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REGIONAL GROWTH AND CONVERGENCE OF THE NUTS 3 REGIONS OF EASTERN EUROPEAN COUNTRIES

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The catch-up of Eastern European economies to EU-15 countries has come into prominence since the early 1990s. In our analysis, we use NUTS2/3 delimitation and per capita GDP in PPS USD and chain linked volumes in euro data for the period of 2000-2014 with shorter sub-sample periods. The per capita GDP doubled on the average in the reference period, with relatively high differences. Neither beta convergence nor sigma convergence cannot be proved, instead we can observe the twin-peaks phenomenon of convergence clubs. The growth rates are country-specific and agglomeration externalities can be proved.

Keywords: convergence, Visegrad countries, econometric models
JEL codes: R11, R12, C21, C22

1. Introduction

Following the Solow growth model, the convergence process has appeared in the economic literature. However, it has become a hot topic through the work of Barro and Sala-i-Martin in the early 90s. We have several definitions, approaches, and measurement possibilities. Over convergence (and divergence), independent analysis of catch-up or levelling appeared. Through the improvement of econometric methods, not only beta and sigma convergence can be verified, but their absolute, conditional and club versions.

The catch-up of Eastern European economies to EU-15 countries has come into prominence since the early 1990s. Many papers analyzed it at country level (for an earlier overview, see Rey 2001), but to meet European regional policy goals, the regional level analysis of the convergence process has become crucial (Dall'erba-Le Gallo 2008). It is also shown that regional level processes can be different from state level (Young et al 2008). A wide range of theoretical literature is available from a regional economics perspective (Abreu 2014; Capello-Nijkamp 2009; Lengyel 2010; McCann 2013), but new streams include evolutionary economic geography (Acs-Sanders 2014; Elekes 2016; Varga 2009) or urbanization factors (Lengyel-Szakálné Kanó 2012). In most cases, these researches focus on NUTS2 regions as Structural Funds sources are distributed at this level, only a few of them has been realized at NUTS3 level (e.g. Artelaris et al 2010, Bourdin 2013 and 2015, Kotosz 2016), but the use of a NUTS2/3 nomenclature created by considering functional urban areas is very rare. In our study, the four Visegrad countries (Czech Republic, Hungary, Poland, Slovakia) are under investigation for the period of 2000-2014, with shorter sub-sample periods (2000-2004 as the before EU-accession period, 2004-2008 as the pre-crisis golden age, and 2010-2014 as the resilience period).

In our paper, we focus on two issues, once the catch-up of V4 countries to the EU-15 level, and their convergence without considering extern reference level. While the first is better a social phenomenon, and we used data in purchasing power parity, the real convergence can be better approximated by the production, so the chain linked volumes in euro were chosen for the second aim. In this exploratory analysis, we do not consider the spatial interdependence (spatial autocorrelation, spatial regression). We are looking for answers to the following questions:

- Can we observe convergence or divergence?
- Is this tendency stable over time?
- What are the factors contributed to differences of growth performance?
- Do countries, metropolitan regions have distinct paths?

The remaining part of the paper is constructed as the following. Section 2 is devoted to the general issues of convergence literature review. In section 3, we describe our dataset and the statistical methods we used in the analysis. Section 4 is devoted to empirical findings, results about the catch-up to EU-15 level and convergence of the analyzed regions of the Visegrad countries. At the end, we conclude.

2. Theoretical review

First, we discuss the approaches of convergence.

1. Absolute convergence is the situation when lagging regions are converging towards developed regions without any additional condition. From the point of view of the neoclassical growth theory, regions are converging to the same steady state (Solow, 1956). As this approach does not need control variables, its measurement is the easiest, and can be done both in σ and β approach. (Barro-Sala-i-Martin 1991).
2. Conditional convergence can be proved in the presence of control variables, so this approach allows to have constant differences caused by control variables determined steady states. It is close to the idea of the proof of economic model by econometric tools (in the concept of β-convergence we can easily add control variables).
3. Club convergence was introduced by Baumol (1986). In this approach convergence is determined by initial conditions (that determines clubs, e.g. members of the European Union), and club members converge to the club steady state, while other regions converge to other steady state if at all. It can be measured by club-specific regressions, in the framework of β-convergence (with time invariant control variables) or by ω-convergence (Gáspár 2010). Based on the idea of Chatterji (1992), this approach can be extended through non-linear version of the β-convergence regression (Alexiadis 2013). The number of supposed convergence clubs is always depending on the modeler (Guetat-Serenito 2008). First results about Eastern European convergence clubs are published in Artelaris et al (2010) and Simionescu (2015).

Most common methods of measuring of convergence are based on comparison of distributions in time or on cross-sectional regressions. In the first family, several indicators of a distribution can be used (see e.g. Monfort 2008), but the most widely used solution is a variance based one. As in regional growth, relative differences are more important than absolute ones, the coefficient of variation is the preferred one. A decrease of differences is defined as convergence, so in econometrics, a significantly decreasing trend is a proof of convergence. The simplest equation is the following:

$$V_t = \beta_0 + \beta_1 \cdot t + \varepsilon_t \tag{1}$$

where V_t is the coefficient of variation in period t.

As a simple measure of inequality, we applied the Theil-index, and as in the σ-convergence analysis, the core indicator is the coefficient of variation, the variance was also used.

In chapter 4.1, for the analysis of catch-up, we preferred the Theil-index because of its decomposability. The index is a special case of generalized entropy. Its formula as given by Dusek-Kotosz (2016) and Lengyel-Szakálné Kanó (2012):

$$T = \frac{1}{n}\sum_{i=1}^{n}\left[\frac{y_i}{\bar{y}}\ln\left(\frac{y_i}{\bar{y}}\right)\right] \tag{2}$$

where $\bar{y}$ is the mean. Its set of values is the $[0;\ln n)$ interval, dividing by $\ln n$, it can be normalized to the $[0;1)$ interval. Its 0 value suggests the lack of inequalities, while its maximum can be reached when the observed phenomenon is concentrated in one territorial unit (in our example it would mean to have economic activity in only one county). When applied for a relative measure (e.g. GDP per capita), its weighted version should be applied. This version conserves the characteristics that higher inequalities are indicated by higher index value (Major-Nemes Nagy 1999).

The Theil index – as all entropy-based measure – can be decomposed into two or more levels (Galbraith-Hale 2014). In our example, inequalities between counties of the V4 countries can be decomposed to a part of inequalities between countries (between differences) and to a part of inequalities between the counties within the countries (within differences). Technically, the value of the index is equal to the sum of the Theil index of group averages (country indicators) and the weighted average of within group (country) Theil indices. The proportion of within and between sums can be interpreted as percentage contributions to the total inequalities. If we have *m* groups (countries) let $\bar{y}_i$ be the mean of groups (countries), s_i, the share of the *i*th group (country) of the sum, while T_{T_i} the Theil index of the *i*th group (country):

$$T = \sum_{i=1}^{m} s_i T_{T_i} + \sum_{i=1}^{m} s_i \ln \frac{\bar{y}_i}{\bar{y}} \quad (3)$$

A cross-sectional test of convergence is β-convergence (Fuss, 1999). Its test equation is

$$\frac{lny_{jt} - lny_{j0}}{t} = \alpha - \beta \cdot lny_{j0} + \varepsilon_j \quad (4)$$

where y_j is the value of interest (e.g. income) in region j, t and 0 are for time periods, α and β are parameters to estimate, while ε is the random variable (Rey-Janikas 2005).

Conditional convergence is written in the general growth regression form:

$$\frac{lny_{jt} - lny_{j0}}{t} = \alpha - \beta \cdot lny_{j0} + \sum_{i=1}^{k} \theta_i \cdot x_{ji} + \varepsilon_j \quad (5)$$

where x_i are control variables.

It can be proved that speed of convergence (b) can be comptued by the following formula:

$$b = -ln(1 + \beta t)/t \quad (6)$$

The half-life of the convergence is now ${}^{ln2}/_{b}$. (Oblath 2013)

Urbanization of regions is considered and empirically proved driving power in regional growth by Huggins and Thompson (2017) or by Czaller (2016) in an Eastern European perspective. Cuaresma et al (2015) conclude that regions including the capital cities have better growth performance, especially in Central and Eastern Europe. They also report the positive impact of people with higher education degree. Pede (2013) focused on the role of variety (economic sectors, race, education) measured by entropy, and concludes that generally higher diversity is better for growth. In their city-level study, González-Val and Olmo (2015) found that population density has a negative impact on growth of cities; proportion of people with higher education has a positive, and proportion of people with secondary education has no impact.

Capello et al (2015) offer a typology of regions to separate regions with different growth paths. A modification of this classification (see Table 1) is applied in this article.
A series of studies emphasize the importance of national impact, including Forgó-Jevcak (2015) where country differences explained by different macroeconomic processes and policies or Thissen et al (2016), where the population is also reported having positive impact. Cortinovis et al (2016) suggest that the regional governance matters, while by McCann and Oort (2009) national and regional institutions have positive impact on growth. Kotosz (2005) could also show the impact of country borders. The money walls of Bourdin (2013) are Structural Funds determined convergence clubs in the iron curtain regions.

Table 1. A typology of regions

Type of region	Quantitative criteria
Agglomeration	A city with more than 300,000 inhabitants, and population density is over 300 people/km^2.
Urban region	Neither agglomeration, nor rural region.
Rural region	Population density is below 100 people/km^2.

Source: Based on Capello et al 2015, with modifications

3. Data and methods

3.1. Data

The measurement of the economic performance is not free of tensions (Stiglitz et al 2009), but the most widely used and available data is the gross domestic product (GDP). Due to demand of regional decision makers and scientists, the regional GDP is also estimated. In the European Union, common principles help data users, and a widening range of data is available at low territorial level. However, changes in the definition of the GDP and redrawing of the map of the European regions does not help the users to find consistent data in time and space. Our data is based on the ESA2010 standard.
When we consider comparison in space, we also face the problem of currencies, shifts in exchange rates modify inferences on the convergence process. To avoid distortions, in the first part of the analysis (catch-up) we used the purchasing power parity point of view, our data is expressed in purchasing power standard, while we used the chain linked volume approach in the convergence analysis. The first solution is closer to the catch-up idea, the disappearance of inequalities in Europe, and as there is a general convergence of prices in the EU, a common base of calculation is expedient. When we are looking for real convergence, the use of volume indices is advisable to filter out price changes. In the lack of low territorial level price index, all these measures are approximative estimations, exertion of multiple solutions can prove (or reject) the robustness of the results (Dusek-Kiss 2008).
Our time horizon is also limited by the availability of data. After several changes in the NUTS3 regions in Eastern Europe, especially in Poland, the NUTS2013 delimitation was applied. At the desired territorial level – due to frequent changes of the NUTS nomenclature – comparable data is not available before 2000. In our analysis, we use NUTS2/3 delimitation based on metropolitan regions' distortion effects and functional urban areas suggested by the ESPON

documents (Grasland-Madelin, 2007, Bourdin 2013). Finally, we got 99 territorial units, 13 in the Czech Republic, 19 in Hungary, 60 in Poland, 7 in Slovakia. For simplicity, hereafter, we use the term ‘county’ for these units. The unified NUTS3 regions:

- Czech Republic: Praha+ = Praha and Středočeský,
- Poland: Warsaw+ = M. Warszawa, Warszawski-wschodni and Warszawski-zachodni; Łódź+ = M. Łódź and Lódzki; Kraków+ = M. Kraków and Krakowski; Katowicki+ = Katowicki, Bytomski, Gliwicki, Sosnowiecki and Tyski; Poznań+ = M. Poznań and Poznański; Szczecin+ = M. Szczecin and Szczeciński; Wrocław+ = M. Wrocław and Wrocławski; Gdański + = Gdański and Trójmiejski,
- Hungary: Budapest+ = Budapest és Pest,
- Slovakia: Bratislava+ = Bratislavský és Trnavský.

Over our main variable of interest (GDP per capita), we added several control variables in the models. As institutional economics emphasizes the role of institutions in economic growth, but institutions are country specific, we added country dummies (and we observed also processes for the four countries). The urbanization was taken into account through two variables, population of the largest city (in 2011, in the year of census when data is the most reliable), and population density. We also created categories from these variables based on previous typology, for the population of the largest city: (1) over 300,000 (based on Capello et al 2015), (2) between 100,000 and 300,000 (the 100,000 is suggested by the catch-up analysis), and (3) below 100,000 people. The region typology demonstrated in chapter 2 (based on Capello et al 2015) was also included as control variable.

3.2. Estimation methods

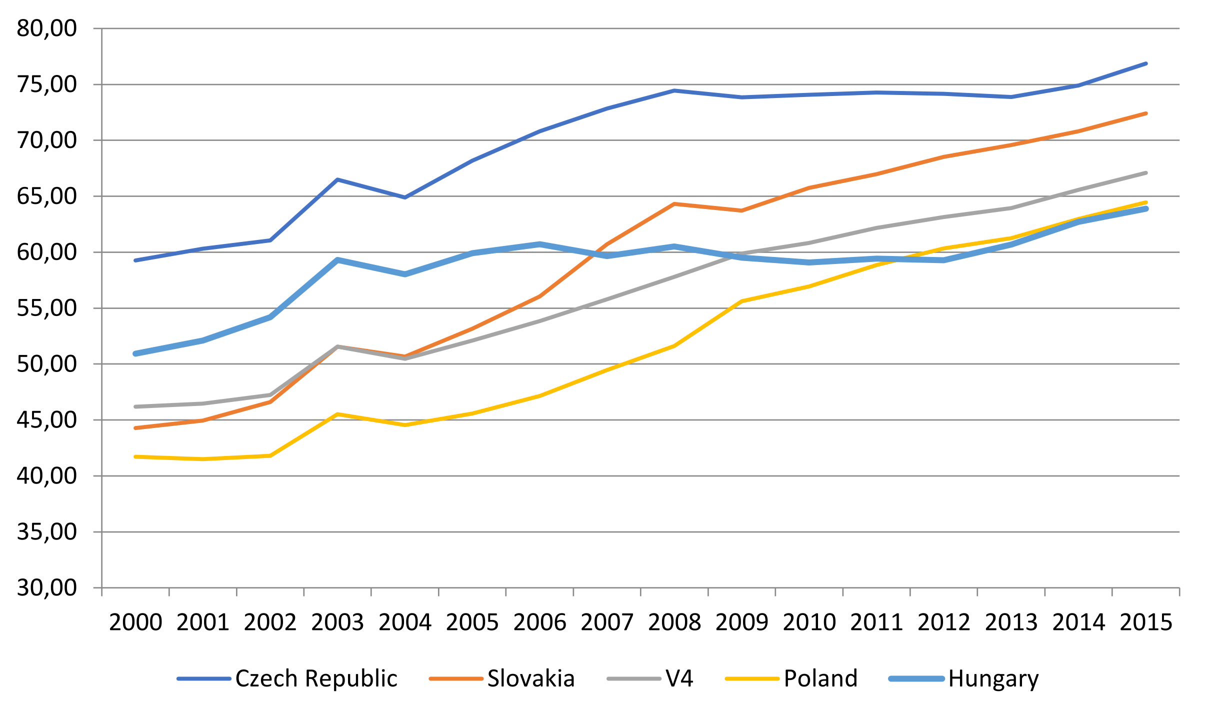
The σ-convergence – due to short time series – can be analyzed by simple time series methods. Downward trends can be tested by simple *t*-tests. In the case of the absolute β-convergence, we estimate equation (2) by regression analysis. By adding theoretical time-variant and time invariant variables, we can test conditional and club convergence. By the concept of the absolute β-convergence, endogeneity problems cannot arise (the economic growth cannot cause the initial level), thereby OLS estimator can be used, if other assumptions are met (we computed heteroskedasticity corrected standard errors). The sample size of 99 allows us the use of asymptotic tests. This exploratory phase of the research does not necessitate GMM estimators as the models including spatial terms (Durlauf et al 2009).

4. Empirical evidence

4.1. Catch-up

As Figure 1 shows, the Visegrad countries had two different path patterns, while in Poland and Slovakia, the convergence towards the EU-15 level was continuous, in the Czech Republic and in Hungary, a long post-crisis trauma can be observed, their growth restarted since 2013. In the background of the Polish success, we have to mention that this catch-up is relative, during the crisis, the old European countries' GDP fell. The most dynamic country was Slovakia (with 28% catch-up), while the worst was Hungary (13%) which slipped down from the second to the last position.

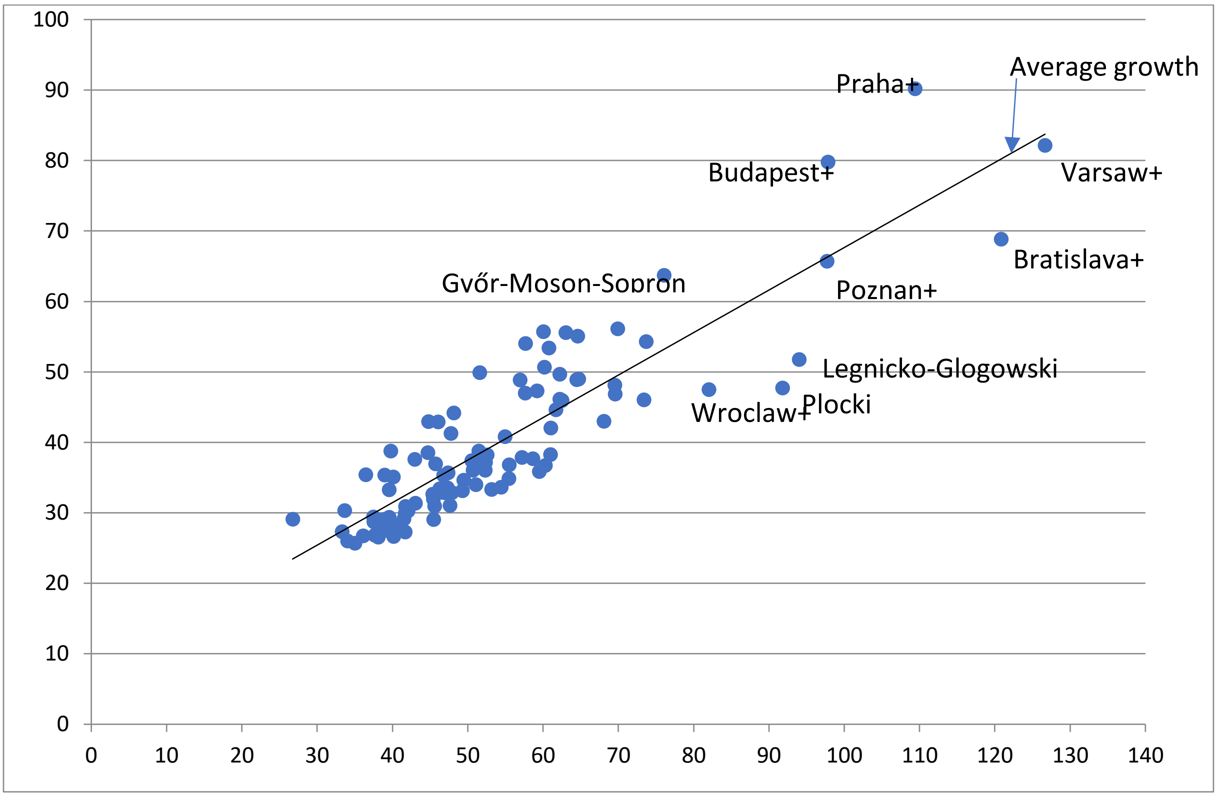
Figure 1. GDP per capita in PPS (USD) in % of EU-15



Source: Own construction

We compared the 2000-2001, and the 2013-2014 positions of the counties. Their relative position did not change greatly by Figure 2. Most of the counties are close to the average growth in this period ($r = 0.88$). While in 2000-2001, none of the counties reached the EU-15 average, in 2013-2014, three of them was over this level (Warsaw+ at 127%, Bratislava + at 121%, and Praha+ at 109%). If we add that the Budapest+ region is at 98%, we can conclude that capital city regions are on the top of development in the V4 countries.

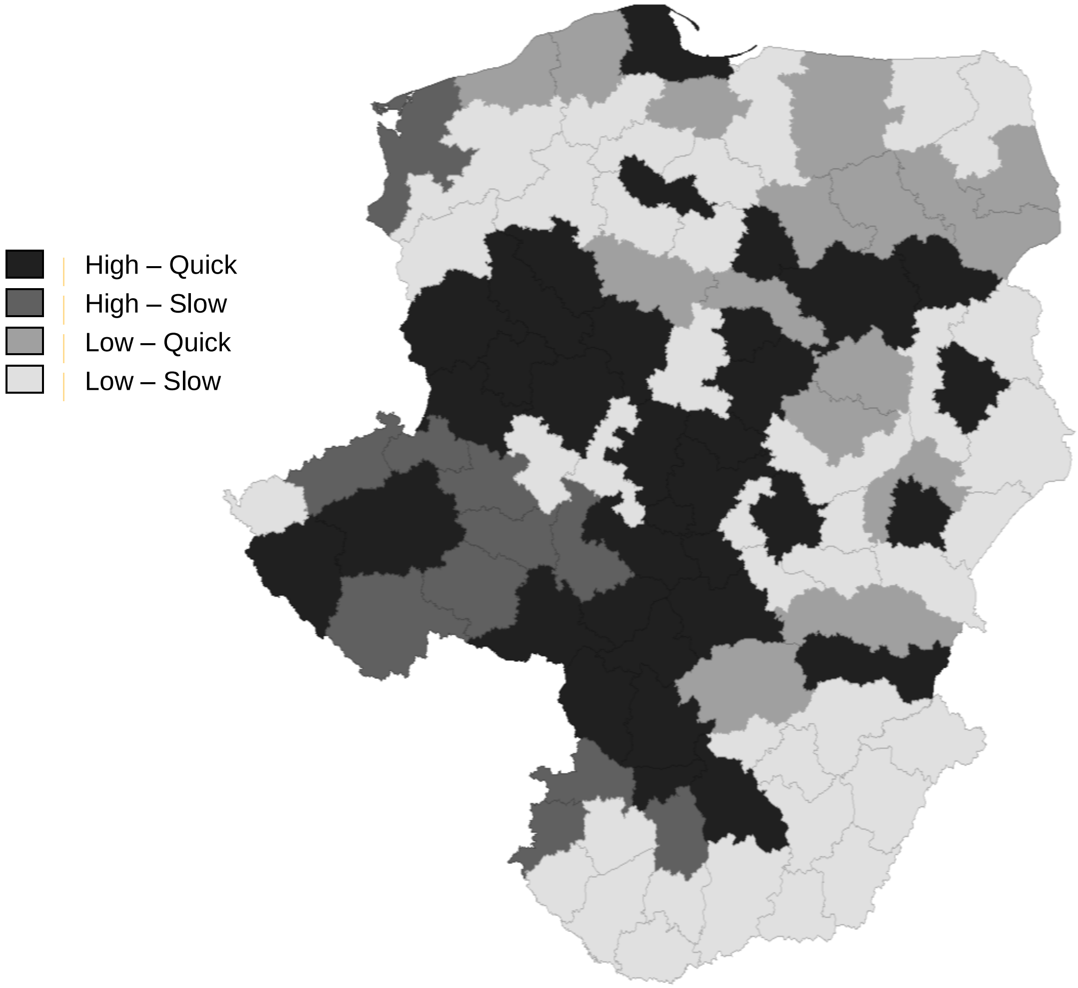
Figure 2. GDP per capita (PPS, USD) in the counties of V4 countries, in % of EU-15 in 2013-2014 (horizontal axe) and in 2000-2001 (vertical axe)



Source: Own construction

The highest catch-up was noticed in the Bratislava+ and Warsaw+ counties, but Praha+ is also over the average. It is interesting that 15 of 18 worst performance counties are Hungarian ones, the last Nógrád county is the only one which could not catch-up, but fell behind by 2.3%. According to Goecke and Hüther (2016), the combined results of development level in 2013-2014 and the growth performance are figured out in Map 1. We can also observe a core-periphery relationship (with metropolitan islands (Copus 2001) on this map: the Northern part of Poland, the Eastern zone of the V4 region, and the Southern part of Hungary forms a "*Visegrad croissant*" around the core. Metropolitan islands (e.g. Gdansk in the north, Rzeszow in the east) and post-industrial grabens (counties in Silesia) are atypical territories in their surroundings.

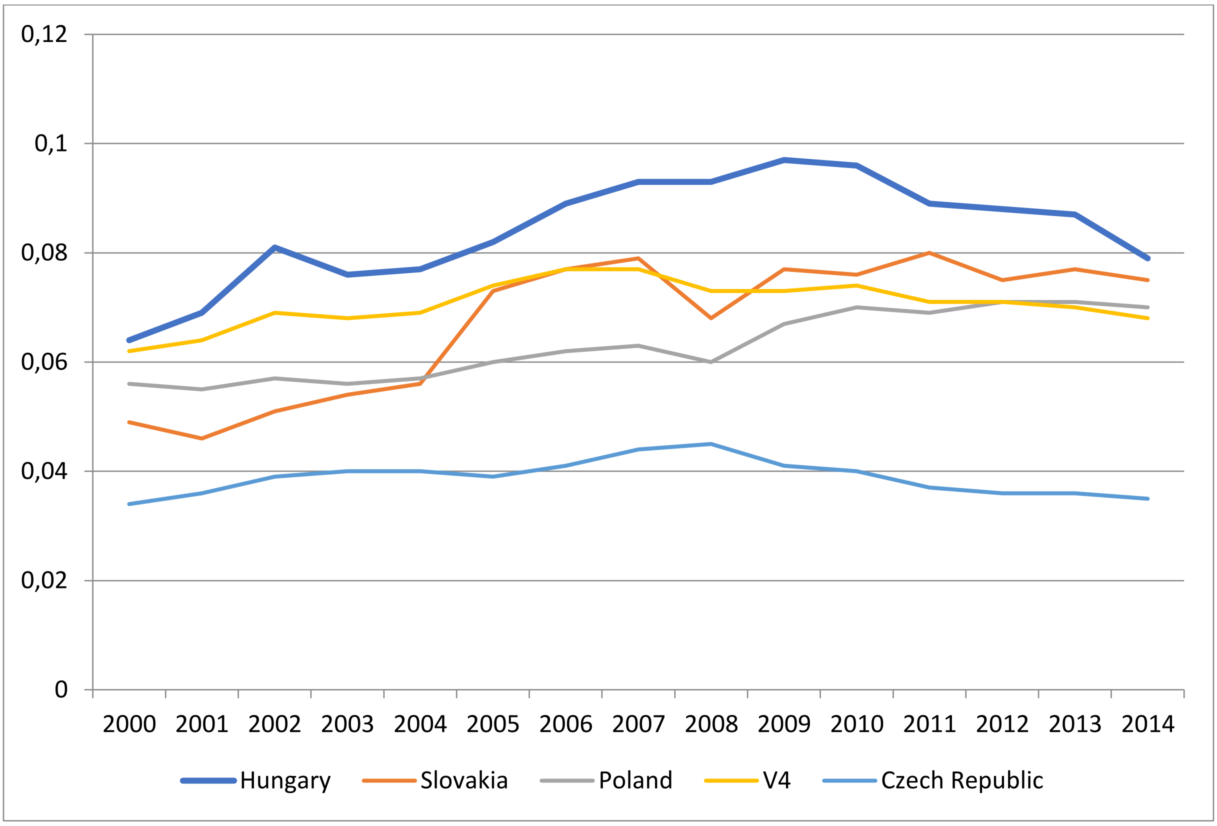
Map 1: Types of regions by final development level (over or below median) and catch-up (over or below median)



Source: Own construction

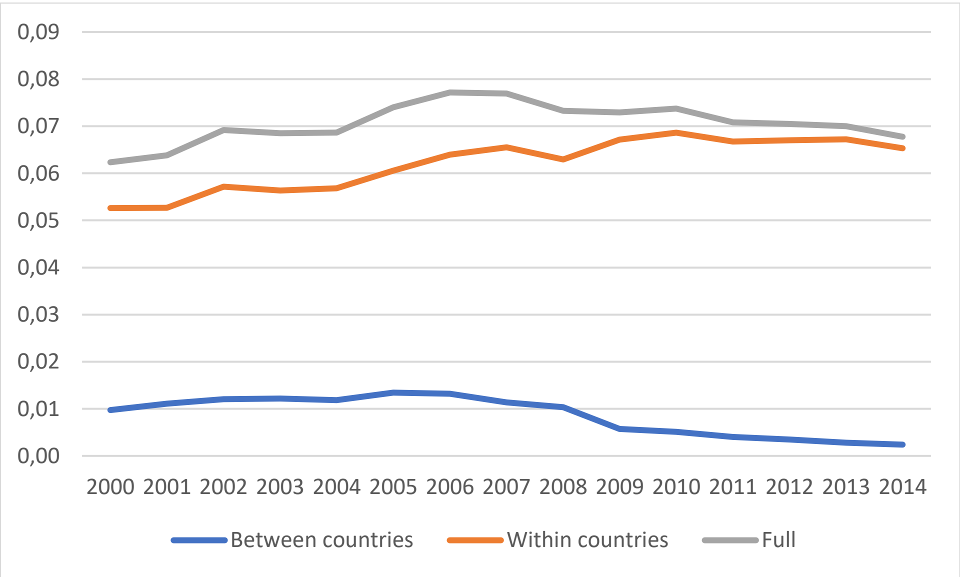
When we move towards the convergence process in the area, we look for inequalities of catch-up. By the Theil index, differences in the catch-up increased until 2006, followed by a slow decrease (see Figure 3). The country patterns are different, while in Slovakia and in Poland the increase is more continuous, in the Czech Republic and in Hungary the turning point is visible. The decomposition of the index suggests that while in 2000, 16% of inequalities was between countries, this proportion decreased to 3.5% in 2014, the role of inequalities within the country escalated (see Figure 4).
These facts denote that the catch-up process is not homogeneous, not only the countries show miscellaneous paths, but counties within countries, and increasing inequalities between counties may switch over any convergence between countries. This finding corresponds to Aiginger et al (2013).
In a previous study (Lengyel-Kotosz, 2017) we also proved that up to 100,000 person, the population of the largest city has a positive relationship with the level of development, and with the growth, but this relationship becomes insignificant over 100,000 persons.

Figure 3. Theil-index of GDP per capita in % of EU-15



Source: Own construction

Figure 4. Decomposition of Theil-index between and within countries



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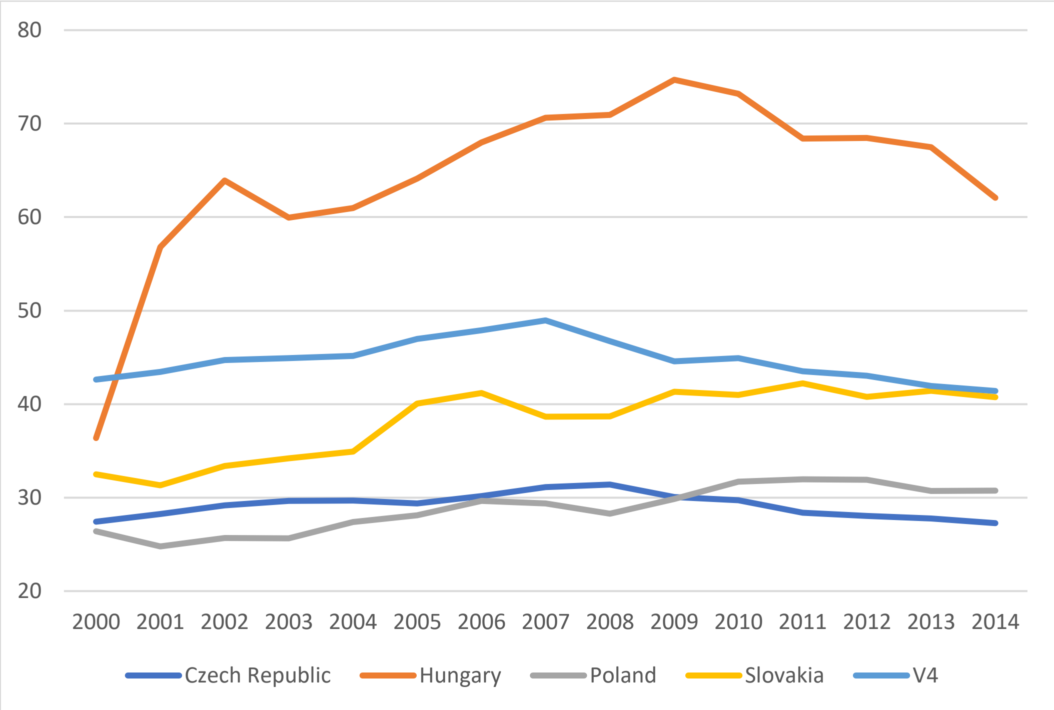
4.2. Convergence

First, the analysis of σ-convergence of the Visegrad counties was launched. Figure 5 suggests that there is no clear decreasing tendency of inequalities, the trend is increasing until 2007, and decreasing after. The countries ran on various paths, but while in Poland and Slovakia inequalities are better continuously increasing, turning points can be observed in the Czech Republic and Hungary. The deterministic trend analysis confirmed the lack of σ-convergence (see Table 2). In Hungary, Poland and Slovakia, significant divergence was observed, in the Czech Republic, and in the V4 counties together non-significant convergence.

Figure 5. σ-convergence (coefficient of variation) between 2000-2014



Source: Own construction

Table 2. Signs of main trend parameters of coefficient of variation

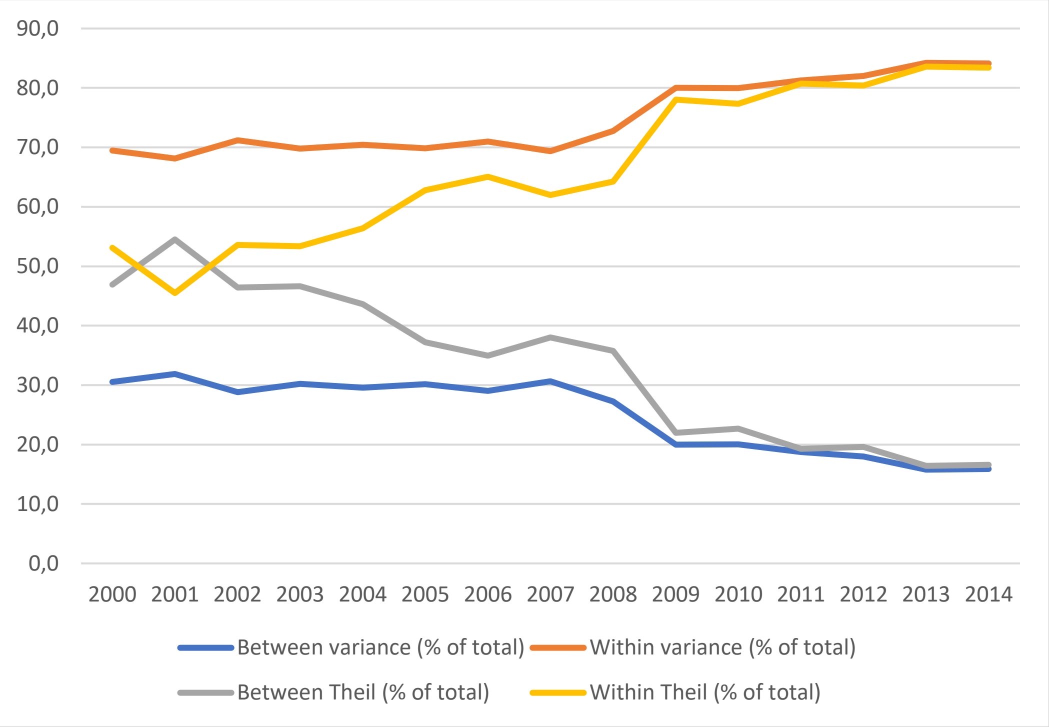
Country	Linear	Quadratic	Cubic
Czech Republic	–	–	+
Hungary	+**	–	+
Poland	+***	–	–
Slovakia	+***	–	–
V4	–	–	+

** significant at 10%, ** significant at 5%, *** significant at 1% (only for linear trend)*
Source: Own construction

Because of non-linearities, we also tested the quadratic and cubic trends. In the V4 region together, and country-by-country the quadratic trend has a negative sign, forecasting a long-run decrease of inequalities (convergence). However, the cubic trend prognosticates divergence in the whole region, and especially in the Czech Republic and in Hungary. These results confirm that the Czech Republic and Hungary show different path for Slovakia and Poland, and the past and the future of the Visegrad region's convergence is ambiguous. The β-convergence allows us to study shorter periods.

Decomposition of inequality indicators (here the Theil index and the variance) confirms that within differences has become dominant, so overall convergence depends more and more on what happens in the countries, and not on the convergence of the countries (Figure 6).

Figure 6. Decomposition of Theil-index and variance



Source: Own construction

Section a) of Figure 7 also fastens the lack of clear convergence in the 2000-2014 period. A slight negative slope of the β-convergence equation can be noticed, but in the sub-periods 2000-2004, and 2004-2008, the regression line is practically horizontal. Only the resilience period of 2010-2014 shows the evidence of convergence of counties.

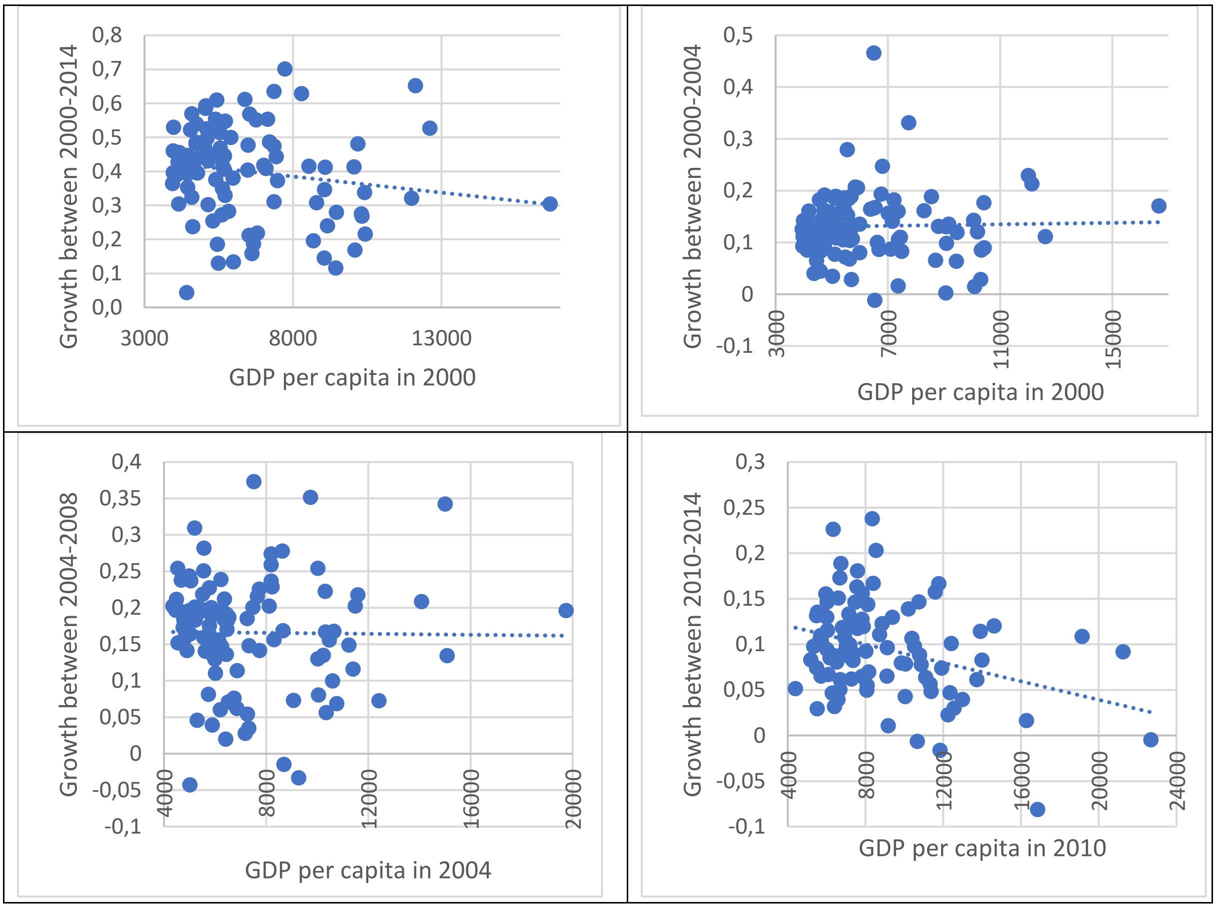
In Table 3, we reported the results of the estimation of equation (2). In the whole period, a very weak convergence is present, the half-life is 28.6 years, slightly over twice as long as the observed period. In the pre-accession and in the golden age (pre-crisis) period, coefficients are insignificant, changes do not show neither convergence, nor divergence. However, in the resilience period, the convergence has become significant with 52.2 years half-life (Table 6). The miscellaneous facts of significance and half-life can be caused by the more scattered processes in the whole period, the Visegrad counties realized an almost monolithic pattern of growth only in the 2010-2014 years.

Table 3. Absolute β-convergence

	2000-2014	2000-2004	2004-2008	2010-2014
Initial level	-0,0708* (0,042)	0,0070 (0,018)	-0,0117 (0,024)	-0,0479*** (0,017)
Constant	1,0171*** (0,366)	0,0698 (0,155)	0,2696 (0,212)	0,5278*** (0,151)

heteroskedasticity corrected standard errors in parentheses,
** significant at 10%, ** significant at 5%, *** significant at 1%*
Source: Own construction

Figure 7. β-convergence between 2000-2014 (a), before the EU-accession (2000-2004, b), in the golden age (2004-2008, c), and in the resilience period (2010-2014, d)



Source: Own construction

As several previous works (e.g. Aiginger et al 2013) suggest, and our results also confirms, the convergence process is remarkably different between and within countries in Eastern Europe, we suppose that countries are convergence clubs. In this view, we added country dummies to the absolute convergence regressions (using Slovakia as the reference group). By separating country effect, we have lost the convergence, instead in the whole period, we can diagnose significant divergence. Results in Table 4 confirms the common way of the Czech Republic and Hungary for the whole period, the distinct path of Czech Republic and Slovakia for any sub-period. Half-life of convergence can be interpreted for the non-significant 2010-2014 period, when inequalities diminish to half in 140 years within the countries. This value excites that our conclusion based on Figure 5 and Table 2 is relevant, decrease of differences are quite slow and cannot anticipate the disappearance of regional dissimilarities in the foreseeable future.

Table 4. Club convergence

	2000-2014	2000-2004	2004-2008	2010-2014
Initial level	0,0977*** (0,035)	0,0117 (0,027)	0,0172 (0,025)	-0,0190 (0,025)
CZ	-0,2614*** (0,044)	-0,0584*** (0,018)	-0,1300*** (0,026)	-0,0499*** (0,015)
HU	-0,2833*** (0,038)	-0,0310 (0,026)	-0,2285*** (0,023)	0,0067 (0,022)
PL	-0,0328 (0,035)	-0,0431*** (0,013)	-0,0886*** (0,023)	0,0030 (0,016)
Constant	-0,3441 (0,307)	0,0691 (0,237)	0,1280 (0,222)	0,2711 (0,231)

heteroskedasticity corrected standard errors in parentheses,
** significant at 10%, ** significant at 5%, *** significant at 1%*
Source: Own construction

Table 5. Conditional convergence

	2000-2014	2000-2004	2004-2008	2010-2014
Initial level	0,0655 (0,066)	-0,0313 (0,056)	-0,0358 (0,050)	-0,0140 (0,050)
CZ	-0,2563*** (0,049)	-0,0525** (0,026)	-0,1159*** (0,029)	-0,0465*** (0,0171)
HU	-0,2875*** (0,040)	-0,0357 (0,028)	-0,2346*** (0,023)	0,0101 (0,027)
PL	-0,0459 (0,040)	-0,0619*** (0,022)	-0,1065*** (0,028)	0,0076 (0,024)
City size	0,00003 (0,000)	0,00003 (0,000)	0,00005* (0,000)	0,00000 (0,000)
Pop. density	0,0001 (0,000)	0,0003*** (0,000)	-0,00001 (0,000)	0,00010 (0,000)
Agglomeration	-0,0246 (0,059)	-0,0391 (0,031)	0,0204 (0,025)	0,0275 (0,024)
Constant	-0,076 (0,576)	0,4216 (0,488)	0,5984 (0,444)	0,2333 (0,456)

heteroskedasticity corrected standard errors in parentheses,
** significant at 10%, ** significant at 5%, *** significant at 1%*
Source: Own construction

We can apply many control variables in the convergence equation. As we have chosen a relatively low territorial level, we focus here on the role of cities and of urbanization, thereby the population of the largest city in the county (city size), population density, and a dummy variable to theoretically defined agglomerations were added. On a theoretical base (Capello et al 2015), we expected positive sign of their coefficients. The results in Table 5 do not confirm the theoretical expectations. Country dummies remains significant, and urbanization variables are typically not significant with various signs in sub-periods. After filtering out country and urbanization impacts, very weak and insignificant convergence was detected with centennial half-life.

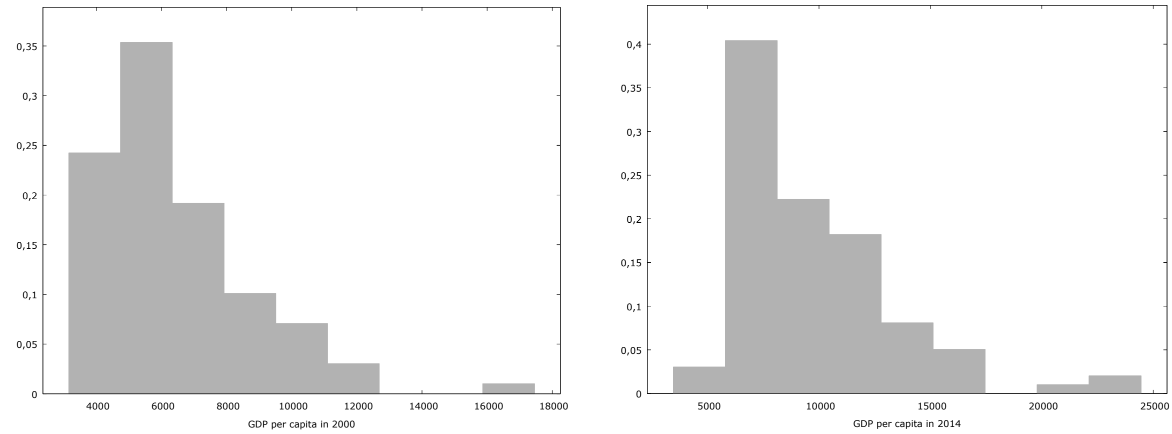
Table 6. Half-life of convergence (in years)

	2000-2014	2000-2004	2004-2008	2010-2014
Absolute	28.6	n.a.	231.1	52.2
Club	n.a.	n.a.	n.a.	140.0
Conditional	n.a.	82.9	71.1	191.9

Source: Own construction based on tables 3-5.

Finally, we compared the distribution of GDP per capita in the Visegrad counties in 2010 and 2014. The comparison of the distributions affirms that the relatively homogenous mass of counties in 2000 became more polarized in 2014 (increased asymmetry and kurtosis) with the presence of the dominance of poor regions and a larger elite. Weak signs of the twin peaks concept of Quah (1996), realized in European empirics by Fiaschi-Lavezzi (2007) can be caught.

Figure 8. Distribution of GDP per capita in 2010 and in 2014



Source: Own construction

5. Conclusion

In the pilot study, we concluded that the per capita GDP almost doubled on the average in the reference period, with relatively high differences (less than 30% and more than 140% increase). On overall data neither beta convergence nor sigma convergence cannot be proved, instead we can observe the twin-peaks phenomenon of convergence clubs, and important country effects. In our sub-samples, significant beta convergence cannot be found, but the growth rates are country-specific (initial values remain insignificant in the presence of – significant – country dummies) and agglomeration externalities can be proved. The variance and the Theil index decomposition affirm the importance of within country difference, while at the millennium, 30-50% of differences were between countries, this rate diminished to 15% by 2014.

In this pilot study, we did not consider several factors used in the literature (e.g. sectorial structure of the economy, education level of the population), as most of the data seems to be unreliable (even tenfold differences in various sources). At this relatively low level of aggregation, the crucial limit is the available and reliable data, but due to large and multiproduct enterprises, economic production and employment data is very sensitive to measurement issues. The EU Regional Competitiveness Index would be an opportunity, but data is available at NUTS2 level (Annoni et al 2016). As earlier results suggest (Lengyel-Rechnitzer 2013, Lengyel 2016, Lengyel 2017), a more detailed analysis should be run for metropolitan and non-metropolitan regions.

For the 2010-2014 resilience period, more detailed analysis is necessary to understand why some regions hit by the crisis were able to grow (Martin-Sunley, 2015).

Our models can be improved from an econometric point of view, instead of the OLS estimator, robust estimators (e.g. quantile regression) can be applied. We can also extend the research with spatial econometrics methods, thereby the local convergence can be analyzed. The results of Bourdin (2013 and 2015) or Kotosz (2016) offer local hot-spots of economic growth in Eastern Europe. These first results open the path towards models considering spatial dependence and heterogeneity.

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