An empirical estimation of Balassa – Samuelson Effect in case of Eastern European Countries

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Abstract

Integration into the European Monetary Union (EMU) and adoption of Euro became a specific objective for Eastern European Countries after their accession into the European Union. This objective implies specific nominal and real economic convergence for these countries within a given period of time (Copenhagen criteria). Nominal convergence measurement is based on well-defined system of economic indicators (Maastricht and Amsterdam criteria). Real convergence refers to real economic performance of a country and it is commonly associated with GDP growth rate and productivity level. From a broader perspective, real and nominal convergence could be seen as complementary. Tensions between real and nominal convergence are tested through Balassa – Samuelson Effect. In this paper it is analyzed the evolution of nominal and real convergence based on a proposed set of indicators and it is estimated Balassa-Samuelson Effect on non-Euro countries.

Introduction

The European Monetary Union has been conceived according to the main principles of an Optimal Currency Area, as they were for the first time defined by Mundell in 1961. [Eichengreen (1992), Emerson et al (1992), De Grauwe (2002), Mongelli (2005) provides a comprehensive review of the optimal currency area literature]. The OCA criteria rely on factor mobility (labour and capital), price and wage flexibility, trade openness, respectively production diversity. As a complementary update to these rather classical conditions, the Maastricht agreement introduced four new nominal criteria of convergence on interest rate, exchange rate, price stability and public debt, and recommended a series of criteria of real convergence to be considered in phasing the adoption of the euro as single currency for each country (Zaman, 2002). The twelve new member states (NMS) which have joined the EU since 2004 do not have an opt-out like Denmark and the United Kingdom and have to adopt the euro under the Treaty. The timing of euro adoption depends on satisfying the Maastricht requirements of nominal convergence. The benefits of a currency union, in general, and of the adoption of the euro by the EU member states, in particular, have been widely discussed in the literature (Darvas and Szapáry, 2008). The fulfilment of the above criteria should overcome the effects of giving up the two main policy instruments that disappear by adopting a single currency: exchange rate policy, respectively monetary policy. The two instruments are used, at national level, as an adjustment mechanism aimed to reconcile disturbances and asymmetric shocks generated by differences in economic conditions between a country and the rest of the world.

There has been a long debate in the economic literature of various aspects – theoretical as well as empirical – of the notion of (real) convergence and its theoretical foundation. Three main convergence hypotheses have been formulated (Galor, 1996):

- the absolute (unconditional) convergence hypothesis – per capita incomes of countries converge to one another in the long run independently of their initial conditions [Baumol, 1986; DeLong, 1988]. If countries in general failed to converge, this absence is then explained through institutions [Abramovitz, 1986; Heitger, 1987; Alam, 1992];
- the conditional convergence hypothesis – per capita incomes of countries that are identical in their fundamental structural characteristics converge to one another in the long run independently of their initial conditions [Dowrick and Nguyen, 1989;

Barro and Sala-i-Martin, 1991, 1992; Mankiw et al., 1992; Levine and Renett, 1992; Barro et al., 1995];

- the "club convergence" hypothesis (polarization or clustering) – per capita incomes of countries that are identical in their fundamental structural characteristics converge to one another in the long run, provided their initial conditions are similar as well.

Empirical work on testing these hypotheses largely relies on the actual measurement of the process of convergence between countries and nations. Two main quantitative definitions of convergence have been used mostly in the literature [Barro and Sala-i-Martin (1995), Sala-i-Martin (1996) Vohra (1997), Martin and Sanz (2003), Iancu, (2008)]:

- β ("beta") implies that the poor countries (regions) grow faster than the richer ones and it is generally tested by regressing the growth in per capita GDP on its initial level for a given cross-section of countries (regions)
- σ ("sigma") covers two types of convergence: absolute and conditional (on a factor or a set of factors in addition to the initial level of per capita GDP), meaning the reduction of per capita GDP dispersion within a sample of countries (regions).

There are also a number of problems – and policy dilemmas – that arise from the asymmetric treatment of the dimensions of convergence. In particular, during a catch up process there emerges an essential and fundamental economic link between nominal and real variables that often tends to be neglected but which is likely to have profound economic implications for the acceding transition economies. The fact is that real convergence cannot be de-coupled from nominal convergence as these are essentially the two sides of one and the same coin; the link between them is given by the dynamics of the real exchange rate.

Balassa-Samuelson Effect

The original Balassa – Samuelson Effect refers to the correlation between general price level of a specific country and its level of per capita income [Balassa, 1964; Samuelson, 1964]. Any increase in the productivity level of a country participating to a currency area will generate an increase in the level of relative prices.

Let's start with an example of two countries offering two kinds of goods on the market: tradable and non-tradable goods. The productivity level in both sectors / countries is measured based on marginal product labor. For the simplicity of the model the marginal product labour in non-tradable sector was set to be equal with 1 in both countries (A and B):

$$\text{Productivity}^{\text{Non-tradable}}{}_{\text{A}} = \text{Productivity}^{\text{Non-tradable}}{}_{\text{B}} = 1 \quad (1)$$

The wages (w_A and w_B) in tradable and non-tradable sectors (both countries) depend on the level of prices and productivity level:

$$\begin{cases} w_A^{\text{Non-tradable}} = p_A^{\text{Non-tradable}} \times \text{Productivity}_A^{\text{Non-tradable}} = p_A^{\text{Non-tradable}} \; (2) \\ w_A^{\text{Tradable}} = p_A^{\text{Tradable}} \times \text{Productivity}_A^{\text{Tradable}} \; (3) \\ w_B^{\text{Non-tradable}} = p_B^{\text{Non-tradable}} \times \text{Productivity}_B^{\text{Non-tradable}} = p_B^{\text{Non-tradable}} \; (4) \\ w_B^{\text{Tradable}} = p_B^{\text{Tradable}} \times \text{Productivity}_B^{\text{Tradable}} \; (5) \end{cases}$$

Assuming full capital mobility between the two sectors (tradable and non-tradable) in both countries (interest rate is an exogenous variable) and the labor market is a competitive one: the wages between sectors and/or countries tends to be equal:

$$w_A^{\text{Non-tradable}} = w_A^{\text{Tradable}} \quad \Rightarrow \quad p_A^{\text{Tradable}} \times \text{Productivity}_A^{\text{Tradable}} = p_A^{\text{Non-tradable}} \quad (6)$$

$$w_B^{\text{Non-tradable}} = w_B^{\text{Tradable}} \quad \Rightarrow \quad p_B^{\text{Tradable}} \times \text{Productivity}_B^{\text{Tradable}} = p_B^{\text{Non-tradable}} \quad (7)$$

Supposing that both countries are using the same currency, the exchange rate E between the currencies will be equal with 1 (E=1). Based on the hypothesis of purchasing power parity[1] that is valid only in case of tradable sectors, we have that exchange rate E could be expressed in relation with prices differential between the two countries ($p_A^{\text{Tradable}}/p_B^{\text{Tradable}}$):

$$E = \frac{p_A^{\text{Tradable}}}{p_B^{\text{Tradable}}} \quad \stackrel{E=1}{\Longrightarrow} \quad p_A^{\text{Tradable}} = p_B^{\text{Tradable}} \quad (8)$$

But the prices of tradable goods could be expressed in relation with productivity in the tradable sector of country A and prices in the non – tradable sector and the same in the case of country B:

$$p_A^{\text{Tradable}} = \frac{p_A^{\text{Non-tradable}}}{\text{Productivity}_A^{\text{Tradable}}} \quad (9)$$

$$p_B^{\text{Tradable}} = \frac{p_B^{\text{Non-tradable}}}{\text{Productivity}_B^{\text{Tradable}}} \quad (10)$$

According to the relationship between prices in the tradable sector we have that:

$$\frac{p_A^{\text{Non-tradable}}}{\text{Productivity}_A^{\text{Tradable}}} = \frac{p_B^{\text{Non-tradable}}}{\text{Productivity}_B^{\text{Tradable}}} \quad \Rightarrow \quad \frac{p_A^{\text{Non-tradable}}}{p_B^{\text{Non-tradable}}} = \frac{\text{Productivity}_A^{\text{Tradable}}}{\text{Productivity}_B^{\text{Tradable}}} \quad (11)$$

If in the country A the productivity in the tradable sectors is higher than in the country B, the prices in the non-tradable sectors of country A is higher than the prices in the non-tradable sectors of country B. So, there is an incompatibility between real convergence (based on productivity level) and nominal convergence (based on inflation). So, the conclusion of this theory is quite clear: Balassa – Samuelson Effect states that we can obtain in the same time a real and a nominal convergence between two countries.

A similar effect could be registered in case of real exchange rate. The prices in both countries could be expressed as a weighted average of prices for tradable and non-tradable goods. If we note with θ_A and θ_B the weights for tradable prices in the total prices of both countries, the price level in both countries will be:

$$p_A = \left[p_A^{\text{Tradable}}\right]^{\theta_A} \times \left[p_A^{\text{Non-tradable}}\right]^{(1-\theta_A)} \text{ and } p_B = \left[p_B^{\text{Tradable}}\right]^{\theta_B} \times \left[p_B^{\text{Non-tradable}}\right]^{(1-\theta_B)} \quad (12)$$

[1] We assumed that there are no barriers against the trade with tradable goods between two countries. The tradable goods are free from any intervention on the market.

For simplicity, the structure of prices in country A and B are considered to be the same ($\theta_A = \theta_B$). Assuming again that purchasing power parity (PPP) is valid only on tradable sector we have that:

$$E = \frac{p_A^{Tradable}}{p_B^{Tradable}} \quad \Rightarrow \quad p_A^{Tradable} = E \times p_B^{Tradable} \quad (13)$$

Under the assumption of competition in the labor market, the wages in tradable and non-tradable sectors are equal inside each country (and the marginal product labor is equal with 1 in case of non-tradable goods in each country):

$$w_A^{Non-tradable} = w_A^{Tradable} \quad (14)$$

$$w_B^{Non-tradable} = w_B^{Tradable} \quad (15)$$

and,

$$w_A^{Tradable} = p_A^{Tradable} \times Productivity_A^{Tradable} \quad (16)$$

$$w_B^{Tradable} = p_B^{Tradable} \times Productivity_B^{Tradable} \Leftrightarrow p_B^{Tradable} = \frac{w_B^{Tradable}}{Productivity_B^{Tradable}} \quad (17)$$

Combining (13) with (16) we obtain that:

$$w_A^{Tradable} = p_A^{Tradable} \times Productivity_A^{Tradable} = E \times p_B^{Tradable} \times Productivity_A^{Tradable} \quad (18)$$

$$w_A^{Tradable} = E \times p_B^{Tradable} \times Productivity_A^{Tradable} \overset{(17)}{=} E \times \frac{w_B^{Tradable}}{Productivity_B^{Tradable}} \times Productivity_A^{Tradable}$$

$$w_A^{Tradable} = E \times \frac{w_B^{Tradable}}{Productivity_B^{Tradable}} \times Productivity_A^{Tradable} \quad (19)$$

that is equivalent with:

$$\frac{w_A^{Tradable}}{w_B^{Tradable}} \times \frac{1}{E} = \frac{Productivity_A^{Tradable}}{Productivity_B^{Tradable}} \quad (20)$$

Real exchange rate is defined as nominal exchange rate adjusted with prices differential between the two countries:

$$E_{real} = E \times \frac{p_B}{p_A} \overset{(12)}{=} E \times \frac{\left[p_B^{Tradable}\right]^{\theta_B} \times \left[p_B^{Non-tradable}\right]^{(1-\theta_B)}}{\left[p_A^{Tradable}\right]^{\theta_B} \times \left[p_A^{Non-tradable}\right]^{(1-\theta_A)}} = E \times \frac{\left[p_B^{Tradable}\right]^{\theta_B}}{\left[p_A^{Tradable}\right]^{\theta_A}} \times \frac{\left[p_B^{Non-tradable}\right]^{(1-\theta_B)}}{\left[p_A^{Non-tradable}\right]^{(1-\theta_A)}} \quad (21)$$

Log terms of this equation will be (initially we assumed that $\theta_A=\theta_B=\theta$):

$$Log(E_{real}) = Log(E) + \theta \times [Log(p_B^{Tradable}) - Log(p_A^{Tradable})] + (1-\theta) \times [Log(p_B^{Non-tradable}) - Log(p_A^{Non-tradable})]$$

Rewriting the last formula keeping only the factors in the equation we obtained:

$$E_{real} = E + \theta \times [p_B^{Tradable} - p_A^{Tradable}] + (1-\theta) \times [p_B^{Non-tradable} - p_A^{Non-tradable}] \quad (22)$$

Deriving this formula with respect to time we obtain:

$$\frac{dE_{real}}{dt} = \frac{dE}{dt} + \theta \times [\frac{dp_B^{Tradable}}{dt} - \frac{dp_A^{Tradable}}{dt}] + (1-\theta) \times [\frac{dp_B^{Non-tradable}}{dt} - \frac{dp_A^{Non-tradable}}{dt}] \quad (23)$$

Deriving the PPP formula (13) with respect to time we obtain:

$$E = \frac{p_A^{Tradable}}{p_B^{Tradable}} \quad \Rightarrow \quad \frac{dE}{dt} = \frac{dp_A^{Tradable}}{dt} - \frac{dp_B^{Tradable}}{dt} \Leftrightarrow \frac{dp_A^{Tradable}}{dt} = \frac{dE}{dt} + \frac{dp_B^{Tradable}}{dt} \quad (24)$$

Combining (23) with (24), the variation of real exchange rate with respect to time is equal with:

$$\frac{dE_{real}}{dt} = \frac{dE}{dt} \times (1+\theta) + (1-\theta) \times [\frac{dp_B^{Non-tradable}}{dt} - \frac{dp_A^{Non-tradable}}{dt}]$$

$$\frac{dE_{real}}{dt} = (1-\theta) \times [\frac{dE}{dt} + \frac{dp_B^{Non-tradable}}{dt} - \frac{dp_A^{Non-tradable}}{dt}] \quad (25)$$

If we consider that nominal exchange rate is fixed than $\frac{dE}{dt} = 0$, the variation of real exchange rate in time being dependent on the variation of prices for non-tradable goods in those two economies:

$$\frac{dE_{real}}{dt} = (1-\theta) \times [\frac{dp_B^{Non-tradable}}{dt} - \frac{dp_A^{Non-tradable}}{dt}] \quad (26)$$

This relationship states that if the inflation rate in non-tradable sector for country B is higher than inflation rate in non-tradable sector for country A than real exchange rate will increase. The level of prices in non-tradable sector for both countries depends on the relative growth of productivities in the two sectors and in the two countries.

Deriving now the formula of wages in non-tradable sector with respect to time we obtain that:

$$\frac{dw^{Non-tradable}}{dt} = \frac{dp^{Non-tradable}}{dt} + \frac{d\,Productivity^{Non-tradable}}{dt} \quad (27)$$

Replacing again in formula (26) the inflation in both countries for non-tradable sector we obtain that:

$$\frac{dE_{real}}{dt} = (1-\theta) \times [\frac{dw_B^{Non-tradable}}{dt} - \frac{d\,Productivity_B^{Non-tradable}}{dt} - \frac{dw_A^{Non-tradable}}{dt} + \frac{d\,Productivity_A^{Non-tradable}}{dt}]$$

If the variation of productivity level for non-tradable sector in both countries is equal, the real exchange rate variation will be equal with (the countries differ only in the growth rate for tradable sector):

$$\frac{dE_{real}}{dt} = (1-\theta)\times\left[\frac{dw_B^{Non-tradable}}{dt} - \frac{dw_A^{Non-tradable}}{dt}\right] \quad (28)$$

We assumed that the wages in non-tradable sector increases as the wages in tradable sector increases inside each country (assuming high competition level between sectors) it can be obtained:

$$\frac{dE_{real}}{dt} = \frac{dE}{dt} + \frac{dp_B}{dt} - \frac{dp_A}{dt} = (1-\theta)\times\left[\frac{dw_B^{Tradable}}{dt} - \frac{dw_A^{Tradable}}{dt}\right] \quad (29)$$

$$\frac{dp_A}{dt} = \frac{dE}{dt} + \frac{dp_B}{dt} + (1-\theta)\times\left[\frac{dw_A^{Tradable}}{dt} - \frac{dw_B^{Tradable}}{dt}\right] \quad (30)$$

$$\frac{dw_A^{Tradable}}{dt} = \frac{dp_A^{Tradable}}{dt} + \frac{d\,Productivity_A^{Tradable}}{dt} \quad (31)$$

$$\frac{dw_B^{Tradable}}{dt} = \frac{dp_B^{Tradable}}{dt} + \frac{d\,Productivity_B^{Tradable}}{dt} \quad (32)$$

We assumed that the nominal exchange rate is fixed so $\frac{dp_A^{Tradable}}{dt} = \frac{dp_B^{Tradable}}{dt}$. In this case we obtain that:

$$\frac{dp_A}{dt} = \frac{dE}{dt} + \frac{dp_B}{dt} + (1-\theta)\times\left[\frac{d\,Productivity_A^{Tradable}}{dt} - \frac{d\,Productivity_B^{Tradable}}{dt}\right]$$

If nominal exchange is fixed, the country with a higher productivity growth rate will have a higher inflation. In other words, the country with a real convergence toward Euro Area will face with a lower nominal convergence. This is the Balassa – Samuelson Effect and this is its impact on the real and nominal convergence required for Euro Area.

Research methodology

In our study it is proposed a specific measure of convergence based on distances between cases (individual countries or group of countries). There are a lot of methods used to calculate the distance between two points from a multi-dimensional space, in order to assess the convergence between two or more individuals (countries in our case). The most used distances used in convergence analysis are: Euclidian distance, „City Block" (Manhattan) distance, Cebyshev distance, Minkowski of order „m" distance, Quadratic distance, Canberra distance, Pearson correlation coefficient and Squared Pearson correlation coefficient. In our analysis it is used euclidian distances rescaled to 0-1 range (normalized vectors of data).

Euclidian distance measures the distance between a case (country) and another case based on the following formula:

$$d_{ij} = \sqrt{\sum_{k=1}^{n} \left(x_{ik} - x_{jk} \right)^2}$$

This formula is derived from Pitagora distance and is equal with the distance between two points A(x_i, y_i) and B(x_j, y_j) in a space with n dimensions. In our model, the nominal convergence is tested on a number of EU Countries that have not joined the 16-member Euro Zone yet: Bulgaria, Czech Republic, Denmark, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Romania, Slovakia, Sweden and United Kingdom. The nominal convergence it is estimated based on the following indicators:

1. Public balance (as % of GDP): net borrowing (+)/net lending (-) of general government is the difference between the revenue and the expenditure of the general government sector. The general government sector comprises the following subsectors: central government, state government, local government, and social security funds. GDP used as a denominator is the gross domestic product at current market prices.
2. Public debt (as % of GDP): Debt is valued at nominal (face) value, and foreign currency debt is converted into national currency using end-year market exchange rates (though special rules apply to contracts). The national data for the general government sector are consolidated between the sub-sectors. Basic data are expressed in national currency, converted into euro using end-year exchange rates for the euro provided by the European Central Bank.
3. Inflation (based on HICP): Harmonized Indices of Consumer Prices (HICPs) are designed for international comparisons of consumer price inflation. HICP is used for example by the European Central Bank for monitoring of inflation in the Economic and Monetary Union and for the assessment of inflation convergence as required under Article 121 of the Treaty of Amsterdam. For the U.S. and Japan national consumer price indices are used in the table.
4. Long term interest rate: Ten year government bond yields are often used as a measure for long-term interest rates. Yields vary according to the price of the bond. Secondary market means that the bond price is not an issue price (primary market) but determined by supply and demand on the market.
5. Exchange rate: it was measured an annual variation of exchange rate (depreciation or appreciation) based on nominal exchange rates against Euro (excepting Euro Area and Bulgaria that has a currency board and a fixed exchange rate against Euro and it was used an exchange rate against USD).

The nominal convergence were measured based on Euro Area mean calculated by Eurostat. It is assessed also a nominal convergence based on Maastricht criteria for all five variables: public balance less than 3% of GDP (as deficit), public debt less than 60% from GDP, inflation less than 1.5% plus the mean of the top three EU members with lowest inflation, interest rate less than 2% plus the mean of the top three EU members with lowest inflation and exchange rate with a variation less than 15% in absolute value (see Appendix 1).

The real convergence was measured based on system of economic indicators reflecting the economic performance in terms of economic growth, productivity, competitiveness and innovation:

1. GDP growth rate (defines economic growth);
2. GDP per capita in volume (defines productivity);
3. Exports to GDP (measures the international openness and competitiveness);

4. FDI intensity (reflects the openness to international capital);
5. Stock market capitalization (shows the dimension of economy and its development level);
6. Unemployment rate (labor market disequilibrium);
7. Labor cost;
8. R&D expenditures made by private sector (private sector innovation capacity).

Data description

Nominal convergence and real convergence was tested on the following Eastern European member states that didn't accessed Euro Area yet: Bulgaria, Czech Republic, Estonia, Latvia, Lithuania, Hungary, Poland and Romania. It is used annual data about mentioned indicators observed for a period between 1999 and 2007. Data source was Eurostat[2].

Nominal convergence in case of Eastern European Countries

The Euclidian distances calculated against Euro Area for individual countries between 1999 and 2007 reflects a nominal convergence for all countries, excepting Bulgaria.

Nominal convergence with EU Area	1999	2000	2001	2002	2003	2004	2005	2006	2007
Bulgaria	17,02	87,05	43,41	15,25	23,90	32,41	41,51	46,40	48,43
Czech Rep.	55,45	51,32	43,57	40,27	42,70	40,50	41,11	39,25	38,07
Estonia	68,49	65,06	63,98	62,91	66,86	65,62	65,95	64,49	63,73
Latvia	60,33	56,76	54,54	54,73	55,53	55,32	58,30	58,08	58,01
Lithuania	50,95	45,21	45,45	46,00	52,13	51,29	51,94	50,64	50,28
Hungary	21,20	19,94	18,12	14,53	19,80	15,49	10,75	10,93	8,77
Poland	36,96	34,61	32,08	26,24	23,22	25,35	25,79	21,24	22,37
Romania	97,75	89,21	70,37	54,93	51,07	53,52	56,04	56,51	53,71

Table 1: Synthesis of Euclidian Distances toward Euro Area 16 for nominal convergence

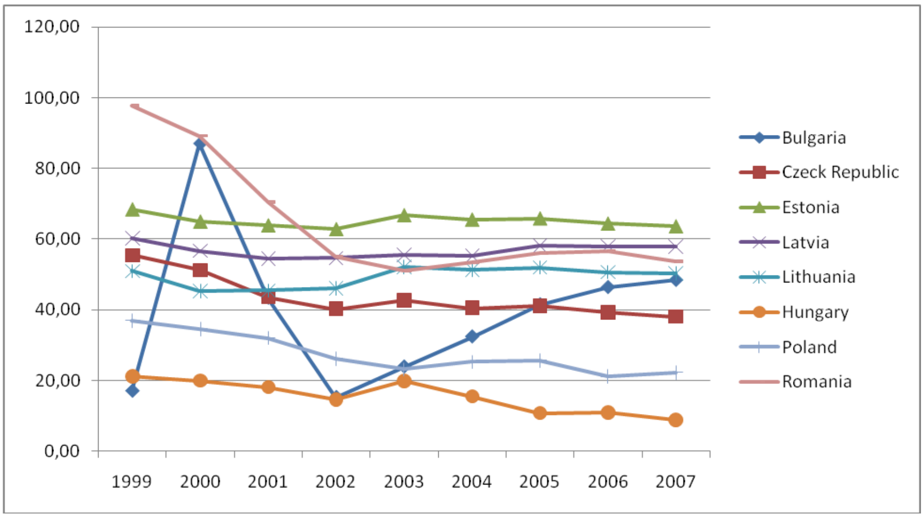

Figure 1: Nominal convergence toward Euro Area for Eastern European Countries

[2] http://ec.europa.eu/eurostat/

In 2007 the closest countries to Euro Area from the perspective of nominal convevergence are Hungary, Czech Republic and Poland. In the same year, the countries with highest distance toward Euro Area are Latvia, Estonia and Romania.

Based on these distances it is estimated a linear trend equation for all countries and it is tested the statistical relevance of this trend (p-value, R-squared and F test).

Countries	Time parameter	P-values	Intercept	P-values	F test signif.	R-squared
Bulgaria	0,284	0,927	38,067	0,059	0,927	0,001
Czech Rep.	-1,840	0,003	52,783	0,000	0,003	0,733
Estonia	-0,235	0,321	66,409	0,000	0,321	0,140
Latvia	0,046	0,869	56,614	0,000	0,869	0,004
Lithuania	0,531	0,168	46,668	0,000	0,168	0,253
Hungary	-1,509	0,001	23,049	0,000	0,001	0,816
Poland	-1,866	0,001	36,870	0,000	0,001	0,822
Romania	-5,073	0,009	90,154	0,000	0,009	0,645

Table2: Trend parameters values and statistical relevance

The parameters estimated for linear trend associated to the evolution of each analyzed country prove a statistical relevance only in case of Czech Republic, Hungary, Poland and Romania. For other countries other trend equation describes better this evolution (for instance in case of Bulgaria a moving average trend seems to fit better). According to this evolution, it was estimated the necessary time (in years) for each country to "catch-up" the Euro Area. Required time for total convergence express in years should be added to the end of 2007 in order to determine the estimated moment. These estimations should be made with the notice that the linear trend is relevant only in case of four mentioned above countries.

Countries	Years	Estimated moment
Czech Rep.	9,68	Aug. 2016
Hungary	6,27	Mar. 2013
Poland	10,75	Sept. 2017
Romania	8,77	Sept. 2015

Table 3: Catching-up Euro Area estimation for Eastern European Countries

The same analysis was made using Maastricht Criteria instead of Euro Area performance. The referential value for inflation and interest rate according to these criteria was initially calculated (see Appendix 1). Euclidian distances show a similar nominal convergence with the previous one.

Nominal convergence with Maastricht	1999	2000	2001	2002	2003	2004	2005	2006	2007
Bulgaria	21,85	86,40	32,38	12,25	14,44	23,75	34,74	40,53	42,79
Czech Rep.	44,76	43,09	36,60	32,14	32,50	33,16	31,29	32,10	33,81
Estonia	55,99	56,95	57,38	56,45	56,65	57,23	57,70	57,98	58,85
Latvia	48,06	48,00	48,35	47,89	45,68	46,70	49,00	51,79	53,13
Lithuania	38,52	36,36	38,82	39,56	41,84	43,35	44,32	44,75	45,71
Hungary	13,54	15,63	17,11	12,31	11,78	15,48	14,58	12,02	12,88
Poland	24,80	26,83	23,89	20,53	13,50	19,00	13,54	17,21	19,41
Romania	92,99	83,45	60,31	45,41	42,09	44,33	44,96	49,33	48,11

Table 4: Synthesis of Euclidian Distances toward Euro Area 16 for nominal convergence

In 2007 the closest countries to Maastricht Criteria from the nominal convevergence perspective are Hungary, Poland and Czech Republic. In the same year, the countries with highest distance toward Euro Area are Estonia, Latvia and Romania.

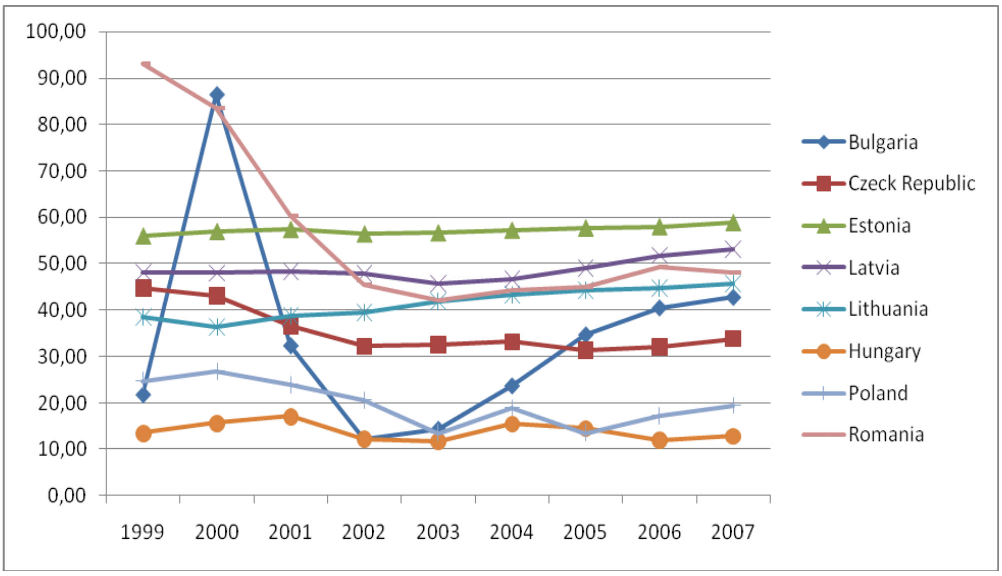

Figure 2: Nominal convergence toward Maastricht criteria for Eastern European Countries

Based on these distances it is estimated a linear trend equation for all countries and it is tested the statistical relevance of this trend (p-value, R-squared and F test).

Countries	Time parameter	P-values	Intercept	P-values	F test signif.	R-squared
Bulgaria	-0,628	0,844	37,486	0,066	0,844	0,006
Czech Rep.	-1,439	0,012	42,689	0,000	0,012	0,614
Estonia	0,266	0,004	55,912	0,000	0,004	0,709
Latvia	0,530	0,076	46,087	0,000	0,076	0,382
Lithuania	1,146	0,000	35,742	0,000	0,000	0,915
Hungary	-0,256	0,320	15,205	0,000	0,320	0,141
Poland	-1,211	0,035	25,911	0,000	0,035	0,494
Romania	-5,227	0,016	82,912	0,000	0,016	0,585

Table 5: Trend parameters values and statistical relevance

The parameters estimated for linear trend associated to the evolution of each analyzed country prove a statistical relevance only in case of Czech Republic, Estonia, Latvia, Poland and Romania. In case of Estonia and Latvia it is registered a positive trend (divergence) in average for the entire period so it is difficult to estimate the required catching-up time based on linear trend.

Countries	Years	Estimated moment
Czech Rep.	10,6627	Aug. 2017
Poland	12,3966	May. 2019
Romania	6,8610	Oct. 2013

Table 6: Catching-up Maastricht Criteria estimation for Eastern European Countries

Real convergence in case of Eastern European Countries

The evolution of Euclidian distances for Eastern European countries between 1999 and 2007 reflects an important convergence of all countries. In 2007 the closest countries to Euro Area are Czech Republic and Poland. In the same year, the countries with highest distance toward Euro Area are Bulgaria, Romania and Hungary.

Nominal convergence with EU Area	1999	2000	2001	2002	2003	2004	2005	2006	2007
Bulgaria	87,71	85,32	69,22	45,40	50,06	52,94	51,52	45,85	44,21
Czech Rep.	65,53	66,23	57,65	34,42	37,49	31,75	25,31	25,83	19,09
Estonia	55,02	54,89	46,72	18,93	19,53	11,88	31,99	32,86	34,46
Latvia	81,23	79,03	61,48	39,54	44,07	46,60	41,40	44,60	48,17
Lithuania	57,86	60,06	47,90	26,86	27,00	22,67	24,64	27,98	29,33
Hungary	52,46	62,33	51,46	35,13	35,00	31,10	25,66	26,45	38,81
Poland	70,59	70,49	58,34	33,29	37,21	30,86	23,88	15,20	12,85
Romania	98,64	95,36	78,98	46,90	48,73	44,06	39,03	37,84	41,29

Table 7: Synthesis of Euclidian Distances toward Euro Area 16 for real convergence

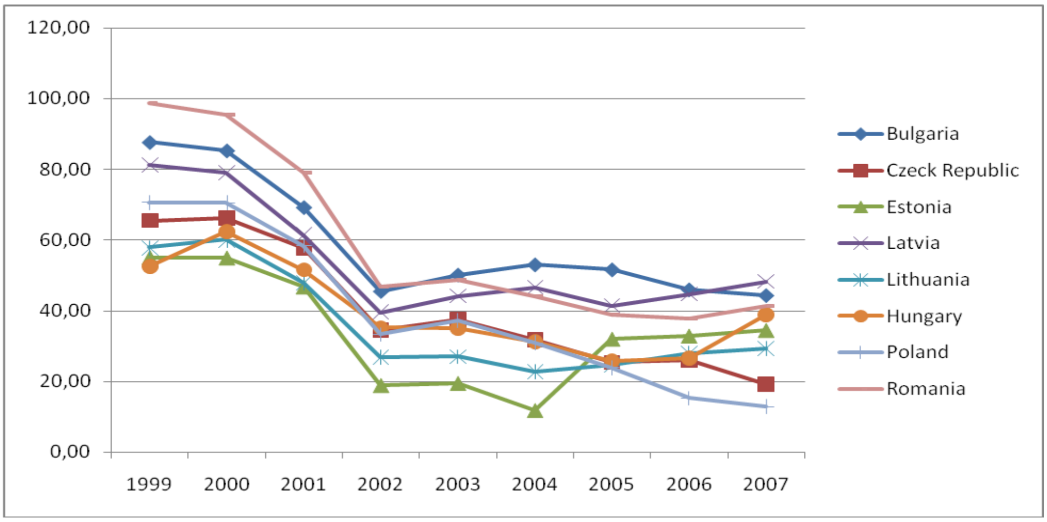

Figure 2: Real convergence toward Euro Area for Eastern European Countries

Based on these distances it is estimated a linear trend equation for all countries and it is tested the statistical relevance of this trend (p-value, R-squared and F test).

Countries	Time parameter	P-values	Intercept	P-values	F test signif.	R-squared
Bulgaria	-5,338	0,004	85,824	0,000006	0,0038	0,721
Czech Rep.	-6,238	0,0001	71,559	0,000001	0,0001	0,895
Estonia	-3,081	0,1356	49,435	0,001946	0,1356	0,289
Latvia	-4,477	0,0168	76,400	0,000031	0,0168	0,582
Lithuania	-4,351	0,0098	57,787	0,000072	0,0098	0,639
Hungary	-3,631	0,0134	57,977	0,000034	0,0134	0,607
Poland	-7,803	0,0000	78,207	0,000001	0,0000	0,926
Romania	-8,079	0,0012	99,373	0,000009	0,0012	0,795

Table 8: Trend parameters values and statistical relevance

The countries with higher rhythm of convergence between 1999 and 2007 are Romania, Poland and Czech Republic. The countries with the lowest rhythm of convergence are Estonia and Hungary. In case of Estonia the trend of real convergence is not relevant from statistical point of view.

According to this evolution, it was estimated the necessary time (in years) for each country to "catch-up" the Euro Area. Required time for total convergence express in years should be added to the end of 2007 in order to determine the estimated moment.

Countries	Years	Estimated moment
Bulgaria	7,0794	Jan. 2014
Czech Rep.	2,4708	Jun. 2009
Estonia	7,0462	Jan. 2014
Latvia	8,0650	Jan. 2015
Lithuania	4,2814	Mar. 2011
Hungary	6,9677	Dec. 2013
Poland	1,0225	2008
Romania	5,3009	Apr. 2010

Table 9: Catching-up Euro Area estimation for Eastern European Countries

The countries that are closest to Euro Area and / or that had a strong "catching-up" rhythm are estimated to reach sooner the average of Euro countries than others: Poland (2008), Czech Republic (2009) or Romania (2010). The result in case of Romania could be explained by its strong economic growth and significant increase in the productivity level. These results reflect the performance of these countries during 9 years and are estimated by comparing individual countries with Euro Area average. A disadvantage for this method is related to the fact that the indicators used in the model for measuring real convergence could be not weighted according to their importance.

Estimating Balassa – Samuelson Effect on Eastern European Countries

As it was defined, Balassa-Samuelson Effect is associated to the incompatibility between real convergence and nominal convergence. Based on the evolution of distances, we estimated real and nominal convergence for Eastern European Countries that didn't acceded Euro Area yet.

	Bulgaria		Czech Rep.		Estonia		Latvia		Lithuania	
Years	**Real**	**Nominal**	**Real**	**Nominal**	**Real**	**Nominal**	**Real**	**Nominal**	**Real**	**Nominal**
1999	87,71	17,02	65,53	55,45	55,02	68,49	81,23	60,33	57,86	50,95
2000	85,32	87,05	66,23	51,32	54,89	65,06	79,03	56,76	60,06	45,21
2001	69,22	43,41	57,65	43,57	46,72	63,98	61,48	54,54	47,90	45,45
2002	45,40	15,25	34,42	40,27	18,93	62,91	39,54	54,73	26,86	46,00
2003	50,06	23,90	37,49	42,70	19,53	66,86	44,07	55,53	27,00	52,13
2004	52,94	32,41	31,75	40,50	11,88	65,62	46,60	55,32	22,67	51,29
2005	51,52	41,51	25,31	41,11	31,99	65,95	41,40	58,30	24,64	51,94
2006	45,85	46,40	25,83	39,25	32,86	64,49	44,60	58,08	27,98	50,64
2007	44,21	48,43	19,09	38,07	34,46	63,73	48,17	58,01	29,33	50,28

Years	Hungary		Poland		Romania	
	Real	Nominal	Real	Nominal	Real	Nominal
1999	52,46	21,20	70,59	36,96	98,64	97,75
2000	62,33	19,94	70,49	34,61	95,36	89,21
2001	51,46	18,12	58,34	32,08	78,98	70,37
2002	35,13	14,53	33,29	26,24	46,90	54,93
2003	35,00	19,80	37,21	23,22	48,73	51,07
2004	31,10	15,49	30,86	25,35	44,06	53,52
2005	25,66	10,75	23,88	25,79	39,03	56,04
2006	26,45	10,93	15,20	21,24	37,84	56,51
2007	38,81	8,77	12,85	22,37	41,29	53,71

Note: Nominal convergence was calculated toward Euro Area

Table 10: Nominal and real convergence in Eastern Europe (estimated Euclidian distances)

Based on this evolution it was tested a regresional model in which the dependent variable is real convergence and independent variable is nominal convergence. The estimators for this regresional model tested on each individual country are presented in the table 11.

Countries	Nominal	P-values	Intercept	P-values	F test signif.	R-squared
Bulgaria	0,2426	0,4216	49,5557	0,0058	0,4216	0,0943
Czech Rep.	2,7594	0,0010	-79,8914	0,0089	0,0010	0,8088
Estonia	2,1335	0,5443	-105,1439	0,6450	0,5443	0,0548
Latvia	3,0201	0,3271	-117,6686	0,4939	0,3271	0,1369
Lithuania	-2,6517	0,1569	166,8207	0,0832	0,1569	0,2642
Hungary	1,9216	0,0403	10,0326	0,4419	0,0403	0,4741
Poland	3,7509	0,0001	-64,1100	0,0016	0,0001	0,9060
Romania	1,3702	0,0001	-29,7936	0,0274	0,0001	0,9123

Table 11: Estimators for statistical test of Balassa-Samuelson Effect on Eastern European Countries

The test of Balassa-Samuelson Effect based on Euclidian distances has a statistical significance only in case of four countries: Romania, Poland, Hungary and Czech Republic. The only country with a negative value for the coefficient of nominal convergence is Lithuania. The countries with highest positive correlation between real and nominal convergence are: Romania, Poland, Hungary and Czech Republic. Balassa-Samuelson Effect is present only in case of the following group of countries: a group composed by a single country - Lithuania (in this case we have a negative correlation between nominal and real convergence) and another group of countries including Estonia, Latvia and Bulgaria (in this case we have a weak positive correlation between real and nominal convergence).

Final conclusions

Balassa-Samuelson effect states a very interesting incompatibility between real and nominal convergence. These tensions are very strong and, if the catching-up process is accelerated there could be induced serious pressures at the level of less developed countries interested to adopt Euro. Balassa-Samuelson effect is due to the differences of productivity level between countries and currency area in tradable sectors. This effect is could be also generated by different growth rates for productivity in tradable sector. The main impact is on real exchange rate and inflation level.

The main conclusions that could be drawn from this study are the following:

- We assisted to a visible nominal convergence of Eastern European Countries toward Euro Area and Maastricht Criteria;
- Real convergence of Eastern European Countries has a different evolution than nominal one being more accelerated in the last years;
- In the case of real convergence, Eastern European Countries registered a more homogenous evolution than in case of nominal convergence;
- The countries with highest nominal convergence rhythm are: Czech Republic and Latvia;
- The countries with highest real convergence rhythm are: Poland, Czech Republic, Romania and Bulgaria;
- In 2007 the closest countries to Euro Area from the perspective of nominal convergence are Hungary, Czech Republic and Poland. In the same year, the countries with highest distance toward Euro Area are Latvia, Estonia and Romania;
- In 2007 the closest countries to Euro Area from the perspective of real convergence are Czech Republic and Poland. In the same year, the countries with highest distance toward Euro Area are Bulgaria, Romania and Hungary.
- Balassa-Samuelson Effect measuring the compatibility between real and nominal convergence based on Euclidian Distances has a week evidence at the level Eastern European Countries;
- Clear evidences of Balassa-Samuelson Effect is registered only in case of Lithuania;
- Another group of countries registered a weak positive correlation between real and nominal convergence: Estonia, Latvia and Bulgaria;
- A distinct group of countries registered a high positive correlation between real and nominal convergence: Romania, Poland, Hungary and Czech Republic;
- Nominal and real convergence rhythm tested in case of Romania and taken into consideration the period between 1999 and 2009 indicated that the time horizon of adopting Euro around 2014 is achievable.

The results obtained by this study didn’t take into consideration the economic effects of current crisis that started to be visible in Eastern Europe with the beginning of the second part of the year 2008 (this study depends on the availability of data on Eurostat). We estimate that this crisis will significantly reduce the economic growth rate, the dynamic of innovation, competitiveness and the dynamic of productivity in tradable and non-tradable sector. It is quite clear that current crisis will reduce the nominal and real convergence for Eastern European Countries and will increase the required time for these countries to catch-up Maastricht Criteria or Euro Area performance. In case of those countries that registered a high positive correlation between nominal and real convergence (Romania, Poland, Hungary and Czech Republic) we estimate a higher deterioration of real convergence due to the deterioration of nominal convergence as consequence of current crisis. In further studies that will be made, the trend associated to different countries will be better fitted (it will be tested other trends than linear when it is not obtained a statistical significance), the sample date will be extended and will be included other countries that are outside from Euro Area and will test different regresional models for Balassa-Samuelson Effect (other than simple regression).

Appendix 1: Maastricht Criteria for inflation and interest rate

Inflation rate criteria

EU Treaty definition: Price stability criteria = 1.5% more than average of 3 best performing Member States

Country	**1996**	**Country**	**1997**	**Country**	**1998**	**Country**	**1999**	**Country**	**2000**	**Country**	**2001**
Luxemb.	0,6	Austria	1,2	Germany	0,6	Austria	0,5	UK	0,8	UK	1,2
Austria	0,6	Finland	1,2	France	0,7	Sweden	0,5	Sweden	1,3	France	1,8
Belgium	0,8	Ireland	1,3	Austria	0,8	France	0,6	Germany	1,4	Germany	1,9
Maastricht	*2,10*	*Maastricht*	*2,73*	*Maastricht*	*2,20*	*Maastricht*	*2,03*	*Maastricht*	*2,67*	*Maastricht*	*3,13*
Country	**2002**	**Country**	**2003**	**Country**	**2004**	**Country**	**2005**	**Country**	**2006**	**Country**	**2007**
UK	1,3	Germany	1	Finland	0,1	Finland	0,8	Poland	1,3	Malta	0,7
Germany	1,4	Austria	1,3	Denmark	0,9	Sweden	0,8	Finland	1,3	France	1,6
Belgium	1,6	Finland	1,3	Sweden	1	Netherlands	1,5	Sweden	1,5	Netherlands	1,6
Maastricht	*2,93*	*Maastricht*	*2,70*	*Maastricht*	*2,17*	*Maastricht*	*2,53*	*Maastricht*	*2,87*	*Maastricht*	*2,80*

Source: estimations based on Eurostat data

Inflation	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Maastricht	2,10	2,73	2,20	2,03	2,03	2,67	3,13	2,70	2,17	2,53	2,87	2,80

Source: estimations based on Eurostat data

Long term interest rate criteria

EU Treaty definition: Interest rate criteria = 2% more than average of 3 best performing Member States

Country	**1996**	**Country**	**1997**	**Country**	**1998**	**Country**	**1999**	**Country**	**2000**	**Country**	**2001**
Luxemb.	6,32	Austria	5,68	Germany	4,71	Austria	4,68	UK	5,33	UK	5,01
Austria	6,32	Finland	6,29	France	4,57	Sweden	4,98	Sweden	5,37	France	4,80
Belgium	6,49	Ireland	5,96	Austria	4,64	France	4,61	Germany	5,26	Germany	4,94
Maastricht	*8,38*	*Maastricht*	*7,98*	*Maastricht*	*6,64*	*Maastricht*	*6,76*	*Maastricht*	*7,32*	*Maastricht*	*6,92*
Country	**2002**	**Country**	**2003**	**Country**	**2004**	**Country**	**2005**	**Country**	**2006**	**Country**	**2007**
UK	4,91	Germany	4,07	Finland	4,11	Finland	3,35	Poland	5,23	Malta	4,72
Germany	4,99	Austria	4,15	Denmark	4,30	Sweden	3,38	Finland	3,78	France	4,30
Belgium	4,78	Finland	4,13	Sweden	4,43	Netherlands	3,37	Sweden	4,37	Netherlands	4,29
Maastricht	*6,89*	*Maastricht*	*6,12*	*Maastricht*	*6,28*	*Maastricht*	*5,37*	*Maastricht*	*6,46*	*Maastricht*	*6,44*

Source: estimations based on Eurostat data

LT interest rate	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Maastricht	8,38	7,98	6,64	6,76	7,32	6,92	6,89	6,12	6,28	5,37	6,46	6,44

Source: estimations based on Eurostat data

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