The Effect of Labor Productivity on Real Exchange Rate: Evidence from Czech Republic, Hungary, Poland and Slovakia[1]

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Abstract

The paper builds on an intertemporal model of an open economy to formulate the hypothesis of the dependance of real exchange rate on labor productivity. The model is formulated under those assumption on which the Balassa-Samuelson theorem rests. The hypothesis is tested using cointegration technique and vector error correction model. Usually testing the Balassa-Samuelson effect gives mixed results, sometimes finding the opposite reaction of the real exchange rate to the one predicted by the Balassa-Samuelson theorem, pointing to the restrictive nature of the assumptions on which it is based. The analysis shows a little supportive evidence for the Balassa-Samuelson effect. However, according to the analysis the effect of labor productivity on the real exchange rate can hardly be considered as clear-cut as predicted by the Balassa-Samuelson theorem.

Keywords: *Balassa-Samuelson effect, cointegration, intertemporal model, VECM*

JEL Classification: C32, F31, F41

Introduction

The paper derives and tests one of the widely discussed hypothesis of real exchange rate determination – the Balassa-Samuelson effect. The developing economies usually find their real exchange rates appreciating during the convergence process toward the more developed benchmarks and one of the leading hypothesis is that the real exchange rate appreciation is driven by the rising labor productivity in the sector of tradable goods. Being a small open economy with return on capital fixed to the given international interest rate and under the assumption of capital and labor mobility (or wage rate adaptability among the

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tradable and nontradable sectors), the rise in labor productivity in the tradable sector gives rise to the price of nontradable goods and thus appreciating the real exchange rate (Balassa, 1964; Samuelson, 1964).

The empirical results on the Balassa-Samuelson effect are rather mixed. In some studies, for a survey Taylor and Taylor (2004), the effect seems to play a role in real exchange rate determination while in some cases, the effect of a change in productivity in the traded sector seems to be the opposite (Devereux, 1999).

Clearly, the relationship between labor productivity and the real exchange rate is much more complex than the theorem suggests. The wage rates in the traded and nontraded sectors are not perfectly adaptable to each other, firms use pricing-to-market techniques, terms of trade may change.

The paper focuses on the analysis of the impact of labor productivity on the real exchange rate in the Czech Republic, Hungary, Poland and Slovakia, i.e. the most developed non-euro (which holds for Slovakia in most of the sample too) countries in the region.

The hypothesis of the impact of labor productivity on the real exchange rate in the fashion of the Balassa-Samuelson effect is tested using the cointegration technique which enables to detect long-run linear relationship between variables integrated of the same order. The technique is convenient for use, however, one of its main drawbacks is that it assumes a linear relationships among variables while the real adjustment can be highly nonlinear. Nonlinear dynamics for the Balassa-Samuelson effect is estimated by Sager (2006) who uses smooth threshold autoregressive models. In addition to this one must take account of the fact that the series at disposal are not very long. This is true especially in the case of Poland where the author did not manage to obtain particular series beyond 2001.

The paper falls into four parts. In the first part the hypothesis is formulated within an intertemporal two sector model of a small open economy which makes use of the assumptions on which the Balassa-Samueslon theorem is built. The part ends with the formulation of the empirical hypothesis. The second part presents the data used in the analysis. The results of the analysis are given in the fourth part where the outcome is broadly compared with some of the earlier results obtained in this area. Fifth part reports the main conclusions drawn from the analysis.

The contribution of the paper is twofold. First it presents derivation of Balassa-Samuelson hypothesis in a complete dynamic intertemporal setting and directly tests its main implication for the behavior of real exchange rate. Second it presents evidence for each of the countries as it uses methods of time series analysis and not panel methods as most of the papers concerned with these countries did (due to extremely short series at that time).

1. Model

The impact of labor productivity on the real exchange rate will be recovered within the representative agent model of a small open economy under perfect capital mobility in continuous time under similar assumptions to those of the Balassa-Samuelson hypothesis. The model is developed in the fashion of Turnovsky (1997). A representative household and representative firm will be dealt with separately.

More traditionally the Balassa-Samuelson hypothesis has been derived only as a result of a static optimization of the supply side of the economy. In the end this holds in this framework as well, but apart from the traditional approach the behavior of all the basic agents is specified and the model is derived within a generally more relevant intertemporal framework. All in all the fact that Balassa-Samuelson hypothesis is a supply side phenomenon is even more obvious in this setting.

The representative household is assumed to consume private goods C, public goods G, derive direct utility from holding money m and derive utility from free time expressed as disutility from labor L. The inclusion of government consumption in the utility function may seem somewhat extreme, but the key results will be unaffected by this approach. The intertemporal utility function of the representative household will be expressed:

$$\int_0^\infty e^{-\beta t} U\left(C, G, m, L\right) dt \tag{1}$$

where

β − rate of time preference and is assumed to be constant.

The following holds:

$$\frac{\partial U}{\partial C} > 0, \frac{\partial^2 U}{\partial C^2} < 0\,; \frac{\partial U}{\partial G} > 0, \frac{\partial^2 U}{\partial G^2} < 0\,; \frac{\partial U}{\partial m} > 0, \frac{\partial^2 U}{\partial m^2} < 0\,; \frac{\partial U}{\partial L} < 0, \frac{\partial^2 U}{\partial L^2} < 0$$

The private consumption of the representative household may be divided into two different private goods: traded and nontraded C_T, C_N, respectively. The total consumption is a function of consumption of these two goods:

$$C = c\left(C_T, C_N\right)$$

No special form is imposed on the composite consumption function here as it would add little effect regarding the way the hypothesis will be formulated. The representative household faces an intertemporal budget constraint. His resources come primarily from the labor income determined by the amount of labor supplied and the wage rate w. The production of the consumption goods is carried out via neoclassical production functions:

$$\begin{aligned} Y_T &= F\left(K_T, L_T\right) \\ Y_N &= Z\left(K_N, L_N\right) \end{aligned} \qquad (2)$$

where

Y − output,

K − capital.

The total amount of labor and capital is divided into traded and nontraded sector:

$$\begin{aligned} L &= L_T + L_N \\ K &= K_T + K_N \end{aligned}$$

Another source of income of the agent is the return on tradable bonds, b, whose value is denominated in the foreign currency. The following holds:

$$b = \frac{EB}{P}$$

where

E − the nominal exchange rate (amount of domestic currency per unit of foreign currency),

B − the value of bonds in foreign currency and P is the domestic price level.

The return on traded bonds is given by foreign interest rate cleared of foreign expected inflation rate:

$$IR^* - \pi^{*e}$$

The income is used for consumption of both traded and nontraded goods. Regarding the relative prices of traded and nontraded goods, the expenses will be expressed as:

$$\frac{P_T}{P} C_T + \frac{P_N}{P} C_N$$

Assuming nonzero expected domestic inflation rate, the households's wealth is reduced by a friction of the money they hold due to lost value resulting from nonzero expected inflation rate:

$$\pi^e m$$

The household receives transfers from the government and pays lump-sum taxes. Net lump-sum taxes, T, are assumed to be negative and thus lowering the income.

The difference between income and expenses may be allocated to the stock of money or traded bonds. The intertemporal budget constraint for the representative household will be stated as:

$$\dot{m}+\dot{b}=wL+\left(IR^{*}-\pi^{*e}\right)b-\frac{P_T}{P}C_T-\frac{P_N}{P}C_N-\pi^{e}m-T \tag{3}$$

The representative household chooses private consumption, money holdings, amount of labor services they will supply and bond accumulation. Initial value of money and bond is given for the starting period. The Hamiltonian for the optimization problem of the representative household is:

$$H\equiv e^{-\beta t}U\left(C,G,m,L\right)+\lambda e^{-\beta t}\begin{bmatrix} wL+\left(IR^{*}-\pi^{*e}\right)b-\frac{P_T}{P}C_T-\frac{P_N}{P}C_N- \\ -\pi^{e}m-T-\dot{m}-\dot{b} \end{bmatrix} \tag{4}$$

where

λ − the shadow value of wealth in terms of traded bonds.

The first order conditions for choice variables are:

$$\frac{\partial H}{\partial C_T}=\frac{\partial U}{\partial C}\frac{\partial C}{\partial C_T}-\lambda\frac{P_T}{P}=0 \tag{5a}$$

$$\frac{\partial H}{\partial C_N}=\frac{\partial U}{\partial C}\frac{\partial C}{\partial C_N}-\lambda\frac{P_N}{P}=0 \tag{5b}$$

$$\frac{\partial H}{\partial m}=\frac{\partial U}{\partial m}-\lambda\pi^{e}-\lambda\beta=-\dot{\lambda} \tag{5c}$$

$$\frac{\partial H}{\partial L_T}=\frac{\partial U}{\partial L_T}+\lambda w=0 \tag{5d}$$

$$\frac{\partial H}{\partial L_N}=\frac{\partial U}{\partial L_N}+\lambda w=0 \tag{5e}$$

The first order conditions for state variables are:

$$\frac{\partial H}{\partial b}=\lambda\left(IR^{*}-\pi^{*e}\right)-\lambda\beta=-\dot{\lambda} \tag{6}$$

The condition in the form of the budget constraint is not stated. The transversality conditions must hold:

$$\lim_{t\to\infty}\lambda e^{-\beta t}m=0 \tag{7a}$$

$$\lim_{t\to\infty}\lambda e^{-\beta t}b=0 \tag{7b}$$

Conditions (5a) and (5b) equate marginal utility from consumption of private goods with relative prices. Condition (5c) states that in the optimum the marginal utility from money holdings must equal the marginal costs of the money holdings. Conditions (5d) and (5e) state that the disutility from increased labor services must equal the relative value of the marginal product of labor.

Condition (6) is the arbitrage condition. It states that in equilibrium (marginal utility of wealth, λ, is constant), the rate of return on consumption must equal the return on traded bonds.

Let's turn the attention to the production sector of the economy. The representative firm's objective function can be expressed:

$$\Pi = e^{-r^{*}t}\int_{0}^{\infty}\left[\frac{P_T}{P}F\left(K_T,L_T\right)+\frac{P_N}{P}Z\left(K_N,L_N\right)-w\left(L_T+L_N\right)-IC\left(I_T\right)-IC\left(I_N\right)\right]dt \quad (8)$$

where

- Π − current value of all future profits discounted at the market real rate of interest r^*, which for a small open economy is equal to the world (foreign) real interest rate,
- $IC(I_{K/N})$ − installation costs associated with putting new capital (current investment) into production.

The function is assumed to be strictly positive and convex in investment and the same in both sectors. In additon the accumulation equation must be met:

$$\dot{K}_T+\dot{K}_N=I_T+I_N \quad (9)$$

The firm's optimization problem is to choose investment and labor to maximize (8) subject to (9), hence the Hamiltonian for this problem is:

$$H \equiv e^{-r^{*}t}\left[\frac{P_T}{P}F\left(K_T,L_T\right)+\frac{P_N}{P}Z\left(K_N,L_N\right)-w\left(L_T+L_N\right)-IC\left(I_T\right)-IC\left(I_N\right)\right]+ +qe^{-r^{*}t}\left[I_T+I_N-\dot{K}_T-\dot{K}_N\right] \quad (10)$$

where

q − the shadow price of capital – Tobin q.

The necessary conditions for the choice variables, i.e. labor and investment, are:

$$\frac{\partial H}{\partial L_T}=\frac{P_T}{P}\frac{\partial F\left(K_T,L_T\right)}{\partial L_T}-w=0 \quad (9a)$$

$$\frac{\partial H}{\partial L_N}=\frac{P_N}{P}\frac{\partial Z\left(K_N,L_N\right)}{\partial L_N}-w=0 \quad (9b)$$

$$\frac{\partial H}{\partial I_T}=\frac{\partial IC\left(I_T\right)}{\partial I_T}=q \tag{9c}$$

$$\frac{\partial H}{\partial I_N}=\frac{\partial IC\left(I_N\right)}{\partial I_N}=q \tag{9d}$$

The optimal conditions for the state variables are:

$$\frac{\partial H}{\partial K_T}=\frac{P_T}{P}\frac{\partial F\left(K_T,L_T\right)}{\partial K_T}\frac{1}{q}+\frac{\dot{q}}{q}=r^* \tag{10a}$$

$$\frac{\partial H}{\partial K_N}=\frac{P_N}{P}\frac{\partial Z\left(K_N,L_N\right)}{\partial K_N}\frac{1}{q}+\frac{\dot{q}}{q}=r^* \tag{10b}$$

Conditions (9a) and (9b) equate the value of marginal product of labor with wage rate. The wage rate must be the same in both sectors as labor is assumed to be perfectly mobile. Of course, the values of marginal products being the same does not mean that the productivity (in physical units) is the same in both sectors. The values can be equated by the movement of relative prices.

Conditions (9c) and (9d) equate the marginal cost of investment with the price of capital. Conditions (10a) and (10b) equate the return on capital (left hand side, i.e the dividend yield and capital gain) with the foreign real interest rate. Considering equation (6) the return on capital and bonds is the same and fixed at the foreign real interest rate.

The government faces the following budget constraint:

$$\dot{m}+\dot{a}=G+\left(IR^*-\pi^{*e}\right)a-\pi^e m-T \tag{11}$$

The receipts in the forms of net lump-sum taxes and segnoirage are channelled into public goods and interest payments connected with traded bonds issued by the government, a. The (negative) difference between receipts and payments is covered by increasing money supply or new issue of traded bonds.

The fact that a small open economy under the condition of perfect capital mobility is modelled results in both domestic and foreign bonds yielding the foreign real interest rate.

Combining all the constraints yields:

$$\dot{b}-\dot{a}=\begin{bmatrix}\frac{P_T}{P}F\left(K_T,L_T\right)+\frac{P_N}{P}Z\left(K_N,L_N\right)-\frac{P_T}{P}C_T-\frac{P_N}{P}C_N-IC(I_T)-\\ IC(I_N)-G\end{bmatrix}+ \\ +\left[\left(IR^*-\pi^{*e}\right)\left(b-a\right)\right] \tag{12}$$

The equation (12) is just a constraint for an open economy. The first expression on the right hand side of (12) is the difference between domestic output and domestic expenditures, i.e. net exports and the second expression on the right hand side is a net return on tradable bonds. The right hand side thus presents current account of the economy, or national savings, while the left hand side measures the change in the net holdings of traded bonds, the financial account of the economy.

The reason why the model was set up is, however, to capture the relationship between the real exchange rate and labor productivity.

The domestic price level measured by CPI is influenced by the price level of both tradable and nontradable goods:

$$P = \chi P_T + \left(1-\chi\right) P_N \tag{13}$$

where

χ – the share of tradable goods in the consumption basket.

Conditions (9a) and (9b) will now be restated as follows:

$$P_T = \frac{\partial L_T}{\partial F\left(K_T, L_T\right)} Pw \tag{14a}$$

$$P_N = \frac{\partial L_N}{\partial Z\left(K_N, L_N\right)} Pw \tag{14b}$$

Combining (14a) and (14b) one obtains for the price of nontraded good:

$$P_N = \frac{\partial L_N}{\partial Z\left(K_N, L_N\right)} \frac{\partial F\left(K_T, L_T\right)}{\partial L_T} P_T \tag{15}$$

Now the general price level (13) will be expressed using (15):

$$P = P_T \left[\chi + \left(1-\chi\right) \frac{\partial L_N}{\partial Z\left(K_N, L_N\right)} \frac{\partial F\left(K_T, L_T\right)}{\partial L_T} \right] \tag{16}$$

Assuming the same share of tradable goods in the consumption basket, the general price level for the foreign economy can be expressed using (16):

$$P^* = P_T^* \left[\chi + \left(1-\chi\right) \frac{\partial L_N^*}{\partial Z\left(K_N^*, L_N^*\right)} \frac{\partial F\left(K_T^*, L_T^*\right)}{\partial L_T^*} \right] \tag{17}$$

The real exchange rate is given by:

$$R = E \frac{P^*}{P} \tag{18}$$

that is the foreign price level expressed in domestic currency relative to domestic price level. Plugging (16) and (17) into (18), one readily sees that the real exchange rate is determined in the following way:

$$R = E\frac{P_T^*\left[\chi+(1-\chi)\dfrac{\partial L_N^*}{\partial Z\left(K_N^*,L_N^*\right)}\dfrac{\partial F\left(K_T^*,L_T^*\right)}{\partial L_T^*}\right]}{P_T\left[\chi+(1-\chi)\dfrac{\partial L_N}{\partial Z\left(K_N,L_N\right)}\dfrac{\partial F\left(K_T,L_T\right)}{\partial L_T}\right]} \tag{19}$$

Generally, the foreign price level of tradables expressed in domestic currency relative to domestic price level of tradables is the terms of trade (TT):

$$TT = E\frac{P_T^*}{P_T}$$

In fact here I assume an inverse expression for terms of trade as terms of trade is usually defined as a ratio of export and import prices. Taking logarithm of (19), the log of real exchange rate (r) is given by:

$$r = e + \ln\left(\frac{P_T^*}{P_T}\right) + \ln\left(\frac{\chi+(1-\chi)\dfrac{\partial L_N^*}{\partial Z\left(K_N^*,L_N^*\right)}\dfrac{\partial F\left(K_T^*,L_T^*\right)}{\partial L_T^*}}{\chi+(1-\chi)\dfrac{\partial L_N}{\partial Z\left(K_N,L_N\right)}\dfrac{\partial F\left(K_T,L_T\right)}{\partial L_T}}\right) \tag{20}$$

Equation (20) may be further stated as:

$$\begin{aligned} r = -tt &+ \ln\left(\chi+(1-\chi)\frac{\partial L_N^*}{\partial Z\left(K_N^*,L_N^*\right)}\frac{\partial F\left(K_T^*,L_T^*\right)}{\partial L_T^*}\right) - \\ &-\ln\left(\chi+(1-\chi)\frac{\partial L_N}{\partial Z\left(K_N,L_N\right)}\frac{\partial F\left(K_T,L_T\right)}{\partial L_T}\right) \end{aligned} \tag{21}$$

where

tt − the logarithm of terms of trade now defined in the traditional way (i.e. ratio of export and import prices).

From equation (21) one can readily see of the well-known implications of the Balassa-Samuelson effect. An increase in the productivity in the tradable sector in domestic economy lowers the value of real exchange rate (appreciates the real exchange rate), other variables being the same.

Of course, the Balassa-Samuelson effect disregards such factors as influence of the terms of trade or the effects of pricing-to-market.

According to the formulation of the Balassa-Samuelson effect in the previous part, the hypothesis may be stated as a regression:

$$RER = \alpha_0 + \alpha_1 \left[\left(LP_T - LP_N \right) - \left(LP_T^* - LP_N^* \right) \right] + \alpha_2 tt + \varepsilon_t \qquad (22)$$

where

RER – the real exchange rate,
α_0 – a constant,
α_1 and α_2 – regression coefficients,
ε – a disturbance term.

As the variables are expected to be nonstationary, using OLS regression would mean estimating spurious regression. Therefore, the cointegration approach will be adopted.

2. Data

Quarterly data for nominal exchange rates, price levels (measured by Harmonised index of Consumer Prices – HICP), gross value added, employment were taken from Eurostat and where missing, national databases were used.

Using the data for the bilateral nominal exchange rates between the respective country and the eurozone, the real exchange rates were computed.

The productivity was computed as gross value added per unit of employment (measured in thousand persons). The sectors for which the productivity was computed were: agriculture, hunting, forestry and fishing; industry; manufacturing; construction; wholesale and retail trade; financial intermediation, real estate, renting and business activities; public services.

For each sector relative productivity (with respect to Eurozone) was computed. Three versions of traded sector were used. The first labor productivity in the traded sector (LP1) is based solely on manufacturing. All the rest is taken to be nontradable. The second version of labor productivity in the traded sector (LP2) includes the whole sector of industry. All the rest is taken as nontradable. The third labor productivity in the traded sector (LP3) consists of industry and wholesale and retail trade. All the rest is considered as nontradable. The assumption of tradable and nontradable sectors being the same across the countries is maintained.

The beginning of the sample period differs across the countries (the most distant data date from 1995) and the information on the number of observations is given for each cointegration. The data used for the computations of productivity differentials were seasonally adjusted. Eurozone is dominant for all the countries. Among other issues Egert and Hal-pern (2005) present a comparative study examining the role of various definitions of productivity in the tradable sector on the results of estimation of the real equilibrium exchange rate.

Terms of trade (TT) were based on export and import deflators. Of course, this means some inaccuracy as deflators include not just the trade with the Eurozone. However, trade with the Eurozone is dominant for all the countries.

All the series enter in logs. The unit root behavior was examined by the ADF tests. Table 1 reports the results for both levels and first differences.

Table 1
ADF Tests, LHS for Levels, RHS for First Differences

Variable	t-statistic	Variable	t-statistic
logs of real exchange rates		*logs of real exchange rates*	
$RER_{CZK/EUR}$	–0.574647	$RER_{CZK/EUR}$	–5.919063***
$RER_{HUF/EUR}$	–1.417992	$RER_{HUF/EUR}$	–7.778810***
$RER_{SKK/EUR}$	0.253220	$RER_{SKK/EUR}$	–6.462417***
$RER_{PPL/EUR}$	–2.276236	$RER_{PPL/EUR}$	–5.738926***
logs of relative productivity LP1		*logs of relative productivity LP1*	
$LP1_{CZ} – LP1_{EA}$	–0.277708	$LP1_{CZ} – LP1_{EA}$	–10.80645***
$LP1_{HU} – LP1_{EA}$	–1.261987	$LP1_{HU} – LP1_{EA}$	–5.542781***
$LP1_{SK} – LP1_{EA}$	0.313683	$LP1_{SK} – LP1_{EA}$	–8.809323***
$LP1_{PL} – LP1_{EA}$	–1.089653	$LP1_{PL} – LP1_{EA}$	–6.379425***
logs of relative productivity LP2		*logs of relative productivity LP2*	
$LP2_{CZ} – LP2_{EA}$	–1.794986	$LP2_{CZ} – LP2_{EA}$	–9.260595***
$LP2_{HU} – LP2_{EA}$	–2.030831	$LP2_{HU} – LP2_{EA}$	–7.333504***
$LP2_{SK} – LP2_{EA}$	–0.282795	$LP2_{SK} – LP2_{EA}$	–9.421334***
$LP2_{PL} – LP2_{EA}$	–1.910791	$LP2_{PL} – LP2_{EA}$	–7.606701***
logs of relative productivity LP3		*logs of relative productivity LP3*	
$LP3_{CZ} – LP3_{EA}$	–1.256596	$LP3_{CZ} – LP3_{EA}$	–7.811947***
$LP3_{HU} – LP3_{EA}$	–1.594962	$LP3_{HU} – LP3_{EA}$	–5.497216***
$LP3_{SK} – LP3_{EA}$	–2.004318	$LP3_{SK} – LP3_{EA}$	–9.102505***
$LP3_{PL} – LP3_{EA}$	–1.504919	$LP3_{PL} – LP3_{EA}$	–8.192379***
logs of terms of trade		*logs of terms of trade*	
TT_{CZ}	–2.224574	TT_{CZ}	–4.775838***
TT_{HU}	–2.470289	TT_{HU}	–6.698281***
TT_{SK}	–2.404033	TT_{SK}	–8.373968***
TT_{PL}	–2.322736	TT_{PL}	–10.53948***

***, **, * shows rejection of the null at 1%, 5%, 10% level of significance respectively.
Source: Original analysis.

For levels the null hypothesis of unit root behavior could not be rejected for any of the series. For first differences the unit root behavior is rejected for all of them at 1% level of significance. Thus, the series are taken to be I(1).

3. Results

Cointegration was carried out within VAR following the Johansen procedure, e.g. Lutkepohl (2007). In the case of the vector error correction models (VECMs) the dependance of the exchange rate on the cointegrating vectors is given and adjusted R-squared together with F-statistic and Akaike Information Criterion are reported. Given the way the vector autoregressive (VAR) models were estimated (no serial autocorrelation or remaining heteroskedasticity in the residuals and residuals following normal distribution), they meet the standard diagnostic tests regarding residuals.

Table 2
Cointegration Tests for LP and TT

Czech Republic			
no. of observations 52	***lag***	***Trace Statistic***	***M-E Statistic***
Cointegration equation	3	34.73074**	22.56229**
coefficient (standard error)	***$RER_{CZK/EUR}$***	***$LP1_{CZ} – LP1_{EA}$***	***TT_{CZ}***
	1	–1.010512 (0.08843)	–2.099032 (0.32062)
Hungary			
no. of observations 41	***lag***	***Trace Statistic***	***M-E Statistic***
Cointegration equation	5	34.24798**	21.77813**
coefficient (standard error)	***$RER_{HUF/EUR}$***	***$LP1_{HU} – LP1_{EA}$***	***TT_{HU}***
	1	–2.482521 (0.56336)	–6.189770 (2.19186)
Slovakia			
no. of observations 52	***lag***	***Trace Statistic***	***M-E Statistic***
Cointegration equation	3	32.72095**	19.63432*
coefficient (standard error)	***$RER_{SKK/EUR}$***	***$LP1_{SK} – LP1_{EA}$***	***TT_{SK}***
	1	–0.762065 (0.06300)	–0.569058 (0.29882)
Poland			
no. of observations 31	***lag***	***Trace Statistic***	***M-E Statistic***
Cointegration equation	4	36.64866***	24.14587**
coefficient (standard error)	***$RER_{PPL/EUR}$***	***$LP3_{PL} – LP3_{EA}$***	***TT_{PL}***
	1	–2.331023 (1.09914)	–3.945154 (1.24687)

***, **, * shows rejection of the null at 1%, 5%, 10% level of significance respectively. Number of observations refers to the number of observations with which the cointegration equation was found. Number of lags refer to the underlying VAR.

Source: Original analysis.

Table 3
VECMs for LP and TT

Czech Republic		**Hungary**	
Error Correction Term		***Error Correction Term***	
coefficient (standard error) [t-statistic]	–0.315656*** (0.08027) [–3.93240]	***coefficient (standard error) [t-statistic]***	–0.133550* (0.06131) [–2.17840]
Adj. R	0.277168	***Adj. R***	0.426451
F-statistic	3.793682	***F-statistic***	2.858824
AIC	–4.395341	***AIC***	–4.046694
Slovakia		**Poland**	
Error Correction Term		***Error Correction Term***	
coefficient (standard error) [t-statistic]	–0.175313* (0.08194) [–2.13965]	***coefficient (standard error) [t-statistic]***	–0.344015*** (0.09332) [–3.68654]
Adj. R	0.021084	***Adj. R***	0.332637
F-statistic	1.007909	***F-statistic***	2.495308
AIC	–4.144808	***AIC***	–3.190988

***, **, * shows rejection of the null at 1%, 5%, 10% level of significance respectively.

Source: Original analysis.

Two sets of results will be given below. The first set of cointegration equations and resulting vector error correction models were estimated using the relative productivity factor and terms of trade. The given results make use of such a measure of relative productivity which gave the best result for the particular country. The second set of cointegration and vector error correction models also includes linear trend in the cointegration equations to account for trend appreciation. For additional visual analysis the evolution of the real exchange rate and its components for each economy is given in the Appendix.

Czech Republic

Both terms of trade and relative productivity measure were proven significant. Estimates for both the parameters yield expected (negative) signs, i.e. higher relative productivity and/or improvement in terms of trade result(s) in real appreciation. Relative productivity is based on the manufacturing sector as a tradable sector. The resulting vector correction model displays stability, the adjustment parameter is statistically significant at 1% level, and explains about 28% of the variability of the real exchange rate. When linear trend is included in the cointegration equation the parameters of the resulting vector error correction model are improved. The adjustment parameter is increased significantly (in absolute terms) implying the half-life of a shock to the equilibrium condition is approximately 1.7 quarter. The model explains about 33% of the variability of the real exchange rate.

Hungary

In the case of Hungary both relative productivity and terms of trade enter the cointegration equation significantly and with expected signs. Relative productivity in the tradable sector is again based on the manufacturing sector. The cointegration equation bears a little higher statistical significance than in the case of the Czech Republic.

The resulting vector error correction (VEC) model displays stability and explains about 43% of the variability of the real exchange rate. Apart from the previous case the inclusion of linear trend in the cointegration equation does not enhance the resulting VEC model. In such a case the estimated adjustment coefficient is lower and the model explains less of the variability of the real exchange rate; 31% to be exact. Considering the adjustment parameter from the first model, the half-life of a shock to the equilibrium condition is approximately 5.2 quarters, which is significantly higher than in the previous case.

Table 4
Cointegration Tests for LP, TT and Trend

Czech Republic				
no. of observations 52	***lag***	***Trace Statistic***	***M-E Statistic***	
Cointegration equation	3	40.25841*	24.54038*	
coefficient (standard error)	***$RER_{CZK/EUR}$***	***$LP1_{CZ} - LP1_{EA}$***	***TT_{CZ}***	***trend***
	1	–0.690737 (0.21955)	–1.290858 (0.49572)	–0.003254 (0.00139)
Hungary				
no. of observations 42	***lag***	***Trace Statistic***	***M-E Statistic***	
Cointegration equation	4	43.727451**	23.51622*	
Coefficient (standard error)	***$RER_{HUF/EUR}$***	***$LP1_{HU} - LP1_{EA}$***	***TT_{HU}***	***trend***
	1	–3.358215 (1.22377)	–11.71788 (4.13782)	–0.010484 (0.00432)
Slovakia				
no. of observations 52	***lag***	***Trace Statistic***	***M-E Statistic***	
Cointegration equation	3	42.00673*	21.63456*	
Coefficient (standard error)	***$RER_{SKK/EUR}$***	***$LP1_{SK} - LP1_{EA}$***	***TT_{SK}***	***trend***
	1	0.607245 (0.14487)		–0.004918 (0.00214)
Poland				
no. of observations 30	***lag***	***Trace Statistic***	***M-E Statistic***	
Cointegration equation	5	62.57955***	33.94206***	
coefficient (standard error)	***$RER_{SKK/EUR}$***	***$LP1_{PL} - LP1_{EA}$***	***TT_{PL}***	***trend***
	1	–1.120993 (0.48032)	–2.451434 (1.02585)	–0.015323 (0.00582)

***, **, * shows rejection of the null at 1%, 5%, 10% level of significance respectively. Number of observations refers to the number of observations with which the cointegration equation was found. Number of lags refer to the underlying VAR.

Source: Original analysis.

Table 5
VECMs for LP, TT and Trend

Czech Republic		Hungary	
Error Correction Term		***Error Correction Term***	
coefficient (standard error) [t-statistic]	–0.396688*** (0.08930) [–4.44233]	***coefficient (standard error) [t-statistic]***	–0.044624* (0.02172) [–2.05451]
Adj. R	0.325602	***Adj. R***	0.308697
F-statistic	4.517567	***F-statistic***	2.875486
AIC	–4.464698	***AIC***	–3.936451
Slovakia		**Poland**	
Error Correction Term		***Error Correction Term***	
coefficient (standard error) [t-statistic]	–0.223726** (0.08756) [–2.55513]	***Coefficient (standard error) [t–statistic]***	–0.814353*** (0.14529) [–5.60518]
Adj. R	0.112865	***Adj. R***	0.651024
F-statistic	2.101630	***F-statistic***	5.161550
AIC	–4.251850	***AIC***	–3.777450

***, **, * shows rejection of the null at 1%, 5%, 10% level of significance respectively.

Source: Original analysis.

Poland

Relative productivity and terms of trade both enter significantly in the cointegration equation. However, in contrast to the previous cases, the productivity in the tradable sector is approximated by the sectors of manufacturing and wholesale and retail trade. This is hard to interpret considering the results of the second model for Poland and the reason may be the fact that the sample is by far the shortest for Poland which can bring about additional distortions into the estimations. The resulting VEC model displays stability and explains about 33% of the variability of the real exchange rate. When the linear trend is included in the cointegration equation, the cointegration equation is considerably more significant and the tradable sector can be approximated by the manufacturing sector. The resulting VEC model is highly significant and explains about 65% of the variability of the real exchange rate. Taking account of the estimated adjustment parameter, the half-life of a shock to the equilibrium condition is approximately 0.9 quarter.

Slovakia

Both relative productivity and terms of trade enter significantly in the cointegration equation but it is evident that the estimated value of the coefficient for relative productivity is much lower than in the previous cases. The resulting VEC model is barely statistically significant. The adjustment parameter is low and the model explains just about 8% of the variability of the real exchange rate. When linear trend is included it is not possible to estimate a model with terms of trade. When the parameter is dropped out, a statistically significant model is arrived at, however it still explains just about 11% of the variability of the exchange rate. The estimated adjustment parameter implies that the half-life of a shock to the equilibrium is about 3.1 quarter.

Overall Assessment

The results show that the hypothesis under test finds most empirical support in the cases of the Czech Republic and Poland. On the other hand, the least significant results were reported for Slovakia. The estimated results show a great deal of stability in the cases of the Czech Republic and Hungary. The estimated parameters are much less stable in the case of Slovakia. In the case of Poland the much shorter time series do not enable to run proper stability tests so that the presented results must be viewed with caution. Even though the hypothesis under test does not test solely the Balassa-Samuelson effect, the results show that the expected role of relative productivity can be assumed in the cases of the

Czech Republic, Hungary and Poland. Regarding the estimated half-lives of adjustment, the models for the Czech Republic and Poland come out as most supportive of the hypothesis.

A large number of studies verifying the Balassa-Samueleson effect have been published. However, they typically use panel analysis or in general quite different methods for evaluation of the Balassa-Samuelson effect.

Kovacs (2002) presents evidence for the effect of the Balassa-Samuelson effect on real appreciation for all the economies and its importance varied according to the method used for the estimation.

Flek, Marková and Podpiera (2002) find little evidence for the Czech Republic.

Egert at al. (2002) reports very weak cointegration relationship for the transition economies when price indices are used as a measure for the relative price of nontradables and tradables. The main reasons he sees is a relatively small share of nontradables in the respective baskets (as compared with much higher share in GDP) and the role of administrative prices. Again the result of the tests is critically conditional on the data which are used to proxy the needed variables of the model. He reports relatively higher significance of the Balassa-Samuelson effect for Poland and Slovakia.

Mihaljek and Klau (2003) estimate the contributions of productivity differentials to inflation differentials between the respective country and the euro area for Croatia, Czech Republic, Hungary, Poland, Slovakia and Slovenia. The estimated contributions for the Czech Republic, Hungary are relatively significant when they estimate the model in terms of the Balassa-Samuelson effect. When they consider the problem in the context of the Baumol-Bowen effect, i.e. without relation to the foreign benchmark, they find some evidence for Poland instead.

Lojschova (2003) finds evidence in favor of the Balassa-Samuelson hypothesis and more significant results are obtained for Poland and Hungary.

Brandmeier (2006) using an ad hoc model for explaining relative differentials in inflation finds very little evidence for the role of productivity in the cases of the Czech Republic and Hungary but the results show some support for Slovakia and Poland.

Vintrová and Žďárek (2007) present some qualitative facts on the relation between real and nominal convergence. First a positive relationship on panel data between GDP per capital in PPS (purchasing power standard) and comparative price level is given which points to the Baumol-Bowen effect and second a positive relationship between GDP per capital in PPS and compensation per employee is given, which draws similar connotations.

Interesting results can be found in Mirdala (2008) who uses SVAR (structural vector autoregressive) model to investigate the effects of nominal and real shocks on the behavior of exchange rates. He shows that a supply shock has an apreciating effect on the real exchange rate in the Czech Republic, Hungary and Slovakia while in the case of Poland the effect is very weak. Indeed the underlying nature of Balassa-Samuelson effect is a supply shock.

The presented results cannot be directly compared to any of the cited papers because they differ significantly in the methods used. However, regarding the results of those papers, the estimates presented here cannot be considered as being in stark contradiction.

Conclusion

The paper gave a derivation of the Balassa-Samuelson effect in a full intertemporal model which again proved the hypothesis to be a supply side phenomenon. The output of the theoretical model was tested using the cointegration method. The tested hypothesis was presented as a dependance of the real exchange rate on the terms of trade and relative productivity. Hence it was not just the Balassa-Samuelson effect which was tested by the models. Regarding the results of the models it seems reasonable to approximate the tradable sector of the economy by the manufacturing sector.

The results showed some support in the cases of the Czech Republic and Poland when by far the highest explanatory power of the model was obtained in the case of Poland. However, the time series used in the case of Poland were by far the shortest which casts some uncertainty on the validity of the results. Two versions of the model where tested: one with and one without a linear trend built in the cointegration equation. The linear trend proved to be useful in the cases of the Czech Republic, Poland and Slovakia.

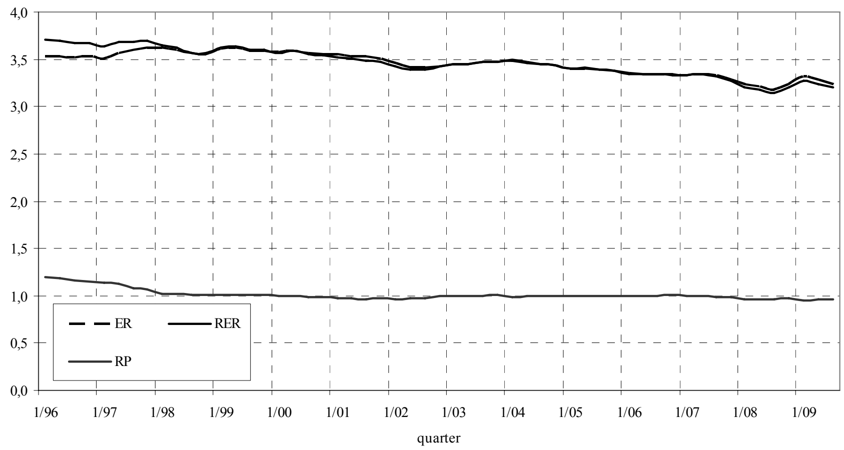
However, in the case of Slovakia the resulting model was still rather disappointing displaying low explanatory power and rather a long half-life of adjustment to the equilibrium relationship as well as in the case of the baseline model for Hungary. On the other hand the estimated half-lives of adjustment in the cases of the Czech Republic and Poland were rather high pointing to the validity of models.

It is extremely difficult to quantitatively compare the results of this analysis with the numerous analyses published in the past as quite different approaches were used to check the various hypotheses concerning the role of productivity in determining the relative prices. The overview given in the paper did not indicate that the presented results could be considered implausible.

Appendix

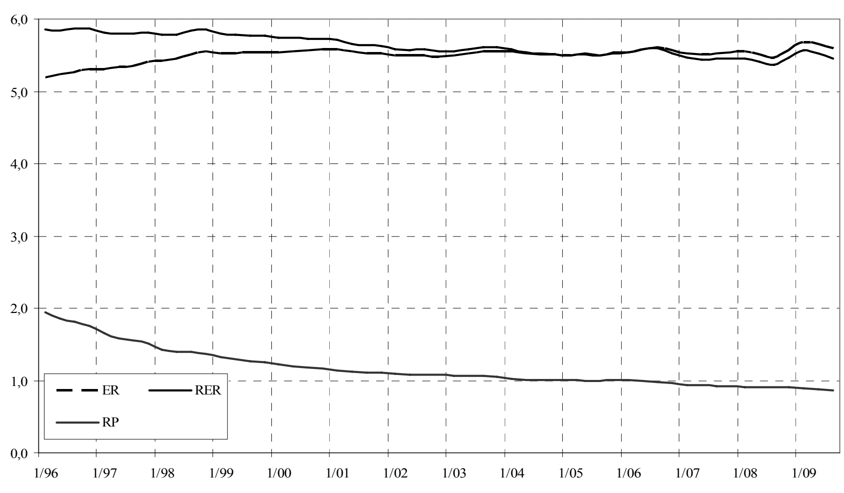
F i g u r e 1

Log of Real Exchange Rate (RER), Log of Nominal Exchange Rate (ER) and Relative Price Level (foreign – eurozone – price level to domestic price level) for the Czech Republic (original analysis)

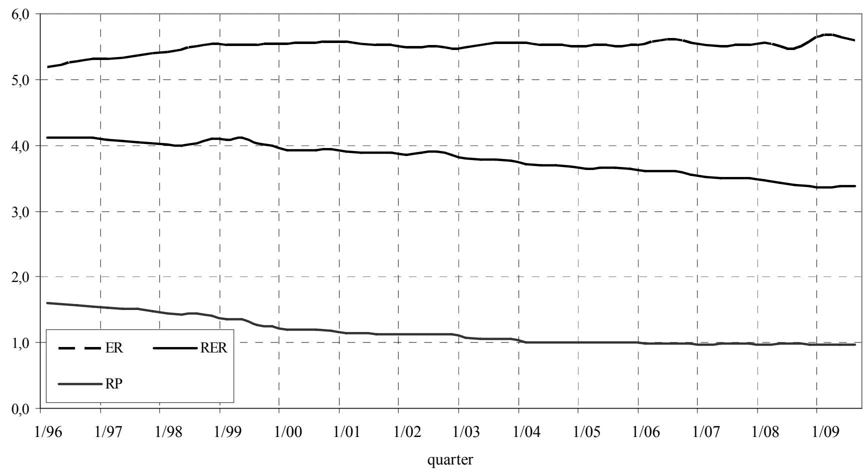


F i g u r e 2

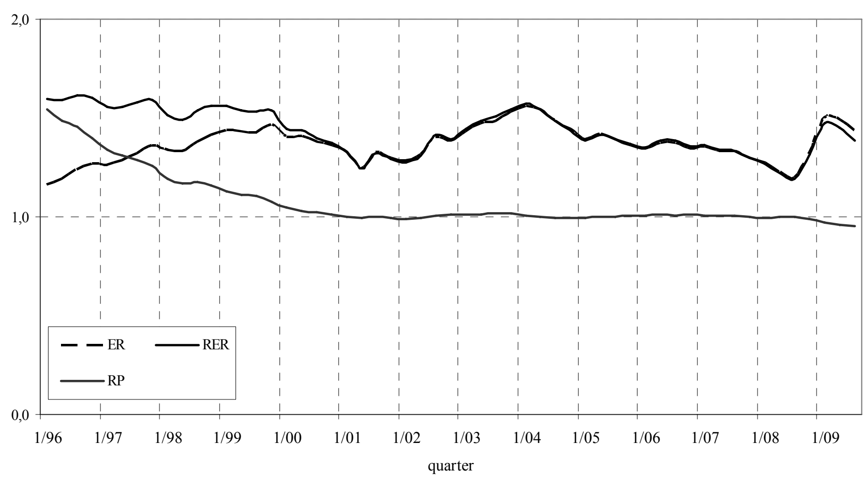
Log of Real Exchange Rate (RER), Log of Nominal Exchange Rate (ER) and Relative Price Level (foreign – eurozone – price level to domestic price level) for Hungary (original analysis)



F i g u r e 3
Log of Real Exchange Rate (RER), Log of Nominal Exchange Rate (ER) and Relative Price Level (foreign – eurozone – price level to domestic price level) for Slovakia (original analysis)



F i g u r e 4
Log of Real Exchange Rate (RER), Log of Nominal Exchange Rate (ER) and Relative Price Level (foreign – eurozone – price level to domestic price level) for Poland (original analysis)



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