HARROD-BALASSA-SAMUELSON EFFECT IN SELECTED COUNTRIES OF CENTRAL AND EASTERN EUROPE

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Abstract

This study investigates the HBS effect in a panel of nine CEECs during 1993:Q1-2003:Q4 (unbalanced panel). Prior to estimating the model, we analyze several key assumptions of the model (e.g. wage equalisation, PPP and sectoral division) and elaborate on possible consequences of their failure to hold. In the empirical part of the paper, we check the level of integration of the variables in our panel using the Pedroni panel-stationarity tests. We then investigate the internal and external version of the HBS effect with the Pedroni panel-cointegration tests as well as by means of group-mean FMOLS and PMGE estimations to conclude that there is a strong evidence in support of the internal HBS and ambiguous evidence regarding the external HBS. Our estimates of the size of inflation and real appreciation consistent with the HBS effect turned out generally within the range of previous estimates in the literature (0-3 % per annum). However, we warn against drawing automatic policy conclusions based on these figures due to very strong assumptions on which they rest (which may not be met in near future). Finally, following the hypotheses put forward in the literature, we elaborate and attempt to evaluate empirically the potential impact of exchange rate regimes on the magnitude of the HBS effect.

Niniejsze opracowanie bada efekt HBS w 9. krajach Europy Środkowo-Wschodniej (EŚW) w okresie 1993:Q1-2003:Q4 (panel niezrównoważony). Przed estymacjami modelu, analizujemy kilka kluczowych założeń modelu (np. o wyrównywaniu się płac, parytecie siły nabywczej czy o podziale sektorowym) i zastawiamy się nad potencjalnymi konsekwencjami ich niespełnienia. W części empirycznej sprawdzamy stopień integracji zmiennych w naszym panelu wykorzystując panelowe testy stacjonarności Pedroniego. Następnie badamy wewnętrzny i zewnętrzny efekt HBS za pomocą panelowych testów kointegracji Pedroniego oraz estymacji metodami group-mean FMOLS oraz PMGE, które dostarczają silnych dowodów na istnienie wewnętrznego HBS, ale nie dają jasnych wyników co do zewnętrznego HBS. Nasze

szacunki skali inflacji i realnej aprecjacji związanej z efektem HBS okazały się zbliżone do wcześniejszych szacunków innych autorów (0-3% w skali rocznej). Przestrzegamy jednak przed automatycznym wykorzystywaniem tych szacunków w polityce gospodarczej, gdyż są one oparte na bardzo mocnych założeniach (których spełnienie nie jest pewne w bliskiej przyszłości). Na końcu zastawiamy się nad hipotezami, które pojawiły się w literaturze przedmiotu, zakładającymi potencjalny wpływ reżimów kursowych na skalę efektu HBS oraz podejmujemy próbę empirycznego oszacowania tego wpływu.

1. Introduction

Since the beginning of the transition process, Central and Eastern European countries (CEECs) have experienced relatively high inflation rates and substantial appreciation of their real exchange rates. While in the early 1990s, inflation was mainly reflecting price liberalisation, sizeable adjustments of administrative prices and monetary overhang – the legacy of the socialist system[1] – the inflation performance in recent years can no longer be attributed to those early-transition phenomena. It is widely argued that the positive inflation differential and trend appreciation of currencies in CEECs vis-à-vis most Western economies may be explained (at least to some extent) by structural factors. The Harrod-Balassa-Samuelson (HBS) effect, which links the inflation differential and real exchange rate movements to productivity growth differentials, gained a prominent role among these factors.

The HBS theory offers a supply-side explanation of higher inflation and the associated real exchange rate appreciation in countries experiencing higher relative productivity growth. In its domestic version relative inflation in a given economy is explained by relative productivity growth between the tradable and nontradable sectors. It has been observed for some time that the tradable sector usually enjoys higher productivity growth than the nontradable sector (for example, in Baumol and Bowen, 1966). If wages equalise between sectors, higher productivity-driven wages in the tradable sector push wages in the nontradable sector above levels commensurate with its productivity gains. This in turn drives prices of nontradables up and raises the ratio of nontradable to tradable prices. In a two-country setting the HBS effect predicts that the country with higher sectoral productivity-growth differential will experience higher relative inflation (or, higher absolute inflation levels if tradable inflation differential is assumed to be zero).

In the international context the causal link between relative productivity and relative prices can be further used to explain real appreciation of the exchange rate of a country with higher

[1] Monetary overhang was built over the years in the form of forced savings across socialist economies as a result of pervasive shortages and rationing of goods and services.

relative productivity growth. Assuming that the law of one price holds in the tradable sector, the productivity-driven inflation differential will result in appreciation of the real exchange rate deflated with any measure of inflation containing the tradable and nontradable component.

Therefore, in view of the fact that each of the three effects related to the HBS theory (rising relative productivities, relative prices and real appreciation of exchange rates) has been observed in the CEECs, it is not surprising that the HBS hypotheses have attracted a lot of attention in the regional context. Higher growth rates of real GDP and productivity in CEECs are to some extent a natural consequence of the transition from highly regulated economies, where productive resources were employed in less than fully efficient manner, closer to their natural level. Another plausible hypothesis is that the process is triggered by convergence, where growth rates differentials ensue from large income and productivity disparities between the region and its Western European neighbours and are facilitated by their progressively closer economic integration. While substantial gains in this process have been achieved already, there still seems to be a sizeable room for convergence and the relative productivity growth differentials are expected to persist for many years in the future.

Additionally, as a consequence of the EU accession of eight CEECs as well as the debate on the adoption of the euro, the HBS theory has become a popular framework used for an assessment of the feasibility of meeting the Maastricht criteria. It has been argued that simultaneously setting the ambitious inflation and exchange rate stability criteria, as is the case in the Maastricht Treaty, might be in conflict with the underlying trend of productivity growth. The posited inappropriateness of combining the two criteria stems from the general prediction of the HBS theory that certain productivity growth differentials can result in violating any joint criterion on inflation and nominal exchange rate. The productivity-driven excess inflation and real appreciation should be viewed as a natural equilibrium process in faster-growing economies which in principle does not call for policy intervention. Thus, investigation of the HBS effect in transition economies is of a key importance from the point of view of EMU accession. An evaluation of this effect can shed empirical light on potential problems associated with meeting the Maastricht criteria. It can also provide guidance in choosing the central parity and managing the exchange rate in the ERMII period.

Related to the question of meeting the joint inflation-nominal-exchange-rate criterion is the issue of the posited trade-off between nominal convergence implied by the Maastricht criteria and the real convergence manifested by the GDP catch-up. The problem might arise in the new EU Member States (NMS thereafter), if the inflation and nominal exchange rate consistent with the Maastricht criteria are impossible to achieve in the presence of the sizeable HBS effect. A monetary tightening that might be necessary to bring inflation (or exchange rate) to the Maastricht-consistent level could also suppress real growth. Consequently, there would be a risk of sacrificing the real convergence for the nominal one.

The high policy relevance of the above-mentioned issues has spurred interest in empirical research of the HBS effect in CEECs. The existing literature contributions differ considerably in their methodological approaches as well as country and time coverage. While most of them detect that the HBS effect is indeed at work in CEECs, they usually conclude that observed inflation differential and a real exchange rate appreciation is only in small part explained by the HBS effect. Additionally, the estimates of the HBS-consistent inflation and real appreciation differ considerably suggesting the productivity-driven real appreciation in the range of 0-3% per annum.

Against this background, we seek to reassess the HBS model for CEECs and to contribute to the empirical literature on this topic. The HBS theory rests on restrictive assumptions and their violation can be one of the factors explaining the fragility of empirical estimates. In the presented study we undertake a detailed investigation of the extent to which several key assumptions of the HBS theory (such as wage equalisation or PPP) hold in our panel. Subsequently, we verify the HBS hypotheses using quarterly panel data for nine CEECs during the period 1995-2003. In doing so, we include two alternative versions of the sectoral division and various alternative definitions of key model variables. This is motivated by theoretical controversies and practical problems related to dividing the economy into tradable and nontradable sectors as well as by robustness checks. In addition to estimating the internal and external versions of the HBS model we enhance the policy usefulness of these estimates by calculating the size of the HBS-consistent inflation and real appreciation. Finally, following the hypotheses put forward by Halpern and Wyplosz (2001) and Egert et al. (2003) we elaborate and evaluate empirically the potential impact of exchange rate regimes on the magnitude of the HBS effect.

The remainder of the paper is composed as follows. In the second chapter we present a theoretical exposition of the model. Chapter three contains a concise literature review related to HBS effect covering both the selection of early papers from the 1970s and 1980s as well as recent empirical studies devoted specifically to CEECs. Chapter four presents the data used in empirical analysis as well as the results of stationarity tests of the data. In the fifth chapter we investigate the extent to which assumptions of the HBS theory are met in our sample. In particular, we focus on wage equalisation, PPP and the issue of proper sector division. In addition, we elaborate on the possible consequences of violation of these assumptions for both the theoretical analysis of the HBS model and its empirical evaluation. Chapter six presents panel-cointegration tests and estimations of the internal and external versions of the HBS by means of panel regressions. Subsequently, inflation and appreciation consistent with the HBS effect are computed and discussed in the context of their usefulness for inference about the near future (e.g. the EMU membership). The seventh chapter discusses the hypothesis of the potential impact of exchange rate regimes on the HBS effect and presents an attempt of its empirical verification. Chapter eight concludes.

2. The Harrod-Balassa-Samuleson Model

Initiated by Harrod (1939) and formalised independently by Balassa (1964) and Samuelson (1964), the HBS theory posits a relationship between sectoral productivity differentials across countries and patterns of deviations from PPP (i.e., the fact that, abstracting from transition costs, prices of identical goods measured in one currency are not empirically the same across countries, either continuously or over significantly long periods) in order to investigate the implications of such deviations for international real-income comparison. Over the years, however, the processes predicted by the HBS theory have been extensively modelled in studies, which seek to explain the behaviour of real exchange rates. The formal exposition of the HBS model is presented below.[2]

It is assumed that a small open economy produces two goods: composite traded and composite nontraded and that outputs are generated with constant–return production functions (CRS):

(1) $Y^T = A^T F(K^T, L^T)$ and $Y^{NT} = A^{NT} F(K^{NT}, L^{NT})$

where subscripts T and N denote tradable and nontradable sectors, respectively. Parameters A, K and L with T and N superscripts assigned stand for productivity, labour and capital in the two sectors in question. Assuming that both goods are produced the total domestic labour supply is constant and equal to $L = L^T + L^N$.

It is further assumed that capital is mobile across sectors and countries (i.e. there are no resource constraints on capital), but labour only domestically. Labour mobility ensures that workers earn the same wage W in either sector, where the numeraire is the traded good (i.e. relative wage). Perfect capital mobility implies that the domestic rate of return

[2] The formalisation of the HBS model provided in this section extensively draws on Obstfeld and Rogoff (1996).

on capital R is fixed to the world interest rate and is exogenous. If R is the world interest rate in terms of tradables, then, under perfect foresight, R must also be the marginal product of capital in the tradable sector. At the same time R must be the value, measured in tradables, of marginal product of capital in nontradable sector (for details see Obstfeld and Rogoff (1996)). Under the assumption of a perfect capital mobility, the production possibilities frontier of an economy becomes linear and therefore technology is the unique determinant of relative prices of tradables in terms of nontradables (P^{NT}/P^{T}).

Thus, the profit maximisation in tradable and nontradable sectors implies:

(2a) $R = (1-\gamma)\, A^{T} \{K^{T} / L^{T}\}^{-\gamma}$ and

(2b) $R = (P^{NT}/P^{T})(1-\delta)\, A^{NT}\{K^{NT}/ L^{NT}\}^{-\delta}$

(3a) $W= \gamma A^{T} \{K^{T} / L^{T}\}^{1-\gamma}$ and

(3b) $W = (P^{NT}/P^{T})\delta A^{NT}\{K^{NT}/ L^{NT}\}^{1-\delta}$

where γ and δ are labour's share of income generated in the traded and nontraded sector, respectively.

Equations (2a&b)-(3a&b) fully determine the relative price of tradables to nontradables with an important implication that for a small country, the relative price of T and NT is independent of consumer demand patterns. But introducing a nontradable good into the analysis is not enough to violate the theory of absolute PPP. If the two countries had identical production functions and capital was perfectly mobile, prices of nontradables expressed in terms of tradables would equalise. According to the HBS effect, what causes persistent deviation of real exchange rate from its PPP values are differences in sectoral labour productivity.

By log differentiating (2a&b)-(3a&b), a systematic relationship between relative productivity shifts and the **internal** real exchange rate (i.e., the price of nontradable good expressed in terms of tradable goods) can be derived:

(4) $\Delta(P^{NT}/P^{T}) = \Delta p^{NT} - \Delta p^{T} = (\delta/\gamma)\Delta a^{T} - \Delta a^{NT}$

Equation (4) can be interpreted as follows: provided that the inequality $\delta/\gamma >= 1$ holds, faster productivity growth in the tradable relative to nontradable sector will push the price of nontradables upward. If both sectors had the same degree of labour intensity ($\delta=\gamma$), then the change in relative prices would be equal to the productivity growth differential. The larger the share of labour in the production of nontradables relative to tradables ($\delta>\gamma$), the larger the effect will be. This is the so-called *'domestic'* version of HBS effect and was first introduced by Baumol and Bowen (1966) who looked at historical data of industrialised countries and found that technological progress in service-intensive goods was smaller than in traded-manufactured goods. However, as Froot and Rogoff (1994) argue, the Baumol-Bowen effect is not a sufficient condition to imply the international HBS effect.

The *'international'* version of the HBS effect rests on the assumption that the PPP holds in the tradable sector. The aggregate price level ***p*** (in the logarithmic form) can be decomposed into prices of tradables and nontradables (at home and abroad) with weights **α** and **$1-\alpha$**, where '*' denotes a foreign country:

(5a) $$p = \alpha p^{T} + (1-\alpha)p^{NT} \quad \text{and}$$

(5b) $$p^{*} = \alpha^{*}p^{T*} + (1-\alpha^{*})p^{NT*}$$

The real exchange rate ***q*** is the relative price of tradables produced abroad (measured in domestic currency) with respect to home produced tradables (again, all variables are expressed in logarithms), ***e*** represents a nominal exchange rate (and is defined in domestic currency units per foreign currency so that a decrease implies appreciation):

(6) $$q = (e + p^{*}) - p$$

Now, substituting both equations (5a&b) into (6) and expressing the result in terms of changes, we obtain:

(7) $$\Delta q = (\Delta e + \Delta p^{T*} - \Delta p^{T}) + [(1-\alpha^{*})(\Delta p^{NT*} - \Delta p^{T*}) - [(1-\alpha)(\Delta p^{NT} - \Delta p^{T})]$$

If the law of one price for tradables holds,

(8) $$\Delta p^{T} = \Delta e + \Delta p^{T*}$$

then by substituting (4) into (7) and using (6) and (8) one can show how the real exchange rate can shift in a response to sectoral productivity changes between home and foreign country:

(9a) $\Delta p^T - \Delta p^{T*} = \Delta e^T + (1 - \alpha)[(\delta/\gamma)\Delta a^T - \Delta a^{NT}] - (1 - \alpha^*)[(\delta^*/\gamma^*)\Delta a^{T*} - \Delta a^{NT*}]$

or equivalently:

(9b) $\Delta q^T = \Delta e^T + \Delta p^{T*} - \Delta p^T = -\{ (1 - \alpha)[(\delta/\gamma)\Delta a^T - \Delta a^{NT}] - (1 - \alpha^*)[(\delta^*/\gamma^*)\Delta a^{T*} - \Delta a^{NT*}]\}$

Again assuming that $\delta/\gamma>=1$ holds (at home and abroad), faster productivity growth in tradable relative to nontradable sector at home than abroad will lead to a rise in the relative price level and therefore to the real appreciation of the domestic currency. As is the case with the 'domestic' version of the HBS effect, equation (9a&b) implies that demand plays *no* role in determining the relative price and therefore the real exchange rate.[3]

At this stage, it is worth mentioning that there are other theories that try to explain the so-called 'Penn-effect', i.e., the tendency for PPP-based real-income comparisons to be systematically biased (Asea and Corden, 1994). These depend largely on assumptions regarding demand. For example, Kravis and Lipsey (1983) and Bhagwati (1984), building on imperfect capital mobility, heterogenous tastes and factor endowments between countries, draw a conclusion that is the same as the one drawn from the basic HBS effect.

[3] Given that we can expect a large number of individual tradable goods (i.e. T_1 and T_2) we can extend the HBS model to the more general case in which there are additional factors of production (for example skilled and unskilled labour) without invoking demand restrictions. This is the case because for demand to have no role in determining relative prices, the perfect capital mobility is essential administracyjnych.

3. Empirical Studies

This chapter provides an overview of the literature investigating both the PPP puzzle and real exchange rate behaviour in the HBS framework. To provide a more complete research perspective the chapter distinguishes between the general literature on the HBS effect and its applications to CEECs.

Drawing on the early work of Ricardo and Harrod, Balassa (1964) and Samuelson (1964) point to the fact that divergent international productivity levels could, via their effect on wages and domestic prices of goods, lead to permanent deviations from the absolute version of PPP due to Cassel (1916). In his seminal paper, Balassa tests the relationship between price levels and GDP per capita and finds a positive relationship between countries' income and prices. This positive relationship leads him to conclude that this is why the *cost-of-living* PPP tends to bring about a spurious overvaluation of currencies of higher income countries. He further states that if international productivity differences are greater in the production of tradables than in the production of nontradables, the currency of the country with high productivity increases will be overvalued in terms of PPP. Consequently, the ratio of PPP to the exchange rate will be an increasing function of income.

Thus, the HBS theory is an appealing and relatively simple theoretical explanation of trends in real exchange rates.[4] A pertinent question is therefore how useful an explanation of trends in relative prices and real exchange rates the HBS theory really is? Unfortunately, empirical studies are rather inconclusive and many of them point to the limitations of the theory offering competing rationalisations. Also, arguing that demand shifts affect the composition of output, many researchers add additional variables to the basic HBS model. It should be born in mind however that, as an anecdote states "while all models are wrong, some are useful". This question is the main motivation behind extensive empirical literature discussed concisely below.

The 1980s studies of the HBS effect confirm that it is indeed at work. Hsieh (1982) verifies

[4] Obstfeld (1993) develops a formal model in which real exchange rates contain a deterministic trend.

the existence of the HBS effect using the time-series approach Focussing on determinants of the real exchange rate in Germany and Japan against their respective trading partners between 1954 and 1976, Hsieh finds that the productivity-differential variables are significant and have the correct sign. Martson (1987) uses OECD data and calibrates a model of the yen/dollar real exchange rate over the years 1973 to 1983. His findings confirm that labour productivity differentials between traded and nontraded sectors play a positive role in explaining the long-run trend appreciation of the yen against the dollar.

HBS studies of the early 1990s detect a somewhat more tentative evidence of the link between productivity disturbances and real exchange rates. Froot and Rogoff (1991) do not find a strong support for the traded-goods sector productivity growth differential and the real exchange rate movements across EMS countries for years 1979 to 1990. Also, Ito et al. (1997), who assess the validity of the HBS model for a number of ASEAN countries, find that although there is some evidence that these countries move in the direction indicated by the HBS effect, the real exchange rate did not appreciate or appreciated only slightly. Furthermore, they cannot find support for the assumptions behind the HBS effect including the law of one price in the tradable sector or the pattern of nontraded versus traded price movements consistent with the evolution of the real exchange rate.

The notable exception is a study by Heston et al. (1994) who, working with the extended data developed by Gilbert and Kravis (1954),[5] find strong HBS effects across countries and time (i.e., the difference between prices of nontradables and tradables changes with income). Canzoneri et al. (1999) – another exception – test a panel of 13 OECD countries using FMLS estimator. They divide their study into two parts: first they test the *'domestic'* version of HBS, and then look at the crucial assumption of the PPP in the traded sector. Their results show that the relative price of nontraded goods indeed reflects the relative labour productivities in the traded and nontraded sectors. However, the evidence is somewhat mixed when it comes to PPP in the traded sector. Although, PPP seems to hold when DM exchange rates are examined, it shows large and long-lived deviations when US dollar exchange rates are considered.[6]

A further range of studies point out that real exchange rates could be affected by other real and macroeconomic factors than the HBS mechanism. In terms of these studies, the HBS effect, real interest rate differentials (i.e., interest rate parity), net foreign assets (in portfolio balance models), government spending, and GDP per capita *all*, individually and together, play a role in determining real exchange rates.

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[5] Originally, it was Gilbert and Kravis (1954) who developed price level measures for common baskets of goods across countries.

[6] It should be noted in general that it is somewhat difficult to compare the results of these kinds of studies. This is because the empirical literature includes a wide range of approaches to explain the HBS hypothesis, and very often departs from its basic Ricardian framework.

For example, Asea and Mendoza (1994) apply a dynamic-general-equilibrium model to disaggregated data for 14 OECD countries between 1975 and 1990 in which they explicitly take into account tastes, technology and endowments. They do it in order to take into account microeconomic factors specified in the original formulation of the HBS model in the Ricardian framework. Their results support the proposition that sectoral differences in productivity growth help explain the trend rise in relative prices of nontradables within OECD countries. However, they find less empirical support for the overall HBS effect – i.e., there is little evidence that long-term differences in the level of the real exchange rate reflect differences in the relative price of nontradables.

De Gregorio and Wolf (1994) base their study on a sample of 14 OECD countries from 1970 until 1985 to examine the joint effect of productivity differentials and terms of trade movements on a real exchange rate and the relative price of nontradables. The main purpose of the joint analysis is to solve the omitted variable problem. They also show how their results are affected if the key assumption relating to international capital mobility is lifted. They find that productivity differentials across sectors are very significant determinants of real exchange rate fluctuations, but not of changes in the relative price of nontradables (terms of trade changes are significant in both cases). Furthermore, they include real income per capita and government spending in their specification. As these regressors capture demand effects and come out highly significant, De Gregorio and Wolf (1994) question the perfect capital mobility assumption of the HBS effect.[7]

The HBS effect: CEECs focus.

Even if the HBS effect was originally developed to unveil the PPP puzzle, equation (9) is crucial to the better understanding of *why* the currencies of CEECs appreciate in real terms once these economies liberalise their markets and *why* the relative tradables productivity growth differentials between the NMS and the euro area might lead to **structurally** higher inflation once they lock their central parities to the euro.

Table 1 presents the differences in results of the key studies of the HBS effect in CEECs and describes the estimation methods applied.

Jakab and Kovacs (1999) use a structural VAR model on Hungarian data over 1993 to 1998 to test the hypothesis that the real exchange rate appreciation in transition economies reflects productivity gains in the tradable sector (they use the real effective exchange rate as a measure of real exchange rate). They find a strong support for the HBS effect amounting to about 2.9 percentage points per year. This result could speak against the EMU participation. For example, sustaining a stable nominal exchange rate could result in the inflation rate of 2.9 percentage points above that of the euro area.

[7] For other examples see also Bergstrand (1991), Obstfeld and Rogoff (1996), Balvers and Bergstrand (1997), Chinn (1997).

Cipriani (2000) focuses on structural inflation rather than exchange rates in his study on the HBS effect. He examines a panel of ten CEECs between 1995 and 1999 using quarterly data. The dependent variable in the estimated regression is the relative price of nontradable goods (i.e., he measures the Baumol-Bowen effect). Cipriani (2000) concludes that productivity growth differentials between tradable and nontradable sectors are not substantial, and argues that it can only explain around 0.7 percentage point of observed inflation.

De Broeck and Slok (2001), test the presence of the HBS effect in the two groups of transition countries: 1) the EU accession countries and 2) the other transition countries. They use the Pooled Mean Group estimator (PMGE) – due to Pesaran, Shin and Smith (1999) – and test the impact of different productivity measures in the tradable and nontradable sectors on the real effective exchange rate during the period 1991 and 1998. The tradable sector is proxied by industry and construction, while nontradable - by services. However, in order to control for macroeconomic development, which can also cause real exchange rate disturbances, they include additional variables like agriculture productivity, broad money, openness, government balance, terms of trade, and the index of fuel and nonfuel prices. The result of their analysis provides a clear evidence of the HBS effect in the NMS, with somewhat less evidence in other transition countries, Russia and other former Soviet Union countries. They suggest that further income catch-up will be associated with further appreciation of the real exchange rate of around 1.5% per annum. Unfortunately, their use of trade-weighted exchange rates calculated by the IMF is problematic because trading partners continue to change over time and include countries from outside the euro area. Moreover, the very short time span of annual data and a large number of explanatory variables makes the quality of the PMGE estimation questionable.

Halpern and Wyplosz (2001) modify the HBS model so that it is more relevant to transition countries. They achieve this by adding demand side variables and argue that it is the catching-up process (i.e., real convergence) that largely drives economic growth in these countries. They provide direct estimates of the HBS effect for all the transition economies for the period 1991 to 1999 using the methodology developed by De Gregorio et al. (1994). As there are many missing observations, they estimate the HBS effect using fixed and random effects, OLS and GLS regressions for an unbalanced panel. Their results confirm the presence of the HBS effect, of the magnitude of 3 percentage points per annum. The important contribution of Halpern and Wyplosz study is that they distinguish between different exchange rate regimes in the HBS model.[8]

[8] For the broader discussion on Halpern and Wyplosz study see chapter 7.

Egert (2002) studies the HBS effect in the Czech Republic, Hungary, Poland, Slovakia and Slovenia. Using quarterly data between 1991:Q1 and 2001:Q2, he applies time series and panel cointegration techniques as well as panel group means FMOLS estimator of Pedroni (2001) to test the presence of the HBS effect in those five countries. In addition, he quantifies the impact of the productivity growth differential on overall inflation, and investigates the extent to which it can explain real exchange rate appreciation in the CEECs. He concludes that while the HBS effect seems to be at work and does lead to the real appreciation of currencies, it does not endanger the fulfilment of the Maastricht inflation criteria by theses countries – somewhat in contrast with the previous studies. The drawback to Egert's study is that he assumes zero productivity growth in the nontradable sector. This assumption may be too strict given rapid (and unequal across countries) productivity growth in the service sector after its suppression during the central planning (see IMF, 2001). Also, he uses Germany as a proxy for the entire euro area, which may further bias his results.

Egert et al. (2002) explore Egert's (2002) hypothesis about the impact of the regulated prices on the magnitude of the HBS effect. Using Pedroni panel cointegration techniques they estimate the HBS effect in nine CEECs. They focus on a sample spanning from 1995 to 2000 to eliminate the early phase of the transition period, since, in their view, price and productivity developments during that time were mainly driven by initial reforms and not by the HBS effect. Similarly to Egert (2002), they are able to detect that productivity growth in the traded goods sector is likely to bring about nontradable inflation. However, they argue, it is not obvious that these gains will automatically cause overall inflation to go up and cause the real exchange rate to appreciate. This in fact depends on the composition of the CPI basket (i.e., the lower the share of nontradables, the lower will be the impact of relative price on overall inflation) as well as the share of the regulated prices. Furthermore, they cannot find support for PPP in the traded sector. Summing up, their results suggest that the role of the HBS effect in the price level convergence might be limited and that other factors may be important as well.

The conclusion drawn from the studies investigating the HBS effect in CEECs is that although there is a clear and strong evidence for the long-run relationship between the relative productivity growth and the relative price of nontradables (i.e., high productivity growth in tradable sector brings about relative price inflation), the evidence for the relative productivity differential and related movements in the real exchange rate is somewhat mixed. The most recent studies (see De Broeck-Sløck (2001) and Egert (2002)) tend to be more cautious in their estimates and conclude that the HBS effect is likely to cause the real exchange rate appreciation of around 1.5% per year. This is in sharp contrast to the previous works that detected the HBS-consistent annual real exchange rate appreciation of 3% or more. There are probably a few reasons that can explain differences in estimates. All of these studies employ different econometric techniques and rest on different assumptions (i.e. proxies used for tradable and nontradable sectors, measures of productivity, assumptions about productivity increases in the nontradable sector, nominal exchange rate deflators, etc.). Also, some of them only measure the domestic version of the HBS effect (i.e. the Baumol and Bowen effect); some additionally try to detect demand-side effects. It should be stressed that more recent studies are probably more reliable as they are based on additional observations and therefore render more accurate results.

4. Presentation of the Data

4.1. Data Sources and Definitions

Given the exposition of the HBS model and its variants (see chapter 2), their estimations require data on relative prices, relative productivity, and real exchange rates. For this purpose the tradable and nontradable sectors must be defined. Motivated by practical and theoretical considerations of the sectoral division, two alternative definitions of the tradable sector are adopted:

1) with the subscript '1' where the tradable sector comprises industry only, i.e. sections C, D and E of the NACE[9] classification of the economic activity (mining and quarrying, manufacturing industries as well as electricity, gas and water supply),
2) with the subscript '2' where the tradable sector comprises industry as well as agriculture, forestry and fishing, i.e. sections A, B, C, D and E of the NACE classification of the economic activity.

As far as the nontradable sector is concerned, we use a single definition which includes the part of the economy complementing the second definition of tradables, i.e. all sectors except agriculture, fishing, forestry and industry. In line with this division, all remaining variables have two variants: one in which the tradable sector is consistent with definition 1), and the second consistent with definition 2). The complexity of sectoral division at an empirical level will be discussed in more detail in section 5.1.

The data analysed in this study come from various sources. We use quarterly data series with different initial and final observations for various series. Most series, however, start in 1994-1995 and end in 2003. The choice of the sample period was motivated both by data availability and by the conscious decision to eliminate observations from the early 1990s that reflect mostly early transition phenomena rather than long-run relationships (such as

[9] NACE is the Classification of Economic Activities in the European Community compatible with ISIC - the International Standard Industrial Classification of all Economic Activities.

the HBS effect). The data on quarterly Gross Value Added (GVA) and employment by sectors (both in current and constant prices) are taken from Eurostat. In cases of gaps in the Eurostat database we turned to alternative sources. For employment data we used CANSTAT[10] and prior to 2000 – CESTAT[11] while GVA data was sourced from national statistical offices. For data on the CPI and PPI we used the IMF IFS database, while for exchange rates and nontradable component of the CPI we used the OECD Main Economic Indicators database. Whenever these databases had gaps, we used the data from national statistical offices.

Since it is impossible to calculate total factor productivity (TFP) in our sample, we proxy it with average labour productivity:

(10) $$PRO\_Ti\_xxx = \frac{VA\_Ti\_xxx}{EMP\_Ti\_xxx} \qquad PRO\_NT\_xxx = \frac{VA\_NT\_xxx}{EMP\_NT\_xxx}$$

– average labour productivity in the tradable and nontradable sectors

where *VA_Ti_xxx* and *VA_NT_xxx* stand for GVA in constant prices in the tradable (i=1 or 2) and nontradable sectors for a given country (*xxx*) while *EMP_Ti_xxx* and *EMP_NT_xxx* represent total employment in respective sectors of the same country. Sectoral productivities serve as a basis for calculating relative productivities:

(11) $$PROi\_xxx = \frac{PRO\_Ti\_xxx}{PRO\_NT\_xxx}$$

where *i* refers to the type of sectoral division and takes on values 1 and 2. Relative productivitiy differential, denoted as *RPROi_xxx* are defined as a ratio of relative productivities in the CEECs and the euro area.

Further, we define three versions of relative price indices:

(12) $$RPi\_xxx = \frac{PNT\_xxx}{PTi\_xxx}, \text{ where i=1 or 2}$$

(13) $$RP3\_xxx = \frac{CPI\_NT\_xxx}{PPI\_xxx}$$

[10] CANSTAT- the Quarterly Bulletin of Candidate Countries complied by statistical offices of the 8 new EU member states as well as Bulgaria and Romania.

[11] CESTAT is the comparative quarterly bulletin of Visegrad countries, Romania and Slovenia.

where: *PTi_xxx* – value added deflator for tradables,
PNT_xxx – value added deflator for nontradables,
CPI_NT_xxx – CPI prices of services (national definitions),
PPI_xxx – producer price index (industry excluding construction).

And finally, below we define the euro real exchange rate in three ways, deflated by the deflator of GVA (*RER1*), by the *CPI (RER2)* and by the *PPI (RER3)*:

(14) $$RER1\_xxx = \frac{EUR\_xxx * DEF\_EU}{DEF\_xxx}$$

(15) $$RER2\_xxx = \frac{EUR\_xxx * CPI\_EU}{CPI\_xxx}$$

(16) $$RER3\_xxx = \frac{EUR\_xxx * PPI\_EU}{PPIM\_xxx}$$

where: *EUR_xxx* – nominal euro exchange rate[12] in country xxx (domestic price of a unit of the euro),
DEF_xxx – Gross Value Added deflator for country xxx,
CPI_xxx – the Consumer Price Index for the country xxx,
PPIM_xxx – the *PPI* in manufacturing for the country xxx.

The comprehensive information on all names, definitions and sources of variables used in this study are available in Appendix 1.

4.2. Data Description

Figures 1-3 present developments of several indicators of interest for nine CEECs: Bulgaria (BUL), the Czech Republic (CZE), Estonia (EST), Hungary (HUN), Latvia (LAT), Lithuania (LIT), Poland (POL), Slovakia (SLK) and Slovenia (SLO). Additionally Figures 1-2 depict series for the euro area (EUR). The presented series are transformed into logarithms, seasonally adjusted (with the use of the software Demetra), and then scaled with the base period equal to 2003:Q4 (figures 1 and 3) and 2002:Q1 (Figure 2).

[12] An increase in the exchange rate means a depreciation of domestic currency. The euro exchange rate prior to 1999 refers to the synthetic euro exchange rate as calculated by the ECB.

Table 2 and Table 3 present average annual percentage changes of various indicators subsequently used in the empirical part of the paper. The data presented in the table have been based on the 'raw' series, i.e. prior to log transformation and seasonal adjustment.

Figure 1 presents relative productivity indices, which in line with theoretical predictions of the HBS model, have been on the rise in most CEECs. Due to the generally low share of agriculture in gross value added, the extent of the increase in relative productivities is very similar for both variants of sectoral division and across most countries with the exception of Bulgaria, Slovakia and Romania. This follows from the greater significance of agriculture in generating gross value added in these countries. In Bulgaria, both measures of relative productivity are extremely volatile. In terms of trends, if only industry is considered tradable, one can speak of a slight increase in relative productivities; when agriculture is added to the tradable sector, the trend relative productivity has actually been falling since 2000. In Romania, developments in relative productivities calculated using the sector division of type 1 points to a gradual increase of relative productivity during 1998-2001 and a slight fall afterwards, while productivities calculated using the sector division of type 2 suggest a stable (or slightly falling) relative productivity during 1998-2000, and an increase during 2001-2003. Slovakia presents yet another case: both relative productivity measures are highly volatile, but when smoothed out, point to a stable relative productivity growth.

Relative price indices (Figure 2) have been on the rise for the majority of CEEC during most of the analysed period. For most countries, the definition that exhibits the highest rise is the RP3, i.e. the ratio of price level of services to the PPI. This is particularly pronounced in Estonia (1993-1998), the Czech Republic (1994-2001), and Slovakia (1995-1999). Figures also point to the slowdown of relative price growth in recent years (with an exception of Slovakia where the opposite trend is observed).

As the theory suggests, real exchange rates (Figure 3) have visibly appreciated over the past several years. This trend is particularly pronounced in countries with fixed exchange rate regimes: Estonia, Latvia, Lithuania and Bulgaria. In most countries, in line with declining inflation, the pace of real appreciation has slowed down in recent years and in some of them (e.g. Poland, Latvia and the Czech Republic) the period 2002-2003 saw a nominal and real depreciation.

4.3. Unit Root Tests

Before we proceed to the estimation of the HBS model, we examine our dataset by performing standard tests for unit roots. In line with subsequent analysis, we carry out these tests in the panel framework.

The presence of unit roots is checked by the Im-Pesaran-Shin test (IPS) as well as Levin and Lin (LL) tests. The versions of tests used in our analysis (including the set of critical values) are based on procedures proposed by Pedroni (1999)[13]. Methodological details on both tests are given in Appendix II. It is worthwhile mentioning that the main difference between those tests is that under the alternative hypothesis, the IPS requires only some of the series to be stationary, while the LL test requires all of them to be stationary (Harris and Sollis, 2003).

Results of both tests are presented in Table 4. Tests were performed on levels transformed into logarithms and after seasonal adjustment for specifications with and without trend (both with a constant).

Most series turned out nonstationary in levels. This result is robust to the inclusion of a trend for all seven price indicators (deflators, CPI and PPI). In the case of specifications with a trend, some tests point to the rejection of the null hypothesis of nonstationarity for all productivity indicators and the euro exchange rate (and the PPI in the case of the IPS test). Thus, the tests are inconclusive in the case of these variables. However, visual inspection of the productivity measures as well as analogous tests applied to the same indicators by other authors (for example, Egert et al., 2003),[14] lead us to conclude that all (or most) variables are nonstationary in levels. This conclusion motivates an examination of cointegration presented in section 6.1.

[13] We are grateful to Prof. Pedroni for providing us with RATS codes for his panel procedures.

[14] Egert et al. (2003) perform the IPS test on a similar set of variables in levels and first differences and conclude that all series follow nonstationary processes.

5. Empirical verification of the basic assumptions of the HBS model

The internal and external transmission mechanisms of the HBS model rest on several restrictive assumptions that were discussed in chapter 2. These assumptions include among others: perfect capital mobility across countries and sectors, free sectoral labour mobility implying economy-wide wage equalisation and the PPP in the tradable sector. On a practical level, an important assumption is a clear division of the economy into two sectors: one producing a composite good which is perfectly tradable in the world markets and the other that produces a nontradable good sold only in domestic markets. Thus, any attempt to empirically verify the HBS effect, necessitates not only testing basic assumption underlying the model, but also calls for the division of the economy into two such sectors. However, at a practical level this is hardly possible and the assumption of two distinct sectors of tradables or nontradables is typically violated as well.

In this chapter we take a closer look at the key assumptions of the HBS theory which may not be met in practice and elaborate on possible implications of their violation for the theory and estimations of the HBS effect. We commence with the sector division assumption, then consider the wage equalisation assumption and finally conclude with the discussion of the PPP assumption.

5.1. Sector division and measurement of prices

5.1.1. Sector division

The HBS theory distinguishes between two separate sectors: one fully open to foreign trade facing externally determined prices (tradables), and one sheltered from foreign competition and producing for the domestic market at prices that are determined domestically (nontradables). As equations (1) through (9) all involve variables (productivities, wages and price levels) that refer to either of the sectors, a clear and precise sectoral division becomes a very central assumption of the HBS theory.

Therefore, any empirical study, aiming to verify the HBS effect, will inevitably have to address this issue in more detail and make some important judgments. In this section we intend to highlight some consequences of problems related to defining the two sectors and the possible impact of these problems for empirical estimation of the HBS effect.

The actual division of the real economy into the tradable and nontradable sectors is a compromise between the guidelines following from the theory, the practice of international trade and the data availability. The measurement problems following from this compromise are further exacerbated by the lack of unanimity among various authors as to the assignment of specific branches of industry into one of the two sectors (e.g. agriculture, mining and quarrying, energy sector etc. are particularly problematic). Furthermore, in view of the high share of services in the foreign trade flows of many countries, the common assumption of nontradability of services is highly problematic as well.

In general, problems related to the sectoral division fall into two closely interrelated categories. In the first case, the proper assignment of some branches or sub-branches of the economy to either sector is made impossible due to the lack of data at a sufficiently disaggregated level. For instance, this is the case with the energy sector whose tradability can easily be questioned, but in view of the problems with obtaining detailed data at the section level, they are commonly included in the tradable sector (together with other branches of industry). Furthermore, there are many services that are traded internationally and are subject to foreign competition (e.g. air transportation services), but due to the lack of data they are treated as nontradable, together with other purely nontradable services (such as for example, haircutting).

The second category of problems arises at a conceptual level. Even if we are in a position to obtain very precise data at a sufficiently disaggregated level, the problem with sector division would not disappear. This is because tradability of goods and services is a highly disputed characteristic and there is no agreed way to measure it.[15] Although some authors propose formalised algorithms for distinguishing between tradables and nontradables,[16] these methods are not straightforward and are not universally accepted. Moreover, once the division following such an algorithm has been made, frictions to arbitrage (mainly transport costs and trade barriers) could make some goods and services nontradable for some ranges of prices, but tradable otherwise. Consequently, even with an access to very detailed and disaggregated datasets, problems with classifying problematic sections or branches of the economy do not disappear.

[15] Problems with assigning agriculture to either sector is a good example.

[16] For instance, De Gregorio et al. (1994) define tradables as those sectors for which the export share in total production is larger than 10%.

While there is a clear distinction between these two problems, at a practical level, their consequences are similar. Once the actual empirical division into two sectors has been made, one can be sure that the part of the economy defined as nontradables will inevitably contain an element of the tradable sector while the part of the economy defined as tradables will contain an element of the nontradable sector.

Figure 4 presents the graphical illustration of the sector division problem. In order to focus the argument, let us assume that the actual tradable segment of the economy is *A*, and consequently, that of the nontradable sector amounts to *(1-A)*. Due to poor data availability (insufficiently detailed disaggregation) as well as imperfect knowledge, the empirical division implies a different break-up of the economy: the total tradable sector makes up *100*a%* of the economy, while the rest *100*(1-a)%* is assigned to the nontradable sector. It has to be mentioned that, in reality the value of *A* remains unknown. If we mistakenly estimate the shares of respective sectors: *A* and *(1-A)* as *a* and *(1-a)* both estimated shares are 'contaminated' and can be expressed as weighted averages of the 'correct' and 'incorrect' sector (see Figure 4). The true price levels in both sectors are P^T and P^{NT} while the estimated price levels, p^T and p^{NT} are equal to:[17]

$$p^T = (1-m)\, P^T + m\, P^{NT} \quad \text{and} \quad p^{NT} = (1-n)\, P^{NT} + n\, P^T \tag{17}$$

where *m* and *n* are coefficients indicating the extent of 'contamination' of price level measures in sector T and NT, respectively.

The indicator of interest from the point of view of our research is the index of relative prices $RP=P^{NT}-P^T$ and its estimated version:

$$rp = p^{NT} - p^T \tag{18}$$

If we plug (17) into (18) and rearrange the terms we get:

$$rp = (P^{NT} - P^T)(1-m-n) = RP\,(1-m-n). \tag{19}$$

which means that the estimated relative prices are equal to true relative prices corrected for 'contamination' of sectors by the factor (1-m-n).

[17] To simplify algebra and in line with the original formulation of the HBS theory, we assume that we deal with two composite products and two related prices (i.e. P^T and P^{NT} are the only prices in the economy). The same concerns productivity measures: we only single out two values of productivity.

If our measure of productivity is likewise improperly measured, we encounter the same problem. To allow for heterogeneity of measurement errors, we assume that the share of 'nontradable productivity' in a measure of productivity in the tradable sector (pro_T) equals *p*, while the share of 'tradable productivity' improperly included in the measure of productivity in the nontradable sector (pro_NT) is *r*.[18] By analogy the true relative productivity (RPRO) and the estimated relative productivity (rpro) are related through the 'correction' factor:

(20) $$\text{rpro} = \text{RPRO}\,(1\text{-s-r})$$

If we estimate a simple univariate equation where relative productivities explain relative prices by OLS (internal HBS, see equation (4)), then, following from the standard formula for the coefficient $\beta=(X'X)^{-1}X'y$ (where X is the matrix/vector of explanatory variables and y is the vector of a dependent variable) we obtain:

(21) $$\beta = \mathrm{B}\frac{1-s-r}{1-m-n}$$

where β is the resultant coefficient while B stands for the coefficient that would be obtained where both variables measured correctly over the two sectors and *m*, *n*, *s*, *r* are numbers ranging from 0 to 1 that reflect the extent of 'contamination' in measures of sectoral indicators. The bias disappears when the aggregate 'contamination' of both indicators is identical, i.e., the sum of shares of improperly assigned sectors is identical for both indicators. Unquestionably, the bias in the series also causes the actual estimates of the standard error to deviate from the estimates that would be obtained if both sectors were defined properly. Without calculating specific estimates of this bias,[19] we can make a claim that the resulting t-statistics of the regression will deviate from the values of these statistics in the situation of precise sectoral definitions.

In the case of other techniques used in the empirical analysis in this paper, i.e. panel group mean Fully Modified OLS (FMOLS) and Pooled Group Mean Estimation (PMGE),[20] the correction factor is much more complicated. It remains, however, to be a function of the extent of 'contamination' of sectoral indicators.

Thus, this section points out that the impossibility to measure precisely the various

[18] The scale of 'contamination' of each indicator may be different due to various data sources and related possibilities to extract sufficiently disaggregated data. However, we assume that this scale is constant in time.

[19] This estimate is much more complicated than the estimate of the coefficient bias.

[20] For methodological details see Appendix II

indicators over the tradable and nontradable sector might introduce a systematic bias in these series and consequently in the resulting estimates of the HBS effects. Therefore, if the empirical definition of the two sectors is problematic, there are reasons to expect problems with the final estimates of elasticities of the HBS effect, such as the bias in the coefficients and unreliable t-statistics.

5.1.2. Price series problems

Furthermore, additional problems may arise if price series cover goods and services whose prices are administratively controlled by the state. As explained in section 2.3, the HBS model assumes that the price level in the tradable sector is fixed by the PPP condition, while the price level of nontradables is determined in the domestic market as a result of profit maximisation by firms faced with the economy-wide wage rate *w* and sectoral productivity. Thus, the HBS model assumes a price setting process that is essentially free-market and follows from adjusting prices in response to wage and productivity changes.[21]

The reality of transition economies is quite different. Central and local governments continue to maintain substantive control over many prices in the economy (Wozniak, 2002 and Egert et al., 2003). This is particularly the case for services many of which used to be part of the social safety net during communist times with prices kept at extraordinarily low levels (e.g. utilities, electricity, telecommunication, and transport). Although in the course of the 1990s, prices of many services were liberalised, central and local governments still regulate a substantive portion of the nontradable sector and a somewhat smaller share of the tradable sector.[22] In most transition economies (and not only) such controls are exercised over large parts of the transportation sector (e.g. railways), rents, postal and telecommunication, health-care and judiciary services. Various types of agencies typically control growth of prices of electricity, gas and hot water (the bulk of the E section of NACE). Furthermore, prices of fuel, alcohol and cigarettes are determined largely by changes in excise taxes set by the government.[23]

As a result of this regulation, the price setting process is heavily distorted and departs from that assumed in the HBS theory. In reality, it is the administrative decisions and not the labour cost pressure that drive prices up in specific parts of the nontradable and tradable sector and determine the timing and scale of these adjustments. As mentioned earlier, this problem is

[21] In the HBS theory the process is somewhat more complex as involves solving the system of four equations: 2a, 2b, 3a and 3b.

[22] For example, the weight of the administratively controlled goods and services in the CPI basket is about 25% in Poland (NBP materials) and 20% in the Czech Republic and Slovakia.

[23] Excise tax is one of the many factors determining prices of these products, however, in the case of some of them (e.g. cigarettes and alcohol) it is, by far, the most important factor.

particularly pronounced in the case of services. Using the example of the Polish CPI, we can notice a substantial disparity of inflation rates in free-market and regulated services (Wozniak, 2004). During the period 1991-2003 the average monthly growth of prices of unregulated services was 1.6%, and it was 2.1% for administratively controlled services (1.4% for the CPI). On a cumulated basis, this amounts to the annual inflation difference of 6 percentage points on average during this period. The inflation disparity between the two types of services declines as we approach the end of the sample,[24] however, it still remains positive.

Such a disparity is very common across the CEECs and the Polish example can be considered representative for this process. There are many reasons for the persistence of the positive bias of regulated service prices. In addition to the already mentioned initial undervaluation of many services under the socialist safety net, we can point to a few other factors common for most administratively controlled services. Most of them are generated in companies that are still state-owned monopolies and have gone through a process of gradual restructuring aiming at replacing the obsolete capital stock and achieving cost recovery (e.g. electricity plants, water supply companies, railways).[25] Their prices are regulated by various regulatory agencies where price adjustment decisions are made taking into account various nonmarket factors, such as national policies vis-à-vis specific industries (including but not limited to privatisation and restructuring processes), concerns over social consequences of price adjustments and purely political factors. In view of the fundamental difference of such a price setting policy in comparison with the market price setting policy, including such 'problematic' sectors in the measure of services is bound to introduce bias in the sectoral price index.

However, due to insufficient disaggregation of data, we are unable to single out and eliminate these industries from the sectoral price indicators that consequently cover both the free market and the administered portion of both sectors. In doing so, we cannot hope that the assumption about the price setting behaviour in both sectors is met and consequently, we might encounter problems with observing and estimating the effects posited by the HBS theory.

5.2. Wage equalisation

In this section we closely look at the wage equalisation process between tradable and nontradable sectors. The inter-sectoral equalisation of nominal wages is one of the two fundamental assumptions of the HBS model (see chapter 2). Because wage equalisation is

[24] Partly due to falling overall inflation and partly due to the fact that the bulk of the relative price catch-up has been attained already for the administratively controlled sectors.

[25] Additionally, many of these industries have had to comply with restrictive ecological regulations which substantially raised their costs throughout the 1990s.

a critical transmission channel between productivity differentials and nontradable prices, the failure to find evidence of inter-sectoral wage equalisation can undermine the HBS theory. Before we move to the visual inspection of the data for CEECs, however, the possible implications of the lack of wage equalisation for the HBS analysis are discussed.

5.2.1.Relative wage differential – consequences for the HBS model

Below, we consider the model discussed in detail in chapter 2, but allow wages in the tradable sector to differ from wages in the nontradable sector. Using equations (1) through (3), we first derive the 'modified Baumol-Bowen' effect:

$$(22) \qquad \Delta(P^{NT}/P^{T}) = \Delta p^{NT} - \Delta p^{T} = (\delta/\gamma)\, \Delta a^{T} - \Delta a^{NT} + \delta(\Delta w^{NT} - \Delta w^{T})$$

In equation (22) the price differential between sectors is not solely explained by the supply side of the economy – i.e., productivity differentials – but also by the relative sectoral wage. Thus, if we omitted the last term of equation (22) in our estimation, when in fact it was significant, we would run into the omitted variable problem. In economic terms, this means that the observed inflation differential between nontradable and tradable sectors may be additionally explained by sectoral wage differences. In other words, the differences between the observed price differential and the price differential implied by the productivity developments may be a result of existing differences in sectoral wages.

Equation (23) sets out the implication of the violation of perfect labour mobility in the 'international' version of the HBS effect (assuming that PPP holds):

$$(23) \qquad \Delta p^{NT} - \Delta p^{*T} = \Delta e^{T} + (1 - \alpha)[(\delta/\gamma)\Delta a^{T} - \Delta a^{NT} + \delta\, (\Delta w^{NT} - \Delta w^{T})] - (1 - \alpha^{*})[(\delta^{*}/\gamma^{*})\Delta a^{*T} - \Delta a^{*NT} + \delta^{*}\, (\Delta w^{*NT} - \Delta w^{*T})]$$

Similar to the 'domestic' version of the HBS effect, the lack of wage equalisation means that the sectoral wage differences term at home and abroad does not vanish from the equation. Equation (23) can be regarded as a 'generalised form' of the HBS effect in which sectoral wages do not equalise. However, this has different implications under different conditions:

1) If $\delta\, (\Delta w^{NT} - \Delta w^{T})>0$ or $\delta\, (\Delta w^{NT} - \Delta w^{T})<0$ and $\delta^{*}\, (\Delta w^{NT} - \Delta w^{T})=0$, then the inability of the HBS effect to explain the observed trend in real appreciation or depreciation of real exchange rates, may result from the existing wage differences between the two sectors under consideration;

2) If the wage differentials abroad and at home are equal in magnitude (and $\alpha=\alpha^*$ and $\delta=\delta^*$) then the differentials will cancel out, and the HBS effect may still fully explain international price differentials.
3) If the sectoral wage differentials at home and abroad are different (and $\alpha\neq\alpha^*$ and $\delta\neq\delta^*$), then this implies that there exist additional factors responsible for differences in inflation between home and abroad.

The domestic HBS hypothesis which assumes wage equalisation suggests that productivity shocks pass perfectly through to relative price changes. Nevertheless, the question remains if, for the HBS to hold, it is enough to just test for stationarity in relative wages (the implication of which is cointegrated relationship between w^{NT} and w^{T}) or the condition should be stronger, i.e., sectoral wages do not only have to be cointegrated, but also the cointegrating coefficient must be equal to 1. It can be shown that if the sectoral wage differential is different than 1 but persistent (i.e., stationary), it is **still possible for the HBS effect to hold**. This is because the total differentiation of $w^{NT}=w^{T}+c$ (where *c* is a positive constant) is equal to total differentiation of $w^{NT}=w^{T}$ (see (3a) and (3b)).[26] In this case equations of interest are equivalent to previously derived equations (4) and (9) (see chapter 2).

5.2.2. Data and Definitions

For the purpose of this study, we verify the wage equalisation assumption in nine CEECs covered in our sample. The annual data on sectoral employment and average earnings per worker[27] is sourced from the LABORSTA ILO database (Table 2B and 5A, respectively) and spans the period 1992-2003.[28] Regrettably, data on the number of employees in each sector are missing for three countries (Bulgaria, Latvia and Lithuania). Therefore, our results for these countries may be biased, as the performance of wages on the aggregate level (tradable or nontradable) may be dominated by the performance of wages in sections where employment is higher. Also, the lack of quarterly data makes it impossible to conduct any econometric analysis.

We define equalisation of wages between the tradable and nontradable sectors in five alternative ways. The first two definitions are in line with definitions 1 and 2 discussed in

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[26] This is also true for $w^{T}=w^{NT}+c$, but in the case of CEECs, the nontradable wages seem to be higher than tradable wages.

[27] Earnings should include: direct wages and salaries, remuneration for time not worked, bonuses and gratuities and housing and family allowances paid by the employer.

[28] Due to data availability, the span of the data varies between countries (see presented Figures).

Section 4.1. Given the classification problems in the tradable and nontradable sector discussed in Section 5.1, the remaining three definitions are used as sensitivity checks. In all of them tradables are classified as manufacturing only (i.e., section D); nontradables consists of the part of the economy comprising sections from F to O, which was further divided into market (i.e., sections F to K) and nonmarket nontradables (i.e., sections L to O).

Consequently, we look at the wage equalisation process between the following sections of the economy:

1. (ALL excluding C-E)/(C-E)
2. (F-O)/(A-E)
3. (F-O)/D
4. (F-K)/D
5. (L-O)/D.

5.2.3. Empirical results

The graphical analysis shows (Figure 5) that in majority of cases the results do not point to wage equalisation assumed in the HBS theory. There is a tendency for wages in services to be higher than in manufacturing in all countries. This remains true even when we classify agriculture, fishing, mining and quarrying as well as gas, water and electricity sectors as tradable (except for Bulgaria and partly Poland). Tradable wages are only higher than nontradable wages when we include agriculture and fishing in the sheltered sector. On average, the HBS condition concerning wage equalisation between open and sheltered sectors is not met. We now turn to the particular country cases where we focus on relative wages as defined by the first two definitions given above and compare them with the rest of the results.

In Bulgaria,[29] since 1997 the ratio of nontradable to tradable wages is on a stable, increasing path, regardless of the definition used. Nevertheless, the pace at which nontradable wages have been catching up differs and depends on the definition used. For the (F-O)/(A-E) definition, wages only equalise in 2002. When we include agriculture in nontradables, however, the ratio is still below one. On the other hand, when the tradable sector is only represented by manufacturing, wages equalise already in 1999. Since then, nontradable wages exceed tradable wages. The differences between market and nonmarket nontradable wages vanish. It is difficult to predict a further course for wage developments, but at present, the trend appears to point toward an increase in nontradable wages. Relative wages in Bulgaria neither equalise nor seem to be stationary.

[29] As already pointed data for Bulgaria, Latvia and Lithuania is not weighed by the sectoral employment. This can result in the upward or downward bias of the results.

In the Czech Republic, the relative wage of nontradables in terms of tradables has remained above 1 during the entire period under investigation. Unlike in Bulgaria, there is a divergence in relative nonmarket and market nontradable wages after 1996. The overall picture for the Czech Republic reveals stability in relative wages for all the definitions but (F-K)/D and (L-O)/D. The former seems to be trending upwards after 1996; the latter exhibits larger fluctuations comparing with other relationships considered.

In Estonia, between 1994 and 1999, the relative nontradable wage for the open sector has been increasing albeit moderately. After a drop in 2000, tradable wages again picked up. Since 1994 the difference between relative wages in the (F-O)/(A-E) and (F-K)/D sectors has been almost negligible, i.e., both definitions could be used interchangeably. When we include agriculture in the nontradable sector, wages in the sheltered sector are lower than wages in the more productive, tradable, sector until 1999, then the relationship shifts in favour of nontradables.

In the Hungarian case, the relative wages seem to be quite volatile. Wages in the (F-O) and (A-E) sectors can be considered equalised between 1995 and 2001. However, from 2001 onwards, the sectoral wage gap increases for all tested definitions. When agriculture is classified as part of the nontradable sector, the wage ratio between sheltered and open sectors is below 1 until 2001. Interestingly, in Hungary the pattern of relative nontradable earnings per worker defined as (F-O) and (A-E) almost mirrors the pattern that arises using the definition of (F-O)/D. This is because high wages in sectors C and E are almost entirely offset by low wages in agriculture.

In Latvia, from 1998 ratios (F-O)/(A-E), (F-K)/D and (F-O)/D have all been above 1 and steadily increasing (except for the second definition when the relative wage declines after 2001). The ratio of nonmarket nontradable wages to wages in manufacturing exhibits the same increasing trend, but reaches 1 only in 2000. When nontradables are classified as F-O plus agriculture and fishing (sections A and B, respectively) and tradables consist of manufacturing, mining and quarrying as well as gas, water and electricity (lines C to E), the wage ratio between the two is, on average, only 6% below 1 and does not display any significant increase.

In Lithuania, before 1998 wages in market services were 33% higher than in manufacturing; when nonmarket services are included, manufacturing wages were 21% lower. Similar to previous findings, broadening the definition of tradable goods lowers the wage gap between the sectors; again, including agriculture in the numerator results in a higher tradable wage (on average almost 20%). After 1998, fluctuations in relative nontradable wages in Lithuania seem to be negligible.

In Poland, relative nominal wages trend upwards and remain on average 4% above unity for all three different definitions of services expressed in terms of manufacturing. In 2002, this tendency was reversed. In Poland, the difference between market and nonmarket nontradable wages is the smallest of the whole sample examined. Relative wages defined both as (ALL excluding C-E)/(C-E) and (F-O)/(A-E) also trend upwards. However, Poland is the only country in which both of these ratios almost constantly remain below 1 which is explained by significantly higher wages in mining and quarrying compared with wages in manufacturing.[30]

Market nontradable wages in Romania, when compared with wages in manufacturing, are among the highest in the sample (on average by 9%). Since 1998 the ratio has been close to 1, but has continued to move upwards. The scenario is repeated for the remaining definitions. Unlike in Poland, the ratio between (F-O) and (A-E) is higher than between (F-K) and D. The large discrepancy between (F-O)/(A-E) and (F-O)/D is a consequence of the fact that manufacturing wages constitute only 55% of wages in sectors C and E.

In Slovakia, manufacturing wages exhibit the smallest underperformance. Manufacturing wages are on average 0.5% lower than in the total nontradable sector and tend towards equalisation. This is due to low wages in the public sector services, which are on average 7% lower than wages in manufacturing. Looking at the behaviour of relative nontradable wages in accordance with the (ALL excluding C-E)/(C-E) definition, we record higher wages in the tradable sectors. As in Bulgaria and Poland, wages in mining and quarrying, as well as in gas, water and electricity, are significantly higher than in manufacturing. In general, relative wages in Slovakia have been on the fall since 1997.

Finally, in Slovenia, unlike in any other country in our sample, relative nontradable wages are above 1 for all five definitions used. Wages in the total service sector are, on average, 30% higher than wages in manufacturing. This is the highest divergence in our sample. An interesting feature of the performance of the wage gap in Slovenia is that wages in public sector services are 45% of those in manufacturing. Additionally, although still above 1 – the HBS assumed value – relative wages, except for private sector services in terms of manufacturing, since 1998 seem to be stable.

5.2.4. Concluding Remarks

The visual inspection suggests that the HBS assumption about cross-sectoral wage homogeneity may be violated. There is a tendency for wages in services to be higher than in manufacturing in all countries (i.e., $\delta(\Delta w^{NT} - \Delta w^{T})>0$). Such a result is rather counterintuitive and it is in stark contrast to results obtained for developed countries, where wages in tradables tend to be higher than wages in nontradables (see for example

[30] On average, during the period under investigation, wages in manufacturing were only 52% of those in mining.

Søndergaard, 2003).[31] Given that productivity in manufacturing is higher, this may reflect strong unions in the nontradable sector, the presence of monopolistic competition or high wages in the financial sector and suggest that relative wages could have an impact on real exchange rate appreciation. However, in countries like the Czech Republic, Lithuania, Poland or Slovenia, even though relative wages are not equal one, the difference between tradable and nontradble wages looks relatively stable (at least for some definitions used). This suggests, in line with the theoretical exposition presented in section 4.3.2, that the mechanism which leads to the HBS effect in those countries may be present. Still, these results should be treated with caution, since, due to the lack of data, we are unable to perform any more advanced econometric analysis. Furthermore, ongoing structural changes in CEECs (i.e., price liberalisation) may also contribute to fluctuations in relative wages.

At this point it is worth mentioning that other studies which look at the wage equalisation in CEECs differ in their conclusions. For example, Egert (2002), who analyses relative wage developments in five CEECs between 1991 and 1999, assumes wage equalisation. Wage equalisation was also assumed implicitly in Egert et al. (2002). This is surprising given that the graphical analysis presented in both papers does not appear to suggest this. On the other hand, Mihajlek and Klau (2003) assume uniform wage growth in some, but not all countries (in countries where wage homogeneity was ruled out, nontradable wage growth was higher than tradable wage growth). Nonetheless, it might very well be that different conclusions concerning sectoral wage equalisation in various studies conducted for CEECs, may stem from different sectoral definitions and time periods considered and only reflect measurement difficulties.

From the theoretical point of view, the violation of the wage homogeneity assumption implies that the HBS effect is not able to fully explain the observed sectoral and cross-country price differentials (i.e., domestic and international version of the model) and that the relative wage gap may also play a role in explaining changes in real exchange rates. However, as shown in Section 5.2.1, persistent differences between tradable and nontradable wages do not prevent the HBS effect from coming into play. This proposition should be further tested empirically using, for example, panel unit root tests and cointegration techniques.

5.3. Purchasing Power Parity

The PPP enters the HBS theory in the equations leading to the final determination of the real exchange rate (equations 5-9 in chapter 2). The PPP model is based on the law of one

[31] In CEECs, tradable wages are only higher than nontradable wages when we include agriculture and fishing in the sheltered sector.

price which is extended to a basket of tradable goods. According to the absolute PPP paradigm, a nominal exchange rate of any two currencies should reflect closely the relative purchasing powers of the two monetary units represented by national price levels. The strong version of PPP requires that the nominal exchange rate is exactly equal to the ratio of price levels of tradables in the two countries. Consequently, the real exchange rate deflated with prices of tradables must be stationary and equal to one. The weak version of PPP does not require the unit elasticity and entails only that the real exchange rate reverts to some constant mean (Pedroni, 2001).

In this section we will verify the assumption of the PPP in CEECs by means of various econometric tests. As mentioned before, this assumption is a key element of the international version of the HBS model (or the external transmission mechanism) and empirical evidence against it may severely impair the empirical results of the HBS estimations.

5.3.1. Stylized facts on PPP in CEECs

Prior to formal empirical testing of the relative PPP hypothesis[32] in CEECs, we analyse main trends in nominal and real exchange rates deflated with prices of tradables and nontradables over the period 1993-2003. Because the PPP model should work in principle only for goods that could be traded internationally, the real exchange rate will be deflated with producer prices in manufacturing (*RER3*).[33] This measure is believed to be the best readily available proxy for prices of tradables.[34]

In Bulgaria, apart from two periods of real depreciation of the lev against the euro (in 1994 and from 1996 to 1997), a clear appreciation trend was observed. After the financial crisis in 1997 and fixing the lev to the German mark (in 1999 to the euro), the appreciation of the real exchange rate stemmed primarily from higher inflation of Bulgarian tradables prices as compared to the euro area.

In the Czech Republic, there was also an appreciation trend in the real exchange rate of the koruna against the euro with the few exceptions in 1997 and 2002. Between 1993 and 1997 changes in the nominal exchange rate against the euro were small; the positive tradable inflation differential between the Czech Republic and the euro area was the main

[32] Relative PPP refers to price indices as opposed to absolute PPP, where the condition is defined in terms of price levels.

[33] In case of Bulgaria, due to lack of data, the PPI for total industry was used. In all analysed countries, however, these two price indices (the PPI for the industry and for manufacturing only) were very similar.

[34] However, due to the impossibility to obtain measures of value added for such a narrow aggregate (equivalent of the section D) this formulation of the real exchange rate is not used for subsequent empirical analysis of the HBS effect. Alternative definitions of the real exchange rate (*RER1* and *RER2*) are presented in Figure 3.

cause of the real appreciation. After the financial crisis in 1997, the observed trends reversed: the nominal exchange rate of the koruna against the euro was appreciating and the inflation differential approached zero and even turned negative in 2003.

In Estonia due to early fixing of the kroon to the German mark (in 1999 to the euro), developments in real exchange rate were largely dominated by changes in inflation. However, before 1999 some changes in the kroon exchange rate against the synthetic euro played a role as well. Until 1999, prices of tradables in Estonia tended to grow faster than in the euro area, though the difference was gradually declining. Afterwards, no clear trend in tradables inflation differential was evident. As a result of these developments the real exchange rate stabilised somewhat starting from around 1997-1998.

In Hungary, the real euro exchange rate for tradables followed a clear appreciation trend with the two short periods of relative stabilisation in 1996/1997 and 2001/2002. The real appreciation was mainly attributable to positive inflation in tradables (until 2001) as nominal exchange rate of the euro exhibited a sustained depreciation trend with some reversal in 2002. As in the case of Estonia the difference in inflation rates for tradables was on the fall.

In Latvia, the trend appreciation lasted until around 1999. To some extent this stemmed from higher inflation of tradables in comparison to the euro area (only up to around 1997/1998) and to nominal appreciation of the Latvian lat against the euro in 1993, 1997-1998 and 1999/2000. Afterwards, changes in the real exchange rate as well as in inflation differential were two-sided.

In Lithuania, the real exchange of the litas against the euro continued to appreciate until 2000 and only then stabilised due to changing the pegging currency from the dollar to the euro (in February 2002) and equalisation of growth rates in tradables inflation with the euro area. The real exchange rate appreciation until 1998 was a result of higher inflation in Lithuania than in the euro area, but afterwards appreciation was mainly driven by nominal appreciation. At the turn of 1999/2000 there was a period of increases in PPI which could be attributed to increases in oil prices as oil production and products thereof constitute a significant part of manufacturing output (and consequently these prices have had substantial weight in the PPI basket).

In Poland until the end of 1999, the real exchange rate did not exhibit any trend and was mean reverting. The nominal depreciation of the zloty against the euro was accompanied by a constant – though declining – positive inflation differential in tradables inflation vs. the euro area. After 1999 the inflation differential approached zero, but nominal exchange rate started to drive the appreciation (1999-2001) and later the depreciation (2002-2003) of the real exchange rate.

In Slovakia, the nominal exchange rate against the euro was largely mean reverting over the period 1993-2001 with a depreciation of the mean in 1999. At the same time inflation deferential was positive and fairly constant from 1996 to the end of 2001 and approached zero afterwards. Consequently, there was a constant real appreciation in the exchange rate with a break in 1999.

In Slovenia the real exchange rate of the euro was fluctuating around a constant mean though with long periods of diverting from the mean and with large peaks and troughs. This was accompanied by fairly constant inflation differential for tradables prices and a constant depreciation of the nominal exchange rate, which was a deliberate exchange rate policy of Slovenian authorities.

To sum up, for most observations between 1993 and 2003 there was a clear appreciation trend in real exchange rates of domestic currencies against the euro deflated with prices of tradables in CEECs. Poland and Slovenia were the main exceptions. This stemmed (at least in the initial phase) from higher domestic tradables inflation than in the euro area as nominal currencies were fixed or depreciated at a slower rate. As in most CEECs the convergence of inflation rates for tradables was evident in recent years, in few cases the real appreciation was explained by the appreciation of nominal exchange rates – mostly evident in the Czech Republic, Poland and Hungary. In addition, a close unconditional correlation between CEECs' and euro-area's tradables inflation was observed.

Although the real appreciation was mainly driven by inflation differential (at least in the initial period), the pattern of changes in the real exchange rate was dominated by volatility of nominal exchange rates – mostly evident for countries with more flexible exchange rate regimes (Poland, the Czech Republic, and Slovakia), but also for Lithuania and Latvia that have been pursuing fixed exchange rate policies.[35] Thus, the close correlation of nominal and real exchange rates observed in developed economies is also evident in CEECs.[36]

The above observations of a clear appreciation trend of real exchange rates against the euro deflated with tradables prices in CEECs may seem to be at odds with the relative PPP hypothesis.[37] Formal test of the PPP model are discussed below.

5.3.2. Econometric tests of PPP in CEECs

The empirical literature on PPP testing is vast and generally two approaches are distinguished. The first deals with testing stationarity of the real exchange rate, i.e. testing

[35] For these two countries domestic currencies were not pegged to the euro - in Lithuania the litas became pegged to the euro only in February 2002 and before it was pegged to the US dollar; and in Latvia the lat has been pegged to SDR.

[36] Demonstrated among others by Engel (1999).

[37] The recent consensus on the PPP theory suggests that this is a very long phenomenon and the speed of convergence is very slow (for developed countries between three and five years - Rogoff, 1996). Thus, it could be claimed that the analysed period is too short to uncover the long-term PPP behaviour or that the observed appreciation trend is in fact a transition towards the PPP equilibrium.

whether the real exchange rate reverts to a constant mean. This property is usually analysed using time series or panel unit root tests which do, however, raise a considerable controversy (see Maddala and Kim, 1998). Recently, panel unit root tests attracted a lot of attention and they have been extensively used in PPP testing. The unit-root approach to PPP testing was applied among others by Parsley and Wei (1995), Frankel and Rose (1996), MacDonald (1996), Bayoumi and MacDonald (1998), and Chortareas and Driver (2001). These tests are appropriate for testing only the weak version of the PPP hypothesis.

The visual inspection indicating clear trends in the real euro exchange rates for CEECs (Figure 6.1 and Figure 6.2) and formal stationarity tests performed in section 4.3, lead us to reject the hypothesis of nonstationarity.[38] In this section we also pursue the second method of testing for PPP, i.e. a direct estimation of the coefficients in the following equation:

(24) $$e = \alpha_1 P^T - \alpha_2 P^{T^*}$$

If the coefficients (α_1 and α_2) in equation (24) – the definition of the nominal exchange rate (e) – are equal to [1,-1], then the real exchange rate (deflated with prices of tradables) will be constant and equal to one. This is the so called strong version of relative PPP.

In practice, equation (24) can be also estimated with a homogeneity restriction (i.e., restricting the coefficients on prices to be the same). The former approach seems to be more universal as it allows for explicit testing of the homogeneity restriction[39] and could shed more light on the divergence from the PPP model, if such a divergence is present. This approach was applied among others by Moon and Perron (2002). They stressed that in this model the PPP hypothesis is the null hypothesis unlike in most unit-root approaches to PPP testing, where if the null hypothesis of real exchange rate nonstationarity (i.e. the evidence against the PPP model) cannot be rejected, then it is unclear whether that is because PPP does not hold or because the selected test has low power. On the other hand, testing of the restricted PPP model was pursued, among others, by Pedroni (2001) and Taylor (1996).

In addition to homogeneity restriction, the specification of equation (24) can be further complicated by the choice of dependent variable. It is often the case, that the PPP framework is interpreted as a model of exchange rate determination – as might be inferred from the formulation of equation (24). However, in general the PPP framework explains

[38] Although the tests in section 4.3 were performed for PPI and not PPIM, the two measures are very close to one another and hence we can assume the same result of unit root tests for PPIM.

[39] More precisely, the symmetry and proportionality condition.

international arbitrage only and thus the PPP model could be interpreted also as a model of domestic or foreign price determination (only for tradables). This distinction has important consequences for empirical testing of PPP as it relates to the issue of exogeneity of variables. The very simple theoretical framework of the PPP model does not indicate which variable should be dependent. For time-series estimations, this issue could be addressed in the VAR framework where exogeneity of variables could be tested formally. However, in the case of panel models this cannot be easily done. Therefore, other information on the tested variables should be used in order to determine the most appropriate specification of the PPP model.

The nominal exchange rate for some CEECs was a predetermined or controlled variable – due to the adoption of the *de facto* fixed or crawling peg exchange rate regimes.[40] On the one hand, under the fixed exchange rate regime, it does not make sense to use the nominal exchange rate as a dependent variable in time series estimations as it is simply a constant. On the other hand, under more flexible exchange rate regimes, nominal exchange rates tend to be very volatile and difficult to predict. Given both arguments, the nominal exchange rate is not a good candidate for a dependent variable in the PPP model for CEECs.[41] The same should apply to foreign prices of tradables. CEECs are small economies and do not have enough market power to influence foreign prices (in this particular application proxied by the euro area prices). Given these considerations and the potential problem of exogeneity, the following specification of equation) seems the most appropriate in the case of CEECs:

(24a) $$P^T = \beta_1 e + \beta_2 P^{T*}$$

Estimations of PPP models are conducted for the unbalanced panel of nine CEECs (Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovak Republic, and Slovenia) covering generally the period 1993-2002. Prices are proxied by producer prices in levels in manufacturing.[42] To check robustness of results, PPP models are estimated by two methods developed for heterogeneous dynamic panels: Panel Group Mean FMOLS due to Pedroni (2001) and PMGE due to Pesaran et al. (1999). Both methods are later used for the analysis of the HBS effect.[43] The methodology of FMOLS

40 Changes in exchange rate regimes were quite frequent in some CEECs. See Rawdanowicz (2003) for a brief description of exchange rate regimes in this region.

41 Such an approach is justified only if one is convinced that the volatility of nominal exchange rate is not driven by volatility of prices (home or abroad).

42 PPP models were also estimated for the PPI for the entire industry (i.e. including mining as well as gas, water, and electricity supply sectors) to proxy the sector division used subsequently to verify the HBS effect. They render similar results and will not be reported here. In the case of Bulgaria, due to lack of the PPI for manufacturing, prices for total industry were used

43 Also results for the Mean Group Estimator (MGE) are provided in tables as reference values, but are not discussed in the text.

and PMGE is concisely reviewed in Appendix II. In order to secure sufficient number of degrees of freedom only the restricted version of the model (24a) is estimated. The estimates obtained by applying these two methods should be interpreted as long-run coefficients (i.e., a cointegration vector). Therefore, they are appropriate for inferring about the strong version of the PPP hypothesis (i.e., slope coefficients equal to 1 or -1) as coefficient restrictions could be tested formally.

The estimated coefficient of model (24a) turned out to be below 1 for both methods of estimation, but in the case of the FMOLS estimator the coefficient was not statistically different from 1 (see Table 5). Thus, the PMGE estimation does not support the PPP hypothesis and indicates a depreciation bias, while the FMOLS estimation confirms the PPP hypothesis. Both of these findings are at odds with the stylized facts presented in section 5.3.1. A closer look into the country specific results provides some explanation of this outcome. Under the FMOLS method, the estimated coefficient for Lithuania was negative and significant (for Latvia only negative). This could be hardly reconciled with the nominal exchange rate model. In the case of Lithuania, this peculiar result could be attributable to the increases in producer prices in manufacturing due to soaring oil prices in 1998-1999.[44] A further analysis of country-specific cases shows that the coefficient for Slovenia is below one, though it is not statistically different from one. In this case we have the confirmation of the PPP model. This could stem from the deliberate exchange rate policy of permanent nominal devaluation of the Slovenian tolar. For other countries, however, the estimated coefficients turned out significantly higher than one, indicating the appreciation bias.[45] FMOLS panel coefficients are mean averages of country-specific results and thus are sensitive to outlier estimates (similarly to the mean group estimator discussed in Pesaran et al. (1999)). In order to check the scope of the bias due to the specific outcome for Lithuania, the model (24a) was re-estimated excluding this country. Dropping Lithuania from the sample proved to have a downward bias on the panel estimates in the case of FMOLS estimations, but changed the estimates marginally under the PMGE estimations (compare Table 5 and Table 6). Summarising, both methods of estimations reject the strong version of PPP, but only FMOLS estimates confirmed the appreciation bias.

Rawdanowicz (2004) checks the sensitivity of the coefficients to the selection of the dependent variable in the PPP model by introducing two remaining specifications (with the nominal exchange rate and foreign prices as dependent variables), but the results remain the same. Among alternative explanations of the PPP puzzle suggested and discussed by the author the following issues are addressed:

[44] The differences in the goods baskets among countries used for calculations of PPI indices (in this case due to higher share of oil products in Lithuania) could be the reason for this peculiar outcome and in general for the observed deviation from PPP.

[45] Though for Poland, like for Slovenia, it was not statistically different from one. Thus, the estimates for Slovenia and Poland are consistent with the observed trends in exchange rates and prices (see Table 5).

- Problems with precise sector division (analogous to the problems described in section 5.1)
- Incomplete substitutability of tradables in Western Europe and CEECs (or the ensuing slack in the arbitrage mechanism)
- The existence of the nontradables processing component introducing frictions to the international arbitrage.

5.3.3. Deviations from PPP - Consequences for the PPP model

Regardless of its sources, both visual inspection of graphs and empirical analysis provide evidence for serious departures from PPP, or rather, indicate the impossibility to prove PPP when related measures of prices are conventionally defined as producer prices in manufacturing industries. Regardless of the many possible explanations of the PPP puzzle, the fact that we cannot hope for the law of one price to hold (equation (8)), means that the first three terms in equation (7) do not vanish and the international version of the HBS model (equation (9b)) takes the form:

(9c) $$\Delta p - \Delta p^{*} = \Delta p^{T} - \Delta p^{T} + (1 - \alpha)[(\delta/\gamma)\Delta a^{T} - \Delta a^{NT}] - (1 - \alpha^{*})[(\delta^{*}/\gamma^{*})\Delta a^{T*} - \Delta a^{NT*}]$$

If we fail to account for the fact that the PPP does not hold, and we estimate the external HBS by means of the standard formulation of the model of the type of equation (9b), our estimations are subject to the typical omitted variable problem with all the detrimental consequences for the reliability of the regression coefficients.[46]

It has to be mentioned, that unlike in the case of sector division and wage equalisation assumptions, the inability to empirically confirm PPP, does not impact on the entire HBS reasoning, but only on its international version (i.e. the external transmission mechanism). Thus, the estimates of the internal HBS should not be distorted by the problems with the PPP revealed in our analysis.

46 When PPP does not hold and the equation with real exchange rate on the LHS and relative productivity differentials on the RHS is estimated, we fail to account for an additional term on the RHS that follows from the model derivation : $\Delta q = (\Delta e + \Delta p^{T*} - \Delta p^{T}) - \{ (1 - \alpha)[(\delta/\gamma)\Delta a^{T} - \Delta a^{NT}] - (1 - \alpha^{*})[(\delta^{*}/\gamma^{*})\Delta a^{T*} - \Delta a^{NT*}]\}$

6. Panel Estimations of the HBS Effect

6.1. Models and Cointegration Tests

In our paper we consider numerous versions of the domestic and international version of the HBS model. In line with equation (4), the domestic HBS (Baumol-Bowen effect) is tested through an estimation of the following three alternative equations:

(25a) bb_01: $RP1 = \mathrm{f}(PRO\_T1 - PRO\_NT2) = \mathrm{f}(PRO1)$

(25b) bb_02: $RP2 = \mathrm{f}(PRO\_T2 - PRO\_NT2) = \mathrm{f}(PRO2)$

(25c) bb_03: $RP3 = \mathrm{f}(PRO\_T1 - PRO\_NT2) = \mathrm{f}(PRO1)$

They all embody the basic relationship of the internal HBS effect, i.e. the causal relationship between relative productivity and relative prices, but differ with respect to the definitions of the variables used in estimations (see section 4.1). Alternative definitions of productivity and price indicators should enable checking the robustness of results.

Likewise, we investigate alternative formulations of the external HBS, following the equation (9b):

(26a) hbs_01: $RER1 = \mathrm{f}(PRO\_T1 - PRO\_NT2) = \mathrm{f}(RPRO1)$

(26b) hbs_02: $RER1 = \mathrm{f}(PRO\_T2 - PRO\_NT2) = \mathrm{f}(RPRO2)$

(26c) hbs_03: $RER2 = \mathrm{f}(PRO\_T1 - PRO\_NT2) = \mathrm{f}(RPRO1)$

(26d) hbs_04: $RER2 = \mathrm{f}(PRO\_T2 - PRO\_NT2) = \mathrm{f}(RPRO2)$

We check for cointegration by means of panel cointegration tests developed by Pedroni (1997). These tests involve checking for unit roots in residuals obtained from postulated long-run relationships. The seven alternative versions of this test (Table 7) vary with respect to the functional form of the test statistics and with respect to the pooling method: first four tests are based on pooling the observations across the time dimension, while the latter three are based on pooling the observations across the group dimension. Additional methodological details can be found in Appendix II.

Table 7 presents results of the Pedroni tests carried out with specifications with and without a linear trend for all seven relationships indicated above. Cointegrated relationships are marked with one, two or three stars indicating rejection of a null hypothesis of nonstationarity at a 10%, 5% and 1% significance level. In the case of specifications without a trend (first seven columns), the tests point to the existence of cointegrating relationships postulated by bb_01, bb_02. These tests do not, however, reject the hypothesis of no cointegration for the remaining five models (bb_03, hbs_01, hbs_02, hbs_03 and hbs_04). Including a trend changes the results somewhat. While most tests still indicate cointegration for bb_01 and bb_02, one test finds cointegration also for bb_03 and hbs_03, four tests confirm it for hbs_01 and hbs_04 while six tests point to cointegration in hbs_03.

The results reveal that the models of the internal HBS effect are generally cointegrated, with the possible exception of bb_03, which involves the use of the relative price measure defined as a ratio of the *CPI* in services to the *PPI* (unlike in bb_01 and bb_02 where ratios of respective sectoral deflators are used). In contrast to the internal HBS, the evidence for cointegration of the external HBS models is weak and confirmed only by selected tests for the specification involving the trend. Thus, we can conclude that the relationship postulated by the internal HBS effect seems to be cointegrated in our panel, while that described by the external HBS effect comes out highly problematic. In the latter case the acceptance or rejection of the null hypothesis of no cointegration depends heavily on the inclusion of the trend. With these preliminary findings in mind, we now turn to the core part of our empirical analysis where we test elasticities of the HBS model for the panel of CEECs.

6.2. Estimations of the HBS equations

The empirical verification of the HBS hypotheses was conduced for an unbalanced panel of nine CEECs in period 1995-2003. Estimations were performed separately for each of the seven formulations of the HBS model: three alternative formulations of the internal HBS effect (equations 25– a, b and c) and four alternative formulations of the external HBS effect (equations (26– a, b, c and d). All models are estimated by the two methods for heterogeneous dynamic panels: group mean FMOLS and PMGE previously used to test the PPP. The estimates of these two methods should be interpreted as long-run coefficients, thus, we expect the empirical results (statistical properties of the coefficients, model fitness, etc.) to be in line with the findings following from the cointegration analysis presented in the preceding section. Both methods are reviewed in Appendix II.

Tables 8-10 present results of FMOLS and PMGE[47] estimations for the internal HBS models where a relative prices indicator is the dependent variable and the relative productivity - the explanatory variable together with the Error Corrections Mechanism (ECM) terms for PMGE. Tables 11-14 present analogous results for the external HBS models where a real exchange rate is a dependent variable and explanatory variables are relative productivity differentials. Tables 8-14 contain the FMOLS country-specific estimates of the long-run elasticities and in the last row of the tables, the group-means FMOLS estimate, equal to a simple average of country-specific estimates. Unlike FMOLS, the PMGE estimation restricts the long-run coefficients to be equal for all countries, but allows for individual country-specific coefficients of short-run elasticities (not reported in the tables) and the ECM term. Thus, for the PMGE, the tables report the long-run estimate of the elasticity (equal for all countries and for the panel) as well as ECM terms estimated for individual countries.

In line with cointegration results, FMOLS and PMGE estimations point to a well behaved and statistically significant internal transmission mechanism. In all three models, panel long-run coefficients are positive and statistically significant. Elasticities of those coefficients range from 0.35 to 0.53 for the first model, 0.55 to 0.56 for the second model and 0.94 to 2.53 for the third model. The error correction term, which indicates the presence of the error correction mechanism (i.e. the tendency to return to the long-run relationship after short-run distortions) is significant and correctly (i.e. negatively) signed in all models except for bb_03. The latter result implies that there might be some problems with existence of the relationship in bb_03. This is further confirmed by regression diagnostics tests (not presented in the table). Thus, the PMGE estimate of long-run elasticity of 2.53 (very high both in comparison to the FMOLS estimate of the same model and estimates of the other two models by both methods) is of small reliability and has to be treated with caution.

Even though the most important information on the long-run relationship is contained in group-mean (panel) elasticities, looking at individual country estimates might shed some light on country-specific factors. Examining country-specific estimates is also motivated by their subsequent use in quantifying the HBS effect carried out in the next section. Country-specific FMOLS results are strongly heterogeneous. Elasticities are significant

[47] Orders of lags for each country in the ARDL model were selected by a SBC criterion.

and correctly signed for the Czech Republic, Estonia, Lithuania and Poland (in all models) as well as Hungary and Slovenia (bb_03) and their magnitudes range from 0.54 to 2.11.[48]

For all countries in the sample, PMGE estimates of bb_01 and bb_02 indicate significant and negative ECM terms. In line with previous findings, the PMGE estimation of bb_03 reveals serious stability problems with the panel and that most country-specific ECM terms are insignificant and/or of an incorrect sign.

The results of estimations of the external HBS models are highly inconclusive (see tables 11-14). The FMOLS procedure yields significant and correctly signed group-mean coefficients in three models (all except hbs_01), while the PMGE procedure - in two models (in hbs_03 and hbs_04). The significant and correctly signed long-run coefficients' estimates for both methods range from -0.4 to -1.3.

The first two models (hbs_01 and hbs_02), based on the real exchange rate deflated with the GVA deflator, are particularly problematic due to the insignificance of the PMGE (both models) and FMOLS (hbs_01) panel elasticities and problems with diagnostic tests. Even though for hbs_02 the FMOLS mean-group coefficient is significant and correctly signed, only two out of seven country-specific estimates have this characteristic. Models using the *CPI*-based real exchange rate (hbs_03 and hbs_04) are more robust, albeit hbs_03 exhibits some diagnostic problems. PMGE yields a correctly signed and significant ECM for all four models at the panel level, but reveals a few insignificant country-specific ECM terms (especially for hbs_03 and hbs_04).

Country-specific FMOLS elasticities with significant and correctly signed coefficients are rather scarce and found mostly for Lithuania, Romania, Hungary and Slovenia.

Summing up, the FMOLS and PMGE results are broadly in line with findings from the cointegration analysis. It seems that there is more evidence in favour of the internal than external HBS effect. In the case of the internal HBS effect, cointegration tests established robust cointegration relationships for models bb_01 and bb_02 for which both panel estimation techniques produced significant and correctly signed panel long-run coefficients and ECM terms (PMGE). In the case of bb_03 there were significant problems with finding cointegration (only one out of 14 tests rejected the hypothesis of no cointegration),[49] which was later confirmed by problems with the stability of the model estimated by PMGE (positive and insignificant error correction term).[50]

The cointegration tests applied to the external HBS models found cointegration only when linear trend was included. The cointegrating relationship was partially confirmed for

[48] We ignore the incorrectly signed coefficients.

[49] There are seven tests with trend and seven without a trend (see Table 7).

[50] However, for bb_03 both methods produced significant and correctly signed long-run elasticity coefficients.

hbs_03 (six out of seven tests), hbs_01 (five out of seven tests) and hbs_04 (four out of seven tests), while it was confirmed only in one test for hbs_02. Consequently, the results of the panel estimation of the external HBS models are very heterogeneous: only hbs_03 and hbs_04 yielded significant and correctly signed long-run coefficients and error correction terms for both methods, while the estimations of hbs_01 and hbs_02 rendered highly ambiguous results.

Such outcomes can be interpreted in light of the findings in chapter 4, where we investigated key assumptions of the HBS model. In particular, our findings related to wage equalisation questioning the robustness or the very existence of this process in many countries, seem not to hinder the relationship between relative productivity and relative prices. This relationship came out statistically significant and fairly robust. It may point to the fact that even though it is hard to find clear empirical evidence in favour of sectoral wage equalisation (see section 5.2), wage equalisation holds in real life and a failure to detect it empirically comes from using unreliable data and imprecise sector definitions. Alternatively, it might be the case – as presented in section 5.2.1– that the stable ratio of sectoral wages found for many countries, is enough for the internal HBS effect to hold.

On the other hand, the external transmission mechanism turned out problematic. This can be reconciled with the apparent violation of the PPP as evidenced in section 5.3. The assumption of the PPP in the tradable sector is the only assumption that is added to the internal HBS in the process of obtaining the external HBS equation. Therefore, in light of evidence supporting the internal HBS, the failure to empirically detect the external HBS can well be explained by the lack of empirical evidence of PPP. Therefore, the ambiguous results of the estimates of the external HBS model (inconclusive cointegration tests results, often incorrectly signed or insignificant elasticities and problems with the ECM) might be due to the omitted variable problem, i.e. ignoring the real exchange rate deflated by tradable prices. If this diagnosis of the ambiguous results of the external HBS is correct, the model to be estimated should have the form of equation (9c) rather than (9b) in line with the suggestion in section 5.3.3.

6.3. Policy relevance and estimation of the size of the HBS effect

A natural follow-up of the above estimations is the quantification of the HBS effect in CEECs. The size of the inflation differential and real appreciation associated with the relative productivity growth has been a hotly debated issue in the region because of concerns related to the appropriateness of the Maastricht criteria. The policy relevance of the HBS theory is that, as phrased by De Broeck and Sløk (2001), productivity gains in the tradable sector are an equilibrium phenomenon.[51] Therefore the real exchange rate movements driven by the HBS effect do not require a policy response. Given the relatively strong real appreciation of all CEECs' currencies in the transition period the bulk of the work in this area has focused on the estimation of the size of real appreciation that could be associated with the HBS model. The results generally point to the fact that the observed real appreciation in the CEECs is only partly explained by the HBS effect (e.g. Egert et al., 2002). As argued in Egert et al. (2002), estimations concerning the extent to which the HBS effect is reflected in inflation differentials and in real exchange rate movements differ considerably. The estimates from the literature (see Table 1) point to the productivity-driven real appreciation in the rage of 0-3% per annum.

It is worth stressing that the interest in the HBS effect in the CEECs context is predominantly associated with its *external* version. Although, monetary authorities may be interested in the inflation differentials between the tradable and nontradable sectors (estimates of the internal transmission mechanisms may provide information about the inflation differentials that are consistent with the observed differentials in the sectoral productivity growth rates), it is unclear how in practice this information could be used given that only economy-wide monetary policy instruments are available.

As far as the external transmission mechanism is concerned, the presence of the HBS effect may provide useful information about the inflation differential with respect to some foreign country that is consistent with differentials in productivity growth rates or equivalently an indication of real exchange appreciation which is consistent with productivity growth differentials. In the regional context the policy relevance of productivity-driven inflation differential (real appreciation) is strictly associated with the EU and EMU accession.

Overall, while the internal transmission mechanism is a key building block of the HBS effect and proves to be more easily confirmed by the data (see sections 6.1 and 6.2), the external transmission mechanism is of key importance from the policy point of view. Since, among other criteria, the obligatory EMU membership involves the fulfilment of inflation and nominal exchange rate stability conditions, it is argued that the estimation of the HBS effect can be relevant for the conduct of monetary/exchange rate policies in the run-up to EMU and, particularly, for the ERM II period. Given certain expectations of sectoral productivity growth differentials in this period the HBS estimates may help in setting the central parity and managing the exchange rate during the ERM II period so that both the inflation and exchange rate criteria could be met without risking undesirable financial market tensions.

[51] Although it is rather problematic to evoke competitiveness in the HBS framework where only tradables are traded internationally and the PPP is assumed to hold for them. Therefore, by definition, competitiveness follows from the PPP and is implicitly embedded in this framework.

Indeed, the HBS model has been frequently employed to address the feasibility and desirability of the speedy fulfilment of the Maastricht criteria and entry to EMU by the NMS. In this context the HBS served as a tool for assessing whether meeting simultaneously the Maastricht criteria on inflation and on exchange rate stability could be problematic for countries converging to the EU per capita income levels (e.g. Egert et al, 2002 citing a number of earlier contributions). Halpern and Wyplosz (2001), for example, estimated that keeping the nominal exchange rate stable throughout the ERM II period could create inflation rate that is higher than in the euro area by 3.5 percentage points. By simple calculation, preventing such an inflation rate by appropriate adjustments to the exchange rate would require a nominal appreciation of 3.5% each year representing half of the ERMII band at the end of the ERMII period. Halpern and Wyplosz (2001) interpret this result as a warning that the catching-up itself, leaving aside other factors affecting nominal exchange rates, could push these countries dangerously close to the ERMII band.

Another important consideration – and one that goes beyond what is predicted by the HBS effect but is nevertheless closely associated with what is predicted by the HBS – is that a too speedy accession to the EMU may involve a trade-off between the nominal convergence (fulfilment of the Maastricht criteria) and real convergence (growth rates). This follows from the necessity to counteract inflation at the cost of lower economic growth when the HBS-consistent nontradable inflation is incompatible with meeting both Maastricht criteria.

For these reasons, investigating the size of inflation and real appreciation consistent with the HBS effect is of utmost relevance to policymakers in NMS and other CEECs hoping to join the EU in 2007 (e.g. Bulgaria and Romania). As indicated earlier, a great number of empirical studies produced point or range estimates of these effects in CEECs. We extend this list by contributing the estimates calculated using the results of panel estimations based on the most recent data. Table 15 and Table 16 present inflation and Table 17 the real appreciation associated with the HBS effect for the two four-year periods: 1996-1999 and 2000-2003. The calculation of the contribution of the HBS effect to inflation was made assuming that the growth in relative prices consistent with the growth in relative productivities pushed up prices in the nontradable sector only (i.e. did not affect the tradables' inflation).[52] For all countries, group-mean panel elasticities were used. Tables 15-17 report simple averages of inflation and real appreciation over the two indicated periods.

When FMOLS and PMGE produced different elasticities (see tables 8-14), we report estimates based on both of them. Because the estimation of bb_03 by PMGE and hbs_01

[52] On a practical level this means that the size of the HBS effect presented in the tables is calculated by taking the actual historical tradables inflation as given and obtaining the inflation of nontradables from the 'theoretical' value of relative price growth consistent with the actual relative productivity growth and the model elasticity.

and hbs_02 by both methods revealed critical problems with regression diagnostics or rendered insignificant or incorrectly signed results, we do not report estimates based on these methods.

Table 15 indicates that the estimates of contribution of the HBS-related nontradable inflation to total inflation measured by the GVA deflator are rather dispersed: they range from 0 percentage points (for Bulgaria) up to 3 percentage points per annum (for Poland during the first period). Most estimates for the later period point to the HBS contribution of well below 1.5 percentage points (with the exception of Estonia where estimates range from 1.5 to 2.4 percentage points).

The contribution is much smaller when we look at the CPI instead of GVA deflator presented in Table 16. This is certainly due to the fact that the share of nontradables in the CPI basket is much smaller[53] than in the GVA structure. Hence, the CPI indicator reflects the HBS effect to a much smaller extent than do the GVA deflators. Estonia is again, the country with the highest contribution of about 1 and 2.7 percentage points in the first and second period, respectively. For all the other countries, significantly smaller contributions of the HBS effect are reported, not exceeding 1.5 percentage points.

The estimates of the contribution of the HBS effect to real appreciation are reported in Table 17. They indicate the importance of the HBS effect in real appreciation in most countries both in the first and second period, albeit to varying extents for different countries. Notwithstanding the dispersion of estimates, the highest contribution of the HBS effect to real appreciation in the first period was revealed for Poland and Hungary. In the second period, the countries with the relatively high contribution included Estonia, Lithuania and Romania.

There are several important caveats that have to be mentioned in relation to these estimates. Their usefulness in the ongoing debate on the EMU accession stemming from the policy relevance of the HBS as sketched at the beginning of this section, rests on several simplifying assumptions that tend to be ignored by the participants of this debate.

First, it has to be mentioned that due to focusing on panel[54] elasticities in the calculation of the HBS effect there is no room for country-specific effects related to the strength of the relative-productivity-growth pass-through. This might be problematic when some features of the countries' macroeconomic regimes make the HBS visibly stronger or weaker in comparison to the remaining countries in the panel.[55]

[53] While services account for about 50-70% of the GVA, they account for about 20-40% of the CPI basket depending on the country.

[54] Using country-specific elasticities is not a good alternative. First, due to a very limited number of observations for each country, the panel elasticities represent a clearly superior measure of the HBS relationship which is essentially a long-run process. Second, country specific coefficients often come out insignificant or incorrectly signed (as evidenced in tables 8-14).

[55] The hypothesis related to exchange rate regime is elaborated in the next chapter.

Second, in the absence of the country-specific effects in the applied elasticities, the difference in the contribution of the HBS effect to inflation and real appreciation stems from different GVA and CPI basket structure[56] as well as underlying relative productivity changes (in the case of inflation) or relative productivity differentials vis-à-vis the euro area (in the case of real appreciation). Because the obtained estimates are based on past data, by quoting them in the context of future EMU accession, we implicitly assume that both the shares of nontradables in GVA and CPI as well as relative productivity developments in CEECs and the EU will remain to be approximately the same. However, this is not a good assumption. First, we observe a clear upward trend in the share of nontradables both in the GVA and (particularly) in the CPI basket in CEECs, which will act to reinforce the HBS effect. Second, the relative productivity domestic performance and differentials vis-à-vis the euro area are very hard to forecast in the near future. While there is a considerable consensus that over longer periods, relative productivities will rise and relative productivity differential in CEECs will be positive, it does not have to be the case during several future years when most countries plan to enter the ERMII. This is evident from Table 2 which indicates that in recent years relative productivity changes and relative productivity differentials have often been close to zero or even negative (e.g. Czech Republic, Slovakia, Romania and Poland).

Therefore, assuming that in line with the long-term trend the relative productivity growth in CEECs will be positive in the near future and will outpace that in the euro area, thus producing a sizeable HBS effect, is burdened with a substantial risk. In general, as chapter 2 made clear, the HBS is a long-run theory and inferences from its estimations are better used in a longer perspective. While the empirical results obtained from panel regressions can, they *do not have to* be indicative of developments in the run-up to the euro adoption. The ERM II period could last only two years, and no more than one year matters for inflation criterion. In a longer perspective to which the HBS is suited, this period might be too short to make any model-related conclusions (such as contribution estimates presented in this section) of *real* value for policymakers.

Finally, as mentioned in section 5.1.2, it might be inappropriate to assume that the entire nontradable component of the price indices is subject to the HBS effect due to the administrative character of price changes and the detachment of the productivity-price link (Egert et al., 2002). This is a factor reducing the importance of the HBS effect in all countries, albeit to varying degrees depending on the scale of the administratively controlled sector. Since it is hard to predict the direction and the pace of changes in the administratively controlled sectors, the specific parts of the nontradable sector that are not subject to the HBS effect, will remain unknown. As these sectors are likely to undergo

[56] The share of nontradables in GVA and in the CPI consumption basket.

dynamic changes in several years to come, our ability to infer from the estimates based on past data about the future size of the effect, might be seriously impaired.

It is important to keep in mind that all the abovementioned caveats concern using the estimates of the HBS effect calculated conventionally with the use of the regression elasticities and actual productivity and price data from the sample. It was not, however, meant to undermine the use of the HBS theory in the general context of analysing inflation and real appreciation in CEECs.

7. The HBS and the Distinction between Exchange Rate Regimes

Given the potential policy context in which the estimations of the HBS have been pursued (see Section 6.3), it is somewhat surprising that very few of the existing contributions make a distinction between the exchange rate regimes adopted in the investigated economies. Presumably, one of the main reasons for the absence of this distinction is that the HBS theory does not in itself distinguish between different modes of realisation of the internal and external transmission mechanisms. As discussed above, according to the HBS theory, the real appreciation can materialise via various combinations of inflation/deflation and nominal appreciation/depreciation. This may be seen as problematic both from the empirical point of view and in the context of usefulness of the HBS theory for economic policy making.

7.1. Different Modes of Realization of HBS Effect and the Role of Nominal Exchange Rate

According to the HBS theory, the changes in relative prices <u>will not</u> unambiguously lead to inflation being higher in absolute terms in the fast growing country though they <u>will</u> unambiguously lead to an appreciation of the *CPI* based real exchange rate. The real appreciation according to this model occurs through inflation being higher in the faster growing country. Since the HBS theory does not assume anything about the nominal exchange rate apart from the law of one price in the tradable sector, the HBS real appreciation is consistent with any combination of nominal exchange rate change and *CPI* inflation as long as the underlying relative price differentials are consistent with the relative productivity differentials. For example, if the HBS internal and external transmission is accompanied by a nominal appreciation of an exchange rate, domestic inflation of tradables goes down allowing the domestic inflation differential (implied by the HBS) to be achieved with a lower inflation in nontradables: the same real appreciation is realised with a lower aggregate inflation.

The adopted exchange rate regime does impose constraints on the way in which the HBS can operate. In a fixed exchange rate regime the HBS effect will necessarily have to occur through nominal wage adjustments and nontradable inflation. In the case of a downward inflexibility of the exchange rate (e.g. when monetary authorities abstain from devaluations) the HBS effect will have to be realised through a combination of the tradable deflation, nominal wage adjustment and nontradable inflation.[57] In the case of an upward inflexibility of the exchange rate (monetary authorities abstain from nominal appreciation but accept depreciation) the HBS effect will have to occur through a combination of inflation in both sectors and nominal wage adjustments. In a flexible exchange rate regime with unconstrained nominal exchange rate movements the HBS can occur through any combination of the above-mentioned mechanisms.

As a consequence, estimates of the HBS effect may differ according to the constraints imposed by the nominal exchange rate regimes. In the short run due to differentials in the flexibility of nominal exchange rates and prices (and wages) in the tradable and nontradable sectors the dynamics of achieving the HBS effect may be affected. For example assuming higher flexibility of nominal exchange rates as compared to commodity prices it can be expected that the adjustment to the equilibrium as indicated by the HBS effect may be more rapid under flexible exchange rates as compared to a fixed exchange rate regime. Similarly, if prices are less flexible downwards it may take longer for the HBS effect to feed through in an exchange rate regime in which the exchange rate is characterised by a downward rigidity.

This is indeed the hypothesis put forward as an explanation of differences in estimated coefficients of the HBS model for different exchange rate regime sub-groups obtained by Halpern and Wyplosz (2001). They explicitly include the exchange rate regime as an explanatory variable in their panel estimations of the relationship between the services to industrial products price ratio and measures of productivity in the two sectors although the exact specification of the equation they estimate is somewhat unclear. Seemingly, the base panel that Halpern and Wyplosz (2001) use for the estimation of the HBS effect is divided into two sub-panels: one containing the observations for exchange rate regimes without any formal commitment (managed or free floating), and one for all remaining exchange rate regimes. The effect of productivity in the traded goods sector increases under "no commitment" regime and the coefficient on the nontraded sector productivity changes signs. Halpern and Wyplosz (2001) conclude that a floating exchange rate regime

[57] Whether this leads to the CPI inflation or deflation will depend on the size of nominal appreciation and the relative shares of tradables and nontradabes in the CPI.

"strengthens" the HBS effect which they find as hardly surprising. The interpretation is that if the exchange rate is free to absorb some of the equilibrium real appreciation in the form of a nominal appreciation rather than forcing the adjustment through absolute price changes, the effect is bound to appear faster. This is supposed to be making the difference given the short time-series. The authors expect that with the longer time series, such nominal short-term rigidities should vanish. They do not, however, provide and further investigation of this hypothesis.

Halpern and Wyplosz (2001) are the only known contribution to the HBS theory that distinguishes between the exchange rate regimes – a clear indication of a gap to be filled. Additionally, some questions can be raised about the robustness of estimates by Halpern and Wyplosz (2001). They specify their equation as an unobserved effect panel data model and estimate it with a range of estimators (fixed effects, random effects, FGLS, OLS). Nevertheless, model specification and in particular the inclusion of lagged dependent variable as an explanatory variable in panel estimations results in violation of the strict exogeneity assumption (Woolbride, 2002). Violation of this assumption results in inconsistency of all above-mentioned estimators. Finally, Halpern's and Wyplosz's (2001) results are based on a very small sample of observations. Annual observations for nine countries in the period 1990-2000, after accounting for some gaps in the data, offer only 56 observations which then further divided into two separate sub-panels. Overall, there is a considerable interest in verifying Halpern's and Wyplosz's (2001) results both from the scientific/academic and policy point of view.

Furthermore, in view of the fact that the HBS effect can generate various magnitudes of inflation (and various magnitudes of exchange rage movements), the exogeneity of productivity growth may be considered a weak element of the HBS theory. In fact, Andres et al. (1996) address a related question. They make an observation that according to the HBS theory growth and inflation are positively correlated in economies with pegged currencies as well as the costs of inflation are underestimated in samples that include countries and periods with different exchange rate regimes. They do not, however, comment on the fact that whether observed inflation is driven by the HBS effect or by other factors it will still impose an economic cost and may affect the productivity growth itself.

Coricelli and Jazbec (2001) are more explicit and state that inflation differentials associated with the HBS effect reflect an equilibrium phenomenon, without any negative implications. This statement, however, is not convincing as even if the HBS inflation does not undermine international competitiveness, it may still be associated with economic costs and impinge upon productivity growth itself – especially if the productivity growth differentials are large generating high rates of HBS inflation. If this is the case, it could be argued that the usefulness of an estimate of the HBS effect based on a flexible exchange rate regime period (with presumably lower resulting HBS inflation) will be of limited usefulness in the period in which the country adopted a fixed exchange rate (with presumably higher resulting HBS inflation) as the productivity growth could itself be affected. This would be especially the case if the HBS effect involves nonlinearities: estimated HBS elasticities change with different levels of productivity growth rates. Arguably, this is not the case in the standard exposition of the model but these functional forms, while mathematically convenient and economically appealing, cannot be taken for granted. Chang (2002) suggests a possibility of structural breaks in the context of HBS effect estimation and existence of different exchange rate regimes.

In this context, the existing estimates of the HBS real appreciation, suggest that fixed nominal exchange rate would be associated with rather moderate inflation levels and that nominal exchange rate appreciation would not make much of a difference. Put together with the consensual view that costs of inflation are low for low inflation levels may suggest that there is no big difference whether the HBS real appreciation in the CEECs is realised through higher inflation levels or absorbed partially or entirely by the nominal appreciation. This argument, however, does not take into account that the potential for nonHBS inflation in the CEECs may be already higher than in other countries and that even moderate increments associated with the HBS may make a difference. Additionally, as we pointed out in section 6.3, the estimates of the HBS effect are always conditional on the dynamics of underlying catch-up process. A faster catch-up after the EU accession may generate higher resulting HBS effect which if coupled with a fixed exchange rate regime may result in inflation rates that may make a difference.

In addition to exchange rate-related heterogeneity of realisation of the internal transmission mechanism, the realisation of the HBS may be additionally affected by associated behaviour of the nominal exchange rate through the PPP (or its violation) in the tradable sector. Rawdanowicz (2004) suggests that since "PPP is based primarily on international arbitrage, it seems more reasonable to expect to find evidence for PPP under fixed exchange rate regimes than under floats. The arbitrage is less likely to occur (or occur in a less smooth manner) when changes in nominal exchange rates are volatile and unpredictable – the usual feature of floating exchange rates." It has to be pointed out that, the principle of arbitrage itself does not suffice for expectations that the violation of the PPP is more likely in flexible exchange rate regimes–nominal exchange rate volatility can in principle itself be caused by arbitrage in commodity markets. As a matter of fact exchange rate flexibility may facilitate arbitrage. Nevertheless, in line with what is argued further in Rawdanowicz (2004), exchange rate volatility that is detached from the goods markets will blur the price comparison and may result in emergence of the so-called no-arbitrage thresholds.

The presented discussion suggests that while the HBS theory is not very well positioned to provide a basis for an assessment of alternative exchange rate regimes, its mechanics as well as policy relevance may be linked to the issue of exchange rate regimes. Since assumptions about the behaviour of nominal exchange rate constrain the modes of realisation of the HBS effect and thus require different sets of adjustments in macroeconomic variables, the regime in place may affect the extent to which the productivity differentials transmit to real appreciation. For example a fixed nominal exchange rate requires internal adjustment through nominal wage and nontradable prices while a floating exchange rate regime will usually require tradable price adjustment but not necessarily wage and nontradable price adjustments. Depending on relative stickiness of these variables, the final outcome of the internal transmission mechanism may differ between different modes of realisation of the HBS and may affect the HBS estimates. It is therefore interesting to account for such heterogeneity in the estimation of coefficients.

7.2. Empirical Verification

The previous sections explained why accounting for heterogeneity associated with differentials in nominal exchange rate behaviour could be important in the context of estimating the HBS effect. In what follows we present results of estimations of three models of the internal transmission mechanism (bb_01, bb_02, and bb_03) and one model of external transmission mechanism (hbs_03) accounting for an impact of adopted exchange rate regimes. The results are presented in Tables 18-22.

Two methodological approaches are pursued. In the first approach the influence of an adopted exchange rate regime is estimated with the panel group mean FMOLS estimator on two separate sub-panels: one containing observations where a commitment to an exchange rate target (commit=1 in Table 18) was present and one containing observations where there was no such commitment (commit=0).[58] The second approach attempts the estimation of the selected HBS model specifications with an inclusion of explicit commitment dummies. The latter set of estimations are pursued with standard panel data techniques such as fixed and random effects, feasible generalised least squares with heterogenous panels and autocorrelated standard errors (FGLS) as well as the panel corrected standard errors (PCSE) (Tables 21-22). For the sake of comparison, estimations for specifications with and without the exchange rate commitment dummy are presented for each of the model and estimator employed.

The FMOLS estimations pertaining to the internal transmission mechanism models (bb_01, bb_02, and bb_03) yield statistically significant coefficients which tend to indicate

[58] By commitment we understand either a fixed exchange rate regime or an intermediate one. See Appendix IV for explanation of the classification methodology.

a larger magnitude of the internal HBS effect for no-commitment regimes. This is the case for bb_02 and bb_03 models while the opposite result is obtained for the bb_01 model. FMOLS estimations of the external transmission mechanism render results that are statistically questionable – a confirmation of the conclusion drawn from the analysis in Chapter 6.

The estimation of the internal transmission mechanism with regime-commitment dummies generally indicates lower estimated coefficients on measures of relative productivity. Nevertheless, (1) the coefficients on regime dummies are statistically significant and positive; (2) constants estimated in the specifications with the regime commitment dummies are generally lower. One general observation that follows from these results is that accounting for the regime commitment seems to matter. Since the estimated coefficients on relative productivity are in most cases lower in specifications with the regime dummies, one conclusion that could be drawn is that the inference based on basic estimations (without accounting for the regime) would tend to overstate the size of the HBS effect for both types of exchange rate regimes but marginally more so for a commitment regime. This is however where a straightforward interpretation of these results stops. The consistently positive estimates of coefficients on regime dummies indicate a positive impact of a commitment on the relationship between the relative productivity and relative prices – a result that is counterintuitive in the context of discussion in Section 7.1.

Estimation of the external transmission mechanism with the regime commitment dummies is inconclusive. While coefficients on regime-commitment dummies are statistically significant they change signs between different estimators. More importantly, the coefficients on relative productivity variables denote low statistical significance. Once again, these estimates complete the picture of generally inconclusive results of estimations of the external HBS effect discussed at length in Chapter 6.

8. Summary and Conclusions

Our research sought to investigate the HBS effect in CEECs. Prior to estimating the model, detailed analyses of several key assumptions of the model were pursued. First, potential problems arising from the inability to make a precise division of the economy into the tradable and nontradable sector was raised. The problems stem from controversies regarding the classification of many industries or services as well as difficulties to obtain data at a sufficiently disaggregated level. It was shown how the failure to make an appropriate division may introduce noise to the series and result in biased estimates of coefficients. Also the wage equalisation assumption of the HBS model was investigated. It was found that while the absolute wage equalisation (equal wage levels) may be difficult to prove, evidence for stationary wage ratios (i.e. common wage changes) was easier to find. We showed that the stationarity of wage ratios was enough to keep the accounting of the HBS-model unchanged. Also a verification of the PPP model (another key assumption of the HBS model) in our sample was attempted rendering no clear empirical evidence in its favour.

In the empirical part of the paper, the Pedroni panel-stationarity tests led us to conclude that the variables used in subsequent estimations (productivities, prices levels and the euro exchange rate) are stationary in first differences. Panel cointegration tests (also due to Pedroni) detected the existence of cointegration in the internal HBS (three alternative formulations of the model) and only partly in the external HBS (four alternative formulations of the model). Similar evidence resulted from panel estimations with the use of the panel group mean FMOLS and PMGE methods. While the internal HBS relationship proved to be significant and robust to alternative model formulation, the evidence concerning the external HBS was less convincing and sensitive to the selection of the model. Such results could be reconciled with the findings about the extent to which key assumptions of the model hold in our panel. Evidence of stable wage ratios (and a lack of absolute wage equalisation) seemed sufficient for the realisation of the internal HBS, but the failure of PPP was believed to be potentially the main reason for ambiguous empirical results of the external HBS regressions.

Based on the regression estimates of elasticities we calculated the contribution of the HBS effect to inflation and real exchange rate appreciation during two four-year periods: 1996-1999 and 2000-2003. Our estimates of annual contribution of the HBS effect to inflation (generally below 2 percentage points in the later period) and to real appreciation (generally below 3 percentage points in the later period) must be interpreted with caution. This was motivated, among others, by the fact that they were based on **past** relative productivity growth and differentials vis-à-vis the euro area which on average, exhibited, positive trends in our sample. Both productivity indicators are, however, subject to short-run fluctuations which may lead to negligible or even negative HBS effect. Thus, we stressed that the HBS theory, being the long-run theory, was better suited for inferring about long-run trends of relative inflation and real appreciation of exchange rates rather than for producing point estimates of these indicators for a specific two or three-year period.

In the last part of the paper the hypothesis of the potential impact of exchange rate regimes on the significance and size of the HBS effect postulated in the literature was discussed. Two distinct modes of realisation of the HBS effect were identified and elaborated. In a fixed exchange rate regime the HBS effect would necessarily have to occur through nominal wage adjustments and nontradable inflation, while in the flexible exchange rate regime, nominal exchange rate movements could facilitate adjustment of relative prices without wage adjustments. Thus, it was demonstrated that flexible exchange rate regimes could smooth the realisation of the HBS effect (i.e. adjustments to the equilibrium suggested by the HBS). We attempted an empirical verification of these hypotheses but failed to obtain clear-cut results. Estimations picked up a statistically significant impact of regimes on HBS estimates and showed that failing to account for their heterogeneity would tend to overstate the size of the HBS effect for both types of exchange rate regimes. However, they also indicated a positive impact of a commitment to an exchange rate target on the relationship between the relative productivity and relative prices – a result that is counterintuitive in the context of the discussion preceding the estimations.

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Table 1. Selected empirical studies of the HBS effect in CEECs

Study Author(s) Country Sample	Dependent Variable	Sectoral decomposition		Other explanatory variables	Estimation method	Estimate the BS effect (percentage points per annum)
		Tradables	Nontradables			
Kovács and **Simon** (1998) Hungary, 1991–96	REER	Manufacturing (excluding agriculture, mining and energy)	Services (excluding public administration)	—	No regressions	**2.9**
Cipriani (2001) 10 accession candidates, 1995–99, quarterly data	*PN/PT* (NT/T goods and services from CPI)	Industry and mining (goods from CPI)	Residual (excluding agriculture), services from CPI	—	OLS	**0.5–0.7**
De Broeck and Sløk (2001) 25 transition economies, 1993–98	REER	Industry and construction	Services	Agricultural productivity, broad money, openness, budget balance, terms of trade, commodity prices	Pooled mean group estimation	**0.2–0.6**
Egert (2002a) 12 transition economies, 1993–2001, quarterly data	*PN/PT* (CPI/PPI) RER (D-mark)	Industry	Not considered (productivity set at zero)	—	VAR and panel cointegration	**0.9** (pooled estimates) **0–3.5** (country estimates)
Fischer (2002) 10 accession candidates, 1993–99	REER	Industry	Services	Agricultural productivity, gvt cons/GDP, world real interest rate, terms of trade, commodity prices	SUR fixed effects	**0.7–2.2** (partly attributed to investment demand channel)
Halpern and Wyplosz (2001) 8 accession candidates, Russia, 1991–98	*PN/PT* (services/ nonfood manufactured goods from CPI)	Industry	Services	GDP per capita, inflation acceleration term, lagged relative price	GLS	**3.0**
Coricelli and Jazbec (2001) 19 transition economies, 1990–98	*PT/PN* (sectoral GDP deflators)	Manufacturing, mining, energy and construction	Residual	Share of nontradables consumption, government consumption, "structural misalignment" measure	Fixed effects panel estimation	**0.9–1.2**
Arratibel et al (2002) 10 accession candidates, 1990–2001	*PN/PT* (CPI decomposition of NT/T goods and services)	Manufacturing	Not considered	Exchange rate regime, budget deficit, GDP per capita, wage growth, unemployment, oil price, terms of trade, etc	Method of moments	Insignificant

Source: Mihaljek and Klau (2003).

Table 2. Average annual growth rates of absolute and relative productivities in CEECs

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	sample average
RPRO1_BUL								1.3	0.2	2.0	1.2
RPRO1_CZE	.	5.1	20.5	3.5	-10.6	-2.4	12.3	-6.9	-8.2	-7.3	0.7
RPRO1_EST	1.7	-14.2	0.7	11.6	-3.0	-3.0	2.4	3.5	8.0	12.9	2.1
RPRO1_HUN	.	.	1.6	6.4	0.3	7.3	5.3	-6.5	-7.6	-6.9	0.0
RPRO1_LAT	.	.	.	.	.	.	.	.	-5.4	2.3	-1.5
RPRO1_LIT	.	.	9.0	-3.0	4.9	-3.4	-0.6	6.5	5.3	2.3	2.6
RPRO1_POL	.	.	5.5	6.2	1.4	1.5	8.2	-1.8	-0.8	1.6	2.7
RPRO1_ROM	.	.	.	.	.	3.5	11.8	5.6	-3.3	-11.6	1.2
RPRO1_SLK	.	.	2.8	-18.6	5.2	8.3	-1.2	-1.1	-7.9	-7.9	-2.6
RPRO1_SLO	.	.	.	.	1.3	1.1	2.7	2.5	1.0	0.4	1.5
RPRO2_BUL	.	.	.	.	.	.	.	2.5	3.2	1.6	2.4
RPRO2_CZE	.	3.8	22.2	4.7	-7.2	2.0	10.8	-6.1	-7.6	-7.0	1.7
RPRO2_EST	6.1	4.4	0.6	10.9	-2.8	0.2	3.0	1.0	5.1	10.0	3.9
RPRO2_HUN	.	.	0.8	6.1	0.4	7.7	4.2	-0.4	-2.9	-4.2	1.5
RPRO2_LAT	.	.	.	.	.	.	.	.	0.1	1.9	1.0
RPRO2_LIT	.	.	7.3	7.9	-0.2	-3.1	2.5	14.0	12.3	5.6	5.8
RPRO2_POL	.	.	5.9	10.9	7.3	4.0	0.9	-5.2	-5.3	-3.6	1.9
RPRO2_ROM	.	.	.	.	.	-2.1	-3.4	8.8	10.2	13.5	5.4
RPRO2_SLK	.	.	4.6	-15.0	8.1	11.3	1.8	-0.3	-7.3	-9.9	-0.9
RPRO2_SLO	.	.	.	.	7.8	5.1	2.3	-1.6	-0.8	0.2	2.2
PRO_T1_BUL	.	.	.	.	.	.	.	7.9	5.7	6.1	6.6
PRO_T1_CZE	.	7.8	17.9	2.9	-6.9	1.4	12.3	-1.7	-2.4	-2.2	3.2
PRO_T1_EST	3.3	-0.6	7.0	19.9	4.3	2.4	11.4	8.3	10.1	14.8	8.1
PRO_T1_HUN	.	.	3.8	9.4	3.0	6.1	7.6	-1.3	-1.9	-1.6	3.2
PRO_T1_LAT	.	.	.	.	.	.	.	.	-2.8	3.5	0.3
PRO_T1_LIT	.	.	9.6	4.1	13.0	-3.3	7.6	15.7	15.6	14.5	9.6
PRO_T1_POL	.	.	8.0	9.4	4.5	9.5	11.3	2.0	3.0	5.4	6.6
PRO_T1_ROM	.	.	.	.	.	4.7	14.0	9.9	8.7	7.1	8.9
PRO_T1_SLK	.	.	4.8	-7.7	7.4	9.8	2.9	4.1	0.6	0.1	2.7
PRO_T1_SLO	.	.	.	.	3.2	7.0	12.2	3.3	2.5	2.5	5.1
PRO_T2_BUL	.	.	.	.	.	.	.	10.9	10.6	7.3	9.6
PRO_T2_CZE	.	6.7	17.7	3.3	-4.1	4.4	10.6	-0.7	-1.5	-1.6	3.9
PRO_T2_EST	5.3	14.3	6.7	18.1	4.7	4.7	11.7	6.2	7.5	11.9	9.1
PRO_T2_HUN	.	.	3.2	8.8	3.1	5.9	6.6	3.4	1.8	0.7	4.2
PRO_T2_LAT	.	.	.	.	.	.	.	.	1.5	2.9	2.2
PRO_T2_LIT	.	.	7.7	10.6	8.1	-3.5	9.8	20.2	19.7	16.4	11.1
PRO_T2_POL	.	.	7.3	11.2	7.6	10.4	5.7	-0.1	-0.1	1.3	5.4
PRO_T2_ROM	.	.	.	.	.	-0.9	0.3	11.2	14.7	20.0	9.0
PRO_T2_SLK	.	.	5.9	-4.0	8.8	11.1	4.8	4.9	1.6	-0.9	4.0
PRO_T2_SLO	.	.	.	.	6.7	8.9	11.5	0.6	1.4	2.4	5.2
PRO_NT_BUL	.	.	.	.	.	.	.	8.2	7.2	5.6	7.0
PRO_NT_CZE	.	2.9	-3.8	-1.3	3.3	2.2	-0.1	5.9	6.6	5.8	2.4
PRO_NT_EST	-1.0	9.5	6.2	6.3	7.8	4.3	8.6	5.0	2.4	1.6	5.1
PRO_NT_HUN	.	.	2.4	2.4	2.7	-1.7	2.4	3.8	4.8	5.1	2.7
PRO_NT_LAT	.	.	.	.	.	.	.	.	1.6	1.2	1.4
PRO_NT_LIT	.	.	0.5	2.4	8.1	-0.1	6.9	5.3	6.5	10.7	5.1
PRO_NT_POL	.	.	1.4	0.3	0.3	6.0	5.0	5.4	5.5	5.1	3.6
PRO_NT_ROM	.	.	.	.	.	1.5	3.3	1.7	4.3	6.3	3.4
PRO_NT_SLK	.	.	1.3	12.7	0.9	-0.4	3.3	5.4	9.0	9.7	5.2
PRO_NT_SLO	.	.	.	.	-1.1	3.6	9.0	2.2	2.1	2.1	3.0

Notes: For sources and definitions see section 4.1 and Appendix I

Table 3. Average annual growth rates of relative prices and real exchange rates in CEECs

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	sample average
RP1_BUL	.	5.2	-3.5	6.9	1.2	-0.1	-6.2	3.5	5.6	6.5	2.1
RP1_CZE	4.6	1.4	3.9	3.3	5.6	1.1	-0.9	1.8	2.8	3.2	2.7
RP1_EST	8.5	2.5	7.2	2.0	3.9	4.6	-0.8	1.3	2.4	3.0	3.5
RP1_HUN	5.9	0.0	1.3	-1.7	2.5	4.7	-0.9	3.9	5.9	7.0	2.9
RP1_LAT	16.4	11.7	3.5	4.1	2.8	6.6	2.0	0.8	1.0	1.1	5.0
RP1_LIT	.	9.0	6.3	4.5	12.6	-1.7	-13.5	6.3	8.2	9.4	4.6
RP1_POL	1.8	1.7	6.3	2.5	4.2	1.5	2.1	3.8	4.0	3.2	3.1
RP1_ROM	0.7	-2.2	-7.1	-1.3	19.3	1.2	-4.9	-4.9	-3.1	-1.7	-0.4
RP1_SLK	3.2	0.8	1.6	1.6	3.3	6.5	2.1	0.7	1.8	2.2	2.4
RP1_SLO	2.8	0.7	2.8	2.2	1.8	4.0	1.1	-0.5	0.4	1.0	1.6
RP2_BUL	.	.	.	.	-11.7	-6.8	1.0	0.5	0.0	-1.2	-3.0
RP2_CZE	.	4.8	3.3	9.9	-4.7	-1.1	6.7	-5.8	-5.3	-3.7	0.5
RP2_EST	1.6	7.4	3.2	4.7	-1.6	4.2	-1.3	2.4	3.1	3.7	2.7
RP2_HUN	.	.	.	.	.	.	.	.	.	.	.
RP2_LAT	12.9	-9.8	4.8	0.2	21.3	7.1	3.9	0.3	0.5	1.5	4.3
RP2_LIT	.	.	10.3	0.7	8.3	-2.0	-4.0	3.7	4.8	5.5	3.4
RP2_POL	.	.	10.9	8.8	7.1	0.7	6.5	6.5	5.7	4.2	6.3
RP2_ROM	.	.	.	.	.	5.0	2.0	3.8	3.6	-0.3	2.8
RP2_SLK	-2.4	2.3	9.7	1.8	1.7	-3.9	-1.4	1.1	0.1	2.0	1.1
RP2_SLO	.	.	.	.	.	.	.	.	.	.	.
RP3_BUL	.	.	1.8	-3.0	30.6	22.3	-1.8	7.0	8.9	10.1	9.5
RP3_CZE	.	1.9	7.1	6.2	6.4	3.8	-0.1	4.6	6.3	7.1	4.8
RP3_EST	33.9	16.1	11.0	5.4	10.0	11.0	0.5	2.8	3.9	4.6	9.9
RP3_HUN	7.2	-1.8	3.7	-1.0	4.3	9.3	-1.0	4.4	6.6	8.1	4.0
RP3_LAT	43.8	27.7	8.1	11.5	9.5	9.5	4.7	0.4	-0.3	-0.1	11.5
RP3_LIT	.	11.5	3.6	10.9	19.5	3.6	-9.8	9.7	11.2	13.0	8.1
RP3_POL	1.5	2.8	6.7	6.3	9.3	5.0	3.1	7.0	7.2	6.3	5.5
RP3_ROM	6.4	5.6	-1.5	9.9	45.2	20.7	10.1	-11.7	-6.7	0.1	7.8
RP3_SLK	.	.	1.6	2.4	5.1	19.4	14.8	7.1	6.4	5.5	7.8
RP3_SLO	7.3	5.0	7.9	3.8	3.9	5.6	0.3	1.2	2.3	3.4	4.1
RER1_BUL	.	.	.	.	28.4	6.5	6.6	-0.6	3.5	0.0	7.4
RER1_CZE	.	9.9	6.7	15.4	6.7	6.9	-2.1	-6.5	-3.9	-7.8	2.8
RER1_EST	32.7	24.4	23.4	14.4	11.1	2.5	3.2	3.4	3.0	2.5	12.1
RER1_HUN	.	.	.	.	.	.	.	.	.	.	.
RER1_LAT	4.4	15.7	16.9	2.4	-0.7	2.7	-6.2	-4.5	0.2	-0.5	3.0
RER1_LIT	.	.	17.8	2.1	-2.4	-1.8	-11.3	-10.2	-5.7	-7.1	-2.3
RER1_POL	.	.	28.3	27.3	12.5	17.8	2.5	-11.3	-7.3	-5.4	8.0
RER1_ROM	.	.	.	.	.	138.7	79.0	68.7	61.4	46.0	78.7
RER1_SLK	12.0	11.1	4.6	7.9	2.7	22.7	4.4	-1.5	0.8	-2.3	6.2
RER1_SLO	.	.	.	.	.	.	.	.	.	.	.
RER2_BUL	277.6	108.4	605.2	7801.8	16.8	5.0	9.5	-0.4	4.2	1.2	882.9
RER2_CZE	2.1	8.8	8.3	13.2	5.8	7.5	-0.4	-7.0	-4.2	-8.4	2.5
RER2_EST	42.5	21.3	22.5	13.1	7.8	1.2	1.9	3.3	2.8	2.4	11.9
RER2_HUN	28.3	66.5	45.0	29.4	23.1	19.4	12.0	0.0	0.7	-4.1	22.0
RER2_LAT	6.1	27.4	19.5	2.4	-0.3	-0.2	-8.7	-4.6	0.7	-0.4	4.2
RER2_LIT	51.1	51.5	21.1	-2.5	-1.5	-1.0	-13.3	-9.0	-3.7	-4.7	8.8
RER2_POL	57.4	47.0	29.3	25.0	11.9	19.6	3.6	-10.6	-6.4	-4.3	17.2
RER2_ROM	353.0	75.3	104.8	425.9	85.6	146.9	76.5	62.6	59.8	49.9	144.0
RER2_SLK	10.9	10.2	6.2	4.2	4.9	27.2	7.1	1.7	4.1	-0.1	7.6
RER2_SLO	29.3	12.9	22.1	14.3	5.3	14.0	14.4	6.7	11.0	7.3	13.7
RER3_BUL	.	100.6	659.5	7178.9	17.0	6.3	13.6	-2.8	0.7	-2.6	885.7
RER3_CZE	-1.6	6.1	5.9	10.1	1.7	6.4	-1.4	-7.9	-5.3	-9.6	0.4
RER3_EST	32.0	9.9	15.7	10.6	4.2	-3.4	1.2	2.2	1.5	0.7	7.5
RER3_HUN	.	.	45.0	32.1	21.0	14.8	11.3	-3.4	-3.8	-9.0	13.5
RER3_LAT	-6.0	13.7	16.1	-1.2	-2.8	-6.5	-13.0	-4.1	2.0	1.2	-0.1
RER3_LIT	27.0	36.6	15.6	-5.7	-11.2	2.0	0.2	-10.6	-6.7	-7.7	4.0
RER3_POL	53.7	42.5	22.9	19.1	8.4	18.2	-1.5	-14.5	-10.0	-6.7	13.2
RER3_ROM	.	.	.	.	60.9	140.5	79.6	80.2	71.8	56.8	81.6
RER3_SLK	.	.	6.7	3.9	3.0	20.3	1.5	1.3	3.0	-1.4	4.8
RER3_SLO	15.1	9.3	20.0	12.3	4.9	11.5	10.9	9.3	13.7	9.4	11.6

Notes: For sources and definitions see section 4.1 and Appendix I

Table 4. Panel Unit Root Test Statistics

	Without trend			
	LL Tests			IPS Test
	ρ statistic	ρ -t statistic	ADF statistic	ADF statistic
PT	0.38	-0.42	1.80	1.76
PT2	0.27	-0.85	1.53	0.92
PNT2	0.72	-0.87	1.70	0.81
DEF	0.74	-0.89	1.80	1.38
PRO_T1	1.56	1.83	2.6	2.51
PRO_T2	1.37	1.34	2.28	1.81
PRO_NT2	1.92	2.33	2.20	2.70
CPI	0.74	**-1.33** *	3.17	3.41
EUR	-1.13	-0.59	0.61	-0.96
PPI	0.48	-1.05	2.28	7.33
CPI_NT	1.14	-0.14	3.04	4.43
	With trend			
	LL Tests			**IPS Test**
	ρ statistic	**ρ -t statistic**	**ADF statistic**	**ADF statistic**
PT	0.28	-0.54	-0.07	-0.73
PT2	-0.04	-0.65	0.33	0.75
PNT2	3.25	0.40	0.85	1.17
DEF	3.31	0.49	0.84	1.38
PRO_T1	**-6.82** ***	**-2.42** ***	**-1.92** **	**-3.46** ***
PRO_T2	**-4.38** ***	**-1.41** *	-1.26	**-1.94** **
PRO_NT2	**-5.52** ***	**-1.76** **	-1.08	**-1.43** *
CPI	3.73	0.49	1.38	1.62
EUR	**-2.31** *	**-1.43** *	-1.05	**-2.15** **
PPI	3.35	0.51	0.46	**-4.28** ***
CPI_NT	4.71	0.96	2.12	4.80

Notes: Rejection of the null hypothesis of nonstationarity at a 10% (*), 5%(**) or 1%(***) significance level. Methodological details in Appendix II

Table 5. PPP test - model (17a)

	FMOLS estimates	PMGE estimates	MGE estimates
Dependent variable	*PPIM*	*PPIM*	*PPIM*
Explanatory variables			
PPP (EUR + PPIM_EUR)	0.991 (39.487)	0.950 (38.510)	0.800 (5.969)
Error Correction (Phi)		-0.086 (-4.551)	-0.123 (-5.773)
No. of countries	9	9	9
No. of quarters by countries	37 42 39 34 40 40 42 34 39	33 38 35 30 36 36 38 30 35	33 38 35 30 36 36 38 30 35
Lag truncation/ maximum lag	4	4	4

Notes: t-ratios in parentheses. Countries included in the panel: BUL, CZE, EST, HUN, LAT, LIT, POL, SLK, and SLO. For variable sources and definitions see section 3.1 and Appendix I.

Table 6. PPP test - model (17a) excluding Lithuania

	FMOLS estimates	PMGE estimates	MGE estimates
Dependent variable	*PPIM*	*PPIM*	*PPIM*
Explanatory variables			
PPP (EUR + PPIM_EUR)	1.269 (42.630)	0.952 (39.037)	0.915 (7.869)
Error Correction (Phi)		-0.088 (-4.107)	-0.126 (-5.274)
No. of countries	8	8	8
No. of quarters by countries	37 42 39 34 40 42 34 39	34 39 36 31 37 39 31 36	34 39 36 31 37 39 31 36
Lag truncation/ maximum lag	4	3	3

Notes: t-ratios in parentheses. Countries included in the panel: BUL, CZE, EST, HUN, LAT, LIT, POL, SLK, and SLO. For variable sources and definitions see section 3.1 and Appendix I.

Table 7. Panel Cointegration Test Statistics

	Without trend						
	panel				group		
	υ variance **statistic**	ρ **statistic**	**t statistic** non-parametric	**t statistic** parametric	ρ **statistic**	**t statistic** non-parametric	**t statistic** parametric
bb_01	1.64 *	-2.78 ***	-2.43 ***	-2.04 **	-2.21 **	-2.94 ***	-1.59 *
bb_02	2.10 **	-4.19 ***	-3.74 ***	-2.20 **	-3.60 ***	-4.68 ***	-0.59
bb_03	-1.92	1.34	1.11	1.48	1.05	0.44	0.30
hbs_01	-1.32	0.72	0.01	0.82	0.91	-0.65	0.17
hbs_02	-1.15	0.23	-0.13	-0.34	1.22	0.44	-0.09
hbs_03	-1.40	0.58	-0.18	0.26	0.28	-1.22	-0.38
hbs_04	-1.32	0.21	-0.33	-0.54	0.23	-0.54	-0.37
	With trend						
	panel				group		
	υ variance **statistic**	ρ **statistic**	**t statistic** non-parametric	**t statistic** parametric	ρ **statistic**	**t statistic** non-parametric	**t statistic** parametric
bb_01	1.03	-3.03 ***	-3.80 ***	-3.26 ***	-1.67 **	-3.81 ***	-2.91 ***
bb_02	1.40 *	-3.38 ***	-4.00 ***	-2.70 ***	-2.01 **	-4.04 ***	-1.84 **
bb_03	1.69 **	1.30	0.79	-0.20	2.28	1.26	0.05
hbs_01	0.42	-0.82	-1.50 *	-1.91 **	-0.05	-1.55 *	-1.96 **
hbs_02	-0.20	0.20	-0.90	-0.61	0.16	-1.67 **	-1.23
hbs_03	1.10	-2.47 ***	-3.93 ***	-4.40 ***	-1.76 **	-4.49 ***	-4.78 ***
hbs_04	0.35	-1.11	-3.08 ***	-3.45 ***	-1.27	-4.25 ***	-3.83 ***

Notes: Rejection of the null hypothesis of no cointegration at a 10% (*), 5%(**) or1%(***) significance level. Methodological details in Appendix II

Table 8. Estimation of the internal HBS (bb_01)

MODEL bb_01: dependent variable: RP1 explanatory variables PRO1						
COUNTRY (#obsFMOLS/# obsPMGE)	**FULLY MODIFIED OLS (FMOLS)**		**POOLED MEAN GROUP ESTIMATES (PMGE)**			
	Long-Run Coefficients		**Long-Run Coefficients**		**Error Correction Coefficients**	
	coefficient		coefficient		coefficient	
BUL (16/12)	-0.85	**				
CZE (40/36)	0.54	***			-0.61	***
EST (44/40)	0.77	***			-0.19	**
LIT (36/32)	0.91	***			-0.28	***
POL (36/32)	1.16	***			-0.11	***
ROM (24/20)	0.14				-0.23	*
SLK (36/32)	-0.20				-0.14	**
PANEL	**0.35**	***	**0.53**	***	**-0.37**	***

Notes: Variable significant at a 10% (*), 5%(**) or 1%(***) significance level. Methodological details in Appendix II. For sources and definitions see section 4.1 and Appendix I.

Table 9. Estimation of the internal HBS (bb_02)

MODEL bb_02: dependent variable: RP2 explanatory variables PRO2						
COUNTRY (#obsFMOLS/# obsPMGE)	**FULLY MODIFIED OLS (FMOLS)**		**POOLED MEAN GROUP ESTIMATES (PMGE)**			
	Long-Run Coefficients		**Long-Run Coefficients**		**Error Correction Coefficients**	
	coefficient		coefficient		coefficient	
BUL (16/12)	0.35	*			-0.69	***
CZE (40/36)	0.61	***			-0.54	***
EST (44/40)	0.95	***			-0.25	**
LIT (36/32)	0.84	***			-0.29	***
POL (36/32)	1.29	***			-0.16	***
ROM (24/20)	-0.41	***				
SLK (36/32)	0.18				-0.12	**
PANEL	**0.55**	***	**0.56**	***	**-0.43**	***

Notes: Variable significant at a 10% (*), 5%(**) or 1%(***) significance level. Methodological details in Appendix II. For sources and definitions see section 4.1 and Appendix I.

Table 10. Estimation of the internal HBS (bb_03)

MODEL bb_03:
dependent variable: RP3
explanatory variables PRO1

COUNTRY (#obsFMOLS/#obsPMGE)	FULLY MODIFIED OLS (FMOLS) Long-Run Coefficients		POOLED MEAN GROUP ESTIMATES (PMGE) Long-Run Coefficients		Error Correction Coefficients	
	coefficient		coefficient		coefficient	
BUL (11/9)	-0.51				0.15	*
CZE (40/38)	0.79	*			-0.01	
EST (39/37)	2.11	**			-0.05	***
HUN (36/34)	1.14	***			0.02	
LIT (32/30)	1.82	***			-0.15	***
POL (36/34)	1.22	***			0.02	*
ROM (24/22)	0.12				0.10	**
SLK (36/34)	0.66				0.00	
SLO (22/20)	1.10	***			0.01	
PANEL	**0.94**	*******	**2.53**	*******	**0.01**	

Notes: Variable significant at 10% (*), 5%(**) or 1%(***) significance level. Methodological details in Appendix II. For sources and definitions see section 4.1 and Appendix I.

Table 11. Estimation of the internal HBS (hbs_01)

MODEL hbs_01:
dependent variable: RER1
explanatory variables RPRO1

COUNTRY (#obsFMOLS/#obsPMGE)	FULLY MODIFIED OLS (FMOLS) Long-Run Coefficients		POOLED MEAN GROUP ESTIMATES (PMGE) Long-Run Coefficients		Error Correction Coefficients	
	coefficient		coefficient		coefficient	
BUL (16/12)	0.41				-0.41	**
CZE (40/36)	0.19				-0.09	*
EST (44/40)	0.30				-0.12	***
LIT (36/32)	-3.31	**			-0.07	*
POL (36/32)	-1.09	**			-0.10	*
ROM (24/20)	-0.75	**			-0.28	***
SLK (36/32)	0.75	**			-0.15	
PANEL	**-0.50**		**0.27**		**-0.18**	*******

Notes: Variable significant at a 10% (*), 5%(**) or 1%(***) significance level. Methodological details in Appendix II. For sources and definitions see section 4.1 and Appendix I.

Table 12. Estimation of the internal HBS (hbs_02)

MODEL hbs_02:
dependent variable: RER1
explanatory variables RPRO2

COUNTRY (#obsFMOLS/# obsPMGE)	FULLY MODIFIED OLS (FMOLS) Long-Run Coefficients		POOLED MEAN GROUP ESTIMATES (PMGE) Long-Run Coefficients		POOLED MEAN GROUP ESTIMATES (PMGE) Error Correction Coefficients	
	coefficient		coefficient		coefficient	
BUL (16/12)	-0.50					
CZE (40/36)	-0.38				-0.09	*
EST (44/40)	-4.01				-0.12	***
LIT (36/32)	-2.94	*			-0.07	**
POL (36/32)	-0.78				-0.12	**
ROM (24/20)	-0.70	*			-0.28	**
SLK (36/32)	0.20				-0.10	
PANEL	**-1.30**	***	**-0,14**		**-0.26**	**

Notes: Variable significant at a 10% (*), 5%(**) or 1%(***) significance level. Methodological details in Appendix II. For sources and definitions see section 4.1 and Appendix I.

Table 13. Estimation of the internal HBS (hbs_03)

MODEL hbs_03:
dependent variable: RP
explanatory variables PRO1

COUNTRY (#obsFMOLS/# obsPMGE)	FULLY MODIFIED OLS (FMOLS) Long-Run Coefficients		POOLED MEAN GROUP ESTIMATES (PMGE) Long-Run Coefficients		POOLED MEAN GROUP ESTIMATES (PMGE) Error Correction Coefficients	
	coefficient		coefficient		coefficient	
BUL (11/9)	0.21				-0.21	**
CZE (40/38)	0.15				-0.06	
EST (39/37)	0.46				-0.09	***
HUN (36/34)	-1.68	**			-0.02	
LIT (32/30)	-3.16	**			-0.08	*
POL (36/34)	-1.23	**			-0.14	**
ROM (24/22)	-0.54	*			-0.81	***
SLK (36/34)	0.88	*			-0.01	
SLO (22/20)	-1.09	***				
PANEL	**-0.67**	***	**-0,86**	***	**-0.21**	**

Notes: Variable significant at 10% (*), 5%(**) or 1%(***) significance level. Methodological details in Appendix II. For sources and definitions see section 4.1 and Appendix I.

Table 14. Estimation of the internal HBS (hbs_04)

MODEL hbs_04: dependent variable: RP2 explanatory variables PRO2			
COUNTRY (#obsFMOLS/#obsPMGE)	**FULLY MODIFIED OLS (FMOLS)**	**POOLED MEAN GROUP ESTIMATES (PMGE)**	
	Long-Run Coefficients	**Long-Run Coefficients**	**Error Correction Coefficients**
	coefficient	coefficient	coefficient
BUL (11/9)	0.36		-0.56 ***
CZE (40/38)	-0.39		-0.11 **
EST (39/37)	-3.56 **		-0.09 ***
HUN (36/34)	-2.22 **		-0.02
LIT (32/30)	-2.72 **		-0.07 **
POL (36/34)	-0.83		-0.10 *
ROM (24/22)	-0.46		-0.29 **
SLK (36/34)	0.01		-0.03
SLO (22/20)	-0.70 ***		
PANEL	**-1.17 *****	**-0.41 *****	**-0.25 ****

Note: Methodological details in section 6.3.

Table 15. The contribution of the HBS effect to annual dynamics of GVA deflator in CEECs (average annual percentage changes over indicated periods)

		Period	**BUL**	**CZE**	**EST**	**LIT**	**POL**	**ROM**	**SLK**
DEF (actual)		96-99	20.62	7.23	12.57	9.34	12.87	42.15	5.76
		00-03	3.59	3.21	4.22	0.49	3.57	31.70	5.29
MODEL	**Elasticity Produced by**	**HBS Cntribution:**							
bb_01	FMOLS	96-99		0.74	0.67	0.89	1.77	-0.81	0.10
		00-03	0.73	0.21	1.55	0.71	0.95	-0.42	0.12
	PMGE	96-99		1.20	0.97	1.27	2.48	-0.56	0.19
		00-03	0.87	0.39	2.35	1.14	1.43	-0.06	0.20
bb_02	both methods	96-99		1.79	1.05	1.28	3.03	-0.24	0.92
		00-03	-0.05	0.40	1.92	1.42	0.69	0.98	0.66

Note: Methodological details in section 6.3.

Table 16. The contribution of the HBS effect to CPI inflation in CEECs (average annual percentage changes over indicated periods)

		Period	BUL	CZE	EST	HUN	LIT	POL	ROM	SLK	SLO
CPI (actual)		96-99	344.31	7.53	11.38	16.55	9.94	13.46	74.92	7.30	8.08
		00-03	6.43	2.63	3.67	7.22	0.47	4.55	29.76	7.85	7.59
Model	**Elasticity Produced by**	**HBS CONTRIBUTION**:									
bb_03	FMOLS	96-99		1.44	0.92	0.94	0.53	1.52	2.23	0.31	0.90
		00-03	-0.73	0.66	2.66	0.81	0.68	1.17	0.78	0.51	1.30

Note: Methodological details in section 6.3.

Table 17. The contribution of the HBS effect to the appreciation of the real exchange rate (average annual percentage changes over indicated periods)

		Period	BUL	CZE	EST	HUN	LIT	POL	ROM	SLK	SLO
RER2 (actual)		96-99	-3.05	-2.66	-7.17	-1.58	-10.53	-2.44	-1.85	-0.89	0.70
		00-03	-5.52	-5.33	-2.43	-6.06	-5.02	-2.27	-3.94	-8.13	-2.07
Model	**Elasticity Produced by**	**HBS CONTRIBUTION**:									
HBS3	FMOLS	96-99	0.00	-1.88	-0.60	-1.83	-1.25	-2.93	-1.22	0.34	-1.82
		00-03	-0.24	-0.04	-3.05	-0.95	-1.40	-1.49	-1.41	0.53	-0.92
	PMGE	96-99	0.00	-2.41	-0.77	-2.35	-1.60	-3.76	-1.56	0.44	-2.34
		00-03	-0.31	-0.05	-3.92	-1.22	-1.80	-1.91	-1.81	0.68	-1.18
HBS4	PMGE	96-99		-1.53	-0.23	-0.78	-0.51	-2.10	1.59	-0.32	-1.99
		00-03	0.17	-0.03	-1.37	-0.54	-1.12	-0.09	-1.47	-0.18	-0.72
	FMOLS	96-99		-4.37	-0.66	-2.22	-1.45	-6.00	4.53	-0.92	-5.67
		00-03	0.50	-0.10	-3.92	-1.54	-3.19	-0.26	-4.21	-0.51	-2.05

Note: Methodological details in section 6.3.

Table 18. Group Mean FMOLS estimates of the elasticities in 2 subpanels

Observations with commit=0			**Observations with commit=1**		
BB MODELS			BB MODELS		
Model	coefficient		model	coefficient	
bb_01r0	0.15	***	bb_01r1	0.36	***
bb_02r0	0.50	***	bb_02r1	0.33	**
bb_03r0	0.81	***	bb_03r1	0.47	***
HBS MODELS			HBS MODELS		
model	coeffiecient		model	coeffiecient	
hbs_01r0	-0.58		hbs_01r1	0.13	
hbs_02r0	-1.27	*	hbs_02r1	0.25	
hbs_03r0	-0.67		hbs_03r1	-0.35	**
hbs_04r0	-1.00		hbs_03r1	-0.32	**

Notes: Variable significant at a 10% (*), 5%(**) or 1%(***) significance level. Methodological details in section 7.2.

Table 19. Internal HBS with regime dummies (bb_01)

BB_01: dependent variable: RP1					
Ordinary model			**Models with regime dummies**		
	coeff			**coeff**	
Fixed-effects (within) regression					
pro1	0.65	***	pro1	0.64	***
			commit	0.00	
Random-effects GLS regression					
pro1	0.65		pro1	0.64	***
			commit	0.01	
Cross-sectional time-series FGLS regression					
pro1	0.37	***	pro1	0.34	***
			commit	0.02	*
Linear regression, correlated panels corrected standard errors (PCSEs)					
pro1	0.62	***	pro1	0.61	***
			commit	0.02	***

Notes: Variable significant at a 10% (*), 5%(**) or 1%(***) significance level. Methodological details in section 7.2.

Table 20. Internal HBS with regime dummies

BB_02: dependent variable: RP2					
Ordinary model			Models with regime dummies		
	coeff			coeff	
Fixed-effects (within) regression					
pro2	0.67	***	pro2	0.68	***
			commit	0.00	
Random-effects GLS regression					
pro2	0.56	***	pro2	0.32	***
			commit	0.03	***
Cross-sectional time-series FGLS regression					
pro2	0.03		pro2	-0.09	**
			commit	0.05	***
Linear regression, correlated panels corrected standard errors (PCSEs)					
pro2	-0.34	***	pro2	-0.31	***
			commit	0.10	***

Notes: Variable significant at a 10% (*), 5%(**) or 1%(***) significance level. Methodological details in section 7.2.

Table 21. Internal HBS with regime dummies (bb_03)

BB_03: dependent variable: RP3					
Ordinary model			Models with regime dummies		
	coeff			coeff	
Fixed-effects (within) regression					
pro1	0.93	***	pro1	0.74	***
			commit	0.11	***
Random-effects GLS regression					
pro1	0.90	***	pro1	0.74	***
			commit	0.10	***
Cross-sectional time-series FGLS regression					
pro1	0.00		pro1	0.04	
			commit	0.01	
Linear regression, correlated panels corrected standard errors (PCSEs)					
pro1	0.41	***	pro1	0.43	***
			commit	-0.06	***

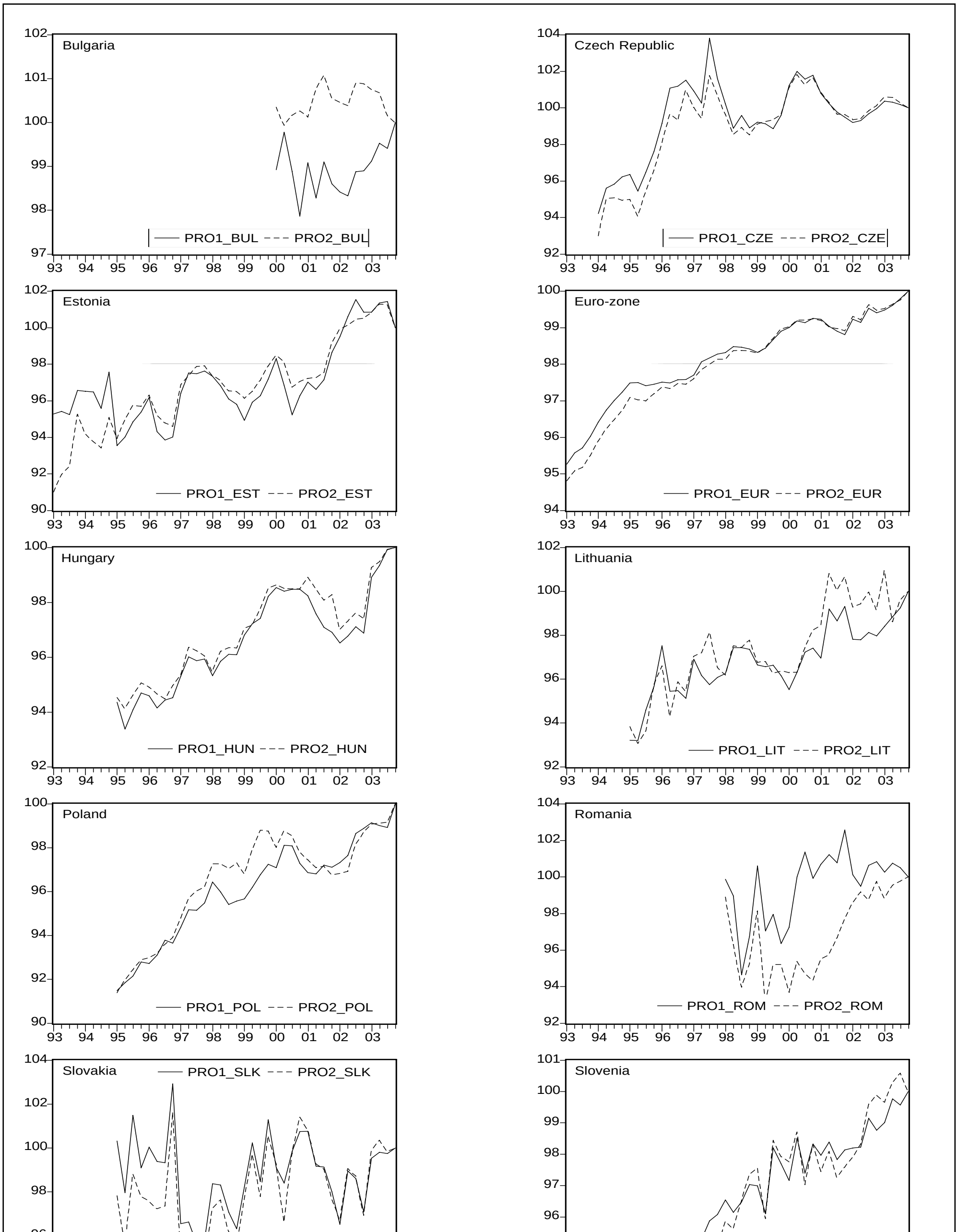
Notes: Variable significant at a 10% (*), 5%(**) or 1%(***) significance level. Methodological details in section 7.2.

Table 22. External HBS with regime dummies (hbs_03)

BB_03: dependent variable: RP3					
Ordinary model			Models with regime dummies		
	coeff			coeff	
Fixed-effects (within) regression					
pro1	0.93	***	pro1	0.74	***
			commit	0.11	***
Random-effects GLS regression					
pro1	0.90	***	pro1	0.74	***
			commit	0.10	***
Cross-sectional time-series FGLS regression					
pro1	0.00		pro1	0.04	
			commit	0.01	
Linear regression, correlated panels corrected standard errors (PCSEs)					
pro1	0.41	***	pro1	0.43	***
			commit	-0.06	***

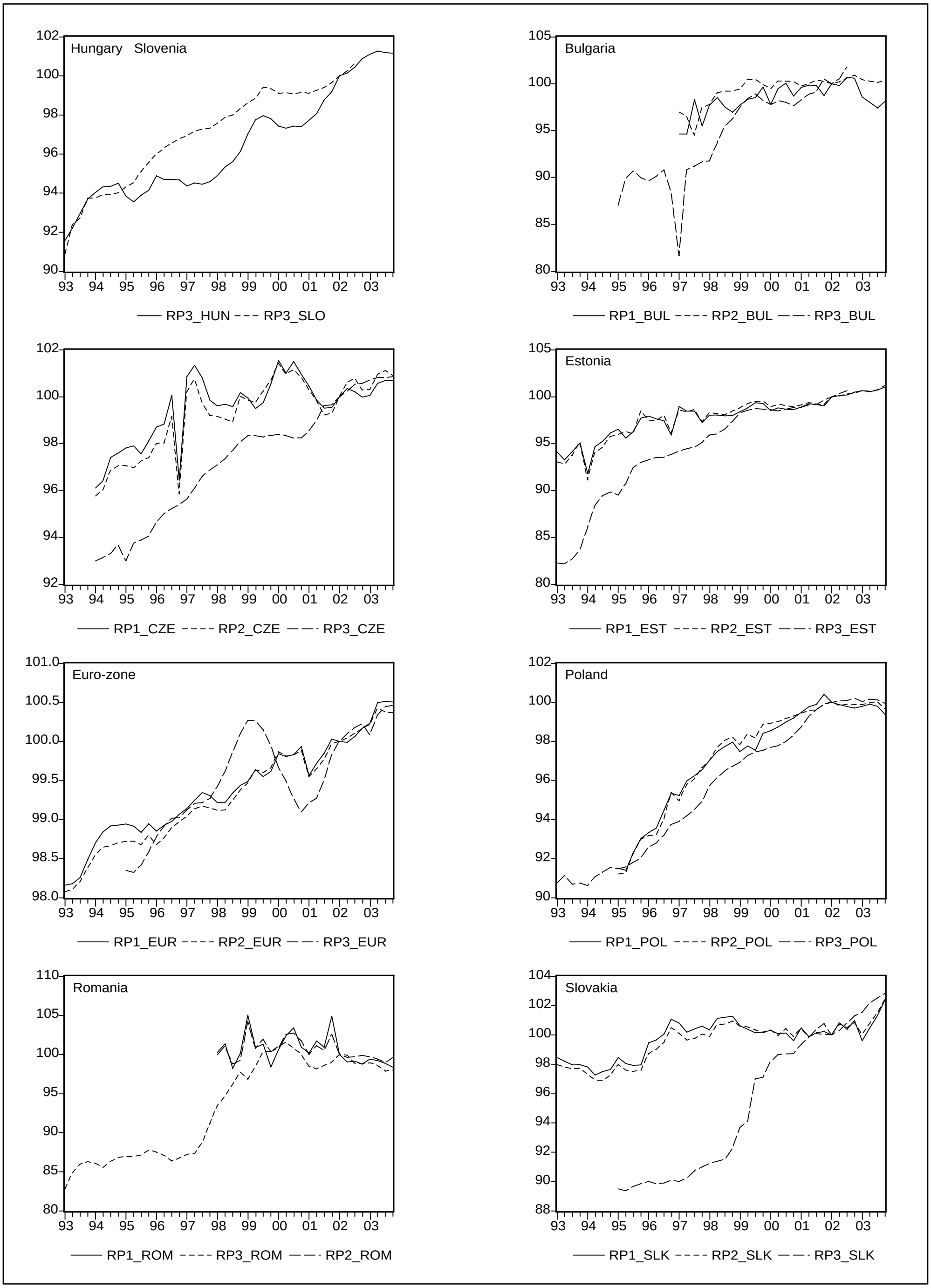
Notes: Variable significant at a 10% (*), 5%(**) or 1%(***) significance level. Methodological details in section 7.2.

Figure 1. Relative productivity indices in CEECs, 2003:Q4=100



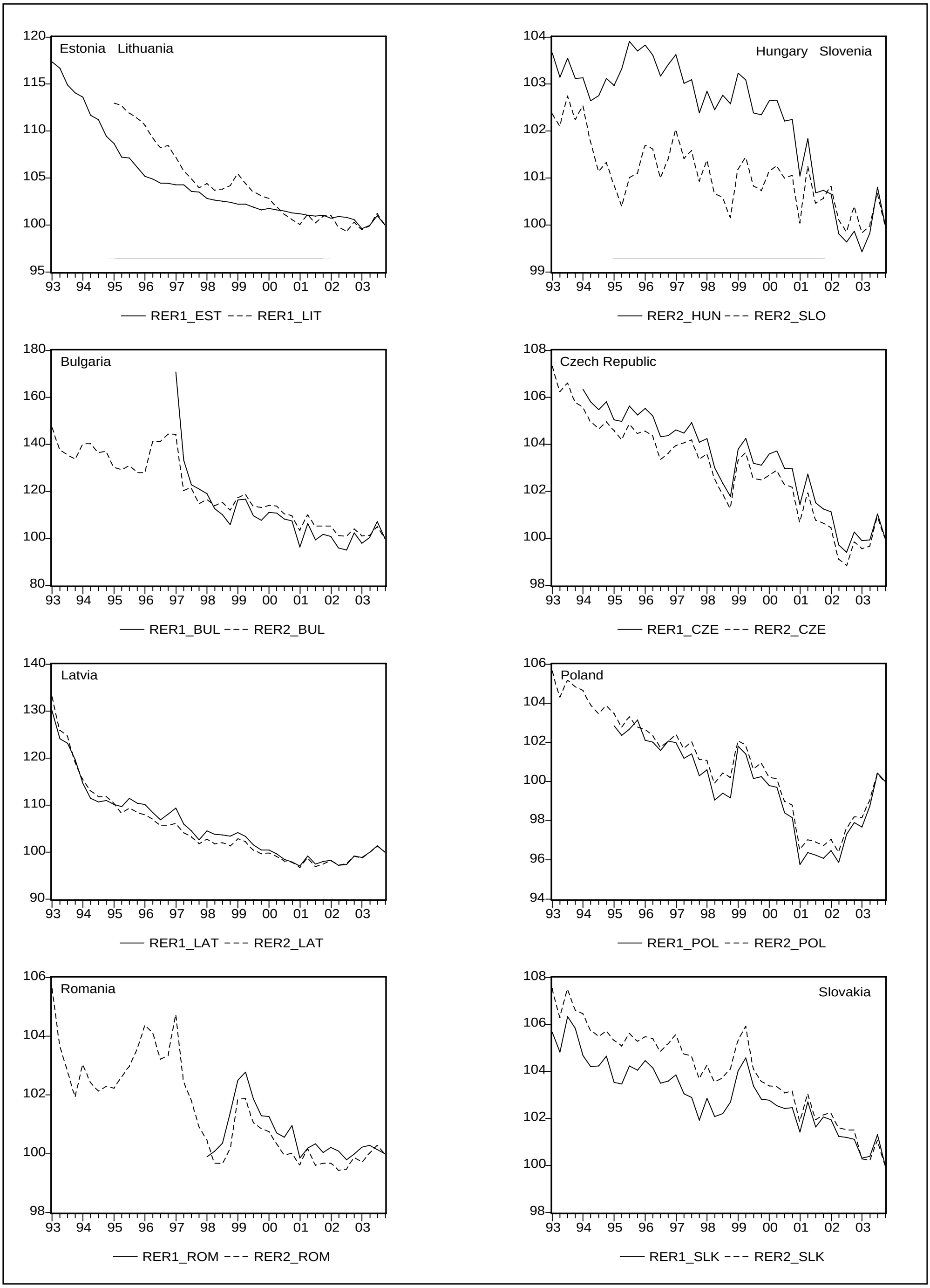
Note: *PRO* are ratios of productivity in tradables to productivity in nontradables;
For sources and definitions see Section 4.1 and Appendix I

Figure 2. Relative price indices in CEECs, 2002:Q1=100



Note: *RP* are ratios of the price level of nontradables relative to the price level of tradables,
For sources and definitions see Section 4.1 and Appendix I

Figure 3. Real exchange rate indices in CEE, 2003:Q4=100



Note: *RER1* - deflated with GVA deflators, *RER2* - deflated with *CPI*
For sources and definitions see Section 4.1 and Appendix I

Figure 4. Sectoral division problems - diagram illustration

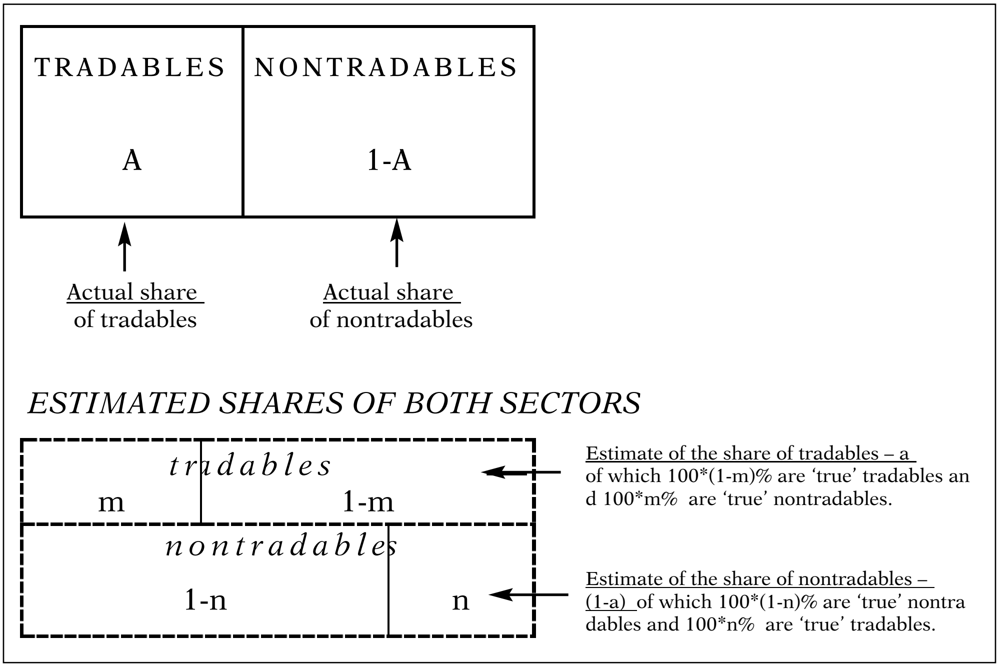
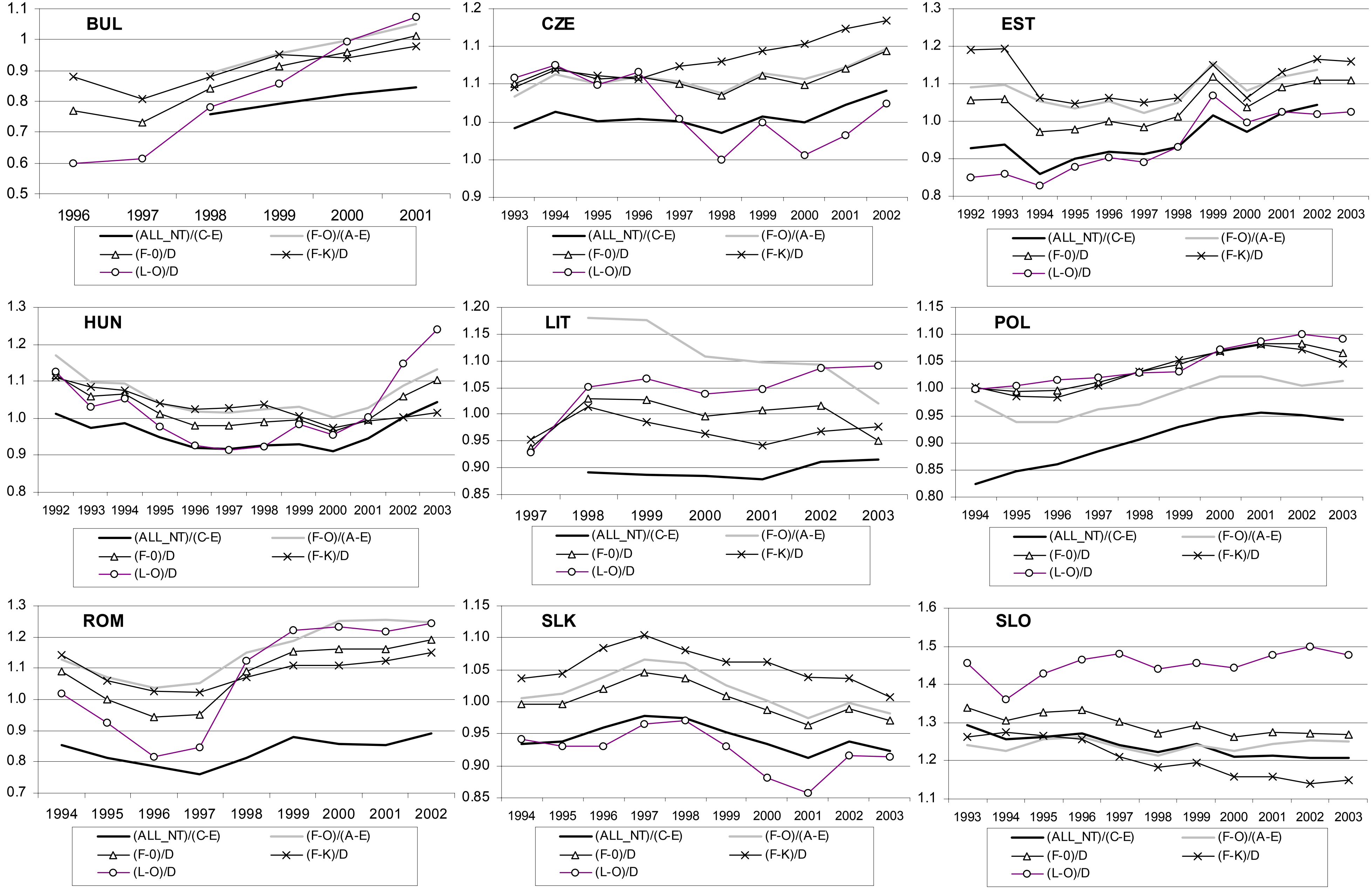
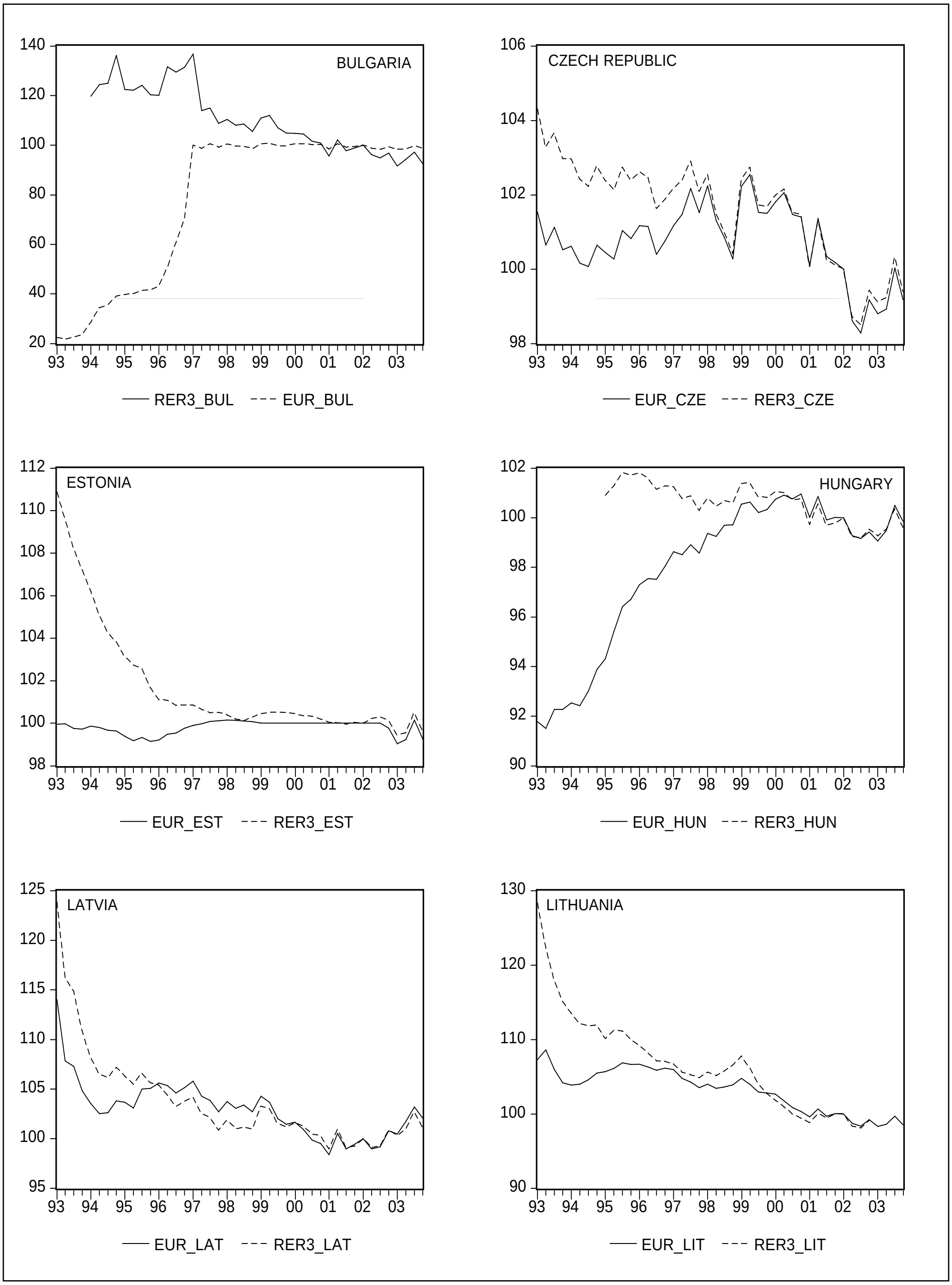


Figure 5: Wage ratios in CEECs



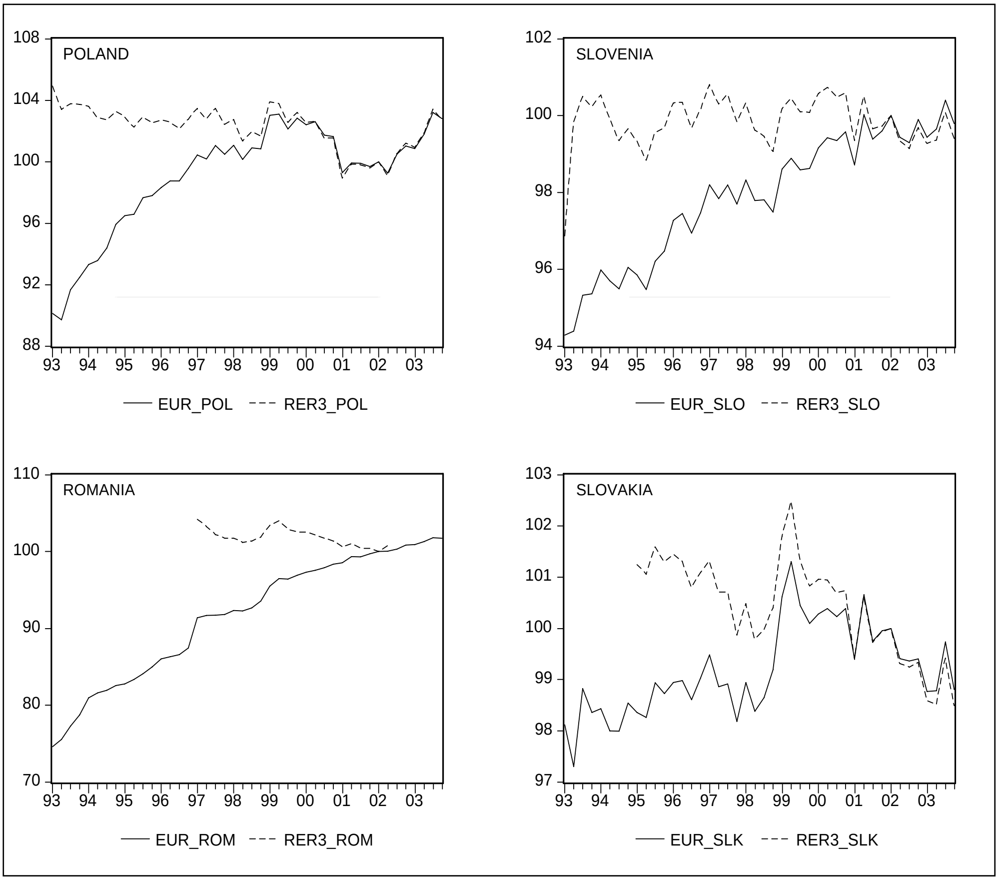
Note: For sources and definitions see Section 5.2

Figure 6.1. Indices of nominal exchange rate and real exchange rate deflated by producer prices in manufacturing (BUL, CZE, EST, HUN. LAT, LIT); 2002:Q1=100



Note: *EUR_xxx* denotes nominal euro exchange rate
RER3_xxx denotes real euro exchange rate deflated by producer prices in manufacturing

Figure 6.2. Indices of nominal exchange rate and real exchange rate deflated by producer prices in manufacturing (POL, ROM, SLK, SLO); 2002:Q1=100



Note: EUR_xxx denotes nominal euro exchange rate
RER3_xxx denotes real euro exchange rate deflated by producer prices in manufacturing

Appendix I. Data sources and definitions

The following variables are calculated for each country separately.

Name	Definition	Source
P_Ti	Value Added Deflator for tradables (i=1,2 indicate two alternative definitions of the sector, see note below)	Eurostat
P_NT	Value Added Deflator for nontradables	Eurostat
DEF	Deflator of Gross Value Added	Eurostat
CPI_NT	CPI prices of services (definition differs across countries)	MEI-OECD and national sources
PPIM	Producer price index for manufacturing (with exception of BUL)	IFS-IMF and national sources
RPi	$\frac{P\_NT}{P\_Ti}$; prices of nontradables relative to tradables (i=1,2 indicate two alternative definitions of the sector, see note below)	
RP3	$\frac{CPI\_NT}{PPIM}$; relative prices (non-tradables vs. tradables)	
EUR	Nominal exchange rate: domestic currency per unit of the euro (increase = depreciation)	IFS-IMF
RER1	$\frac{EUR\_xxx * DEF\_EU}{DEF\_xxx}$ Real exchange rate of the euro deflated by gross value added deflators	
RER2	$\frac{EUR\_xxx * CPI\_EU}{CPI\_xxx}$ Real exchange rate of the euro deflated by CPI	
RER3	$\frac{EUR\_xxx * PPI\_EU}{PPIM\_xxx}$ Real exchange rate of the euro deflated by the PPI in manufacturing	
VA_Ti	Value added at constant prices in the tradable sector (i=1,2 indicate two alternative definitions of the sector, see note below)	Eurostat
VA_NT	Value added at constant prices in the non-tradable sector	Eurostat
EMP_Ti	Employment in the tradable sector (i=1,2 indicate two alternative definitions of the sector, see note below)	Eurostat
EMP_NT	Employment in the non-tradable sector	Eurostat
PRO_Ti	$\frac{VA\_Ti}{EMP\_Ti}$; productivity in the tradable sector (i=1,2 indicate two alternative definitions of the sector, see note below)	
PRO_NT	$\frac{VA\_NT}{EMP\_NT}$; productivity in the non-tradable sector	
PROi	$\frac{PRO\_Ti}{PRO\_NT}$; relative productivity (tradables vs. non-tradables) (i=1,2 indicate two alternative definitions of the sector, see note below)	
RPROi	$\frac{PROi\_xxx}{PROi\_EUR}$; relative productivity (tradables vs. non-tradables) in country xxx relative to the euro zone (i=1,2 indicate two alter native definitions of the sector, see note below)	

The euro-zone data is collected from the ECB's monthly bulletin and OECD databases.

Two alternative definitions of the sectoral division are as follows:

1)with the subscript '1' where the tradable sector comprises industry only, i.e. sections C, D and E of the NACE[59] classification of the economic activity (mining and quarrying, manufacturing industries as well as electricity, gas and water supply),

2) with the subscript '2' where the tradable sector comprises industry as well as agriculture, forestry and fishing, i.e. sections A, B, C, D and E of the NACE classification of the economic activity.

Country abbreviations:
BUL – Bulgaria, CZE – the Czech Republic, EST – Estonia, HUN – Hungry, LAT – Lithuania, LIT – Lithuania, POL – Poland, SLO – Slovenia, SLK – the Slovak Republic, and EUR – the euro zone.

[59] NACE is the Classification of Economic Activities in the European Community compatible with ISIC - the International Standard Industrial Classification of all Economic Activities.

Appendix II. Methodological notes

Panel Unit Root Tests

Consider a panel equation of *y*:

(II-1) $$y_{it} = \rho_i y_{i,t-1} + z'_{it}\gamma + e_{it}$$

where:
z_{it} is the deterministic component in the model and can take the form of the constant, time trend, etc.
e_{it} are IID($0,\sigma_e^2$)

The first-difference form the above equation can be written as follows:

(II-2) $$\Delta y_{it} = \rho_i^* y_{i,t-1} + \sum_{L=1}^{p_i} \theta_{iL} \Delta y_{i,t-L} + z'_{it}\gamma + u_{i,t}$$

where ρ_i*=ρ_i *-1*

The IPS test (Im et al., 2002) involves testing for unit roots by means of the standardized t-statisic based on the augmented Dickey-Fuller statistics averages across all groups. Thus, the group-specific *ńi* as well as the number of lags *pi* are allowed to vary across different groups. The test hypotheses are as follows:
H_0: $\rho_i^*=0$ *for all i's*
H_1: $\rho_i^*<0$ *for at least one group.*
Thus, under the null hypothesis series in all groups contain a unit root and under an alternative there is at least one series that is stationary.

In contrast, the Levin-Linn tests (Harris and Sollis, 2003) require that $\rho_i=\rho$ for all *i*'s. Specific forms of the test vary with respect to imposing homogeneity on the number of lags and coefficients in the autoregressive and deterministic component of equation II-2. Therefore the test hypotheses are:
H_0: $\rho^*=0$
H_1: $\rho^*<0$.
Thus, under the null hypothesis series in all *i* groups contain a unit root and the alternative is that all *i* series are stationary. Clearly, the LL test is therefore, far more restrictive than the IPS test.

Table 4 contains 6 different versions of the LL test that differ with respect to the form of the deterministic component matrix, *z* and to imposing homogeneity on the number of lags and/or equality of autoregressive coefficients. There are 2 versions of the IPS test: one including a trend and another one without a trend.

Panel cointegration tests

Panel cointegration tests proposed by Pedroni (1999) involve estimating the panel cointegration regression of the general fully unrestricted form:

(II-3) $$y_{i,t} = \alpha_i + \delta_i t + \beta_{1i} x_{1i,t} + \beta_{2i} x_{2i,t} + \ldots + \beta_{Mi} x_{Mi,t} + e_{i,t}$$

where
$t=1,\ldots,T$ refers to the number of observations over time
$i=1,..,N$ refers to the number of individual members of the panel and
$m=1,\ldots,M$ refers to the number of regression variables.

Tests of the null hypothesis of no cointegration are based on the residuals $\hat{e}_{it}$ estimated using:
(II-4) $\hat{e}_{it} = \rho_i \hat{e}_{i,t-1} + v_{it}$

There are several alternative forms of the test (see table 7) depending on the way the dynamics are taken into account to correct for serial correlations (Harris and Sollis, 2003). In addition, two modes of estimating equation II-3 are considered. Panel statistics involve pooling the data within-dimension, whereas group statistics are averages of group-specific statistics (analogous to group-means FMOLS estimates discussed below). As a consequence the alternative hypotheses vary in these two types of tests. While the null hypothesis for both of them is the hypothesis of no cointegration, the alternative hypotheses are as follows:

H1: $\rho_i = \rho < 1$ *for all i's* for panel statistics
H1: $\rho_i < 1$ *for all i's (allowing for heterogeneity of coefficients)* for group statistics

The exact formulas for the test statistics are given in Pedroni (1999, pp. 660-661).
The test statistics have been standardized by Pedroni (1999) who also provided appropriate critical values. Under the alternative hypothesis, the panel variance statistics diverges to positive infinity, while for all the other six tests, test statistic diverge to negative infinitity.

Group-Means Fully Modified Ordinary Least Squares (Group-Means FMOLS)[60]

The group means FMOLS by Pedroni (2000) involves averaging of FMOLS estimators calculated separately for each group (country). The FMOLS procedure corrects the OLS estimator in a semi-parametric way to eliminate bias related to the endogeneity of regressors (contemporaniety and the failure of weak exogeneity).

We consider a simple bivariate panel regression with N groups (i = 1,..N) and T observations (t=1,…T):

(II-5) $$y_{it} = \alpha_i + \beta_i x_{it} + u_{it}$$

The group means FMOLS estimator of β is given by:

(II-6) $$\hat{\beta}^*_{GFM} = N^{-1} \sum_{i=1}^{N} \hat{\beta}^*_{FM,i}$$

which is a simple average of FMOLS estimators for each individual group:

$$\hat{\beta}^*_{FM,i} = \left(\sum_{i=1}^{T} (x_{it} - \overline{x}_i)^2 \right)^{-1} \left(\sum_{i=1}^{T} (x_{it} - \overline{x}_i)\, y^*_{it} - T\hat{\gamma}_i \right)$$

(II-7) *where*

$$y^*_{it} = (y_{it} - \overline{y}_i) - \frac{\hat{\Omega}_{21i}}{\hat{\Omega}_{22i}} \Delta p_{it}$$

$$\hat{\gamma}_i = \hat{\Gamma}_{21i} + \hat{\Omega}^0_{21i} - \frac{\hat{\Omega}_{21i}}{\hat{\Omega}_{22i}} \left(\hat{\Gamma}_{22i} + \hat{\Omega}^0_{22i} \right)$$

And $\hat{\Omega}$ *and* $\hat{\Gamma}$ are covariances and weighted sums of covariances obtained from long-run covariances matrix of (II-5) (for details see Pedroni, 2000).

Likewise, the group-means FMOLS t-statistics can be constructed from the within-group FMOLS t statistics as an average of within-group FMOLS t statistics multiplied by square root of N.

In the case of estimations in our paper (tables 8-14), the FMOLS procedure yields long-run estimates in line with (II-5) estimated separately for each country as well as a panel estimate calculated as a simple average of country-specific coefficients (in line with II-6). Thus, group-means FMOLS allows for heterogeneity of long-run coefficients among

[60] Pedroni (2000) and Harris and Sollis (2003)

groups (countries) which makes a panel estimate sensitive to outliers in the within-group estimators.

Pooled Means Group Estimates (PMGE)

The PMGE procedure due to Pesaran et al. (1999) involves estimating ARDL models as well as their error correction representations with explicit long-run relationships. For each group (country) in a panel, an error correction model (ECM) is estimated with a homogeneity restriction imposed on long-run coefficients, whereas short-run coefficients are allowed to vary and are averaged across groups.

We consider a panel with N groups (i=1,..N) and T observations (t=1,…T) modelled by an ARDL (p,q). If we assume that a stable, long-run relationship exists between model variables and that long-run coefficients are restricted to be the same across groups, the modelled relationship (with time-series observations stacked up for each group) can be written as:

(II-8)
$$\Delta y_i = \phi_i \zeta_i(\theta) + W_i \kappa_i + \varepsilon_i$$
$$where$$
$$\zeta_i(\theta) = y_{i,-1} - X_i \theta$$

ζ_i denotes the error correction coefficient (ECM),
Δ denotes first difference ($\Delta y_i = y_i - y_{i,-1}$),
$y_{i,-j}$ denotes a series lagged j periods
X_i is the matrix of explanatory variables
$W_i = (\Delta y_{i,-1}, \ldots, \Delta y_{i,-p+1}, \Delta X_i, \Delta X_{i,-1}, \iota)$
$\iota = (1,\ldots,1)'$ denotes a T x 1 vector of ones.
κ - short-run coefficients on autoregressive part, X and a constant term, respectively
ϕ_i – group-specific ECM terms.
θ – common long-run parameter
$Var(\varepsilon_{it}) = \sigma_i^2$

Estimation of the parameters of interest (ϕ_i, θ, σ_i^2) are done by maximising the associated log-likelihood function.

As II-8 suggests, the PMG estimation imposes a common long-run coefficient on the panel and allows all short-term coefficients (ECMs as well as coefficients in κ) to vary. The name of these estimators highlights both 'pooling' implied by homogeneity restrictions imposed on long-run coefficients as well as the averaging across groups used to obtain means of the estimated short-run coeffiecients. Thus, a PMGE can be viewed as an intermediate approach between the mean group estimator (the average of separate estimates for each group) and fixed/random effects panel models which allow only an intercept to vary across groups – all other coefficients and error variances are constrained to be homogenous (Pesaran *et al.*, 1999).

Appendix III. Exchange rate regimes and the HBS effect

The productivity growth differential between the tradable and non-tradable sector can be expressed as:

$$\ln \frac{W}{P^{N}} > \ln \frac{W}{P^{NT}} \Rightarrow \ln P^{T} - \ln W < \ln P^{NT} - \ln W$$

The law of one price in the tradable sector:

$$Q^{T} = \frac{EP^{T*}}{P^{T}} = 1 \Rightarrow \ln P^{T} = \ln E + \ln P^{T*}$$ where $\ln P^{T*}$ is assumed to be equal zero.

and the domestic CPI

$$P = (P^{N})^{a} (P^{NT})^{1-a} \Rightarrow \ln P = a \ln P^{N} + (1-a) \ln P^{NT}$$

In the case of a fixed exchange rate regime we obtain

$$\ln E = 0 \Rightarrow \ln P^{T} = 0, \ln P^{NT} > 0, \ln P > 0$$

where the magnitude of the CPI inflation depends on the size of the share of the non-tradable sector (1-a) in the CPI.

In the case of upward flexibility of an exchange rate:

$$\ln E \leq 0 \Rightarrow \ln P^{T} \leq 0, \ln P^{NT} \in (P^{T};+\infty), P \in (-\infty,+\infty)$$

In the case of downward flexibility of an exchange rate

$$\ln E \geq 0 \Rightarrow \ln P^{T} \geq 0, \ln P^{NT} \geq 0, P \in (0,+\infty)$$

Appendix IV. Exchange rate regime classification

Despite similar economic and geo-political situation at the beginning of the transition, different economies in Central and Eastern Europe have opted for different and completely uncoordinated paths of improving macroeconomic stability and growth. The Czech Republic started with a peg, widened its band in 1996 and proceeded to managed float in 1997. Hungary started with a frequently adjusted peg, adopted a crawling peg in 1995 and moved to a crawling band in 1998, so as to finally broaden this band to +/- 15% in 2001. Poland started with the adjustable peg in 1990, moved to a crawling peg in 1991, which was converted into the crawling band in 1995, bands of which were gradually widened in 1998-1999 finally resulting in adoption of a fully floating exchange rate regime in 2000. Estonia had a currency board from 1992. Lithuania and Bulgaria, on the other hand, started with floating rates to retreat to currency boards in 1994 and 1997 respectively.

This wide range of choices revealed different starting points (e.g. availability of monetary reserves) and different macroeconomic conditions: differentials in the levels of credibility of monetary authorities; diverse degrees of the need for effective macroeconomic stabilisation (Calvo and Reinhart, 2002); different initial inflation developments; or finally different structures of the real sector, which may have resulted in different lobbying patterns. An analytical classification of exchange rate regimes into floating, intermediate and fixed exchange rate regime used in this paper builds on Kowalski et al. (2003) and is included in the Appendix III. In practical implementation, the differences between the exchange rate polices have been less pronounced. Fixers had to change the official parity or widen the permissible bands of fluctuations and floaters frequently intervened in the exchange rate markets.

In classifying the regimes, one possibility is to follow a *de jure* classification based on the public declarations made by each countries' authorities. Such information is also provided, for instance, by the IMF (1999), which distinguishes eight categories, ranging from the adoption of another currency (dollarisation, euroisation) to an independent float. However, it is widely known that *de facto* regimes often differ from officially declared regimes (Calvo and Reinhart, 2002).

The differences between declarations and reality have stimulated efforts to find algorithmic methods for classifying regimes based on available data (usual parameters include nominal exchange rates, international reserves and interest rates). Levy-Yeyati and Sturzenegger (2002) undertook such an approach and provided a classification of exchange rate regimes for a large set of countries. Such methods, however, also have drawbacks and in particular cases may fail to provide realistic descriptions. Ghosh, Gulde and Wolf (2002) propose a "consensus" classification based on the de jure classification eliminating cases where the actual exchange rate behavior is markedly different from official classification. Reinhart and Rogoff (2002) base their "natural classification' on the actual behavior of exchange rates. The latter approach does not however distinguish between the case where exchange rate behavior is a result of shocks affecting the economy and authorities' attempts to affect the exchange rate movements. Maliszewska and Maliszewski (2004) use both these classification in an investigation of stability and inflation properties of various exchange rate regimes and compare the results between the two classifications.

Overall, however, the approach chosen should reflect the angle taken in the particular study. Given the relatively small and specific sample of countries that are of interest in this project, combined with the need for classification on a quarterly basis a modified version of the classification provided in Kowalski, Paczynski and Rawdanowicz (2003) is used. This classification comprises three exchange rate regimes (peg, intermediate and float) and reflects information on both official declarations made by monetary authorities (an overview can be found in de Souza, 2002) and data from Levy-Yeyati and Sturzenegger (2002). In the opinion of authors of these classification such an approach provides a good description of the de facto exchange rate regimes pursued by the group of CEE countries in the period 1994-2002 (see Appendix III). By necessity this classification is to some extent arbitrary. First of all, classification of Slovakian and Czech fixed but adjustable regimes at the beginning of the period as fixed, and thereby analytically equivalent to currency boards in Estonia and Lithuania, may be considered problematic. Secondly, the current exchange rate regime in Slovakia is classified as managed floating according to the IMF definition and as floating in the discussed classification. As discussed in Kowalski (2003) the incidence of fixed exchange rates is concentrated at the beginning of the sample and the incidence of the floating exchange rates at the end of the sample. This may pose some problems with interpretation of econometric results. In particular, some effects characteristic for the beginning of transition process may be incorrectly interpreted as consequences of fixed exchange rate regime and effects characteristic of later stages of transition as a consequence of floating exchange rate regime.