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ABSTRACT

The paper explores the effect of productivity convergence on the catch-up of price levels. A simple model is presented to extend the Harrod-Balassa-Samuelson theory to more than two products. The theory is tested on a panel database of relative price levels of 34 commodity groups in 29 European countries over ten years. The predictions of the model are partially supported by evidence. Controlling for the endogeneity of productivity removes substantial bias from the estimations. Estimated parameters are used for a simple projection of price convergence. If productivity trends of the last ten years continue, prices in Central European countries will catch up to the German level very slowly if driven only by real convergence. Excess inflation due to productivity growth is between 0.5-1.5% per year. The Harrod-Balassa-Samuelson effect is even smaller, not exceeding 1% for any country.

JEL codes: E31, F15, F36, O47

Keywords: Harrod-Balassa-Samuelson model, relative prices, inflation, real convergence, Central Eastern Europe

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1. Introduction

The process of price convergence is an important phenomenon in the enlarged European Union. Large differences in price levels are present between old and new member states (see Table 1 where Turkey is also included). However, a number of factors are driving prices in new member states upwards. The causes and the persistence of such price level differentials can have serious policy consequences. A fast adjustment of prices can cause high inflation and exchange rate appreciation. This can make the fulfilment of the Maastricht criteria difficult for new EU members wanting to introduce the euro. Moreover, a ‘one-size-fits-all’ monetary policy would also become unfeasible in an enlarged euro-area. On the other hand, if prices converge slowly then wage convergence is also likely to be slower. This should encourage further migration from the east towards the west, piling up social pressures in both old and new member states. Jobs may flow in the opposite directions as western companies take advantage of cheaper labour.

Table 1: Price level of household consumption basket (Germany=100)

	1995	2005
Czech Republic	34.1	56.0
Estonia	35.1	61.7
Hungary	36.4	60.6
Latvia	31.7	53.8
Lithuania	25.4	51.9
Poland	38.5	58.0
Romania	38.7[a]	51.1
Slovakia	32.9	54.4
Slovenia	63.3	72.2
Turkey	41.7	65.3

Note: [a] 1998

The process of price level convergence can be modelled in many ways. The theory of the Law of One Price (LOOP) – stating that prices of tradable products are equal everywhere if measured in a common currency – is a natural starting point. In practice deviations from the LOOP can be large. Transport costs, taxes, incomplete exchange rate pass-through and pricing-to-market practices are some of the main reasons. In the context of “emerging” Central Eastern Europe other explanations of international productivity and income differences arise. The most prominent idea, the Harrod-Balassa-Samuelson hypothesis predicts that non-tradable prices rise in poorer countries as the productivity of their tradable sector increases relative to richer countries. Other studies point to the role of relative factor endowments, demand-side effects and regulated prices.

The empirical literature on price convergence in Europe is very rich. In the context of Eastern European transition countries the HBS hypothesis has dominated thinking. It was first established in the early 1990s that the HBS effect explains a significant part of the real exchange rate appreciation experienced in Central Eastern Europe. As theories and methodologies have become more sophisticated in recent years, the estimated HBS effect has been found much smaller. A common feature of almost all studies on Central Eastern Europe is their macro approach: they usually examine real exchange rate or aggregate price level developments. Much less research has been done on the micro scale, utilising individual product price data. Such approaches have already been applied to examine the effects of the single market or the euro on price convergence in Western Europe. An exception is the study of Čihák and Holub (2003). They assessed not just the significance of the HBS effect in the enlarged European Union, but also the effect of productivity on the prices of 30 commodity groups. They found that the elasticity of prices on GDP per head (a proxy for productivity) was between 0.4-0.9%. Based on these estimates they calculated that it might take 10-25 years for prices in Eastern Europe to converge to the least developed Western European countries.

This paper continues the research of Čihák and Holub by expanding their calculations. The most important modification is the treatment of non-tradable productivity. A simple theoretical model is introduced, where labour is used to produce tradable and non-tradable intermediate products with a linear technology. These intermediary products are then combined into final consumer products, allowing for substitution between inputs. This model suggests that tradable productivity growth increases prices as in the HBS framework. But non-tradable productivity growth decreases prices if wages equalise across sectors. The theory is tested on an unbalanced panel dataset of 34 commodity groups in 29 European countries across 10 years. By explicitly taking into account the role of non-tradable productivity as well as various sources of endogeneity in the relationship of productivity and prices (including business cycle effects, government intervention and other non-specified forms of cross-country heterogeneity), the estimates of Čihák and Holub are refined.

The predictions of the proposed theory are partially supported by evidence. However, the hypothesis of wage equalisation across the tradable and non-tradable sectors can be contested. The introduction of control variables alters results significantly. The estimated model is also used for a simple forecast of price level convergence in Central Europe. If productivity trends of the last ten years continue, prices in Central European countries will catch up to the German level very slowly (if driven only by real convergence), causing 0.5-1.5% extra annual inflation in the process. The HBS effect is even smaller, causing between 0.1-1% excess inflation according to various estimation methods. It suggests that real convergence is no threat to price stability and to the fulfilment of the Maastricht inflation criterion. Price level convergence in Central Eastern Europe needs other explanations, which can include demand factors, pricing to local markets and regulated price increases.

2. Theory and empirical evidence

A natural starting point for the theory behind price level convergence is the Law of One Price (LOOP). This theory states that the before-tax price of any commodity calculated in the same currency should be equal everywhere provided there are no transaction costs. The LOOP is the building block of the Purchasing Power Parity (PPP) theory pioneered by Cassel (1916a, 1916b, 1918), which implies that the exchange rate equals the relative price level of two countries (absolute PPP), or at least exchange rate movements equal changes in the relative price level (relative PPP).

In reality large-scale and persistent deviations from the LOOP are apparent. Besides local taxes and transportation costs, incomplete exchange rate pass-through and pricing-to-market are understood to cause these deviations. Incomplete exchange rate pass-through means that changes in the exchange rate do not alter domestic prices one-for-one. Pricing-to-market occurs when companies apply international price discrimination, absorbing the effects of exchange rate movements and letting their mark-ups change in order to stabilise their prices (see Rogoff, 1996 or Goldberg and Knetter, 1997 for further details).

Convergence of price levels can be a result of a number of factors. International integration, the argument goes, reduces trade barriers, and in case of a currency union fosters price transparency. These in turn make goods arbitrage easier, hence international prices converge. This process can take place for tradable goods, but price convergence can and does occur for non-tradable goods as well. Perhaps the Harrod-Balassa-Samuelson (HBS) effect is cited most often to explain convergence of non-tradable prices. The theory links nominal (price) convergence to real convergence: faster productivity growth of less developed countries drives up their non-tradable prices provided that tradable prices tend to equalise among countries (see Harrod, 1933, Balassa, 1964 and Samuelson, 1964).

The most prominent alternatives to the HBS theory include explanations based on relative factor endowments, demand factors and regulated prices. As Bhagwati (1984), Kravis and Lipsey (1983) argue, higher labour productivity of richer countries is a consequence of their higher capital-to-labour ratio. However, the relative abundance of capital also implies higher wages; therefore prices of labour-intensive goods and services will also be higher. Bergstrand (1991) offers another mechanism for price level convergence: differences in preferences (affecting consumer demand for luxury goods) can generate price level deviations. Regulated prices are especially important in the new eastern members of the European Union. In these countries state subsidies persist in many industries and services, especially public utilities, driving the prices of these goods (electricity, heating, transport, etc.) under their true costs. The abolishment of subsidies – enforced by the liberalisation of public utilities – results in rapid increases in price levels (Égert, 2002).

This paper is linked to two broad strands of the empirical literature that deals with price convergence. Some studies test the LOOP and estimate how fast deviations diminish (e.g. Asplund and Friberg, 2001, Haskel and Wolf, 2001, Sarno et al., 2004). A similar group of papers analyses policy effects (the single European market, the adoption of the euro) on the dispersion of prices (Allington et al., 2005, Engel and Rogers, 2004, Goldberg and Verboven 2004, Lutz, 2004). Some of these papers reject the LOOP while others find evidence in favour of it. Geographical distance and initial price level differences are important determinants of the pace of convergence. Increasing trade integration and stable exchange rates in Europe throughout the 1990s fostered the convergence of prices but the launch of the euro did not seem to have significant effects according to a number of studies (Allington et al., 2005 is an exception). A common feature of these studies is that they focus on Western Europe or the United States, where initial differences between price levels of countries or states are relatively small.

The second branch of the literature focuses on aggregate price levels and tests the PPP theory. For transition economies in Central Eastern Europe the main policy question has been the appreciation of the real exchange rate and its implications for monetary and exchange rate policy. A large part of this vast literature is summarised by Égert et al. (2006). Up to 7% annual real appreciation was attributed to the HBS effect by initial studies in the 1990s; as methodologies developed and longer data series became available, newer estimates put the HBS effect at 0-1% (but certainly not more than 2%) in Central Europe.

This paper uses the methodology and data of the first group of papers (panel estimation of commodity-level data) to answer questions asked by the second group of papers (what causes real appreciation in Central Eastern Europe). The only similar paper to the author's knowledge is the study of Čihák and Holub (2003). They focused on the total effect of productivity levels on price levels. Therefore their approach is broader than the HBS effect. They also regressed productivity levels against the prices of 30 commodity groups on panel data for the enlarged European Union. They found that the elasticity of prices on GDP per head (a proxy for productivity) was between 0.4-0.9%. Based on these estimates they calculated that it might take 10-25 years for prices in Eastern Europe to converge to the least developed Western European countries. This paper continues their calculations by separating the effects of tradable and non-tradable productivity growth and by taking into account the endogeneity of productivity in the regressions.

3. Methodology

This paper estimates the impact of productivity on price levels for many commodity groups. From a theoretic point of view, such estimation can be regarded as an empirical testing of the HBS hypothesis with more than two types of products. The applied econometric model takes into account the endogeneity of productivity and allows for alternative explanations beside the HBS framework.

The theoretical model underlying the estimation was taken from Holub and Čihák (2003). It also resembles the model utilised by Crucini et al. (2005). Consider a two-stage model of production. In the first stage, tradable and non-tradable intermediary products are created using labour as the only input. The LOOP holds for tradable goods; for simplicity, the price of the tradable good is fixed at unity. All markets are competitive, so prices equal marginal costs. Labour is immobile across countries, therefore wages in the tradable and non-tradable sectors equalise. The production technology for all sectors and countries is

$$X_j = A_j L_j \tag{1}$$

where *j = T, N* stand for tradable and non-tradable, and variables of foreign countries will be denoted with asterisks. Wages in the tradable sector equal the marginal product of labour employed here:

$$w = A_T \tag{2}$$

This determines the price of the non-tradable product:

$$P_N = \frac{w}{A_N} = \frac{A_T}{A_N} \tag{3}$$

In the second phase of production, intermediary products are assembled into various final goods and services using a Cobb-Douglas technology with constant returns to scale:

$$Y_i = X_T^{\alpha_i} X_N^{1-\alpha_i} \tag{4}$$

This convenient functional form allows substitution between tradable and non-tradable inputs, which is a reasonable assumption to some extent. If product markets are competitive, prices equal marginal costs. Assuming identical technologies across countries the relative price of the final product is:

$$\frac{P_i}{P_i^*} = \left(\frac{A_T}{A_T^*}\right)^{1-\alpha_i} \left(\frac{A_N}{A_N^*}\right)^{\alpha_i - 1} \tag{5}$$

Taking logs of both sides (and denoting the logs of original variables with lower cases) an easily estimable linear expression emerges:

$$p_i - p_i^* = (1-\alpha_i)\left(a_T - a_T^*\right) + \left(\alpha_i - 1\right)\left(a_N - a_N^*\right) \tag{6}$$

Relative product prices depend on three factors: relative productivities in the tradable and non-tradable (intermediate) sectors and their shares in the production of the final good. How do productivity changes affect prices? A rise in tradable productivity raises wages; therefore the (domestic) relative price of non-tradables (against tradables) increases. Dearer non-tradable inputs are substituted with more tradables, but this cannot offset non-tradable price increases. In the end, the (international) relative price of final goods will rise. This effect is fully captured by the first term on the right-hand side of (6). A rise in non-tradable productivity pushes down non-tradable prices. More non-tradable inputs will be used to produce final goods, and their price will decline. This effect is measured by the second term of (6). Note that this is a result of the assumption that wages equalise across sectors. Because wages in the non-tradable sector are set independent of non-tradable productivity, rising marginal products need not increase wages therefore prices can decline. If non-tradable productivity has any influence on non-tradable wages then rising non-tradable productivity can increase prices.

In the empirical estimation the parameters of relevance are the partial effects of tradable and non-tradable productivities on prices (E stands for expected value):

$$PE_i^T = \frac{\partial E\left[\left(p_i - p_i^*\right) \middle| \left(a_T - a_T^*\right), \left(a_N - a_N^*\right), X\right]}{\partial\left(a_T - a_T^*\right)} \quad (7)$$

$$PE_i^N = \frac{\partial E\left[\left(p_i - p_i^*\right) \middle| \left(a_T - a_T^*\right), \left(a_N - a_N^*\right), X\right]}{\partial\left(a_N - a_N^*\right)} \quad (8)$$

The simple theoretical model considered above suggests that (7) is positive and (8) is negative. MacDonald and Ricci (2002) consider a model with a variety of imperfectly substitutable tradable goods. They show that a rise in tradable productivity has a direct negative effect on the real exchange rate (in the setup of this paper, the price of the final product). This is a potential explanation if (7) turns out to be negative. Positive values of (8) can in particular signal that wages do not equalise across sectors. The partial effect of tradable productivity captures the HBS effect for individual products. It measures how much a catch-up of tradable productivity to a more developed country affects the relative price of product i, holding non-tradable productivities constant.

Since productivity is endogenous, control variables in vector X are added to the equation. In this analysis three control variables are considered to proxy unobserved effects that simultaneously influence productivity and prices. Distorting economic policies (variable IEF) affect both productivity and prices in many ways. For example, barriers to trade shelter the domestic sector from external competition, undermining productivity while pushing up domestic prices. Higher corporate taxes discourage productivity-enhancing investments while increasing prices if taxes are passed on to the consumer. Product market regulations are likewise detrimental for investments while the lack of productivity increases and insufficient competition increases prices. Rigid labour market regulations can lead to lower productivity if they prevent firms from investing and innovating. A second source of biases is the business cycle, because productivity and prices are both pro-cyclical (variable GAP). Third, various kinds of cross-country heterogeneity can lead to biased estimations. These include the effects of different capital-labour ratios and differences in consumer preferences among other factors.

The estimated model is a panel with country fixed effects:

$$p_{i,j,t} - p_{i,t}^* = \mu_j + \beta_1\left(a_{T,j,t} - a_{T,j,t}^*\right) + \beta_2\left(a_{N,j,t} - a_{N,j,t}^*\right) + \beta_3 GAP_{j,t} + \beta_4 IEF_{j,t} + u_{i,j,t} \quad (9)$$

where i, j and t are the product, country and time indices respectively. The partial effects in question are β1 and β2. The estimation method is GLS with cross-country weights to allow for heteroskedasticity.

The persistence of price data needs further consideration. Panel unit root tests indicate the nonstationarity of price levels. One way to get around this problem is to assume a priori the stationarity of time series. There are two good reasons for doing this. First, the time series are short and therefore unit root tests may give misleading results. Second, one can rely on previous empirical results (e.g. Asplund and Friberg, 2001, Haskel and Wolf, 2001, Sarno et al., 2004) and simply assume that the LOOP holds (i.e. the price series are stationary). Another, more general solution is to use the first-difference (FD) method instead of the fixed-effects (FE) regression. They are asymptotically equivalent but differencing is preferable with highly persistent data. In this paper both fixed-effects and first-difference estimation results are reported.

4. Data

Most data were obtained online from Eurostat and the AMECO database of the Directorate General for Economic and Financial Affairs of the European Union. Comparative price levels for 34 product groups of individual final consumption for the EU25 countries as well as Romania, Turkey, Iceland and Norway were used in this paper, all retrieved from the website of Eurostat. These relative prices are available for individual years (usually 2003). Relative price levels were deflated with annual harmonised consumer price indices for each product group for years 1996-2005. Germany was chosen as reference country; all values were expressed as the natural logarithms of price levels relative to the German level.

Similar data were used by a number of studies including Allington et al. (2005) as well as Sosvilla-Rivero and Gil-Pareja (2004). The advantage of this dataset is its representative nature: a great variety of goods and services is examined across a relatively wide range of time and space. The key disadvantage is information lost by aggregation, and the bias stemming from substitution effects in consumption baskets.

Labour productivity was defined as log of the gross value added at constant ECU/euro prices divided by the number of employed persons, relative to the German productivity level. The tradable sector consisted of agriculture and industry while the non-tradable sector included building and construction, and services. Business cycle effects were approximated by a simple measure of output gap. A trend GDP was estimated by a Hodrick-Prescott filter from available series of constant price GDP; the deviation of actual GDP from this trend (in percentages) was utilised. Government intervention was measured by the Index of Economic Freedom of Heritage Foundation. It is a simple average of ten factors: trade barriers, tax burden, government ownership of enterprises, monetary policy, banking and finance regulations, intervention into wages and prices, quality of judiciary, red tape and the informal economy. Smaller values of the index mean more economic freedom. While some factors may be more important than others in this analysis, the aggregate index was used as a simple and convenient proxy.

5. Estimation results

Detailed tables of results are provided in the annex. A simple regression of tradable and non-tradable productivities on product prices is highly significant. Adjusted R-squared values usually exceed 0.8. The parameter of tradable productivity is significant at 1% in 26 equations; at 10% two more parameters become significant. Their sign is positive in all but two cases. Their values range from -0.009 to 0.511, but most parameters are between 0 and 0.2. Non-tradable productivities are significant in 23 equations at 1% and in one more at 10%. They are positive in 26 cases; individual values are between -0.215 and 0.765. It suggests that the hypothesis of wage equalisation between sectors may be false. Furthermore, high Durbin-Watson statistics suggest the presence of autocorrelation.

The inclusion of control variables and country effects changes results considerably. Both the FE and FD regressions are significant according to the F-test. The FE estimation performs much better in explanatory power and the significance of parameters. The adjusted R-squared is generally above 0.98 but again, autocorrelation cannot be ruled out. The parameter of productivity is significant at 1% in 17 equations out of 34 and significant in 10% in further six cases. It has the correct (positive) sign in 23 equations; its magnitude varies greatly, from –0.106 to 1.124. Non-tradable productivity is significant at 1% in 12 regressions; at 10% six more are significant. It is negative (as the simple theoretical model suggests) in just ten equations. The lowest value is –0.329 and the maximum is 0.637. Overall, estimations confirm the theoretical predictions about the signs of coefficients in only eight commodity groups. The hypothesis that the sum of the two productivity coefficients is zero finds support in 16 cases out of 34.

Output gap is significant at 10% in 19 equations while the index of economic freedom in 31 cases. The coefficient of output gap takes positive and negative signs in almost equal proportions; its absolute values are typically in the order of 0.001 to 0.01. It means that an output gap of 1% results in 0.1-1% lower (or higher) prices controlling for productivity developments. The economic freedom variable has negative coefficients in all equations but one. In other words, more economic freedom leads to higher prices if differences in productivity levels are accounted for. A possible explanation is that regulated prices (for example energy, other utilities and transport) are kept artificially low where state interference is high, reducing production costs for a wide range of products.

In the FD regressions adjusted R-squared is usually in the order of 0.05 to 0.2. FD estimation appears less efficient than FE. Productivity is significant at 10% in 20 cases; non-tradable productivity in 15 cases, output gap 11 times and economic freedom in 13 regressions. The FD regressions show marginally more support for the theoretical model. The signs of the productivity parameters are correct in nine equations. If both FE and FD are unbiased, then we can treat them as upper and lower bounds of the actual parameter values. The range between FE and FD values can be as much as 0.2.

The sign of the bias caused by the endogeneity of productivity is ambiguous: the inclusion of control variables increases both FE and FD partial effects of tradable productivity in ten equations and reduces both of them in 16 cases. The partial effects increase for some foodstuffs and non-tradable services (including utilities, health, recreation and culture, education as well as restaurants and hotels). They decrease for other foodstuffs, alcohol and tobacco and some tradable goods like clothing, furniture and similar items. The case of non-tradable productivity is clearer: control variables increase its partial effect in only eight cases but decreases them in 24 equations. The initial bias appears to be larger in the case of non-tradable productivity. A plausible explanation is that government intervention, the business cycle and country-specific factors has more influence on the typically non-tradable services sector than on tradables.

6. A simple projection of price convergence

The estimates for the sensitivity of relative prices to relative productivity levels can be used to project the path of prices as productivities of new EU members converge to Western European levels. Between 1996-2005 the annual tradable productivity growth differential between these countries and Germany (the reference country of this analysis) was between 1.9-5.6%. Only Romania and Turkey experienced some divergence during this period due to economic crises. Non-tradable productivity growth differential during the same period varied between 0-6.2%. The first two columns of Table 2 summarise productivity developments in new EU members and Turkey. Elasticities of aggregate price levels to total and non-tradable productivity were constructed using the 12 one-digit COICOP consumption categories. Then productivity data were used for a simple projection of price level convergence.

Two measures of price convergence are calculated: inflation differential against a reference country, Germany, and the number of years needed to reach the German price level. With constant exchange rates and fixed consumption baskets (w_i share for product i) over time the inflation differential expressed in a common currency is

$$\pi_t - \pi_t^* = \frac{\sum_i w_i p_{i,t}}{\sum_i w_i p_{i,t-1}} - \frac{\sum_i w_i^* p_{i,t}^*}{\sum_i w_i^* p_{i,t-1}^*} = \sum_i \left(w_i \frac{p_{i,t} / p_{i,t}^*}{p_{i,t-1} / p_{i,t-1}^*} - w_i^* \right) \frac{p_{i,t-1}^*}{p_{i,t}^*} \tag{10}$$

For simplicity the German inflation rate will be set to zero. Relative price levels are functions of relative productivity levels; substituting the estimated partial effects into (10) yields

$$\pi_t - \pi_t^* = \sum_i w_i \left(1 + g_T \frac{a_{T,t} / a_{T,t}^*}{a_{T,t-1} / a_{T,t-1}^*}\right)^{\beta_{T,i}} \left(1 + g_N \frac{a_{N,t} / a_{N,t}^*}{a_{N,t-1} / a_{N,t-1}^*}\right)^{\beta_{N,i}} - 1 \tag{11}$$

The catch-up period for complete price convergence is

$$CP = -\frac{\log \sum_i w_i p_i - \log \sum_i w_i^* p_i^*}{\log\left(\pi - \pi^*\right)} \tag{12}$$

These measures can be calculated by considering both tradable and non-tradable productivity growth or by focusing on tradable productivity. The latter will be called HBS effect because its nature is similar to the original Harrod-Balassa-Samuelson effect (which is in fact the ceteris paribus effect of growth in relative tradable productivity). The total effects of tradable and non-tradable productivity growth on price levels are reported in the remaining columns of Table 2.

Table 2: Productivity and price level convergence

	Annual productivity growth 1995-2005 (%)		Inflation differential due to productivity growth (%)			Years to reach German price level based on productivity growth		
	Tradable	Non-tradable	No controls	FE	FD	No controls	FE	FD
Czech Republic	1.91	0.70	288	117	288	0.45	0.53	0.21
Estonia	5.33	6.20	49	24	49	2.35	2.04	0.98
Hungary	3.17	1.67	125	53	125	0.89	0.94	0.39
Latvia	4.19	4.78	68	33	68	1.85	1.62	0.78
Lithuania	5.60	4.55	80	36	80	1.95	1.77	0.79
Poland	4.20	1.44[a]	149	64	149	1.01	1.17	0.50
Romania	4.08[b]	2.74[b]	130	61	130	1.28	1.21	0.57
Slovakia	3.73	1.06	166	67	166	0.80	1.09	0.44
Slovenia	4.48	1.52	66	25	66	1.01	1.12	0.42
Turkey	4.08[b]	2.74[b]	85	38	85	1.30	1.24	0.56

Notes: [a] 1996-2003, [b] set equal to regional average due to lack of data

If control variables are not considered, recent trends in productivity imply that excess inflation due to productivity growth amounts to 1-2% in most countries. This means that prices will reach the German level in three decades in the Baltic countries, Slovenia and possibly Turkey. On the other hand, Hungary and Poland need at least five decades, while the Czech Republic and Slovakia around a century. If the endogeneity of productivity is taken care of, the inflation differential falls to 0.5-1.5% in most countries. As a result, the catch-up period can rise considerably. The Baltic countries, Slovenia and Turkey may need as much as 5-8 decades. The lower bound for other countries is around six decades; the upper bound may even exceed 100 years. These figures are much higher than those reported by Čihák and Holub (2003), suggesting that their estimates might have been biased.

The HBS effect alone implies an even slower process of price convergence. Excess inflation attributed to the HBS effect is very small. The FD estimation suggests 0.1-0.4% a year, while FE estimation leads to 0.4-1.1%. If only tradable productivity growth is taken into account and everything else is held constant, prices in most Central Eastern European countries will reach the German level only after a century. The front-runners are again Slovenia (with at least 33 years), the Baltic states (at least 5-6 decades) and Turkey (58 years). The upper bounds are so high for every country that they can be considered infinite. In any case, this paper confirms recent results that the HBS effect in Central Eastern Europe is small or even negligible (see Égert et al., 2006, and the references therein). The fact that the HBS effect itself implies slower convergence than tradable and non-tradable productivity together seems counter-intuitive if tradable productivity is believed to have a positive ceteris paribus effect on prices and non-tradable productivity has a negative one. However, these signs were derived under the assumption of wage equalisation across sectors: in other words, assuming that tradable productivity fully determines non-tradable wages. If this assumption fails and non-tradable productivity has any effect on non-tradable wages, the partial effect of non-tradable productivity can be positive. In this case, the HBS effect itself (as defined in this paper) will imply slower price convergence than tradable and non-tradable productivity growth together.

Table 3: The Harrod-Balassa-Samuelson effect[a]

	Inflation differential due to HBS effect (%)			Years to reach German price level based on HBS effect		
	No controls	FE	FD	No controls	FE	FD
Czech Republic	0.25	0.43	0.15	244	144	419
Estonia	0.74	1.08	0.36	65	45	135
Hungary	0.42	0.69	0.22	119	72	222
Latvia	0.52	0.90	0.29	102	59	184
Lithuania	0.73	1.13	0.36	87	56	173
Poland	0.53	0.96	0.36	139	77	207
Romania	0.44	0.87	0.29	168	85	255
Slovakia	0.43	0.91	0.32	169	80	230
Slovenia	0.60	0.84	0.25	47	33	112
Turkey	0.49	0.82	0.26	96	58	186

Note: [a] defined as the ceteris paribus effect of relative tradable productivity levels on relative price levels

Some reservations and comments are necessary. First, the assumption of fixed consumption structure is clearly unrealistic and biases the projections. For example, the prices of utilities are relatively sensitive to productivity levels, but their demand could be relatively insensitive to demand. Therefore their share in the average consumption basket should decrease as productivity (and income) grows, making price level convergence slower than reported above. Second, the process of price convergence is well known to be non-linear: the larger the initial distance, the faster the convergence. Convergence will again be slower; it may not even end in the perfect equalisation of prices (see Sarno et al., 2004, for a brief overview). As a result, price convergence can be even slower than Tables 2 and 3 suggest. Third, exchange rates need not be fixed in reality; if they are allowed to appreciate, prices expressed in a common currency can converge even without inflation. Indeed, six of the ten Eastern European countries considered have flexible exchange rates and Lithuania also has a narrow fluctuation band around its peg. However, all of them (bar Turkey) aim to introduce the euro much sooner than price convergence will have completed. Therefore stable exchange rates are a reasonable assumption in the long term. Finally, the assumption of zero inflation in the reference country (Germany) is arbitrary, but it simplifies the calculations without significantly changing the results.

The key policy implication is that fast real convergence seems to be no threat to price and exchange rate stability in most countries. Only the three Baltic economies can expect 1-2% excess inflation because high growth rates. The Maastricht inflation criterion can be fulfilled even under these conditions though. Since prices obviously converge to Western European levels faster than productivity developments should imply, other factors need to be considered. Some candidates are the changing structure of demand, pricing to local markets and rising regulated prices.

7. Conclusions

This paper analysed the elasticity of price levels to productivity on a panel database of 34 product groups and 29 countries between 1996-2005. A simple theoretical model was offered to explain the effect of productivity growth on price levels. The model suggests that tradable productivity growth leads to increasing prices while rising non-tradable productivity decreases prices. During the empirical testing control variables were included to account for deviations from the model's assumptions and account for the endogeneity of the productivity variables. These controls included output gap, government interference (proxied by Heritage Foundation's Index of Economic Freedom) and country fixed effects. As autocorrelation of data could not be ruled out, both fixed-effects and first-difference estimation methods were applied. Both estimations showed some support for the underlying theory, but non-tradable productivity turned out to increase prices ceteris paribus. It can imply that wages do not equalise across the tradable and non-tradable sectors. Since FE and FD are asymptotically equivalent methods, they can be thought of as upper and lower bounds for the actual parameter values. The estimated parameters were then used for a simple projection of price level convergence in Central Eastern Europe and Turkey. Slovenia, the Baltic countries and possibly Turkey exhibit faster convergence than the rest of the region. Even front-runners need 5-8 decades to reach German price levels if only the price effects of real convergence are considered. The rest may need over 100 years. Real appreciation caused by productivity catch-up is around 0.5-1.5%. The ceteris paribus effect of tradable productivity growth on the aggregate price level can be thought of as the Harrod-Balassa-Samuelson effect. The HBS effect itself is small or even negligible, accounting for no more than 1% of real appreciation. As a consequence, real economic convergence does not seem to threaten price or exchange rate stability. Price level convergence in Central Eastern Europe needs other explanations, which can include demand factors, pricing to local markets and regulated price increases.

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Annex: Estimation results

Notes: estimations with no controls are regressions of relative price levels on relative tradable and non-tradable productivity levels and a constant. Fixed effects regressions with controls and fixed effects include variables for the business cycle (GAP), government intervention (IEF) as well as country fixed effects. First difference regressions are carried out on differenced data and include controls for the business cycle and government intervention. Standard errors are shown under the estimated parameters in parentheses. Asterisks indicate the insignificance of estimated parameters at levels of 10 percent (*) and 1 percent (**).

Baseline and fixed effects estimation

	Baseline (no controls)		Fixed effects				
	PR_T	PR_NT	PR_T	PR_NT	GAP	IEF	Adjusted R^2 (number of observations)
Food and non-alcoholic beverages	0.068** (0.019)	0.298** (0.025)	0.087* (0.042)	0.032 (0.035)	0.003* (0.001)	-0.110** (0.023)	0.985 (214)
Food	0.054** (0.015)	0.320** (0.024)	0.132** (0.034)	0.074 (0.046)	0.001 (0.001)	-0.072** (0.017)	0.992 (201)
Bread and cereals	-0.009 (0.017)	0.469** (0.028)	0.010 (0.054)	0.119** (0.045)	0.001 (0.001)	-0.086** (0.025)	0.990 (201)
Meat	0.192** (0.017)	0.262** (0.029)	0.007 (0.055)	0.104 (0.076)	-0.001 (0.002)	-0.049** (0.018)	0.995 (201)
Fish and seafood	0.021* (0.009)	0.352** (0.013)	0.119** (0.018)	-0.146* (0.060)	0.001 (0.001)	-0.061** (0.015)	0.998 (201)
Milk, cheese and eggs	0.007 (0.024)	0.281** (0.033)	0.178** (0.046)	0.046 (0.061)	0.003** (0.001)	-0.090** (0.025)	0.977 (201)
Oils and fats	-0.066** (0.018)	0.298** (0.025)	0.360** (0.075)	-0.079 (0.101)	0.004** (0.001)	-0.010 (0.035)	0.962 (201)
Fruit	0.118** (0.023)	0.200** (0.037)	0.258** (0.052)	-0.110 (0.104)	0.003 (0.003)	-0.038** (0.014)	0.971 (201)
Vegetables	0.114** (0.021)	0.322** (0.029)	0.217* (0.119)	0.175 (0.082)	0.006 (0.004)	-0.116** (0.035)	0.981 (201)
Sugar, jam, honey, chocolate and confectionery	0.023 (0.021)	0.252** (0.020)	-0.051* (0.029)	0.356** (0.061)	0.002 (0.001)	-0.077** (0.010)	0.990 (201)
Food products n.e.c.	0.047** (0.009)	0.207** (0.016)	0.124** (0.034)	-0.035 (0.058)	0.001 (0.001)	-0.051** (0.009)	0.990 (201)
Non-alcoholic beverages	0.190** (0.011)	-0.014 (0.019)	-0.047 (0.046)	-0.227** (0.082)	0.003* (0.001)	-0.093** (0.023)	0.976 (201)
Coffee, tea and cocoa	0.052** (0.015)	0.109** (0.024)	-0.102* (0.049)	-0.254* (0.099)	0.005** (0.002)	-0.010 (0.023)	0.931 (201)
Mineral waters, soft drinks, fruit and vegetable juices	0.203** (0.026)	-0.014 (0.041)	0.097* (0.054)	-0.075 (0.080)	-0.003 (0.001)	-0.105** (0.024)	0.981 (201)
Alcoholic beverages, tobacco and narcotics	0.440** (0.042)	-0.108** (0.039)	0.126* (0.050)	-0.329* (0.168)	0.002** (0.001)	-0.173** (0.023)	0.975 (214)
Alcoholic beverages	0.297** (0.036)	-0.215** (0.042)	0.037 (0.050)	-0.134* (0.052)	0.005** (0.001)	-0.088** (0.015)	0.998 (201)

	Baseline (no controls)		Fixed effects				
	PR_T	PR_NT	PR_T	PR_NT	GAP	IEF	Adjusted R^2 (number of observations)
Tobacco	0.511** (0.047)	0.084 (0.061)	0.459** (0.141)	-0.230 (0.276)	-0.002 (0.002)	-0.089** (0.031)	0.979 (201)
Clothing and footwear	0.156** (0.029)	-0.026 (0.030)	0.031 (0.051)	0.360** (0.108)	-0.004** (0.001)	-0.136** (0.025)	0.999 (214)
Clothing	0.136** (0.024)	-0.007 (0.026)	0.047 (0.029)	0.515** (0.123)	-0.005** (0.001)	-0.083** (0.013)	0.999 (201)
Footwear incl. repair	0.072* (0.030)	0.033 (0.028)	-0.057 (0.059)	0.260** (0.074)	-0.003** (0.001)	-0.058** (0.021)	0.996 (201)
Housing, water, electricity, gas and other fuels	0.043** (0.018)	0.686** (0.038)	0.432** (0.059)	0.158** (0.060)	-0.005* (0.001)	-0.222** (0.047)	0.977 (214)
Electricity, gas and other fuels	0.281** (0.018)	0.053 (0.037)	0.561** (0.092)	0.247 (0.177)	-0.016** (0.004)	-0.019 (0.034)	0.948 (201)
Furnishings, household eq. and routine maintenance of the house	0.130** (0.008)	0.174** (0.016)	-0.015 (0.056)	0.006 (0.080)	0.000 (0.001)	-0.107** (0.026)	0.982 (214)
Furniture and furnishings	0.146** (0.004)	0.130** (0.010)	-0.106** (0.033)	0.085 (0.072)	0.001 (0.001)	-0.068** (0.011)	0.990 (201)
Carpets and other floor coverings	0.017 (0.013)	0.221** (0.020)	-0.051** (0.025)	0.179* (0.074)	-0.001 (0.001)	0.020** (0.006)	0.987 (201)
Glassware, tableware and household utensils	0.329** (0.015)	0.019 (0.015)	-0.039 (0.034)	0.096 (0.081)	-0.001** (0.001)	-0.076** (0.016)	0.998 (201)
Health	0.172** (0.010)	0.556** (0.019)	0.514** (0.100)	0.073 (0.093)	-0.008 (0.003)	-0.107* (0.045)	0.990 (214)
Transport	0.278** (0.005)	-0.001 (0.016)	0.019 (0.033)	0.366** (0.115)	-0.003** (0.001)	-0.088** (0.019)	0.978 (214)
Operation of personal transport equipment	0.153** (0.006)	-0.013 (0.016)	-0.037 (0.028)	0.637** (0.107)	-0.004** (0.001)	-0.073** (0.012)	0.973 (201)
Communications	-0.002 (0.012)	0.094* (0.041)	1.124** (0.100)	0.407* (0.226)	0.003 (0.006)	-0.255** (0.073)	0.859 (214)
Recreation and culture	0.011 (0.015)	0.421** (0.013)	0.343** (0.038)	0.072 (0.083)	-0.004* (0.002)	-0.116** (0.028)	0.987 (214)
Education	0.192** (0.012)	0.765** (0.017)	0.226** (0.032)	0.356** (0.106)	-0.008** (0.002)	-0.172** (0.028)	0.998 (210)
Restaurant and hotels	0.101** (0.008)	0.376** (0.023)	0.182** (0.055)	0.312** (0.096)	-0.003** (0.001)	-0.198** (0.037)	0.982 (214)
Misc. goods and services	0.120** (0.009)	0.401** (0.008)	0.120** (0.038)	0.341** (0.070)	-0.006** (0.001)	-0.123** (0.025)	0.982 (214)

First difference estimation

	PR_T	PR_NT	GAP	IEF	Adjusted R^2 (number of observations)
Food and non-alcoholic beverages	0.016 (0.021)	0.081 (0.056)	0.002* (0.001)	0.006 (0.012)	0.861 (190)
Food	0.054* (0.026)	0.082* (0.044)	0.001 (0.001)	0.008 (0.012)	0.934 (177)
Bread and cereals	-0.062 (0.040)	0.183** (0.058)	0.002 (0.001)	0.005 (0.007)	0.174 (177)
Meat	0.050 (0.079)	0.057 (0.068)	0.001 (0.002)	0.010 (0.013)	0.046 (177)
Fish and seafood	0.070 (0.044)	-0.106 (0.092)	0.005** (0.002)	-0.025 (0.016)	0.059 (177)
Milk, cheese and eggs	-0.014 (0.038)	0.163* (0.073)	0.003 (0.002)	0.003 (0.013)	0.056 (177)
Oils and fats	-0.018 (0.086)	0.097 (0.143)	0.004 (0.003)	0.045* (0.022)	0.187 (177)
Fruit	0.197* (0.115)	-0.142 (0.123)	-0.004* (0.002)	-0.005 (0.023)	0.040 (177)
Vegetables	0.232* (0.104)	0.018 (0.161)	-0.004 (0.003)	0.055** (0.020)	0.083 (177)
Sugar, jam, honey, chocolate and confectionery	-0.074** (0.024)	0.230** (0.052)	0.002 (0.001)	0.002 (0.007)	0.282 (177)
Food products n.e.c.	0.024 (0.027)	-0.041 (0.070)	0.000 (0.001)	-0.006 (0.012)	0.025 (177)
Non-alcoholic beverages	0.018 (0.037)	-0.166** (0.064)	0.003* (0.002)	-0.008 (0.018)	0.052 (177)
Coffee, tea and cocoa	0.099 (0.063)	-0.289** (0.088)	0.003 (0.003)	0.033 (0.022)	0.028 (177)
Mineral waters, soft drinks, fruit and vegetable juices	0.045 (0.032)	-0.003 (0.092)	-0.001 (0.001)	-0.013 (0.018)	-0.004 (177)
Alcoholic beverages, tobacco and narcotics	0.158* (0.077)	-0.253 (0.188)	0.002 (0.001)	-0.060** (0.026)	0.055 (190)
Alcoholic beverages	-0.011 (0.033)	-0.117 (0.097)	0.003** (0.001)	-0.020** (0.008)	0.162 (177)
Tobacco	0.312* (0.136)	-0.239 (0.250)	0.001 (0.002)	-0.085* (0.047)	0.064 (177)
Clothing and footwear	-0.071* (0.041)	0.213* (0.108)	-0.003** (0.001)	-0.027* (0.011)	0.084 (190)
Clothing	-0.023 (0.041)	0.226* (0.091)	-0.003** (0.001)	-0.025* (0.010)	0.053 (177)
Footwear incl. repair	-0.189** (0.043)	0.265** (0.082)	-0.001* (0.001)	-0.011 (0.015)	0.108 (177)
Housing, water, electricity, gas and other fuels	0.186** (0.033)	0.200** (0.076)	-0.003* (0.001)	-0.017* (0.010)	-0.047 (190)
Electricity, gas and other fuels	0.337** (0.082)	0.240 (0.185)	-0.002 (0.004)	-0.008 (0.015)	0.088 (177)

	PR_T	PR_NT	GAP	IEF	Adjusted R^2 (number of observations)
Furnishings, household eq. and routine maintenance of the house	-0.095** (0.016)	-0.015 (0.025)	0.000 (0.000)	0.000 (0.004)	0.477 (190)
Furniture and furnishings	-0.096** (0.026)	-0.042 (0.047)	0.001* (0.000)	-0.003 (0.006)	0.227 (177)
Carpets and other floor coverings	-0.071** (0.021)	0.120* (0.061)	0.001 (0.001)	0.006 (0.004)	0.051 (177)
Glassware, tableware and household utensils	-0.064* (0.030)	-0.031 (0.029)	0.000 (0.001)	-0.007 (0.006)	0.172 (177)
Health	0.249* (0.108)	-0.107 (0.270)	-0.002 (0.003)	-0.131* (0.074)	0.101 (190)
Transport	-0.010 (0.038)	0.243** (0.069)	0.000 (0.001)	-0.016* (0.007)	-0.030 (190)
Operation of personal transport equipment	-0.098* (0.047)	0.426** (0.153)	0.002 (0.002)	0.006 (0.012)	0.082 (177)
Communications	0.399** (0.136)	0.125 (0.267)	0.009 (0.006)	-0.087* (0.043)	0.028 (190)
Recreation and culture	0.082** (0.031)	0.072 (0.099)	-0.002 (0.002)	0.002 (0.009)	-0.067 (190)
Education	0.070* (0.036)	0.211** (0.080)	-0.003 (0.002)	-0.034* (0.016)	0.051 (186)
Restaurant and hotels	0.008 (0.027)	0.214* (0.083)	-0.001 (0.001)	-0.031** (0.009)	0.107 (190)
Misc. goods and services	0.084* (0.037)	0.073 (0.086)	-0.003** (0.001)	-0.006 (0.006)	0.162 (190)