

THE IMPACT OF ECONOMIC CRISIS ON CONVERGENCE PROCESSES IN EUROPEAN UNION REGIONS

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Abstract

The effects of the financial crisis, that started in 2008 and first emerged on the American housing market, have been experienced by many European economies. The purpose of this article is to attempt to measure and assess the sensitivity of convergence processes to crisis in European Union's regional economies taking into consideration their sectoral structure. Particular resistance to crisis is associated with the presence of "modern" sectors of the economy. The study covers the panel of the European Union NUTS-2 level regions in the period 2005–2011. In the analysis, the application of panel data allows for inclusion of the specific non-measurable aspects characteristic for particular regions and time.

Keywords: smart specialisation, economic crises, convergence, European Union

JEL Classification: O47, R11, R15, C23

1. Introduction

The focal point for the financial crisis was the downfall of the US sub-prime mortgage market in 2007. According to Hodson, Quaglia (2009) "the collapse of a major United States (US) subprime mortgage provider's (New Century Financial Corporation) problems quickly spread to the US banking sector and the international financial system at large". The effects of the global financial crisis disturbed the functioning of many national and regional economies in the European Union. Regional economies faced business investment lags, competitiveness decreases, unemployment rises, and consumption decline. The crisis, initiated on the market, affected, not only the financial and economic spheres, but also the public one. Not all economies responded in the same way. The research results of Groot *et al.* (2011) indicate that the differences in sectoral structure of particular economies were the main reason of diverse crisis consequences. Particular resistance to crisis is associated with "modern" sectors of the economy and these related to non-material services rendering, the development of which is based on knowledge and innovation.

The purpose of this article is to assess the effects of the economic crisis on the processes of economic convergence in the EU NUTS-2 regions with different level of smart specialization, perceived as the level of knowledge sectors development in services and industry.¹

In order to arrive at the presented research goal it is essential to discuss the following two concepts: regional convergence and smart specialization.

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1 The concept of smart growth pillars was based on research study: *European Regional Space Classification in the Perspective of Smart Growth Concept – Dynamic Approach* (Grant NCN No. 2011/01/B/HS4/04743); Markowska, Strahl (2012).

The concept of smart specialization appeared in the context of the EU development policy. By focussing on what gives a region its greatest competitive potential, smart specialisation helps to position the region in specific global markets/niches and international value chains. As is defined in the [European Commission, 2014] “it also means strengthening regional innovation systems, maximizing knowledge flows and spreading the benefits of innovation throughout the entire regional economy”. In the analysis presented below, smart specialization is defined not only as the unique characteristics and assets of each country and region, but also as one of the smart growth components, that points to the increasing role of knowledge and innovation as the driving forces in economy. Knowledge and innovation continue to be the advancement strengths of contemporary economies, the importance of which is emphasized in, among others, the assumptions of such theories as the new theory of endogenous growth by Romer (1986, 1990) and Lucas (1988), the concept of new policy for endogenous development by Molle and Cappelin (1988), the theory of growth poles by Perroux (1995), as well as the learning region theory by Florida (2000) and Asheim (1995). These theories indicate that gaining competitive advantage and dynamic growth is possible owing to research and development expenditure, as well as the establishment of knowledge-based economy and technical advancement. The competitiveness of economies approached in such way is manifested by the development of industrial sectors implementing advanced technologies and knowledge-intensive services. The approach applied in the presented analysis and identification of smart growth with knowledge sectors, as well as those of high and mid- technology, follows the one discussed by [Markowska, Strahl (2012)].

Smart specialization is perceived as the key factor in economies aiming at bolstering their potential and improving both national and regional competitive position. In the circumstances when the selected regions gain an exceptionally strong position it may have a negative impact on the cohesion policy as the stimulating agent for long-term socio-economic transformations. As a result of these transformations the processes of levelling off disproportions among regions and reducing development delays of the poorest areas keep advancing, which should bring about harmonious growth of the entire European Union. In the opinion of Marelli (2007) “considering (...) specialization in a long term perspective, many empirical studies conclude that national and regional specializations are an important factor for economic growth, while being themselves influenced by the level of development. These structural relations can normally change only in the long term and may explain the persistence of European income disparities”. In other words, gaining competitive advantage by the selected regions, *e.g.* as a result of specialization, creates conditions for their faster development, and thus also enhances divergence and polarization process.

Divergence and convergence processes have been attracting attention of scientists and politicians for many years. The term convergence is used in the subject literature in several meanings, which correspond to different concepts of convergence. The research carried out in this area represents an attempt to answer questions about the reduction of disproportions in the level of regional development (*sigma* convergence), but also about the pace of particular economies in reaching the state of long-term equilibrium, as well as about growth factors (*beta* convergence).² Beta convergence describes the so-called catch-up effects when a product or income *per capita* tend to grow at faster rates in poorer economies than in richer

2 Divergence remains the opposite of beta convergence, whereas polarization is the opposite of sigma convergence.

ones. In accordance with neoclassical growth theory faster growth of less developed regions is justified by the decreasing marginal productivity of production factors. The new theory of growth (the theory of endogenous growth) lists, among others, investments in human capital and knowledge dissemination as factors facilitating convergence. The occurrence of beta convergence should result in sigma convergence phenomenon.

Club convergence represents another type of convergence, which stipulates that income levelling occurs only when regions remain similar in terms of initial income level and are equipped in similar immobile production factors. In accordance with this concept the regions concentrated within the framework of particular convergence clubs can approach their long-term development paths and simultaneously divergence processes can occur between clubs. Therefore, the same factors (innovation, knowledge, technologies) the diffusion of which is supposed to facilitate convergence processes, may result in some cases in opposite effects and enhance the divergence and polarization processes.

The studies covering regional convergence processes in conjunction with innovation, human capital and smart specialisation sectors were published by the following authors: Archibugi, Filippetti (2011), Pukeliene, Butkus (2012). The research conducted by Archibugi, Filippetti (2011, p. 1) on innovation performance indicates that “the European Union Member States have converged in their innovative potential over the 2004–2008 period. The economic crisis of the fall 2008 is striking innovative investment in almost all EU countries, but the catching up countries are the most affected leading to increasing divergence. The danger of growing disparities in innovative capabilities may lead to divergence also in income and well-being”.

This article is focussed on the assessment of convergence rate diversification observed in the economies of regional groups featuring diverse specialization, taking into consideration knowledge and innovation based economies. The research covers 268 NUTS-2 EU regions in the period before (2005–2007), during and after the crisis (2008–2011).

The aim of this article is to attempt to answer the ensuing questions: (1) what was the impact of the 2008 crisis on gross domestic product level and income level in particular EU regions (NUTS-2)? (2) Did the regions presenting higher level of smart specialization demonstrate stronger resilience to the adverse economic effects of the crisis? (3) How did the 2008 crisis affect sigma and beta convergence processes in the EU regions taking into account their smart specialization level in service and industrial sectors?

The paper is structured as follows: Section 2 discusses the concept and method of measuring beta and sigma convergence. Section 3 focuses on the statistical analysis of diversification of GDP and incomes of population in the EU regions representing varying levels of development of the smart specialisation sector. Section 4 analyses the beta and sigma convergence of regional GDP and income. Section 5 provides concluding remarks.

2. Research Procedure

The 2008 economic crisis manifested itself in many spheres and had an impact on the deteriorating socio-economic situation of the EU regions. Essentially, economic growth rate slowdown, production decline and higher unemployment rate were recorded. This study concentrates on the analysis of two measures:

- total production volume measured by GDP *per capita* (PPS),
- disposable income of private households (based on final consumption) *per capita* (PPS).

The first measure represents the overall size of the economy and illustrates the final result of activities performed by all national economy entities. The latter refers to the financial situation of households. GDP is the central measure of national accounts, which summarises the economic position of a region. It can be calculated using following approaches: the output, the expenditure, and the income approach. GDP *per capita* is also a broad economic indicator of living standards. As for the disposable income of private households it is the balance of primary income (operating surplus/mixed income plus compensation of employees plus property income received minus property income paid) and the redistribution of income in cash. These transactions comprise social contributions paid, social benefits in cash received, current taxes on income and wealth paid, as well as other current transfers. Disposable income does not include social transfers in kind coming from public administration or non-profit institutions serving households. Using purchasing power parities to convert expenditure expressed in national currencies into an artificial common currency, the purchasing power standard (PPS) eliminates the effect of price level differences across regions created by fluctuations in currency exchange rates [Eurostat Reference Metadata].

Adhering to the purpose of the research smart specialization was chosen to describe the impact of innovativeness and knowledge level on the growth in EU regions. Smart specialization emphasizes the actual size and role of knowledge-based sectors (manufacturing and service) in the employment structure. Smart specialization was defined by means of two diagnostic indicators:

- *KIS* – employment in knowledge-intensive services as the share of total employment (%),
- *HMMS* – employment in high and medium high-technology manufacturing as the share of total employment (%).

Due to the fact that Eurostat methodology services are mainly aggregated into knowledge-intensive services (KIS) and less knowledge-intensive services (LKIS), based on the share of tertiary educated persons at NACE 2-digit level, KIS sector includes the following services:

- high-tech: post and telecommunications; computer and related activities, research and development;
- market: water transport, air transport, real estate activities, renting machinery and equipment without an operator, and of personal and household goods, other business activities;
- financial services: financial intermediation, excluding insurance and pension funding, insurance and pension funding except compulsory social security, activities auxiliary to financial intermediation;
- other: education, health and social work services, recreational, cultural and sporting activities;

High and medium high-technology manufacturing comprises of the subset of manufacturing industries in which expenditure on research and development exceeds 8% (high) or 2% (medium) of revenues. This sector lists in particular:

- high: basic pharmaceutical products and pharmaceutical preparation; computer, electronic and optical products; air and spacecraft and the related machinery;

- medium and high: chemicals and chemical products, weapons and ammunition, electrical equipment, machinery equipment, motor vehicles, trailer and other, medical and dental instruments and supplies.

The hereby presented analysis is comprised of two parts. The first part describes the assessment of economic crisis effects' diversification across the spectrum of EU regions and in the defined classes of regions regarding the level of smart specialization in manufacturing and service sector. In the second part the analysis of levelling off the disproportions among regions is discussed in the context of beta and sigma convergence investigations.

As far as the analysis of convergence is concerned, its essence is to level the developmental disproportions among regions and, in this context, to estimate the growth rate. In particular, two types of convergence are considered: sigma and beta. Sigma convergence refers to the reduction of disparities among regions in time. The presence of sigma convergence (S_t) can be concluded based on the analysis of standard deviation logarithm values of y_i (*GDP*, product, income) calculated for all regions N ($i = 1, 2, \dots, N$) over the ensuing years:

$$S_t = \sqrt{\frac{\sum_{i=1}^N (\ln y_i - \ln \bar{y})^2}{N}} \quad (1)$$

If these values are declining the phenomenon of sigma convergence occurs.

The occurrence of beta convergence means that poorer regions (featuring lower development level) catch up with the more developed ones. Beta convergence can be discussed in absolute (unconditional) or conditional terms. In the model of absolute convergence the influence of initial product (*GDP per capita*) level on the speed of economic growth is analysed. When each of the economies is assumed to depend on a series of determinants such as factor endowment or institutions, which can vary from one economy to another even in the long run (in terms of *GDP per capita*), beta convergence is defined as conditional.

For the purposes of convergence model estimation various data series, such as cross-series or panel data, can be used [Baltagi (2005)]. Conducting research based on different data series can result in obtaining varying values of the estimated parameters. In the presented article panel data were used. The application of panel data allows for the improvement of estimation conditions and takes into account heterogeneity, that results from differences in factors inherent in a given region specificity (e.g. location and other components not covered by the model). The authors studying convergence indicate that the analysis of convergence by applying panel data frequently results in obtaining higher values of convergence parameter compared to models based on cross-section data [Islam (1995), Barro, Sala-i-Martin (2003), Pukeliene, Butkus (2012)].

In general, in the model of absolute convergence the only variable is the lag $\ln GDP$ level. Owing to panel data the unobservable effects can be included in the model structure characteristic for a particular region α_i (individual effects) or time period - α_t (time effects), which can be defined as:

$$\ln y_{it} = (1 + \theta) \ln y_{i(t-1)} + \alpha_i + \alpha_t + \varepsilon_{it} \quad (2)$$

where: $\ln y_{it}$ – refers to *GDP per capita* logarithm of i -th region ($i = 1, 2, \dots, N$) in t -th year ($t = 1, 2, \dots, T$); α_i – represents individual, specific for each region and fixed in time, effects; α_t – means time effects common for all regions and represents factors specific for each studied period (the period-specific intercepts); ε_{it} – random term.

The most interesting value of that model is β – parameter which defines convergence speed towards the long-run balance rate, which is obtained form $(1 + \theta)$ parameter after transformation in line with the formula: $\theta = -\frac{(1 - e^{-\beta T})}{T}$ (where: T – number of years in which speed rate is calculated).

It is possible to illustrate that the sigma convergence condition is associated with catch up processes, *i.e.* beta convergence. Beta convergence is the necessary, albeit insufficient, condition for sigma convergence occurrence. Sala-i-Martin'a (1996) discusses three possible scenarios describing the relations between sigma and beta convergence. Having assumed the existence of two regions w and k , of which w is characterized by higher initial development level, it is possible that in the final period T :

- 1) w region features lower growth rate than k region and, as a result, k region is catching up in its development level with w region and finally their development level is similar (which indicates that the necessary condition for sigma convergence is beta convergence),
- 2) w region experiences significantly lower growth rate than k region, and thus much faster developing k region overtakes the level of w region development in T period – despite the initially occurring beta convergence processes – sigma convergence is not observed (the regions will change places in the ranking),
- 3) w region features higher growth rate than k region and thus the differences between both regions keep growing, so at the end their development level shows much larger distance (divergence and polarization).

Among the three above presented situations describing relations between sigma and beta convergence values, the first situation occurs most frequently – when as a result of poorer regions' faster development the disproportions are levelled, or the third situation, when the regions characterized by a strong position maintain high growth rate and expand regional wealth level disparities (divergence and polarization).

While analysing regions grouped in clubs, characterized by similar structure and advancement in creating innovation and knowledge-based economy, it should be expected that the regions presenting the highest development level will keep developing at least at the rate of the catching-up regions. It can result in polarization processes, *i.e.* increasing disproportions in the level of regional development (as opposed to sigma convergence processes). It is consistent with the suggestion made by Nowak (2006) who indicates that “if capital plays the decisive role in the process of convergence, then the differences in *GDP per capita* processes between economies presenting various development levels should disappear over time. If it is technology that remains the major reason of convergence, then one should expect that the levelling of *GDP per capita* shall occur only between countries (regions) characterized by similar level of development.”

Having grouped regions by the level of smart specialization one should expect to identify the groups of regions with predominance of knowledge resources and technology, which can result in their faster development than the remaining ones and therefore convergence processes can be observed within a group along with simultaneous divergence processes between groups.

The results of various studies on convergence among NUTS-2 regions confirm some of the above presented findings. Regional economies within one country, covering metropolitan regions, can serve as an example. Such results were obtained for Czech regions (Mazurek, 2013). Beta and sigma convergence processes were also analysed regarding the regional innovation levels both in service and industry sectors - Bal-Domańska (2011). The research in the period of 1999–2007 among 247 EU NUTS-2 regions, that were divided into 4 groups: (1) innovation leaders both in services and industry sectors, (2) service innovators, (3) industry innovators, (4) non-innovators was conducted. Based on this research the absence of convergence refers to regions which reached high development level and were characterized by well-developed knowledge (smart specialisation) sectors, both in services and in industry (innovation leaders) and also in knowledge-intensive services (service innovators). Convergence processes have been observed in the two remaining groups of regions – those featuring low development level along with the absence of developed knowledge-based sectors, human capital and innovations (non-innovators), and those with high and medium-high technology sector as the only developed sector (industry innovators). The annual conditional convergence rate in these groups of regions amounted to 5.2% in industry innovators group and 3,9% in non-innovators regions respectively (assuming that the discussed regions reached the same rate of investments, employment growth and the share of tertiary educated people). As the research shows, among the regions of moderate development level, the ones with higher smart specialisation level tend to reach the common equilibrium state faster compared to the regions lacking adequate knowledge base - Bal-Domańska (2011).

Other conclusions of the research review indicate that:

- a beta convergence process is taking place among EU regions – Eckey, Türk (2006), Monford (2008),
- “the speed of convergence is not constant in time, with low values being generally found during the eighties and higher values being detected for periods before and after that decade” (2000–2010) – Monford (2008),
- beta convergence processes, analysed in the classes of similar regions, are successfully described by absolute convergence models, which consider only the initial product level in their structure – Bal-Domańska (2013),
- “the estimated speed of convergence is rather low when absolute convergence models are used and higher when using conditional convergence models, which mostly reflects the fact that although convergence is sometimes higher within some groups of regions compared to others, it is often much lower between these groups” – Monford (2008).

While analysing the concept of beta convergence one should note that the speed rate depends on the situation of a given economy in terms of its long-term balance level. Regional growth rate is high when the initial *GDP* level is low compared to its long-term situation.

Quantitative identification of β convergence poses several problems for researchers related to e.g. the choice of adequate estimation method, the problem of variables' endogeneity, measurement errors and the availability of statistical data. Some of them can be solved by the selection of proper estimation methods. In Behr's (2003) opinion, based on his research applying Monte Carlo analysis, different dynamic panel data estimators lead to the same conclusions.

In order to obtain estimates of model parameters the system generalized method moments (GMM) estimator was used. The estimation procedure is presented among others (in addition

to the original papers) Arellano, Bover (1995), Blundell, Bond (1998) and Roodman (2006). They are designed for research cases with few time periods and many individual, independent variables that are not strictly exogenous, what makes them increasingly popular in the field of growth model estimation. The idea is to estimate the system of equations in first-differences with suitably lagged levels as instruments, with an additional set of equations in the levels with suitably lagged first-differences as instruments. One of the problems encountered in estimating models by means of GMM method is the selection of instruments that are numerous and, in system GMM, potentially unreliable. The effects of instrument proliferation were discussed by e.g. Roodman (2006), Roodman (2009).

For obtaining the reliable results, the models were estimated by applying various sets of instruments and using estimates of different covariance matrix of the idiosyncratic error $\mathbf{H}(2)$ defined as in Doornik, Arellano and Bond (2002) or $\mathbf{H}(3)$ defined in Roodman (2006) – 5 alternative specifications were analysed:

1. Sys-GMM 1 – $\mathbf{H}(2)$ covariance matrix and instruments for differenced equation – all available, and for levels – only GMM-type (lags of $\Delta \ln GDP$).
2. Sys-GMM 2 – $\mathbf{H}(2)$ and instruments defined as above but only one lag of dependent variable to use as instrument.
3. Sys-GMM 3 – $\mathbf{H}(3)$ and all available instruments.
4. Sys-GMM 4 – $\mathbf{H}(3)$ and instrument as in Sys-GMM 1.
5. Sys-GMM 5 – $\mathbf{H}(3)$ and instrument as in Sys-GMM 2.

To assess the quality of estimations supporting tests were applied, among them Arellano-Bond test for the autocorrelation (H_0 : zero second order autocorrelation in first-differenced errors) and Sargan/Hansen test of overidentifying restrictions (joint validity of instruments in first-differenced). All calculations were done in STATA 11 (xtdpdsys, xtabond2).

3. The Diversification of Gross Domestic Product Level and Incomes of Population in Regions with Different Level of Development of Smart Specialisation Sectors

The analysis was conducted based on the panel covering 268 EU NUTS-2 regions (excluding French overseas territories)³ in the period 2005–2011.

In order to answer the question of how the 2008 crisis affected regional economies smart specialization groups of regions were distinguished:

- low KIS and high KIS groups – each of these groups covered 134 regions which recorded values below/above the median calculated for the percentage of employment in KIS in total employment in 2008;
- low HMMS and high HMMS groups – each of these groups covered 134 regions which recorded values below/above the median calculated for the percentage of employment in HMMS in total employment in 2008.

3 For *INCOME* variable the available data covered 264 regions (excluding overseas territories, Cyprus, Malta and 2 Croatian regions).

If the role of smart specialization sectors in regional economies is analyzed as divided into manufacturing and services it is well visible that the role of KIS sector is much more significant in regional economy offering from 15.5% jobs in the Romanian region Nord-Est (in 7 out of 8 Romanian regions KIS sector share was lower than 19%), up to 63.3% in Spanish Ciudad Autónoma de Melilla. In case of HMMS sector these numbers range from less than 0.5% up to roughly 20% of the total employment (in German Stuttgart, Braunschweig).

Table 1 | Statistics for Analysed Variables in the Group of EU Regions Defined in Terms of KIS and HMMS Smart Specialisation Sectors Development in 2008

	KIS groups of regions						HMMS groups of regions					
	KIS		GDP		INCOME		HMMS		GDP		INCOME	
	low	high	low	high	low	high	low	high	low	high	low	high
Median value	29.3	42.6	20,000	26,150	13,100	16,100	3.3	7.4	22,750	25,100	14,600	16,150
Mean value	29.3	44.0	20,377	27,982	12,706	16,230	2.9	8.3	24,360	24,000	14,238	14,717
Min value	15.5	37.3	7,000	16,700	3,800	9,100	0.5*	5.1	7,000	7,500	3,800	4,100
Max value	37.2	63.3	42,100	85,900	20,500	25,500	5.0	20.5	85,900	50,200	25,500	22,300
V (variation coef.) (%)	16.6	11.6	36.8	32.9	38.0	14.8	50.0	36.4	42.8	32.6	27.6	30.0

Note: * Approximate value

GDP, INCOME expressed as the *per capita* values

Source: author's compilation

As the data presented in Table 1 illustrate the regions characterized by low level of development of smart specialisation sectors (low KIS/HMMS) represent, on average, also the regions featuring lower *INCOME* and lower *GDP*. The differences between “low” and “high” class are much larger for KIS regions. In “low” group the average *GDP* level in 2008 was 20,377, whereas in “high” group it was by about 40%–50% higher (slightly lower disproportions were true for *INCOME* in 2008 – about 35%). With reference to HMMS regions the average values for *GDP per capita* and *INCOME per capita* were very similar (24,360 in low, and 24,000 in high group).

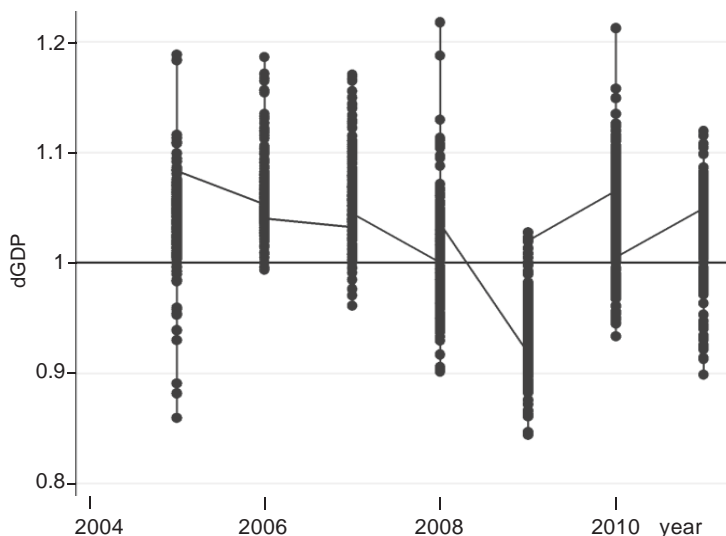
What's more, the level of development of smart specialisation sectors in HMMS groups was more diversified than in KIS regions (Table1), which means that within the groups of regions the role of smart specialisation sectors differs significantly. Simultaneously, groups described as “low” were characterized by larger internal disproportions compared to “high” ones – see Table 1 (except *INCOME* variable in HMMS groups for which the diversification level was quite similar in both low and high ones).

As is widely acknowledged, one of the evident consequences of the crisis was the decline of *GDP per capita* value. Figure 1 presents the growth rate values in the period 2005–2011. The years 2006 and 2007 were the most favourable with *GDP* growth noted in almost all regions. Since 2007 the increasing number of regions experiencing growth rate decline was observed. In 2008 *GDP* level dropped in 112 out of 268 studied regions (against

2 or 7 in the years before the crisis). The peak was in 2009, when for almost all regions the drop in *GDP* rate was observed. In 2010 the situation improved, but in 2011 a slight decline was recorded.

The conclusions regarding distribution of *INCOME* variable changes are convergent with the ones referring to *GDP* variable and therefore further part of the analysis is focussed on *GDP* variable.

Figure 1 | EU Regions which Noticed the Worsening Situation in the Period 2005–2011 (previous year = 1)



Source: author's compilation

Figure 2 presents the spatial distribution of *GDP* growth rate in NUTS-2 regions in 2009. In 2009 the decrease was observed for the regions of all countries except for some regions of Poland and the single region of Hungary, France and the Czech Republic (dark). Most affected were some regions of Sweden, Finland and Lithuania, Latvia and Estonia. In those groups of regions *GDP* drop was even 16% (Netherlander Groningen, Lithuania).

Figure 3 provides more detailed information about the number of regions featuring *GDP* growth rate decrease in the groups identified with regard to smart specialisation sectors.

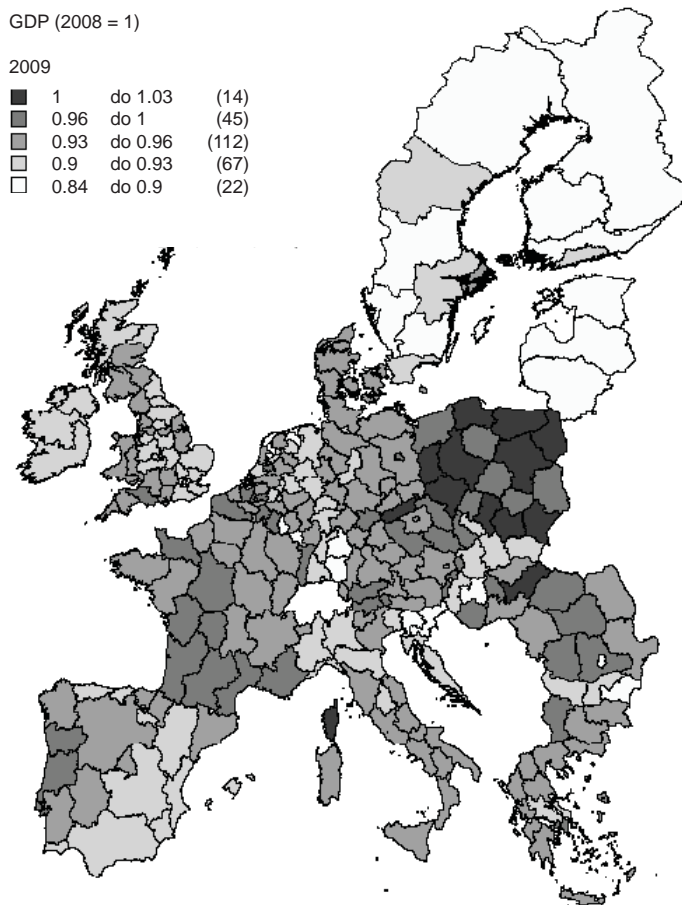
In case of regions distinguished by KIS level, in the first years of the crisis those featuring *GDP* drop were usually the ones presenting high KIS level. Since 2010 the number of regions with declining *GDP per capita* in low and high KIS groups was more or less balanced.

In case of HMMS regions in 2008 and 2009 the number of regions with decreasing *GDP* was similar in both groups (low and high). In the following years only a few high HMMS regions recorded *GDP* drop (less than 9), while in the low group regions the number was about 35–38 (26%–28% of all HMMS regions).

In accordance with the above mentioned theories and assumptions the development of smart specialization sectors is identified as one of the factors facilitating stronger competitive

position and greater regional wealth. This thesis is confirmed by the above quoted *GDP* and *INCOME* values referring to the analysed groups of regions (Table 1), clearly favouring the groups characterized by highly developed smart specialization sectors. The conclusion is that smart specialization regions remained the wealthiest ones throughout the crisis.

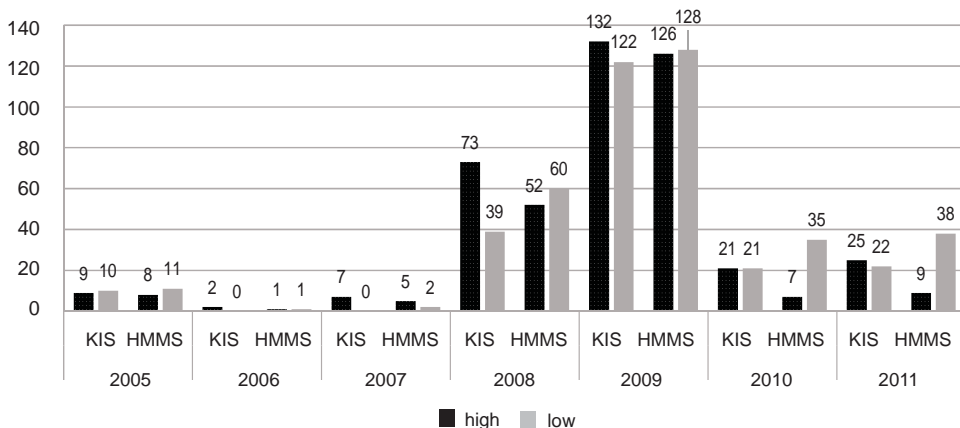
Figure 2 | EU Regions which Noticed the Worsening Situation in 2009 (2008 = 1)



Source: author's compilation

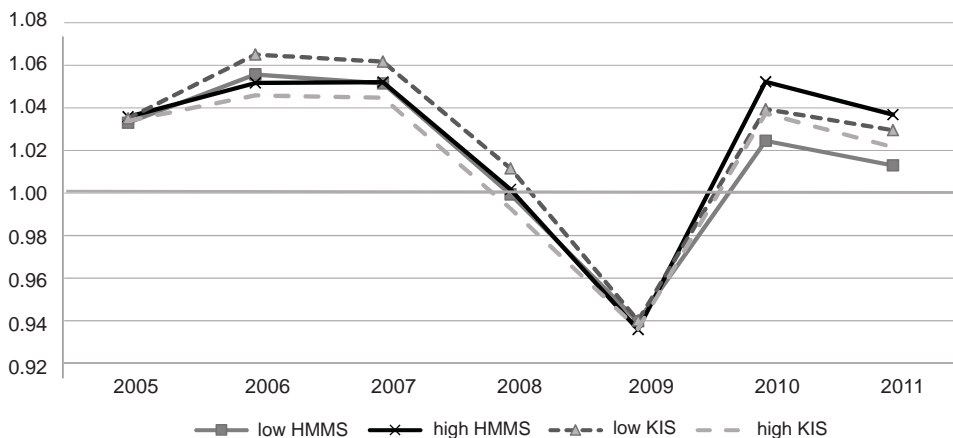
The most interesting aspect, from the perspective of the conducted analysis, is the observation of changes in *GDP* growth rate. Following the idea of convergence, higher growth rate should be characteristic for the regions presenting lower level of development – in our case “low groups”. Their faster growth facilitates the levelling of disproportions among the groups of regions. It is possible when the decreasing marginal productivity of production factors emerges as the stronger driving force than supplying regions with technology and knowledge resources. Figure 4 presents the distribution of growth rate in smart specialization groups of EU regions.

Figure 3 | Number of EU Regions (out of 134) which Noticed the Worsening Situation Compared to the Previous Year



Source: author's compilation

Figure 4 | GDP Growth Rate *per capita* for the KIS and HMMS Groups of EU Regions in the Period 2005–2011 (previous year = 1)



Source: author's compilation

Prior to the crisis – in accordance with assumptions presented by the neoclassical theory – the group of regions characterized by the highest growth rate was the group of the poorest “low KIS” regions (Table 1). The wealthiest “high KIS” regions showed the lowest average growth rate. This resulted in an upward trend collapse in all groups of regions during the crisis.

The highest growth rate drops were observed in 2009 in highly developed group of regions (6.4% in high KIS and high HMMS group to 6.0% in low KIS and low HMMS one). As stated by Jaegers, Lipp-Lingua, Amil (2013, p. 2) “the decline in the production of high-technology businesses between the second quarter of 2008 and the first quarter of 2009 was mainly due to a fall in the production of computers, electronic and optical products”.

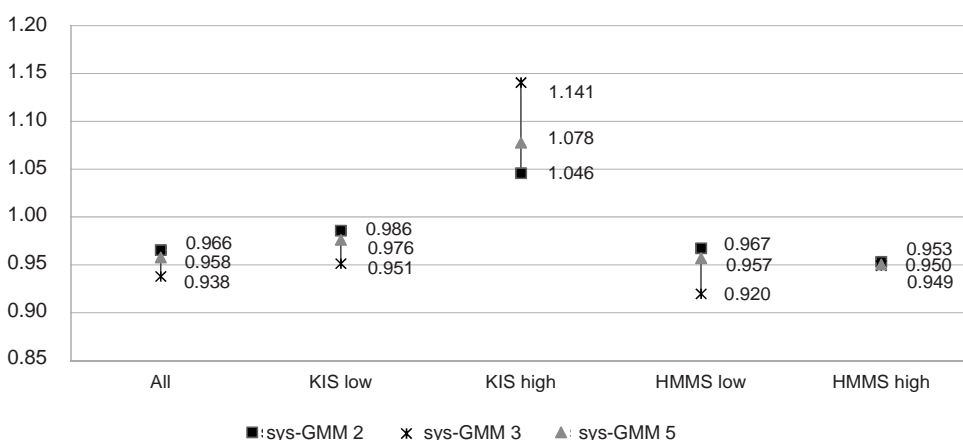
After the crisis, in the period 2010–2011 all smart specialization groups entered the growth path again. The regions characterized by well-developed high and mid-tech industry sectors suffered the least in the crisis. The growth rate in high HMMS group was higher than in other groups. In terms of high-technology manufacturing the Eurostat study concludes that the recovery was driven by pharmaceuticals and air and spacecraft machinery – Jaegers, Lipp-Lingua, Amil (2013). The lowest GDP growth rate after the crisis (2010–2011) was characteristic for low HMMS group. In case of KIS regions after the crisis (2008–2011), low KIS group experienced a more favourable situation (than the high one).

4. Convergence Analysis Results

The assessment of convergence processes was performed for all regions jointly (*ALL*) and for groups of regions distinguished by median level with regard to smart specialization in 2008 (*KIS*, *HMMS*).

Table 2 and Table 3 and Figure 5 present the results of absolute convergence rate estimations by means of applying system GMM estimator. All parameter estimates with $\ln GDP_{t-1}$ variable were statistically significant at any given significance level. Figure 5 presents estimation results for three most promising out of 5 alternative specifications defined in the Section 2. The estimator sys-GMM 1 usually showed the highest estimations for convergence processes (parameter value below 1) and the lowest estimations for divergence processes (parameter value above 1). The estimator sys-GMM 3 in most cases indicated (quite the contrary) the lowest estimations for convergence processes and the highest for divergence. Having considered the results of specification tests the best results by specification sys-GMM 5 were presented and were taken into consideration in the next part of this paper. Despite some estimates imperfections (Table 2) (Sargan/Hansen test, also AR(2) test for high KIS and high HMMS group) the models seem to describe the observed reality.

Figure 5 | The Results of GDP Absolute Beta Convergence Estimates (Two-Step Sys-GMM) Using Different Sets of Instruments in the Groups of EU Regions in the Period 2005–2011



Source: author's compilation

Table 2 | The Estimation (Two-Step Sys-GMM 5) Results of Absolute Beta Convergence GDP Models in the Period 2005–2011

	All	KIS		HMMS	
		low	high	low	high
InGDP	0.958 (0.000)***	0.976 (0.000)***	1.078 (0.000)***	0.957 (0.000)***	0.950 (0.000)***
Speed of convergence	4.3	2.4	No	4.4	5.1
Half life time	16	29	No	16	14
Sargan/Hansen	(0,000)/(0.000)	(0,000)/(0.000)	(0,000)/(0.004)	(0,000)/(0.000)	(0.000)/(0.000)
AR(2) (p value)	0.62 (0.535)	−0.97 (0.334)	1.61 (0.108)	0.01 (0.989)	1.89 (0.059)

Note: p values in brackets (on the basis on robust (Windmeier) standard errors). *** significant at the 0,001 level.
Source: author's compilation

Convergence processes were recorded in the majority of regional groups except for high KIS. The absence of convergence processes is most probably related to the fast development of regions which, at the current stage, have already achieved high development level. It should result in the growing disproportions among regions which, from the perspective of EU policy, should be regarded as an unfavourable phenomenon. The slowest growth rate was observed in the regions featuring low level of knowledge-intensive services – 2,4% rate. The growth rate (until the situation of long-term balance is reached) in regions distinguished by HMMS level reached the level of about 4.4%–5%, which means that it would take about 14–16 years to reduce the development gap by half.

Table 3 | The Estimation (Two-Step Sys-GMM 1) Results of Absolute Beta Convergence INCOME Models in the Period 2005–2011

	All	KIS		HMMS	
		low	high	low	high
In INCOME	0.964 (0.000)***	0.985 (0.000)***	1.02 (0.865)***	0.962 (0.000)***	0.969 (0.000)***
Speed of convergence	3.7	1.5	No	3.9	3.2
Half life time	19	46	No	18	22
Sargan/Hansen	(0.000)/ (0.000)	(0.000)/ (0.000)	(0.000)/ (0.000)	(0.000)/ (0.000)	(0.000)/ (0.000)
AR(2)	2.024 (0.043)	2.494 (0.013)	−1.67 (0.096)	1.283 (0.2)	1.589 (0.112)

Note: see Table 2.

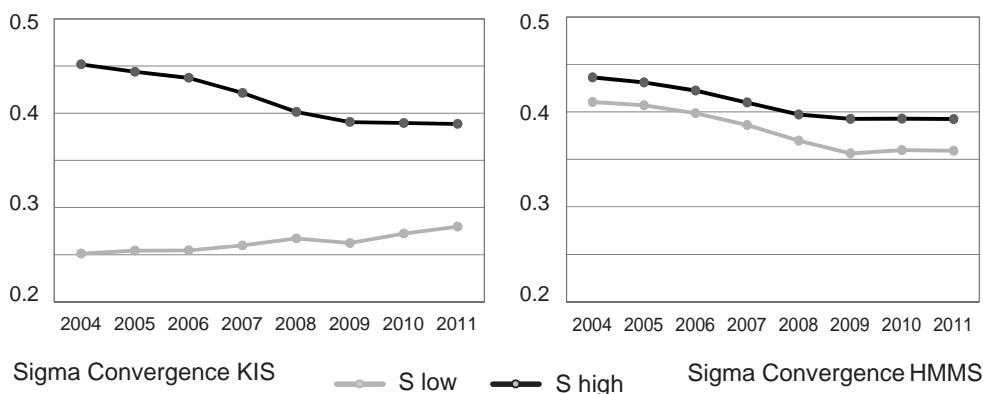
Source: author's compilation in STATA 11

The analysis of *INCOME* convergence rate introduces similar conclusions as in case of *GDP* model estimations (Table 3), which can be perceived as the confirmation of development assessment correctness and the presence of regional economies convergence in low KIS regions and in both HMMS groups, as well as the statistically significant β -divergence in high KIS regions.

In case of *INCOME* variable the rate of convergence to the long-term equilibrium state was lower than for *GDP* and in low KIS regions equals about 1.5%, whereas in HMMS regions it ranged from 3.2% in the high group to 3.9% in the low group. In case of development level measured by *GDP* value in HMMS group the period necessary to reduce by half the distance to the long-term equilibrium state would amount to about 14–16 years, in case of income of households it would be 18–22 years.

The occurrence of beta convergence means that poorer regions catch up with the richer regions, which should result in the sigma convergence phenomenon, *i.e.* decreasing differences in the development level among regions. The confirmation of beta convergence model estimations could be sigma convergence indicators for *GDP* presented on the Figure 6.

Figure 6 | Sigma Convergence in KIS (left) and HMMS (right) Groups of EU Regions in the Period of 2004–2011



Source: author's compilation

Their analysis proves that:

- 1) "low" regions in each group – KIS or HMMS were much more diversified,
- 2) the processes of levelling between regions were observed until 2008. As of 2009 they were largely halted and the situation deteriorated by far.
- 3) polarization processes were observed in high KIS regions which means that the disproportions in development level of particular regions in this group keep increasing.

High KIS group covered the regions which included country capitals and ones presenting strong economic position. These regions, in spite of having already reached high development level, keep maintaining high growth rate. Among the regions characterized by rapid growth rate, along with high development level, the following can be listed: Luxembourg (LU), Île de France (FR), Praha (CZ), Bratislavský kraj (SK), Groningen (NL), Oberbayern (DE), Mittelfranken (DE), Karlsruhe (DE), Düsseldorf (DE), Köln (DE).

5. Conclusions

Convergence processes have been observed in the cross section of all NUTS-2 EU regions for many years. The 2008 financial and economic crisis, with its onset, did affect the regional economies to a great extent.

While answering the question of how the crisis impacted on economic growth rate and convergence processes in the EU regions depending on the level of smart specialization sectors' development it should be observed that the regions featuring higher level of smart specialisation sectors development (KIS and HMMS) are also the ones presenting higher *GDP per capita* and income of households *per capita*.

The number of regions recording *GDP* drops was dramatically higher in the period immediately after the crisis, which was particularly visible in the case of regions with well-developed knowledge-intensive services (high KIS), that resulted from the nature of the crisis started on the financial market.

The regions characterized by well-developed high and mid-tech industry sector were revealed to be most resilient to crisis. After the crisis – especially considering the final analysed years 2010–2011 – high HMMS regions presented the highest growth rate in terms of *GDP* changes, whereas the lowest growth rate was observed in low HMMS regions. The regions presenting low level of knowledge sectors development suffered the most during the crisis, which was manifested *e.g.* by returning to lower growth path after the crisis.

The results of regional economies convergence analysis indicate as follows:

- a beta convergence processes were taking place among all EU regions, which means the poorest regions presented the fastest pace of development,
- in the case of smart specialization groups: only the high KIS group of regions did not show any convergence. The disproportions in economic development among regions comprised in this group were advancing. It resulted from the fast growth of highly developed regions and in consequence stronger divergence and polarization processes. The remaining groups of regions (low KIS, low and high HMMS) presented beta and sigma convergence tendencies.
- The crisis halted regional sigma convergence processes and regional income levelling, that had occurred in the previous period in all researched groups (low KIS, low and high HMMS).

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