THE BALASSA-SAMUELSON EFFECT IN CENTRAL EUROPE:
A DISAGGREGATED ANALYSIS

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Abstract

This paper aims to explain differences in inflation between six central European economies – Croatia, the Czech Republic, Hungary, Poland, Slovakia and Slovenia – and the euro area in terms of differences in productivity growth between tradable and non-tradable sectors. The coverage of tradable and non-tradable sectors is broader and more detailed than in previous studies and the data samples are larger, as quarterly data for up to 10 years are used. The main conclusion is that productivity differentials explain on average only between 0.2 and 2.0 percentage points of annual inflation differentials vis-à-vis the euro area. Productivity differentials also explain only a small proportion of domestic inflation in central European economies. Earlier studies that estimated the Balassa-Samuelson effect to be larger have often neglected to consider the impact of productivity differentials on inflation relative to the euro area, focusing instead only on their impact on domestic inflation. Many studies have also neglected the relatively high productivity growth in non-tradable industries. The estimates in this paper suggest that differences in productivity growth between EU accession countries and the euro area are unlikely to widen sufficiently to become a determining factor in the ability of these countries to satisfy the Maastricht inflation criterion.

JEL classification numbers: E31, F36, O11, P20

Keywords: Balassa-Samuelson effect, productivity, inflation, EMU, transition

April 2004

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Introduction[1]

This paper provides estimates of the Balassa-Samuelson effect – the extent to which differences in productivity growth between tradable and non-tradable industries explain the observed differences in inflation between central European countries and the euro area. The Balassa-Samuelson effect has major implications for interpretation of the inflation and exchange rate criteria for membership in the European monetary union (EMU). If the productivity growth differential between the traded and non-traded goods sectors is larger in the accession countries than the euro area, the relative price of non-traded to traded goods will be rising faster in the accession countries than in the euro area. Under a fixed exchange rate regime the Balassa-Samuelson effect will result in CPI inflation and real exchange rate appreciation. Under a flexible exchange rate regime it will result in some combination of nominal appreciation and CPI inflation. If the Balassa-Samuelson effect is strong, the authorities in countries with fixed exchange rate regimes might feel compelled to maintain very restrictive monetary and fiscal policies in order to meet the Maastricht inflation criterion, putting at risk growth and employment. On the other hand, the authorities in countries with flexible exchange rate regimes might feel compelled to allow the exchange rate to appreciate rapidly, which may attract volatile capital inflows and hurt competitiveness.

The available estimates of the Balassa-Samuelson effect in central European countries range from zero to 4 percentage points per annum (see Table 1). However, most of the studies do not test the extent to which productivity differentials explain the differences in inflation between accession countries and the euro area. Rather, they test a related "domestic" version of this hypothesis developed by Baumol and Bowen (1966), according to which service prices grow faster than manufactured goods prices due to faster productivity growth in manufacturing industries. Such estimates do not shed any light on the policy issue noted above – whether, and to what extent, productivity growth differentials can account for CPI increases above the Maastricht inflation criterion. The additional inflation can be explained in terms of underlying productivity developments only if the productivity growth differential (between traded and non-traded industries) is sufficiently higher in accession countries than in the euro area.

Against this background, this paper aims to assess, with some degree of accuracy, the empirical relevance of the Balassa-Samuelson effect in six central European countries – Croatia, the Czech Republic, Hungary, Poland, Slovakia and Slovenia. The paper extends previous work by clarifying testable hypotheses, ie, the international and domestic versions of the Balassa-Samuelson effect, and by considering a disaggregated set of tradable and non-tradable industries as well as larger data samples. The paper finds clear evidence of the Balassa-Samuelson effect – in both its international and domestic versions – in all six countries. However, the size of the effect is found to be relatively small. Productivity differentials vis-à-vis the euro area explain on average only between 0.2 and 2.0 percentage points in annual inflation differentials, considerably less than the observed inflation differentials. Likewise, sectoral productivity growth differentials explain a relatively small proportion of domestic CPI inflation in individual countries. The paper argues that many previous studies had obtained higher estimates of the Balassa-Samuelson effect because they had neglected to consider inflation and sectoral productivity growth relative to the euro area, focusing instead only on the impact of productivity differentials on domestic inflation. Moreover, many studies had neglected to take into account relatively high productivity growth in non-tradable industries.

The next two sections lay out the analytical and empirical framework used in the paper. The fourth section looks at historical trends in inflation and productivity differentials. The fifth section provides econometric estimates of international and domestic versions of the Balassa-Samuelson effects. The concluding section discusses some policy implications of the results.

1. Analytical framework

Balassa (1964) and Samuelson (1964) identified productivity growth differentials between the sectors producing tradable and non-tradable goods as a factor introducing systematic biases into the relationship between relative prices and real exchange rates. Historically, productivity growth in the traded goods sector has been faster than in the non-traded goods sector. By the law of one price, the prices of tradables tend to get equalised across countries, while the prices of non-tradables do not. Higher productivity in the tradable

[1] The authors acknowledge helpful comments from Palle Andersen, Claudio Borio, Balász Égert, Andrew Filardo, Renato Filosa, Christoph Fischer, Boštjan Jazbec, Ali Kutan, Jeffrey Miller and Velimir Šonje. The authors also thank central bank colleagues for supplying the data. Earlier versions of this paper were presented at the 8th Dubrovnik Economic Conference (June 2002); the International Centre for Economic Growth (European Centre) conference on *Exchange rate strategies during the EU enlargement* (November 2002); and a BIS seminar (June 2003). A version of this paper will be published in *Comparative Economic Studies*, Spring 2004.

goods sector will bid up wages in that sector and, with labour being mobile, wages in the entire economy will rise. Producers of non-tradables will be able to pay the higher wages only if the relative price of non-tradables rises. This will in general lead to an increase in the overall price level in the economy.

To formalise this model, the aggregate price level is first decomposed into its traded and non-traded components, both at home and abroad (the latter are indicated by "*"):

$$p_t = \alpha p_t^T + (1 - \alpha) p_t^{NT} \tag{1}$$

$$p_t^* = \alpha^* p_t^{T*} + (1 - \alpha^*) p_t^{NT*} \tag{1'}$$

where lower-case letters denote logarithms; p_t^T is the price of traded goods, p_t^{NT} is the price of non-traded goods, and α is the share of traded goods in each economy.

The real exchange rate q is defined as the ratio of foreign and domestic price levels measured in domestic currency (all variables are expressed in logarithms):

$$q_t = (e_t + p_t^*) - p_t \tag{2}$$

where e_t is the nominal exchange rate expressed in units of the domestic currency per unit of the foreign currency. Substituting (1) and (1') into (2) and expressing the result in terms of changes, the following expression can be obtained:

$$\Delta q_t = (\Delta e_t + \Delta p_t^{T*} - \Delta p_t^T) + [(1-\alpha^*)(\Delta p_t^{NT*} - \Delta p_t^{T*}) - (1-\alpha)(\Delta p_t^{NT} - \Delta p_t^T)] \tag{3}$$

If the law of one price (in changes) holds in the tradable sector, then:

$$\Delta p^T = \Delta e + \Delta p^{T*} \tag{4}$$

ie the first term on the right-hand side of (3) will be zero. Next, an expression for the movements of relative prices in terms of the productivity differentials between traded and non-traded goods is derived. A model of a small open economy with the following sectoral production functions is assumed (time subscripts are omitted to simplify notation and adjustment costs are ignored):

$$Y^T = A^T (L^T)^\gamma (K^T)^{1-\gamma} \tag{5}$$

$$Y^{NT} = A^{NT} (L^{NT})^\delta (K^{NT})^{1-\delta} \tag{5'}$$

where Y denotes output of traded and non-traded goods and A, K and L are productivity, capital and labour inputs respectively. Assuming perfect mobility of capital both internationally and across the two sectors internally, as well as perfect competition in both sectors, profit maximisation implies:

$$R = (1-\gamma) A^T \left(\frac{K^T}{L^T} \right)^{-\gamma} \tag{6}$$

$$R = \frac{P^{NT}}{P^T} (1-\delta) A^{NT} \left(\frac{K^{NT}}{L^{NT}} \right)^{-\delta} \tag{7}$$

$$W = \gamma A^T \left(\frac{K^T}{L^T} \right)^{1-\gamma} \tag{8}$$

$$W = \frac{P^{NT}}{P^T} \delta A^{NT} \left(\frac{K^{NT}}{L^{NT}} \right)^{1-\delta} \tag{9}$$

where R is the rental rate on capital (determined in world markets), W is the wage rate (measured in tradables) and P^{NT}/P^T is the relative price of non-tradables to tradables.

A key insight of Balassa and Samuelson is that, with perfectly mobile and homogeneous capital and labour, the relative price of non-tradables P^{NT}/P^T is governed entirely by the production side of the economy. Equations (6)–(9) involve four equations in four variables (K^T/L^T, K^{NT}/L^{NT}, W and P^{NT}/P^T) that can be solved recursively.[2]

By log-differentiating equations (6)–(9), one can obtain the following (domestic) version of the Balassa-Samuelson hypothesis:

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[2] Given the constant returns to scale production functions, equation (6) implies a unique level of K^T/L^T consistent with the world rate of return on capital R. Given K^T/L^T, equation (8) determines the economy-wide wage rate W. The remaining two equations then determine K^{NT}/L^{NT} and P^{NT}/P^T.

$$\Delta \frac{p^{NT}}{p^{T}} = \Delta p^{NT} - \Delta p^{T} = \left(\frac{\delta}{\gamma}\right)\Delta a^{T} - \Delta a^{NT} \tag{10}$$

where lower-case letters denote logarithms and Δa^T and Δa^{NT} are growth rates of total factor productivity in the two sectors.

An important point that is often overlooked in the literature is that if non-traded goods are more labour-intensive (ie $\delta > \gamma$), then even a balanced growth of productivity ($\Delta a^T = \Delta a^{NT}$) will lead to an appreciation of the relative price of non-traded goods (see Froot and Rogoff (1985)). A second point is that the change in relative prices will be equal to the productivity growth differential only if both sectors have the same degree of labour intensity.

The foreign economy (the euro area) is introduced by substituting (10) into (3) and using (2) and (4):

$$\Delta p_t - \Delta p_t^* = \Delta e_t + (1-\alpha_t)[\left(\frac{\delta}{\gamma}\right)\Delta a_t^T - \Delta a_t^{NT}] - (1-\alpha_t^*)[\left(\frac{\delta^*}{\gamma^*}\right)\Delta a_t^{T*} - \Delta a_t^{NT*}] \tag{11}$$

The difference between the rates of inflation in an accession country and the euro area can thus be expressed as a sum of the change of the accession country's currency vis-à-vis the euro, Δe, and a weighted average of the productivity growth differentials between the traded and non-traded goods sectors in the accession country ($\Delta a^T - \Delta a^{NT}$) and the euro area ($\Delta a^{T*} - \Delta a^{NT*}$).[3]

A final analytical point to note is that the Balassa-Samuelson effect is closely related to – but distinct from – the so-called Baumol-Bowen effect. Baumol and Bowen (1966) argued that within a country there is a broad tendency for the prices of service-intensive goods (education, health care, banking, etc) to rise over time as, historically, productivity growth in these activities has tended to be slower than in more capital-intensive manufacturing. Although there is a considerable overlap between non-tradables and service-intensive goods, the presence of a rising relative price of services, established on the basis of equation (10), is not sufficient to imply a Balassa-Samuelson effect. As noted above, a higher rate of inflation at home than abroad can be explained as an equilibrium phenomenon only if differential productivity growth between the sectors producing traded and non-traded goods is greater at home than abroad.

2. Empirical framework

Most studies investigating the Balassa-Samuelson effect in transition economies use a measure of the relative price of non-tradables as the dependent variable and estimate a version of equation (10) (see Table 1).[4] In fact, these studies estimate the Baumol-Bowen effect and only seek to establish a positive correlation between differential productivity growth and the relative price of non-tradables.

The remaining studies focus on the evolution of real effective exchange rates (REER).[5] The main problem with this approach (which could be overcome but is typically ignored) is that REER indices include inflation differentials as well as nominal exchange rate changes vis-à-vis countries outside the euro area. As a result, this approach may lead to inaccurate measurement of the Balassa-Samuelson effect.[6]

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[3] An equivalent expression can be derived within the Scandinavian model of inflation (Aukrust (1977)). This model ignores factor intensities and explains the domestic rate of inflation (π) and the increases in domestic money wages in the open (or "exposed") and "sheltered" sectors through an exogenously given rate of increase in the foreign price level, π^*, and the development of labour productivity in the two sectors (a_E and a_S): $\pi = \pi^* + \alpha_S(a_E - a_S)$.

[4] This is also true of many studies of the Balassa-Samuelson effect in industrial countries, eg De Gregorio et al (1994) and Swagel (1999). One exception is Alberola-Ila and Tyrväinen (1998).

[5] In a two-country model, the CPI-based real effective exchange rate corresponds to the real exchange rate in equation (2), which was used to derive the Balassa-Samuelson equation (11). Using the notation in (1), (1') and (2), the evolution of the real exchange rate is: $e - [\alpha p^T + (1-\alpha) p^{NT}] + [\alpha p^{T*} + (1-\alpha) p^{NT*}]$, where the share of traded goods in consumption (α) is assumed to be same at home and abroad. The real exchange rate then changes as: $-(1-\alpha)[(p^{NT} - p^T) - (p^{NT*} - p^{T*})]$, ie it appreciates when $p^{NT} - p^T > p^{NT*} - p^{T*}$.

[6] Fischer (2002) points out that, in a model with investment demand, rising productivity in the export sector (which is usually relatively capital-intensive) raises the equilibrium capital stock and thus investment demand. This in turn increases prices and, ceteris paribus, leads to a real exchange rate appreciation. The estimated total effect of productivity on the real exchange rate may thus include not only the pure Balassa-Samuelson effect, but also the investment demand effect.

Table 1 **Selected empirical studies of the Balassa-Samuelson effect in central European economies**						
Study author(s) **Country sample**	**Dependent variable**	**Sectoral decomposition**		**Other explanatory variables**	**Estimation method**	**Estimate of the BS effect** (percentage points per annum)
		Tradables	**Non-tradables**			
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	P^N/P^T (NT/T goods and services from CPI)	Industry and mining (goods from CPI)	Residual (excluding agriculture), services from CPI	—	OLS	**0.5–0.7**
Rother (2000) Slovenia, 1993–98, quarterly data	P^N/P^T (producer price index/ labour costs)	Manufacturing	Residual (excluding agriculture)	Monetary base, budget deficit/GDP, gvt cons/GDP	OLS	**1.0–4.0**
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	P^N/P^T (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	P^N/P^T (services/non-food 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	P^T/P^N (sectoral GDP deflators)	Manufacturing, mining, energy and construction	Residual	Share of non-tradables consumption, government consumption, "structural misalignment" measure	Fixed effects panel estimation	**0.9–1.2**
Arratibel et al (2002) 10 accession candidates, 1990–2001	P^N/P^T (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

Only few studies have so far attempted to estimate to what extent inflation differentials between accession countries and the euro area can be explained by relative productivity differentials.[7] In particular, equation (11) has not been tested empirically despite its obvious policy content. The main contribution of this paper is to try to fill this gap.

The paper also extends the existing literature in terms of the data used to estimate the Balassa-Samuelson effect. A major weakness of many existing studies is that the sectoral data used are highly aggregated. The traded goods sector typically includes industry – usually only manufacturing, but often also industries whose output is traded only to a small extent, such as construction and electricity, gas and water supply. The non-traded sector is in some studies the residual (ie GDP less industry) (see Table 1). In others, it covers all services irrespective of their traded content. Some studies do not even consider non-tradables, assuming that productivity growth in the sector is zero or equal across countries.[8] Another frequent problem is the use of industrial production indices (which measure gross output rather than value added) in constructing labour productivity measures.

To overcome these shortcomings and obtain more reliable estimates, this paper uses a disaggregated analysis. The coverage of traded and non-traded industries is much broader and more detailed than in previous studies. In particular, the traded sector includes not only manufacturing, but also mining, transportation and communications, and tourism, while the non-traded sector includes energy, construction, wholesale and retail trade, real estate and business services, education, health and personal services (see Appendix).

Another weakness of existing empirical work that this paper tries to overcome is that most studies use annual data for the 1990s and try to compensate for the short time series by pooling data from different countries. Such cross-country panels often include very heterogeneous economies, from advanced transition economies in central Europe to poorly developed central Asian economies.[9] This paper relies instead on larger data samples, as quarterly data for up to 10 years are used. This makes it possible to estimate the Balassa-Samuelson effect for individual countries rather than a panel of economies with different structural characteristics. The data series are nevertheless still very short and are of poor quality for some countries. This underlines the need to interpret the results cautiously.

Finally, most studies assume the shares of non-traded goods to be the same across countries. This paper, by contrast, calculates country-specific shares of non-traded goods. While these shares are similar across central and eastern Europe (where they range from 54 to 60%), they are significantly lower than in the euro area (76%). This makes it possible to provide more precise estimates of the Balassa-Samuelson effect.

One simplifying assumption that this paper has in common with existing literature is that factor intensities in non-traded and traded sectors (δ and γ) are the same.[10] However, rather than ignoring this assumption, the paper highlights its importance for the estimates.

Finally, like other studies of the Balassa-Samuelson effect, this paper uses data on average labour productivity as a proxy for total factor productivity. The reason is the lack of data on capital stocks for central European economies. While, in theory, one could construct these data from statistical series on capital investment, data on initial capital stocks are either unavailable (in particular at industry level) or so unreliable as to make the exercise of questionable empirical value. One consequence of using this proxy is that labour productivity differences exaggerate true differences in *total* factor productivity.[11] In particular, extra capital raises output, holding other factor inputs constant, and therefore raises measured output per worker. The resulting bias is likely to be greater for relatively capital-intensive tradables than for non-tradables, as well as for countries with relatively higher endowment of capital (ie the euro area). How this affects the estimates of the Balassa-Samuelson effect in this paper is discussed further below.

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[7] Egert (2002a, b); Egert et al (2002); and Flek et al (2002) estimate the inflation differentials vis-à-vis Germany as a proxy for the European Union.

[8] See Egert (2002a, b). Egert (2003), however, provides a detailed analysis of the Balassa-Samuelson effect in Estonia based on highly disaggregated data.

[9] See eg Coricelli and Jazbec (2001), De Broeck and Sløk (2001) and Jazbec (2001).

[10] Under the assumptions of equal productivity growth in domestic and foreign non-tradable industries, equal shares of non-tradables, and equal factor intensities, equation (11) simplifies to: $\Delta p_t - \Delta p_t^* - \Delta e_t = (1 - \alpha_t)(\Delta a_t^T - \Delta a_t^{T*})$. The left-hand side of this equation is frequently used as the dependent variable in the empirical work using the CPI-based real effective exchange rates.

[11] Using a simple production function $Y = AL^{\alpha}K^{(1-\alpha)}$, one can easily show that $(dY/Y)/(dL/L) = \alpha + (dA/A)/(dL/L) + (1-\alpha)(dK/K)/(dL/L)$, ie growth of average labour productivity is a sum of total factor productivity growth per worker and capital deepening.

3. Historical trends in inflation and productivity differentials

In order to obtain a first impression of the Balassa-Samuelson effect, the sectoral data on productivity and prices in various countries are plotted in Charts A1–A4 in the Appendix. Most of the series are shown as unadjusted four-quarter percentage changes in order to highlight the data measurement problems for some countries. In the econometric work all the time series are seasonally adjusted using the X-12 procedure.

As the first panel for each country shows, productivity in the traded goods sector has grown faster than in the non-tradable sector over the whole sample period. The exception is Slovakia, where the growth rate of labour productivity in non-traded industries was higher during 1996–97. According to the theoretical model, faster productivity growth in tradable industries should have implied faster growth of non-traded goods prices. The second panel for each country shows that this has in general been the case. One exception is again Slovakia in the mid-1990s; another is Slovenia in the early 1990s.

The core of the productivity hypothesis is shown in the third panel for each country. Relative prices of non-tradables have tended to rise as relative productivity in the tradable sector has increased. This provides support for the Baumol-Bowen effect. From Chart A4 one can observe, however, that the productivity growth differential in the euro area has also been large. Thus, despite evidence that relative prices of non-tradables in central European economies have increased in line with the relative productivity of tradables, one should not jump to the conclusion that the Balassa-Samuelson effect has been present vis-à-vis the euro area.

The data also suggest that the assumption of the Balassa-Samuelson model on uniform wage growth – due to sectoral labour mobility – seems to hold in most countries (see the fourth panel for each country in Charts A1–A4). However, the growth rate of wages in Croatia's non-tradable industries has been consistently higher, despite higher labour productivity growth in traded goods industries. The same phenomenon could be observed in Slovakia as well as the Czech Republic (in 2000) and Poland (in 1999). In the latter two cases, however, the deviations probably reflect data problems. Non-uniform growth of wages in Croatia and Slovakia suggests that relative wages may also have played a role in the long-run relationship between sectoral prices and productivity growth differentials. Relative wages were therefore used as an additional variable to derive the Balassa-Samuelson effect in these two countries.

Data on productivity and relative prices are summarised in Chart 1. All central European economies achieved higher productivity growth than the euro area in both tradables and – with the exception of the Czech Republic – non-tradables. The average productivity differential between traded and non-traded industries ranged from 2 percentage points in Poland to almost 9 percentage points in the Czech Republic. But the average productivity differential with respect to the euro area was equivalent to 1 percentage point or less in Hungary, Poland and Slovakia. In contrast, inflation differentials between central European countries and the euro area were generally much higher, ranging from 3 to 14 percentage points. Thus, despite preliminary evidence of the presence of the Balassa-Samuelson effect, the historical averages suggest that productivity differentials were probably not sufficiently large to explain inflation differentials between central Europe and the euro area.

This point is further elaborated in Table 2, which shows average values of different components of equation (11), and Chart 2, which shows percentage contributions of different determinants of inflation differentials. In Hungary, Poland and Slovakia, the contribution of productivity differentials to inflation differentials was on average very small. In Croatia, the Czech Republic and Slovenia it was somewhat higher, although relative to exchange rate changes and other factors productivity differentials mattered only in the Czech Republic (Chart 2). In 2000–01, however, productivity differentials explain a higher fraction of inflation differentials in all the countries with the exception of Poland and Hungary (Table 2).

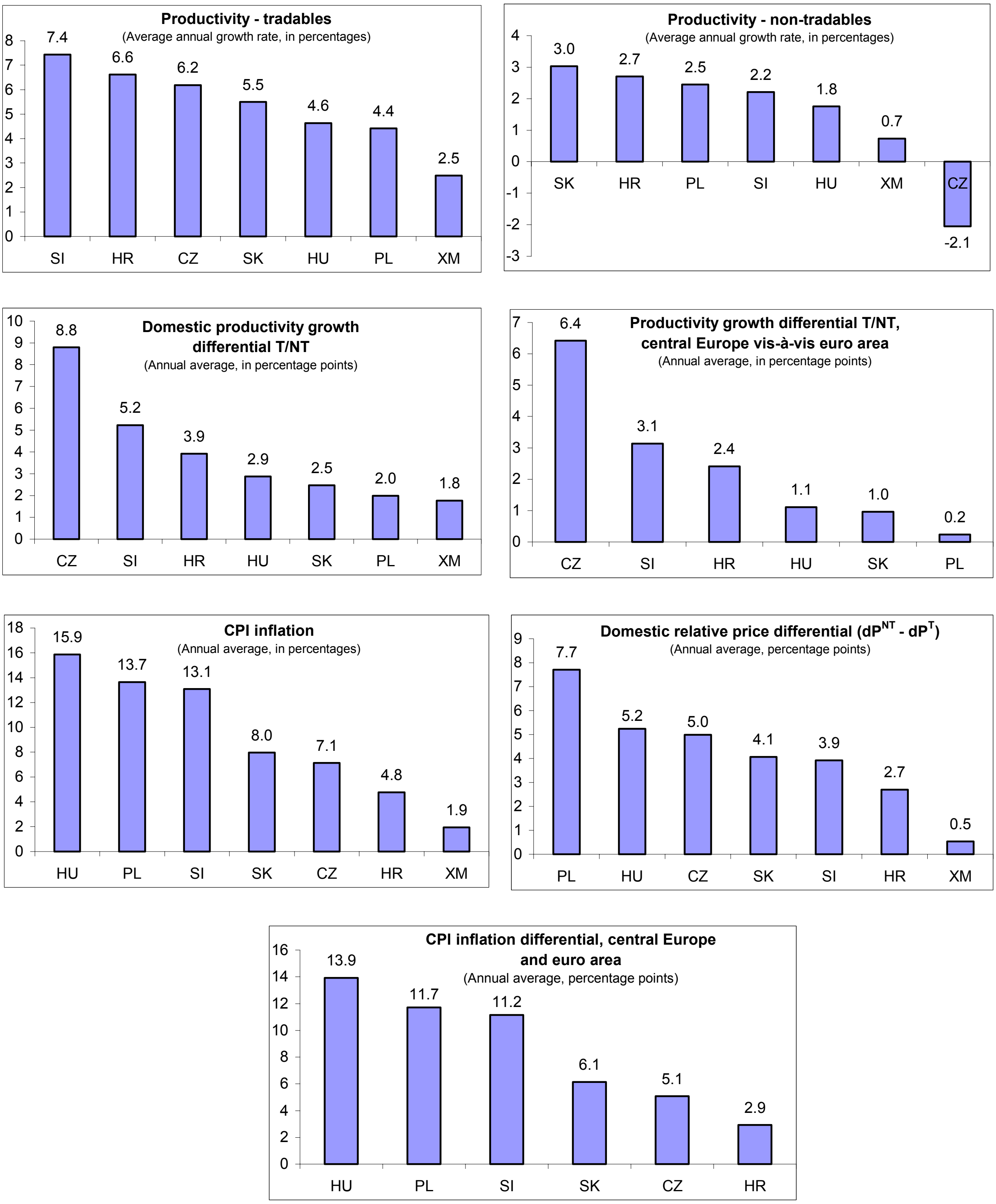
According to the theoretical model captured by equation (11), differences in inflation between two countries can be explained by changes in nominal bilateral exchange rates and relative productivity differentials. The null hypothesis is thus that coefficients on the three terms on the right-hand side of (11) are, respectively, 0, 1 and 1. A Wald test indicates, however, that these coefficients are significantly different from 0, 1 and 1.

It should be noted that the results of this test and those presented in Table 2 and Chart 2 are sensitive to the assumptions of equal factor intensities in tradable and non-tradable industries ($\delta = \gamma$), and equal ratios of labour shares in central European countries and the euro area ($\delta/\gamma = \delta^*/\gamma^*$). Assuming that factor intensities can be approximated by factor shares – a result that holds only in equilibrium – the former assumption could be verified only for Hungary, where it apparently holds.[12] In general, however, one would

[12] To calculate the factor shares from national accounts data, one needs a breakdown of GDP by income component for different production sectors of the economy. In central Europe, only Hungary publishes such data.

expect the labour share in non-tradable industries to be higher and, moreover, the ratio of labour shares (δ^*/γ^*) to be somewhat higher in the euro area than the less developed central European economies (since tradable industries in central Europe are more labour-intensive relative to the euro area). This effect would tend to further reduce the contribution of productivity differentials to inflation differentials.

Chart 1. Summary of productivity and relative price data[1]



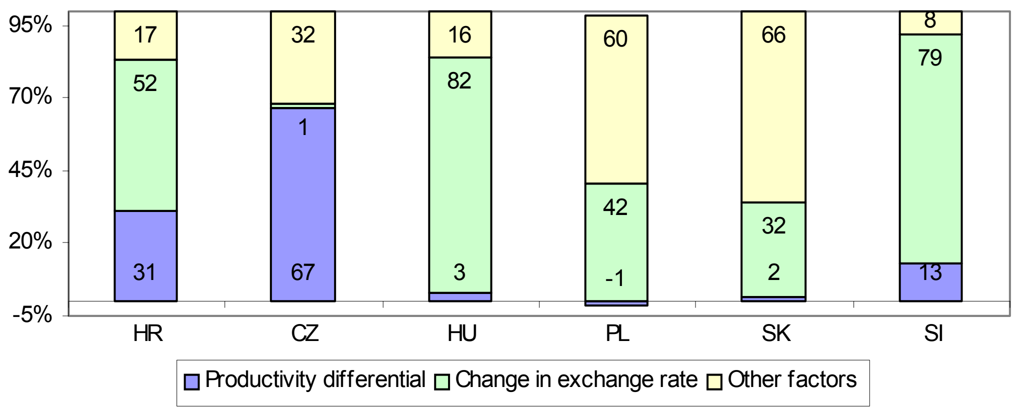
[1] For sample periods, see the Appendix.

Notation: CZ = Czech Republic, HR = Croatia, HU = Hungary, PL = Poland, SI = Slovenia, SK = Slovakia, XM = euro area.

Table 2	Determinants of inflation differentials (in percentage points)[1]					
Entire sample period[2]						
Country	Inflation differential vis-à-vis euro area	Change in nominal exchange rate vis-à-vis euro	Share of non-tradables	Productivity growth differential vis-à-vis euro area		Contribution of productivity differential to inflation differential[3]
				Tradables	Non-tradables	
Croatia	2.9	1.5	58	6.6	2.7	0.9
Czech R	5.1	0.1	57	6.2	–2.1	3.4
Hungary	13.9	11.4	60	4.6	1.8	0.4
Poland	11.7	4.9	60	4.4	2.5	–0.2
Slovakia	6.1	2.0	58	5.5	3.0	0.1
Slovenia	11.2	8.8	54	7.4	2.2	1.5
Euro area	...	...	76	2.5	0.7	...
Average for 2000–01						
Croatia	3.0	–0.7	58	8.1	1.4	2.4
Czech R	1.8	–3.8	57	5.4	–0.3	1.8
Hungary	6.7	0.8	60	5.0	2.3	0.1
Poland	4.9	–6.8	60	4.1	4.3	–1.6
Slovakia	6.8	–0.8	58	6.1	0.8	1.6
Slovenia	7.5	5.9	54	6.4	0.8	1.6
Euro area	...	...	76	3.1	1.2	...

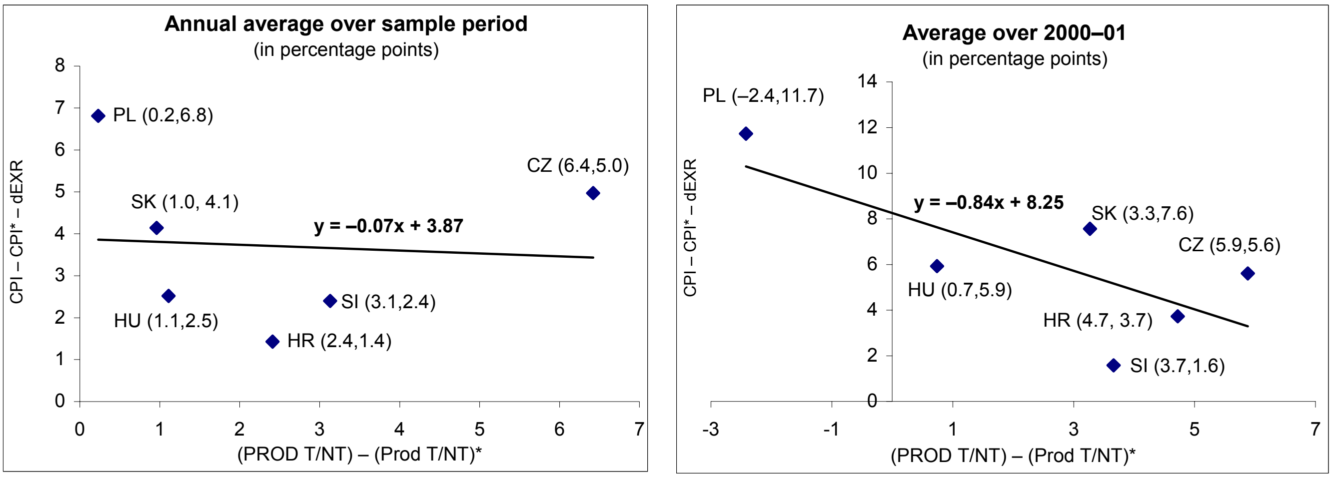
[1] Calculations are based on equation (11). Non-tradable shares and entries in the last column are in percentages.
[2] For sample periods, see the Appendix.
[3] Calculated for country i as: $(1–\alpha_i)[\text{Prod } T_i – \text{Prod } NT_i] – (1–\alpha^*)[\text{Prod } T^* – \text{Prod } NT^*]$.

Chart 2. Determinants of inflation differentials
(percentage contributions, entire sample period)



In summary, preliminary evidence based on the historical data suggests that the productivity growth differentials are not sufficiently large to explain the relatively high inflation differentials between central European countries and the euro area. A cross-country plot of the data on inflation (corrected for exchange rate changes) and productivity differentials further illustrates this point. As can be seen from Chart 3, in this – admittedly very small – sample, the cross-country correlation between inflation and productivity differentials is negative. Countries that could, in theory, “afford” higher inflation differentials vis-à-vis the euro area on account of stronger productivity growth actually had lower inflation differentials. This result holds for the entire sample period (left-hand panel) and for the more recent period (right-hand panel).

Chart 3. Productivity (T/NT) and inflation differentials relative to the euro area



4. Estimates of the Balassa-Samuelson effect

This section estimates two versions of the Balassa-Samuelson effect: the "international" version, ie the impact of inter-country productivity differentials on inter-country inflation differentials; and the "domestic" version, ie the impact of domestic productivity differentials on domestic inflation (the Baumol-Bowen effect).

Explaining inter-country differences in inflation by productivity differentials

To estimate the international version of the Balassa-Samuelson effect using time series data, equation (11) was re-specified and estimated for each country using ordinary least squares. Two different specifications were used: first, with logs of the corresponding indices (equation (12)); and then with first differences of logs (equation (13)):

$$log(CPI/CPI^*)_t = c + \beta_0 log(CPI/CPI^*)_{t-1} + \beta_1 log(E_t/E_{t-1}) + \beta_2[(1-\alpha)_t\, log(LP^T/LP^{NT})_t - (1-\alpha^*)_t\, log(LP^{T^*}/LP^{NT^*})_t] + \varepsilon_t \qquad (12)$$

$$log(CPI/CPI^*)_t - log(CPI/CPI^*)_{t-1} = c + \beta_1{}' [log(E_t/E_{t-1}) - log(E_{t-1}/E_{t-2})] + \beta_2{}' \{ [(1-\alpha)_t\, log(LP^T/LP^{NT})_t - (1-\alpha^*)_t\, log(LP^{T^*}/LP^{NT^*})_t] - [(1-\alpha)_{t-1}\, log(LP^T/LP^{NT})_{t-1} - (1-\alpha^*)_{t-1}\, log(LP^{T^*}/LP^{NT^*})_{t-1}] \} + \varepsilon_t \qquad (13)$$

where c is a constant; CPI is the consumer price index; E is the nominal exchange rate index (nominal exchange rates are expressed in units of domestic currency per euro); and LP^T and LP^{NT} are indices of labour productivity in tradable and non-tradable industries, respectively. The indices are normalised to 100 in the initial quarter for which the time series in a given country are available. All time series are seasonally adjusted using the X-12 procedure. Augmented Dickey-Fuller unit root tests indicate that the time series used in regressions (12) and (13) are stationary. A lagged dependent variable is included on the right-hand side of (12) because the use of quarterly data resulted in autoregressive residuals. As noted above, in Croatia and Slovakia there is evidence of non-uniform wage growth, so relative wage differentials are used as an additional explanatory variable.[13]

No other explanatory variables – in particular, demand side factors such as government expenditure or the growth of per capita income – are included. The main purpose of the exercise is to see whether sensible estimates of the coefficient β_2 (which measures the impact of productivity growth, with an expected positive sign) can be obtained. The results are reported in Table 3. To allow for the possibility of a delayed pass-through of productivity effects on inflation differentials, productivity terms are lagged up to four quarters for most countries. Specification tests (not reported) do not indicate violations of standard regression assumptions.

[13] See also Alberola-Ila and Tyrväinen (1998) and Swagel (1999). The expected sign of the wage differential coefficient $[(w^T - w^{NT}) - (w^{T^*} - w^{NT^*})]$ is negative: the employers in the non-tradable sector are expected to react to wage pressures by increasing their prices. The estimated coefficient on wage differential for Slovakia is negative, in line with this hypothesis, but for Croatia it is positive. Both estimated coefficients are statistically highly significant.

The third column in Table 3 indicates that a percentage point increase in the productivity differential in Hungary, Poland and Slovenia is associated with an increase in the inflation differential of about ½ percentage point. In Slovakia, inflation relative to the euro area increases by about 0.2 percentage points, and in the Czech Republic by 0.15 percentage points for every percentage point increase in the productivity differential. The estimated productivity parameter for Croatia is positive but not statistically significant. The fifth column indicates that a 1 percentage point *faster* growth of the productivity differential in Slovenia is associated with an acceleration in Slovenian inflation of 0.7 percentage points relative to the euro area. Estimates of this parameter for other countries are much lower.

Table 3 **Estimates of the "international" Balassa-Samuelson effect**

Country Sample period	**Equation (12)** Dependent variable: $log(CPI/CPI^*)_t$			**Equation (13)** Dep variable: $\Delta log(CPI/CPI^*)_t$		**Balassa-Samuelson effect**[3]
	$log(CPI/CPI^*)_{t-1}$ β_0	$log(E_t/E_{t-1})$ β_1	Productivity growth differential[1] β_2	$[log(E_t/E_{t-1}) - log(E_{t-1}/E_{t-2})]$ β_1'	Change in prod. growth differential[2] β_2'	
Croatia[4] 1996:1–2002:1	0.954	0.317	0.069*	0.153	–0.064*	**0.167**
Czech R 1994:2–2002:1	0.865	0.103	0.153	0.138	0.074	**0.980**
Hungary 1996:1–2002:1	0.837	0.100	0.506	0.349	0.318	**0.562**
Poland 1995:1–2001:3	0.655	0.057	0.507	0.132	0.293	**0.118**
Slovakia[4] 1995:3–2001:4	0.937	0.162	0.185	0.333	0.095	**0.178**
Slovenia 1993:1–2002:1	0.616	0.306	0.587	0.356	0.692	**1.839**

[1] Defined as: $[(1-\alpha)_t \, log(LP^T/LP^{NT})_t - (1-\alpha^*)_t \, log(LP^{T*}/LP^{NT*})_t]$.

[2] Defined as: $\{[(1-\alpha)_t \, log(LP^T/LP^{NT})_t - (1-\alpha^*)_t \, log(LP^{T*}/LP^{NT*})_t] - [(1-\alpha)_{t-1} \, log(LP^T/LP^{NT})_{t-1} - (1-\alpha^*)_{t-1} \, log(LP^{T*}/LP^{NT*})_{t-1}]\}$.

[3] Contribution of productivity differential to inflation differential vis-à-vis euro area, in percentage points. Calculated as β_2 times average productivity differential from Chart 1, fourth panel.

[4] Due to non-uniform wage growth in tradable and non-tradable industries, regressions based on equation (12) for Croatia and Slovakia include relative wage differential $[(w^T-w^{NT}) - (w^{T*}-w^{NT*})]$ as an additional explanatory variable. Estimated relative wage parameters (–0.317 for Slovakia and 0.271 for Croatia) are statistically highly significant.

* Denotes estimates that are not statistically significant at the 5% test level.

The last column of Table 3 provides estimates of the Balassa-Samuelson effect. They are calculated as a product of estimated parameters β_2 (third column of Table 3) and average productivity differentials (Chart 1, fourth panel). According to these estimates, differential productivity growth resulted in 2 percentage points higher inflation in Slovenia, 1 percentage point higher inflation in the Czech Republic, ½ percentage point higher inflation in Hungary, and 0.2 percentage points higher inflation in Slovakia relative to the euro area. In Croatia and Poland, the Balassa-Samuelson effect amounted to about 0.15 percentage points or less.

The first point to note is that the estimated parameters on the productivity growth differential (β_2) are positive and, with the exception of Croatia, statistically significant. This provides clear evidence of the presence of the Balassa-Samuelson effect. However, the estimated parameters and, hence, the Balassa-Samuelson effect are small: faster productivity growth in tradable vs non-tradable industries, relative to the euro area, can explain at most about 2 percentage points of the difference in inflation rates relative to the euro area. These estimates are considerably lower than those found in the early literature (Halpern and Wyplosz (2001); Rother (2000); Kovács and Simon (1998)). But they are close to the estimates in the newer literature, which, as noted above, also finds little support for the Balassa-Samuelson hypothesis in central Europe (Cipriani (2001); Egert et al (2002); Flek et al (2002), Kovács (2002)).

Explaining domestic inflation by productivity differentials

A major reason why many earlier studies had obtained higher estimates of the Balassa-Samuelson effect is that they had failed to consider the impact of productivity differentials on inflation *relative to the euro area*, focusing instead only on their impact on the domestic relative price of non-tradables. In other words, earlier studies mostly estimated the Baumol-Bowen effect, not the Balassa-Samuelson effect. To illustrate this point, Table 4 provides estimates of such "domestic" Balassa-Samuelson effects obtained from the following empirical specification of equation (10):

$$\log(\frac{CPI_t^{NT}}{CPI_t^{T}}) = const. + \beta_0 \log(\frac{CPI_{t-1}^{NT}}{CPI_{t-1}^{T}}) + \beta_2 (\left(\frac{\delta}{\gamma}\right)\log LP_t^{T} - \log LP_t^{NT}) + \varepsilon_t \qquad (14)$$

Equation (14) thus estimates for each country the impact of the differential in labour productivity growth between domestic tradable and non-tradable industries (LP^T and LP^{NT} denote indices of productivity growth) on changes in the relative price of non-tradables (CPI^{NT} and CPI^T denote indices of non-tradable and tradable price components of the CPI). The estimated parameter β_2 was then multiplied by the historical average of the domestic productivity differential (from Chart 1, third panel) to obtain the contribution (in percentage points) of the productivity differential to the increase in relative prices (see the third column in Table 4). Finally, this contribution was multiplied by the share of non-tradable goods and services in the CPI to obtain the "domestic" Balassa-Samuelson effect (fourth column).

As can be seen from Table 4 and Chart 4, with the exception of the Czech Republic and Slovenia, the "domestic" Balassa-Samuelson effect is indeed larger than its international counterpart. For instance, in Hungary and Poland, domestic productivity differentials explain about 10% of domestic CPI inflation, whereas productivity differentials relative to the euro area explain only 4% and 1%, respectively, of these countries' inflation differential relative to the euro area (Chart 4).

Table 4 **Estimates of the "domestic" Balassa-Samuelson effect**

Country	**Equation (14)** Dep variable: $log(CPI^{NT}/CPI^{T})$ — $log(CPI_{t-1}^{NT}/CPI_{t-1}^{T})$ [1] β_0	Domestic prod growth differential[2] β_2	Contribution of productivity differential to $\Delta(CPI^{NT}/CPI^{T})$[3]	Domestic Balassa-Samuelson effect [4]
Croatia	0.390	0.569	2.2	1.26
Czech Republic	0.946	0.068	0.6	0.32
Hungary	0.660	0.924	2.7	1.58
Poland	0.692	1.196	2.3	1.41
Slovakia	0.968	0.446	1.1	0.64
Slovenia	0.889	0.211	1.1	0.60
Euro area	0.863	0.030*	0.1	0.04

[1] Estimates of parameter β_0 from equation (14).

[2] Estimates of parameter β_2 from equation (14).

[3] Calculated as β_2 times average domestic productivity differential (from Chart 1, third panel); in percentage points.

[4] Third column multiplied by the share of non-tradables in CPI; in percentage points.

* Denotes estimates that are not statistically significant at the 5% test level.

Estimates in Table 4 are generally lower than those obtained in other studies testing this version of the Balassa-Samuelson hypothesis (see Table 1). One reason is that some of these studies (eg Egert (2002a)) did not consider productivity growth in non-tradable sectors, which has been quite high in many countries. Another reason is that some studies (Cipriani (2001), Rother (2000)) defined non-tradable sectors too broadly, including for instance public administration, where productivity growth is bound to be low.

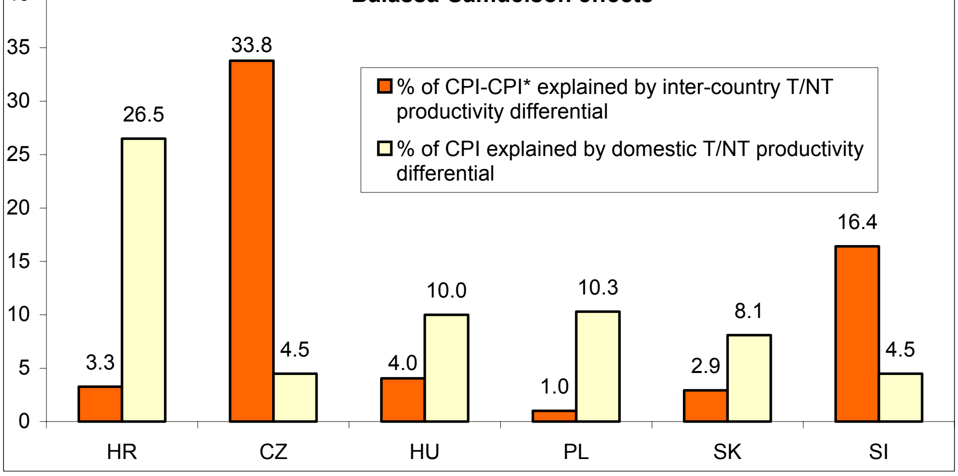
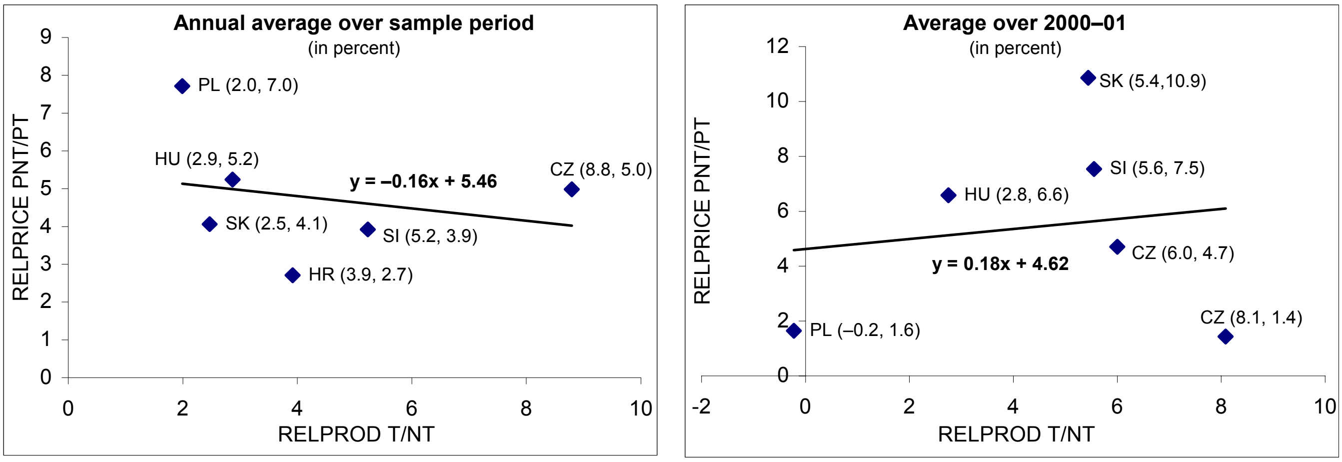


Chart 4. Comparison of international and domestic Balassa-Samuelson effects

A cross-country plot of changes in relative prices and relative productivity provides some limited support for the Baumol-Bowen hypothesis only in the more recent period (Chart 5, right-hand panel). Over the whole sample period, however, relative prices tended to grow more slowly in countries that experienced faster productivity growth (Chart 5, left-hand panel), which is the opposite to theoretical predictions. This suggests that factors other than differential productivity growth (eg administrative price increases) have been a more important factor behind increases in relative prices and overall inflation in central Europe.

Chart 5. Growth of relative prices (NT/T) and relative productivity (T/NT)



One should not forget that there are significant data measurement problems for some central European countries, which make it difficult to provide accurate estimates of labour productivity growth in tradable and non-tradable industries. At the same time, a more disaggregated approach followed in this paper (as well as in Egert (2003)) does indicate that broadening the coverage of tradable and non-tradable sectors is essential if one wants to obtain more reliable estimates of the Balassa-Samuelson effect. In particular, neglecting productivity growth in non-tradable industries and not comparing productivity differentials to the euro area (as well as assuming equal shares of non-tradables across countries) can result in significant overestimates of the Balassa-Samuelson effect.

5. Concluding remarks

Two main conclusions emerge from the above analysis. First, factors other than differential productivity growth seem to have been mainly responsible for higher inflation in central European countries relative to the euro area. Second, one needs to distinguish carefully between empirical evidence that faster productivity growth in tradable industries contributes to rising relative prices of non-tradables (and hence domestic inflation) and evidence that productivity differentials widen the inter-country inflation differentials. While both effects have been present in central Europe, both are relatively small, with the "domestic" Balassa-Samuelson effect generally being stronger than the international effect. Claims that the Balassa-Samuelson effect is a major determinant of inflation in central European countries thus seem to have weaker empirical foundations than previously thought.

Several recent studies of inflation tend to support this conclusion. After a significant jump in the early 1990s due to price and trade liberalisation and large currency devaluations, inflation in central Europe has followed two broad patterns (see ICEG European Centre (2002)). In Croatia and the Czech Republic, low inflation was achieved rapidly and has been maintained since despite external shocks and changes in the structure of domestic relative prices. The choice of fixed exchange rates (followed by the implementation of inflation targeting in the Czech Republic since 1997) has been instrumental in achieving the disinflation, as it provided a stable anchor for expectations. Inflation has thus been driven mainly by ongoing adjustments of administered prices and indirect taxes; import price developments; shifts in demand towards non-tradables brought about by rising real incomes; and, more recently, the effects of large capital inflows.

In Hungary, Poland, Slovakia and Slovenia, the initial price stabilisation was followed by persistent moderate inflation and strong price inertia (see papers in Cotarelli and Szapáry (1998)). Monetary authorities apparently gave equal weight to restricting inflation and maintaining external competitiveness. Thus either crawling pegs (Hungary, Poland) or tightly managed exchange rate regimes (Slovakia, Slovenia) were chosen to avoid nominal appreciation and loss of price and cost competitiveness. Several factors added to the inflation inertia: high pass-through of exchange rate and import price changes into inflation (see Brada and Kutan (2002), and Mihaljek and Klau (2001)); the dominance of backward-looking expectations; inflationary pressure from wage convergence; and inconsistencies between fiscal and monetary policies. More rapid disinflation started only in the late 1990s, when the authorities showed greater willingness to tolerate temporary output losses of disinflation, and central banks shifted to inflation targeting (in Hungary and Poland) combined with greater exchange rate flexibility (including in Slovakia and Slovenia). Brada and Kutan (2002) show, however, that exogenous factors (in particular, lower commodity and energy prices) played a major role in the decline in inflation in the Czech Republic, Hungary and Poland to historically low levels in 1999–2001.

Looking ahead, a key question is whether differences in productivity growth between EU accession countries and the euro area are likely to widen. Long-term elasticities of inflation with respect to productivity differentials are higher than the short-term elasticities shown in Tables 3 and 4.[14] However, one should recognise that the large productivity gains realised in central Europe in the second half of the 1990s are not likely to be sustained until 2007–08 or even later, when candidates for entry to the euro area will have to satisfy the Maastricht inflation criterion. The past increases in labour productivity have been due to both capital deepening and labour quality improvements, the pace of which will diminish as the convergence to the euro area proceeds (see Doyle et al (2001)). This suggests that the Balassa-Samuelson effect is likely to be smaller in the future. One should also note that the use of average labour productivity instead of total factor productivity in the empirical part of this paper leads to overestimates of the Balassa-Samuelson effect, so the "true" effect is smaller already today than the above estimates suggest.

What are the policy implications of these results? If the Balassa-Samuelson effect is small and its importance diminishes in the next four to five years, it should not become a determining factor in the ability of central European countries to satisfy the Maastricht inflation criterion. In 2003, inflation in all countries studied in this paper with the exception of Slovakia fell to record lows since the start of the transition. Had they been members of EMU, the Czech Republic, Lithuania and Poland would have been the three member countries with the lowest inflation, setting the benchmark for the Maastricht inflation criterion that eight of the 12 current EMU members would not have met.[15] Contrary to concerns expressed in the

[14] For the two versions of the Balassa-Samuelson effect (equation (12), Table 3; and equation (14), Table 4) the long-term elasticities (calculated as $\beta_2 / (1 - \beta_0)$) are as follows: Croatia (1.5, 0.9); Czech Republic (1.1, 1.3); Hungary (3.1, 2.7); Poland (1.5, 3.9); Slovakia (2.9, 13.9); Slovenia (1.5, 1.9). For the euro area, the long-term domestic Balassa-Samuelson elasticity is 0.16.

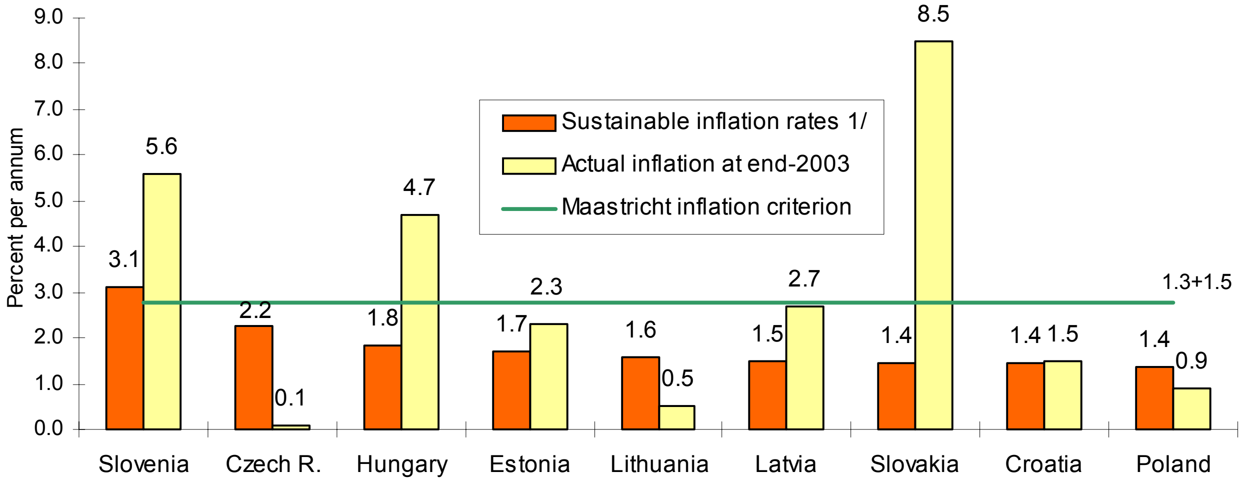
[15] Average inflation in the Czech Republic, Lithuania and Poland in 2003 was 0.5%. Adding a 1½ percentage point margin would have given an inflation criterion of 2%. In 2003, only Austria, Belgium, Finland and Germany had inflation below 2%.

literature (eg, Buiter and Grafe, 2002; Eichengreen, 2003), achieving such low rates of inflation did not require sharp tightening of monetary policy nor did it result in a growth slowdown. Nominal interest rates were at record low levels in 2003, and the average growth rate of the six central European and the three Baltic countries has been virtually unchanged since 2001 (at 4¼%). This raises the question whether concerns about the ability of acceding countries to meet the Maastricht inflation criterion have been overdone and have become a matter of the past.

As can be seen from Chart 6, only Hungary, Slovakia and Slovenia would not have met the Maastricht criterion with their end-2003 inflation figures.[16] However, these historically low inflation figures may not be sustained: the impact of special factors such as declining food prices has started to reverse in the second half of 2003, and most countries have scheduled a series of one-off adjustments in administered prices. The effect of such adjustments was clearly visible in Slovakia in 2003. It may also be hard to avoid wage increases in the public sector in the face of tight conditions in the labour market for skilled civil servants.

Chart 6

Actual and "sustainable" inflation on the eve of hypothetical (2004) monetary integration



[1] CPI inflation rates implied by the estimated Balassa-Samuelson effect, assuming unchanged productivity grow th, annual inflation in the three best performing euro area countries of 1.3%, and fixed exchange rates vis-à-vis the euro.
Source: BIS estimates.

European Commission projections of inflation for 2005, based on the forecasts that the acceding countries submitted in March 2004, also indicate that the recent gains in disinflation may not be taken for granted. The Maastricht inflation criterion is projected to be lower (2.5% in 2005 vs. 2.8% in 2003), but inflation in all acceding countries with the exception of Hungary, Slovakia and Slovenia is projected to be higher, partly due to cyclical reasons, and partly due to the effects of adjustments in administered prices (Chart 7). Only Croatia, Lithuania and Poland would meet the Maastricht inflation criterion in this example, none of them with a comfortable margin. This suggests that concerns about inflation are not yet passé; stabilising inflation at current levels might become an important challenge for central banks in central Europe and the Baltics.

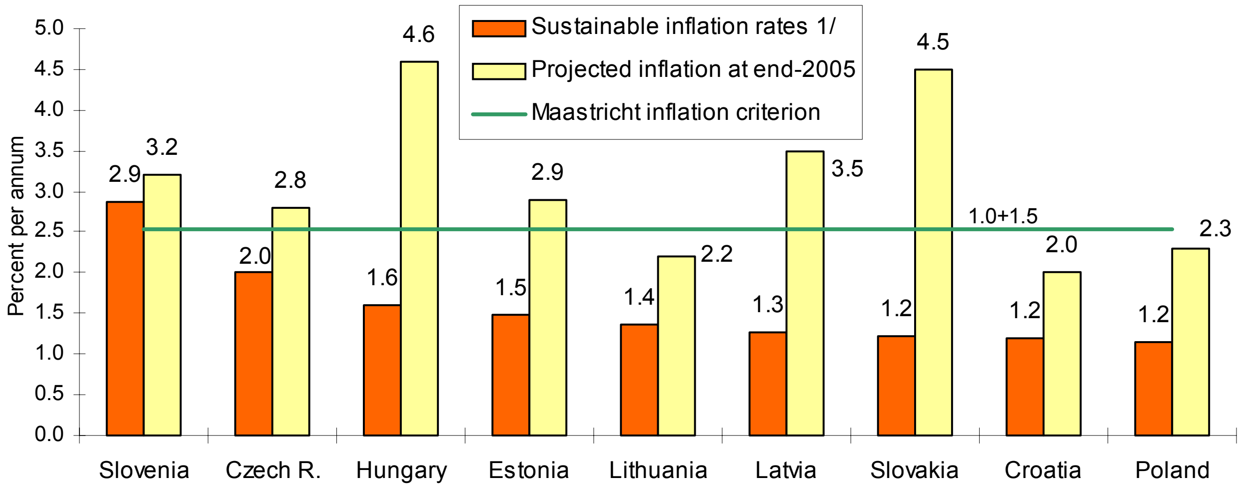
Charts 6 and 7 also show “sustainable” inflation rates, defined as the average rate of inflation in three benchmark euro area countries plus the estimated Balassa-Samuelson effect. These rates should be regarded as “permissible” even if they exceed the Maastricht criterion (ie, the average rate in three benchmark countries plus 1½ percentage points) because the Balassa-Samuelson effect is a real phenomenon – the “physiological” component of inflation (Padoa-Schioppa (2002)) – over which the monetary authorities have no control. As can be seen from Charts 6 and 7, the “sustainable” rate of inflation would exceeded the Maastricht inflation criterion at both end-2003 and end-2005 only in Slovenia. In all other countries, the estimated Balassa-Samuelson effect is lower than the 1½ percentage point

[16] Estimates of the Balassa-Samuelson effect for the Baltic countries are taken from Egert (2003) and are as follows (in percentage points): Estonia 0.45, Latvia 0.23 and Lithuania 0.32. These estimates indicate by how much inflation in accession countries exceeds inflation in Germany due to faster intersectoral (tradable vs non-tradable) productivity growth relative to Germany.

margin set by the Treaty. Thus, only Slovenia would have to perform better than the three benchmark euro area countries in order to satisfy the Maastricht inflation criterion in these hypothetical scenarios.

Chart 7

Actual and "sustainable" inflation on the eve of hypothetical (2006) monetary integration



[1] CPI inflation rates implied by the estimated Balassa-Samuelson effect, assuming unchanged productivity growth, annual inflation in the three best performing euro area countries of 1%, and fixed exchange rates vis-à-vis the euro.
Source: BIS estimates.

Appendix A

Derivation of equation (10), domestic Balassa-Samuelson (or Baumol-Bowen) effect

Let $k^T = K^T/L^T$, $k^{NT} = K^{NT}/L^{NT}$, $p^N = P^{NT}/P^T$.

Then:

$$k^T = \left(\frac{R}{(1-\gamma)A^T}\right)^{\frac{1}{-\gamma}} \quad (6') \qquad\qquad k^T = \left(\frac{R}{(1-\delta)A^T}\right)^{\frac{1}{-\delta}} \quad (7')$$

Substitute (6') into (8):

$$W = \gamma A^T \left(\frac{R}{(1-\gamma)A^T}\right)^{\frac{1-\gamma}{-\gamma}} \quad (8')$$

Substitute (7') into (9):

$$W = p^N \delta A^{NT} \left(\frac{R}{p^N(1-\delta)A^{NT}}\right)^{\frac{1-\delta}{-\delta}} \quad (9')$$

Set (8') = (9'):

$$\gamma A^T \left(\frac{R}{(1-\gamma)A^T}\right)^{\frac{1-\gamma}{-\gamma}} = p^N \delta A^{NT} \left(\frac{R}{p^N(1-\delta)A^{NT}}\right)^{\frac{1-\delta}{-\delta}}$$

Take logs:

$$\log\gamma + \log A^T + \frac{1-\gamma}{-\gamma}\left(\log R - \log(1-\gamma) - \log A^T\right) = \log p^N + \log\delta + \log A^{NT} + \frac{1-\delta}{-\delta}\left(\log R - \log p^N - \log(1-\delta) - \log A^{NT}\right)$$

Collect the terms:

$$\log p^N\left(1 - \frac{1-\delta}{-\delta}\right) = \log A^T\left(1 - \frac{1-\gamma}{-\gamma}\right) - \log A^{NT}\left(1 - \frac{1-\delta}{-\delta}\right) + \left(\log R\left(\frac{1-\gamma}{-\gamma} - \frac{1-\delta}{-\delta}\right) + \log\gamma - \frac{1-\gamma}{-\gamma}\log(1-\gamma) - \log\delta + \frac{1-\delta}{-\delta}\log(1-\delta)\right)$$

$$\log p^N\left(\frac{1}{\delta}\right) = \log A^T\left(\frac{1}{\gamma}\right) - \log A^{NT}\left(\frac{1}{\delta}\right) + c$$

$$\log p^N = c\delta + \log A^T\left(\frac{\delta}{\gamma}\right) - \log A^{NT}$$

where c is a constant (note that R is given). Differentiating this expression gives equation (10):

$$\Delta\frac{p^{NT}}{p^T} = \Delta p^{NT} - \Delta p^T = \left(\frac{\delta}{\gamma}\right)\Delta a^T - \Delta a^{NT}$$

where lower-case letters denote logarithms and Δa^T and Δa^{NT} are growth rates of total factor productivity in the two sectors.

Appendix B

Data description

Economies and periods covered

Euro area (1992:1–2001:3), Croatia (1995:1–2001:3), Czech Republic (1993–2001:3), Hungary (1994–2001:3), Poland (1994–2001:3), Slovakia (1995–2001:3), and Slovenia (1992–2001:3).

Traded and non-traded sectors

Traded goods and services: manufacturing; mining; hotels; transportation and communications.

Non-traded goods and services: electricity, gas and water supply; construction; wholesale and retail trade and repair services; financial intermediation; real estate, renting and business activities; education; health and social work; and other community, social and personal activities.

Not considered are, on the traded goods side, agriculture, forestry and fishing because trade in agricultural products is distorted by the Common Agricultural Policy and different agreements on agricultural trade between the European Union and accession countries; on the non-traded goods side, public administration, defence and compulsory social security are not considered because of the difficulty in interpreting labour productivity figures caused by large shifts in the number of public sector employees.

The above classification follows De Gregorio et al (1994), who define a sector as "tradable" if more than 10% of total production is exported. In this paper, hotels and restaurants are also included among tradables because of their large service export content in several central European countries (the Czech Republic, Hungary, Croatia, Slovenia).

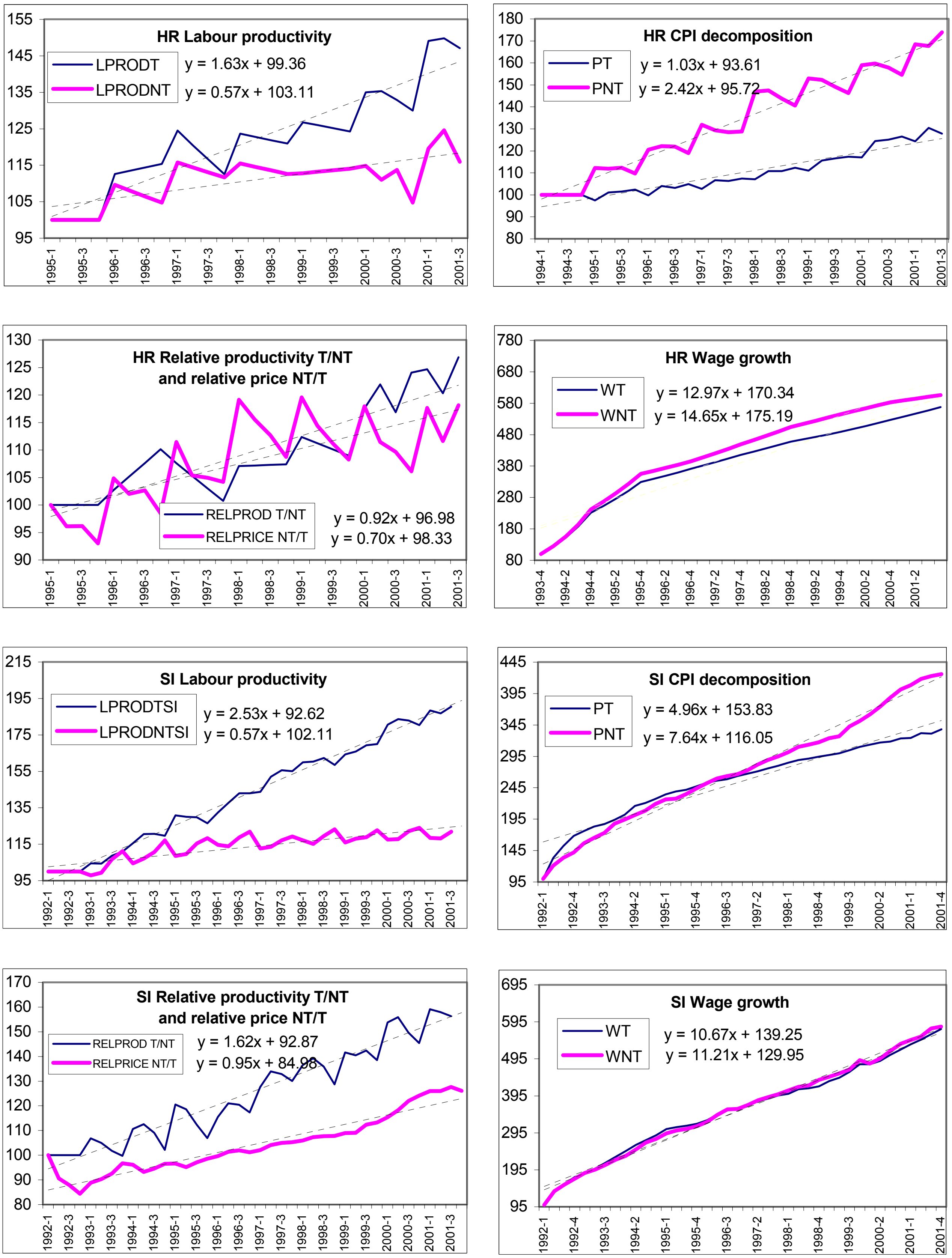
Description of variables

- Quarterly indices of value added (in constant prices) from the production side GDP estimates. The weights used to aggregate individual industries into traded and non-traded sectors are industries' shares in total value added (corrected for agriculture and public administration). For Poland (and some years in a few other countries), only annual data on the GDP breakdown by industry were available. Quarterly data on industrial production were then used to determine quarterly growth rates for tradables; and quarterly GDP data to determine quarterly growth rates for non-tradables (as a "residual" between GDP and tradables).
- CPI rates of inflation with subcomponents enabling a breakdown into traded and non-traded goods and services; the subcomponents are aggregated into traded and non-traded goods inflation on the basis of respective weights in the CPI basket (quarterly averages).
- Nominal exchange rates of domestic currency against the euro (quarterly averages).
- Employment (quarterly averages) in traded and non-traded goods industries. The weights used to derive employment in traded and non-traded sectors are industries' shares in total employment (corrected for agriculture and public administration).
- Nominal wages (quarterly averages) by industry. The weights used to derive wages in traded and non-traded sectors are industries' shares in total employment (corrected for agriculture and public administration).

Data sources

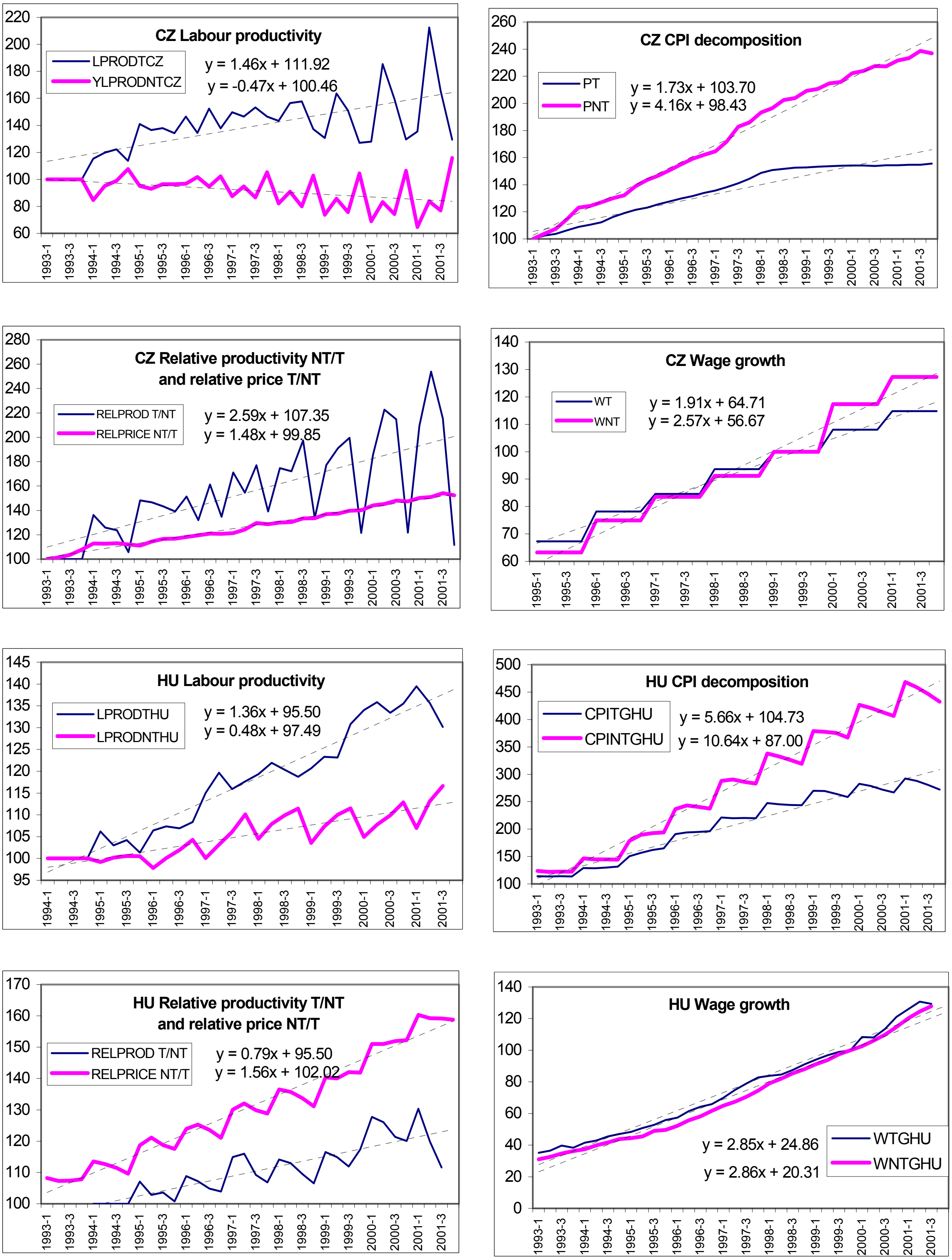
National central banks and statistical offices (data for six central European countries); European Central Bank (data for the euro area); BIS; and staff estimates.

Chart A1. Croatia and Slovenia[1]



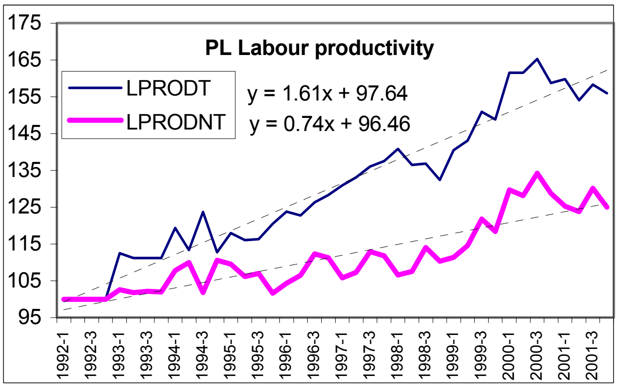
[1] Dotted lines represent linear time trends. Estimated regression lines show time trend ("x") regressed on the dependent variable ("y") shown in the legend on the left.

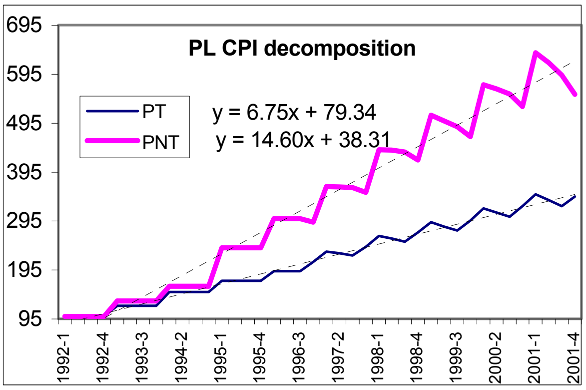
Chart A2. Czech Republic and Hungary[1]

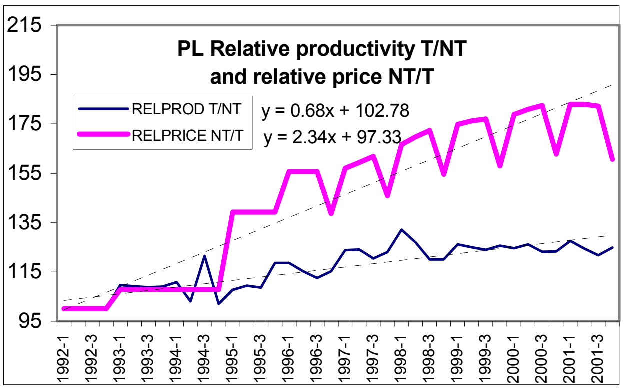


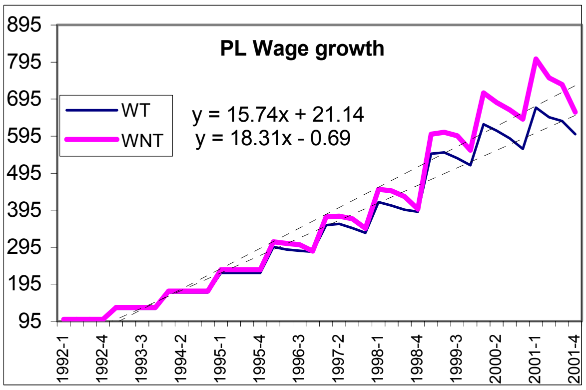
[1] Dotted lines represent linear time trends. Estimated regression lines show time trend ("x") regressed on the dependent variable ("y") shown in the legend on the left.

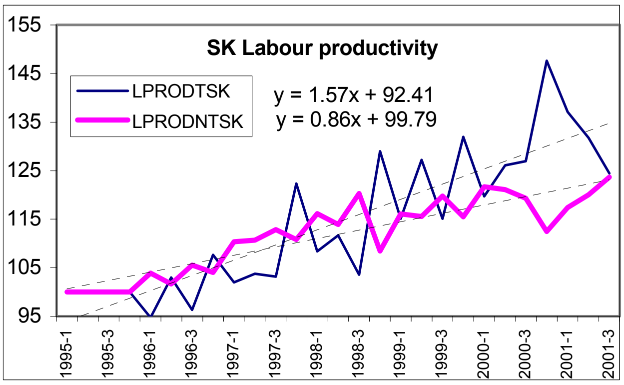
Chart A3. Poland and Slovakia[1]

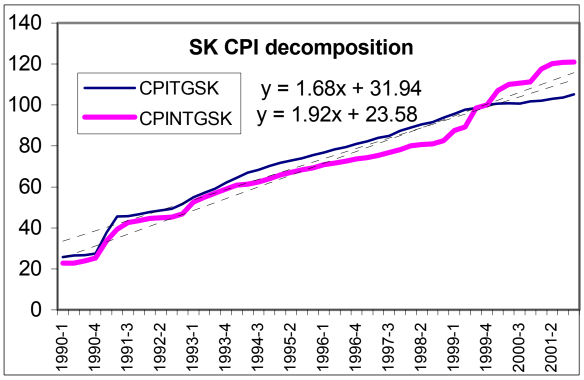


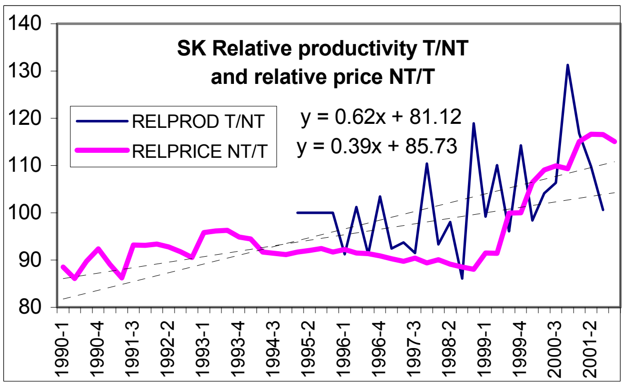


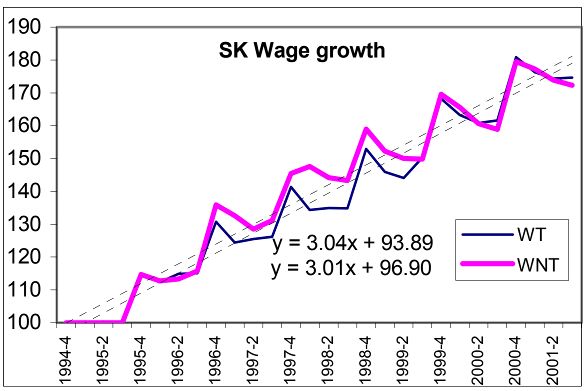






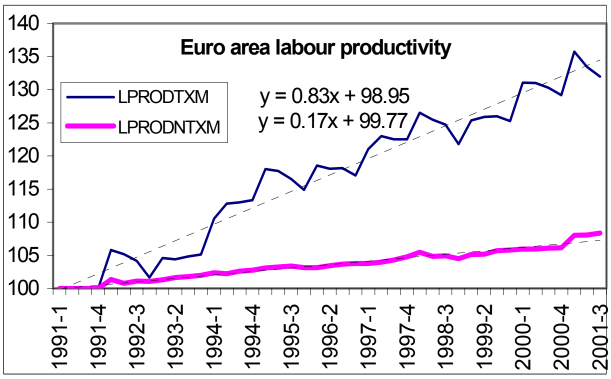


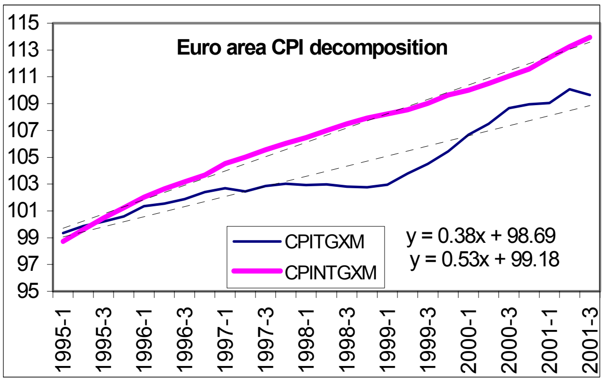


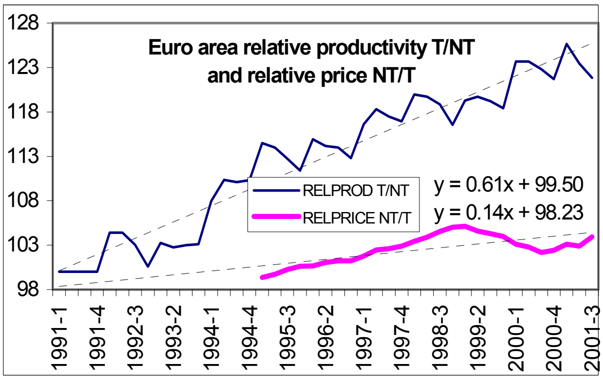


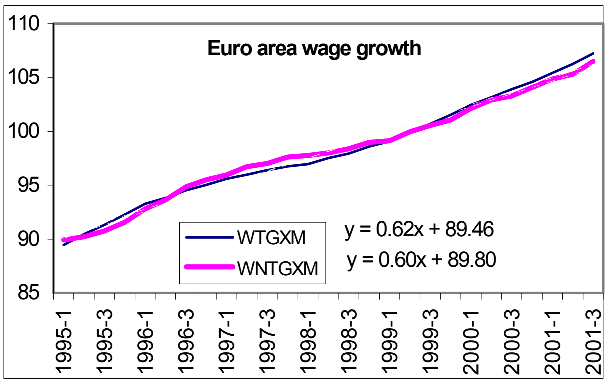
[1] Dotted lines represent linear time trends. Estimated regression lines show time trend ("x") regressed on the dependent variable ("y") shown in the legend on the left.

Chart A4. Euro area[1]









[1] Dotted lines represent linear time trends. Estimated regression lines show time trend ("x") regressed on the dependent variable ("y") shown in the legend on the left.

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