BETA AND SIGMA CONVERGENCE OF V4 COUNTRIES AND THE EUROPEAN UNION

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Abstract

In the first half of the nineties, the Visegrad group countries (the Czech Republic, Hungary, Poland, and Slovakia) had a significantly lower real gross domestic products per capita than the European Union average was. In the paper, we solve two problems. The first one is whether four Visegrad countries, based on cooperation with EU countries as well as their EU membership, were able to gradually reach the average European level of real gross domestic product per capita during the last 25 years. The second and related problem is whether is observable in a gradual reduction of differences in the real gross domestic products per capita among the Visegrad group countries in the same period. We apply the beta convergence criterion to evaluate the relationship between the Visegrad group countries and the European Union. The beta and sigma convergence criteria were used to solve the second problem.

Keywords: beta convergence, sigma convergence, European union, Visegrad group, V4

JEL code: O47, O52

Introduction

In the early nineties, immediately after the collapse of the Soviet bloc, the discussion about the participation of Central and Eastern European countries in the European Union started. The formal expression of this discussion can be regarded as the Copenhagen criteria, defined at the meeting of the European Council in 1993. Ten candidates (eight Central and Eastern European countries - the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, and Slovenia - plus two Mediterranean countries - Malta and Cyprus) join the European Union on 1 May 2004.

The Copenhagen criteria require, inter alia, the existence of a functioning market economy as well as the capacity to cope with competitive pressure and market forces within the European Union. From the long-run perspective, we can assess the capacity to cope with competitive pressure and market forces within the Union by the convergence criteria.

There is not only the problem of the relationship between these ten countries and "old" EU members but also the mutual relations between these ten countries. The Visegrad group was founded on 15 February 1991 and now it is one of several regional bodies within the EU. The current members of the Visegrad group (or Visegrad Four, V4) are the Czech Republic, Hungary, Poland, and the Slovak Republic. Further regional bodies within the EU are Benelux (Belgium, the Netherlands, Luxembourg), Nordic Council of Ministers (Denmark, Finland, Iceland, Norway, Sweden), and Baltic Assembly (Estonia, Latvia, and Lithuania). All the activities of the Visegrad group are aimed at strengthening stability in the Central European region and the whole European Union.

In the first half of the nineties, the Visegrad group countries had a significantly lower real GDP per capita than the EU-28 average. The first solved question is whether Visegrad four, based on cooperation with EU countries as well as EU membership, was able to gradually reach the average European level of GDP per capita. We will apply the beta convergence criterion to evaluate the relationship between the Visegrad group countries and the European Union.

The second and related question is whether possible beta convergence resulted also in a gradual reduction of differences in the real GDP per capita among the V4 countries. We will apply the sigma convergence criterion to solve this problem.

1 Methodology

From a theoretical point of view, we can distinguish between real and nominal convergences. Real convergence may be defined as the process whereby the real GDP per capita levels of lower-income economies catch up, on a durable basis, with those of higher-income economies. Barro and Sala-i-Martin (1992) convergence defined as the tendency for poor economies to grow faster than rich economies.

Nominal convergence is defined here as the process of converging price levels of two countries or groups of countries. The process of nominal convergence can be understood differently:

- convergence of the price levels of goods and services only
- convergence of the level of nominal variables in a broader sense (prices, incomes, etc.)
- meeting the five Maastricht convergence criteria

In the literature, real and nominal convergence is captured by several concepts. In the empirical part of our contribution, we will regard the concepts of beta and sigma convergences.

In the literature, convergence is captured by several concepts. For example, Galor, Oded (1996) or Rojíček (2016) distinguishes the following theoretical approaches:

- Absolute convergence is the process by which countries converge to one common value of a given indicator (e. g., GDP per capita), regardless of a given starting level and structural characteristics of the economy. The implication is the lower initial GDP will lead to a higher average growth rate.

- Conditional convergence is a process in which countries with different initial values of a given indicator converge only if they show identical structural characteristics. The implication is that structural characteristics (e.g., preferences, technologies, rates of population growth, government policies, etc.) determine the long-run level of a given indicator (e. g., GDP per capita).

Generally speaking, the beta convergence (β-convergence) occurs when lower-income economies grow faster than higher-income economies, i.e. they experience a process of catching up.

Suppose the interval between dates 0 and T. Let g represent the average growth rate of the real GDP per capita between dates 0 and T, and y_0 represents the initial level of the real GDP per capita at time 0. If we apply the simple linear regression approach we get a regression function

$$g = \alpha + \beta \, y_0 \qquad (1)$$

The regression function is represented by a straight line with slope β and y-intercept α. A negative parameter β indicates that convergence is occurring. The higher the absolute value of the parameter β, the more rapid the convergence is.

We will use the compound annual growth rate (CAGR) for the calculation of the average growth rate of the real GDP per capita between dates 0 and T. CAGR describes the rate at which the GDP per capita would have grown if it had grown the same rate every year. The formula for calculating CAGR is:

$$CAGR = (y_T / y_0)^{1/n} - 1 \qquad (2)$$

y_0 is the initial level of the real GDP per capita; y_T is the real GDP per capita at the end of the period and n is the number of years.

For empirical verification of beta convergence, the following formula is often used (Barro, Sala-i-Martin, 1992) or (Slavík, 2007):

$$\frac{1}{n}\log\left(\frac{y(T)}{y(0)}\right) = \alpha + \beta \log(y_0) \qquad (3)$$

Sigma convergence means a reduction in the dispersion of a given indicator (e. g., GDP per capita) across economies. In the simplest case, sigma convergence can be characterized by the evolution of the variance (or standard deviation) of an indicator over time (Simionescu, 2014). The variance is computed as:

$$\sigma^2 = \frac{1}{n} \sum_1^n (y_i - y^*)^2 \qquad (4)$$

For small samples the denominator is replaced with (n-1) instead of n; y_i is the variable, i is the index for countries, y*is simple arithmetic average:

$$y^* = \frac{1}{n} \sum_1^i y_i \qquad (5)$$

The variance is used to calculate the standard deviation ($\sigma = \sqrt[2]{\sigma^2}$) and the coefficient of variation ($CV = \sigma / y^*$). The coefficient of variation is useful in convergence analysis because it does not depend on the unit of measurement and the measure order of the indicators and it allows making comparisons.

Let time series are used on a discrete interval from t to T. The decreasing variation indicates the existence of a convergence process. In a certain period, if the variance of the variable decreases the convergence process took place, i.e.,

$$\sigma_T < \sigma_t \qquad (6)$$

When the variance grows the divergence process took place, i.e.,

$$\sigma_T > \sigma_t \qquad (7)$$

Finally, we have to remark the beta and sigma convergences are not independent. Sala-i-Martin (1995) points out that sigma convergence is sufficient but not necessary for beta convergence. This result implies that the absence of sigma convergence cannot be taken as implying the absence of beta convergence.

In the empirical part of the contribution, we will deal with the real convergence processes between the Visegrad group and the EU-28 and also within four Visegrad group countries. For the analysis of the relationship between the Visegrad group and the EU-28, we will apply the

concept of absolute beta convergence. For the analysis of the relationship among four Visegrad group countries, we will apply the concept of sigma convergence.

2 Visegrad Group and the European Union: Beta Convergence

We analyse the situation in the period 1992 – 2019. For all Visegrad group countries and the whole period, GDP per capita in purchasing power parity (PPP) is below the average of the EU-28 or EU-27 (if we include the United Kingdom or not). The question is whether the V4 countries gradually approached the European Union average during this period.

Let's start solving the problem of beta convergence by visualizing this problem. In Figure 1, we apply data for the GDP per capita. Gross domestic product is expressed in current international dollars converted by purchasing power parity conversion factor. The conversion factor is a spatial price deflator and currency converter that controls price level differences between countries. Total population is a mid-year population based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. Subsequently, we adjusted the data for the Visegrad group countries so that they are expressed to the European Union average set to equal 100.

Fig. 1: GDP per capita, PPP (current international USD), EU28 in 2019 = 100
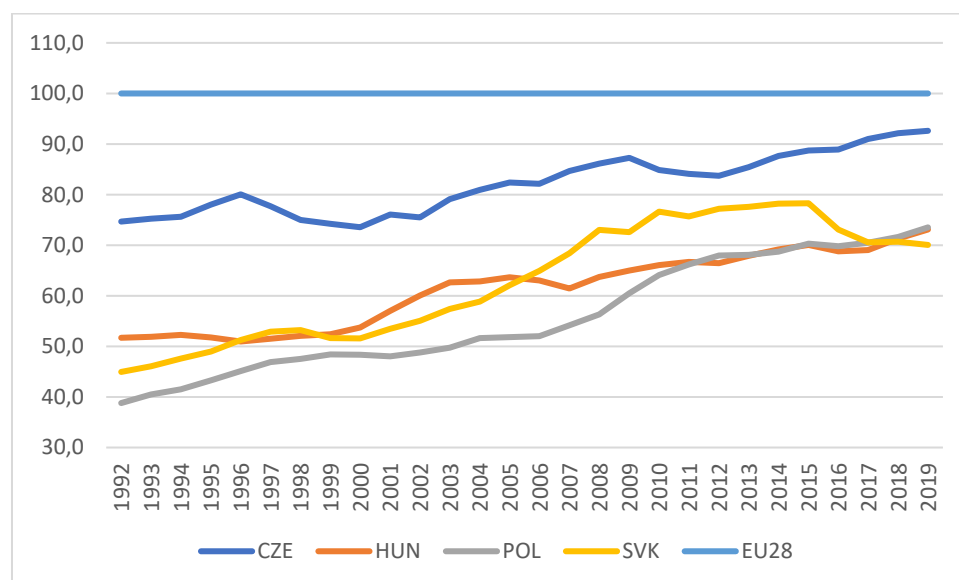
Source: own calculation, based on World Bank-Eurostat-OECD PPP Programme (2021)

We can reach similar conclusions using data available in the Eurostat database. Figure 2 shows the development of the gross domestic product per capita in purchasing power standard (PPS) indicator in the period 2008 – 2019. The volume index of GDP per capita in PPS is expressed to the EU-27 average set to equal 100.

Fig. 2: Volume indices of real expenditure per capita (in PPS, EU27 in 2020 = 100)
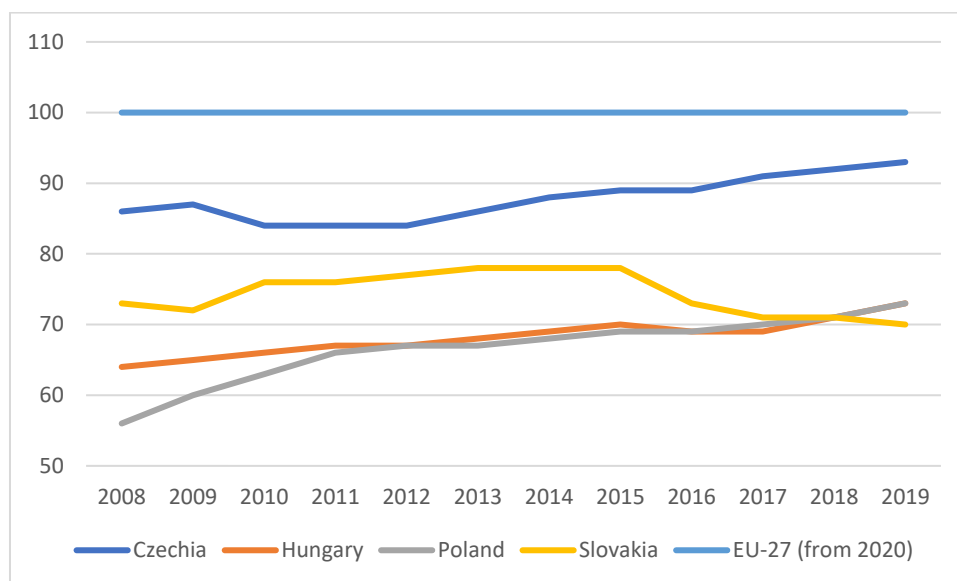
Source: Eurostat (2021)

Figures 1 and 2 indicate that all four Visegrad countries are gradually approaching the average level of real GDP per capita in PPP for all EU-27 (EU-28 respectively) countries. Both figures suggest that beta convergence occurred during the considered period.

Now we apply equation (3) and data from Table 1 to estimate beta convergence for EU-28 countries in the years 1995 - 2019.

Tab. 1: GDP per capita, PPP (current international USD)

	1992	1995	2019
Austria		23 640	60 418
Belgium		22 392	56 349
Bulgaria		7 724	25 312
Cyprus		17 065	41 254
Czech Republic	11 893	13 826	44 296
Germany		23 508	57 530
Denmark		22 641	62 090
Spain		16 248	43 496
Estonia		6 457	39 986
Finland		19 540	53 172
France		20 727	50 993
United Kingdom		20 504	49 932
Greece		15 395	32 506
Croatia		7 996	31 131
Hungary	8 237	9 170	34 966
Ireland		18 921	89 684
Italy		22 341	45 723

Lithuania		5 916	40 016
Luxembourg		39 601	124 591
Latvia		5 501	33 021
Malta		13 957	47 578
Netherlands		23 389	61 285
Poland	6 178	7 667	35 165
Portugal		14 372	37 918
Romania		5 416	33 340
Slovak Republic	7 158	8 677	33 516
Slovenia		13 595	42 431
Sweden		23 050	56 632

Source: World Bank-Eurostat-OECD PPP Programme (2021)

In Table 2, we present the results for four models. The first one (EU28, 1995 – 2019) considered development in all 28 members of the European Union. But data for two countries (Ireland and Luxembourg) are significantly different from other countries. These two countries showed high growth at a high starting level of GDP per capita. For this reason, we did not include data for these two countries in the second model (EU26 (1995 – 2019). This operation increased the value of the correlation coefficient but it has no significant impact on the beta coefficient.

Tab. 2: Beta convergence

Model	α	β	R^2
EU28 (1995 – 2019)	0,1052	0,0204	0,643
EU26 (1995 – 2019)	0,1221	0,0247	0,8339
V4 (1995 – 2019)	0,1114	0,0223	0,8931
V4 (1992 – 2019)	0,1037	0,0207	0,8931

Source: own computation

Both models for the European Union confirm that beta convergence has taken place over the years 1995 – 2019. A negative beta coefficient confirms that countries with a lower beginning level of real GDP per capita showed higher average annual economic growth between 1995 and 2019.

The third and fourth models consider the situation only in four Visegrad countries (the Czech Republic, Hungary, Poland, and Slovakia). The third model (V4, 1995 – 2019) analyses data for the same period as the models for the EU did. Although data before 1995 were not available for some EU countries, data for the V4 countries were. This allowed us to prepare the fourth model for the V4 countries, which considered the longer period.

Also, both models for the Visegrad group countries show a negative value of the beta coefficient. It confirms that countries with a lower beginning level of GDP per capita are connected with higher average annual economic growth.
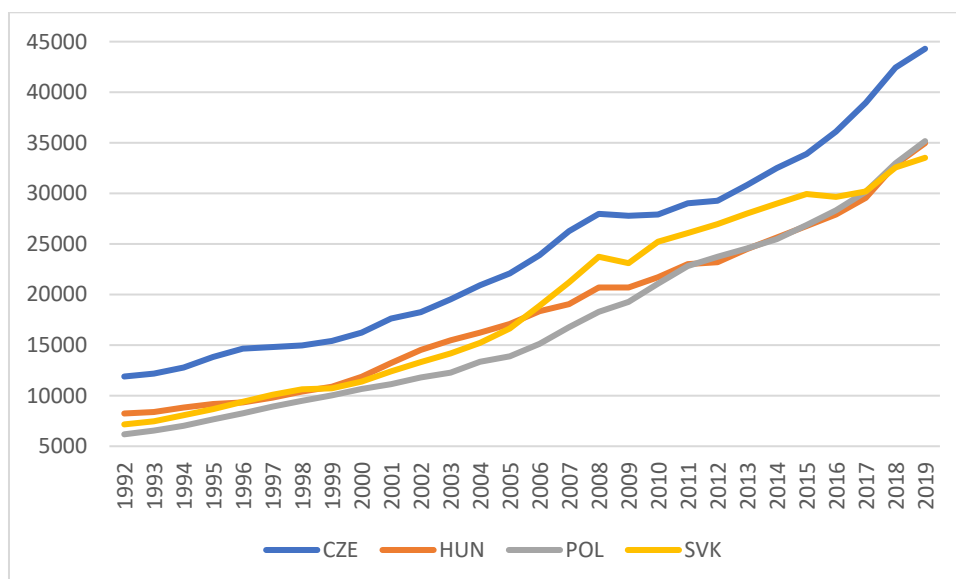
3   Inside the Visegrad Group: Sigma Convergence

As already mentioned in the methodological part of the paper, the existence of beta convergence does not automatically ensure that there will also be sigma convergence.

We try to solve the relation between beta and sigma convergence on data for the countries of the Visegrad Group for the years 1992 - 2019. In the first half of the nineties, the Visegrad countries had a significantly lower real GDP per capita than the EU-28 average. In the previous section, we showed that there was beta convergence between EU countries. This also resulted in a gradual convergence of the real GDP per capita in V4 countries to the average in the EU. The question is whether beta convergence resulted also in a gradual reduction of differences in the real GDP per capita among the V4 countries (i.e. led to sigma convergence).

Again, we will start solving the problem of sigma convergence by visualizing this question. Figure 3 illustrates the volume of the real GDP per capita in purchasing power parity in current international US dollars. It is evident the disparities among Hungary, Poland and Slovakia decreased, and the difference between the Czech Republic and other V4 countries remained.

Fig. 3: Real GDP per capita of Visegrad group countries (purchasing power parity, current international USD, 1992 – 2019)

Source: own calculation, based on World Bank-Eurostat-OECD PPP Programme (2021)

To verify whether sigma convergence occurs among the countries of the Visegrad Group, we use the coefficient of variation (reasoning for the use of this indicator, see the methodological part of the contribution).

Fig. 4: Sigma convergence (coefficient of variation) for the Visegrad group countries
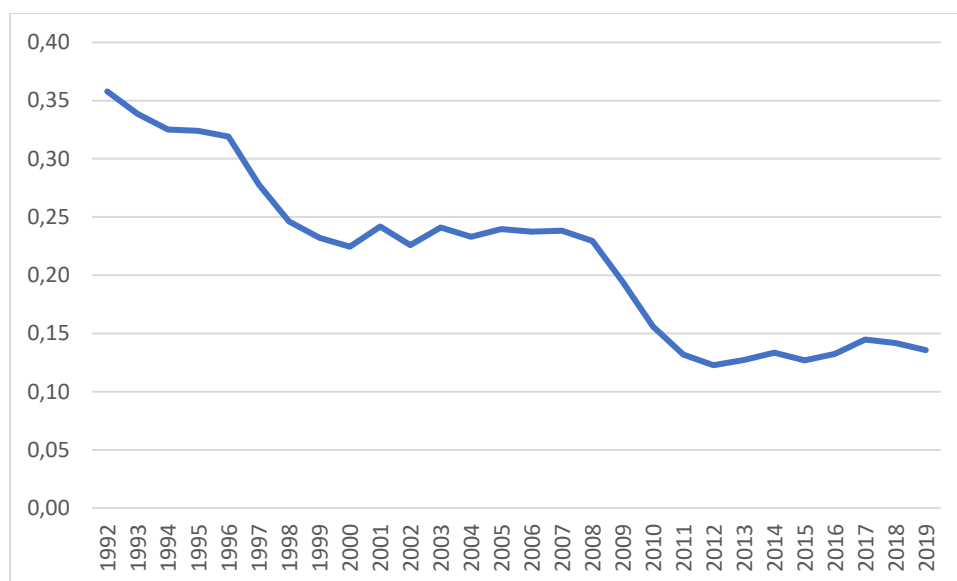
Source: own calculation, based on World Bank-Eurostat-OECD PPP Programme (2021)

We calculated the average amount of real GDP per capita for the V4 countries and on this basis, we calculated the variance and the coefficient of variation. Figure 4 shows a long-term decrease in the coefficient of variation, which is accompanied by certain periods when its value stagnated. However, in the long run, sigma convergence prevailed during the analysed period. We can confirm a gradual reduction of differences in the real GDP per capita among the V4 countries.

Conclusion

In our models, we apply beta and sigma convergence criteria to address two problems related to the comparison of the economic performance of the Visegrad Group countries.

The analysis confirmed beta convergence between all the countries of the European Union including the Visegrad group countries in the years 1995 - 2019. The existence of beta convergence resulted in a gradual convergence of the real gross domestic product per capita in purchasing power parity in V4 countries to the average in the EU.

The analysis of beta and sigma convergence for the Visegrad group countries in the period 1992 – 2019 confirmed a gradual reduction of differences in the real gross domestic products per capita among the Visegrad group countries.

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