.2686
Hungary	0.1066	0.1374	0.4721
Latvia	0.4201	0.3722	0.1555
Lithuania	0.3694	0.1352	0.1533
Poland	0.1411	0.2063	0.2930
Romania	0.3323	0.4510	-
Slovakia	0.2703	0.8941	0.6697
Slovenia	0.7967	0.7777	-

Notes: The null hypothesis of the EG-ADF test: the variables are co-integrated. *Observation*: no IPI data available for Romania and Slovenia.

Figure 9: Estimated producer price elasticities, rolling sample with a window size of 20 quarters (end Q2/2010)

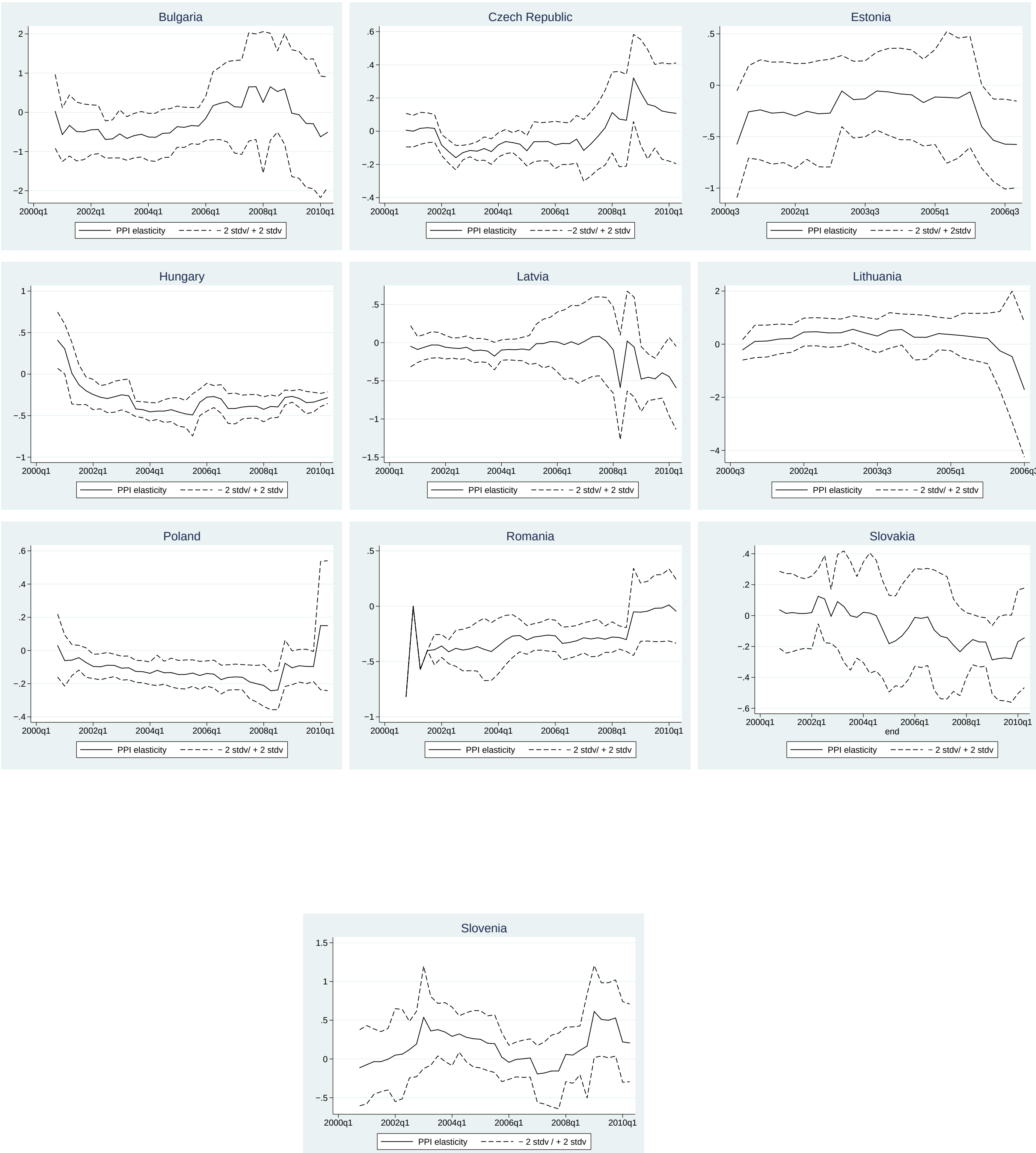
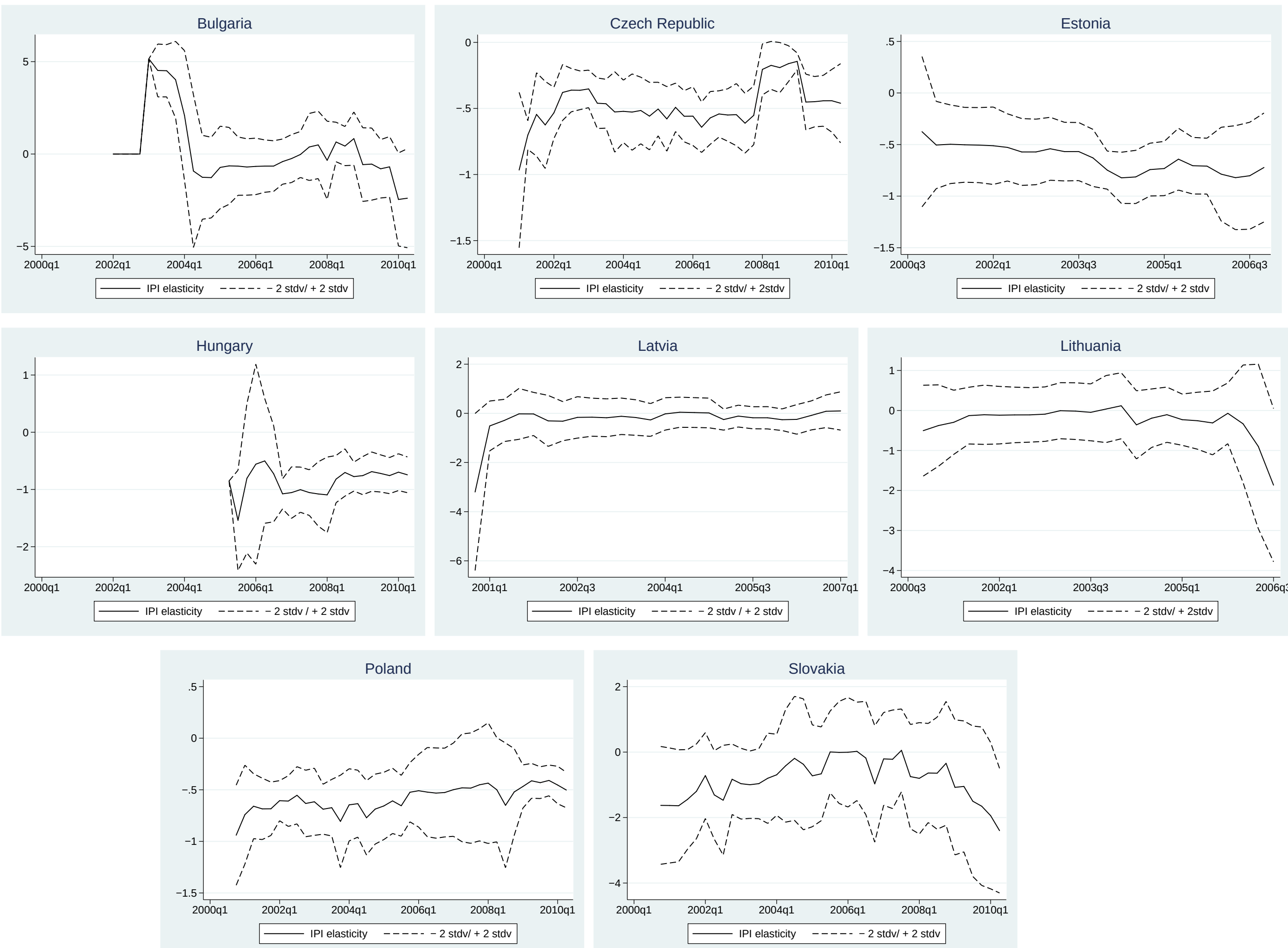


Figure 10: Estimated importer price elasticities, rolling sample with a window size of 20 quarters (end Q2/2010)



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