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Christoph Fischer

Real currency appreciation in accession countries: Balassa-Samuelson and investment demand

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Christoph Fischer *

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Abstract

The Balassa-Samuelson effect is usually seen as the prime explanation of the continuous real appreciation of central and east European (CEE) transition countries' currencies against their western counterparts. The response of a small country's real exchange rate to various shocks is derived in a simple model. It is shown that productivity shocks work not only through a Balassa-type supply channel but also through an investment demand channel. Therefore, empirical evidence apparently in favour of Balassa-Samuelson effects may require a re-interpretation. The model is estimated for a panel of CEE countries. The results are consistent with the model, plausibly explain the observed real appreciation and support the existence of the proposed investment demand channel.

JEL classification: F31, F41, C33

Keywords: real exchange rate, Balassa-Samuelson effect, transition economies, panel

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Christoph Fischer

Real currency appreciation in accession countries: Balassa-Samuelson and investment demand

Tiivistelmä

Balassan–Samuelsonin efektiä (BSE) pidetään yleisesti suurimpana syynä Keski- ja Itä-Euroopan maiden valuuttojen reaaliseen vahvistumiseen suhteessa länsimaiden valuuttoihin. Pienen kansantalouden reaalisen valuuttakurssin reaktiota erilaisiin sokkeihin tarkastellaan tässä työssä yksinkertaista mallia käyttäen. Mallissa osoitetaan, että sokit tuottavuudessa eivät vaikuta reaaliseen valuuttakurssiin ainoastaan traditionaalisen tarjontaväylän kautta, vaan myös investointien kautta. Balassan–Samuelsonin efektiä koskevat empiiriset tulokset saattavat sen takia vaatia uudelleentulkintaa. Paperissa estimoidaan malli KIE-maille. Saadut tulokset ovat yhdenmukaiset mallin ennustusten kanssa ja selittävät havaitun reaalisen vahvistumisen. Investoinnit vaikuttavat reaaliseen vahvistumiseen.

Asiasanat: Balassan–Samuelsonin efekti, reaalinen valuuttakurssi, siirtymätaloudet, paneeli

1 A stylized fact and the literature

Real exchange rates certainly belong to those macroeconomic variables whose pattern of movement seems to be diagnostic for transition economies: As a rule, they appreciate in real terms. Figure 1 shows the real effective exchange rate of all the central and east European transition countries which are currently negotiating accession to the European Union. The series are calculated using CPIs and are expressed in relation to the trade-weighted averages of 21 OECD countries. Although the scale differs enormously across countries, all of them share the common feature of a positive trend in their real effective exchange rate.[1] These real appreciations have been quite substantial except in the case of Slovenia and Hungary. In the extreme case of Lithuania, the index rose by the breathtaking rate of more than 1,300 % over a period of 37 quarters, ie in less than ten years. To put these figures into perspective, consider comparable indices for the G7 countries: since the collapse of the Bretton Woods system, none of these indices doubled in any given decade.

The real currency appreciation in transition countries apparently occurred quite independently of the specific exchange rate regimes which these countries had chosen because, on the one hand, the chosen regimes differ considerably across countries, ranging from independent floats to currency boards, and, on the other hand, several countries changed their regime over time. Bulgaria and Lithuania, for instance, replaced a regime of independently floating exchange rates by a currency board. The Czech Republic and the Slovak Republic, by contrast, gradually transformed their conventional fixed pegs into regimes of managed or independently floating exchange rates.[2]

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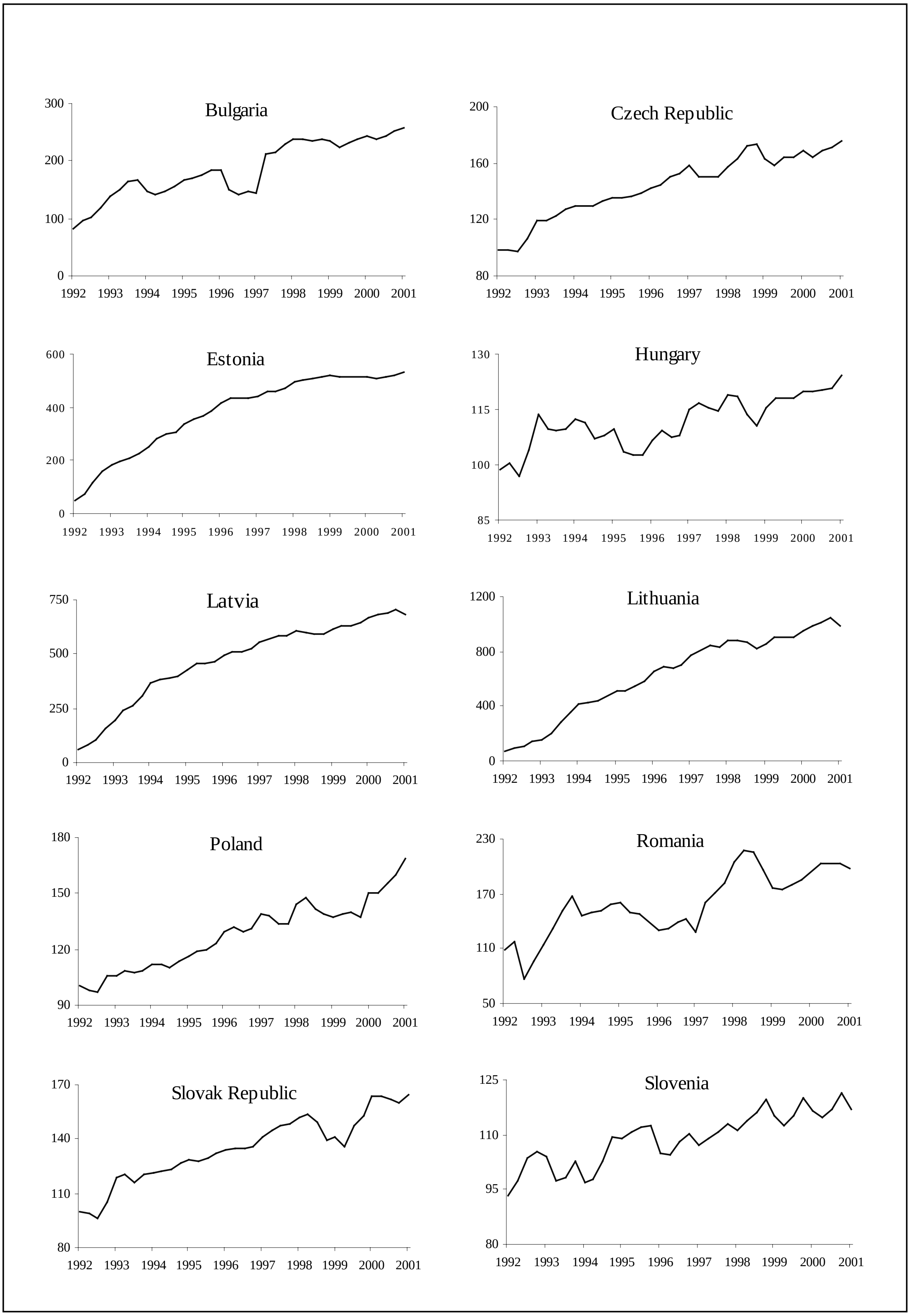
1 The observation that the real value of transition countries' currencies rises is quite robust vis-à-vis different measures of the real exchange rate; see Halpern/Wyplosz (1997).

2 Table 2 in Begg et al. (2001) and Table 6.2.1 in UN, Economic Commission for Europe (2001) give an overview of exchange rate regimes for all the central and east European accession countries since 1990.

Figure 1. CPI-based real effective exchange rates of central and east European transition countries against a trade-weighted average of 21 (non-transition) OECD countries; quarterly data; 1992:1 to 2001:1; average value for 1992 normalized to 100; source: BIS



This paper addresses the question as to what factors might cause the stylized fact that the currencies of transition countries appreciate in real terms. This issue is not only important for the transition countries concerned. Movements in the real effective exchange rate can be interpreted as inflation differentials, expressed in a common currency, between the (possibly different) baskets of goods of the respective transition country, on the one hand, and those of OECD countries, on the other. Such inflation differentials may become an issue for the euro currency area (which accounts for nearly 75% of OECD country weights in the real effective exchange rate computations) as soon as the access of EU accession countries to European Monetary Union (EMU) is discussed. In these discussions, it may be valuable to have an idea of the origin of such inflation differentials.

The papers of Halpern/Wyplosz (1997), Krajnyák/Zettelmeyer (1998) and Begg *et al.* (1999) argue that an initial real undervaluation accounts for part of the real appreciation in the first half of the 1990s. They observe a sharp real depreciation for some transition countries at the time they gave up the command economy, ie in 1989, 1990 or 1991, which Halpern/Wyplosz (1997) attribute to a sudden excess demand for foreign assets, flight from the domestic currencies because of a burst of inflation, and/or loose exchange rate policies. These papers, rather than being concerned with equilibrium real exchange rate developments, aim at determining the degree of real undervaluation and thus the level of an equilibrium real exchange rate. Consequently, they use the dollar wage as their measure of the real exchange rate and regress it mainly on productivity and some slow-moving variables which indicate structural properties of the respective economy for a large panel of (mostly non-transition) countries. When they apply their results to transition economies, they find, indeed, that most transition countries' currencies have been undervalued in the early 1990s. However, the most recent of these studies, that of Begg *et al.* (1999), which analyzes the period until 1996 or 1997 respectively, already concludes "that the catch-up phase is mostly over" (page 32). This has recently been confirmed by Kim/Korhonen (2002).

A second strand of literature considers the real exchange rate movements of specific transition countries separately or only one exchange rate at all instead of estimating panels. Richards/Tersman's (1996) arguments, for instance, resemble those of the papers which were mentioned in the previous paragraph. They attribute the real appreciation of the Baltic states' currencies partly to an adjustment of relatively low domestic prices to the levels of countries with similar income levels and partly to the differential of productivity growth rates in the tradeable and non-tradeable sectors, ie the Balassa-Samuelson effect. Similarly, Hungarian real exchange rate movements can well be explained by Balassa-Samuelson effects, according to Jakab/Kovács (1999). Filipozzi (2000) investigates the real exchange rate of Estonia, and Darvas (2001) those of the Czech Republic, Hungary, Poland and Slovenia.

Three very recent papers bear a particularly close relationship to our econometric analysis in the sense that they use a panel of transition countries to regress some measure of the real exchange rate on variables, which are supposed to represent its fundamental determinants. De Broeck/Sløk (2001) and the UN, Economic Commission for Europe (2001) concentrate their analysis on the Balassa-Samuelson effect. Coricelli/Jazbec (2001) pursue a somewhat broader approach and try to account for some other possible fundamental determinants. In their reduced form estimations, the UN, Economic Commission for Europe (2001) and Coricelli/Jazbec (2001) use a proxy for the domestic relative price between tradeable and non-tradeable goods as a measure for the real exchange rate whereas De Broeck/Sløk (2001) use trade-weighted real effective exchange rates similar to those depicted in figure 1. All of the three papers conclude that the Balassa-Samuelson effect plays an important role in explaining the real appreciation of EU accession countries' currencies. According to Coricelli/Jazbec (2001), demand factors are significant determinants as well, especially for the Baltics.

In preparation for our econometric analysis, a simple theoretical model of real exchange rate determination is derived in section 2. Particular attention will be paid to the role of the Balassa-Samuelson effect. Based on the theoretical model of section 2, an equation for the determination of real exchange rates will be estimated for a panel of EU accession countries in section 3. Section 4 concludes.

2 Real exchange rate determination for small countries

A model of real exchange rate determination for the EU accession countries should take into account that these countries are small on world goods and capital markets. The model economy should therefore be unable to affect interest rates and prices of tradeable goods on world markets. The only (real) element of the real exchange rate, which can change endogenously, is then the relative price between internationally tradeable and non-tradeable goods. A simple model for such a small economy is the Balassa-Samuelson hypothesis, which recent papers regard as the prime explanation for the real appreciation in transition countries. In this chapter, this argument will therefore be presented first. Afterwards, the model is slightly extended in order to show in which way investment demand can play a role in the determination of small-country real exchange rates. The rigorous analysis will be confined to intratemporal issues because this is already sufficient to demonstrate that the usual measures of Balassa-Samuelson, ie supply effects, may in fact, at least partly, represent investment demand effects on the real exchange rate.

2.1 The hypothesis of Balassa and Samuelson

Today, the hypothesis of Balassa (1964) and Samuelson (1964) is usually discussed in a model like that of Froot/Rogoff (1995). The domestic country produces two goods, tradeables, T, and non-tradeables, N. Each sector uses a linear homogenous Cobb-Douglas technology and capital, K, and labour, L, as inputs:

(1) $$Y_i = \theta_i K_i^{\alpha_i} L_i^{1-\alpha_i}$$

where Y_i denotes output and θ_i total factor productivity (TFP) in sector i with i = T, N. Both of the factors are intersectorally mobile, which implies that factor returns, ie nominal wages, w, and interest, r, equalize across sectors. The cost-minimizing representative firm of sector i derives conditional factor demands. In log-differentiated form, these are

(2) $$\hat{K}_i = \hat{Y}_i - \hat{\theta}_i + (1-\alpha_i)(\hat{w} - \hat{r}),$$

(3) $$\hat{L}_i = \hat{Y}_i - \hat{\theta}_i + \alpha_i(\hat{r} - \hat{w})$$

with $\hat{x} = d\ln x$. Profit maximization yields the supply functions, which are in log-differentiated form

(4) $$\hat{p}_i = -\hat{\theta}_i + \alpha_i \hat{r} + (1-\alpha_i)\hat{w}$$

where p_i denotes the price of good i. For the small domestic country, the price of the tradeable, p_T, is fixed by world markets. Domestic demand for the non-tradeable determines Y_N. Capital is assumed to be internationally mobile. Thus, its return, r, is given by world capital markets.[3] Labour, on the contrary, is internationally immobile. The wage is therefore determined on the domestic labour market, for which the simplest possible assumption is a fixed labour supply, $L = L_T + L_N$. Log-differentiating this equation[4] yields

(5) $$L_T \hat{L}_T + L_N \hat{L}_N = 0 .$$

The system of seven equations (2), (3), (4) for each of the two sectors and (5) can be solved for the seven endogenous variables K_T, K_N, L_T, L_N, w, Y_T, and p_N if Y_N is given by demand.

The famous Balassa-Samuelson hypothesis states that a rise in TFP in the tradeables sector raises wages not only in this sector but, owing to intersectoral labour mobility, also in the non-tradeables sector, thus raising non-tradeables prices, which constitutes a real appreciation. However, the model also implies that a rise in TFP in the non-tradeables sector just lowers non-tradeables prices, which amounts to a real depreciation. In this case, wages do not change because they are determined in the tradeables sector. Equation (6), which is derived from (4) for $\hat{p}_T = \hat{r} = 0$, demonstrates both of these arguments:

(6) $$\hat{p}_N = \tfrac{1-\alpha_N}{1-\alpha_T}\hat{\theta}_T - \hat{\theta}_N .$$

A further well-known implication of the model is that domestic demand cannot affect the real exchange rate of a small country because the two equations (4) uniquely determine the two variables p_N and w. Since wages are given by the tradeables sector and interest by world capital markets, the supply curve in the non-tradeables sector is horizontal. However, there is ample evidence that demand does, in fact, influence real exchange rates; see, for example, Coricelli/Jazbec (2001) for transition countries and De Gregorio *et al.* (1994) generally. While the latter refer to non-perfect competition and non-perfect capital mobility to explain their results, the theory of international trade suggests that an extension of the Balassa-Samuelson model to consider additional non-tradeable factors could re-establish a link between demand and real exchange rates.[5]

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[3] This is not meant to imply, of course, that interest rates on world capital markets and EU accession countries are the same. Instead, the return on capital employed in these countries may exceed that on world markets by a constant risk premium.

[4] Usually, no labour market equation is specified; see, for example, Froot/Rogoff (1995) or Obstfeld/Rogoff (1996). Then, however, the system can only be solved in its intensive form, but not for Y_i, K_i, and L_i.

[5] See, for example, Ostry (1991). For the specific case of the Balassa-Samuelson model, this is suggested by both Froot/Rogoff (1995) and Obstfeld/Rogoff (1996), p 215. However, neither of them presents a model.

2.2 A simple model of real exchange rate determination

Consider an extended version of the Balassa-Samuelson model with three basic goods, non-tradeables, N, export goods, X, and import goods, M, and four factors, capital, labour and two types of skill. The domestic economy produces N and X and consumes N and M. Both tradeables prices, p_X and p_M, are given by world markets, and p_M is normalized to 1. Apart from capital, K_i, and unskilled labour, L_i, the production of good i where i = N, X requires the input of skills, S_i. Again, linear-homogenous Cobb-Douglas technology is used:

$$(7) \qquad Y_i = \theta_i K_i^{\alpha_i} L_i^{\beta_i} S_i^{1-\alpha_i-\beta_i}$$

where $0 < \alpha_i, \beta_i, \alpha_i + \beta_i < 1$. Capital is internationally mobile, and its return, r, is therefore given by world markets. Assume for now that the capital good is identical to the import good. Both skilled and unskilled labour are internationally immobile. Their return is determined domestically. Again, unskilled labour is mobile across sectors with a common wage, w. This assumption, however, can hardly be applied to the multitude of real world skills, which, in a highly specialized economy, can often only be employed in a quite narrow range of occupations. For simplicity, it is therefore assumed that two types of skill exist, each of which can only be employed in one of the two sectors. Accordingly, the returns on the two skills, h_N and h_X, can differ from each other. For simplicity, neither production of unskilled nor of skilled labour, reproduction, on the one hand, and education and learning-by-doing, on the other, is modelled: a given amount of S_N, S_X, and L exists in the domestic economy and, replacing the index T by X, equation (5) again applies.

In such a model, the log-differentiated conditional factor demands of the representative firm of sector i, where i = N, X, are

$$(8) \qquad \hat{S}_i = \hat{Y}_i - \hat{\theta}_i + \beta_i \hat{w} + \alpha_i \hat{r} - (\alpha_i + \beta_i)\hat{h}_i ,$$

$$(9) \qquad \hat{K}_i = \hat{Y}_i - \hat{\theta}_i + \beta_i \hat{w} - (1-\alpha_i)\hat{r} + (1-\alpha_i-\beta_i)\hat{h}_i ,$$

$$(10) \qquad \hat{L}_i = \hat{Y}_i - \hat{\theta}_i - (1-\beta_i)\hat{w} + \alpha_i \hat{r} + (1-\alpha_i-\beta_i)\hat{h}_i .$$

The log-differentiated supply function of sector i is

$$(11) \qquad \hat{p}_i = -\hat{\theta}_i + \beta_i \hat{w} + \alpha_i \hat{r} + (1-\alpha_i-\beta_i)\hat{h}_i .$$

Equations (8), (9), (10), (11) for each of the two sectors together with equation (5) can be solved for the variables K_X, K_N, L_X, L_N, h_X, h_N, w, Y_X, Y_N, and p_N if either Y_N or p_N is given by demand.

In this model, a Balassa-type effect, ie the positive (negative) dependence of the price of non-tradeables on TFP in the export (non-tradeables) sector, is still present:

$$(12) \qquad \frac{d\ln p_N}{d\ln\theta_X} = \frac{\beta_N L_X}{(1-\alpha_X)(\alpha_N+\beta_N)L_X + \alpha_N(1-\alpha_X-\beta_X)L_N} > 0 ,$$

$$(13) \qquad \frac{d\ln p_N}{d\ln\theta_N} = \frac{-[\beta_X L_X + (1-\alpha_X-\beta_X)L]}{(1-\alpha_X)(\alpha_N+\beta_N)L_X + \alpha_N(1-\alpha_X-\beta_X)L_N} < 0$$

if Y_N is given by demand.

In contrast to the two-factor model, however, domestic demand affects the price of non-tradeables and thus the real exchange rate in this model. Even if the wage were still uniquely determined in the export sector, this would not fix the price of non-tradeables because, apart from r and w, this price also depends on h_N as can be seen from (11) where $i = N$. A rise in non-tradeable output raises the return on skills employed in the non-tradeable sector and thus the price of non-tradeables, in short, the supply curve in the non-tradeables sector has a positive slope.

In order to derive some hypotheses on the determination of the price of non-tradeables, the effect of changes in the exogenous variables on non-tradeable output will be calculated first. For this purpose, it is temporarily assumed that p_N is given by demand. Afterwards, demand for non-tradeables is considered for a given p_N, before both supply and demand are equated to determine p_N.

Output of non-tradeables depends positively on the price of non-tradeables which is the slope of the supply curve previously described:

$$\text{(14)} \qquad \frac{d\ln Y_N}{d\ln p_N} = \frac{(1-\alpha_X)(\alpha_N+\beta_N)L_X + \alpha_N(1-\alpha_X-\beta_X)L_N}{(1-\alpha_X)(1-\alpha_N-\beta_N)L_X + (1-\alpha_N)(1-\alpha_X-\beta_X)L_N} > 0 .$$

Similarly, a rise in non-tradeables TFP raises non-tradeables output,

$$\text{(15)} \qquad \frac{d\ln Y_N}{d\ln \theta_N} = \frac{\beta_X L_X + (1-\alpha_X-\beta_X)L}{(1-\alpha_X)(1-\alpha_N-\beta_N)L_X + (1-\alpha_N)(1-\alpha_X-\beta_X)L_N} > 0 .$$

A rise in tradeables TFP or in tradeables prices lowers non-tradeables output because tradeables output increases, and this raises wages:

$$\text{(16)} \qquad \frac{d\ln Y_N}{d\ln \theta_X} = \frac{d\ln Y_N}{d\ln p_X} = \frac{-\beta_N L_X}{(1-\alpha_X)(1-\alpha_N-\beta_N)L_X + (1-\alpha_N)(1-\alpha_X-\beta_X)L_N} < 0 .$$

Furthermore, non-tradeables output depends on world interest. As can be seen from equation (17), the sign is indeterminate. The only positive term in the numerator, $\alpha_X\beta_N$, will be especially large if export technology relies relatively more on capital than non-tradeables technology, $\alpha_X > \alpha_N$, and if non-tradeables technology relies relatively more on labour, $\beta_N > \beta_X$:

$$\text{(17)} \qquad \frac{d\ln Y_N}{d\ln r} = \frac{[\alpha_X\beta_N - (1-\alpha_X)\alpha_N]L_X - \alpha_N(1-\alpha_X-\beta_X)L_N}{(1-\alpha_X)(1-\alpha_N-\beta_N)L_X + (1-\alpha_N)(1-\alpha_X-\beta_X)L_N} .$$

The assumption that the capital good is identical to the import good implies that non-tradeables are used exclusively for consumption. In the real world, however, a share of investment will fall on non-tradeables, especially where infrastructure and installation costs are concerned. As a consequence, supply-side fundamentals in this model will affect the price of non-tradeables not only through Y_N, the traditional supply-side channel, but also through an investment demand channel. In order to catch these effects, assume now that the capital good is a composite good, which consists of the non-tradeable and the import good in given fractions.[6]

[6] This modification of assumptions requires, of course, the replacement of r by rp_K in equations (8) to (11) where p_K is the price of capital, which is now a price index of p_M and p_N. As a

The significance of the investment demand channel depends on the impact of the fundamentals on capital. First, note that by definition

(18) $$d\ln K = (K_X / K)\cdot d\ln K_X + (K_N / K)\cdot d\ln K_N$$

holds. Using (18) and the system of equations (8) – (11) and (5), the impact of r on K can be expressed as

(19) $$\frac{d\ln K}{d\ln r} = \frac{-[(1-\alpha_N-\beta_N)L_X + (1-\alpha_N-\beta_X)L_N]K_X}{[(1-\alpha_X)(1-\alpha_N-\beta_N)L_X + (1-\alpha_N)(1-\alpha_X-\beta_X)L_N]K}$$
$$-\frac{[(1-\alpha_X-\beta_N)L_X + (1-\alpha_X-\beta_X)L_N]K_N}{[(1-\alpha_X)(1-\alpha_N-\beta_N)L_X + (1-\alpha_N)(1-\alpha_X-\beta_X)L_N]K},$$
$$\left.\frac{d\ln K}{d\ln r}\right|_{K_X=K_N;L_X=L_N} = \frac{-(1-\alpha_X-\beta_X)-(1-\alpha_N-\beta_N)}{(1-\alpha_X)(1-\alpha_N-\beta_N)+(1-\alpha_N)(1-\alpha_X-\beta_X)} < 0 .$$

As expected, a rise in interest decreases the amount of capital employed in the whole economy. For a benchmark case, in which capital and labour are uniformly distributed across the sectors, this is shown by the second equation of (19). This uniform distribution, however, is just an example. In fact, the ratio L_N/L_X usually takes a value between 1 and 2 in EU accession countries.[7] But even for $L_N \neq L_X$ and $K_N \neq K_X$, dlnK/dlnr can only be positive if *inter alia* the partial production elasticity of capital in sector i is much higher than in j while, at the same time, K_i is much smaller than K_j and L_i is much larger than L_j, a completely implausible point of reference. Thus, dlnK/dlnr < 0.

As is shown by equations (20) and (21), capital will usually increase in response to an increase in export prices or a positive productivity shock in one of the sectors:

(20) $$\frac{d\ln K}{d\ln\theta_X} = \frac{d\ln K}{d\ln p_X} = \frac{[(1-\alpha_N-\beta_N)L + \beta_N L_N]K_X - \beta_N L_X K_N}{[(1-\alpha_X)(1-\alpha_N-\beta_N)L_X + (1-\alpha_N)(1-\alpha_X-\beta_X)L_N]K},$$
$$\left.\frac{d\ln K}{d\ln\theta_X}\right|_{K_X=K_N;L_X=L_N} = \left.\frac{d\ln K}{d\ln p_X}\right|_{K_X=K_N;L_X=L_N}$$
$$= \frac{(1-\alpha_N-\beta_N)}{(1-\alpha_X)(1-\alpha_N-\beta_N)+(1-\alpha_N)(1-\alpha_X-\beta_X)} > 0 ,$$

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consequence, the derivatives (12) to (14) will change slightly, but their sign is not affected. The modified derivatives are shown in Appendix 1 for the special case where the capital good is identical to the non-tradeable. Equations (15) to (21) are independent of the modification.

The existence of both tradeable and non-tradeable capital in small open-economy models has been considered by Brock/Turnovsky (1994), who solve a model which had been set up by Bruno (1976). They regard non-tradeable capital as structures as opposed to equipment, which is tradeable capital. Regarding the relationship between the two types of capital, they distinguish between substitutes and complements. The simplifying assumption that capital consists of tradeables and non-tradeables in given fractions, which is made here, represents an extreme form of complementarity, of course. Murphy (1989) and Schröder/Pfadt (1998) consider models where capital is tradeable but installation requires non-tradeables.

[7] The calculation is based on the period 1992 to 1999. As in the econometric part of the paper, the industrial sector proxies tradeables, and all the sectors except industry and agriculture proxy non-tradeables. Over time, L_N/L_X is usually rising in accession countries.

(21) $$\frac{d\ln K}{d\ln\theta_N}=\frac{[\beta_X L_X+(1-\alpha_X-\beta_X)L]K_N-\beta_X L_N K_X}{[(1-\alpha_X)(1-\alpha_N-\beta_N)L_X+(1-\alpha_N)(1-\alpha_X-\beta_X)L_N]K},$$
$$\left.\frac{d\ln K}{d\ln\theta_N}\right|_{K_X=K_N;L_X=L_N}=\frac{(1-\alpha_X-\beta_X)}{(1-\alpha_X)(1-\alpha_N-\beta_N)+(1-\alpha_N)(1-\alpha_X-\beta_X)}>0.$$

For a uniform distribution of capital and labour, the sign of all the derivatives in (20) and (21) is clearly positive. For $L_N \neq L_X$ and/or $K_N \neq K_X$, one must account for the fact that a rise in the price or TFP of one sector lowers output and thereby capital (and labour) input in the other by a relatively small amount. If this shrinking sector employed much more capital and/or much less labour than the other and if, at the same time, the partial production elasticity of the third factor, skills, is very small in the shrinking sector, the rising demand for capital in the expanding sector might be met by intersectoral redistribution from the shrinking sector, with the result that the national capital stock does not need to rise and may even fall. It is often conjectured that more capital is employed in the tradeables than in the non-tradeables sector, $K_X > K_N$, and for the EU accession countries, $L_N > L_X$ definitely holds. Such a redistribution effect will therefore play only a minor role in the case of rising prices or TFP in the export sector, and $d\ln K/d\ln\theta_X = d\ln K/d\ln p_X > 0$ in (20). For rising TFP in the non-tradeables sector, however, $K_X > K_N$ and $L_N > L_X$ imply a relatively large redistribution effect. Nevertheless, $d\ln K/d\ln\theta_N < 0$ would still require a very small partial production elasticity of skills in the export sector. Finally, the value of the derivative $d\ln K/d\ln p_N$ falls with a growing fraction of non-tradeables in the capital good. If this fraction is zero, $d\ln K/d\ln p_N = d\ln K/d\ln\theta_N$. If the fraction is 1,

(22) $$\frac{d\ln K}{d\ln p_N}=\frac{\beta_N L_X K_N-[(1-\alpha_N-\beta_N)L+\beta_N L_N]K_X}{[(1-\alpha_X)(1-\alpha_N-\beta_N)L_X+(1-\alpha_N)(1-\alpha_X-\beta_X)L_N]K},$$
$$\left.\frac{d\ln K}{d\ln p_N}\right|_{K_X=K_N;L_X=L_N}=\frac{-(1-\alpha_N-\beta_N)}{(1-\alpha_X)(1-\alpha_N-\beta_N)+(1-\alpha_N)(1-\alpha_X-\beta_X)}<0.$$

Equations (22) show that, in this case, $d\ln K/d\ln p_N < 0$ is probable and definitely holds for $K_X \geq K_N$ and $L_N \geq L_X$. This is because a rise in non-tradeables prices now not only raises output and thus capital input but also raises capital costs.

In order to formulate, as a next step, a market clearing equation for non-tradeables, which enables one determine p_N, demand must be specified. For a rigorous analysis of this step, intertemporal considerations should generally be taken into account. As these intertemporal considerations will not impinge on the argument concerning the investment demand channel, however, demand is characterized, for simplicity, by some simple assumptions, which are consistent with the model discussed. As far as investment demand is concerned, the derived changes in the equilibrium stock of capital should be transformed into a genuine investment function by a stock adjustment function. In intertemporal models for a small open economy with internationally mobile capital and perfect foresight, the equilibrium stock of capital is usually accumulated at once, simply by borrowing on world capital markets. This can be prevented by introducing installation costs into the model. Here, simply assume some monotonic adjustment. Apart from adjustment processes, a larger equilibrium stock of capital will require permanently greater investment to replace capital which will have been depreciated. Both mechanisms imply [sign(dI_N/dz) =] sign(dI/dz) = sign(dK/dz) for a given z.

Non-tradeables consumption, C_N, is included in the model simply because of its undeniable relevance in the real world. The results do not depend on its existence. Therefore, it is simply assumed that C_N depends negatively on p_N, which is consistent with both static and intertemporal optimization. If, for convenience, any other effects on C_N are ignored, equilibrium in the non-tradeables market is given by

(23) $$Y_N(p_N;\theta_X,\theta_N,p_X,r) = I_N(p_N;\theta_X,\theta_N,p_X,r) + C_N(p_N) + G_N$$

where G_N denotes exogenous government demand for non-tradeables, the signs of the partial derivatives of Y_N are given by (14) to (17) and those of I_N by (19) to (22). If it is assumed, now, that the two derivatives with an indeterminate sign, $\partial I_N/\partial p_N$ and $\partial Y_N/\partial r$, are relatively small, fundamentals will affect the non-tradeables price of a small open economy in the following way:

(24) $$\frac{dp_N}{dG_N} = \frac{-1}{\Delta} > 0\,,$$

(25) $$\frac{dp_N}{d\theta_X} = \left(\frac{\partial Y_N}{\partial \theta_X} - \frac{\partial I_N}{\partial \theta_X}\right)\frac{1}{\Delta} > 0\,,$$

(26) $$\frac{dp_N}{d\theta_N} = \left(\frac{\partial Y_N}{\partial \theta_N} - \frac{\partial I_N}{\partial \theta_N}\right)\frac{1}{\Delta}\,,$$

(27) $$\frac{dp_N}{dp_X} = \left(\frac{\partial Y_N}{\partial p_X} - \frac{\partial I_N}{\partial p_X}\right)\frac{1}{\Delta} > 0\,,$$

(28) $$\frac{dp_N}{dr} = \left(\frac{\partial Y_N}{\partial r} - \frac{\partial I_N}{\partial r}\right)\frac{1}{\Delta} < 0\,, \text{ where}$$

$$\Delta = \frac{\partial C_N}{\partial p_N} + \frac{\partial I_N}{\partial p_N} - \frac{\partial Y_N}{\partial p_N} < 0\,.$$

Results (24) and (28) are quite intuitive. Note, however, that, in contrast to (24), $dp_N/dG_N = 0$ in the basic Balassa-Samuelson model of section 2.1. Results (25) and (26) may be more interesting. They show that productivity changes affect the real exchange rate of small countries not only through the usual Balassa-Samuelson supply channel, $\partial Y_N/\partial\theta_i$, but also through an investment demand channel, $\partial I_N/\partial\theta_i$: if TFP rises in one of the sectors, investment demand increases, and this raises non-tradeable prices. This model formalizes the previous supposition that investment demand may have been one of the reasons for the real appreciation in transition countries; see Roubini/Wachtel (1998). The reason why such an investment demand channel exists here but not in the usual intratemporally or intertemporally optimizing models of a dependent economy[8] can be traced back to the combination of two assumptions.[9] First, some fraction of the composite capital good, for instance structures and installation, falls on non-tradeable goods. Otherwise, non-tradeable demand would be unaffected by productivity, of course. Second, there is a third factor in addition to capital and labour, namely skills, which allows the non-tradeable supply function to be

[8] For an overview of the usual intertemporally optimizing models, see Obstfeld/Rogoff (1996), chapter 4.

[9] Note that the proposed investment channel is not only a completely different phenomenon from the Balassa-Samuelson hypothesis but also from the mechanisms proposed by Kravis/Lipsey (1983) and Bhagwati (1984), on the one hand, and Baumol/Bowen (1966), on the other. The former explain rising non-tradeables prices with the adoption of a more capital-intensive technology, the latter with slow productivity growth in labour intensive services.

positively sloped. Otherwise, the rise in non-tradeable investment demand could not raise non-tradeable prices. The existence of an investment demand channel has implications for the interpretation of regressions of some measure of the real exchange rate on a proxy for productivity θ_X and θ_N or the ratio θ_X/θ_N. A significant positive coefficient of θ_X/θ_N or θ_X is generally interpreted as evidence in favour of the Balassa-Samuelson effect, for example, by Coricelli/Jazbec (2001), De Broeck/Sløk (2001), UN, Economic Commission for Europe (2001), Begg *et al.* (1999), as well as in the literature which is not related to transition countries, as, for example, in Hsieh (1982), De Gregorio *et al.* (1994), Strauss (1996, 1999), Chinn (1997), Canzoneri *et al.* (1999), Alexius/Nilsson (2000) and DeLoach (2001). Equation (25), however, demonstrates that this can follow simply from the fact that growth in the export sector requires non-tradeable inputs. In that case, this coefficient could be significantly positive even with an insignificantly small Balassa-Samuelson effect. Since the estimated coefficient corresponds to the whole expression $dp_N/d\theta_X$ in (25), which comprises both the Balassa-type supply effect and the investment demand effect, or to a combination of the effects (25) and (26), the empirical evidence apparently in favour of Balassa-Samuelson effects may require re-interpretation. Equation (20) even shows that a relatively large investment effect is the more probable the more the usual proposition of a relatively capital-rich tradeables sector and a relatively labour-rich non-tradeables sector applies. In the case of a non-tradeables productivity shock, equation (26), the investment effect forces the non-tradeables price in the opposite direction from the Balassa-Samuelson effect, which contrasts with the case of the tradeable productivity shock. Here, however, one would usually expect the supply effect to dominate in the longer run, especially if the non-tradeables sector uses a relatively large amount of labour and little capital. Nevertheless, in a catching-up economy where foreign direct investment feeds back into a rising TFP, which is not modelled, of course, the total effect on non-tradeables prices might be positive for an extended period.

Finally, the response of non-tradeables prices to changes in export prices, equation (27), can be interpreted in the same way as equation (25). Here, however, a further snag arises: contrary to all the other shocks, the effect on the price of non-tradeables does not necessarily correspond to the effect on the real exchange rate. Based on CPIs, which are chosen because they are used in the econometric analysis, the real exchange rate in the model is defined as

$$R = \frac{p_N^{\gamma} p_M^{1-\gamma}}{p_{N_f}^{\gamma_f} p_X^{1-\gamma_f}} \tag{29}$$

where f denotes a foreign variable, γ is the fraction of the non-tradeable price in a CPI, and a rise in R corresponds to a real appreciation for the domestic consumption basket. As can be seen from (29), the indirect effect of an increase in p_X working through a rise in domestic non-tradeables prices and the direct effect on R oppose each other. In sum, the response of R on changes in p_X is indeterminate.

3 Panel estimation of exchange rate determination in transition countries

The theoretical model of the previous chapter can be used to identify fundamentals of the real exchange rate in transition countries. The solution of equation (23) for p_N, $p_N = f(\theta_X, \theta_N, p_X, r, G_N)$, combined with (29), provides an equation which will be used, in this chapter, to estimate the impact of these fundamentals on the real exchange rate in a reduced form. In this way, the validity of the corresponding forecasts of the model is examined and, at the same time, an explanation for the observed real appreciation is given.

For the estimation, panel methods are used. On the one hand, data limitations due mainly to the short observation period of market-determined real exchange rates in transition countries would call the results of a single-country estimation into question. On the other hand, a panel analysis provides more general evidence on the issue of real appreciation in transition countries. As far as the cross-dimension of the panel is concerned, it was chosen to comprise the ten central and east European transition countries which are currently engaged in negotiations for EU accession. These are the countries which can gain access to EMU in the foreseeable future. The CIS countries have been excluded because they are considerably less advanced in the process of transition and would therefore reduce the homogeneity of the panel. Other candidates for EU accession such as Cyprus and Malta are excluded because they are not transition countries. As far as the time-dimension of the panel is concerned, data from 1993 onward are used. For most transition countries, there is hardly any reliable data for earlier periods. Moreover, the inclusion of earlier periods in the panel, ie the phase immediately after these countries stopped governing their economy through a central plan, would reduce the relevance of the results for present and possibly future developments.

3.1 The data[10]

As a measure of the real exchange rate, the CPI-based real effective exchange rate as introduced in section 1 and shown in figure 1 is used. The (relative) price of non-tradeables may exhibit a closer relationship to the fundamentals but it is much harder to measure properly. Furthermore, and more importantly, the CPI-based real effective exchange rate, and not the price of non-tradeables, is the actual objective variable. It is the inflation differential between transition and (non-transition) OECD countries measured in a common currency, which is to be explained.

Since no reliable measure of capital is available for most transition countries (and none for skills, of course), TFP is proxied by labour productivity, as is common practice. Production is divided into three sectors: industry stands for the tradeables or export sector, services for the non-tradeables sector and, finally, agriculture is the residual sector in which most goods should be tradeable but their prices are often publicly regulated. Labour productivity is calculated as real value added in sector i per number of employees in sector i.

Government consumption of non-tradeables is proxied by total government consumption per GDP. This simplification can be justified either by the frequently cited argument

[10] For more details on the data, particularly their sources, see Appendix 2.

that government consumption primarily consists of non-tradeable goods or, more generally, by the assumption that governments consume tradeables and non-tradeables in rather fixed proportions. Alternatively, a more broadly defined variable is used, namely total, that is private plus public, consumption per GDP. In the theoretical model, it was assumed for simplicity that private non-tradeable consumption just depends on non-tradeable prices, leaving government consumption as the only exogenous variable which affects total non-tradeable consumption. If this is true and (relative) non-tradeables prices affect the structure rather than the level of consumption, estimation results should not change when government consumption is replaced by total consumption. However, if there are important additional fundamentals affecting private consumption apart from those that have an impact through p_N, total consumption will catch them and will thus represent a measure of exogenous consumption demand shocks that is superior to just government consumption.

Real interest rates on world capital markets are measured, for simplicity, by an unweighted average of real interest rates in the USA and in Germany. Real interest rates are calculated as the difference between long-term government bond yields and the ex-post inflation rate of the CPI.[11]

The influence of world market prices is captured by the terms of trade. In equations (23) to (28), only export prices play a role but this is just because import prices have been normalized to one. As can be seen from equation (29), the direct effect of rising import prices is a real appreciation. There are also indirect effects working through p_N: rising import prices increase non-tradeables consumption (a substitution effect) but decrease investment demand, which partly falls on imports. The total impact on the real exchange rate is ambiguous, and even the direct effect could have the opposite sign if import goods are also consumed abroad. Thus, both elements of the terms of trade will clearly affect the real exchange rate, but it is far from clear in which direction. As an alternative measure, a raw materials price index which includes energy has been used. It is narrower than the terms of trade but covers those price elements of the terms of trade which are probably the most volatile. In order to obtain real price movements, the raw materials price index is deflated by the US producer price index.

The real interest rate on world capital markets and the raw materials price index are common to every country. All the other variables are country-specific. Similar to the calculation of the real effective exchange rate, each of the country-specific series has been divided by a trade-weighted average of corresponding series of (non-transition) OECD countries. All the variables except the real interest rate are in logs.

3.2 Methods and results

3.2.1 Panels with annual data

First, an annual data panel is considered. It is mainly sectoral labour productivity which is available only on an annual basis. Since the resulting panel is rather small, the simple fixed

[11] One might argue that, in the early 1990s, the relatively high inflation rates in eastern Germany bias the calculated German real interest rate downward. However, this does not affect the estimation results at all, a fact which has been established by re-estimating the regressions with western German inflation rates instead of those of unified Germany.

effects method of estimation was chosen.[12] Different general specifications, for example, either including government consumption per GDP or total consumption per GDP in the set of regressors and either the terms of trade or the real raw materials price index, have been tried out, and insignificant variables have been eliminated along the lines of a general-to-specific approach.

Table 1. Fixed effects model, 10 countries, annual data, 1993 to 1999

	Model 1.1	Model 1.2	Model 1.3
Labour productivity (agriculture)	0.64 (3.09/2.20)	0.70 (3.42/2.05)	0.64 (2.96/1.99)
Labour productivity (industry)	1.04 (3.66/1.74)	0.95 (3.97/1.97)	1.30 (4.68/2.24)
Consumption/GDP	1.29 (2.28/2.66)		1.42 (2.41/2.73)
Real rate of interest (USA, Germany)	0.10 (2.37/3.08)		
Terms of trade		-1.20 (2.93/1.72)	
Real raw materials prices	-0.65 (2.17/1.91)		

Dependent variable: real effective exchange rate; a positive coefficient implies a real appreciation; t-values in brackets; the t-values in front of the slash are based on the usual standard errors while those behind the slash are based on robust standard errors as suggested by Arellano (1987).

Table 2. Fixed effects model, 8 countries (panel without Bulgaria and Romania), annual data, 1993 to 1999

	Model 2.1	Model 2.2	Model 2.3
Labour productivity (agriculture)	0.55 (3.24/2.71)	0.48 (2.71/2.50)	
Labour productivity (industry)	1.65 (6.07/4.83)	1.66 (7.91/6.10)	1.57 (6.10/4.16)
Labour productivity (services)	0.90 (2.06/2.31)		1.09 (2.60/1.91)
Consumption/GDP	1.82 (3.75/7.32)		
Government consumption/GDP		0.59 (2.22/2.69)	1.20 (5.29/9.69)
Real rate of interest (USA, Germany)	0.08 (2.50/2.39)		0.08 (2.52/3.30)
Terms of trade		-1.17 (3.43/3.18)	

For further explanations see Table 1.

Table 1 shows three models, whose coefficients are significant by conventional standards. Using heteroskedasticity and autocorrelation robust standard errors, however, the results suggest insignificance of several important variables. Since this may be explained by a still too heterogenous panel, Bulgaria and Romania were excluded from the panel. This may be justified by the fact that these two countries started transition later and are, in this respect, still behind the other transition countries in the panel. Table 2 presents results from fixed effects estimations of the panel without Bulgaria and Romania. As it turns out, the significance levels are indeed much higher than previously while the signs of the coefficients do not change. Note, however, that in contrast to Table 1 there are specifications where the coefficient for labour productivity in services, now, is significant.

As is shown in Tables 1 and 2, rising labour productivity in both the industrial and the agricultural sectors contributed to the real appreciation in transition countries. In the case of the industrial sector, this is in line with equation (25) and can be due either to the supply side channel, ie the Balassa-Samuelson effect, or to the investment demand channel or to

[12] Some tests generally confirm this choice: F-tests on the identity of the fixed effects are rejected which implies the superiority of a fixed effects estimation to a simple pooled OLS estimation. The correlation between the fixed effects and the regressors is generally high, which implies the superiority of a fixed effects method to a random effects method. This is confirmed by formal Hausman tests.

both. In the case of the agricultural sector, the positive coefficient either implies that agricultural products are tradeables and equation (25) applies or that the investment demand effect is very strong if these products are non-tradeables and equation (26) applies. Interestingly, the coefficient of labour productivity in the services sector is either insignificant or significantly positive. Since productivity in this sector has been rising significantly in most transition countries, albeit often less than in the other sectors, one might be tempted to argue that services are tradeables like agricultural and industrial goods. This, however, would be misguided because, if they were, the consumer price level in transition countries would be determined entirely by world market prices and the phenomenon of considerable real appreciation in these countries would not exist.[13] Therefore, some of the goods, presumably services, are non-tradeable, which implies that the investment demand channel plays a significant role in the real appreciation in transition countries. The Balassa-Samuelson effect alone cannot account for the fact that productivity increases in each sector entail a real appreciation. The coefficient of at least one sector had to be significantly negative because the Balassa-Samuelson effect relies on structural shifts across sectors and the shrinkage of at least one sector. The investment demand channel, by contrast, is perfectly in line with the results because a productivity increase in each sector raises demand for non-tradeables.

The significantly positive coefficient of consumption shows that components of demand can indeed affect the real exchange rate in small countries. Again, this cannot be reconciled with the Balassa-Samuelson model in its simple form but is consistent with the extended model of section 2.2. The terms of trade are found to have a significantly negative impact on the real exchange rate in some models, which implies that the direct effect in (29) dominates the indirect effect. The only result which is inconsistent with the theoretical model of section 2.2 is the significantly positive coefficient of real rates of interest. Figure 2 provides further insight into the roots of this problem. There, cross-country averages of the real exchange rate for a given year are depicted together with the corresponding world market real interest rate. The graph shows a clear negative relationship and a single outlier in the lower left-hand corner.[14] The outlier represents data from 1993, the first year of the observation period. The fixed effects models have therefore been re-estimated for a panel which starts in 1994. Table 3 shows that, now, the coefficient of the real interest rate has indeed the significantly negative sign expected while all the other coefficients did not change their sign.

[13] The explanation could be valid, however, if the observed real appreciation were entirely due to a correction of an initial undervaluation. This is unlikely over a horizon of ten years and is, as cited in the introduction, not supported by the evidence. See Halpern/Wyplosz (1997) and Begg *et al.* (1999).

[14] This pattern can not only be found for average real exchange rates but, in fact, also for every single country.

Figure 2. Relationship between real effective exchange rates of transition countries and world market real rates of interest; annual data;1993 to 1999; exchange rates are in logs and averaged across transition countries

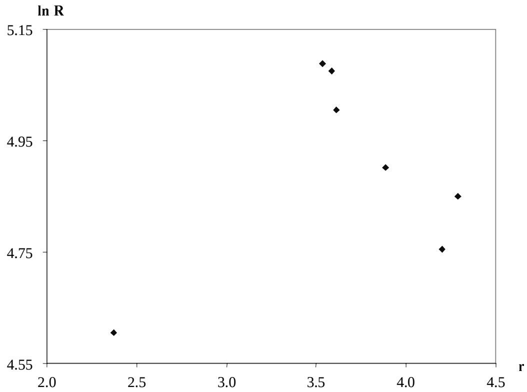

Table 3. Fixed effects model, 8 countries (panel without Bulgaria and Romania), annual data, 1994 to 1999

	Model 3.1	Model 3.2
Labour productivity (agriculture)	0.46 (3.14/2.87)	0.44 (3.01/3.64)
Labour productivity (industry)	0.76 (2.54/3.34)	0.60 (2.14/2.65)
Consumption/GDP	0.89 (1.83/4.13)	
Government consumption/GDP		0.45 (1.99/3.51)
Real rate of interest (USA, Germany)	-0.21 (3.06/4.18)	-0.23 (3.43/4.20)

For further explanations see Table 1.

3.2.2 Panels with quarterly data

The annual frequency of sectoral productivity data has been the main reason for using annual instead of quarterly data. In the last section, however, it was found that the sign of the estimated coefficients of sectoral productivity variables did not depend on the sector. Productivity increases in each sector caused a real appreciation although, in the case of the services sector, the coefficient was often insignificant. Structural change does not seem to be a major force behind the observed real appreciation. The three sectoral productivity variables can therefore be replaced by one aggregated labour productivity series, which is computed as real GDP per number of employees in the whole economy. The proposed relationship can now be estimated with a panel of quarterly data, which allows the application of more suitable estimation methods. Owing to the lack of data, Romania and Slovenia are not part of this new panel, and Bulgaria has been excluded deliberately in some estimations for the same reasons as in the previous section. Moreover, the real raw materials price index has generally been used instead of the terms of trade because, for the latter, no quarterly data have been available. The observation period for this quarterly data panel is 1994:1 to 2000:4.

Table 4 presents the results from a SUR fixed effects estimation which allows for heteroskedasticity across countries and cross-country correlation of the residuals.[15] The coef-

[15] In particular, the latter is important in country-panels where the series of different countries are often subject to the same exogenous disturbances. Here, however, the SUR results hardly differ

ficient of total labour productivity is always positive and highly significant, that of consumption demand is significantly positive and that of the rate of interest significantly negative. The results confirm those of the previous section and are in line with the theory.

Table 4. Fixed effects model, SUR, 8 or 7 countries respectively, quarterly data, 1994:1 to 2000:4

	without RO, SN	without BG, RO, SN	
	Model 4.1	Model 4.2	Model. 4.3
Total labour productivity	0.86 (11.79)	1.68 (17.49)	1.58 (15.81)
Consumption/GDP		0.55 (3.98)	
Government consumption/GDP	0.21 (4.01)		0.24 (3.39)
Real rate of interest (USA, Germany)	-0.09 (6.40)	-0.03 (2.77)	-0.04 (3.52)

Dependent variable: real effective exchange rate; a positive coefficient implies a real appreciation; t-values in brackets. RO = Romania, SN = Slovenia and BG = Bulgaria.

The methods which have been used so far are essentially static. The series in the panel, however, may well be subject to a trend. In order to investigate whether the results of the static methods are robust vis-à-vis a dynamic specification, the pooled mean group estimation method which goes back to Pesaran *et al.* (1999) has been used to re-estimate the real exchange rate equation.[16] This method is chosen because it has been developed in particular for panels comprising a comparatively small number of groups (countries) and a not too small number of periods.[17] It estimates the dynamic equation

$$\Delta y_{it} = \phi_i y_{i,t-1} + \beta_i' x_{it} + \sum_{j=1}^{p-1} \lambda_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \delta_{ij}' \Delta x_{i,t-j} + \mu_i + \varepsilon_{it} \tag{30}$$

which is a reparameterization of an ARDL(p, q, q, ... , q) model where t = 1, 2, ... , T time periods, i = 1, 2, ... , N groups and vector x_{it} comprises k regressors. It is assumed that the disturbances ε_{it} are independently distributed across i and t and that they are independent of x_{it}. The long-run coefficients are constrained to be the same across groups: $\pi_i = -\beta_i/\phi_i = \pi$ where π_i and π are $k \times 1$ vectors as is β_i (and δ_{ij}). The short-run coefficients, λ_{ij} and δ_{ij}, the error variances, σ_i^2, and the intercepts, μ_i, are allowed to differ across countries. This method estimates (30) by using a FIML approach.

The pooled mean group estimation method requires the existence of a long-run relationship between the real exchange rate and its regressors. This assumption is fulfilled if I(1) variables are cointegrated. The IPS test of Im *et al.* (1997) has been used to test for stationarity of those variables which are specific to transition countries, and the ADF test has been used for the other variables, ie for the real rate of interest and the real raw materials price index. While most variables are found to be clearly I(1), the consumption demand variables appear rather to be stationary. In order to test for cointegration, Kao's (1999) approach has been used, and the cointegration regression has been estimated using Phil-

from those obtained with a simple fixed effects estimation method or a GLS, which only allows for cross-country heteroskedasticity.

16 This method has also been used by De Broeck/Sløk (2001). Pesaran *et al.* (1999) provide a program to compute the pooled mean group estimator on *http://www.econ.cam.ac.uk/faculty/pesaran*.

17 Pesaran *et al.* (1999) apply the pooled mean group estimation method to two panels. For the smaller of these, N = 10 and T = 17. The panel of transition countries used here has a dimension of N = 7 or 8 and, for most countries, T = 28.

lips/Hansen's (1990) FMOLS method as suggested by Pedroni (1995) and Phillips/Moon (1999). In order to test for the stationarity of the residuals, the IPS test has been used again. Cointegration results are mixed: for panels with Bulgaria, the variables generally turn out to be cointegrated while for panels without Bulgaria the opposite holds. Im *et al.* (1997) show, however, that the power of the IPS test to reject the nonstationarity of a true value of, for example, 0.9 is just 26 % for a panel of this size. All these results should therefore be considered as indicative.

As can be seen from Table 5, the pooled mean group estimation results generally confirm those obtained with static methods: the coefficients of labour productivity, consumption demand and real interest are all significant with the expected and previously found sign. In contrast to the static methods, this dynamic method always yields a significantly positive coefficient for real raw materials prices. Moreover, in none of the dynamic regressions are the real rate of interest and a consumption demand variable significant in the same model.[18]

Table 5. Pooled mean group estimation, 8 or 7 countries respectively, quarterly data, 1994:1 to 2000:4

	without RO, SN			Without BG, RO, SN		
	Model 5.1	Model 5.2	Model 5.3	Model 5.4	Model 5.5	Model 5.6
Total labour prodactivity	0.98 (12.81)	1.45 (21.71)	0.82 (6.42)	0.99 (12.93)	1.47 (22.35)	0.90 (7.33)
Consumption per GDP	0.73 (2.43)			0.77 (2.53)		
Government consumption per GDP		0.54 (6.78)			0.56 (7.12)	
Real rate of interest (USA, Germany)			-0.07 (3.85)			-0.05 (3.42)
Real raw material prices	0.07 (2.14)	0.11 (8.40)	0.10 (2.22)	0.07 (2.20)	0.11 (8.71)	0.10 (2.39)

Dependent variable: real effective exchange rate; a positive coefficient implies a real appreciation; t-values in brackets. Akaike's AIC has been used to select the lag order for each group individually, where the maximum number of lags is chosen to be 2. The Newton-Raphson algorithm has been used for the computations with the initial values taken from a static fixed effects OLS regression. RO = Romania, SN = Slovenia and BG = Bulgaria.

[18] Diagnostic tests for the models in Table 5 reveal few problems. Tests on serial correlation, functional form misspecification and nonnormal errors indicate violations for, on average, only one of the country-specific equations. Moreover, most of these few problems concern the equation for Bulgaria, which is excluded in models 5.4 to 5.6. Nevertheless, the inclusion of Bulgaria seems to have no major effect on the estimation results, as can be seen in Table 5.

When applying the pooled mean group estimation method, one can choose *inter alia* which algorithm should be used for maximization, how to estimate initial values, how to select the lag order, and whether the homogeneity restriction on the long-term coefficients should be relaxed for some. In the present case, the method turns out to be robust vis-à-vis all of these options except the one involving the lag order. Changes in the method of lag order selection or just in the maximum number of lags can affect the estimated coefficients and significance values noticeably. Table 5 presents the estimation results which have been obtained with the use of Akaike's AIC, where the maximum number of lags is chosen to be 2.

3.2.3 The influence of the process of transition

In the considerations up to now, the actual process of transition has not played a role. The theoretical model is general and applicable to any small country, and the empirics are based on this model. One may wonder, however, whether and how the process of transition could have affected the real exchange rate movements of EU accession countries. In European Bank for Reconstruction and Development (2000), three series concerning institutional arrangements can be found which should impact on the real exchange rate, but are usually left aside because institutional arrangements do not vary much in non-transition economies:

(1) The percentage share of administered prices in CPI. A reduction in the regulation of prices can directly affect the real exchange rate in equation (29). In the medium run, price liberalization may raise prices if they were heavily subsidized before. In the long run, however, price liberalization should tend to have a negative impact on price levels because products are now exposed to competition and because the former subsidies had to be financed somehow.

(2) Tariff revenues as a percentage of imports as a proxy for the degree of trade liberalization. Trade liberalization in the form of a reduction in import tariffs, for instance, should decrease the price of imported goods and thus cause a real depreciation; cf. equation (29).

(3) The private sector share in GDP as a percentage. In contrast to the other two transition variables, this privatization proxy may not affect prices directly but rather through investment demand. While the investment function in equation (23) reflects the demand for investment, the privatization proxy reflects opportunities of investment. If sufficient demand for investment exists and privatization raises the opportunities to invest, a real appreciation would occur under the assumptions of the theoretical model.

On the assumption that these three variables remained rather constant in non-transition OECD countries, these series were not divided by corresponding series of the transition countries' trading partners. All the series, however, have been expressed in logs.[19] Since all the variables are available only in an annual frequency, a simple fixed effects estimation technique has been used. If one adds either the price liberalization proxy or the trade liberalization proxy to the annual data panel of section 3.2.1,[20] their coefficients almost always turn out to be insignificant. In the rare cases in which they are significant, the significance vanishes as soon as the privatization proxy is added. Obviously, the real exchange rate of transition countries is mainly driven by fundamentals which affect investment as the privatization proxy, productivity and the real interest rate on world capital markets. Because of the insignificance of price and trade liberalization proxies, only those results are shown in Table 6 which have been obtained by adding just the privatization proxy to the panel.

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[19] Taking the log of Estonia's tariff revenues poses a technical problem. Since 1996, there have been no such revenues in Estonia. Different ways of tackling this problem, however, did not affect the results at all.

[20] In order to prevent possible multicollinearity problems, the terms of trade series has been eliminated from the panel in those cases. This does not pose much of a problem because the terms of trade coefficients are mostly insignificant anyway.

Table 6. Fixed effects model, annual data including privatization proxy, 1993 to 1999

	10 countries		8 countries (without Bulgaria and Romania)		
	Model 6.1	Model 6.2	Model 6.3	Model 6.4	Model 6.5
Labour productivity (agriculture)		0.45 (2.72/1.99)			0.45 (2.54/2.28)
Labour productivity (industry)		0.53 (2.18/1.71)			1.25 (3.72/15.87)
Total labour productivity	0.66 (2.06/1.22)		2.20 (4.86/5.89)	1.96 (4.69/7.54)	
Consumption per GDP		0.90 (1.98/1.73)	1.45 (3.15/3.35)		1.70 (3.42/4.92)
Government consumption per GDP	0.68 (3.43/3.01)			0.89 (4.21/4.54)	
Proxy for progress in privatization	0.69 (7.59/4.14)	0.64 (6.44/4.10)	0.38 (2.81/1.68)	0.38 (3.01/1.86)	0.43 (3.07/2.20)

For further explanations see Table 1.

In the panel which comprises all the transition countries in the process of EU accession (models 6.1 and 6.2), the coefficient of the privatization proxy is generally significant with the expected positive sign. The addition of the privatization proxy reduces the significance of all the other coefficients considerably (cf. Table 1), and robust t-values often indicate insignificance. In models 6.3 to 6.5, from which Bulgaria and Romania have been excluded, the coefficient of the privatization proxy is much less significant, and with robust t-values mostly insignificant. In these models, the t-values of the other coefficients clearly indicate significance. All the signs are consistent with the theory, and the improperly signed coefficient of the real interest rate of models 1.1, 2.1 and 2.3 is now generally insignificant. Finally, if a panel whose series start in 1994 instead of 1993 is used, the coefficient of the privatization proxy is generally insignificant, and the models collapse to those shown in Table 3. One may conclude that the contribution of the privatization proxy to explaining transition countries' real exchange rate movements is larger in the first few years of the transition process (because of its insignificance if the observation period starts as late as 1994) and is larger for those countries which have made less progress in transition (because its significance falls considerably if Bulgaria and Romania are excluded from the panel). As a consequence, one should expect that privatization (and the other variables that characterize the institutional change in the process of transition) will not play a major role in determining the future real exchange rate movements of these countries.[21]

[21] The observation that many of the EU accession countries have already reached a relatively high degree of privatization is another reason for this expectation.

4 Conclusions

This paper analyzes the causes of the considerable real currency appreciation which can be observed in transition countries in the process of EU accession. To this end, a simple but general model of a dependent economy is developed by extending the commonly used Balassa-Samuelson model. With the help of this model, it is possible to derive which and how fundamental variables can affect the real exchange rate of a small country. The results of the extended model differ from the common Balassa-Samuelson view mainly in two respects: first, changes in non-tradeables demand generally affect the real exchange rate. Expansionary fiscal policy, for instance, causes a real appreciation. Furthermore, it can be shown that total factor productivity shocks impact on the real exchange rate not only through a Balassa-Samuelson-type supply channel but also through an investment demand channel: rising productivity in any sector raises the equilibrium capital stock in the economy and thus raises investment demand which in turn increases prices. In the case of rising productivity in the export sector, which is usually considered in the Balassa-Samuelson framework, the investment demand channel has a particularly large impact on real exchange rates if – as is usually assumed – the production of the export (non-tradeable) good requires a relatively large (small) capital input and a relatively small (large) labour input. Since empirical papers which claim to have found evidence in favour of the Balassa-Samuelson effect for transition or non-transition countries usually estimate the total effect of productivity on the real exchange rate, their results could have been due, instead, to the investment demand channel instead of the Balassa-Samuelson effect and thus may require a re-interpretation.

In the empirical part of the paper, the impact of the fundamentals suggested by theory on the real exchange rate has been estimated for a panel of EU accession countries. The econometric results are consistent with the theoretical model and plausibly explain the observed real appreciation. These results[22] have been used to compute the average contribution of each fundamental to the change in the equilibrium real exchange rates since 1994: around half of this change is due to changing productivity, around one-quarter is due to changing consumption demand and one-quarter to changing real world market interest rates. The contribution of productivity can be subdivided into sectors with the share of industry amounting to slightly more than half and the share of agriculture amounting to slightly less. If discernible at all, the effect of productivity in services is very small. The observed major influence of productivity on the real exchange rate movements of transition countries is consistent with the findings of a number of recent papers on that topic. Those papers, however, attribute the entire impact of productivity to the Balassa-Samuelson effect whereas it is argued here that the simple Balassa-Samuelson model is inconsistent with the evidence, that the Balassa-Samuelson effect alone cannot account for the observed productivity effects, and that the results suggest instead that part of these productivity effects are due to the proposed investment demand channel. The theoretical and empirical analyses suggest that the upward pressure on the real exchange rates of transition countries in the process of EU accession should be expected to continue in the future if these countries enjoy further productivity gains. Regarding the imminent discussion on whether and when

[22] The numbers are mainly derived from the results of the SUR estimations depicted in Table 4 but, in particular, the share of productivity is roughly the same for the results obtained with other estimation techniques. The pooled mean group estimation results suggest that less than one-tenth of the change in the equilibrium real exchange rate is due to changing real raw materials prices with a correspondingly reduced share for the other variables.

these countries should join European Monetary Union, it may be important to note that real convergence apparently implies (possibly considerable) inflation differentials if nominal exchange rates do not adjust. Such inflation differentials can therefore clearly persist even within a monetary union.

Appendix 1. Some derivatives

Derivatives from the system (8) to (11), (5) and (18) in the event that the capital good is the non-tradeable, ie r is replaced by rp_N in (8) to (11):

(A1) $$\frac{d\ln p_N}{d\ln \theta_X} = 1,$$

(A2) $$\frac{d\ln p_N}{d\ln \theta_N} = \frac{-[\beta_X L_X + (1-\alpha_X-\beta_X)L]}{\beta_N L_X} < 0,$$

(A3) $$\frac{d\ln Y_N}{d\ln p_N} = \frac{\beta_N L_X}{(1-\alpha_X)(1-\alpha_N-\beta_N)L_X + (1-\alpha_N)(1-\alpha_X-\beta_X)L_N} > 0.$$

In (A1) and (A2), Y_N is taken as given while, in (A3), p_N is obviously exogenous. The remaining derivatives presented in the paper do not change.

Appendix 2. Data sources and calculations

a) Transition country data

Source of the real effective exchange rates for transition countries: BIS.

Source of sectoral real gross value added and sectoral employment: Vienna Institute for International Economic Studies (WIIW) for all the countries except the Baltic states; Bank of Estonia for value added in Estonia; ILO for employment in Estonia and Latvia; National Statistical Yearbooks for Latvian and Lithuanian data. Industry sector includes energy and construction; services sector includes all activities except agriculture and industry.

Source of quarterly real GDP and employment data: OECD, Main Economic Indicators for Bulgaria (only real GDP), the Baltic states and the Slovak Republic; WIIW for Bulgarian employment;[23] OECD, Quarterly National Accounts and Quarterly Labour Force Statistics for the Czech Republic; BIS for real GDP in Hungary and Poland; IMF, IFS for employment in Hungary and Poland.

Labour productivity has been expressed for a common base period and has been converted into 1999 US dollars using 1999 dollar exchange rates from IMF (IFS) data.

The variables for consumption demand per GDP and the terms of trade have been constructed from national accounts data. Sources: OECD, Main Economic Indicators for Bulgaria (with some WIIW data for its terms of trade), the Baltic states, the Romanian

[23] Only annual data available; quarterly data constructed by interpolation.

terms of trade and Slovenia; OECD, Quarterly National Accounts for the Czech Republic; WIIW for annual consumption per GDP and terms of trade of Hungary and Poland, and for terms of trade of the Slovak Republic; IFS for consumption per GDP of Romania and the Slovak Republic, and for quarterly consumption per GDP in Hungary and Poland. Quarterly national accounts data have been seasonally adjusted.

b) OECD country data

Source of all the data necessary to construct US and German real interest rates: IMF (IFS); exception: Bundesbank data for west German CPI.

Source of the raw materials price index: BIS, which receives it from HWWA. Source of the US producer price index: IMF (IFS).

The countries chosen for constructing OECD trade partner series, which correspond to the transition country series, are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Mexico, the Netherlands, New Zealand, Norway, Portugal, South Korea, Spain, Sweden, Switzerland (in quarterly data), Turkey, the UK and the USA.

Source of employment data: OECD, Quarterly Labour Force Statistics; exceptions: the data for Belgium, Denmark and the Netherlands have been taken from ECB, ESA95 National Accounts and those for Mexico and Turkey from ILO. The ILO data are annual and have been interpolated to obtain quarterly data.

Source of national accounts data: OECD, Quarterly National Accounts; exceptions: sectoral real gross value added is taken from the Cabinet Office, Economics and Social Research Institute, Department of National Accounts for Japan, from ECB, ESA95 National Accounts for the UK, and from U.S. Department of Commerce, Bureau of Economic Analysis for the USA.

The quarterly national accounts data of Austria, Mexico, Turkey, and the quarterly employment data of Korea are provided only seasonally unadjusted and have been seasonally adjusted by the author.

The weights, which are necessary for the aggregation of national data into one composite OECD variable, are based on the fractions of imports from each OECD country and exports into each OECD country for each transition country, which are constructed from annual IMF, Direction of Trade Statistics, data. These fractions are averaged across imports and exports, across all the transition countries, and across the years 1993 to 1999.

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