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Preliminary report

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Estimating the Impact of the Balassa-Samuelson Effect in Central and Eastern European Countries: A Revised Analysis of Panel Data Cointegration Tests

Summary: This paper aims to reassess the contribution of the Balassa-Samuelson effect to the inflation and real exchange rate appreciation using panel data for nine CEECs covering the period ranging from the mid-1990s to the third quarter of 2010. The main idea of this analysis is to answer the question of whether the Global Economic Crisis had a significant impact on the efforts of CEECs to stay on the path of real convergence. The Balassa-Samuelson effect explains less than 1.5 percentage points on average of inflation differential relative to the euro area and around 1 percentage point of the total domestic inflation. The results are robust across the model specification and estimation method. Most of the results point out that the Balassa-Samuelson effect has not changed considerably during the crisis even though it is lower compared to that in the earlier stage of transition (for the period up to 2004).

Key words: Baumol-Bowen effect, Balassa-Samuelson effect, Real appreciation, Inflation.

JEL: C52, E01, O11.

Since the beginning of the transition process, most Central and Eastern European countries (*CEECs*) have experienced relatively high inflation rates and real appreciation of their currencies. The *Balassa-Samuelson* theory (*the BS effect*) provides a supply-side explanation for the relative price of tradables and non-tradables in an economy and is one of the prime explanations for the continuous real appreciation of *CEECs* against their western counterparts. The key idea behind the *BS* theory is that, in a given economy, a higher productivity growth in the tradable sector than that in the non-tradable pushes up wages in all sectors. This in turn increases the relative prices of non-tradable goods and increases the ratio of non-tradable to tradable prices. If the productivity growth in one country is higher than in another, the overall inflation will be higher in the former, and the real exchange rate is likely to appreciate in the long run. Analyzing the extent to which inflation is caused by the *BS* effect is important for at least three reasons.

Firstly, the inflation arising from the *BS* effect does not cause a loss of competitiveness. That is, although the prices of non-traded goods rise relative to the prices of traded goods, the tradable sector does not become less profitable due to its higher rate of productivity growth. Since this component of real appreciation occurs with no loss to competitiveness, there is no risk to external accounts.

Secondly, this issue has implications on the conduct of monetary policy. Rising inflation or continuous real exchange appreciation resulting from a higher productivity growth does not require the same monetary policy response as when it is not productivity driven, and therefore, the monetary authority should consider the strength of the *BS* effect in setting its inflation target. Rising relative prices of non-traded goods would need the prices in the traded goods sector to drop in order to achieve the inflation target. Disinflation in the tradable goods sector requires the exchange rate to appreciate over time, and the central bank has to keep the interest rate high to offset the inflation caused by the non-traded goods sector.

Thirdly, as a consequence of the EU accession of most *CEEC*s, the *BS* theory has become a popular framework for assessing the feasibility of meeting the Maastricht criteria (see Cristian Paun 2010). A problem might arise in the new European Union member countries if the inflation and exchange rate criteria are impossible to achieve in the presence of the *BS* effect.

There would be a risk of sacrificing real convergence for nominal because a monetary tightening, which might be necessary for the inflation or exchange rate to meet the Maastricht criteria, could suppress real growth.

The *BS* effect contains at least two propositions. First, it implies that the relative price of non-traded goods in each country should reflect the relative productivity of labor in the traded and non-traded goods sector. Second, it assumes that purchasing power parity (*PPP*) holds for traded goods.

The first generation of studies, from the late 1990s to the early 2000s, suggested that the *BS* effect is one of the major determinants of the high inflation in *CEECs*. Here, the contribution of the BS effect to inflation usually constitutes up to 3 percentage points.

A second generation of studies pointed out that the *BS* effect may not be as important for the new EU members as had previously been suggested. These studies usually concluded that the observed inflation and real exchange appreciation are explained by the *BS* effect only in small part.

The main difference between these two waves of studies is the finding of the latter that the relative PPP does not hold in the tradable sector. This does not imply that the *BS* effect has a small impact on overall real exchange rate movements because the *BS* effect is supposed to explain the difference between the overall inflation-deflated and real exchange rate based on prices of tradable goods. Hence, if the share of market-based non-tradable prices in the CPI is large enough, the *BS* effect can explain a large part of the overall exchange rate movements. Therefore, another reason for the limited explanation of the real exchange rate appreciation by the *BS* model is the small ratio of market-based non-tradable goods in the CPI (see Balasz Egert, Laszlo Halpern, and Ronald MacDonald 2006). One more reason why earlier studies had obtained higher estimates of the *BS* effect is that the estimates were produced with time series models; in the newer literature, panel models were used. Also, many earlier studies, such as Marco Cipriani (2001), Fabrizio Corricelli and Bostjan Jazbec (2001), Halpern and Charles Wyplosz (2001), and had failed to consider the impact of productivity differentials on inflation relative to the euro area, focusing only on the Baumol-Bowen (*BB* effect) effect, which was usually stronger (as noted in Dubravko Mihaljek and Marc Klau 2004, p. 11).

Only a handful studies (for instance, Egert 2005; Maria Machova 2008; Mihaljek and Klau 2008; Paun 2010) analyzed the importance of the *BS* effect in countries other than the eight *EU* member states mentioned, such as Southeastern European countries. Also, in the literature little attention has been paid to testing the importance of this factor in the period after 2004 (see Mihaljek and Klau 2008). This motivates us to reassess the contribution of the *BS* effect to inflation and real exchange rate appreciation using panel data for nine *CEEC*s covering the period from the mid-1990s to the third quarter of 2010, and to contribute to the empirical literature on this topic. The analyzed period is relevant because, with the exception of Croatia and Macedonia, all sampled countries have since joined the European Union. Assessing the size of the *BS* effect for these countries, as well as for countries that have entered the exchange rate mechanism ERM II, is therefore of particular interest. The key idea of this analysis is to answer the question of whether the Global Economic Crisis had a significant impact on the importance of the *BS* effect in *CEEC*s.

Besides the size and the up-to-dateness of the sample, several features related to the estimation procedure distinguish this study from others. For testing the cointegration between more than two variables, we used the panel cointegration test proposed by Gangadharrao Maddala and Shaoven Wu (1999), which enables identifying the number of cointegrated vectors. For the robustness check of empirical results, we used several panel estimation techniques: fully modified OLS (*FMOLS*), dynamic OLS (*DOLS*), pooled mean group (*PMGE*), and mean group (*MGE*).

The remainder of the paper is organized as follows: The next two chapters lay out the analytical and empirical framework used in the paper. In the first chapter, a theoretical exposition of the *BB* and *BS* effects is presented, as well as the econometric methodology used for estimating and testing those hypotheses. The second chapter covers a review of the empirical literature, a brief discussion of the data sources, definitions of the variables included in the empirical analysis, and the empirical results of the *BB* and *BS* effect. In the third chapter, the main conclusions of the empirical analysis and the policy implications of these results are presented.

1. Analytical Framework

1.1 The Theoretical Concept of the Balassa-Samuelson Effect

Consider the case of a small open economy that produces traded (T) and non-traded goods (N), assuming a *Cobb-Douglas* production function with labor (*L*) and capital (*K*) as production factors:

$$Y^T = A^T K^{T(1-\theta^T)} L^{T\theta^T}, Y^N = A^N K^{N(1-\theta^N)} L^{N\theta^N}, \tag{1}$$

where θ^T and θ^N refer to elasticity of output with respect to labor in the traded and the non-traded goods sector, respectively, and A is the total factor productivity.

Competition in the labor market assures that the wages in the two sectors will be equal to the marginal product of labor:

$$W^T = P^T \frac{\partial Y^T}{\partial L^T} = P^T \theta^T A^T \left(\frac{K^T}{L^T}\right)^{1-\theta^T}, \; W^N = P^N \frac{\partial Y^N}{\partial L^N} = P^N \theta^N A^N \left(\frac{K^N}{L^N}\right)^{1-\theta^N}, \qquad (2)$$

where W^T and W^N represent wages in the traded and the non-traded goods sector, respectively.

Assuming that the wages are the same in the traded and the non-traded sector, the price ratio of tradable to non-tradable goods is defined by:

$$R = \frac{P^N}{P^T} = \frac{\theta^T A^T \left(\frac{K^T}{L^T}\right)^{1-\theta^T}}{\theta^N A^N \left(\frac{K^N}{L^N}\right)^{1-\theta^N}} = \frac{\theta^T \frac{Y^T}{L^T}}{\theta^N \frac{Y^N}{L^N}} . \qquad (3)$$

If the degree of labor and capital intensity is the same in the traded and the non-traded sectors, i.e., $\theta^T = \theta^N$, after log-differencing transformation, the previous equation obtains the following form:

$$\Delta \log R = \Delta \log \frac{Y^T}{L^T} - \Delta \log \frac{Y^N}{L^N} = \Delta a^T - \Delta a^N . \qquad (4)$$

where Δa^T and Δa^N are the labor productivity rates in the traded and the non-traded sectors, respectively and $a^T = \log \frac{Y^T}{L^T}$, $a^N = \log \frac{Y^N}{L^N}$.

The last equation shows that the growth of the relative prices is equal to the difference between the average labor productivity growth in the traded and non-traded goods sector. Assuming that the productivity growth is higher in the traded goods sector, this equation suggests that the relative productivity growth determines the prices in the non-traded goods sector and, consequently, headlines inflation. Given that, firms in the non-traded goods sector will increase the prices of their goods to retain profitability. Consequently, the relative prices will increase, $\log R = \log P^N - \log P^T$. This effect is known in the literature as the domestic *Balassa-Samuelson* or *Baumol-Bowen* effect.

If the wage rates in the traded and non-traded goods sectors are allowed to differ, the equation that describes the behavior of the price of non-traded goods relative to that of traded goods after log-differencing becomes:

$$\Delta \log R = \Delta \log \frac{Y^T}{L^T} - \Delta \log \frac{Y^N}{L^N} - \Delta \log \frac{W^T}{W^N} \tag{5}$$

If the wages in the traded goods sector grow faster relative to the wages in the non-traded goods sector, this will offset the relative increase in productivity and lead to lower growth of the relative prices of non-traded goods.

Furthermore, the inflation rate could be expressed as a weighted average of traded and non-traded inflation:

$$\pi^{CPI} = \alpha\pi^N + (1-\alpha)\pi^T = \pi^T + \alpha\Delta \log R, \tag{6}$$

where α is the share of non-traded goods in the consumer basket.

The expression $\alpha\Delta \log R$, which is defined as the relative productivity growth, represents the contribution of the *BS* effect to domestic inflation.

The *BS* effect can also help explain the inflation differential between two countries:

$$\pi^{CPI} - \pi^{CPIF} = \Delta \log S + \alpha\Delta \log R - \alpha^F \Delta \log R^F, \tag{7}$$

where S is the nominal exchange rate (see Cipriani 2001, p. 6).

Next, it can be seen how the relative productivity difference contributes to real appreciation, assuming that the productivity growth is faster in the home country than in a foreign country (see Jesus Crespo-Cuaresma, Jarko Fidrmuc, and MacDonald 2003, p. 140).

Replacing equation (6) in the real exchange rate change equation ($r = s + \pi^{CPIF} - \pi^{CPI}$) and assuming the same share of non-tradable goods in the consumer basket in the domestic and the foreign country, $\alpha = \alpha^F$, where r is the real exchange rate change, and $s = \Delta \log S$ gives:

$$r = s + \pi^{FT} - \pi^T + \alpha\left[\left(\pi^T - \pi^N\right) - \left(\pi^{FT} - \pi^{FN}\right)\right]. \tag{8}$$

Because the prices in the domestic traded goods sector and abroad are equal, if they are expressed in the same currency, the real exchange rate change is determined by the changes in relative prices in the non-traded goods sector, or

$$r = -\alpha\left(\left[\pi^N - \pi^T\right] - \left[\pi^{FN} - \pi^{FT}\right]\right). \tag{9}$$

Based on equation (4), and replacing it in equation (9), the real exchange rate change can be computed as

$$r = -\alpha\left(\left[\Delta a^T - \Delta a^N\right] - \left[\Delta a^{FT} - \Delta a^{FN}\right]\right). \tag{10}$$

The last equation shows that a faster growth in relative productivity in the tradable sector than in the non-tradable sector results in real appreciation of the domestic currency.

1.2 Estimation Techniques

All empirical tests for verification of the *BS* hypothesis were conducted in a heterogenous dynamic panel framework using Peter Pedroni (1997) and Johansen-type panel cointegration tests, as proposed by Maddala and Wu (1999). Although we presented all seven Pedroni tests, the decision relating to cointegration was made due to group *ADF*, panel *ADF*, and panel ρ statistics, that is, if at least one of those statistics confirms it. Specifically, we had in mind the results of Pedroni (2004) that showed that for values of T larger than 100, all seven statistics that were proposed do fairly well and are quite stable, while for smaller samples (T is lower than 20), group *ADF* statistics are the most powerful, followed by panel *ADF* and panel ρ statistics. We chose to use the non-weighted instead of the weighted panel Pedroni statistics due to their better performance in small samples.

However, Pedroni type cointegration tests do not allow testing of the number of cointegrated vectors between more than two variables. Therefore, for testing cointegration between more than two variables, we used the Johansen panel cointegration test proposed by Maddala and Wu (1999), which enables identifying the number of cointegrated vectors. This test is actually based on combining the *p* values from the Johansen trace and the maximum eigenvalues statistics for each panel member. Therefore, in this work we used Pedroni tests for testing cointegration between two variables and the Johansen panel cointegration test for more than two variables.

The long-run relationship between relevant macroeconomic variables was estimated by fully modified *OLS* (*FMOLS*), dynamic *OLS* (*DOLS*), pooled mean group (*PMGE*), and mean group (*MGE*) estimator techniques.

FMOLS estimation allows for serial correlation in the residuals and for endogeneity of regressors in the cointegrating regression, and results in an asymptotically efficient estimation of the cointegrating vector. The pooled *FMOLS* coefficients can be computed in two different ways: within a dimension and between dimensions. Here, we will present only the between-dimension group *FMOLS* estimator of the mean panel cointegration parameter, which is given as:

$$\beta^*_{GFM} = \frac{1}{n}\sum_{i=1}^{n}\left(\sum_{t=1}^{T}\left(x_{it}-\bar{x}_i\right)^2\right)^{-1}\left(\sum_{t=1}^{T}\left(x_{it}-\bar{x}_i\right)y^*_{it}-T\hat{\gamma}_i\right) \tag{11}$$

where: $y^*_{it} = y_{it} - \frac{\hat{L}_{21i}}{\hat{L}_{22i}}\Delta x_{it}$, $\hat{\gamma}_i = \hat{\Gamma}_{21i} + \hat{\Omega}^0{}_{21i} - \frac{\hat{L}_{21i}}{\hat{L}_{22i}}\left(\hat{\Gamma}_{22i} + \hat{\Omega}^0{}_{21i}\right)$,

x_{it} is the m-dimensional vector of explanation variables, and $\hat{L}_i$ is the lower triangular decomposition of a consistent estimator of the idiosyncratic asymptotic covariance matrix $\Omega_i = \Omega^0{}_i + \Gamma_i - \Gamma_i{}'$, with $\hat{L}_i$ normalized such that $\hat{L}_{22i} = \hat{\Omega}_{i22}^{-1/2}$, and the serial correlation adjustment parameter $\hat{\gamma}_i$ is given by $\hat{\gamma}_i = \hat{\Gamma}_{21i} + \hat{\Omega}^0{}_{21i} - \frac{\hat{L}_{21i}}{\hat{L}_{22i}}\left(\hat{\Gamma}_{22i} + \hat{\Omega}^0{}_{21i}\right)$. The *FMOLS* estimator is distributed normally (see Pedroni 1997, p. 103).

The expression following the summation over *i* is identical to the conventional time series *FMOLS* estimator, and the between-dimension estimator can be constructed simply as the average *FMOLS* estimator for each panel member. Likewise, the associated *t* statistics for the between-dimension estimator can be constructed as:

$$\bar{t}_{\beta^*_{GFM}} = \frac{1}{\sqrt{n}} \sum_{i=1}^{n} \hat{L}_{11i}^{-2} \left(\sum_{t=1}^{T} \left(x_{it} - \bar{x}_i \right)^2 \right)^{-1/2} \left(\sum_{t=1}^{T} \left(x_{it} - \bar{x}_i \right) y^*_{it} - T \hat{\gamma}_i \right) \to N(0,1) \tag{12}$$

Contrary to *FMOLS*, the *DOLS* estimator recommended by Chihwa Kao and Min-Hsien Chiang (2000) employs a parametric correction for endogeneity achieved by augmenting the regression with leads and lags of the first difference of x_{it}, as below:

$$y_{it} = \alpha_i + \beta_i x_{it} + \sum_{k=-K}^{K} \gamma_{ik} \Delta x_{it-k} + \mu_{it} Z, \tag{13}$$

where the estimated coefficient β is given by:

$$\beta^*_{DOLS} = \frac{1}{n} \sum_{i=1}^{n} \left(\sum_{t=1}^{T} z_{it} z'_{it} \right)^{-1} \left(\sum_{t=1}^{T} z_{it} y^*_{it} \right), \tag{14}$$

where $z_{it} = \left(x_{it} - \bar{x}_i, \Delta x_{it-K}, ..., \Delta x_{it+K} \right)$ is the vector of regressors.

The pooled mean group (*PMGE*) estimator involves pooling and averaging, and allows the intercepts, short-run coefficients, and error variances to differ freely across groups, but the long-run coefficients are constructed to be the same. The PGME was introduced by Hashem Pesaran, Yongcheol Shin, and Ronald Smidth (1998), who proposed estimating the following autoregressive distributed lag (*ARDL*) model of orders $l1$ and $l2$:

$$\Delta \mathbf{y}_i = \beta_0 + \rho\left(\mathbf{y}_{i,-1} - \sum_{i=1}^{n}\beta_n X_i\right) + \sum_{j=1}^{l1}\lambda^*{}_j \Delta y_{i,-j} + \sum_{i=1}^{n}\sum_{j=0}^{l2} \Delta \mathbf{X}_{i,-j}\boldsymbol{\delta}^*_{ij} + \varepsilon_i \tag{15}$$

The dependent variable in the first differences is regressed on the lagged values of dependent and independent variables in the levels and first differences. The long-run coefficients, β, are defined to be the same across countries (the *MGE* method allows differences in long-run coefficients across individuals).

The error correction term obtained from the pooled mean group estimator is used as a test of cointegration. A negative and statistically significant error correction term, ρ, confirms the presence of a long-run relationship between y_{it} and x_{it}. The equation is estimated using the maximum likelihood procedure.

The conclusion relating to the empirical testing of the *BB* and the *BS* effect has been based mostly on *FMOLS* and *DOLS* method estimates, while *PMGE* and *MGE* techniques have been used for robustness checking.

2. Empirical Investigation

2.1 Review of the Empirical Studies

The *BS* effect in *CEEC*s has been empirically tested in numerous works. Even though authors use various econometric methods, as well as different indicators of relative prices and relative productivity, and distinguish the tradable and non-tradable sectors in different ways, their results most often confirm the presence of the *BS* effect (see Josip Funda, Gorana Lukinic, and Igor Ljubaj 2007, p. 326).

It is impossible to address all the papers on the subject in this article considering their large number. Therefore, we will summarize the results and the techniques applied in the most cited selected recent empirical studies of the *BS* effect in *CEEC*s (for further review, see Fritz Breuss 2003; Virginie Coudert 2004; Jose Garcia-Solanes 2008; etc.).

The first round of studies, conducted from the late 1990s to the early 2000s, suggested that the *BS* effect is one of the major determinants of the high inflation in *CEECs* (see Andras Simon and Mihaly Andras Kovacs 1998; Philipp Rother 2000; Halpern and Wyplosz 2001; Adriana Lojschova 2003; etc.). Here the contribution of the *BS* effect to the real appreciation in a number of *CEEC*s constitutes up to 3 percent points per annum.

For instance, Halpern and Wyplosz (2001) estimated the *BS* effect in *CEEC*s using fixed and random effects, and ordinary least square and generalized least square methods for unbalanced panels. Their results confirmed the presence of the *BS* effect of a magnitude of 3 percent points per annum.

Lojschova (2003) tested the *BS* effect using time series and panel estimation techniques for Slovakia, Czech Republic, Poland, and Hungary during the period between 1995 and 2002. According to these results, the individual country estimates of the *BS* effect are approximately 2.5% per annum, while when using panel models, this effect is smaller and ranges from 0.8% in Hungary to 2% in Poland. Furthermore, Lojschova (2003) tested an extended version of the *BB* effect with wages as an additional explanatory variable, but the estimated coefficients of productivity were not changed significantly compared to the model that did not take wages into account.

In contrast to previously mentioned studies that estimated a very strong contribution of the *BS* effect in *CEEC*s, a large group of studies (for instance, Cipriani 2001; Mark De Broeck and Torsten Slok 2001; Monika Blaszkiewicz et al. 2004; Mihaljek and Klau 2004; Martin Wagner and Jaroslava Hlauskova 2004; Egert 2005; etc.) found that the *BS* effect is rather modest and that it is not sufficient to explain the observable real exchange appreciation in *CEEC*s. The contribution of the *BS* effect to real appreciation in those studies ranged from 0% to 1.5%.

For example, De Broeck and Slok (2001) regressed the real exchange rate on the productivity differential between sectors for a range of *CEEC*s; depending on the specifications used, the elasticities obtained varied between 0.2 and 0.6. Using a similar regression based on panel data, Corricelli and Jazbec (2001) obtained an elasticity of roughly 0.5.

Cipriani (2001) focused on structural inflation rather than real exchange rate in his study on the *BS* effect. He used a panel of ten *CEEC*s between 1995 and 1999. According to him, the *BS* effect is relatively weak due to the relatively small share of non-tradables in the consumer price index and the pronounced growth of productivity in the tradable and non-tradable sectors. Cipriani (2001) argued that around 0.7 percentage point of observed inflation could be explained by the productivity growth differentials between the tradable and non-tradable sectors.

Egert, Imed Drine, and Christophe Rault (2002) estimated the magnitude of the *BS* effect for nine *CEEC*s using panel cointegration techniques. According to these authors, even in countries where the increase in relative productivity in the tradable sector is very sharp, such as Poland, the impact on relative prices compared to Germany remains moderate, between 1.2% and 2.4% per annum. Even though they detected that the productivity growth in the tradable sector is likely to bring about a non-tradable inflation, they argued that this depends on the composition of the consumer price index basket, as well as on the share of regulated prices.

Using time series models, Mihaljek and Klau (2004) found that the *BS* effect in six *CEEC*s explained, on average, only between 0.2 and 2.0 percentage points of annual inflation differentials vis-a-vis the euro area. They also argued that, as the pace of catching up decelerates, these effects are likely to decrease and hence should not become a determining factor of the ability of these countries to satisfy the Maastricht inflation criterion. An updated analysis of Mihaljek and Klau (2008) confirmed the presence of the *BS* effects in *CEEC*s countries in the period since the mid-1990s through the first quarter of 2008. On average, *BS* effects explain around 24% of inflation differentials vis-a-vis the euro area (about 1.2 percentage points on average) and 84% of the domestic relative price differentials between non-tradables and tradables, or about 16% of overall domestic CPI inflation (about 1.1 percentage points on average).

Blaszkiewicz et al. (2004) conducted an empirical analysis for an unbalanced panel of nine *CEEC*s in the period between 1995 and 2003. *FMOLS* and *PMGE* panel estimations pointed to a well-behaved and statistically significant *BB* effect, while there was less evidence in favor of the *BS* effect. They argued that their estimates of the contribution of the *BS* effect to inflation (below 2 percent points per annum) and to real appreciation (below 3 percent points) must be interpreted with caution because productivity indicators are subject to short-run fluctuations, which may lead to a negligible or even negative *BS* effect.

Wagner and Hlauskova (2004) conducted an assessment of the *BS* effect in eight *CEEC*s in the period between 1993 and 2000. They investigated a variety of specifications of extended models (non-homogeneity of wages, deviations from PPP in tradables, and including demand-side variables to explain inflation differentials). Evidence of the *BS* effect was found, but it was relatively small (around half a percent per annum) and not sufficient to explain the inflation differentials between *CEEC*s and euro area countries.

Following the work of Wagner and Hlauskova (2004), Machova (2008) quantified the *BB* and the *BS* effect for 24 European countries divided into Western nations, *CEEC*s, and Delta (Romania and Bulgaria) countries. Using a panel data method in the period between 1996 and 2005, Machova (2008) obtained the *BB* effect quantified as percent of inflation per annum and the *BS* effect as less than half a percent per annum.

Paun (2010) tested the *BS* effect for the period between 1999 and 2007 based on Euclidian distances between real and nominal convergence, which were previously estimated for each of the *CEEC*s. The author found unconvincing evidence of the *BS* effect in most *CEEC*s; clear evidence of the *BS* effect was found only in Lithuania.

The literature has also identified some puzzles related to the operation of the Balassa-Samuelson effect (see Egert and Jiri Podpiera 2008; Kosta Josifidis, Emilija Beker, and Novica Supić 2008; Egert 2010). Some of those studies, which found the *BS* effect to be modest, provide an explanation for the tendency toward real exchange rate appreciation in *CEEC*s using complementary determinants such as demand-side factors, as well as structural transformation and institutional factors (see Garcia-Solanes 2008, pp. 29-30). Demand-side factors have been proxied by different types of variables, such as real interest rate differential (for instance, Lojschova 2003; Christoph Fischer 2004), real income per capita and government spending as a percentage of GDP (for instance, Rother 2000; Olga Arratibel, Diego Rodriguez-Palenzuela, and Christian Thimann 2002), the budgetary deficit (Arratibel, Rodríguez-Palenzuela, and Thimann 2002), the share of private consumption over GDP (Coricelli and Jazbec 2004; Fischer 2004), and total consumption (Wagner and Hlouskova 2004), among others.

For instance, Arratibel, Rodriguez-Palenzuela, and Thimann (2002) highlighted the importance of nominal wage growth and fiscal policy, as well as the impact of liberalization-oriented reforms on lowering inflation in the non-tradable sector. According to these empirical findings, the productivity growth in the tradable sector does not seem to have been a significant variable explaining the inflation dynamics in the non-tradable goods sector in *CEEC*s.

Fischer (2004) developed and tested a model that included an investment demand channel. The *BS* effect still exists and, additionally, the domestic demand affects the price of non-tradables and thereby the real exchange rate. The model predicts that capital demand is negatively dependent on the price of non-tradables and on the interest rates.

Garcia-Solanes, Francisco Sancho-Portero, and Fernando Torrejon-Flores (2007) found that increases in the demand for differentiated domestic tradables, which are steered by higher economic growth and improvements in the quality of these goods, introduce an upward bias in the prices of tradables in these countries, leading to trend appreciations in the real exchange rate of tradable goods.

Michael Brandmeier (2006) found that the impact of productivity on inflation differences is probably superimposed by the growth rate of the monetary stock or by influences from the demand side of the economy.

Different explanations of the *PPP* puzzle are addressed in the literature; some of the most important are problems with precise sector division, incomplete substitutability of tradables in the euro area and *CEECs*, the existence of the non-tradables processing component introducing frictions to the international arbitrage, and imperfect competition (see Blaszkiewich et al. 2004; Garcia-Solanes and Torrejon-Flores 2009). The results of most empirical studies (see Matthew Canzoneri, Robert Cumby, and Behzad Diba 1999; Egert, Drine, and Rault 2002; Blaszkiewicz et al. 2004; Lukasz Rawdanowicz 2004; Mirjana Palic 2009; etc.) show that the stronger version of PPP is not satisfied in *CEEC*s.

2.2 Data, Sources and Definitions

The data set used in this study consists of average labor productivity data, real wages, relative prices, and real exchange rates. The panel data cover 9 *CEEC*s (Bulgaria, Croatia, Czech Republic, Hungary, Macedonia, Poland, Romania, Slovenia, and Slovakia). All series are transformed into natural logarithms. The empirical testing of the *BB* hypothesis is conducted using quarterly data covering the period from 1995 to 2007; for the *BS* hypothesis, the data cover the period from 1997 to 2007. The first years of transition are eliminated from this analysis due to the fact that during this period, price and productivity developments were driven more by initial reforms than by the *BS* effect. The *BB* effect and the *BS* effect are tested to extend the analysis to the period of the Global Economic Crisis (covering the period from 1995/1997 to the third quarter of 2010). This panel is unbalanced due to the fact that, in the interim, Slovenia and Slovakia became EMU members.

The national account data, wages, and employment data are obtained from Eurostat and national statistical offices, while nominal and real exchange rate data, as well as *CPI* and *PPI* indices, are taken from International Financial Statistics.

One crucial issue in constructing productivity and relative price variables is how to define the tradable and non-tradable sectors. No consensus has been reached in the literature on this issue, but most empirical studies refer to industry, or industry and agriculture, as the tradable goods sector. Egert, Drine, and Rault (2002) highlighted that their results are affected by the way sectors are classified, particularly whether or not agriculture is considered as part of the tradable sector.

Average labor productivity, which is a proxy for average total productivity, is computed using the above classification as a basis and by dividing the sectoral value added to the corresponding number of employees. Considering only the number of full-time employees instead of the total number could change the *BS* and the *BB* effect on inflation and real appreciation, especially in countries with a higher share of agriculture in total gross value. However, those series were not been publicly available for all analyzed countries.

Sectoral productivities serve as a basis for calculating relative productivities, *PRI* (if only industry is considered as tradable) and *PRIA* (if both industry and agriculture are considered as tradable). All other sectors, excluding administration, are considered as non-tradable. Relative productivity differential is defined as the ratio of relative productivities in *CEEC*s and Euro Area 12.

Following the empirical work of Blaszkiewicz et al. (2004), and Egert, Drine, and Rault (2002), we use two types of proxies as a measure of relative prices. Firstly, relative price (*RP1*) is defined as the ratio of the corresponding sectoral *GDP* deflators. The prices of non-tradable goods are given by the *GDP* deflator for services, while the prices of tradable goods are given by the *GDP* deflators for industry. Secondly, the ratio of services in consumer price index and producer price index is used as a proxy for relative prices (*RP2*).

The real exchange rate is calculated using the *GDP* deflator in the services sector (*RERG*). Other measures, such as prices in the tradable sector as well as *CPI*, could be used as the deflator for the real exchange rate.

2.3 Empirical Results

Prior to testing the long-run relationship between different macroeconomic variables, we applied panel unit root tests by In Choi (2001) and Kyung So Im, Hashem Pesaran, and Yongcheol Shin (2003) to test for non-stationarity, a necessary condition for cointegration. The tests were performed on levels and first differences, but for practical reasons, only the results of those carried out on levels are presented (Table 1). The presence of a unit root for all indicators in the specification with constant was confirmed by both tests, while for the specification with trend, the applied tests for some indicators pointed to the rejection of the null hypothesis of non-stationarity. The applied tests are inconclusive, but the presence of a unit root could not be strongly rejected in any case and leads us to conclude that the variables are non-stationary in levels.

Table 1 Results of Panel Unit Root Tests

Period: 1995:1 to 2007:4	Model without trend		Model with trend	
Variable	**IPS statistics**	**Choi statistics**	**IPS statistics**	**Choi statistics**
PRI	0.0149 (0.5059)	0.14212 (0.5565)	-1,26124 (0.1036)	-1,10721 (0.1341)
PRIA	-1.78737 (0.0369*)	-0.78556 (0.2161)	-3.29065 (0.0005***)	-2.48909 (0.0064***)
RPI	-0.86268 (0.1942)	-0.70875 (0.2392)	-1.11965 (0.1314)	-0.94719 (0.1718)
RP2	-1.21851 (0.1115)	-0.86197 (0.1944)	-0.72732 (0.2335)	-0.17849 (0.4292)
RERG	-1.49179 (0.0679)*	-1.27415 (0.1013)	-3.25913 (0.0006)***	-3.04510 (0.0012)***

Note: In all tables, * refers to statistical significance at 10%, ** refers to statistical significance at 5%, and *** refers to statistical significance at 1%. The data source for all tables is the author's calculations. The number of lags included in the model is chosen according to the Schwarz information criterion. P values are given in parentheses.

Source: Author's estimations.

2.3.1 Testing the Baumol-Bowen Effect

Empirical testing of the *BB* effect was conducted in three steps: between productivity and real wages in the tradable sector, between real wages in the tradable and the non-tradable sector, and between relative productivity and prices.

The long-run relationship between productivity (PR_T^{CEEC}) and real wages ($RWAG_T^{CEEC}$) in the tradable sector (industry) is a necessary condition to confirm that the *BS* effect is one of the most important factors of real appreciation. The cointegration relationship is confirmed by most Pedroni tests for the model with constant and trend, and partly for a model with individual intercept only (Table 2).

Table 2 Pedroni Panel Cointegration Test for $RWAG_T^{CEEC}$ and PR_T^{CEEC}

Period: 1995:1 to 2007:4	Model with individual intercepts		Model with individual intercepts and individual trends	
	statistics	p value	statistics	p value
Panel v	2.2152	0.0343**	2.089	0.0449**
Panel rho	-0.0836	0.3975	1.283	0.1751
Panel PP	-2.5939	0.0138**	-3.196	0.0024***
Panel ADF	-1.8801	0.0681*	-1.721	0.0908*
Group rho	1.0253	0.2359	1.4588	0.1377
Group PP	-2.3768	0.0237**	-4.3959	0.0000***
Group ADF	-1.1674	0.2018	-3.4635	0.0010***

Note: In all tables, * refers to statistical significance at 10%, ** refers to statistical significance at 5%, and *** refers to statistical significance at 1%. The data source for all tables is the author's calculations. The number of lags included in the model is chosen according to the Schwarz information criterion.

Source: Author's estimations.

Table 3 Estimation of Cointegration Relationship between Real Wages and Productivity

Period: 1995:1 to 2007:4	Method		
Explanatory variables	**FMOLS**	**MGE**	**PMGE**
PR_T^{CEEC}	0.43 (-46,28)***	0.466 (2.56)***	0.656 (12.21)***
Error correction term	-	-0.184 (-4.71)***	-0.08 (-3.95)***
Specification		**ARDL (1,1)**	**ARDL (1,1)**

Note: Test statistics are given in parentheses.

Source: Author's estimations.

The *FMOLS* and *PMGE* results are broadly in line with the findings from the cointegration analysis, but the estimated coefficient of real wages elasticity is far from that found in the analysis. This suggests that a significant influence of the *BS* effect on inflation and real appreciation is unlikely.

These findings are in line with the results of Egert's (2005) analysis for the panel composed of Bulgaria, Croatia, Turkey, Romania, Russia, and Ukraine, which revealed a real wage elasticity ranging from 0.5 to 0.8.

In the next step, the cointegration between the wages in the traded goods sector and in the non-traded goods sector was tested (Table 4). The wages in construction, transport, trade, education, and health weighted by the number of employees in those sectors were used as a proxy for non-tradable sector wages.

In contrast to the long-run relationship between relative productivity and wages, the long-run relationship between wages in the tradable and in the non-tradable goods sector is less obvious and, more importantly, not confirmed by the tests that we consider as the most appropriate (group *ADF*, panel *ADF*, and panel ρ). This result is of great importance for the empirical testing of the *BB* effect: if the assumption of wage equalization is not satisfied, the difference in wages between the tradable and the non-tradable sector should be included as a factor in domestic inflation, in addition to relative productivity.

Table 4 Panel Cointegration Test for $RWAG_N^{CEEC}$ and $RWAG_T^{CEEC}$

Period: 1995:1 to 2007:4	Model with individual intercepts		Model with individual intercepts and individual trends	
	statistics	p value	statistics	p value
Panel v	-0.1782	0.3927	5.569	0.000***
Panel rho	-1.5669	0.1169	-0.7233	0.3071
Panel PP	-8.9428	0.0000***	-3.2607	0.0020***
Panel ADF	-0.3438	0.3761	2.2137	0.034**
Group rho	1.4982	0.1299	2.7682	0.009***
Group PP	-3.2080	0.0023***	1.3286	0.1650
Group ADF	0.0314	0.3987	0.5576	0.3415

Source: Author's estimations.

The cointegration between relative prices and relative productivity is strongly confirmed by group *ADF* and panel *ADF* statistics for relative prices and relative productivity if *GDP* deflators are used as a proxy for relative prices (Table 5).

Table 5 Panel Cointegration Test for RP1 and PRI

Period: 1995:1 to 2007:4	Model with individual intercepts		Model with individual intercepts and individual trends	
	statistics	p value	statistics	p value
Panel v	2.3779	0.0236**	-0.1053	0.3967
Panel rho	-1.1151	0.2142	0.1922	0.3916
Panel PP	-6.4806	0.0000***	-6.4767	0.0000***
Panel ADF	-5.6037	0.0000***	-3.9147	0.0002***
Group rho	0.2682	0.3848	1.6862	0.0963*
Group PP	-5.2885	0.0000***	-4.3691	0.0000***
Group ADF	-7.2672	0.0000***	-5.2826	0.0000***

Source: Author's estimations.

The estimation of price elasticity from the relative productivity growth is done by the *FMOLS* method. The results of the *FMOLS* method (Table 6) suggest that a faster productivity growth by 1% in the tradable goods sector causes increased prices in non-tradable goods, measured by *GDP* deflators as 0.4 percentage points. The estimation of this effect for separate countries ranges from 0.1 for Bulgaria to 0.65 for Slovakia. All estimated coefficients are positive and statistically significant.

Table 6 FMOLS Estimation of Cointegation between RP1 and PRI

Country	Period: 1995:1 to 2007:4		Period: 1995:1 to 2010:3	
	Coefficient	**Test statistics**	**Coefficient**	**Test statistics**
Czech Republic	0.49	-8.33***	0.33	-12.93***
Croatia	0.14	-11.58***	0.16	-13.89***
Poland	0.52	-5.66***	0.46	-11.58***
Hungary	0.53	-2.90***	0.12	-13.65***
Slovenia	0.56	-13.12***	0.61	-13.92***
Slovakia	0.65	-5.73***	0.46	-16.88***
Macedonia	0.20	-27.05***	0.20	-30.08***
Bulgaria	0.07	-6.87***	-0.35	-8.00***
Average without time effects	**0.40**	**-28.73*** **	**0.25**	**-42.76*** **

Note: The t statistics are for the null hypothesis that the estimated coefficient is equal to one. Therefore, for coefficients that are positive but lower than one, the test statistics are negative.

Source: Author's estimations.

Including the period of the Global Economic Crisis in the analysis does not significantly change the estimation of the *BB* effect, although the estimated the contribution of productivity differential to relative prices is lower. The Crisis significantly changed only the contribution of productivity differential to the relative prices of non-tradable goods in Bulgaria, whose coefficient became negative.

For the sake of robustness checking, we estimated the same relationship by *MGE*, *PMGE*, and *DOLS* methods (Table 7). In line with the *FMOLS* results*, MGE*, *PMGE* and *DOLS* pointed to a well-behaved and statistically significant *BB* effect. In all three models, the panel long-run coefficients are positive and statistically significant. The elasticity obtained by *MGE* is similar to that obtained by *FMOLS*, while the elasticity obtained from the *PMGE* and *DOLS* method is slightly higher. This confirms the robustness of the obtained results related to the *BB* effect.

Table 7 MGE, PMGE, and DOLS Estimators of the Cointegration Vector between Relative Prices (RP1) and Relative Productivity (PRI)

Period: 1995:1 to 2007:4	**Method**		
Explanatory variables	**MGE**	**PMGE**	**DOLS**
PRI	0.25 (2.32)**	0.42 (14.09)***	0.40 (22.85)***
Error correction term	-0.51 (-8.75)***	-0.36 (-5.16)***	
Specification	**ARDL (1,1)**	**ARDL (1,1)**	**DOLS (2,2)**

Source: Author's estimations.

The estimates are not significantly changed when both industry and agriculture are included in the tradable sector (the results of this analysis have not been presented separately). Presuming that the share of agriculture in total gross value is low, except in Slovakia, Romania, and Bulgaria, the inclusion of agriculture does not change the estimation of the impact of productivity on non-tradable prices. The coefficient is negative only in Bulgaria, which has very low productivity in agriculture. The estimates obtained by *MGE*, *PMGE*, and *DFE* methods are, as in a previous case, very close to the *FMOLS* estimates.

The results of the *FMOLS* method suggest that 1% faster productivity in the tradable sector compared to the non-tradable sector causes an approximately 0.5%

increase in relative prices measured by the ratio of services in *CPI* and *PPI* (Table 8). This effect is smaller than most previous studies suggest (for instance, Egert, Drine, and Rault 2002; Mihaljek and Klau 2008).

When the ratio of services in the *CPI* and *PPI* indices is used as a proxy for relative prices, the estimated coefficient for each particular country except Croatia is very close to that obtained using GDP deflators. The average cointegration coefficient is higher because Bulgaria, Romania, and Macedonia are excluded from the analysis. One possible explanation for this difference in Croatia is inappropriate classification of the tradable and non-tradable sectors due to the high share of tourism in overall exports.

As in the previous case, the average cointegration coefficient is slightly lower when the period of the Global Economic Crisis is included in the analysis.

Table 8 FMOLS Estimation of Cointegation between RP2 and PRIA

Country	Period: 1995:1 to 2007:4		Period: 1995:1 to 2010:3	
	Coefficient	Test statistics	Coefficient	Test statistics
Czech Republic	0.25	-7.58***	0.39	-10.45***
Croatia	0.86	-0.89	0.73	-2.64**
Poland	0.41	-2.91***	0.30	-9.51***
Hungary	0.59	-2.70***	0.44	-12.98***
Slovenia	0.42	-5.31***	0.42	-5.31***
Slovakia	0.55	-9.08***	0.44	-14.05***
Average	**0.51**	**-11.62*** **	**0.46**	**-22.91*** **

Note: A panel of six countries is used (excluding Romania, Bulgaria, and Macedonia). Two lags for kernel estimators are used, but the different specification does not alter the estimation. The t statistics are for the null hypothesis that the estimated coefficient is equal to one. Therefore, for coefficients that are positive but lower than one, the test statistics are negative.

Source: Author's estimations.

To find out the contribution of the *BB* effect to domestic inflation according to equation (5), we multiplied the share of non-tradable goods and services in the *CPI* by the estimated coefficient of elasticity, which was previously multiplied by the historical average of the domestic productivity differential.

Table 9 Estimates of the Baumol-Bowen Effect (Covering the Period 1995:1 to 2010:3)

Country	Average inflation	Baumol-Bowen effect (RP1, PRI)	Baumol-Bowen effect (RP2, PRIA)
Czech Republic	3.5	0.742395	0.877376
Croatia	3.3	0.42204	1.925555
Poland	5.4	1.037801	0.676827
Hungary	8.0	0.188119	0.689769
Slovenia	5.5	1.490649	1.026348
Slovakia	5.8	1.207362	1.154868
Macedonia	1.9	0.564531	....
Bulgaria	35.8	-0.2169	....
Average	**8.7**	**0.5879**	**1.081735**

Source: Author's estimations.

These findings suggest that approximately one percentage point of inflation (for RP2 measure) and 0.6 p.p. (for RP1 measure) could be explained by the *BB* effect. These results related to the average *BB* effect are consistent with the findings of Machova (2008) and Mihaljek and Klau (2008) while the individual country estimates are different. The results show that the *BB* effect has the highest contribution in Slovenia, Slovakia, and Croatia (measured by *RP2*), and the lowest contribution in Bulgaria. For instance, according to Machova (2008), the *BB* effect ranges from 0.15% for Bulgaria to 2.5% for Slovakia. The contribution of the *BB* effect in Mihaljek and Klau (2008) is negative for Hungary and positive but very low for Bulgaria; for the Czech Republic and Slovenia, it is much higher than in our analysis.

The main policy implication of these results is that the *BB* effect is not a determining factor of the ability of *CEECs* to satisfy the Maastricht inflation criteria. Taking into account that Slovenia and Slovakia have already satisfied those criteria and become members of the *EMU*, it is unlikely that other countries would not be able to do the same.

In line with equation (5), the standard version of the *BB* effect could be extended to an alternative specification that captures the fact that the assumption of wage equalization is not necessarily satisfied due to differences in skills and human capital. Therefore, we could relax the assumption of wage equalization and test the extended version of the *BB* effect, including wage differential as an additional factor in the increase in relative prices (as was done by Lojschova 2003; Wagner and Hlouskova 2004; Machova 2008). As the previous analysis has not provided clear evidence that wage equalization happens in *CEEC*s, the extended version of the *BB* effect is tested.

Table 10 Johansen Panel Cointegration Test for Relative Prices, Productivity, and Wages (Covering the Period 1995:1 to 2007:4)

Number of vectors	Panel trace statistics	p value	Panel max eigenvalue	p value
None	41.47	0.0000	41.33	0.0000
At most 1	12.80	0.3838	11.51	0.4856
At most 2	9.258	0.6807	9.258	0.6807

Note: The cointegration vector is estimated under the assumption that the number of lags is 2. A panel of six countries is used (excluding Romania, Bulgaria, and Macedonia).

Source: Author's estimations.

The Johansen panel cointegration test proposed by Maddala and Wu (1999) commits that relative prices, wages, and productivity differential are cointegrated, but not their regressors (Table 10). With reference to this result, the *FMOLS* method could be used.

As the results in Table 11 show, the coefficient of wage differential has the opposite sign for some countries, while the coefficient of relative productivity is almost unchanged. In line with the results of Lojschova (2003), these findings lead to the conclusion that including wage differential as an additional factor in inflation does not contribute much to the prices of non-traded goods. Contrary to these findings, Machova (2008) found evidence of the importance of adding relative wages in the estimation of the *BB* effect.

Table 11 FMOLS Estimates of the Cointegration Vector between Relative Prices, Productivities, and Wage Differentials

Period: 1995:1 to 2007:4	Explanatory variables			
	$PR_T^{CEEC} - PR_N^{CEEC}$		$WAG_T^{CEEC} - WAG_N^{CEEC}$	
Country	**Coefficient**	**Statistics**	**Coefficient**	**Statistics**
Czech Republic	0.60	-3.66***	1.28	1.12
Croatia	0.17	-11.65***	-0.86	-2.18**
Poland	-0.06	-8.43***	-1.46	-2.81***
Hungary	0.20	-2.66**	-0.82	-1.49
Slovenia	0.54	-8.80***	0.51	1.08
Slovakia	0.55	-6.92***	-0.12	-0.22
Average	**0.33**	**-17.19*** **	**-0.25**	**-1.84***

Note: A panel of six countries is used (excluding Romania, Bulgaria, and Macedonia). Two lags for kernel estimators are used, but the different specification does not alter the estimated coefficient. The t statistics are for the null hypothesis that the estimated coefficient is equal to one. Therefore, for coefficients that are positive but lower than one, the test statistics are negative.

Source: Author's estimations.

2.3.2 Testing the Balassa-Samuelson Effect

Testing the *BS* effect consists of several steps. In the first step, the cointegration between the real exchange rate and the difference in relative productivity in *CEEC*s relative to the euro area (as the main trading partner for most of these countries) is tested.

Most of the implemented panel cointegration tests suggest a long-run relationship between the real exchange rate and the difference in relative productivity in *CEEC*s and the euro area (Table 12).

Table 12 Panel Cointegration Test of Real Exchange Rate (RERG) and Productivity Differential (RPR1)

Period: 1997:1 to 2007:4	Model with individual intercepts		Model with individual intercepts and individual trends	
	statistics	p value	statistics	p value
Panel v	0.423194	0.3648	1.279142	0.1760
Panel rho	0.537641	0.3453	0.129533	0.3956
Panel PP	-3.952783	0.0002***	-8.391602	0.0000***
Panel ADF	-4.251940	0.0000***	-4.913733	0.0000***
Group rho	1.763114	0.0843*	1.235630	0.1859
Group PP	-2.957042	0.0050***	-7.523959	0.0000***
Group ADF	-1.531205	0.1235	-3.183639	0.0025***

Note: The number of lags differs across the individual members. *RPR1* corresponds to productivity differential *PRI*.

Source: Author's estimations.

Taking into account that all the necessary conditions are fulfilled, the next step of the analysis is to estimate the average contribution of the productivity differential to the inflation differential. Therefore, we estimate the standard version of the *BS* effect. The standard version of the *BS* effect fully corresponds to testing the cointegration between the real exchange rate and productivity differential.

Table 13 FMOLS Estimation of the Cointegration Vector between RERG and RPR1

Country	Period: 1997:1 to 2007:4		Period: 1997:1 to 2010:3	
	Coefficient	**Test statistics**	**Coefficient**	**Test statistics**
Czech Republic	-1.17	-7.49***	-1.07	-13.85***
Croatia	-0.35	-8.02***	-0.44	-9.55***
Poland	-0.87	-3.34***	-0.52	-6.44***
Hungary	0.69	-0.30	-1.14	-6.53***
Slovenia	-0.64	-20.55***	-0.62	-26.22***
Slovakia	-1.06	-10.23***	-0.79	-37.25***
Macedonia	-0.07	-28.78***	-0.08	-29.65***
Bulgaria	0.24	-4.48***	-1.11	-3.11***
Romania	0.04	-5.60***	-0.03	-5.86***
Average	**-0.36**	**-29.60*** **	**-0.65**	**-46.16*** **

Note: The t statistics are for the null hypothesis that the estimated coefficient is equal to one. Therefore, for coefficients that are positive but lower than one, the test statistics are negative.

Source: Author's estimations.

The results of the *FMOLS* method of estimation shows that in contrast to the *BB* effect, which is confirmed for all *CEEC*s, there is less evidence in favor of the *BS* effect. In the case of the *BB* effect, the cointegration tests establish robust long-run relationships, and the estimation techniques produce correctly signed panel coefficients, which is not the case with the *BS* effect. The estimate of the *BS* effect is slightly changed when we extend the analysis to the period of the Global Economic Crisis: the effect becomes stronger and evident for all countries (Table 13). Robert Sonora and Josip Tica (2009) reached similar *DOLS* estimates for the same model specification (-0.55).

Table 14 MGE, DOLS, and PMGE Estimation of the Cointegration Vector between RERG and RPR1

Period: 1997:1 to 2007:4	**Method**		
Explanatory variables	**MGE**	**PMGE**	**DOLS**
PRI	-0.711 (-6.17)***	-0.734 (-13. 67)***	-0.675 (-15.97)***
Error correction term	-0.253 (-3.64)***	-0.226 (-3.31)***	….
Specification	**ARDL (1,1)**	**ARDL (1,1)**	**DOLS(1,1)**

Note: The test statistics are given in parentheses.

Source: Author's estimations.

On the other hand, the relationship between the productivity differential and the real exchange rate is weaker when using the *RPR2* productivity measure, which includes agriculture as a tradable sector. The estimated elasticity in this case is –0.33 and has the right sign for all countries except Romania and Bulgaria. Contrary to these findings, Vasile Dedu and Bogdan Dimitrescu (2010), using a time series model for the period between 2002 and 2006, concluded that the *BS* effect in Romania explains, on average, around 0.6 percentage points of the observed inflation differential.

Table 15 FMOLS Estimation of the Cointegration Vector between RERG and RPR2

Country	Period: 1997:1 to 2007:4		Period: 1997:1 to 2010:3	
	Coefficient	Test statistics	Coefficient	Test statistics
Czech Republic	-1.19	-9.07***	-1.14	-14.92***
Croatia	-0.28	-5.68***	-0.29	-6.00***
Poland	-0.72	-3.40***	-0.47	-7.44***
Hungary	-0.94	-3.45***	-0.82	-13.39***
Slovenia	-0.62	-19.82***	-0.62	-24.93***
Slovakia	-0.93	-16.07***	-1.23	-23.00***
Macedonia	-0.14	-38.54***	-0.17	-39.41***
Bulgaria	0.32	-3.42***	1.46	1.01
Romania	0.31	-7.64***	0.36	-3.26***
Average	**-0.47**	**-35.70*** **	**-0.33**	**-43.78*** **

Note: The t statistics are for the null hypothesis that the estimated coefficient is equal to one. Therefore, for coefficients that are positive but lower than one, the test statistics are negative.

Source: Author's estimations.

As previously mentioned, the inability to empirically confirm the stronger version of *PPP* impacts the *BS* effect. The violation of *PPP* suggests including in the test the real exchange rate deflated by tradable prices. For this reason, the cointegration vector is estimated for prices of tradable goods, productivity differential, and real exchange rate (Table 16). First, however, we have to ensure that there is only one cointegration vector.

Table 16 Johansen Panel Cointegration Test for RERG, RPR2, and Tradable Goods Prices (Covering the Period 1997:1 to 2007:4)

Number of vectors	Panel trace statistics	p value	Panel max eigenvalue	p value
None	75.97	0.0000	77.23	0.0000
At most 1	18.80	0.1727	15.02	0.3770
At most 2	14.77	0.3943	14.77	0.3943

Source: Author's estimations.

Table 17 FMOLS and PMGE Estimation of the Cointegration Vector between RERG, Tradable Goods Prices, and RPR2

Period: 1997:1 to 2007:4	Method	
Explanatory variables	FMOLS	PMGE
RPR2	-0.33 (-29.45)***	-0.45 (-3.95)***
PPI – PPI*	0.01 (-0.72)	-0.15 (-1.61)
Error correction term	…..	-0.21 (-4.03)***

Source: Author's estimations.

Including the tradable goods prices (measured by the differences in PPI between *CEEC*s and Euro Area 12) does not contribute to explaining the real exchange rate by the productivity differential; in the case of *PMGE*, the value has a sign opposite to the one expected and is not statistically significant.

The contribution of productivity differential to growth of relative prices is obtained as the product of the estimated elasticity coefficient and average productivity differential based on historical trends (Table 18).

Table 18 The Balassa-Samuelson Effect (Covering the Period 1997:1 to 2010:3)

Country	*Inflation differential*	*BS effect* (RERG, RPR1)	*BS effect* (RERG, RPR2)
Czech Republic	1.60	-2.233	-2.379
Croatia	1.40	-1.183	-0.780
Poland	3.50	-0.988	-0.893
Hungary	6.10	-0.858	-0.617
Slovenia	3.60	-1.653	-1.653
Slovakia	3.90	-1.998	-3.110
Macedonia	0.05	-0.416	-0.883
Bulgaria	5.50	0.345	-0.453
Romania	20.50	-0.067	0.807
Average	**5.1**	**-1.427**	**-0.724**

Source: Author's estimations.

On average, the contribution of the *BS* effect to the inflation differential relative to the euro area ranges from 0.7% to 1.5% (depending on the measure of relative productivity used). This is a relatively small fraction of the rate of overall inflation. Taking into account that the average inflation differential in *CEEC*s relative to the euro area in the analyzed period is 5%, it could be concluded that the *BS* effect is not the most important cause of real currency appreciation. For instance, these results are similar to those of Mihaljek and Klau (2008), while Machova (2008) reached a lower estimate of the *BS* effect. These findings are in line with those of a number of studies reported in Section 2.1, which also showed that more than the *BS* effect, other factors, such as the process of liberalization and opening of these economies to foreign direct investments, as well as the growth of public expenditure through the aggregate demand channel, contribute to real appreciation in these countries.

The results of this analysis seem to suggest that the *BS* effect is stronger in economies with a stronger convergence process. One of the explanations why the *BS* effect is less evident in Bulgaria, Macedonia, and Romania, which could not be directly explained by productivity growth and the *BS* effect, is the process of price liberalization, which affects the prices of both tradable and non-tradable goods and services. The low share of non-traded goods in the CPI index could be also one explanation. Moreover, what seems to characterize these countries is their fast-growing productivity not only in the tradable goods sector but also in the non-traded goods sector.

3. Concluding Remarks

In this paper we investigated the importance of the *BB* and the *BS* effects in nine *CEECs* in the recent period (from the mid-1990s to the third quarter of 2010). Using panel estimation techniques, we found evidence in favor of the *BB* and the *BS* effects. Panel cointegration tests detected a relationship between productivity and relative prices (the *BB* effect), and between relative productivity differential and real exchange rate vis-à-vis the euro area (the *BS* effect). Similar evidence were found using the *FMOLS, DOLS*, *PMGE*, and *MGE* methods.

The econometric analysis shows that the *BB* and the *BS* effects are less evident, particularly in Romania, Bulgaria, and Macedonia. One possible explanation for the limited role of the *BS* effect in overall inflation and real exchange rate appreciation is the failure to achieve some of the most important preconditions (a stronger version of *PPP* holds, real wages are proportionately linked to productivity in the tradable sector, wage equalization).

The findings suggest that approximately one percentage point of inflation could be explained by the *BB* effect. The results also show that the *BB* effect has the highest contribution in Slovenia and Slovakia, and the lowest contribution in Bulgaria, where the difference in productivity between the tradable and the non-tradable sector is also the lowest. On average, the *BS* effect's contribution to the inflation differential and real appreciation is less than 1.5 percentage points. Based on this result, it could be concluded that the *BS* effect is not the most important cause of the real currency appreciation in *CEECs*.

The *CEECs'* target of adopting the euro, already reached by Slovenia in 2007 and by Slovakia in 2009, has sparked debates about right timing and the pertinence of the Maastricht criteria due to crisis implications. This in turn roused the interest of researchers and policy makers in the dynamics of the *BS* effect. Answering the question whether the *BS* effect has become stronger or weaker during the catching up process as well as during the crisis, this analysis is conducted for the subsample period from 1995 to 2007 and from 1995 to 2010.

Most of the results point out that the *BS* effect was not noticeably changed during the crisis, even though it was lower compared to that in the earlier stage of transition (for the period up to 2004). Thus, it can be anticipated that the slowdown of the convergence process due to a crisis will not be an obstacle for investors and that these countries will again begin the race to catch up.

The analysis suggests that the *BB* and the *BS* effects still play a role in inflation and the real exchange rate, and are likely to remain on the agenda of both policy and research for a while but not as significantly as in the earlier stage of transition. In principle, we should expect the *BS* effect to persist for the entirety of the catching-up period, which should continue for at least the ensuing decade, before and after the adoption of the euro; however, the size of the effect will depend on the speed of the catching-up process.

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