Growth and divergence of the polish subregions over 1995–2006: a search for determinants and spatial patterns

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Abstract

This paper investigates the presence of sigma and beta convergence between the Polish subregions over 1995–2006. We verify for the absolute convergence, as well as for the convergence conditioned on the stock of physical capital, human capital and the size of the central city, these being emphasised in the literature as important factors of regional growth. We also test for the presence of spatial effects in the determination of regional growth rates. In line with research from other countries, we observe a sigma divergence and unconditional beta divergence rather than convergence of income across Polish subregions. Conditional convergence is observed only between the regions around cities of similar size. Large agglomerations in particular increase their economic advantage over peripheral regions during dynamic growth periods in the Polish economy, while during periods of economic slowdown the human capital stock proves significant in determining regional growth.

Introduction

Sala-i-Martin (1990) was the first to use the terms "sigma" and "beta" with respect to economic convergence. "Sigma convergence" describes a decreasing dispersion of per capita income among the territories considered (countries or regions). It takes place if, over time, the less developed areas close the gap in per capita income between them and the more affluent economies. In turn, the term "beta convergence" refers to a negative relationship between the average growth rate and the initial per capita income level.

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The concept of beta convergence is derived from the neoclassical growth models assuming decreasing marginal productivity of capital (Solow, 1956). The existence of beta convergence between national economies has been verified in numerous papers including the early, influential works by Mankiw, Romer and Weil (1992) and Barro and Sala-i-Martin (1992).

Besides distinguishing between sigma and beta approaches, economists refer to two forms of convergence: *unconditional* and *conditional*. Unconditional convergence means that the gap in per capita income closes independently of other characteristics of the economies considered. The less affluent countries or regions grow faster regardless of their structural features. Conditional convergence takes place when the negative relationship between the initial level of income and the growth rate is observed only within those economies that are similar in some characteristics, like institutional infrastructure or human capital stock. Yet another convergence pattern, "convergence of clubs," is seen for countries (or regions) similar not only in terms of structural characteristics, but also with respect to the initial income level. Its presence leads to income polarization between the groups of economies.

A conviction that differences in the level of human capital stock or its change over time affect the economic growth rates and the likelihood of economic convergence finds theoretical support in the endogenous growth models (Romer, 1986; Lucas, 1988) and earlier work by Nelson and Phelps (1966). The endogenous growth models assume increasing returns to production scale, which are caused by accumulation of human capital and knowledge. Therefore the growth rate directly depends on human capital endowment. According to Nelson and Phelps's approach the economies better equipped with human capital grow faster, as they are more able to introduce technological innovations.

The concept of spatial correlation in regional growth, investigated in this paper, is also rooted in regional science and economics theory. The two types of spatial effects are *spillover* and *backwashing*. A "spillover" takes place if the high (or low) rates of growth are spatially clustered, i.e., if the regions are more likely to grow fast if their neighbors are growing fast, other factors controlled. In this case we expect a positive spatial correlation of income. This mechanism is in line with neoclassical economic theory (with its central idea of capital migrating from well-developed areas in the search of higher returns), as well as with central place theory, originating from the works of Perroux (1955) and Hirschman (1958). The effect of "backwashing" is observed if the leading region drains the resources from the neighboring areas, which results in negative spatial correlation of growth; regions are worse off if they are located close to the leading region. In terms of theoretical foundations, backwashing seems related to Myrdal's concept of cumulative causation and the model of regional differentiation proposed by Krugman (1991). In the empirical literature for Poland, the backwash effect has been referred to by Gorzelak (2001) while describing Warsaw's relations with its neighboring areas.

The classical works of Perroux, Hirschman and Friedmann (1966), as well as the later contribution of Castells (1996), also provide a basis for discussing the importance of central-city size for a region's development potential. On the one hand, there is a growing conviction that the world economy is driven by large cities and that only large metropolises can produce a spillover effect that may influence the whole regional economy. On the other hand, there is evidence that global cities are more engaged in economic interactions with other metropolises than with their surrounding regions and that the links between core and periphery gradually weaken.

The empirical literature on the economic convergence between countries and regions, as well as on the role of human capital in this process, is large, and the conclusions vary depending on the time and the territorial scope of the research. Main conclusions from selected works published over the last 20 years are provided in Table 1.

In general, the more that recent data is analyzed, the less that convergence is observed at the regional level. The works covering the 1960s and 1970s, both those focusing on regions within one country and those using international data, usually provide evidence that less developed regions grew faster than did the affluent ones (Persson and Malmberg, 1996; Barro, 1999; Di Liberto and Symons, 2001). The conclusions based on the 1980s and later experiences are more ambiguous, but most researchers do not observe either sigma or beta convergence between regions over this period (Giannetti, 2002; Heidenreich, 2008; Petrakos and Artelaris, 2009). Beta convergence is frequently confirmed, however, in the country level analyses, which suggests that the income differences between economically leading regions across countries are decreasing, while the distance between the economically lagging areas and the leaders is increasing.

Also the empirical findings on the role of human capital in economic growth vary, depending on the period and territory that are investigated. For instance, Di Liberto and Symons's research on Italy (2001) emphasizes the contribution of primary schooling expansion to growth of the southern regions over the 1960s. Perreira and Aubyn (2009), looking for the sources of growth of Portuguese economy between 1960 and 2001, find a positive effect for primary and secondary education, but not for tertiary attainment. In turn, Badinger and Tondl (2002) demonstrate, focusing on 128 EU regions (NUTS 2 level), that only the increase in tertiary (not primary or secondary) education attainment led to a higher growth rate in recent years.

Evidence for the presence of spatial effects in regional growth determination is provided, for example, by Armstrong (1995), López-Bazo et al (1999), Rodríguez-Pose (1999), Le Gallo and Ertur (2003) and Magrini (2004). The authors indicate misspecification of traditional convergence regressions when spatial effects are omitted.

Variants of spatial dependence in convergence equations are empirically modelled: spatial lag model (equation includes spatial lag of the growth rate), spatial error model (spatial lag of the error term is added), spatial cross-regressive model (convergence equation includes spatial lag of the initial per capita income) or spatial Durbin model (spatial lags of all conditioning factors are added to the equation). The empirical evidence on the preferred spatial specification depends on the group of regions analyzed, period of interest and variables used in model specification.

For regional convergence in the EU, statistically significant spatial interaction between regions is found in terms of income levels and growth rates in works by Armstrong (1995), López-Bazo et al. (1999) and Rodríguez-Pose (1999). The results indicate that European regions growing at similar rates are clustered together.

Lesage and Fischer (2008), analyzing data for 255 NUTS 2 regions in 25 European countries for the period 1995–2003 show that growth rate in regions depends on characteristics of neighboring regions, such as initial income level, human capital, population density or structure of employment.

Del Bo, Florio and Manzi (2010) performed convergence analysis for NUTS2 EU-27 regions in the years 1995–2006. They observed that capital stock increase, labor force increase, human capital, and road density in a given region have effects on the growth rates of the neighboring areas.

Also the issue of the central city's size is broadly addressed in the empirical literature, although as a factor contributing to an agglomeration's economic performance rather than in the context of the relationship between the city and its region. The commonly identified channels, through which the size of a city may affect regional growth, are firms' location decisions, economies of scale and externalities emerging from the concentration of economic activity. Malecki and Bradbury (1992) demonstrate that city size is one of the important locational considerations both to professional workers and to firms that conduct R&D. They argue that it reinforces the benefits of agglomeration economics associated with large urban areas for corporate location. Combes et al. (2010) show, using French data, that population density positively affects both local labor productivity and TFP.

A review of works showing the benefits of scale and diversity that flow from concentrations of economic activity in the context of regional development is provided by Turok (2004).

Methods

The classical approach

Over the last 25 years the classical approach to convergence analysis has been widely used in literature. It has been popularized by Barro and Sala-i-Martin; see Barro and Sala-i Martin (1992), Sala-i Martin (2002), and Barro and Sala-i Martin (2004). *Beta* convergence analysis is done by estimating the following equation:

$$\frac{1}{T}\log\left(\frac{y_{i,t+T}}{y_{i,t}}\right) = \alpha - \left(\frac{1-e^{-\beta T}}{T}\right)\log(y_{i,t}) + \gamma X_{i,t} + u_{i,t,t+T} \tag{1}$$

where $y_{i,t}$ stands for *per capita* income of region i at time t, $X_{i,t}$ is a vector of exogenous structural variables that can influence *per capita* income, T stands for time interval between the data (for yearly data T=1), and $u_{i,t,t+T}$ is an error term. Constant α, according to neoclassical theory, is influenced by technological progress rate and income growth rate in steady state.[2] By omitting structural variables $X_{i,t}$ in the estimation, the absolute convergence hypothesis is tested, while non-zero $X_{i,t}$ vector in the regression means testing the conditional convergence hypothesis.

Parameter β is estimated by nonlinear least squares (NLS). The above equation can also be estimated by ordinary least squares (OLS), which involves recalculating the β parameter from the equation $b_T = ((1 - e^{-\beta T})/T)$. Positive β estimate means that poorer countries (regions) grow faster than richer ones, which leads to convergence. The value of parameter β is interpreted as yearly convergence rate (convergence speed). Based on that, one can calculate the time needed for the economy to move halfway to its steady state.

Spatial regression

The spatial regression specification is characterized by the inclusion of a new component – spatially lagged variables on the right-hand side of the estimated equation. In one of the simplest forms there is only one spatially lagged variable included – namely the dependent variable. This new variable captures the spatial interaction effect as a weighted average of neighboring observations. Most often it is applied in a linear form, as

$$y_i = \rho W y_i + X_i \beta + \varepsilon_i \qquad (2)$$

where y is an n×1 vector of observations on the dependent variable, X is an n×k matrix of observations on explanatory variables, W is an n × n spatial weights matrix, ε is an n × 1 vector of independent and identically distributed (i.i.d.) error terms, ρ is the spatial autoregressive coefficient, and β is a k×1 vector of regression coefficients. The spatial model can be further augmented by adding additional terms on the right-hand side of the equation – spatial lags of explanatory variables. The model is described by the formula

[2] Barro and Sala-i-Martin (1992) assume α is identical for regional convergence analysis within one country, where both rates do not differ much between regions.

$$y_i = \rho W y_i + X_i \beta + W X_i \gamma + \varepsilon_i \qquad (3)$$

where γ is the vector of spatial regression coefficients. It may describe the spatial interaction between different phenomena. The spatial model that includes a spatial lag of the dependent variable y, as well as the explanatory variables X, is widely known as Spatial Durbin Model (SDM). Lesage and Fisher (2008) argue that this model specification is a natural choice over competing spatial alternatives – most of which are nested in SDM.

The matrix of spatial weights (W) defines how pairs of units relate to each other. Its values depend on a definition of neighborhood – we chose the common border definition, therefore w_{ij} (elements of W) are non-zero when regions i and j are neighbors, and zero otherwise. In addition, in practice the weights matrix is typically row-standardized, such that spatial weights sum in each row to 1. Many different definitions of the neighbor relation are possible, and there is little formal guidance on the choice of the "correct" spatial weights. The term Wy in above equations is referred to as a spatially lagged dependent variable, or spatial lag. For a row-standardized weights matrix, it consists of a weighted average of the values of y in neighboring locations, with weights w_{ij}. Similar calculations are done in case of WX.

Spatial connectivity relationships are directly incorporated in spatial regression models, which makes feedback effects intristic to spatial regression models. Therefore in models that include a spatial lag of the dependent and independent variables (SDM), a change in a particular explanatory variable in one region will have a direct impact on the dependent variable in that region, but also an indirect impact on other regions. This makes the interpretation of such models' results more difficult. This is why in case of SDM one should not interpret the regression coefficients, but rather the so-called impact measures – direct and indirect impacts.[3] The direct impact measure shows the change in the dependent variable resulting from a change in explanatory variable in the same region (however, it also includes feedback influences that arise from passing impacts through neighboring regions and

[3] For more details see Lesage and Fischer (2008), Lesage and Pace (2009).

back to the region itself). The indirect impact measure in turn shows spatial spillovers – the impact of change in explanatory variable in neighboring regions on the dependent in the analyzed unit.

As stated in Anselin and Bera (1998), there are two main interpretations for a significant spatial autoregressive coefficient ρ. First, this may suggest a presence of spatial spillovers. However, this interpretation is valid only if the process takes place at the spatial unit used in the analysis and is supported by a theoretical model. Second, an alternative explanation for a significant spatial autocorrelation coefficient is the existence of a mismatch between the observed spatial unit and the true spatial scale of the process being studied.

Data

The research is based on the data on Polish subregions (EU NUTS 3 level units) over the period 1995–2006. Statistical information at the subregional level is published in all EU countries, although in the case of Poland NUTS3 are purely statistical units, used solely for research and particularly for international comparisons. There is no administrational power, or competencies of any kind, attached to this tier. In 2008 Poland reshaped its subregions and now consists of 66 such units. However, in this research we used a division existing between 2004 and 2007, consisting of 45 units. Additionally we aggregated the pairs of subregions consisting of a large city and the surrounding area, so that the number of observations were reduced to 39. The period 1995–2006 was then divided into three panels: 1995–1998, 1998–2002 and 2002–2006.

The analysis is generally based on data provided by the Central Statistical Office (GUS), but most of the used variables were not available at the subregional level over the whole period we considered. In fact, only data on GDP and population number was applied in the analysis without any transformations.

The data acquirement faced two major difficulties. First, Poland accessed EU (which led to introduction of NUTS 3 units) in 2004, and only since then has data at the subregional level been available through public statistics. The information on GDP is one of the exceptions – it has been officially recalculated back to the mid-1990s. Second, Poland profoundly reformed its administrative division in 1999, decreasing the number of regions from 49 to 16.

The values of some explanatory variables prior to 2004 needed to be approximated using data available at a different level of aggregation. In the case of the physical capital variable, the numbers for 1995 and 1998 were achieved using data on 49 regions existing prior to 1999. The algorithm transforming "old regional" into "new subregional" data was based on the distribution of population across both types of units. The same method was applied to retrieve the information on proportions of employment in different sectors. Variables referring to demography, density of transport network, and secondary school enrolment by profiles were aggregated from the local (municipal) level for the whole 1995–2006 period. The most problematic task involved constructing the dataset on higher education attainment in subregions. The official data on attainment comes from the national census, which has been performed only once during the considered period (2002). The values for 1995 and 1998 were first calculated for the old 49 regions on the basis of the household survey conducted by the Central Statistical Office (GUS). Then the results were transformed to the NUTS3 level using the aforementioned algorithm. The 2002 values of higher education attainment were taken directly from census data. Finally, the change between 2002 and 2006 was estimated using a two-step calculation. The first step used the number of tertiary school graduates in particular subregions as a proxy for the increase in higher education attainment. In the second step we assumed that there is some interregional mobility of both recent and older graduates, and that their mobility (migration rates) differs across subregions. The graduates' migration rates were calculated in a separate research exploiting a unique dataset acquired from the web portal www.Nasza-klasa.pl, a social media for re-establishing and sustaining contacts with former class mates – see Herbst (2009) for details. The data on graduation numbers and estimated migration rates were then combined to approximate the change in higher education attainment in all NUTS3 units.

Results

Regional income and growth in Poland

A glance at the disparities in the GDP per capital levels in Poland (Figure 1, left panel) reveals two basic regularities. The highest incomes are noted in regions around such metropolitan cities as Warsaw (Warszawa), Wroclaw, Poznan and Gdansk. In these strongly urbanized areas, per capita GDP exceeded PLN 30,000 (ca 15,000 in PPP euro) in 2006. High income is also observed in some regions specializing in mining and petroleum industries, namely Ciechanowsko-Plocki, which is northwest of Warsaw, and Legnicki, which is west of Wroclaw.

A distinct feature of the spatial distribution of income is Poland's division into the relatively wealthy west and the poor east. Three of the four poorest regions are located in the belt directly bordering on Ukraine and Belarus. The Nowosadecki region in the south, the area with the lowest per capita income, neighbors the territory of Slovakia.

The regional differences in growth rates in Poland between 1995 and 2006 suggest that we observe a divergence rather than a convergence of regional economies over this period (see Figure 1, right panel). Most affluent (metropolitan) regions were, on average, developing faster than the country average, while the poor regions became relatively poorer (although no region experienced negative change in real terms). There were exceptions to this rule, however: the most rapidly developing areas include some subregions with rather low per capita GDP, such as Radomski (south of Warsaw) and Rzeszowski in the southeast. The case of the Radomski area, whose labor market can be described as a satellite to that of Warsaw, with a significant number of residents driving to work in the capital city every day, raises the issue of spatial spillovers of growth that we address using spatial lag models.

The leaders in growth between 1995 and 2006 were the metropolitan areas of Warsaw and Poznan as well as the two regions benefiting from high global prices for petroleum and copper (Ciechanowsko-Plocki and Legnicki respectively). The Warsaw metropolitan area economy was growing at the impressive average yearly rate of 10%. The lowest growth dynamics could be observed in the peripheral areas of eastern Poland (the so-called Eastern wall). The regions of Krosniensko-

Przemyski, Chelmsko-Zamojski and Bialski, displayed as a white belt in the east on the right panel of Figure 1, achieved an average GDP growth rate below 2.5% over the 1995–2006 period.

Figure 2 reveals that the impression of economic divergence between 1995 and 2006 is caused mostly by the dynamic growth of the three affluent regions (including the metropolitan areas of Warsaw and Poznan). Without them included in the sample, the relationship between the initial per capita income and the rate of growth has no clear pattern.

It is important to note that the period considered was not a time of stable, uniform growth for the Polish economy. As mentioned in the methodological section, we perform our analysis separately of the three subperiods: 1995–1998, 1999–2002 and 2003–2006. The first of these was the period of Poland's dynamic development, with an average yearly growth rate reaching 6.2%. The subsequent period brought a significant slowdown. The years 2000–2002 were a period of worldwide economic crisis, but in Poland the drop in GDP started earlier than in most European countries (at 1998), most probably due to a negative influence by the financial and structural crisis in Russia. Between 1999 and 2002 the average growth rate of the Polish economy was only 2.8%. Finally the third period considered (2003–2006) was characterized by a return to the fast growth path, with the average yearly growth rate equal to 4.7%.

Figure 3, reporting standard deviations of the regional GDP per capita in 1995, 1998, 2002, and 2006, confirms the intuitive statements on the presence of sigma divergence between the subregional economies within Poland. The income variation between regions clearly increased over time, with the 2006 value of standard deviation being more than double that of 1995 (in real terms). It can also be seen that the differences between regions were deepening faster over the fast-growth periods of the national economy (1995–1998 and 2002–2006) than was happening during the slowdown.

Results of the OLS and SDM estimations

The results of the growth regressions for the Polish subregions are shown in Tables 2–5. Table 2 includes the parameters from the estimation run for the whole period considered (1995–2006). The subsequent tables show the results for subperiods: 1995–1998 (Table 3), 1998–2002 (Table 4) and

2002–2006 (Table 5). Each table contains the results of 10 specifications, the first 5 of which are OLS specifications, and the remaining 5 of which include the spatial effects of the variables (Spatial Durbin Model, SDM). Specifications 1–3 in both OLS and SDM approach use the initial values of the explanatory variables, while specifications 4 and 5 apply the changes of these values over time (between the beginning and the end of the period considered).

The dependent variable in all specifications is the growth rate of GDP per labor force member. Many researchers use number of employed in the denominator. However in Polish public statistics, due to frequent methodological adjustments, the data on employment is not consistent over the considered period and using it may bring misleading results. Applying labor force instead, we account for the differences in GDP per capita reflecting different demographic (age) structure of the regions' populations.

In addition to the variables shown in Tables 2–5, several alternative specifications were tested, including measures of economic structure as well as of physical and institutional capacity of different regions, such as the following: population density, road density, unemployment rate or share of employed by economic sectors. Alternative measures of human capital stock referred to the number of tertiary students and proportion of population holding secondary education. Some of these variables were subject to methodological concerns, while the others didn't significantly explain regional growth patterns. To save space, we present only the most meaningful specifications.

The parameters observed in specification 1, Table 2 suggest that we observe a beta divergence rather than convergence of per capita income between the Polish subregions in 1995–2006, with an annual rate close to 3%. The parameters of equation 2 show that human capital may be considered an advantage for the fast growing regions, although the parameter of the higher education variable is only significant at 10% level. Further investigation shows that the role of the initial level of human capital turns insignificant as we control for the size of the regions' central cities. We also discover that the inclusion of central city size dummies turns the initial GDP variable into *negative* and *significant*. Therefore, we observe a conditional convergence between the regions with similar central cities, rather than conditional on the initial human capital level. The rate of the conditional beta convergence is about 4% yearly.

The OLS specifications 4 and 5 in Table 2 prove also that, when variable changes over time are considered, rather than the initial values, the regional growth rate is strongly associated with the change in physical capital stock, but not with the increase in human capital level, as measured by higher education attainment.

SDM analysis reveals some spatial effects in determining the growth rate among the Polish regions, although these effects are not easily or intuitively explained. As shown in specification 5 (both OLS and SDM), the change in the share of regional value added contributed by the agricultural sector is indifferent for the economic growth rate at the regional level. It seems, however, that neighbouring with a region having increasing agricultural sector's contribution to GDP exerts a positive impact on the income growth (see SDM specification 5). Note that the AIC statistics suggest that the OLS specification slightly outperforms the one including spatial effects, in this case.

Tables 3–5 comparee regional convergence determination between the periods of national economic stagnation and fast growth. The results show that although absolute (unconditional) beta convergence does not occur in either of these periods, conditional convergence does appear in the first two periods, but not in the most recent one, in which we observe divergence. More precisely, comparison of the OLS specification 3 results for the first two periods reveals that while the yearly rate of the conditional beta convergence over 1995–1998 and 1998-2002 was about 5%, there was no convergence at all in the subsequent period. This result is puzzling, in the sense that the former two periods are very different from each other with respect to Poland's economic performance. As mentioned before, between 1995 and 1998 Poland experienced a dynamic growth at a yearly rate exceeding 6%. After that came the crisis and the growth slowed to below 3%. The rate of conditional convergence looks similar for both periods.

Notice that what differs greatly between the two periods considered is the relationship between the size of the region's central city and the growth rate. We can see that during the economic boom, the regional growth and convergence are strongly conditional on the potential of central metropolises. The binary variables indicating Warsaw (the only city with a population over 1,000,000) and the cities with populations over 500,000 are positive and significant, showing that these regions develop faster independently on the measured stock of the physical and human capital.

The role of central city scale then disappears in the regression referring to 1998–2002 (coefficients insignificant) and again gains some power over 2002–2006 (at least in column 5 referring to the SDM model).

Human capital does not seem to play an important role in determining the growth rate or the convergence and divergence patterns for the Polish subregions during economic boom, but it has some impact during a slowdown. The initial share of population holding a higher education degree enters the specification 2 with positive sign for 1998–2002 (Table 4) and 1995–2006 (Table 2), and is statistically significant over these periods. For 1995–2006, this effect vanishes as the size of the central city and some specific features of particular regional economies become controlled in specification 3. However in the 1998–2002 subperiod, with spatial effects included in the specification, the human capital variable remains significant even in the extended specification (equation SDM 3 in Table 4), although only at 10% level.

This finding may not seem in line with the conclusions from some international research emphasizing the importance of human capital and particularly, education, for growth. However, note that the reviews of such research reveal that the crucial role of education is more likely to be observed in the research covering long periods (i.e., reaching far back in time) and in those using international data (thus based on more heterogeneous observations).

Our finding does not necessarily mean that human capital is not an important regional growth factor. Although it is possible that the effect of human capital, measured by other research, reflects in reality the role of omitted variables referring, for instance, to the institutional quality of different (regional) economies; the other interpretation is that academic credentials, which we use as a human capital proxy, fail to account for all its aspects of which some are better captured by variables such as the size of a region's central city. The finding that the effect of human capital turns insignificant after including the city-size variable in the specification simply means that, although the correlation of education and economic growth exists, it can't be observed across the regions with similar sizes of central cities.

The role of endowment in physical capital in determining growth of the Polish regions seems much stronger when the economy is struggling, than when it is developing quickly. In 1998–2002 the regional growth rate was correlated with both a region's initial level of physical capital and its change over the period considered. Moreover, in this period, the physical capital exerted also some significant spatial effect (at 10% level): the neighbours of the well-endowed regions experienced faster growth than the remaining areas.

Over 1995–1998, and especially over 2002–2006, the regional economies based on specific natural resources gained important advantages over the other regions. The binary variable indicating the Legnicki subregion (copper) and the Ciechanowsko-Plocki subregion (petroleum) is highly significant in Table 5 and the parameter value reaches 6%.

The growth of the Polish subregions seems more spatially clustered at the time of economic slowdown than during prosperity. We observe a significant, positive spatial effect of the initial GDP per capita in the SDM specifications 2 and 3 in Table 4. The corresponding effect in Tables 3 and 5 (covering 1995–1998 and 2003–2006, respectively) is nonexistent. Figure 4's left-hand panel reveals that significant, positive spatial autocorrelation (local Moran statistics) for the growth rate over 1998–2002 refers exclusively to the economically lagging subregions in Poland's southeast. This might suggest that the spatial autocorrelation is caused by the fact that the major factor contributing to the 1998–2002 slowdown in Poland was a deep crisis of the post-Soviet countries' economies. The eastern regions of Poland were more engaged in trade with these economies than were the remaining parts of the country. These regions traditionally belong to the least affluent in Poland, which explains the spatial effect of the lagged GDP observed in Table 4.

The values of the local Moran statistics for the GDP growth over the whole 1995–2006 period show in turn that, in addition to the southeastern low-growth cluster, we can speak of the positive spatial effect of the two subregions whose economies are based on the exploiting or treatment of their natural resources – Legnicki in the southwest and Ciechanowsko-Płocki in central Poland. The only large metropolis with a significant spatial spillover is Warsaw (Figure 4, right panel), the positive effect of which on its neighbours can be especially observed in the first subperiod (specification 5, Table 3).

In the first two subperiods a positive spatial effect of the change in higher education variable is observed. This means that regions adjacent to those with growing educational potential were experiencing higher growth rate. However this effect is not significant for the whole 1995–2006 period.

Note that the relatively weak spatial effects observed at the subregional level do not necessarily exclude the existence of stronger spillovers at a local level. Many economic interactions – particularly these related to the labor market, take place within, rather than between, subregions. Looking for spatial patterns in the economic performance of Polish municipalities or counties (smaller territorial units) would be an interesting research project itself, but it can't be done within a framework of growth regression and convergence analysis, since GDP related data is not available at a low aggregation level.

Conclusions

Using OLS and SDM models we attempted to verify the presence of economic convergence between the Polish subregions over 1995–2006. We found that the regional differences in per capita income increased in this period, which means that we observed divergence (in absolute terms) of regional economies. However, a conditional convergence could be observed in the whole period, as well as in two of the three subperiods, after controlling for additional features of the regional economies.

Fast growing regions significantly increased in physical capital stock, although the initial level of physical capital was not necessarily a precondition for a high growth rate in the subsequent period. There is also no convincing evidence for the role of human capital in determining the growth rates for particular regions, although it seems that educational potential has some importance in the periods of economic slowdown. It seems that the advantage of fast growing economies came either from endowment in natural resources and related treatment facilities, or from agglomeration economies. The income gap between regions with large cities and other regions widened, particularly during the dynamic growth of the Polish economy, 1995–1998 and 2002–2006. Moreover, the conditional convergence of regional economies was observed only when the central city size dummies were included in the specification, suggesting that converge occurs only between the regions endowed with metropolises of similar scale.

At the same time, however, the spatial effects exerted by large agglomerations on the neighboring regions seem rather weak. The Warsaw region is the only metropolitan area where a high growth rate seems to have significant, positive impact on the neighboring regions over the period analyzed.

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