REAL CONVERGENCE IN POLAND. A REGIONAL APPROACH

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1. Introduction

The aim of the presented paper is to empirically attempt to analyze the real convergence processes in Poland. They will be analyzed through the prism of labour productivity (GDP per employee) growth rates in particular new voivodships, in the years 1996-2000. The choice of the period mentioned above comes off from the statistical data availability concerning both GDP in voivodships and number of employees disaggregated to new voivodships (data concerning the mentioned macroeconomic variables are available on the website: www.stat.gov.pl).

The structure of the paper is as follows. In the second point basic theoretical concepts of regional convergence processes in macroeconomic models are presented. Point three contains a descriptive analysis of endogenous and exogenous variables used in the model of regional convergence in Poland presented here. In point four, statistical estimations of the model's parameters are shown and discussed. Point five concludes and draws major conclusions from the considerations undertaken in the paper.

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2. Convergence in the macroeconomic models.[1]

Economic convergence is most commonly understood as levelling of the values of essential macroeconomic variables between countries or regions with the initially diversified values of these variables. Both nominal and real variables can undergo this process; we can therefore talk about, respectively, nominal or real convergence. The real convergence, which is a subject of the analyses undertaken by the authors, means reduction of differences in the standard of living, approximated commonly by GDP *per capita* or labour productivity. Macroeconomic theory does not supply us with an unequivocal answer for a question, whether the process of reduction of countries' or regions' economic differentiation takes place. Literature allows us, however, to isolate few factors, which can mould either convergence or divergence – the opposite process.

The first required condition for convergence between regions to appear is the existence of decreasing marginal productivity of capital. This assumption, well known from the neo-classical models of growth, means that as capital outlays grow, its marginal products decrease. A decline of marginal product of capital has a slowing down effect on economic growth rate (see: Tokarski, 2001ab). In the open economy environment with flows of capital being possible, it will be located in the less favoured regions, where capital is scarcer and therefore its marginal product is higher. Under an assumption of perfect mobility of production factors, the inflow of capital to a less developed region will take place until marginal products equalize. The result of this will be alignment of production levels per employee. A factor strengthening this process may be a common currency in the well-developed and less favoured regions, eliminating transaction costs for investors as well as exchange rate risks. In the opposite situation, under an assumption of increasing marginal products of capital, we could expect capital concentration and advancing polarization of economic development between regions. This is due to the fact that countries (regions) with high GDP *per capita* per employee would develop faster than countries (regions) with initially lower levels of these macroeconomic variables.

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[1] The considerations regarding convergence processes, apart from the literature quoted here, can be found e.g. in works of Fagerberg, 1987; Barro, 1991; Mankiw, Romer, Weil, 1992; Gomulka, 1998 (point 15.8); Wojtyna. 1995, 1996; Tokarski, 2001a, Liberda, Tokarski, 1999 or Liberda, Rogut, Tokarski, 2002.

Another crucial factor influencing the process of convergence or divergence of GDP *per capita* and labour productivity is a nature of technical progress. Regional differentiation in generating and adopting new technologies may essentially diversify long-run economic growth paths. If, however, cost of additional innovations would grow, than (assuming also lack of obstacles in flows of innovations, especially fixed costs on the level of enterprises) diffusion of technology would lead to equalization of technical efficiencies across regions. It is doubtful however, since as knowledge accumulation increases, the cost of introducing innovations may decrease. If this is the case, that would mean that regions should diverge in the aspect of technical efficiency of production. Certainly, it will find reflection in divergence trend of labour productivity and GDP *per capita*. In literature, another aspect of technical progress in this context is often raised (see for example: Abramowitz, 1986, Keely, Quah, 1998, Luiten, Harmsen, 1999). Technical progress can be a factor favouring convergence as long as economically backward regions may benefit from the technical improvements. The lack of costs of generating new technologies (accordingly to a concept of imitation costs being lower than costs of innovation) can be a favourable factor equalizing technical efficiencies. What is more, the more universal new technical solutions and (what is important) the lower pace of technical progress, the faster process of convergence we can expect. Fast technical development will make it more difficult for backward regions to catch up.

Other factors, which can exhibit influence on slowing down the convergence process, are disparities in the level of infrastructure, agglomeration effects and the problem of high fixed costs in enterprises. Regions economically weakest are often characterized by poor infrastructure, especially in the meaning of road system, which increases the cost of investments carried out there. However, the theory does not present a unified point of view also on this point. As, for example, Martins notices (see Boldrin, Canova, 2000), construction of the transport and communication infrastructure can act harmfully for the least developed regions since it facilitates migrations of effective production factors. After all, Martin presents an opinion that the liberalization of production factors' flows itself causes divergence between regions. An integral part of a model, analysis of which leads to these conclusions, are increasing returns to scale resulting, among others, from agglomeration effects and high fixed costs, which are an obstacle for flows of technically advanced investments. Theoretical background for this concept can be found in works of e.g. Krugman and Venables (1993) and others (see for example Boldrin, Canova, 2000, p. 9).

In the face of such clashes in points of view on the problem of regional convergence, they are usually classified into four groups, in accordance with the hypotheses framed:

a) Hypothesis of unconditional convergence, according to which, regardless to the initial conditions, since decreasing marginal productivity of production factors exist, in the long-run regions converge towards an equal level of GDP *per capita* and labour productivity. The necessary prerequisites are unconstrained flows of capital and lack of obstacles for technical progress diffusion.
b) Hypothesis of conditional convergence, which the effectiveness of equalizing levels of GDP *per capita* and labour productivity conditions to the initial stock of immobile production factors (such as social and economic infrastructure).
c) Hypothesis of unconditional divergence, followers of which claim that every advance in the level of openness of economies will cause an increase in spatial differentiation of essential indicators describing the level of development.
d) Hypothesis of conditional divergence, which is a frame for the hypothesis of club divergence. According to this concept, convergence takes place between regions similarly equipped with stocks of immobile production factors and natural resources. This, however, generates an increase of real differences in the level of economic development. What is more, regions inside of the convergence club converge towards the unique long-run growth paths. This does not mean convergence between clubs. In the presence of divergent long-run growth paths, crucial for the existence of convergence process in the global scale is a nature of technical progress.

Perhaps the closest to the intuitive notion of convergence is the concept of σ-convergence (see: Barro, Sala-i-Martin, 1992; 1995). The point of σ-convergence is advancing decrease of spatial diversification of GDP *per capita* (or per employee) measured, for example, by variance or standard deviation.

Barro and Sala-i-Martin proposed also a concept of β-convergence, basing on the Solow-type and Ramsey, Cass and Koopmans type models of growth. A starting point there is a neo-classical production function: $Y(t)=F[(K(t),A(t),L(t)]$. From the assumptions of this model we know, among others, that:

- Firstly, in the face of decreasing marginal productivity of capital, growth rate of *per capita* GDP is negatively correlated with the initial level of this variable;

- Secondly, technical efficiency in the production function is multiplicative with labour stock (L). In this way, a stock of effective labour (AL) is created, which grows at an exogenous growth rate g+n, where g is a labour-augmenting technical efficiency (Harrod type) growth rate and n is the growth rate of employment;
- Thirdly, households maximize an inter-temporal expected (discounted) sum of consumption utility:

$$U = \int_{t=0}^{\infty} u(c)e^{nt}e^{-\rho t}dt \qquad (1)$$

where c – consumption per one employee, ρ–discount rate of a typical household (the greater value of ρ, the more importance is attached to present consumption with relation to future consumption) and:

$$u(c) = \frac{c^{1-\theta} - 1}{1-\theta} \qquad (2)$$

$\theta > 0$ and $\theta \neq 1$ so, that $-\theta$ is a constant elasticity of marginal consumption utility with respect to c. It is furthermore assumed that the following formula is satisfied: $\rho - n - (1-\theta) > 0$ which assures us that the problem of utility function (1) maximization has solution (see for example: Romer, 2000, p. 59).

If regions are similar in respect of technical efficiency and households preferences, than we can expect that higher growth rates of *per capita* GDP will be achieved by regions with lower initial level of *per capita* GDP.

In the following equation:

$$\log\left(\frac{y_{it}}{y_{it-1}}\right) = a - \left(1 - e^{-\beta}\right)\cdot \log\left(y_{it}\right) + \xi_{it} \qquad (3)$$

where:

y_{it}–level of GDP *per capita* in region i, in the year t,

a–constant,

ξ_{it}–error term capturing random shock effects in region i, in the year t,

The β parameter determines existence and strength of convergence. Positive values of β imply that economies of poorer regions grow at faster rates than richer ones. Negative values of β

would mean, on the other hand, the existence of economic divergence between regions, while $\beta=0$ signifies no relation between growth rate and the initial value of *per capita* GDP. But even existence of β-convergence [$\beta \in (0,1)$] does not guarantee real reduction of regional disparities in terms of GDP *per capita* (σ-convergence). It comes off from the fact that *per capita* GDP values, to which particular regions converge may differ and, hence, standard deviation of regional GDP's *per capita* can well evolve to a value different from zero. The variance of regional values of $\log(y_{it})$ approaches a steady state value:

$$\sigma_o{}^2 = \frac{\sigma_u{}^2}{1-e^{2\beta}} \qquad (4)$$

where σ_u^2–error term variance. From that we can conclude that although higher values of β decrease the variance value of destination σ_o^2, but they do not guarantee that the process of regional reductions will occur as soon as the initial value of variance is still lower than σ_o^2. Unless regional economic systems are fundamentally different[2], which can be revealed by similar regional values of constant in equation (3) and if random and asymmetric shocks are omitted, than regions would move on converging long-run growth paths and standard deviation of regional *per capita* GDP's bounds to decrease. In the frame of considerations presented by Barro and Sala-i-Martin both unconditional and conditional convergence concepts can be stored.

One of expansions of the model of convergence described above is a concept presented by Mankiw, Romer and Weil, 1992. A change of labour productivity in the region (country), in the period t, can be expressed through equation (5) [(after de la Fuente, 2002ab]:

$$\Delta \ln(y_{it}) = g + \beta(a_{i0} + gt) + \beta\frac{\alpha}{1-\alpha}\ln\frac{s_{it}}{\delta + g + n_{it}} \qquad (5)$$

where a_{i0} – logarithm of labour productivity index in the initial period, g-growth rate of technical efficiency, δ-capital depreciation rate, n_{it}-labour force growth rate in i-th region, in period t and s_{it}-investment rate in region i, in period t. In the model defined in this way, the β parameter can be described by a formula:

$$\beta = (1-\alpha)(\delta + g + n) \qquad (6)$$

[2] That is, regarding essential characteristics constantly influencing economic growth rate path in a given region. For more see: de la Fuente, 2002ab.

One difficulty in implementing this model to empirical analyses is that capital depreciation rate, technical progress rate and a_{i0} variable are not directly observable. A common solution is assuming *a priori* (calibrating) certain reasonable values of these variables.

To neo-classical convergence models we can also subsume the one proposed by de la Fuente, 2002ab. His subject of analysis is a function of labour productivity growth rate given by a formula:

$$g_q = (1-\alpha)(\gamma\phi + \varepsilon b) + \alpha s k^{\alpha-1} - \alpha(n+\delta) \qquad (7)$$

where g_q-labour productivity growth rate, α–elasticity of labour productivity with respect to stock of capital per employee, γ–speed of technology diffusion, ε-R&D productivity, s-investment rate, k-capital per employee, n-growth rate of labour force stock, δ–capital depreciation rate.

Relaxing the assumption of decreasing marginal product of capital in the de la Fuente model leads to an explosive solution, since capital will be located in the regions with largest stocks of it, which implies accelerating divergence. Decreasing marginal product of capital ($\alpha<1$) entail, on the other hand, to equalizing stocks of capital per unit of effective labour (and capita), which in all regions converge to steady-state value:

$$k^* = \left(\frac{s}{n + g_a + \delta} \right)^{1/1-\alpha} \qquad (8)$$

where g_a is the exogenous rate of technical progress[3].

De la Fuente analyzes as well the impact of technical progress diffusion on convergence. In case of $\varepsilon=0$ (no diffusion), countries or regions holding technological advantage will experience higher growth rates of labour productivity as soon as they invest more in R&D. For sample two regions: leader (l) and a follower (g) the problem of technological gap (U_{lg}) looks as follows:

$$U_{lg} = \frac{\gamma(\phi_l - \phi_g)}{\varepsilon} \qquad (9)$$

[3] Stock of k^* in equation (7) stands in accordance with the long-run solution in the Solow, 1956 model with the Cobb-Douglas production function (see Tokarski, 2001b, chapter two).

To sum up, in the light of this concept, the divergence of regions may be caused by existence of increasing returns from capital as well as lack of technical progress diffusion. If none of these situations occur, growth rates of GDP *per capita* will converge to a certain growth path marked by the speed of technical progress.

In opposition to convergence theories there are concepts emphasising an important role of some negative exogenous factors, increasing marginal productivity of capital (especially on the level of companies) and agglomeration effects, which all result in sustaining or deepening the existing regional differences. Ciccione, 2000 proves that the agglomeration effects have significant influence on labour productivity growth, which puts developed regions on favoured position. Ciccione started his consideration from a labour productivity function in region S, being a part of a larger terrain (e.g. a country) c:

$$q = \Omega_{sc}\left[(nH)^{\beta} k^{1-\beta}\right]^{\alpha}\left(\frac{Q_{sc}}{A_{sc}}\right)^{(\lambda-1)/\lambda} \qquad (10)$$

where q – production manufactured, on average, on each acre in the region, Ω_{sc}-total factor productivity in the region, Q_{sc} (A_{sc}) – total size of production (aerial) in the region, n – number of employees employed on each acre, H – human capital stock on each acre, k – physical capital stock used on each acre. It is also assumed that this function is characterized by decreasing or constant marginal products of capital and labour $(0 \le \alpha \le 1)$ and $0 \le \beta \le 1$.

Ciccione eventually arrives at a following labour productivity function:

$$\frac{Q_{sc}}{N_{sc}} = \Lambda_c \Omega_{sc}^{\omega} H_{sc}\left(\frac{N_{sc} H_{sc}}{A_{sc}}\right)^{\theta} \qquad (11)$$

where N_{sc} is number of employees in the region, Λ_c-variable exhibiting the price of capital in the country, ω is a constant, and the θ parameter can be rewritten as follows:

$$\theta = \frac{\alpha\lambda - 1}{1 - \alpha\lambda(1-\beta)} \qquad (12)$$

θ is a measure of an impact, which employment and human capital density have on labour productivity in the region and its value describes strength of agglomeration effect. Since $\alpha \le 1$, than θ can take positive value than and only than, if $\lambda>1$. This, on the other hand, indicates positive influence of spatial density of production on the level of labour productivity. For agglomeration effect to appear it is required that the product $\alpha\lambda$ is greater than 1. The higher is the value of expression $1-\beta$, the stronger the agglomeration effect is.

From the model we can conclude that occurrence of the agglomeration effect can effectively restrain or inverse the convergence process (β type).

In other convergence analyses, one of the major sources of changes of spatial differentiation in *per capita* GDP or labour productivity is recognized to be economic integration (including especially trade integration). The already mentioned Krugman, Venables, 1993 and Young, 1991, present an opinion that trade liberalization contributes to economic divergence between regions. A fairly common is also a concept of club divergence, touched for example by Gianetti, 2001. He undertook a theoretical analysis of an impact, which trade exchange has on development of two hypothetical regions: a rich "North" region, specializing in production of high technology, requiring high human capital outlays, a technologically advanced one, and a poor region, named "South", manufacturing goods in the primary sector. Conclusions from these analyses are in accordance with the club divergence hypothesis.

3. Exogenous and endogenous variables in the regional convergence model for Poland

In the analyses presented further in the paper, concerning the regional convergence processes in Poland, the authors will take advantage of conclusions drawn from the neo-classical Solow growth model. Moreover, variables concerning agglomeration effects and influence of the stock of immobile production factors related to development of the road transportation system in Poland on the process of economic growth will be taken into account. For this reason such macroeconomic variables as level and growth rates of labour productivity, investment rates (share of investment in GDP), urbanization rates (as a kind of measure for agglomeration effects) and length of roads per square kilometre of land in voivodships.

In the considerations presented later on, statistical data concerning the above mentioned macroeconomic variables are used, sourcing from the official Polish Statistics Website – www.stat.gov.pl. The period considered are years 1995-2000. The data refer to the following macroeconomic variables:

- Real GDP, in constant prices from the year 1995;
- Number of employees according to Labour Force Survey, in May of each year except for 1999, where the available data are only from February;

- Length of roads per sq. kilometre;
- Urbanization rates being a relation of inhabitants in cities according to OECD definition to the total number of inhabitants.

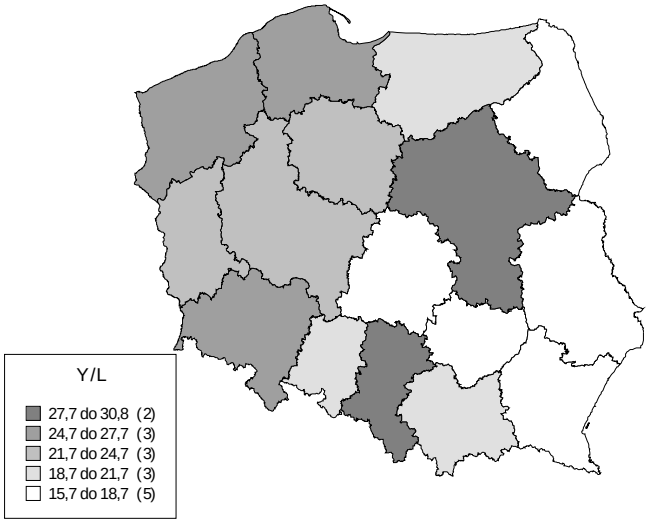
Moreover, on the basis of Statistical Yearbooks of Voivodships data concerning investment outlays in particular voivodships were obtained. Data from the years 1995-1998 were reassessed[4].

Map 1 shows regional differentiation of labour productivity in Poland, in the years 1995-2000. From the map a few following conclusions can be drawn (see also for example Tokarski, Gabryjelska, Krajewski, Mackiewicz, 1999; Kaczorowski, Rogut, Tokarski, 2001 lub Kwiatkowski, Kucharski, Tokarski, 2002:):

- The highest labour productivity levels in the period analyzed were in the mazowieckie and slaskie voivodship (over 27.7 thousand PLN). Amongst the voivodships with GDP per employee higher than 24.7 thousand there are also voivodships: pomorskie, zachodniopomorskie and dolnoslaskie.
- To the voivodships with low or very low level of labour productivity we can subsume voivodships from south-eastern and Eastern Poland: lubelskie, swietokrzyskie, podkarpackie, podlaskie, malopolskie, warminsko-mazurskie as well as lodzkie and opolskie.

[4] Data regarding investments were reassessed to the new voivodships with the following procedure. A simplifying assumption was made that level of investments per inhabitant in particular communes („gmina") of old voivodships was identical with the one referring to all old voivodship. In the next stage (on the base of relevant data concerning the analyzed economic variables and data concerning number of inhabitants in communes from „Bank Danych Lokalnych GUS" on the website www.stat.gov.pl) investment values on the level of communes were assessed and aggregated to the level of voivodships by administrative division binding from 1999.

Map 1. Regional differentiation of labour productivity in Poland in the years 1995-2000 (thousand PLN, 1995 prices)

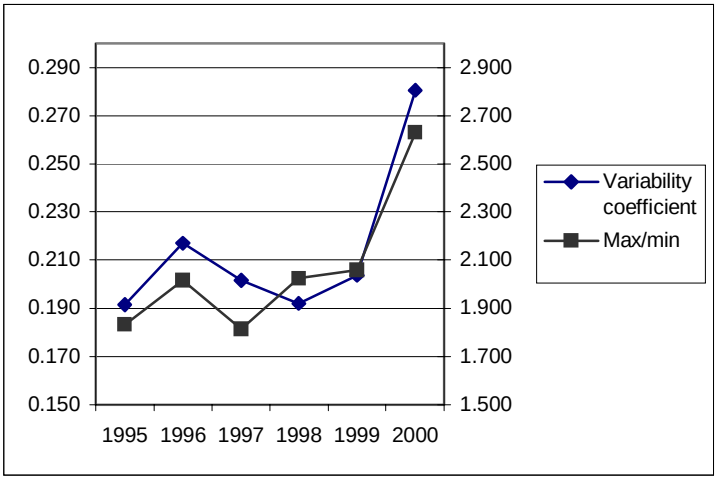


Source: own calculations on the basis of data from www.stat.gov.pl .

- From the earlier analyses of Tokarski, Gabryjelska, Krajewski, Mackiewicz, 1999, Kaczorowski, Rogut, Tokarski, 2001 and Kwiatkowski, Kucharski, Tokarski, 2002, 2003 it comes off that a few following causes of regional labour productivity differentiation can be isolated. Firstly, this differentiation is largely determined by regional disparities of physical capital stock per employee (Tokarski, Gabryjelska, Krajewski, Mackiewicz, 1999, Kaczorowski, Rogut, Tokarski, 2001). Secondly, significant sources of differentiation of labour productivity we suspect to be a diversification of employment structures by sectors (in division for agriculture, industry and construction and services). It is a result of a fact that the labour productivity in the Polish agriculture is almost four times lower than in industry and construction and services. What is more, employment in the agriculture sector significantly weaker reacts for changes in value added to compare it with other sectors (Kwiatkowski, Kucharski, Tokarski, 2002, 2003). From this it results that in regions with high proportion of employed in agriculture or low proportion of employed (especially) in service sector, the level of labour productivity is lower than in other regions. Due to the fact that employment in a low productive private agriculture (with high hidden unemployment) is concentrated mostly in the south-eastern and Eastern Poland, therefore in these regions the lowest level of labour productivity exists.

Figure 1 presents variability coefficients and relation of maximal to minimal labour productivity in Poland in the years 1995-2000. The higher values of these variables, the deeper the regional divergence process of labour productivity is (understood as unconditional divergence). From the values of variability coefficients shown on the graph and relations of maximal to minimal labour productivity, the two following conclusions can be drawn. Firstly, in the years 1995-1998[5] the considered indicators were shaping up at a relatively stable level. Secondly, a significant increase of these values took place in 2000. This was a result of a very high labour productivity growth rates (in relation to 1998) in the voivodships: slaskie (circa 48%), dolnoslaskie (35%), pomorskie (25%) and zachodniopomorskie (20%) and imperceptible (not more than 8%) changes of labour productivity in the voivodships of south-eastern and Eastern Poland (except for swietokrzyskie voivodship, where a labour productivity growth of around 10% was recorded). A high labour productivity growth in the former group of voivodships resulted particularly from significant declines of number of employees in the mentioned period (in the slaskie voivodship the decline by 28%, dolnoslaskie-17%, pomorskie-11% and zachodniopomorskie-11%) with a relatively stable level of the employed in the south-eastern and Eastern Poland (it appears that minor changes in the number of employees in this part of Poland are caused to great extent by high hidden unemployment in the Polish agriculture).

Figure 1. Variability coefficients (left scale) and relation of maximal to minimal labour productivity (right scale) in Poland in the years 1995-2000



Source: own calculations on the basis of data from www.stat.gov.pl.

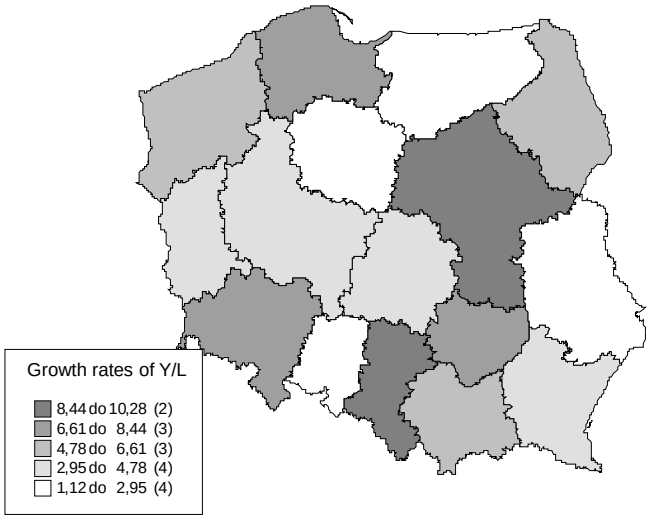
[5] Data regarding labour productivity in 1999 are not directly comparable with other years because data regarding

On map 2, the yearly average labour productivity growth rates are shown in particular voivodships, in the years 1996-2000. From this map, we can draw the following conclusions:

- The highest labour productivity growth rates during the whole period analyzed characterize voivodships slaskie (10.3% on average) as well as mazowieckie (9.1%). Very high growth rates of this macroeconomic variable were recorded also in the voivodships: pomorskie (8.3%), swietokrzyskie (7.3%) and dolnoslaskie (6.7%). An increase of labour productivity in this group of voivodships was a result of both, real GDP growth (in 2000 to compare it with 1995 real GDP increased by: 57% in mazowieckie voivodship, 31% in pomorskie, 27% in dolnoslaskie, 26% in swietokrzyskie and 13% in slaskie) and decline of the number of employees (by 28% in slaskie voivodship, 12% in pomorskie, 11% in swietokrzyskie, 6% in dolnoslaskie and 3% in zachodniopomorskie with a slight increase of 1% recorded only in mazowieckie voivodship). One conclusion is that in the mentioned voivodships an increase of labour productivity was to a large extent related to the process of jobless economic growth (for further readings on the subject of jobless growth see: Tokarski, 2002 or Tokarski, Gajewski, 2002).
- The lowest growth rates of labour productivity in the period analyzed here, occurred in warminsko-mazurskie voivodship (1.1% average during year), opolskie (1.7%), kujawsko-pomorskie (2.3%) and lubelskie (3.6%). The sources of low labour productivity growth in warminsko-mazurskie voivodship should be perceived in a relatively high increase of employment (in May 2000 it was about 17% higher than in May 1995) linked with a relatively low increase of real GDP (by 21%). In the remaining voivodships low labour productivity growth rates were caused by a relatively low increases of GDP (respectively by circa 10% in opolskie voivodship, 13% in lubelskie and 16% in kujawsko-pomorskie) and a stable number of employees (number of employees in the years 1995-2000 practically did not change in lubelskie voivodship, while in voivodships opolskie and kujawsko-pomorskie it rose by 3-4%).

number of employed are from February, whilst in other years they refer to May.

Map 2. Yearly average rates of labour productivity growth in the years 1996-2000 (in %)



Source: own calculations on the basis of data from www.stat.gov.pl.

- To the voivodships, which recorded low growth rates of labour productivity in the second half of the nineties, we should subsume voivodship lubuskie (about 3.6% yearly on average), wielkopolskie (3.9%), podkarpackie (4%) and lodzkie (4.4%). The reasons of low labour productivity growth in lubuskie, podkarpackie and lodzkie voivodships should be associated with a relatively low dynamics of GDP (it increased between 1995 and 2000 by, respectively, 18%, 19% and 23%) together with a fairly stable level of employment (almost constant level in voivodships lubuskie and lodzkie and 2% decrease of the employed in podkarpackie voivodship). The relatively low growth rates of labour productivity in wielkopolskie voivodship resulted, on the other hand, from a very high increase of the number of employees (by circa 16% in 2000 with relation to 1995) jointly with a high GDP growth (by 40%).
- Collating labour productivity growth rates (map 2) and levels of this macroeconomic variable (map 1) it turns out that some premises exist to claim that a process of unconditional divergence takes place (see also figure 1)[6]. This conclusion is based on the observation that mazowieckie voivodship and voivodships of Western Poland (with the highest labour productivity) are characterized by (generally) higher growth

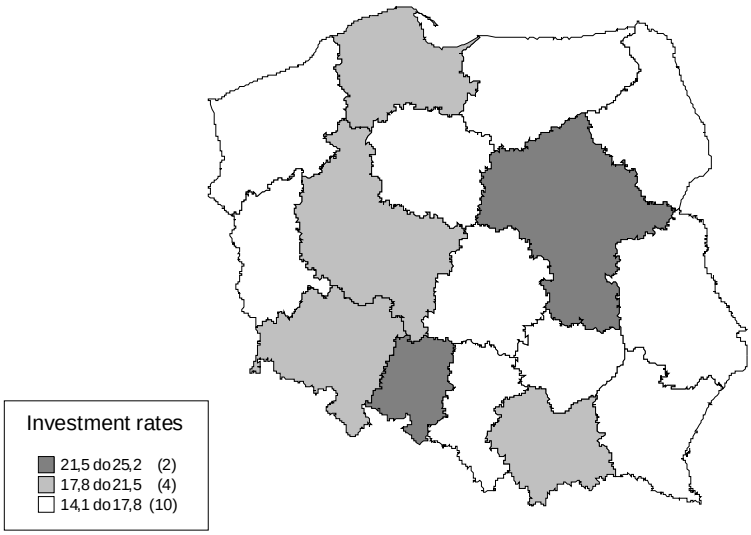
[6] If swietokrzyskie voivodship were not in the group of voivodships with highest growth rates, the authors would be inclined to submit a proposition that a process of club divergence takes place. Because, however, swietokrzyskie voivodship (characterized by low level of labour productivity) recorded high rates of growth, we are rather inclined to accept a view of an unconditional divergence taking place.

rates of labour productivity than it is the case in voivodships of Eastern and south-eastern Poland. The one exception is swietokrzyskie voivodship, which, despite of a low level of labour productivity (row of 17 thousand PLN in 1995 prices) was characterized by over 7% growth of product per employee.

On map 3, regional differentiation of average yearly investment rates in Poland in the years 1995-2000 is exhibited. The following conclusions can be drawn from this map:

- Distinctively highest investment rates in the analyzed period characterized mazowieckie (circa 25.1%) and opolskie (23%) voivodships. To the group of voivodships with fairly high investment rates the following can be subsumed: dolnoslaskie (18.6%), malopolskie (18.3%), pomorskie (18.1%) and wielkopolskie (18.1%). High level of investment rates in both these groups may be linked, as it appears, with a strong influence of the agglomeration effect, which in this case is revealed by the fact that investors (domestic and foreign) concentrate their investments around large cities (Warsaw, Wroclaw, Krakow, Gdansk or Poznan), where they can find well qualified employees and well developed social and economic infrastructure. The thesis made here is additionally supported by the fact that in lodzkie and slaskie voivodships (around Lodz and Katowice with traditional industrial monocultures with a relatively poor developed service sector) the investment rates are substantially lower (16.3% and 15.8% respectively).
- Comparing, on the other hand, labour productivity growth rates to investment rates it appears that in Poland in the years 1996-2000 high investment rates only to a limited extent generated high labour productivity rates. To the voivodships supporting this thesis we can subsume voivodships mazowieckie, pomorskie, dolnoslaskie and (to a lesser extent) malopolskie recording high investment rates and high labour productivity growth rates as well as lubelskie, warminsko-mazurskie, kujawsko-pomorskie and lodzkie voivodships characterized by low shares of investments in GDP but also low GDP per employee dynamics. The thesis is however negated by cases of slaskie voivodship (low investment rates and high increase of labour productivity) and opolskie (low increase of labour productivity yet high investment rate).

Map 3. Yearly average investment rates in the years 1995-2000 (w %)

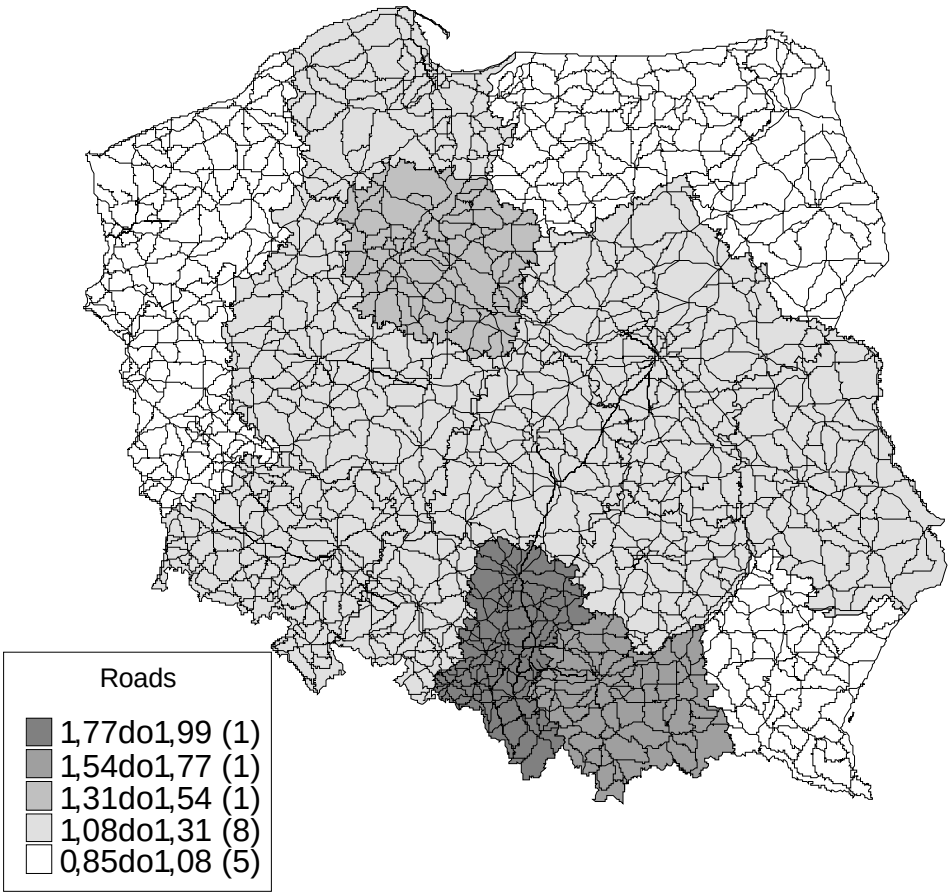


Source: own calculations on the basis of data from www.stat.gov.pl.

On map 4, regional diversification of length of roads per 1 square kilometre of area in Poland in the years 1995-2000 is shown. From this map we can draw the following conclusions:

- The most dense road system in Poland in the period analyzed had slaskie voivodship (1.98 km of roads per 1 sq. kilometre). This may be associated with a well-developed road system in the area of Upper Silesia and the Basin (Zaglebie) region. Also malopolskie voivodship is characterized by a dense road system (1.74 km of roads per 1 sq. kilometre), which can be linked both with a relatively high density of roads around Krakow and dense network of local roads in the mountain areas of Podhale, Gorce and Beskid Sadecki.
- Voivodships kujawsko-pomorskie, mazowieckie, dolnoslaskie, swietokrzyskie, wielkopolskie, opolskie, lodzkie and pomorskie were characterized by a road system with density between 1.1-1.3 km/sq. km. The remaining voivodships, namely podkarpackie, warminsko-mazurskie, lubuskie, podlaskie and zachodniopomorskie have a road system with density 0.85-1.05 km/sq. km, which is about 50% of the density in slaskie and malopolskie voivodships.

Map 4. Density of roads in Poland in the years 1995-2000 (in km/sq. km)



Source: own calculations on the basis of data from www.stat.gov.pl.

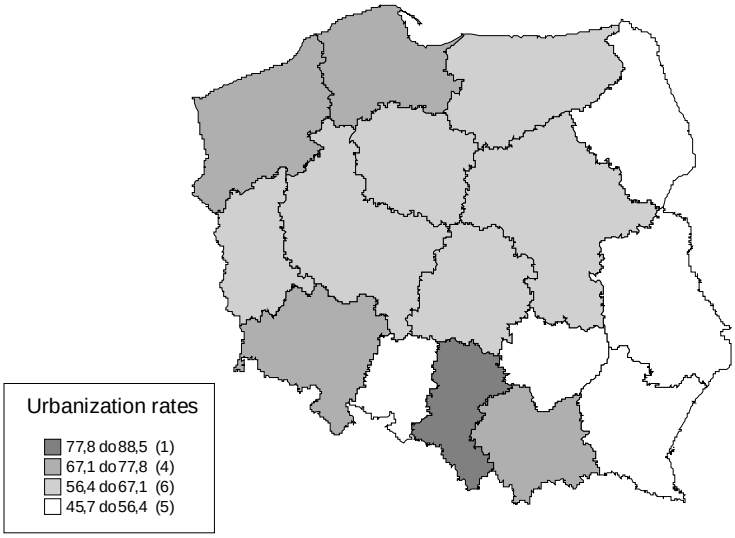
- Putting together regional diversification of roads density and productivity growth rates in Poland in the second half of the nineties, it turns out that there is no direct relation between the two variables. From the group of voivodships with high density of roads, slaskie achieved high labour productivity growth rates, whilst malopolskie was just about average. On the other hand, voivodships mazowieckie, swietokrzyskie, pomorskie and dolnoslaskie – with high or very high labour productivity growth rates were also characterized by merely average density of roads.

On map 5 we present urbanization rates in Poland in the years 1995-2000. From this map the following conclusions can be drawn:

- The highest urbanization rate characterizes slaskie voivodship. It is followed by dolnoslaskie, zachodniopomorskie, pomorskie and malopolskie voivodships. The

lowest urbanization rates were recorded in voivodships: swietokrzyskie, lubelskie, podkarpackie, opolskie and podlaskie.

Map 5. Urbanization rates in Poland in the years 1995-2000 (in %)



Source: own calculations on the basis of data from www.stat.gov.pl.

- Comparing data referring to urbanization rates with labour productivity growth rates, there does not seem to be any apparent link between the two macroeconomic variables. Indeed, voivodships with high or very high rates of urbanization (slaskie, dolnoslaskie, zachodniopomorskie and pomorskie) were also characterized by high labour productivity growth rates (more than 5.2% yearly on average) in the researched period, yet amongst voivodships with the lowest urbanization rates we can find voivodships with very high and high rates of product per employee growth (swietokrzyskie – 7.3% and podlaskie – 5.5%) as well as voivodship, where low growth rates of this macroeconomic variable was recorded (opolskie (-1.7%) or lubelskie – 1.9%).

4. Results of statistical analyses

Aiming at assessing an influence of the variables analyzed in the previous point on the labour productivity growth rates in Poland across regions, the authors estimated parameters of the following equation, diversifying the constant (*fixed effect*):

$$\Delta \ln\left(\frac{Y_{it}}{L_{it}}\right) = \alpha_0 + \sum_j \alpha_j d_j + \gamma_1 i_{it-1} + \gamma_2 r_{it-1} + \gamma_3 u_{it-1} - \beta \ln\left(\frac{Y_{it-1}}{L_{it-1}}\right) + \xi_{it} \qquad (13)$$

gdzie:

Y_{it}-GDP in voivodship i (i=1,2,...,16) in the year t (t=1995, 1996, ..., 2000) in thousand PLN, 1995 prices;

L_{it}-number of employed according to LFS in voivodship i in the year t, thousand of people;

i_{it}-investment rates voivodship i in the year t;

r_{it}-kilometres of roads per sq. km of area in voivodship i in the year t;

u_{it}-urbanization rate voivodship i in the year t;

d_j (j=2,3,...16) dummy variables for non-base voivodships (in the presented further on analyses, mazowieckie voivodship is a base voivodship in the diversification of constant procedure;

ξ_{it}-error term.

Structural parameters in equation (13) are economically interpreted as follows:

α_0-constant, without a direct economic interpretation;

α_j-correction of constant in the j voivodship with relation to mazowieckie voivodship (this correction describes a difference in labour productivity growth rates between j-th voivodship and mazowieckie voivodship, if ceteris paribus condition is realized).

γ_1-parameter describing an influence of investment rate on labour productivity growth rate;

γ_2- parameter describing an influence of road density on labour productivity growth rate;

γ_3- parameter describing an influence of urbanization rate on labour productivity growth rate;

β-parameter describing strength of the conditional β-type convergence effect.

The estimated parameters of different versions of equation (13) are presented in table 1[7].

Table 1. Estimated parameters in equation (13)

Explanatory variables	Dependent variable: $\Delta\ln(Y_{it}/L_{it})$						
Constant	2,212 (0,000)	1,642 (0,0014)	3,263 (0,183)	1,794 (0,0008)	3,455 (0,157)	1,591 (0,539)	1,959 (0,453)
Dolnoslaskie	-0,111 (0,0161)	-0,109 (0,0169)	-0,0339 (0,860)	-0,0993 (0,0312)	-0,0145 (0,939)	-0,113 (0,562)	-0,0870 (0,656)
Kujawsko-pomorskie	-0,205 (0,0005)	-0,247 (0,000)	-0,300 (0,0466)	-0,223 (0,0002)	-0,276 (0,066)	-0,244 (0,107)	-0,232 (0,125)
Lubelskie	-0,448 (0,000)	-0,406 (0,000)	-0,800 (0,280)	-0,416 (0,000)	-0,828 (0,260)	-0,391 (0,609)	-0,466 (0,543)
Lubuskie	-0,162 (0,0016)	-0,0512 (0,554)	-0,201 (0,0019)	-0,0503 (0,560)	-0,182 (0,0051)	-0,0499 (0,643)	-0,0544 (0,613)
Lodzkie	-0,331	-0,319	-0,338	-0,318	-0,335	-0,318	-0,318

[7] In the estimations of parameters in equation (13), dummy variables were included D_{99} and D_{00} for 1999 and 2000 respectively, due to a different specifics of number of employed in 1999 with relation to the remaining years (1999-data from February, other years-data from May).

	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,0001)	(0,0001)
Malopolskie	-0,276 (0,0001)	-0,462 (0,003)	-0,249 (0,0048)	-0,441 (0,0006)	-0,247 (0,0048)	-0,464 (0,0031)	-0,435 (0,0060)
Opolskie	-0,295 (0,000)	-0,255 (0,000)	-0,484 (0,275)	-0,278 (0,000)	-0,522 (0,237)	-0,246 (0,591)	-0,307 (0,504)
Podkarpackie	-0,376 (0,000)	-0,295 (0,0018)	-0,627 (0,231)	-0,305 (0,0013)	-0,642 (0,216)	-0,284 (0,606)	-0,340 (0,538)
Podlaskie	-0,336 (0,000)	-0,204 (0,0587)	-0,518 (0,163)	-0,216 (0,0467)	-0,523 (0,156)	-0,197 (0,631)	-0,242 (0,556)
Pomorskie	-0,0561 (0,203)	-0,00430 (0,9404)	-0,0301 (0,774)	0,00425 (0,9414)	-0,00632 (0,952)	-0,00604 (0,954)	0,00988 (0,925)
Slaskie	0,0272 (0,564)	-0,293 (0,0743)	0,403 (0,633)	-0,230 (0,180)	0,464 (0,580)	-0,311 (0,738)	-0,171 (0,855)
Swietokrzyskie	-0,373 (0,000)	-0,361 (0,0001)	-0,737 (0,325)	-0,362 (0,0001)	-0,757 (0,309)	-0,346 (0,653)	-0,412 (0,593)
Warminsko-mazurskie	-0,273 (0,000)	-0,172 (0,0533)	-0,402 (0,0935)	-0,172 (0,0529)	-0,392 (0,0996)	-0,167 (0,538)	-0,189 (0,487)
Wielkopolskie	-0,158 (0,0015)	-0,158 (0,0013)	-0,314 (0,282)	-0,148 (0,0029)	-0,307 (0,289)	-0,152 (0,614)	-0,167 (0,579)
Zachodnio-pomorskie	-0,0916 (0,0538)	0,0537 (0,611)	-0,0507 (0,731)	0,0566 (0,591)	-0,0184 (0,901)	0,0514 (0,743)	0,0641 (0,683)
i_{it-1}	0,467 (0,160)	-	-	0,375 (0,261)	0,470 (0,160)	-	0,376 (0,264)
r_{it-1}	-	0,413 (0,0766)	-	0,366 (0,121)	-	0,415 (0,0916)	0,361 (0,149)
u_{it-1}	-	-	-1,831 (0,624)	-	-1,933 (0,602)	0,0773 (0,984)	-0,249 (0,948)
$\ln(Y_{it-1}/L_{it-1})$	-0,673 (0,000)	-0,629 (0,000)	-0,594 (0,000)	-0,683 (0,000)	-0,665 (0,000)	-0,630 (0,000)	-0,682 (0,000)
D_{99}	0,0632 (0,0025)	0,0612 (0,0031)	0,0718 (0,0011)	0,0577 (0,0056)	0,0665 (0,0026)	0,0611 (0,0063)	0,0582 (0,0094)
D_{00}	0,101 (0,001)	0,105 (0,0001)	0,103 (0,0002)	0,105 (0,0001)	0,104 (0,001)	0,105 (0,0001)	0,106 (0,0001)
R^2 Adj. R^2	0,403 0,214	0,414 0,229	0,385 0,191	0,427 0,233	0,406 0,204	0,414 0,216	0,427 0,220
DW	1,682	1,757	1,671	1,744	1,692	1,757	1,745
AIC S.C.	-5,395 -4,799	-5,414 -4,819	-5,366 -4,770	-5,411 -4,786	-5,374 -4,749	-5,389 -4,764	5,386 -4,731
Number of observations	80						

R^2 (adj. R^2)–determination coefficient (adjusted determination coefficient), DW–Durbin-Watson statistics; AIC (S.C.)–Akaike (Schwarz) information criterion. Levels of significance for relevant t-student statistics are given in brackets.

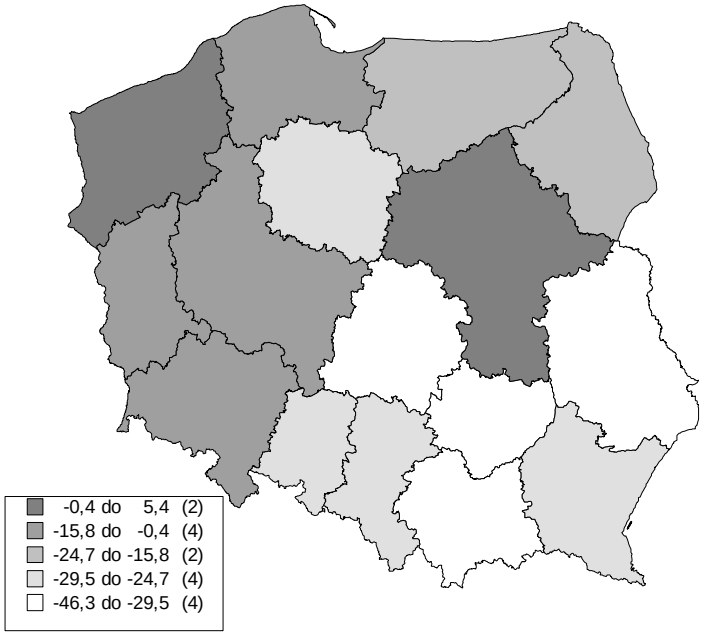
From the estimations of parameters of function (13) presented in table 1 we can draw the following, strictly statistical conclusions:

- Regional differentiation of investment rates statistically significant described regional diversification of labour productivity growth rates on significance levels 16%-26%. Therefore, linking this macroeconomic variable with a growth rate of product per employee in Poland by regions, one has to be especially cautious.
- Density of roads in particular voivodships appeared significant on, circa, 8-15% significance levels. This means that transport infrastructure development had (rather) significant impact on regional differentiation of labour productivity growth rates in Poland.
- Regional diversification of urbanization rates definitively did not significantly influence regional differentiation of product per employee growth rates.

- What appeared statistically significant in case of every estimation of equation (13), was β-regional convergence parameter. Strength of this effect shaped up at a level 0.60-0.68 in the years 1996-2000.

Map 6. Regional diversification of constant in equation:

$$\Delta \ln\left(\frac{Y_{it}}{L_{it}}\right) = \alpha_0 + \sum_j \alpha_j d_j + \gamma_2 r_{it-1} - \beta \ln\left(\frac{Y_{it-1}}{L_{it-1}}\right) + \xi_{it}$$ **w %**



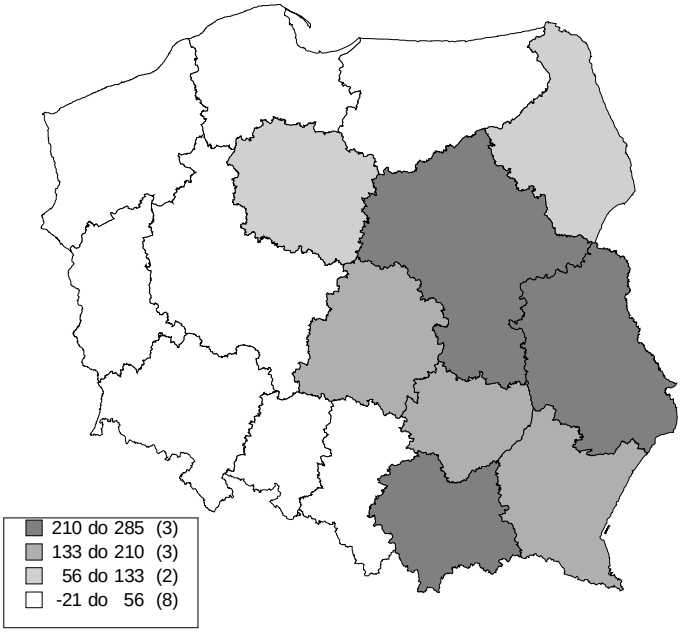
- From the analysis of information Akaike and Schwarz criteria we can presume that the closest to reality are those estimations of function (13), where, apart from the convergence effect, only density of roads per 1 sq. km was included (in this case roads density influences labour productivity growth rates on 8% significance levels). Thus, on the basis of this estimation, regional diversification of constants in equation (13) was calculated. The diversification is presented on map 6.

From the diversification of constant estimations in the equation $\Delta \ln\left(\frac{Y_{it}}{L_{it}}\right) = \alpha_0 + \sum_j \alpha_j d_j + \gamma_2 r_{it-1} - \beta \ln\left(\frac{Y_{it-1}}{L_{it-1}}\right) + \xi_{it}$, a few conclusions can be drawn:

- Highest (ceteris paribus) growth rates of labour productivity characterized voivodships zachodniopomorskie and mazowieckie. In the next group we have pomorskie, lubuskie and dolnoslaskie. To the group of voivodships with the lowest estimated

values of constant, the following voivodships belong: malopolskie, swietokrzyskie, lubelskie and lodzkie, and than, podkarpackie, slaskie, opolskie and kujawsko-pomorskie.

Map 7. Regional diversification of hidden unemployment in agriculture in the years 1995-1999 (thousand of people)



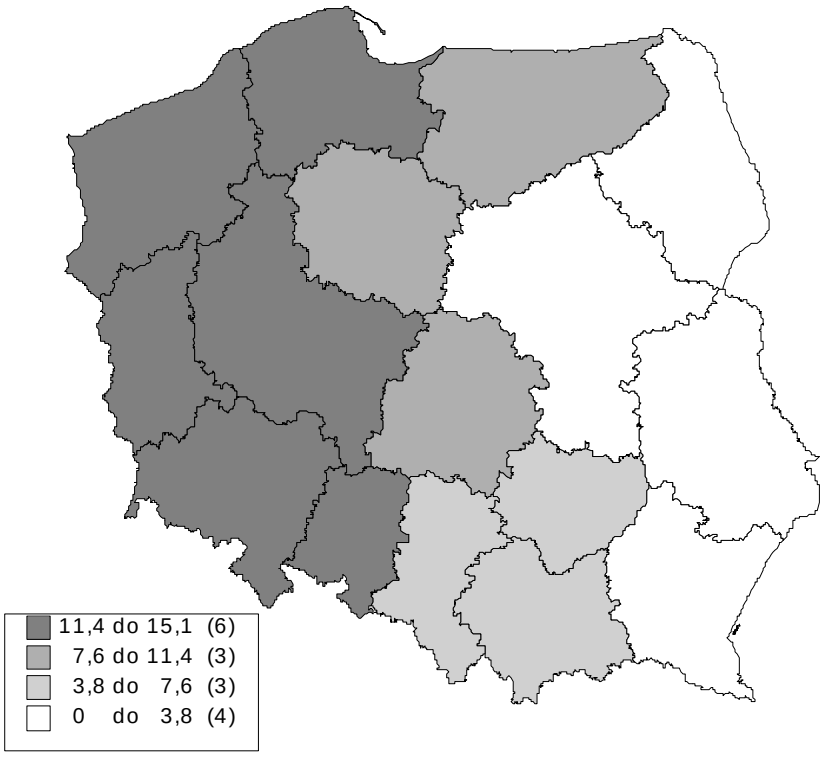
Source: Kwiatkowski, Kucharski, Tokarski, 2003, p.20.

- It is possible to make a hypothesis that regional diversification of constant in the equation $\Delta \ln\left(\frac{Y_{it}}{L_{it}}\right) = \alpha_0 + \sum_j \alpha_j d_j + \gamma_2 r_{it-1} - \beta \ln\left(\frac{Y_{it-1}}{L_{it-1}}\right) + \xi_{it}$ is to a large extent in line with assessment of hidden unemployment in the Polish agriculture in the years 1995-1999 carried out by Kwiatkowski, Kucharski, Tokarski, 2003 (see map 7). Comparing maps 6 and 7 we can arrive at a conclusion that in voivodships with relatively high estimated values of the constant, low levels of hidden unemployment in agriculture exist. In voivodships with low estimated values of the constant, there is high hidden unemployment in agriculture. One apparent exception is mazowieckie voivodship, where high estimated values of constant come together with high hidden unemployment in agriculture. This exception can be explained by the inner heterogeneity of the product market as well as the labour market in mazowieckie voivodship. This voivodship is characterized (on one side) by a very modern labour and product market in Warsaw and its neighbourhood (large proportion of the

employed and value added in service sector) and Plock specifics (with petroleum industry) and (on the other side) by a large proportion of the employed in agriculture east of the Vistula river. High productivity of Warsaw and Plock is merged with high hidden unemployment in the other, agricultural part of mazowieckie voivodship.

- Regional differentiation of the constant in equation $\Delta \ln\left(\frac{Y_{it}}{L_{it}}\right) = \alpha_0 + \sum_j \alpha_j d_j + \gamma_2 r_{it-1} - \beta \ln\left(\frac{Y_{it-1}}{L_{it-1}}\right) + \xi_{it}$ stands also in line with estimations of elasticities of regional labour markets, carried out by Kucharski, Tokarski, 2003 (map 8)[8]. Alike before, the very heterogeneous mazowieckie voivodship makes an exception.

Map 8. Regional diversification of labour market elasticity in Poland (in %)



Source: Kucharski, Tokarski, 2003, p.61.

[8] Elasticity coefficients of regional labour markets from Kucharski and Tokarski paper [2003] presented on map 8are based on diversified constant estimations in augmented matching function in the years 1993-2001. This signifies that they appoint regional growth diversification of outflows from unemployment to employment, which, *ceteris paribus*, would occur on average in particular voivodships during the period analyzed.

5. Summary and conclusions

The considerations undertaken in the paper can be summed up as follows:

- Statistical data referring to regional diversification of labour productivity in Poland in the second half of the nineties suggest that in this period the process of unconditional regional divergence occurred. This divergence was mostly a result of a very fast labour productivity growth in mazowieckie, slaskie and, to a lesser extent, pomorskie, dolnoslaskie and swietokrzyskie voivodships. It is worth to note however, that an increase of GDP, but also the decline in employment caused an increase of labour productivity in these voivodships. This indicates that labour productivity growth in the mentioned voivodships came together with a typical for the Polish economy process of jobless growth.
- On the other hand, voivodships with low levels of labour productivity were generally characterized by lower labour productivity growth rates (with swietokrzyskie voivodship being an exception). It resulted – in the authors' opinion – from an archaic employment structure in these voivodships, characterized by large proportion of the employed in a non-productive private agriculture with high hidden unemployment.
- From the statistical analyses, it emerges that regional diversification of labour productivity was statistically significantly determined by the process of conditional β-convergence. It is worth to note, however, that in this β-convergence process (rather) significant for regional differentiation of labour productivity growth rates was the influence of regional diversification of transport infrastructure (roads density per square kilometre of area), while regional diversification of investment rates was on the border of significance, and regional differentiation of urbanization rates (being the approximation of the agglomeration effect) appeared insignificant.
- Estimations of regional constants in the equation of labour productivity growth rates suggest that mazowieckie and voivodships of Western Poland develop faster than other voivodships. What is more, regional estimations of the constant in the equation of GDP per employee is fairly tightly linked with sectional structure of the labour market as well as the product market. In the voivodships with high proportion of the employed and value added in service sector these estimations are higher than it is the case for voivodships with higher proportion of the employed in agriculture. What is more, the higher level of hidden unemployment, the lower estimated values of

constant in the β-convergence equation. A conclusion can be drawn from this, that supporting the regional convergence process and the economic growth should be linked with the labour market policy, aiming at supporting the creation of new jobs outside of agriculture in the regions with high proportions of the employed in agriculture (that is mainly in South and south-eastern Poland) The estimations of Kwiatkowski, Kucharski and Tokarski suggest that liquidation of hidden unemployment in the Polish agriculture could lead to an increase of labour productivity by 12-13% (see Kwiatkowski, Kucharski, Tokarski, 2003).

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