Equilibrium Real Exchange Rates in Acceding Countries: How Large is Our Confidence (Interval)?

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Abstract

This paper sets out to estimate equilibrium real exchange rates of the Czech Republic, Hungary, Poland, Slovakia and Slovenia. A theoretical model is developed that provides an explanation of the appreciation of the real exchange rate based on tradable prices in the acceding countries. Our model can be considered as a competing but also completing framework to the traditional Balassa-Samuelson model. With this as a background, alternative cointegration methods are applied to time series (Engle-Granger, DOLS, ARDL and Johansen) and to three small-size panels (pooled and fixed effect OLS, DOLS, PMGE and MGE), which leaves us with around 5000 estimated regressions. This enables us to examine the uncertainty surrounding estimates of equilibrium real exchange rates and the size of the underlying real exchange rate distorsions.

1 Introduction

The up-coming enlargement of the European Union catapulted the issue of equilibrium exchange rates of CEE acceding countries into the limelight of policy discussion. In contrast with Denmark and the UK, the new member states do not have an opt out clause from the euro, and are thus obliged to adopt the euro at some point in the future. Sooner or later, it will be therefore necessary to assess what exchange rate might be best suited for entry to ERM-II and for the irrevocable conversion rate.

In accordance with the Maastricht Treaty, important pre-requisits for participation in the monetary union are low inflation and a stable exchange rate for at least two years before examination of convergence. A considerably undervalued exchange rate parity could, however, make it hardly possible to attain low inflation. At the same time, fixing the exchange rate at an overvalued level against the euro would most probably require adjustment mechanisms that harm growth and thus real convergence. The irrevocable conversion rate should therefore trigger neither inflation because of too large undervaluation, nor an immediate loss of competitiveness due to overvaluation. This is all the more important since with fully liberalised capital accounts as a background, financial markets may be eager to test the chosen parity especially in the presence of policy-mixes in the acceding countries perceived as unsustainable. This may induce exchange rate fluctuations incompatible with the criterion on exchange rate stability.

However, assessing equilibrium real exchange rates is no easy task. As argued earlier in this issue of Focus on Transition[2], a systematic analysis that includes all the alternative theoretical and statistical approaches is necessary that enables us to be capable of judging confidently upon equilibrium real exchange rates. Nonetheless, such studies are quasi non-

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[2] Égert (2003a)

existent for acceding countries[3]. One exception is Csajbók (2003) who, in the spirit of Detken et al. (2002), makes use of different approaches to the equilibrium real exchange rate such as the Natural Rate of Exchange (NATREX), the Behavioural Equilibrium Exchange Rate (BEER) and different versions of the Fundamental Equilibrium Exchange Rate (FEER) to derive a range of real misalignments (defined as the difference between the equilibrium and the observed real exchange rates) for the case of Hungary. Although Csajbók (2003) employs all important theoretical approaches, the empirical investigation is rather limited.

This can only mark the beginning of a systematic assessment. Indeed, in this paper, an attempt is made to contribute to the systematic evaluation of equilibrium rates in acceding countries. For 5 acceding countries from Central and Eastern Europe, notably the Czech Republic, Hungary, Poland, Slovakia and Slovenia, reduced form estimations of the real exchange rate are performed. Emphasis is laid more on the comparison of results of different estimation methods than on different theoretical approaches. A number of time series and panel cointegration methods are employed, which leaves us with a score of estimates. This enables us to examine the uncertainty surrounding estimates of equilibrium exchange rates and the size of the real misalignment.

Our approach to the real exchange rate is in line with BEER such as in MacDonald (1997) and Clark and MacDonald (1998), i.e. the choice of the variables included into the reduced form equation is in principle based on a number of standard models of the real exchange rate (cf. MacDonald(1997), Clark and MacDonald(1998)).

However, in the case of transition economies, special attention should be devoted to the appreciation of the real exchange rate that most of these countries witnessed in the aftermath of economic transformation from plan to market. The traditional view is that the Balassa-Samuelson (B-S) effect, based on market service inflation fuelled by productivity increases in the open sector, is capable of explaining this. Recent research, however, attributed a strikingly low relevance to the B-S effect in this respect. Indeed, a sustainable appreciation of the real exchange rate can come also through changes in regulated prices, and most importantly, via the appreciation of the tradable prices-based real exchange rate[4]. Taking account for tradable prices appears crucial given the fact that in a number of transition economies the real exchange rate deflated by means of tradable prices (proxied with the producer price index) appreciated nearly as much as the real exchange rate based on overall inflation (proxied with the consumer price index).In this paper, a theoretical model is introduced that provides an explanation for this phenomenon.

The rest of the paper is outlined as follows: Section II presents the theoretical framework for the appreciation of the real exchange rate based on the price of tradable goods. Section III offers some stylised facts on real exchange rates in transition economies. In Section IV, the reduced form equation is discussed. Section V describes the dataset and overviews econometric techniques. Section VI then interprets the estimation results followed by the presentation of the derived real misalignment. Finally, Section VII concludes.

2 The Model

Let us consider a two-country, two-good framework where the external equilibrium is defined as a balanced trade account with abstraction made from capital flows. The supply sides of the home and foreign economies can be described as functions of capital, labour and total factor productivity, which in turn depends on technology *t*. The level of technology

[3] However, it should be noted that this is also the case for other developed and developing countries.

[4] For an overview, see Égert (2003)

is initially higher in the foreign economy compared with that in the domestic economy. This implies higher GDP per capita in the foreign country. Each country produces one good and consumes both. Goods are at least imperfect substitutes, so that purchasing power parity (PPP) does not hold. Let us now assume that while $t^* > t$ (the asterisk denotes the foreign economy), technology changes faster in the domestic economy ($dt^* < dt$). Hence, GDP growth is higher in the domestic economy due to technological catch-up.

The demand side of the two economies is based on utility functions. The utility function of each economy includes both the foreign and the domestic goods. The utility of consuming the domestic good is a positive function of technology: The higher the technological content, the higher the utility. Demand for the domestic good therefore depends on technology. With increasing technological content, demand for the domestic good increases both in the domestic and the foreign economy. In addition, it is assumed that in the home country, demand for the foreign good is negatively linked to the technological content of the domestic good. It does not affect the demand for the foreign good in the foreign economy, though.

Prices are assumed to be fixed, so that the relative price of the domestic and foreign good is given by the bilateral nominal exchange rate. Prices are fixed in the foreign currency and the exchange rate is defined as units of domestic currency per unit of one foreign currency. Based on these assumptions, the nominal exchange rate, i.e. the relative price of the domestic good to that of the foreign good can be derived from the balanced current account (or trade balance).

Exports (X) of the home economy depend on foreign demand for the domestic good. Thus, domestic exports are a function of foreign income, technological content of the domestic good and the relative price of the domestic to foreign goods:

$$X = X(\overset{+}{Y^*}, \overset{+}{t}, \overset{+}{E}) \tag{1}$$

where E is the nominal exchange rate. Exports are a positive function of foreign income and domestic technology. Note that an increase in the nominal exchange rate (depreciation) boosts exports, because with a depreciated exchange rate domestic firms may want to export more.

Imports (M) are a positive function of domestic income and depends negatively on domestic technological content and the relative price of home to foreign goods. The negative relationship between imports and the nominal exchange rate shows that an increase in the relative price of the foreign good (depreciation) lowers import demand in the home country:

$$M = M(\overset{+}{Y}, \overset{-}{t}, \overset{-}{E}) \tag{2}$$

Equilibrium is determined when the current account is balanced. Note that because of the assumption of no capital flows, the current account (CA) equals the trade balance. Hence:

$$CA = 0 \tag{3}$$

$$P \cdot X = P^* \cdot M \tag{4}$$

where P and P* stand for the price of the domestic and foreign goods. The equilibrium condition can be derived by substituting export (Eq.(1)) and import (Eq.(2)) demand into Eq. (4):

$$CA = 0 = P \cdot X(\overset{+}{Y}{}^*, \overset{+}{t}, \overset{+}{E}) - P^* \cdot M(\overset{+}{Y}, \overset{-}{t}, \overset{-}{E}) \tag{5}$$

The change of the nominal exchange rate, i.e. the relative price of domestic to foreign good, which is due to the growth of technology in the domestic economy can be shown from the total differential of this equilibrium condition:

$$dCA = P \cdot \left[\frac{\partial X}{\partial Y^*} dY^* + \frac{\partial X}{\partial t} dt + \frac{\partial X}{\partial E} dE \right] - P^* \cdot \left[\frac{\partial M}{\partial Y} \frac{\partial Y}{\partial t} dt + \frac{\partial M}{\partial t} dt + \frac{\partial M}{\partial E} dE \right] \tag{6}$$

Setting the rate of growth of foreign GDP to 0, i.e. $dY^* = 0$, and re-arranging terms as in Eq. (7) – (9), the total differential becomes

$$P \cdot \frac{\partial X}{\partial E} dE - P^* \frac{\partial M}{\partial E} dE = P^* \frac{\partial M}{\partial Y} \cdot \frac{\partial Y}{\partial t} dt + P^* \frac{\partial M}{\partial t} dt - P \cdot \frac{\partial X}{\partial t} dt \tag{7}$$

$$\left[P \cdot \frac{\partial X}{\partial E} - P^* \frac{\partial M}{\partial E} \right] \cdot dE = \left[P^* \frac{\partial M}{\partial Y} \cdot \frac{\partial Y}{\partial t} + P^* \frac{\partial M}{\partial t} - P \frac{\partial X}{\partial t} \right] \cdot dt \tag{8}$$

$$\frac{dE}{dt} = \frac{\overbrace{P^* \cdot \frac{\partial M}{\partial Y} \cdot \frac{\partial Y}{\partial t}}^{+} + \overbrace{P^* \cdot \frac{\partial M}{\partial t}}^{-} - \overbrace{P \cdot \frac{\partial X}{\partial t}}^{+}}{\underbrace{P \frac{\partial X}{\partial E}}_{+} - \underbrace{P^* \cdot \frac{\partial M}{\partial E}}_{-}} \tag{9}$$

The expression in the denominator is positive because exports of the domestic good are an increasing function of the relative price, i.e. the nominal exchange rate ($\partial X / \partial E > 0$), and imports of the foreign good decrease with an increase in the exchange rate (depreciation) ($\partial M / \partial E < 0$). The overall effect of the change in technology on the relative price depends on the expression in the nominator. The first term represents increases in imports connected to income. It is positive given that it works toward real depreciation if real income increases. The second term is negative

($\partial M / \partial t < 0$), i.e. with higher supply capacities imports are reduced because domestic goods of higher quality can be consumed instead. The third term stands for the changes in exports due to technology advances, and is positive ($\partial X / \partial t > 0$) as foreign demand for domestic goods is assumed to grow with an increase in the technological content of the domestic good. As the first expression is positive, and the other two components are subtracted, the overall effect of improved technology on the relative price depends on whether or not the increase in exports and the decrease in imports resulting from the higher technological content of domestic products exceed the increase in imports linked to higher income. Then the expression in the nominator would become negative, indicating a negative relationship between technological advances and the nominal exchange rate calculated as units of domestic currency per one unit of foreign currency.

Thus, for the overall effect to be negative, increases in imports related to higher income should be lower than the growth of exports and the decline in imports due to technological change:

$$\overbrace{P \cdot \frac{\partial X}{\partial t}}^{+} - \overbrace{P^* \frac{\partial M}{\partial t}}^{-} > \overbrace{P^* \frac{\partial M}{\partial Y} \frac{\partial Y}{\partial t}}^{+} \tag{10}$$

Given the assumptions $t^* > t$ and $dt^* < dt$, the price of tradable goods increases in the home currency relative to that in the foreign economy. Let us consider the decomposition of the real exchange rate:

$$Q = E\frac{P^{T^*}}{P^T} - ((1-\alpha)\frac{P^{NT}}{P^T} - (1-\alpha^*)\frac{P^{NT^*}}{P^{T^*}}) \quad (11)$$

where Q and E are the real and nominal exchange rates expressed as domestic currency units to one unit of foreign currency (decrease/increase = appreciation/depreciation), and P^T, P^{NT} and α denote tradable, non-tradable prices and the share of tradable goods in the consumer price index. Thus, the real appreciation (Q decreases) would occur through an appreciation of the real exchange rate of the tradable sector ($E\frac{P^{T^*}}{P^T}$) with a decrease in E. Under the equilibrium condition of CA=0, such an appreciation could be viewed as an equilibrium phenomenon similarly as the B-S effect also leads to an equilibrium appreciation.

The level of and changes in productivity can be taken as an approximation of the level of and changes in technology (*t* and *dt*). Hence, the testable relationship of our model looks as follow:

$$Q = f(PR\overset{-}{O}D) \quad (12)$$

where PROD is the productivity in the tradable sector in the home economy relative to that in the foreign economy. The expected sign is negative implying that an increase (decrease) in the productivity variable cause the real exchange rate to appreciate (depreciate).

3. Some Stylised Facts and the Role of Foreign Capital

The above developed model shows that in addition to productivity-induced market-based service price inflation along the lines of the B-S model, successful catch-up may also entail real appreciation based on improvement in supply capacities and quality of tradable goods. Several transition economies in Central and Eastern Europe have indeed recorded an appreciation of the real exchange rate measured in terms of tradable prices[5].

According to most models of open economies, an appreciation of the tradable price-deflated real exchange rate is followed by a loss of competitiveness and entails a worsening of the trade balance and thus the current account. Although most of the transition countries have been running large current account deficits, there have been episodes of improvements in the trade balance and the current account in spite of the real appreciation of the exchange rate. Export revenues measured in foreign currency have indeed experienced tremendous growth and have grown nearly as much as imports.

At the beginning of the transition process, the countries produced goods of lower quality and lower technological content, in particular when compared with more developed countries.[6] The liberalisation of foreign trade necessitated a substantial nominal and real devaluation of the currencies, because exports broke down after the dissolution of the Council of Mutual Economic Assistance (CMEA/COMECON) and imports surged due to

[5] Tradable prices are proxied by the Producer Price Index (PPI). See Égert (2003) for graphs. It should be noted that whereas the PPI-deflated real exchange rate appreciated steadily in the Czech Republic, Poland and Slovakia, it did not appreciate much in Slovenia and it did so only at a later stage of the transition period in Hungary.

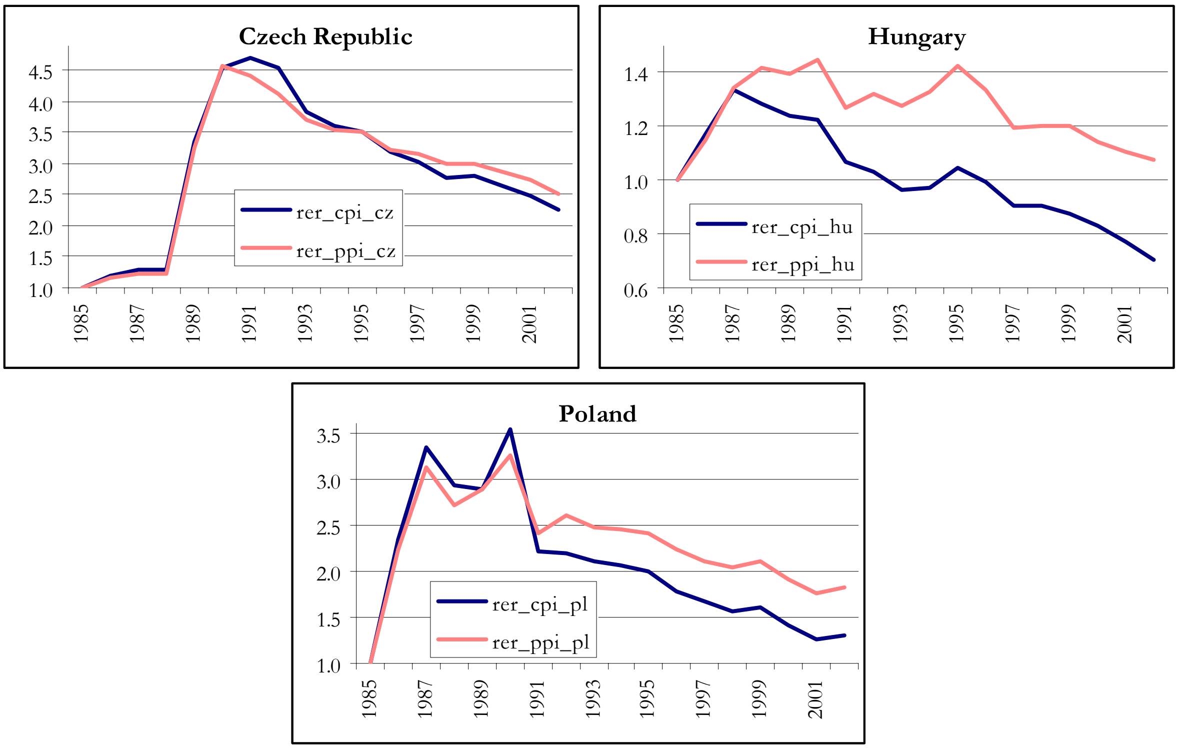
[6] For recent empirical evidence, see e.g. Dulleck et al. (2003).

pent-up demand for foreign goods. Uncertainties surrounding demand for foreign currency coupled with fast trade liberalisation led policy makers to prefer larger devaluation than what the external imbalances would have required as argued in Rosati (1996). For instance, the devaluation of the Polish zloty against the US dollar in early 1990 resulted in an exchange rate that was roughly 20 per cent weaker than the then prevailing black market rate (Rosati (1994)).

These devaluations may have led to or may have amplified initial undervaluation, also detected in Halpern and Wyplosz (1997) and Krajnyák and Zettelmeyer (1998) by means of panel estimations. It could therefore be argued that part of the real appreciation over the last 10 years or so reflects adjustment towards equilibrium. However, this explanation appears insufficient. If the initial devaluation had been too large, the correction towards the pre-transition levels should have occurred within the next few years. Instead, real appreciation in both CPI and PPI terms proved to be a rather steady process. Chart 1 shows the development of the real exchange rate vis-à-vis Germany since 1985. Notwithstanding the fact that prices and exchange rates in the 1980s reflected basically intentions of the planning authorities, important insights can be gained as regards the process of real appreciation since the start of the transition.

Real devaluation was the sharpest in the Czech Republic (Czechoslovakia prior to 1993), where market based information or world market relative prices played a rather limited role in determining the planned price and exchange rate system, and where the uncertainties as regards market assessment of competitiveness were the highest. Note that the devaluation was the lowest in Hungary, where some market orientated reforms were introduced since the late 1960s. Furthermore, because price liberalisation for items included in the CPI basket started in the mid-1980s, the CPI-deflated real exchange rate started appreciating earlier than the real exchange rate based on PPI.

Chart 1 Real exchange rates vis-à-vis the DEM since the late-1980s (1985=100)



Source: IMF IFS Statistics, OECD Main Economic Indicators and Czech National Bank.
Note: Prior to 1993, the nominal exchange rate used for the Czech Republic is the one that prevailed for Czechoslovakia. A decrease (increase) in the real exchange rate denotes an appreciation (depreciation)
Yearly average figures. Data for Slovakia and Slovenia are not available for the period under consideration.

Therefore, the huge initial devaluation may have been necessary because domestic supply lacked competitiveness in domestic and foreign markets. In all three countries the devaluation proved to be rather lasting possibly because the currencies were strongly overvalued when entering transition from plan to market and thus facing the challenge of market forces.

The real exchange rate may appreciate if domestic supply capacities and product quality increase, i.e. during the transition and catch-up process. The transition from plan to market entails a change in incentive structures and a reallocation of existing resources. And this already improves supply. However, a sustained catch-up process requires investments into human as well as fixed capital and quality improvements are needed in capital stock, technology, managerial and organisational skills and in infrastructure.

Foreign capital and in particular foreign direct investment (FDI) can play a very beneficial role in this regard. In the transition countries, FDI gave rise to very rapid changes in the composition of GDP and especially in that of manufactured goods. A marked shift occurred from predominantly low quality, low value added, and labour and raw material intensive goods towards products of increasingly higher quality and higher value-added that triggered increased foreign demand for these products. This may have at the same time supported simultaneous economy-wide quality improvement of goods and services, even if changes in the domestically orientated goods and services may have occurred more slowly. Hence, both exported goods and those sold primarily in domestic markets have changed markedly in quality. It should be, however, underlined that exported goods can differ to a large extent from those sold in the domestic market, with regard to both quality and technological content.

Rapid improvement in quality then increased prices, which through the replacement of low-quality goods for high-quality goods in the price basket led to a rise in the price level. In principle, such changes in the price level should not be reflected in inflation rates and thus the real appreciation of the currency. Nevertheless, adjusting inappropriately for quality improvements may result in higher inflation of tradable goods and the subsequent appreciation of the PPI-based real exchange rate.

Prices may also increase and thus the real exchange rate may appreciate when quality improvements go in tandem with better reputation. The outset of transition was characterised by a strong bias towards imported foreign goods. With ameliorating quality and better marketing of domestically manufactured goods and with a higher capacity of the countries to produce goods of the more preferred foreign brands, the bias towards imported goods may become weaker. In other words, domestic and foreign demand for goods produced domestically increase.

While exported goods enter the trade balance directly and increase export revenues, higher quality of domestic goods sold in domestic markets reduces income elasticity of import demand[7] and thus impacts on the trade balance indirectly. In this context, higher prices are an accompanying phenomenon of the growth in non-price competitiveness. Changes in non-price competitiveness of goods produced in the home country and improving supply capacities could indeed reverse the strong initial devaluation and lead to a steady appreciation of the real exchange rate measured in PPI and CPI terms.

Chart 2 below shows that the five selected transition countries have witnessed, over the period from 1995 to 2002, a strong increase in export revenues expressed in German mark

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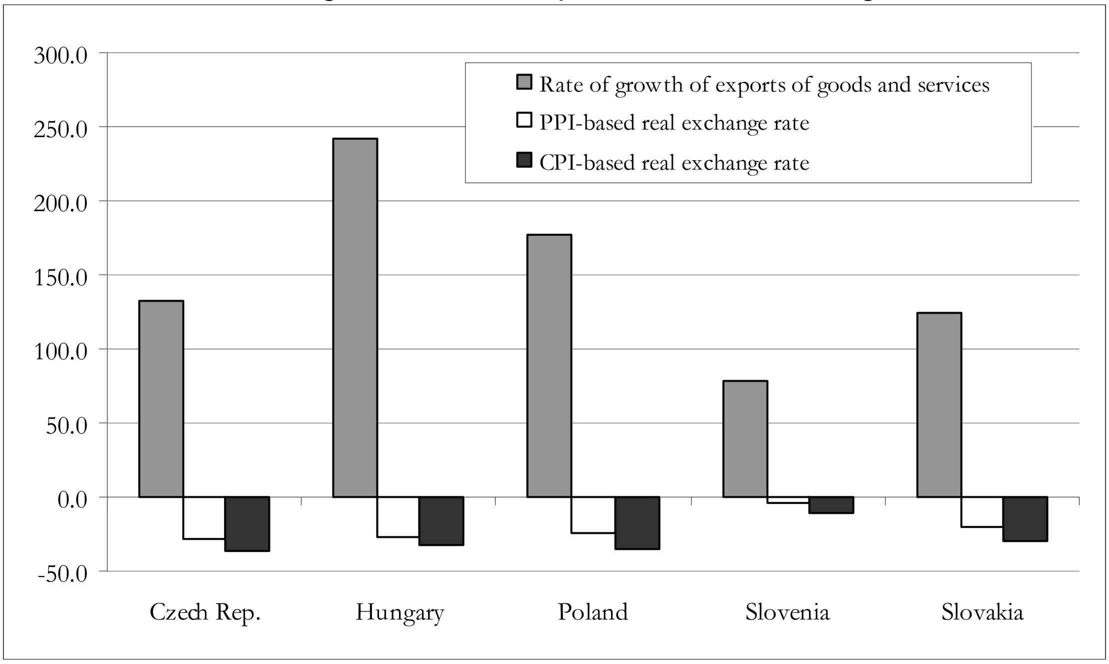
[7] At the same income level, import demand will be lower because residents will consume more domestically produced goods instead of imported goods.

at current prices. More specifically, Hungary and Poland can sport the highest increases, whereas export growth proved the slowest in Slovenia despite the fact that the real exchange rate appreciate the least in this country[8].

Export performance in transition countries seems to be indeed closely related to privatisation strategies and to attitudes towards foreign direct investment inflows. Foreign direct investment has had particularly beneficial effects on exports, which became the engine of economic growth.[9] FDI helped economic restructuring by means of financing fixed capital investment and implementing state-of-the-art technology and Western-style organisational structures and schemes. But most importantly, FDI in manufacturing often aimed at export sectors and hence created new export capacities. Foreign involvement made access to foreign market easier. However, because countries adopted different strategies towards privatisation and capital inflows, the extent to which they benefited from FDI differs largely. Privatisation in Hungary relied heavily on sales to foreign investors whereas in the Czech Republic foreign capital started to pour in on a wider scale only after reforms accelerated in 1997. Political instability in Slovakia prevented direct investments from flowing in until 1998 and Slovenia has been hesitating to open up its economy to foreign investments until quite recently. It turns out that export revenues have grown most in countries with large foreign investments.[10]

For this reason, the observed appreciation of the real exchange rate based on tradable prices could reflect improving supply capacities. Changes in supply capacities and thus the real appreciation may have been faster in countries where foreign investors contributed more to economic restructuring.

Chart 2 Real Exchange Rates and Export Revenues, Changes from 1995 to 2002



[8] Growth in export revenue is also pronounced in 1993 and 1994. However, real appreciation is less marked.
[9] See e.g. Darvas and Sass (2001), Sgard (2001), Campos and Coricelli (2002) and Benacek et al. (2003)
[10] Note, however, that exports and imports to GDP were much higher in Slovenia at the beginning of the 1990s. This higher basis effect could explain lower export growth.

4. Reduced Form Equation

Equation (12) shown in Section 2 can be completed with variables suggested by standard models.[11] This gives the following reduced form equation of the real exchange rate:

$$Q = f(\overset{-}{PROD}, \overset{-}{REG}, \overset{-}{RIR}, \overset{+}{FDEBT}, \overset{+}{OPEN}, \overset{+/-}{TOT}, \overset{+/-}{GOV},) \qquad (13)$$

The real exchange rate (Q) is computed both on the basis of the CPI and PPI indexes. A decrease (increase) denotes an appreciation (depreciation) of the real exchange rate

Labour productivity in industry (PROD) is expected to be negatively related to the real exchange rate, i.e. an increase/decrease in productivity should lead to an appreciation/depreciation of the real exchange rate. Labour productivity primarily stands for higher supply capacities that can lead to an appreciation through the channel of higher quality and changes in preferences in line with increasing technological content of and thus demand for the domestic good in the domestic and foreign economies. The sector that is likely to benefit the most from technological catch-up and produces most of exported goods is industry. However, changes in technology and preferences may not only be limited to domestic tradables, but all goods and services in the economy as a whole. In this case, higher supply capacities will be reflected in higher real GDP *(GDP).* Therefore, real GDP will be used as a forth proxy for productivity. However, labour productivity in industry also captures the traditional BS effect that operates through service prices. But, as summarised in Égert (2003), this effect is rather limited due to the small share of non-tradables in the acceding countries' CPI basket.

The differential in regulated prices *vis-à-vis Germany (REG*) is also included. In transition economies, regulated prices rose the fastest among the components of the CPI over the last 10 years or so. On the one hand, regulated prices constitute a cost-push factor, which may erode competitiveness if it raises the price of traded goods. On the other hand, however, only part of the regulated prices affects directly traded goods costs, so a correction of the real exchange rate may not be needed for maintaining external balance. Furthermore, a rise in regulated prices lowers disposable income and should thus reduce imports. In sum, an increase/decline in regulated prices is expected to bring about an appreciation/depreciation of the real exchange rate.

The real interest rate differential (RIR) reflects indeed imbalances between investment and savings and is expected to be negatively connected to the real exchange rate implying that an increase leads to the real appreciation of the currency.

Foreign debt as percentage of GDP (FDEBT) should lead to a depreciation of the real exchange rate due to the higher interest payments to the rest of the world.

Openness (OPEN) is traditionally viewed as an indicator of trade liberalisation. Increasing openness indicates a higher degree of trade liberalisation. Because it comes through the abolishment of trade barriers and thus allowing foreign products to enter more freely the country, an increase in openness is to worsen the trade balance. Hence, a rise in openness is expected to yield a depreciation of the real exchange rate. However, openness can also stand for higher exports resulting from increasing supply capacities and can thus be negatively connected with the real exchange rate. Nonetheless, we think that this effect should be captured by the productivity variables. Thus, the expected sign of the openness variables is positive.

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[11] See e.g. MacDonald (1997) and Clark and MacDonald (1998).

Terms of trade (TOT), determined as export prices over import prices, do not have an obvious sign. If exports and imports have low price elasticities such as primary or very differentiated goods, an increase in the terms of trade would imply an increase in export revenues and hence an amelioration of the trade balance, which could result in an appreciation of the nominal and thus the real exchange rate. But also, increasing export revenues would lead to higher income and because higher income could imply more consumption falling on non-tradables, a demand-side driven increase in the relative price of non-tradables is also likely to make the real exchange rate to appreciate. By contrast, in the event that exports are price sensitive, an increase in terms of trade would not necessarily yield an improved trade balance. As a result, a combination of price elasticities of domestic supply and foreign demand might or might not lead to an increase in trade when export prices increase. So, whether an increase in the terms of trade will bring about real appreciation or depreciation remains uncertain.

The expected sign of *government debt to GDP (GOV)* is not clear-cut. If an increase in the public debt is due to increasing public spending on non-tradable goods, it is to lead to an appreciation of the real exchange rate through the relative price channel. However, if government spending falls more heavily on tradable goods, no appreciation occurs. Moreover, in the event that public debt is on an unsustainable path, the real exchange rate may depreciate mainly because of the depreciation of the nominal exchange rate. The depreciation related to government debt may dominate the appreciation in the long run and if government debt exceeds a given threshold, even in the medium-term.

5. Data and Econometric Issues

5.1 Data

The dataset used in the paper consists of quarterly time series for the Czech Republic, Hungary, Poland, Slovakia and Slovenia. The period spans from 1993:Q1 to 2002:Q4. The dataset also includes Croatia, Estonia, Latvia and Lithuania, which are used for the panel estimations. The period runs from 1995:Q1 to 2002:Q4 for Croatia and from 1994:Q1 to 2002:Q4 for the Baltic countries.

Average labour productivity is computed as labour productivity in the home country relative to labour productivity in Germany. Three measures are used. PROD1 is calculated using industrial production over industrial employment obtained from the Main Economic Indicators of the OECD or the International Financial Statistics of the IMF. PROD2 is based on similar data but drawn from the WIIW. Finally, PROD3 is obtained as value added over sectoral employment in industry obtained from national accounts. Although representing the same series, PROD1 and PROD2 may differ even markedly in some countries. Value added in industry and industrial production based measures turn out to exhibit significantly different developments; however without obvious causes or regularities across the countries. Note also that PROD1 starts only in 1995 for Estonia and no data for PROD2 is available for the Baltic States. Furthermore, real GDP in the domestic and the reference economies is also used as a proxy for productivity.

The *differential of regulated prices* in the home country and those in Germany are mainly based on regulated prices provided by national sources. Thus, series come from the respective national banks for the Czech Republic, Hungary and Poland. Regulated prices for Germany are obtained from the Federal Statistical Office of Germany. The series for Estonia corresponds to that used in Égert (2003b). For the cases of Slovenia, Slovakia, Croatia and Latvia, regulated prices are proxied by rents. In Lithuania, the price series on fuel and electricity serve as a proxy. Regulated prices are expected to impact not only on the CPI-deflated real exchange rate, but also on the real exchange rate based on PPI. The reason for this is that producer price indexes in the countries under investigation contain prices of domestic energy and water suppliers, which are partly regulated. Also, cost pressure related to increased (regulated) input prices are likely to impact on producer prices.

Chart 3 Consumer price index and its regulated price component

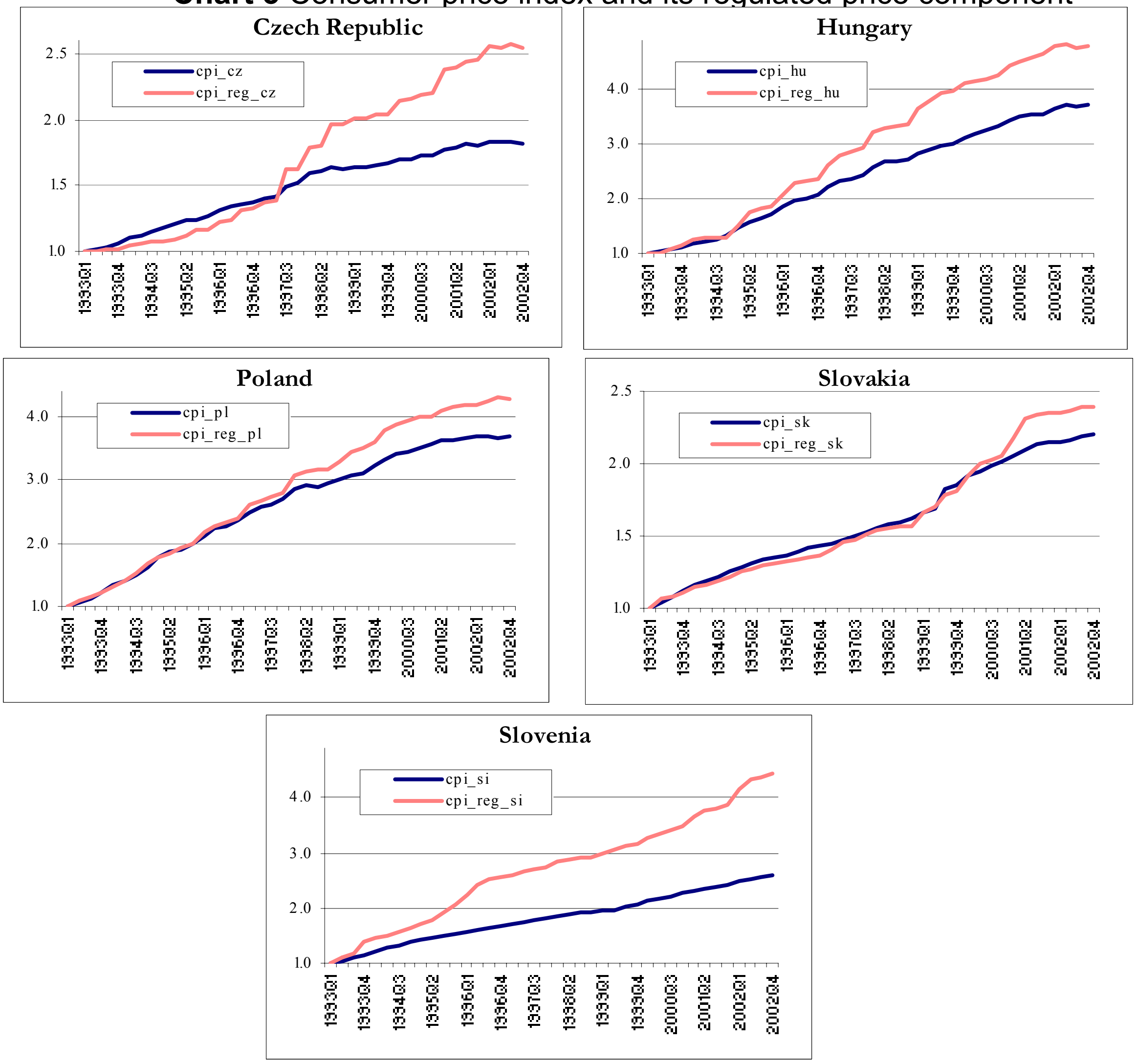
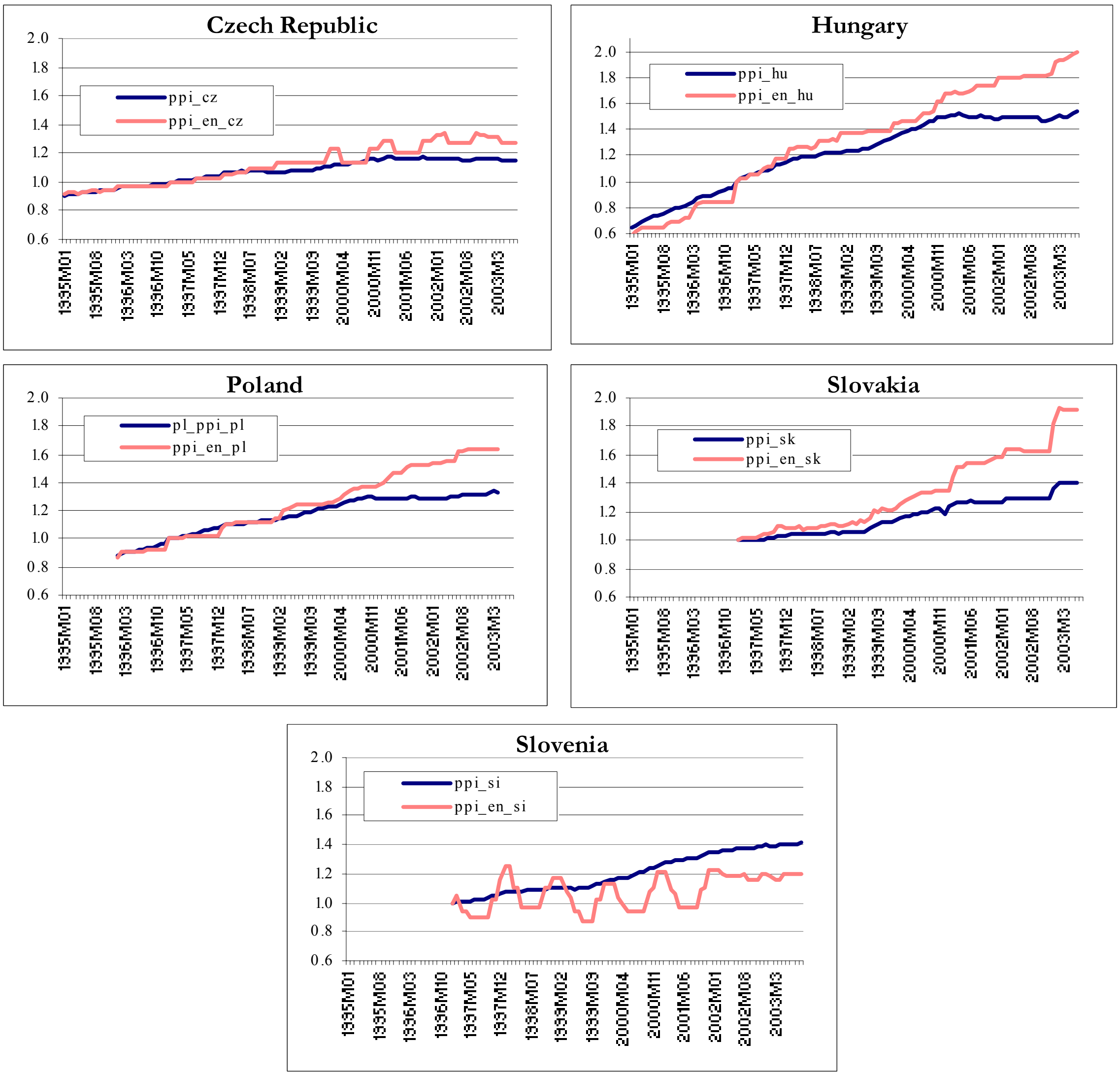


Chart 4 Producer price index and its regulated price component (1997=100)



Note: ppi_en= PPI of energy and water supply

The other variables used in the paper are (a) **real interest differential** towards Germany computed as the one-year treasury bill yield in period t are divided by the CPI or the PPI, which are year-on-year figures from year t-1 to year t (b) **gross foreign debt** as percentage of GDP; (c) **government debt** as percentage of GDP (calculated as cumulated government deficit over GDP) ; (d) **openness** computed as nominal exports and imports of goods and services expressed in nominal GDP; (e) **terms of trade** obtained as export prices over import prices. Data on terms of trade is available only for the Czech Republic, Hungary and Poland.

The source of these data is NewCronos (Eurostat), Main Economic Indicators (OECD), International Financial Statistics (IMF) and the monthly database of the WIIW. Note that all series are seasonally adjusted if needed. An exception are regulated prices because their frequent and perhaps erratic adjustments are not primarily related to seasonal factors. Furthermore, the series are taken in natural logarithms and are normalised to 1994 except the real interest differential.

5.2 Testing Procedure

It is professional wisdom that a large number of macroeconomic time series are integrated of order 1. This is tested for employing conventional Augmented Dickey Fuller (ADF) and Philips-Perron (PP) tests. If the series turn out to be I(1) processes, the appropriate estimation technique to use is the cointegration approach. In this paper, we use four different types of cointegration techniques:

The Engle and Granger (EG) technique, the Dynamic OLS (DOLS) popularised by Stock and Watson (1993), the Autoregressive Distributed Lag (ARDL) approach of Pesaran et al. (2001) and the Maximum Likelihood estimator of Johansen. The EG approach to cointegration is based on the following static equation such as:

$$Y_t = \beta_0 + \sum_{i=1}^{n} \beta_i X_{i,t} + \varepsilon_t \qquad (16)$$

Eq.(1) does not account for endogeneity of the regressors and serial correlation in the residuals. This is corrected for using DOLS that includes leads and lags of the regressors in first differences:

$$Y_t = \beta_0 + \sum_{i=1}^{n} \beta_n X_{i,t} + \sum_{i=1}^{n} \sum_{j=-k_1}^{k_2} \gamma_{i,j} \Delta X_{i,t-j} + \varepsilon_t \qquad (17)$$

with k1 and k2 denoting respectively leads and lags. The error correction form of the ARDL model is given in Eq. (18) where the dependent variable in first differences is regressed on the lagged values of the dependent and independent variables in levels and first differences:

$$\Delta Y_t = \beta_0 + \rho(Y_{t-1} + \sum_{i=1}^{n} \beta_n X_{i,t-1}) + \sum_{j=1}^{l_1} \eta_j \Delta Y_{t-j} + \sum_{i=1}^{n} \sum_{j=0}^{l_2} \gamma_{i,j} \Delta X_{i,t-j} + \varepsilon_t \qquad (18)$$

where l1 and l2 are the maximum lags. In the EG, FMOLS and DOLS approaches, whether or not Y and X are cointegrated is examined by testing for unit root in the residuals and applying critical values tabulated in MacKinnon (1996). In contrast to this, Pesaran et al. (2001) employ a bounds testing approach. Using conventional F-tests, the null of $H_0 : \rho = \beta_1 = ... = \beta_n = 0$ is tested against the alternative hypothesis of $H_1 : \rho \neq 0, \beta_1 \neq 0, ..., \beta_n \neq 0$. Pesaran et al. (2001) tabulate two sets of critical values, one for the case when all variables are I(1), i.e. upper bound critical values and another one when all variables are I(0), i.e. lower bound critical values. Critical values are provided for 5 different models of which model (3) with unrestricted intercept and no trend will be used in the paper. If the test statistic is higher than the upper bound critical value, the null of no cointegration is rejected in favour of the presence of cointegration. On the other hand, an F-statistics lower than the lower bound critical value implies the absence of cointegration. In the event that the calculated F-stat lies between the two critical values, there is no clear indication regarding the absence or existence of a cointegrating relationship.

Nonetheless, in the presence of more than one cointegration relationships the aforesaid single-equation approaches may not be able to identify the addition cointegrating relationships. Therefore, the Johansen cointegration technique is used for testing for the number of cointegrating vectors in a VAR framework. In the event that only one long-term relationship is found using the trace statistics, the Maximum Likelihood estimates are used as a robustness check in the following form:

$$Y_t = (m_0 + m_1 t + (1 + \alpha\beta')Y_{t-1}) - \sum_{i=1}^{p-1} \Phi_i \Delta Y_{t-i} + \varepsilon_t \qquad (20)$$

where Y represents the vector including the dependent and the independent variables.

We first conduct a general-to-specific model selection strategy that involves top-down and bottom-up F pre-search coupled with sample split analysis so as to identify blocks of statistically significant variables. [12] Departing with all variables described in Section IV, the general-to-specific approach to model selection is performed. The residuals of the models chosen are subsequently checked for stationarity à la Engle and Granger and the selected models are taken as an input for the estimation of the DOLS and ARDL. Leads and lags are determined based on the Schwarz, Akaike and Hannan-Quinn information criteria.

The VAR-based Johansen approach is used to verify the number of cointegration relationship that might link the variables. The detection of a single long-term relationships that turns out to be stable over time then validates results of the single-equation methods. The Johansen technique involves the roots of the VAR model to be verified (to ensure stationarity of the AR processes), tests for normality and serial correlation. Furthermore, both the rank of cointegration and parameter constancy are analysed.

Beside time series techniques, panel techniques are also applied to the panel composed of up to 9 countries. Analogously to the time series analysis, stationarity is tested for by means of the panel unit root test proposed by Im et al. (2003) (IPS henceforth). The t-bar statistic is constructed as a mean of individual ADF statistics to test the null hypothesis of a unit root.

Subsequently, panel cointegration tests are employed to detect long-term relationships and in estimating the corresponding coefficients. For this purpose, the residual-based tests of the type Engle and Granger developed in Pedroni (1999) are used. Pedroni(1999) develops seven tests of which the first four statistics are based on pooling along within-dimension whereas the last three tests rest on pooling along between-dimension. Only the last three tests (group rho-statistic, group pp-statistic, group ADF-statistic) will be employed because they allow for heterogeneity in the autoregressive term. According to Pedroni (1999), of the seven tests, the group ADF-stat is the most powerful for samples of small size. Coefficients of the cointegrating vector are then determined using pooled OLS, fixed effect OLS, fixed effect DOLS, the Pooled Mean Group Estimator (PMGE) and the Mean Group Estimator (MGE) proposed by Pesaran et al. (1999).For DOLS, leads and lags are determined on the basis of the Schwarz and Akaike information criterion and a lag structure of 1 is imposed alternatively (DOLS(1,1). The same applies to the choice of the lag structure of PMGE and MGE (PMGE(1,1) and MGE(1,1)). [13]

[12] In the top-down procedure, F-tests are carried out on blocks of regressors, which are organised in an increasing order in terms of their t^2-values until the null hypothesis is rejected. In the bottom-up procedure, F-tests are performed for regressors put in a decreasing order in terms of their t^2-values until the null is not rejected. The sample-split analysis analyses the significance of the variables in two sub-samples. The model is considered robust if significance is also conserved in the two sub-samples. This model selection was conducted using PcGets.

[13] For a discussion of panel unit root and cointegration tests and the estimation methods, see e.g. Banerjee (1999) and Baltagi and Kao (2000). For recent applications, see e.g. Crespo-Cuaresma et al. (2003) and Maeso-Fernandez et al. (2003).

6 Results

6.1 Time Series

Because conventional unit root tests, i.e. ADF and PP indicate that most of the series are not stationary in levels but turn out to be stationary in first differences, the cointegration techniques developed earlier appear the most appropriate approach to test for long-term relationships connecting the real exchange rate to the underlying fundamentals.

We set out to test two sets of equations. First, the CPI-based real exchange is regressed on the gamut of variables described earlier. In this case, the productivity variable is likely to impact on the real exchange rate through three different channels: (a) the traditional BS effect, (b) the indirect BS effect through an increase in the service prices as inputs, and (c) tradable prices because of improved quality and reputation. Second, the PPI-deflated real exchange rate is regressed on the same set of variables. If labour productivity proves to be important in both relationships, the indirect BS effect, and most importantly, the increase in tradable prices brought about by productivity changes make the real exchange rate appreciate systematically. The theoretical framework developed earlier is supported if the two sets of equations yield similar results for labour productivity.

Employing the EG, DOLS, ARDL and Johansen cointegration techniques, estimations are performed for the period 1994-2002 for the Czech Republic, Hungary and Poland and for 1993-2002 for Slovakia and Slovenia.

6.1.1 The Czech Republic

Results obtained for time series are reported in Tables 3 to 7. With regard to the Czech Republic, the specification including the difference in labour productivity, the differential in regulated prices and foreign debt is retained as the most reliable and economically the most compelling. This specification appears remarkably robust given that all methods detect the presence of a cointegrating vector linking the aforementioned variables. It should be noted that although the Johansen trace statistic indicate the presence of two cointegrating vectors, the stability test on the number of cointegrating vectors shows only one stable vector. Moreover, all these variables are found statistically significant, have the expected sign and the size of the estimated coefficients based on different techniques is fairly comparable. These observations apply not only to the equations including the CPI-based real exchange rate but also to those in which the PPI-deflated real exchange rate is used.

The fact that the estimated coefficients for the difference in productivity is very similar for the CPI and PPI-based real exchange rate equations provides strong empirical support to the theoretical framework according to which real appreciation comes mainly through tradable prices. The coefficients tend to be lower for the PPI-based real exchange rate especially when the EG and ARDL techniques are employed. This may indicate that CPI-based real exchange rate appreciates more than the PPI-based real exchange rate due to changes in the relative price of market non-tradable items.

The differential in regulated prices enters both the CPI and PPI-based specifications and an increase in the differential results in an appreciation of the real exchange rates. Nonetheless, when the CPI-based real exchange rate is used, the estimated coefficients are clearly higher than in the case of the PPI-deflated real exchange rate. This may indicate that the difference between the CPI and PPI-based real exchange rates may be partly explained by the differential in regulated prices.

As regards foreign debt, a rise/fall induces a depreciation/appreciation of the real exchange rate and the estimated coefficients are rather similar for the CPI and the PPI-based equations.

Table 3a Cointegration tests for the CPI-based real exchange rate, Czech Republic, 1994-2002

	EG		DOLS SIC,HQ(0,1)		AIC(1,1)		ARDL(1,1) SIC,AIC,HQ		JOH. M3,k=3		
SIC	1	-5.199**	3	-5.528**	3	-5.339**	6.84**		R=0	73.04***	RS ok
AIC	1	-5.199**	3	-5.528**	3	-5.339**			R=1	32.23***	AC ok
HQ	1	-5.199**	3	-5.528**	3	-5.339**			R=2	8.99	JB 0.016
									R=3	0.01	ST 1
	Coeff	t-stat	Coeff	t-stat	coeff	t-stat	Coeff	t-stat	coeff	t-stat	
PROD2	-0.701	-5.51	-0.948	-7.198	-1.021	-6.568	-0.793	-4.108	-0.649	-16.641	
REGD	-0.362	-6.713	-0.361	-3.674	-0.379	-2.667	-0.471	-3.066	-0.457	-32.643	
FDEBT	0.190	4.089	0.292	4.043	0.308	3.063	0.326	3.514	0.278	18.533	

Note: *,** and *** denote respectively the presence of cointegration at the 10%, 5% and 1% levels, respectively. EG represent the Engle and Granger residual based tests. SIC, AIC and HQ in the first column of the Table stand for the Schwarz, Akaike and the Hannan-Quinn information criteria based on which the lag length is selected for the ADF tests applied to the residuals of the EG and DOLS equations. The lag length is chosen so that it minimizes the information criteria. It is shown in the first column of each method (column 2 for EG, column 4 for DOLS etc.). Below DOLS and ARDL are shown the information criteria based on which leads and lags (DOLS) and lags for dY and dX (ARDL) are chosen (shown in parentheses). The test statistic shown below ARDL is the F-stat as in Pesaran et al. (2001). JOH represents the Johansen cointegration technique. k stands for the lag length chosen for the VAR. The trace-test statistics are given below. In the last column, RS and AC are roots of the model and autocorrelation. "ok" indicates that the inverse roots of the model are lower than 1 and the absence of serial correlation in the residuals. JB stands for the Jarque-Bera multivariate normality tests. A figure higher than 0.05 indicates that normality is accepted. Finally, ST indicates the number of cointegration relationship(s) that turn out to be stable over time.

Table 3b Cointegration tests for the PPI-based real exchange rate, Czech Republic, 1994-2002

	EG		DOLS(1,1) SIC,AIC,HQ		ARDL(1,1) SIC,AIC,HQ		JOH. M3,k=3		
SIC	1	-5.122**	4	-5.604**	6.163**		R=0	84.06***	RS ok
AIC	1	-5.122**	4	-5.604**			R=1	39.56***	AC ok
HQ	1	-5.122**	4	-5.604**			R=2	9.23	JB 0..012
							R=3	0.06	ST 1
	Coeff	t-stat	coeff	t-stat	coeff	t-stat	Coeff	t-stat	
PROD2	-0.632	-5.155	-0.974	-6.791	-0.716	-3.927	-0.699	-19.971	
REGD	-0.220	-4.227	-0.210	-1.596	-0.317	-2.334	-0.359	-25.643	
FDEBT	0.189	4.236	0.259	2.793	0.293	3.145	0.278	19.857	

Note: As for Table 3a.

6.1.2. Hungary

Results for Hungary are reported in Tables 4a and 4b. They are less robust when compared with the case of the Czech Republic in that cointegration tests reach no clear consensus on whether or not the variables are linked through a long-term cointegration relationship. In particular, the EG and on some occasions the ARDL technique could not detect the presence of cointegration. However, the DOLS, the Johansen and in some cases the ARDL techniques reveal that both the CPI and the PPI-deflated real exchange rates are connected to the difference in labour productivity, foreign debt and openness.

The coefficients are statistically significant and correctly signed. Thus, an increase/decrease in labour productivity leads to an appreciation/depreciation of both the CPI and the PPI-based real exchange rate. This confirms indeed our conjecture stipulating the role of tradable prices in the appreciation of the real exchange rate. The estimated coefficients for the CPI-based specification are, in most cases, larger than those found for the PPI-deflated real exchange rate. This shows that the higher appreciation of the CPI-deflated real exchange rates may be a result of a rise in the price of market non-tradables, i.e. the B-S effect.

The differential in regulated prices does not enter the equation. Because of possible multicollinearity between labour productivity and the differential in regulated prices, the coefficient may also capture the impact of regulated prices on the PPI- and CPI-based real exchange rates.

Foreign debt and the openness ratio work in the opposite direction as they are positively related to both the CPI and PPI-based real exchange rates. Hence, an increase in these variables yields a depreciation of the real exchange rate.

Table 4a Cointegration test for the CPI-based real exchange rate in Hungary, 1994-2002

	EG		DOLS				ARDL(1,2)		JOH		
			SIC(1,3)		AIC,HQ(2,3)		ARDL_SIC		M3,k=3		
SIC	0	-2.136	1	-4.848**	1	-6.825**	3.466[a]		R=0	74.14***	RS no
AIC	0	-2.136	4	-4.834**	4	-4.69**			R=1	20.46	AC ok
HQ	0	-2.136	4	-4.834**	4	-4.69**			R=2	7.77	JB 0.002
									R=3	1.18	ST 1
	Coeff	t-stat	Coeff	t-stat	coeff	t-stat	Coeff	t-stat	Coeff	t-stat	
PROD3			-2.344	-12.02	-2.489	-7.493	-2.099	-3.164	-2.099	-22.570	
FDEBT			0.811	9.482	0.908	6.795	0.622	2.551	0.730	19.211	
OPEN			0.590	6.855	0.633	4.052	0.434	2.346	0.511	13.447	

Note: As for Table 3a., (a) means that the ARDL test statistics cannot decide whether there is cointegration at the 10% significance level

Table 4b Cointegration test for the PPI-based real exchange rate in Hungary, 1994-2002

	EG		DOLS				ARDL			JOH		
			SIC,HQ(2,3)		AIC(3,3)		SIC(1,0)	AIC,HQ(1,1)		M3,k=3		
SIC	0	-2.747	1	-5.936**	1	-8.101**	2.109	4.032*		R=0	45.09*	RS no
AIC	0	-2.747	1	-5.936**	3	-5.068**				R=1	20.24	AC ok
HQ	0	-2.747	1	-5.936**	3	-5.068**				R=2	8.16	JB 0.110
										R=3	3.58	ST 1?
	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat		Coeff	t-stat	coeff	t-stat	
PROD3			-1.967	-5.821	-2.951	-2.735		-0.902	-2.077	-1.098	-7.572	
FDEBT			0.958	7.041	1.319	3.636		0.401	1.677	0.549	9.305	
OPEN			0.486	3.059	0.927	1.916		0.004	0.029	0.056	1.000	

Note: As for Table 3a.

6.1.3 Poland

As far as Poland is concerned, the long-term relationships include labour productivity, government debt, openness and the real interest differential. Cointegration is found with all methods except for the Engle and Granger technique when applied to the CPI-based real exchange rate. Productivity is found to impact on both the CPI and PPI-based real exchange rates. This supports our conjecture. The reason for the large differences in the size of the estimated coefficients in the case of the CPI and the PPI-based equations are likely to be very similar to what we observed for Hungary, i.e. the influence of the B-S effect and regulated prices. The negative sign of the real interest differential shows that a rise/fall in this variable results in the appreciation/depreciation of the real exchange rate. This finding is in sharp contrast with the cases of the Czech Republic and Hungary where the real interest differential is not found entering significantly the long-term relationship. As shown in Table 5, openness leads to a depreciation of the real exchange rate. A rise in government debt is found to cause a depreciation of the real exchange rate. However, in the PPI-based specification, it becomes significant only when the Johansen technique is employed.

Table 5a Cointegration tests for the CPI-based real exchange rate in Poland, 1994-2002

	EG		DOLS(0,0)		DOLS(1,0)		ARDL(1,0)		JOH.		
			SIC,HQ		AIC		SIC,AIC,HQ		M3,k=2		
SIC	0	-4.057	0	-5.311**	2	-5.825**	6.144**		R=0	73.66**	RS no
AIC	3	-3.88	0	-5.311**	2	-5.825**			R=1	36.67	AC ok
HQ	0	-4.057	0	-5.311**	2	-5.825**			R=2	18.52	JB 0.102
									R=3	6.58	ST 1
									R=4	1.08	
	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	coeff	t-stat	Coeff	t-stat	
PROD1			-1.249	-9.958	-1.08	-7.966	-1.614	-5.281	-1.060	-12.990	
GOV			1.879	3.682	1.416	2.340	3.548	3.543	1.785	5.235	
OPEN			0.341	3.026	0.350	2.938	0.474	2.460	0.411	5.630	
INTCPI			-0.011	-5.063	-0.013	-5.680	-0.010	-2.222	-0.016	-12.308	

Note: As for Table 3a.

Table 5b Cointegration tests for the PPI-based real exchange rate in Poland, 1993-2002

	EG		DOLS(0,0) SIC		DOLS(0,1) AIC,HQ		ARDL(1,1) SIC,AIC,HQ		JOH. M3,k=2		
SIC	0	-6.283**	2	-6.401**	2	-6.569**	7.935**		R=0	85.55**	RS no
AIC	0	-6.283**	2	-6.401**	2	-6.569**			R=1	39.85	AC ok
HQ	0	-6.283**	2	-6.401**	2	-6.569**			R=2	12.57	JB 0.296
									R=3	4.72	ST 1
									R=4	0.03	
	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	coeff	t-stat	
PROD1	-0.433	-4.054	-0.521	-5.067	-0.581	-5.069	-0.497	-4.753	-0.548	-6.683	
GOV	-0.568	-1.337	-0.156	-0.347	0.452	0.852	-0.047	-0.122	0.220	6.377	
OPEN	0.170	2.302	0.187	2.768	0.229	3.130	0.182	3.559	0.153	2.732	
INTCPI	-0.009	-6.450	-0.009	-6.82	-0.010	-7.048	-0.009	-5.23	-0.007	-5.833	

Note: As for Table 3a.

6.1.4 Slovakia

As regards Slovakia, it turned out to be most complicated to find a relationship based on the reduced form equation (13) that could be considered reasonable on economic and econometric grounds. Only real GDP, government debt and regulated prices enter the long-term relationship. It seems that government debt and GDP reflect similar developments: Until 1998, the reform process was rather sluggish in Slovakia and public expenditures increased much faster than GDP[14]. The expansionary fiscal policy then became unsustainable; and the Slovak koruna had to be floated in 1998. After a period of turbulence when the real exchange rate depreciated and government spending and GDP also decelerated, a more coherent reform strategy including the attraction of large FDI was implemented. This marked the return to higher growth and higher government spending. Therefore, the only relationship, which appears to be stable over the whole period studied is the one including government spending/GDP and regulated prices.

Table 6 Cointegration tests for the CPI-based real exchange rate in Slovakia, 1993-2002

	EG		DOLS(0,0) SIC,AIC,HQ		ARDL(2,0) SIC,AIC,HQ		Johansen M3,k=1	
SIC	1	-3.710*	2	-3.851*	5.686**		R=0	10.67
AIC	2	-3.718*	2	-3.851*			R=1	2.54
HQ	1	-3.710*	2	-3.851*			R=2	0.03
	Coeff	t-stat	coeff	t-stat	coeff	t-stat		
GDP	-0.602	-5.58	-0.61	-5.361	-0.655	-2.863		
REGD	-0.343	-5.571	-0.346	-5.389	-0.333	-3.247		

Note: As for Table 3a.

Table 7 Cointegration tests for the CPI-based real exchange rate in Slovakia, 1993-2002

	EG		DOLS(0,0)		ARDL(2,0) SIC,AIC,HQ		Johansen M3,k=1	
SIC	2	-4.113**	2	-4.014**	4.654*		R=0	14.91
AIC	2	-4.113**	2	-4.014**			R=1	5.59
HQ	2	-4.113**	2	-4.014**			R=2	0.19
	Coeff	t-stat	Coeff	t-stat	coeff	t-stat		
REGD	-0.31	-3.922	-0.318	-3.78	-0.303	-2.512		
GOV	-1.305	-4.667	-1.284	-4.307	-1.312	-2.255		

Note: As for Table 3a.

6.1.5 Slovenia

In Slovenia, two relationships can be detected. The first connects the real exchange rate to the real interest differential and regulated prices, and the second considers labour productivity in industry instead of regulated prices. As expected, an increase/decrease in regulated prices as well as in labour productivity is found to bring about an appreciation/depreciation. However, the sign of the real interest differential does not

[14] Real public consumption expenditure measured as in the national accounts increased by 50% between 1993-1997, compared with 25% growth of real GDP. See Beblavy(2002) for more details on Slovak exchange rate policy.

correspond to our expectation as an increase leads to a depreciation of the real exchange rate.

Table 8 Cointegration tests for the CPI-based real exchange rate in Slovenia, 1993-2002

	EG		DOLS(2,3)		ARDL(2,3)		Johansen	
			SIC,AIC,HQ		SIC,AIC,HQ		M3,k=2	
SIC	0	-5.041***	1	-6.695***	10.127**		R=0	63.26***
AIC	1	-4.092***	1	-6.695***			R=1	21.41***
HQ	0	-5.041***	1	-6.695***			R=2	6.18***
	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat		
CONST	-0.107	-12.28	-0.144	-9.02	-0.111	-1.812	RS	Ok
REGD	-0.158	-16.225	-0.131	-8.946	-0.16	-3.281	AC	Ok
INTCPI	0.004	6.683	0.005	5.48	0.001	0.474	JB	0.504

Note: As for Table 3a.

Table 9 Cointegration tests for the CPI-based real exchange rate in Slovenia, 1993-2002

	EG		DOLS				ARDL						JOH.		
			SIC(2,0)		AIC, HQ(3,3)		SIC(1,1)		AIC(2,3)		HQ(2,1)		M3,k=2		
SIC	0	-3.920*	0	-2.865	0	-3.966**	3.711[a]		4.56*		2.482		R=0	50.00***	RS ok
AIC	3	-1.426	0	-2.865	4	-3.747*							R=1	12.90	AC ok
HQ	0	-3.920*	0	-2.865	4	-3.747*							R=2	2.14	JB 0.265
	coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	ST 1
CONST	-0.124	-10.779	-0.197	-16.349	-0.178	-10.096	-0.035	-0.156	-0.804	0.912	-0.015	-0.033	0.028	2.592	
PROD1	-0.742	-10.857	-0.438	-6.777	-0.652	-6.439	-1.119	-1.306	2.424	-0.901	-1.332	-0.868	-0.273	-3.138	
INTCPI	0.004	3.946	0.01	10.523	0.007	4.555	-0.011	-1.002	0.089	-1.924	-0.021	-0.868	0.014	12.727	

Note: As for Table 3a.

These findings can be explained to a large extent by monetary and exchange rate policies in Slovenia (Caprirolo and Lavrac, 2003), which has aimed at a balanced current account and a corresponding real exchange rate position. In particular, the exchange rate strategy consisted in regularly devaluations of the nominal exchange rate in line with the nominal interest differential (uncovered interest parity) in order to preserve price competitiveness. The higher the real interest differential vis-à-vis Germany and subsequently the euro area, the more sizeable the real depreciation that results from such a strategy. The estimation results confirm that this strategy was effectively implemented in Slovenia.

It should be noted that for Slovenia - similarly to Slovakia -, no meaningful relationship could be determined for the PPI-based real exchange rate. This coupled with the facts that productivity is found to be linked to the real exchange rate measured in terms of CPI and that the appreciation of the PPI-deflated real exchange rate is negligible in Slovenia suggests that contrary to the other countries, mainly to the Czech Republic, Hungary and Poland, the moderate appreciation could be largely attributed to the BS effect and regulated prices. Worthy of mention is that Slovenia has attracted, deliberately, the least FDI in terms of GDP during the period of 1993-2002.

6.2 Panels

The panel investigation is carried out on different panels in order to check for robustness of the results. First, the panel cointegration tests are performed on a panel composed of the five countries (panel 5), which are dealt with beforehand, and this for the periods 1993 to 2002, 1994 to 2002 and 1995 to 2002. Subsequently, the three Baltic countries, i.e. Estonia, Latvia and Lithuania are added to the panel (panel 8) for which econometric tests are performed for the periods running from 1994 to 2002, 1995 to 2002 and 1996 to 2002. Finally, the panel is enlarged to 9 members section with the inclusion of Croatia (panel 9) and is investigated for 1995-2002, 1996-2002 and 1997-2002.

Seven specifications are estimated for each panel and for each time period. They are based upon results of the time series analysis and thus are the combination of variables found significant in the time series tests (See Table 10). Note that each specification is estimated using alternatively the different productivity measures (PROD1,PROD2,PROD3, GDP), and for the CPI and the PPI based real exchange rate. For panels including 8 and 9 countries, only PROD1 and PROD3 are used because of the lack of data. As discussed in

Section 5.2, eleven different econometric specifications are estimated[15], which leaves us with a total of 3696 estimated equations.[16]

Table 10 Estimated panel specifications

	Y	X1	X2	X3	X4	X5
Eq1 :	RERCPI	PROD1/PROD2/PROD3/GDP	INTCPI	REGDIFF	FDEBT	OPEN
Eq2 :	RERCPI	PROD1/PROD2/PROD3/GDP	INTCPI	REGDIFF	FDEBT	GOV
Eq3 :	RERCPI	PROD1/PROD2/PROD3/GDP	INTCPI	REGDIFF	OPEN	GOV
Eq4 :	RERCPI	PROD1/PROD2/PROD3/GDP	INTCPI	FDEBT		
Eq5 :	RERCPI	PROD1/PROD2/PROD3/GDP	INTCPI	REGDIFF	FDEBT	
Eq6 :	RERCPI	PROD1/PROD2/PROD3/GDP	INTCPI	REGDIFF	GOV	
Eq7 :	RERCPI	PROD1/PROD2/PROD3/GDP	INTCPI	REGDIFF	OPEN	

After running the equations, Pedroni cointegration tests are applied to the residuals of the long-term relationship. In a score of cases, cointegration test find strong evidence for long-run relationships for specifications based on the CPI based real exchange rate for all three panels. The productivity measures, whether it is PROD1,PROD2, PROD3 or GDP are always negatively related to the real exchange rate, i.e. an increase in productivity leads to a real appreciation based on the CPI index. And this holds true regardless of the time period, number of included countries and the specification of the estimated equation.

Selected results based on panel DOLS estimates are shown in Table 11 for panel 5. These reveal that the estimated coefficient for labour productivity is statistically significant and has the expected sign, irrespective of whether the CPI or the PPI-based real exchange rate is employed. This strongly supports the view that for panel 5 the appreciation of the real exchange rate is to a large extent due to changes in tradable prices induced by productivity increases. The size of the coefficient seems to be systematically higher for the CPI-based real exchange rate when compared with that obtained for the PPI-based real exchange rate. Thus, productivity-induced service price inflation also contributes to real appreciation to some extent.

Table 11 Selected Panel Estimates for Panel 5, DOLS

	PROD	RIR	REG	FDEBT	OPEN	GOV	Cointegration test (p-value)		
Equation 3							P5	P6	P7
CPI, 1993-2002, PROD2	-0.60	-0.004	-0.07		0.13	-1.27	0.000	0.075	0.296
(1,1)	(-6.14)	(-4.73)	(-2.02)		(2.35)	(-7.64)			
PPI, 1993-2002, PROD2	-0.38	-0.003	-0.06		0.08	-0.65	0.001	0.012	0.025
(1,1)	(-4.78)	(-4.54)	(-2.08)		(1.82)	(-4.49)			
Equation 5									
CPI, 1993-2002, PROD 3	-0.47	-0.001	-0.17	0.23			0.000	0.000	0.001
(1,1)	(-4.00)	(-2.29)	(-4.13)	(3.40)					
PPI, 1993-2002, PROD3	-0.22	-0.002	-0.11	0.20			0.001	0.000	0.000
(1,1)	(-4.02)	(-2.70)	(-2.90)	(3.18)					
Equation 6									
CPI, 1995-2002, PROD1	-0.31	-0.004	-0.13			-1.38	0.001	0.040	0.091
(0,0)	(-3.58)	(-3.61)	(-3.48)			(-6.76)			
PPI, 1995-2002, PROD1	-0.17	-0.004	-0.13			-0.62	0.001	0.003	0.013
(0,1)	(-2.25)	(-4.59)	(-4.03)			(-3.58)			
Equation 7									
CPI, 1994-2002, PROD2	-0.84	-0.004	-0.12		0.23		0.000	0.008	0.010
(0,0)	(-7.19)	(-3.93)	(-2.65)		(3.52)				
PPI, 1994-2002, PROD2	-0.46	-0.004	-0.17		0.46		0.000	0.000	0.000

[15] Pooled OLS, fixed effect OLS and DOLS, PMGE and MGE based on three alternative lag structure.

[16] For each panel, 462 equations are estimated (3(periods)*2(CPI,PPI specification)*7(equations as in Table 10)*11(econometric specifications: pooled OLS, fixed effect OLS, DOLS(AIC;SIC,HQ), PMGE(AIC;SIC,HQ), MGE(AIC;SIC,HQ))). For panel 5, four alternative measures for productivity are used whereas for panels 8 and 9, only two of them (462*(4+2+2)).

(1,1)	(-4.46)	(-2.36)	(-2.19)		(2.26)			

Note: PROD1 and PROD2 stand for labour productivity in industry measured by industrial production, PROD3 uses value added from national accounts. Leads and lags are shown in parentheses in column 1. Figures in columns 2-6 are estimated coefficients of the denoted variables in the tested relationship. T-stats are in parentheses below the estimated coefficients. p5, p6 and p7 denote respectively the Group rho-Statistics, the Group PP-Statistics (non-parametric) and the Group ADF-Statistics (parametric) proposed by Pedroni (1999)

Generally speaking and based on the whole set of estimations, similarly to labour productivity, regulated prices are also found to contribute to the real appreciation in all tested relationships. Moreover, an increase in openness is most often leading to a real depreciation. The sign of foreign debt and government debt differs across specifications and applied methods. When foreign debt is leading to a real appreciation, we do not consider this to be an equilibrium phenomenon. Rather, in the chosen time period the inflow of capital might have caused upward pressure on the exchange rate; and its negative impact on the exchange rate due to debt servicing will materialise only at a later point.

6.3 Real Exchange Rate Misalignments

On the basis of the estimated time series and panel equations, the second step of the analysis consists in determining the estimated equilibrium real exchange rate. This is done using three sets of values of the fundamentals: (a) actual values, (b) long-term values obtained by means of the Hodrick-Prescott filter with the smoothing parameter set at the standard 1600 and (c) those computed by means of a smoothing parameter of 100. The later distinction is done to see to what extent radically different smoothing parameters can affect the fitted value. Having done this, in a next step the total real misalignment is computed as the difference between the estimated equilibrium and the observed real exchange rates. First, in a rather benign neglect way, the fitted values and the derived real misalignments are taken as such. Nonetheless, given that some of the series used in the estimations are indexes, the question of the basis/reference year is to be addressed. Indeed, one needs to determine a year over the period under investigation, during which the real exchange rate can be viewed as fairly valued. Judging upon the external position of the countries, 1993 is taken as the reference year for the Czech Republic and Slovenia, whereas 1994 is chosen for Poland and Slovakia. For Hungary, two years, namely 1992 and 1997 are picked out. This enables us to check for the sensitivity of the base year assumption.

For the time series case, real misalignment s could be determined only for the Czech Republic, Hungary and Poland because no useful specification was found for Slovakia and Slovenia. First, actual real misalignment is derived for the CPI-based real exchange rate on the basis of different econometric specifications as presented in Section 6.1. Then, total real misalignment is computed by the substitution of long-term values of the fundamentals that are calculated by means of two different HP filters. The results are reported in Tables 12a to 12c.

In the Czech Republic, actual real misalignment is very close to total real misalignment and both of them indicate an overvaluation of the real exchange rate by up to 12% in the last quarter of 2002. Results derived based on the reference year of 1993 show a higher overvaluation as opposed to when no reference year is used. But more strikingly, substantial differences exist for the same specification estimated on the basis of alternative econometric techniques. For instance, when the base year is set to 1993 and using a HP filter with a smoothing parameter of 1600 (6^{th} line in Table 12a), a difference of 6 percentage points can be observed between the lower end, i.e. 4.01%; DOLS with leads and lags being chosen with the Akaike information criterion and the higher end, i.e. 10.29% obtained with Engle-Granger. Even more astonishing is the fact that using DOLS with different leads and lags structure yields two real misalignment figures the difference between whom is as high as more than 3 percentage points. This is something that can also be observed for Hungary and Poland.

In Hungary, actual real misalignment ranges from –10% to 10%. Nevertheless, what we are really interested in is total real misalignment. Although apparently sensitive to the choice of the reference year, total real misalignment figures clearly indicate an overvaluation of the Hungarian currency in the fourth quarter of 2002.

In Poland, the real exchange rate was overvalued according to figures shown in Table 12c. The results appear relatively insensitive to the choice of the base year.

To sum up the extent of a possible overvaluation of the currencies, Table 12d provides some descriptive statistics for the fourth quarter of 2002, namely the means, confidence intervals, mean +/- confidence intervals and Jarque and Bera normality tests for total real misalignment. The use of confidence intervals makes sense only if the sample follows normal distribution. The mean of the overvaluation is between 4% to 7% in the Czech Republic, 7% to 12% in Hungary and ranges from about 12% to 15% in Poland.

Table 12a Real misalignment s Based on Time Series in 2002:Q4, Czech Republic

BASE YEAR		EG	DOLS_SIC	DOLS_AIC	ARDL	Johansen
		Actual real misalignment				
None	ORIGiNAL	7.81%	4.43%	3.61%	4.41%	5.16%
1993	ORIGINAL	12.94%	8.78%	5.76%	7.44%	11.17%
		Total real misalignment				
None	HP1600	6.03%	2.68%	0.00%	1.17%	4.28%
None	HP100	7.49%	3.73%	1.11%	2.10%	5.29%
1993	HP1600	10.29%	7.16%	4.01%	4.90%	8.51%
1993	HP100	11.35%	7.13%	3.92%	5.61%	9.63%

Table 12b Real misalignments Based on Time Series in 2002:Q4, Hungary

BASE YEAR		DOLS_SIC	DOLS_AIC	ARDL	Johansen
		Actual real misalignment			
None	ORIGINAL	-9.24%	-11.43%	-6.03%	-1.58%
1997	ORIGINAL	-0.01%	-1.77%	2.26%	2.65%
1992	ORIGINAL	7.54%	5.49%	7.87%	10.45%
		Total real misalignment			
None	HP1600	7.94%	6.23%	5.94%	10.64%
None	HP100	4.27%	2.10%	4.38%	7.47%
1997	HP1600	5.53%	3.82%	6.01%	7.66%
1997	HP100	2.52%	0.57%	4.57%	5.09%
1992	HP1600	19.33%	17.90%	16.22%	20.82%
1992	HP100	17.70%	16.04%	16.25%	19.51%

Table 12c Real misalignments Based on Time Series in 2002:Q4, Poland

BASE YEAR		DOLS_SIC	DOLS_AIC	ARDL	Johansen
		Actual real misalignment			
None	ORIGiNAL	10.82%	13.43%	17.31%	4.83%
1994	ORIGINAL	18.47%	22.29%	25.91%	12.44%
		Total real misalignment			
None	HP1600	8.77%	13.86%	10.82%	9.71%
None	HP100	12.65%	16.97%	17.94%	9.93%
1994	HP1600	10.72%	15.84%	12.49%	11.24%
1994	HP100	14.81%	19.25%	19.91%	11.67%

Table 12d Summary of Real misalignments in 2002:Q4

	Czech Republic	Hungary	Poland
No. Obs	20	24	16
Mean	5.32%	9.52%	13.54%
Confidence interval (CI)	1.39%	2.60%	1.73%
Mean-CI	**3.93%**	**6.92%**	**11.80%**
Mean+CI	**6.70%**	**12.12%**	**15.27%**
Jarque-Bera (p-value)	0.727	0.264	0.510

A similar exercise is conducted for the panel setting. At the point of departure, we dispose of nearly 2000 estimated equations for the CPI-based real exchange rate, which are based on (1) the specifications of Table, (2) the alternative productivity measures, (3) different panel estimation techniques, (4) the 3 panels, i.e. panel 5, panel 8 and panel 9 and (5) different time periods for each panel (see footnote 13). Of these nearly 2000 equations, the equation were chosen that fulfilled the following two criteria: (1) the panel cointegration tests reject the null of the absence of cointegration and (2) all the coefficients are statistically significant. Of the nearly 2000 equations estimated, only a fraction appears to meet these selection criteria. We make sure that equations from panel 5, panel 8 and panel 9 are represented equally in the sample. This leaves us approximately 80 equations. This is using the selected equations that the actual and total real misalignments are computed for the five acceding countries.

The observed series and the long-term values obtained by means of the two HP filters are substituted into the estimated equation. For each country, the simply fitted values and the reference year is used. As a result, six sets of real misalignments, each composed of roughly 80 observations are derived for each country. Given the use of two different reference years, nine samples are derived for Hungary. Note that if an increase in foreign debt is found to cause an appreciation of the real exchange rate, foreign debt is not considered any further for the derivation of the real misalignment (its coefficient is set to 0). The real interest differential is not considered when deriving the actual and total real misalignments.

Table 13 Real misalignments Against the Euro, Panel Estimates, 2002:Q4

	ACTUAL	**TOTAL**		**ACTUAL**	**TOTAL**	
	ORIG	HP1600	HP100	ORIG_BY	HP1600_BY	HP100_BY
No. Obs	83	83	83	83	83	83
Czech Republic						
Reference year	--	--	--	**1993**	**1993**	**1993**
Mean	18.43%	24.95%	24.23%	30.42%	31.19%	31.10%
Confidence interval (CI)	2.10%	1.71%	1.62%	1.58%	1.78%	1.58%
Mean-CI	**16.33%**	**23.24%**	**22.61%**	**28.84%**	**29.41%**	**29.52%**
Mean+CI	**20.53%**	**26.66%**	**25.85%**	**32.00%**	**32.97%**	**32.68%**
Jarque-Bera (p-value)	0.295	0.185	0.314	0.394	0.185	0.346
Hungary						
Reference year	--	--	--	**1997**	**1997**	**1997**
Mean	5.34%	-2.19%	-1.18%	-2.94%	-2.42%	-1.52%
Confidence interval (CI)	2.63%	2.54%	2.59%	3.00%	2.68%	2.81%
Mean-CI	**2.71%**	**-4.73%**	**-3.76%**	**-5.93%**	**-5.10%**	**-4.33%**
Mean+CI	**7.97%**	**0.35%**	**1.41%**	**0.06%**	**0.25%**	**1.28%**
Jarque-Bera (p-value)	0.831	0.002	0.000	0.127	0.043	0.041
Reference year				**1992**	**1992**	**1992**
Mean				-7.94%	-6.97%	-6.19%
Confidence interval (CI)				3.12%	2.85%	2.95%
Mean-CI				**-11.07%**	**-9.82%**	**-9.14%**
Mean+CI				**-4.82%**	**-4.12%**	**-3.25%**
Jarque-Bera (p-value)				0.001	0.000	0.000

Poland

Reference year	--	--	--	**1994**	**1994**	**1994**
Mean	3.30%	3.87%	4.94%	6.03%	4.78%	5.53%
Confidence interval (CI)	2.17%	1.66%	1.69%	1.84%	1.70%	1.82%
Mean-CI	**1.13%**	**2.21%**	**3.25%**	**4.19%**	**3.08%**	**3.71%**
Mean+CI	**5.47%**	**5.53%**	**6.62%**	**7.88%**	**6.48%**	**7.34%**
Jarque-Bera (p-value)	0.026	0.009	0.003	0.022	0.050	0.031

Slovakia

Reference year	--	--	--	**1994**	**1994**	**1994**
Mean	23.38%	26.73%	25.91%	26.43%	27.64%	27.20%
Confidence interval (CI)	3.35%	3.29%	3.16%	3.04%	3.25%	3.15%
Mean-CI	**20.03%**	**23.44%**	**22.75%**	**23.39%**	**24.39%**	**24.06%**
Mean+CI	**26.73%**	**30.02%**	**29.08%**	**29.47%**	**30.89%**	**30.35%**
Jarque-Bera (p-value)	0.0949	0.3867	0.6137	0.6220	0.5030	0.5971

Slovenia

Reference year	--	--	--	**1993**	**1993**	**1993**
Mean	-3.87%	-2.36%	-2.73%	-10.00%	-8.66%	-10.19%
Confidence interval (CI)	2.59%	1.88%	1.85%	2.30%	2.16%	2.24%
Mean-CI	**-6.47%**	**-4.23%**	**-4.59%**	**-12.29%**	**-10.82%**	**-12.44%**
Mean+CI	**-1.28%**	**-0.48%**	**-0.88%**	**-7.70%**	**-6.50%**	**-7.95%**
Jarque-Bera (p-value)	0.905	0.155	0.174	0.205	0.118	0.090

Note: Negative/positive figures represent an undervaluation/overvaluation. Confidence intervals at the 5% significance level.

According to the Jarque-Bera tests shown in Table 13, the Czech, Slovak and Slovene samples are all normally distributed. When no reference year is used, the mean of real overvaluation ranges from 17% to 27% for the Czech Republic for the last quarter of 2002. Note that results slightly differ whether or not actual or long-term values of fundamentals (obtained using the HP filter) are used. However, when the reference year is set to 1993, the range of the real overvaluation shifts upwards to 29% to 33%. Also, the range diminishes from about 10 percentage points to 4.5 percentage points and the results appear neutral both for actual and total real misalignments. Similarly, sizeable overvaluation is detected for Slovakia. In the absence of a reference year, the real overvaluation lies between 20% and 30% and it narrows to 24% to 31% when 1994 is employed as a base year.

In contrast to the Czech Republic and Slovakia, real undervaluation is found for Slovenia the mean of which varies from 1% to 6.5% without reference year and from 6.5% to 12% with the base year set to 1993, and this for the last quarter of 2002.

For Hungary, the confidence interval around the mean does not indicate a clear under or overvaluation without using any reference year or with 1997 being the base year. In the former case, real misalignment ranges from a 4.7% undervaluation to a 8% overvaluation, whereas in the latter case, the range is –6% to 1%. However, the use of 1992 as a reference year shifts the extent of real misalignment towards undervalution with –11% to –3%. But non of the total real misalignment samples and actual real misalignment when 1992 is used as a base year turn out to be normally distributed. Hence, the corresponding confidence intervals are difficult to be interpreted.

As for Poland, the means of the distributions indicate a slight overvaluation in the last quarter of 2002. Note that the results seem to be affected little by the reference year. The overvaluation around the sample mean amounts to 1% to 8%. Nevertheless, and once again, normality cannot be rejected at the 5% level only when the HP filter with a smoothing parameter of 1600 and the reference year of 1994 are used. In this case, the confidence interval indicates an overvaluation of 3% to 6.5%.

It is noteworthy that results for the Czech Republic and Hungary are different to those obtained using time series estimates. As a matter of fact, panel results indicate an overvaluation of 17% to 33% whereas time series estimates yields an overvaluation of 4% to 7% for the Czech Republic. Whilst panel estimates are indecisive regarding the direction of a possible real misalignment, time series estimates suggest a clear overvaluation of 7% to 12% for Hungary.

This outcome may be because panel estimates represent average long-term coefficients for the panel members and factors that could not be established to have systematically affected the real exchange rate for the time series case can turn out to be important, on average, for the panel. To put it another way, country-specific variables could be dampened, and at the same time, factors not important to individual countries may be emphasised (either by including new variables or by different size of the coefficient) within the panel framework.

Regulated prices are a case in point. Based on time series techniques, the differential in regulated prices is not included into the estimated relationship for Hungary and Poland. Nonetheless, regulated prices are always significant in the panel setting. Therefore, they are used to derive values of the equilibrium real exchange rate for all countries and thus affect the size of the real misalignment.

7 Conclusion

The issue of equilibrium exchange rates has received a large echo in recent times. New EU member states can be expected to enter ERM-II sometime after EU accession, but not necessarily upon accession. For entering ERM-II, an appropriate central parity should be set for which the equilibrium exchange rate could serve as a yardstick.

In this article, an attempt was made to compare estimates of equilibrium real exchange rates of five acceding countries of Central Europe. In the choice and in the interpretation of the tested relationships, special attention was paid to the appreciation of the real exchange rate based on tradable prices. We developed a theoretical framework which provides a formal explanation to this. During the catch-up process and phases of higher growth, improvement in supply capacities, in the quality and reputation of goods produced in the home economy may result in a trend increase of both the CPI and PPI-deflated real exchange rates, in addition to the traditional source of trend appreciation, namely productivity-fuelled increases in market-based service prices (B-S effect).

Our results support the idea that the equilibrium appreciation of the real exchange rate in the transition economies is based not only on higher service prices, but also on higher prices of domestically produced tradable goods. Taking labour productivity in industry or in the overall economy as a proxy for increasing supply capacities, econometric tests show that labour productivity is found to be the most stable determinant not only of the overall inflation based real exchange rate but also of the real exchange rate measured in terms of tradable prices, proxied by PPI.

A score of time series and panel cointegration techniques were employed to assess real exchange rate determination for the Czech Republic, Hungary, Poland, Slovakia and Slovenia. Regarding time series estimates, it is possible to find long-term relationships between fundamentals and the real exchange rate vis-à-vis the German mark for the Czech Republic, Hungary and Poland. Nonetheless, alternative measures for labour productivity are found to perform differently across countries and cannot be taken as equivalent to one another. Also, beside labour productivity, the included variables differ considerably across the three countries. In contrast to the aforesaid three economies, it is a very hard task to find any economically sound long-term relationships for Slovakia and Slovenia. These two countries could be referred to as economies where it is difficult to establish the role of fundamentals regarding real exchange rate determination.

Going beyond the verification of the theoretical model, the size of total real misalignments is derived on the basis of time series estimates. Total real misalignments turn out to be sensitive with respect to the econometric technique and regarding the base year assumption in particular in Hungary. For all three countries, the results indicate a real overvaluation vis-à-vis the euro in the last quarter of 2002: 4% to 7% for the Czech Republic, 7% to 12% for Hungary and 12% to 15% for Poland.

Panel estimates based on different estimation techniques, panel size and model specification leave us with a number of real misalignments that indicate an overvaluation of 16% to 30% for the Czech Republic, of 20% to 30% for Slovakia and of 1% to 8% for Poland in the last quarter of 2002. An undervaluation ranging from 1% to 12% is found for Slovenia and real misalignments are between –5% (undervaluation) to 8% (overvaluation) for Hungary for the fourth quarter of 2002.

The conflicting results between time series and panel estimates regarding the size (Czech Republic and Poland) or partly even the direction of the real misalignment (Hungary) may be due to the fact that country-specific factors may be crucial, and their neglect in the panel framework can substantially change the derived real misalignment. Moreover, differences are also marked when comparing the results of different econometric methods or time periods.

To conclude, estimates of the equilibrium real exchange rates and the underlying real misalignments are fairly sensitive to the chosen econometric method, period and model specification and regarding differences in the included variables. Therefore, further research is needed to systematically evaluate the sources of different results. In particular, medium-size and large panels are needed as well as a structural model-based assessment.

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