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HUMAN CAPITAL, REGIONAL GROWTH AND CONVERGENCE IN POLAND

The interdependence between human capital and regional development is nowadays very rarely questioned. Even though some authors (Benhabib & Spiegel, 1994; Bils & Klenow, 2000) suggest that the causal nature of this relationship is not as strong as it is commonly believed, most of research findings corroborate the thesis that there exists a significant correlation between education, level of income and rate of economic growth both nationally and in smaller areas.

Although quantitative studies using regional and national data do not differ considerably in term of methodologies and tools applied, they look at rather dissimilar phenomena. This is due to the fact that disparities in the human capital levels and growth dynamics at the regional level result not only from long-lasting accumulation processes but also from much more rapid process of metropolisation in contemporary economies. Big cities are places where knowledge resources are concentrated and at the same time they are drivers of economic development which give thrust to their national economies. The deconcentration trend which could be visible in recent years and which involves migration of the metropolitan class to areas lying outside agglomeration has not as yet affected spatial differentiation of development in any significant way. In such a situation, the relationship between human capital resources and development is frequently more observable in regional-level analyses that in comparisons between different countries, particularly when such an exercise involves countries with similar levels of income and rate of growth.

Regional studies analysing the impact of human capital on economic development can be divided into those looking at individual regions within one national economy and those examining regions in different countries. The latter category often focuses on the area of the European Union where increasing growing linkages and wide-ranging common economic policies create a growing demand for knowledge pertaining to the regional level which takes into account the Community dimension.

One such example of a study showing the 'intra-national' regional regression of growth is the work by A. Di Liberto and J. Symons (Di Liberto & Symons, 2001) which examines the influence of the level of education on the economic convergence of Italian regions. Based on a panel data set comprising the period from the 1960s till the 1990s, the

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authors prove that although education undeniably affected the regional rate of growth this was the case only in some parts of southern Italy. Such an interdependency was not observed in the richer central and northern regions. Moreover, the study indicates that even in the South the benefits originating from accelerated growth were mainly a result of the promotion of elementary schooling connected with the 1960s campaign to eradicate illiteracy, while the later growth of human capital at higher education levels did not significantly affect the rate of development and convergence of Italian regions. These observations invite the conclusion that the profit gained by the society from investing in education is accompanied by diminishing returns of scale – the lower the starting level for the region's human capital, the higher the profit from improving it. Such a tenet however is challenged by other authors studying economic growth both at national and regional levels. H. Badinger and G. Tondl (Badinger & Tondl, 2002) even claim that in the regions of the EU Member States the popularisation of tertiary education (and not primary of secondary) has helped to increase the rate of growth.

The major role of human capital as a factor of regional development is confirmed by A. de la Fuente (de la Fuente, 2002) in his paper discussing Spain. The author proves that equalising of educational levels and import of technological solutions have been the main factors responsible for the economic convergence of Spanish regions.

Definitely, the largest number of studies on regional-scale growth are published in the United States. This is partly due to the much better availability of data, at least in comparison with Europe. While n European countries time intervals of adequate quality go back to the 1950s and the 1960s, some American data cover the periods back to 1840, and a great deal of useful information has been recorded in a regular way since the end of the 1920s. The work by J. Persson and B. Malmberg can be regarded as an example of interesting research on the topic in question (Persson & Malmberg, 1996) which analyses factors of economic growth in US regions in 1920-1990. The authors conclude that in the past the level of human capital (as measured by average length of schooling) had a strong, positive influence on regional rates of growth. This was however true only when the differences in the regions' demographic structure were controlled in the model. In addition, according to the authors, inclusion of human capital into the model considerably increases the estimated rate of convergence, which indicates that this process is strongly affected by educational resources in individual regions.

The issue of economic convergence at the regional level is also discussed in the paper by M. Cárdenas and A. Pontón (Cárdenas & Pontón, 1995) in the context of Columbia. This study also proves that regions which invest in education (or rather whose inhabitants do so) are developing faster irrespective of their level of wealth at the beginning of the research

period, i.e. in 1950. Unlike in the research findings of Persson and Malmberg, here the significant impact of human capital on the growth rate is unconditional, which means that it does not depend on the inclusion of any additional variables in the model.

Empirical studies focusing on regions located in different countries are very frequently confined to Europe, which is partly due to the increasing demand for knowledge about processes taking place in the European Union. This area of research started to develop when a uniform system of statistical information about EU regions was put in place. An example of such studies is the already mentioned work by H. Badinger and G. Tondl, which aimed to verify economic growth factors in EU regions in the 1990s. The research project covered 10 of 15 Member States of the EU at the time (excluding United Kingdom, Sweden, Denmark, Austria and Greece), which altogether had 128 NUTS-2 units . The research findings indicate that both the accumulation of physical and human capital has a positive influence on the rate of regional development. However, the authors pointed out that in the 1990s only the human capital at the tertiary level had a considerable impact on the growth rate. According to the study's findings, increasing the share of people with higher education by 10 percentage points was associated with shifing up meant increasing the average rate of growth in the region by about 1 percentage point in the period 1993-2000. At the same time, no distinct correlation was discovered between the rate of growth and regional disparities concerning the secondary school enrolment rate.

In addition to the above, the study corroborated the existence of the "catching up" effect. Although regions which are relatively underdeveloped economically are frequently impaired by a low level of human capital, on the other hand their situation offers opportunities for fast development by assimilating innovations which have been generated elsewhere. Badinger and Tondl prove that this effect is the stronger the more open the economy of a given region (that is, the higher the role of international trade in such a region). Such a conclusion can be regarded as an argument in favour of a trade liberalisaiton policy as an effective tool promoting development in backwarded regions.

Proposing an effective policy fostering economic development is often the purpose of studying disparities in economic growth between individual regions. The classical regressions of growth, incorporating either human capital recourses or increases of such resources, can only indirectly be used for this purpose. Taking into account the complicity of the very notion of human capital, the impact of public policies on such resources is far from evident and can only be observed (if at all) over long periods of time. For this reason, instead of analysing the influence of variously defined human capital resources on macroeconomic indicators, perhaps

it would be worthwhile in some cases to focus on direct verification of policy effectiveness, that is, of expenditure made in connection with human capital, on the stimulation of economic growth. Such an exercise is described in the paper by Rodriguez-Pose and Fratesi (Rodriguez-Pose & Fratesi, 2004). The authors analysed the efficacy of individual components of EU regional policy (expressed as structural funding expenditure), and in particular its impacts on economic development in backwarded regions – the so-called Objective-1 regions.[2] In the very introduction to the paper, the authors point out that despite the earmarking of over two thirds of the whole Structural Funds allocation to the development of such regions, of 44 regions which were eligible as Objective-1 regions in 1989, 43 still remained in that category over a decade later. This can be seen as a proof of a low effectiveness of cehesion policy. In the further parts of the study, structural funding expenditure is divided into the following categories: support to agriculture and promotion of rural areas; support to business and tourism; investment in education and reorganisation of human capital; investment in infrastructure, transport and environment. The panel survey comprising the years 1989-1999 (two EU budgeting periods) indicates that irrespective of whether all the EU regions or only Objective-1 regions were taken into account, investment in the development of human capital was the only type of expenditure which had a consistently positive and statistically significant impact on the regional rates of growth. In view of the fact that – as the authors rightly point out – such expenditure accounts only for less than 15% of all funds earmarked for Objective-1 regions, this indicates that EU regional policies need to be altered if they are to be effective.

ARE POLISH REGIONS WITH HIGHER HUMAN CAPITAL LEVELS WEALTHIER?

Even a glance at the disparities in the GDP per capital levels in Poland (Fig. 1) will reveal two basic regularities. The highest incomes are noted in subregions (NTS3) around such metropolitan cities as Warsaw, Kraków, Łódź, Wrocław or Poznań. Only those strongly urbanised areas in 2003 reached GDP per capita higher than PLN 20,000 (ca 5700 euro).

[2] These are EU regions where gross product measured by purchasing power parity is lower than 75% of EU average.

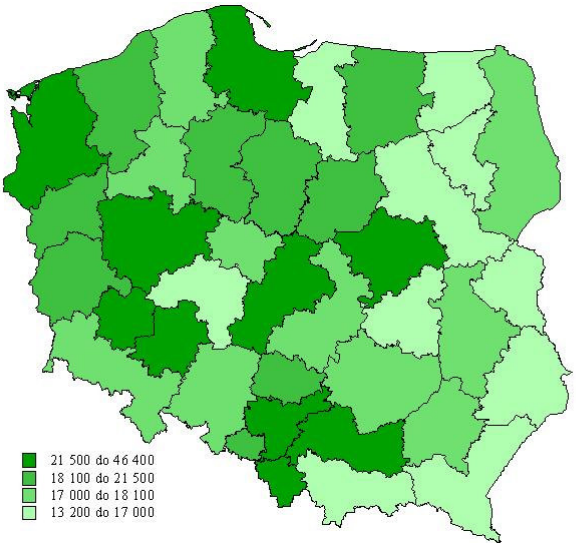

Fig. 1. GDP per capita by subregions (NTS3) in 2003.

Another 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 subregions are located in the belt directly bordering on Ukraine and Belarus, while the Nowy Sącz subregion was the area with the lowest per capita income .

If we regard the share of the population with secondary or tertiary education as the reliable measure of human capital resources, we will see that the spatial distribution of such resources (Fig. 2) largely corresponds to the distribution of income.

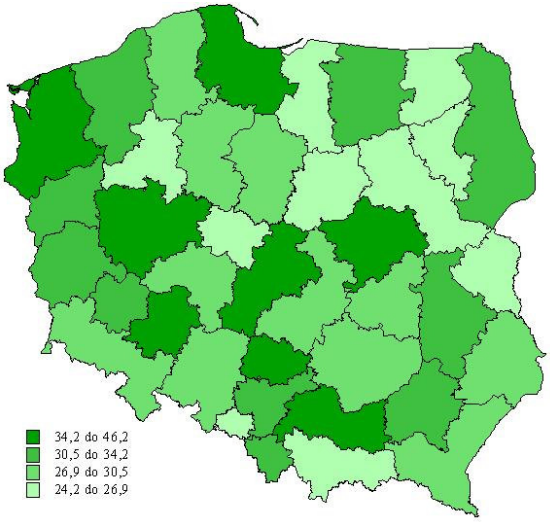

Fig. 2. Share of the population with tertiary or secondary education by subregions in 2002.

As can be expected, subregions with high levels of human capital mainly include areas around big cities, primarily Warsaw and Wrocław. In the Warsaw subregion, nearly one in two inhabitants has a diploma of secondary education, whereas inhabitants of the Nowy Sącz,

Łomża and Ostrołęka subregions have lowest level of education. Nevertheless, the difference in the human capital levels between the eastern and western part of Poland is observably smaller than in the GDP levels. In the subregions of Lublin, Rzeszów or Białystok-Suwałki, the share of people with secondary or tertiary education is relatively high, above the national average.

The statistical correlation between human capital and per capita income proves extremely strong when measured directly. Both of the applied indicators of human capital (share of the population with higher or secondary education and average length of schooling) are significantly correlated with GDP per capita in the region, and such correlation is positive. The linear correlation coefficient is approximately 0.8, which is high even if we take into account the small size of the set. Such a result is most certainly influenced by the co-occurrence of high income and high education level in large cities. However the scatterplots shown in Fig. 3 prove that the correlation between human capital and regional per capita product is also significant at the subregional level.

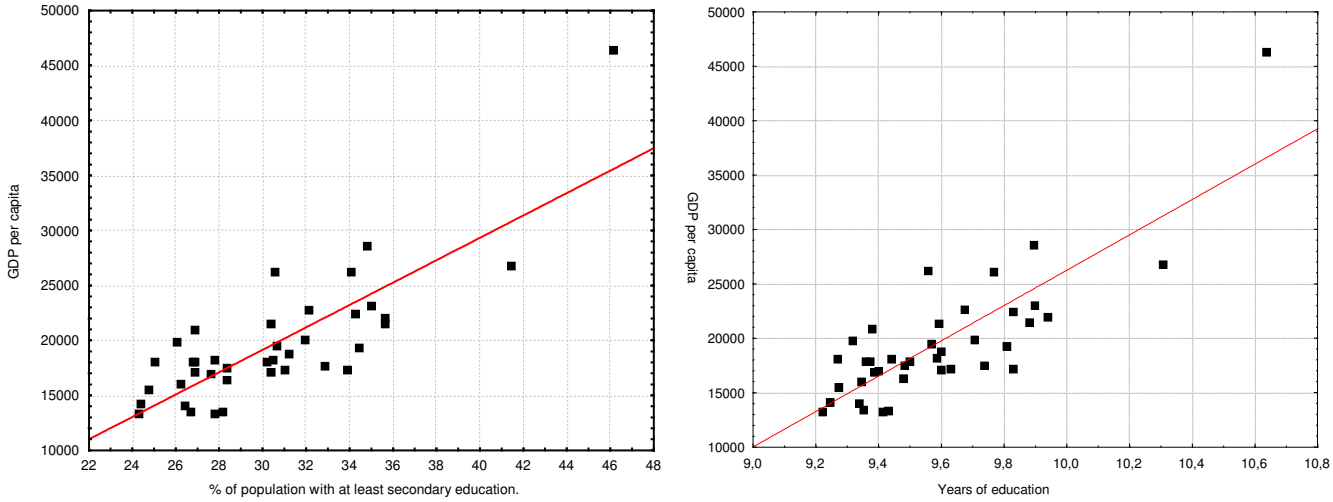

Fig. 3. Human capital and GDP per capita, NTS3, 2002-2003

For the purpose of further analysis, let us assume that the production function in the economy of every subregion is expressed by the following general formula:

(1) $Y_{i,t} = AK_{i,t}{}^{\alpha} H_{i,t}{}^{\beta} L_{i,t}{}^{\gamma}$

where Y_i denotes gross regional product; A – level of technological development, K_i – physical capital stock in the region, H_i – the region's human capital, and L_i – labour resources. Since $L_i = P_i U_i$, where P_i denotes the total population of the subregion, and U_i denotes the

share of people in work in the population, the production function can be expressed as follows:

(2) $Y_{i,t} = AK_{i,t}^{\alpha} H_{i,t}^{\beta} P_{i,t} U_{i,t}^{\gamma}$

When we recalculate the above formula in per capita terms (for the subregion) Przedstawiając and find a logarithm to both sides of the equation, we will obtain the following formula:

(3) $\ln y_{i,t} = \ln A_t + \alpha \ln k_{i,t} + \beta \ln h_{i,t} + \gamma \ln U_{i,t}$

This form of the equation provides the basis for an estimation of the linear regression model. The results of the estimation are shown in Table 1.

Table 1. Results of regression model estimation (1)

Variable	Equation 1		Equation 2		Equation 3	
Intercept	**4.456**	**(9.13)**	-0.631	(-0.55)	**5.743**	**(8.95)**
$\ln h_t$ (% of population with tertiary or secondary education)	**0.643**	**(4.88)**				
$\ln h_t$ (average length of schooling)			**3.343**	**(5.49)**		
$\ln h_t$ (% of general secondary school leavers)					**0.344**	**(2.86)**
$\ln h_t$ (% vocational secondary school leavers)					**-0.204**	**(-2.24)**
$\ln k_t$	**0.378**	**(8.51)**	**0.364**	**(8.49)**	**0.441**	**(10.38)**
$\ln u_t$	-0.138	(-1.38)	-0.178	(-1.86)	-0.210	(-1.76)
N	39		39		39	
R^{2}^	0,87		0,88		0,84	

Variable explained: natural logarithm of GDP per capita in 2003.
k – gross value of fixed assets in enterprises in 2003.
u – % of economically active population
The values in bold denote significance at 5%

These values confirm that human capital resources, regardless of the measures applied, exert a significant influence on the creationof regional per capita income. Equation 2, explaining the highest fraction of GDP variability between the subregions, indicates that the difference of one standard deviation (about 3.5 months) in the average length of schooling is transposed into an approximately 10% change in the regional GDP per capita. On the other hand, Equation 1 shows that a 10% increase of the population with at least secondary education correlates with increasing the per capita income by about 6.5%. Interestingly, this result is

very similar to the one obtained by Mankiw, Romer and Weil (1992) in their study conducted at the level of national economies.[3]

In reality, the correlation between human capital and income is not necessarily that strong. We have to bear in mind the limitation which is, in the case of such an analysis, the need to use one observation over a period of time instead of a panel. Therefore many hidden regional features omitted in the equation, may cause the overestimation of the factors included in the specification. . Another problem is the mutual impact of human capital and regional income.It is difficult to distinguish the influence of human capital on GDP from a reverse correlation using only statistical methods. There can be little doubt however that the research findings strongly speak in favour of regarding human capital as a significant determinant of regional per capita income.

Equation 3 illustrates the different relationships between types of education and regional wealth. While the share of general secondary school leavers among the population of 18-year olds has a major and positive impact on income, the number of vocational secondary school leavers negatively affects the regional GDP. An increase in the share of general secondary school leavers by 3 percentage points is translated into a nearly 3.5% increase in GDP per capita. At the same time, according to these findings a similar increase in the number of vocational secondary school leavers should be correlated to an over 2% reduction in income. Regardless of the issue of human capital which is of the greatest interest to us, all the presented specifications of the model prove that physical capital resources are a major determinant of regional income. Increasing such resources by 10% is translated, *ceteris paribus*, into increasing the regional per capita income by 3.6-4.4%, depending on the specification of the equation.

An unexpected result of the analysis is the lack of any significant impact of the labour market and demographic factor (U) on generated regional income. This factor, represented by the share of professionally active in total population, did not have any pertinent influence on the GDP level in any of the model's specifications, while the observable minor influence had a negative effect. After taking into account an additional variable – the unemployment rate in the subregion (in some of Poland's regions, the unemployed account for a large part of the professionally active population) – the U factor gained in significance, but the direction of its impact on regional GDP remained negative. We can therefore draw a conclusion that the higher professional activity of the population, the lower the income per capita. Such an

[3] MRW used the share of young people attending secondary schools as the variable describing human capital.

observation, running contrary to intuitive views and other research findings, seems to indicate that labour market statistics do not offer the real picture of Poles' career situation, especially as far as its regional disparities are concerned. Such phenomena as grey economy, hidden unemployment in rural areas or large-scale, unofficial (not registered) travels to work in other countries undermine the credibility of official statistics related to employment and unemployment.

DOES HUMAN CAPITAL AFFECT GROWTH RATE OF REGIONAL ECONOMIES?

Literature of the subject lists three usual ways in which human capital can affect regional growth. The first, drawing on the Lucas model (1988), and also based on the empirical labour market studies, involves direct impact of knowledge and skills on workers' productivity. Individuals with a higher human capital potential are more productive, which implies means that their incomes are also higher. At the aggregated level, a group consisting of individuals with a high level of human capital should earn a high income per group member. Making a step further along these lines, increased human capital resources of a given group in a given period should be translated into increased income per individual, *ceteris paribus*. Based on formula (3) we can describe economic growth in the following way:

$$(4)\ \Delta \ln y_{i,t} = \Delta \ln A_t + \alpha \Delta \ln k_{i,t} + \beta \Delta \ln h_{i,t} + \gamma \Delta \ln U_{i,t},$$

where we can observe a linear relationship between the change in natural logarithm of human capital stock and the rate of economic growth in a given area over a given period.

Two other mechanisms of human capital impact are described and then empirically verified in the works by Nelson and Phelps (1966) as well as by Benhabib and Spiegel (1994). According to these authors, human capital resources affect the total factor productivity (TFP), expressed in the equation as (A). This value is traditionally identified with the level of technological development. However, recently it is also believed that it may include the institutional environment of the economy and other of its characteristics which affect the factors' productivity. The impact of human capital on (A) can be explained in two ways: firstly, large knowledge resources facilitate generation of broadly understood innovation in a given economy, and secondly, they foster its development by catching up, that is by using ready-made solutions (import of technologies and organisation) from better developed countries or regions. This means that factor (A), more frequently interpreted as exogenous to

individual economies and describing global technological progress, can also be regarded as an individual regional feature. Given that, we have:

(5) $A = A_0 + A_i$

where A_0 denotes overall technological progress which is common for all the economies, and A_i represents regional knowledge resources and skills affecting the capacity to generate and import innovation. The reference to catching up as one of the forms of the impact exerted by human capital on economic growth must be accompanied by realisation that knowledge capital can mean both upsides and downsides to the region, if we regard the rate of growth as a measure of such gain. With well educated employees, it is easier to absorb innovation in every field of the economy, and therefore human capital resources in a given period should have a positive influence on the rate of growth in the period to follow. On the other hand, however, importing ready-made solutions will be a more effective way to ensure development (at least in relative terms) in those regions which are more technologically backwarded at the beginning of the researched period. Highly developed areas do not face such an 'easy' path of development and that thus statistical relationship between human capital resources and the rate of growth may even prove negative. In order to control such contradictory tendencies, some regressions of growth use a variable which represents the relative level of technological backwardedness of a given economy. For instance (cf. Badinger i Tondl 2002):

(6) $GAP_{i,t} = \frac{y^*_{\max,t} - y^*_{i,t}}{y^*_{i,t}}$

where *GAP* means technological gap in relation to the leader region, y^*_{max} – work productivity in the most productive region, and y^*_i – labour productivity in region *i*.

Each of the aforementioned mechanisms whereby human capital can affect economic growth indicates a different empirical form of the regression model. The table below outlines the specifications used and the underlying rationale.

Table 3. Human capital in growth regression

Specification	Rationale
$\Delta \ln y_{t-1,t} = \alpha + \beta \ln h_{t-1} + ...$	Rate of economic growth depends on human capital resources in the initial period because such resources are indispensable for generating innovation and as such affect the TFP.
$\Delta \ln y_{t-1,t} = \alpha + \beta \ln h_{t-1} GAP_{t-1} + ...$	Economic growth can be accelerated by import of technology, solutions and organizational patterns. from other countries or regions. Such acceleration is more probable the larger human capital stock a region has at the beginning of the researched period; it is also the more easily felt when the region is more technologically underdeveloped in the initial period.
$\Delta \ln y_{t-1,t} = \alpha + \beta \Delta \ln h_{t-1,t} + ...$	Increase in human capital directly affects productivity of work and as such should lead to an increased rate of growth.

Table 4. Two types of human capital effect

High level of human capital effect	
Development mechanism	**Main beneficiaries**
Import of innovation	Underdeveloped regions with relatively high human capital levels
Creation of innovation	Highly developed regions with high human capital levels
Increase of human capital effect	
Development mechanism	**Main beneficiaries**
Increasing productivity	Underdeveloped regions with low human capital levels

Regional distribution of economic growth rates in Polandis shown in Fig. 4. In 1995-2003, the leaders of growth were metropolitan areas of Warsaw, Wrocław and Poznań. In addition, the most rapidly developing areas include the Radom subregion and large agglomerations lying in the north and east of the country: Olsztyn and Rzeszów. Higher than average rates of growth were also recorded in the subregions of central Poland: Piotrków-Skierniewice, Łódź and Kalisz.

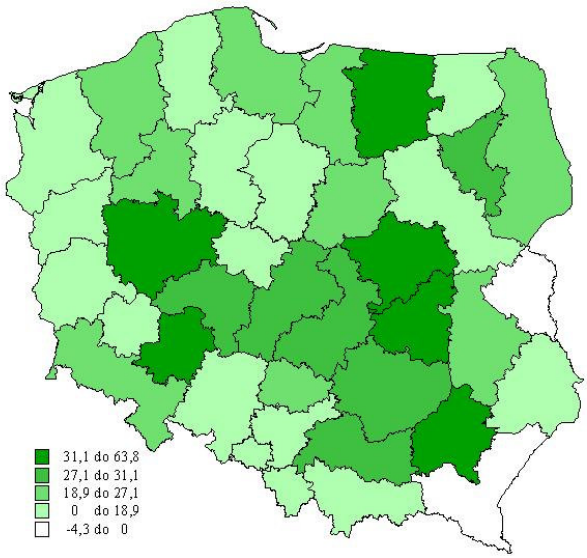

Fig. 4. Real economic growth in 1995-2003 (as a percentage of base year).

The lowest growth dynamics could be observed in the peripheral areas of eastern Poland (the so-called 'Eastern wall') – the subregions of Krosno-Przemyśl and Biała Podlaska where real income fell in the researched period. Also areas lying close to the western border (including the Gorzów Wielkopolski, Zielona Góra and Szczecin subregions) were developing relatively slowly.

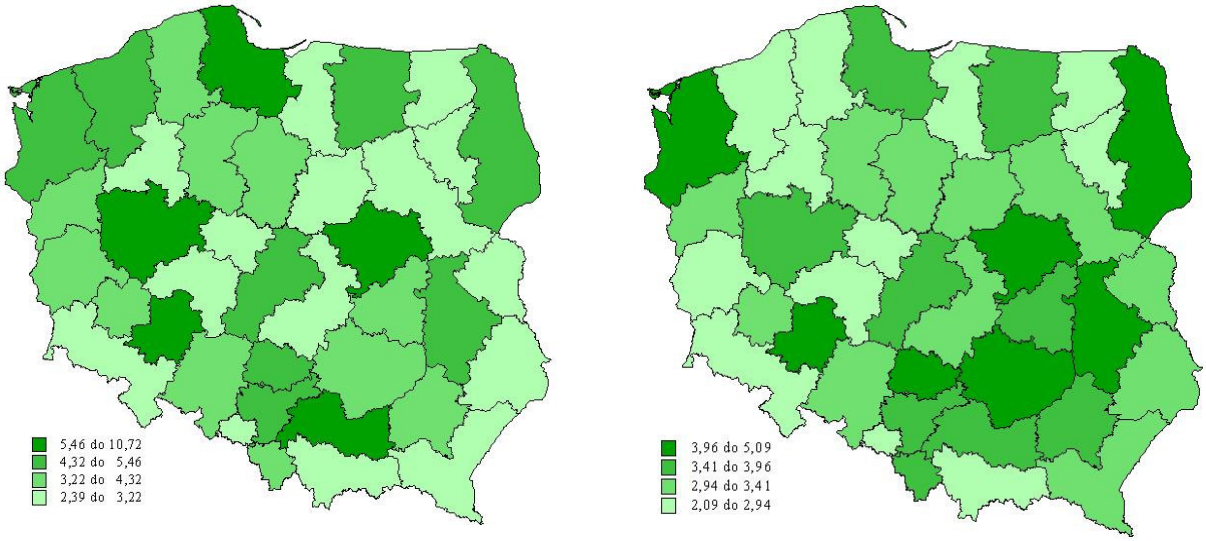

Fig. 5. Share of population with tertiary education in 1988 (left-hand side) and increase in population with tertiary education in 1988-2002 in percentage points (right-hand side), by subregions.

Analysis of spatial differentiation in human capital resources (measured with the education attainment data) in 1988 and the dynamics of human capital stock in the period 1988-2002 leads to interesting observations. In the late 1980s he highest share of people with tertiary education was recorded in the metropolitan areas of Warsaw, Wrocław, Kraków, Gdańsk and Poznań. The worst situation in this respect could be observed in the eastern regions of Poland with the exception of the Lublin and Białystok-Suwałki subregions.

The dynamics of the increase of the population with tertiary education in 1988-2002 was the highest in largest urban areas. However, the leaders in this category – in addition to Warsaw and Wrocław - were the subregions situated in eastern and central Poland: mainly Lublin, Białystok-Suwałki and świętokrzyski, while the lowest human capital increase could be observed in the western part of the country.

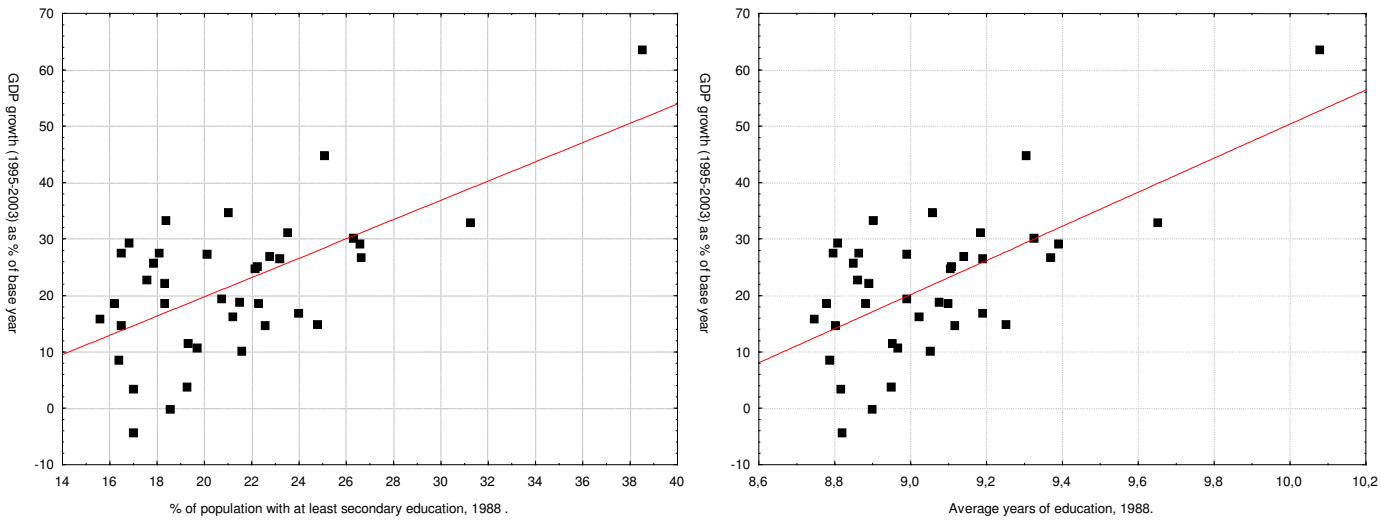

Fig. 6. Human capital and economic growth in, NTS3 level

As shown in Fig. 6, a significant statistical correlation can be found between the rate of growth in a given time interval and the initial level of human capital. Even though it is not as strong as the relationship between the level of GDP per capita and the level of human capital, the linear correlation coefficient reaches a significant value in the range between 0.63 and 0.65. The scatterplots shown above also indicate that although linear approximation of the correlation is justified, it mainly reflects the difference between metropolitan subregions and other types of subregions. Within the latter category, the relationship between human capital and rate of growth is not as straightforward.

The first form of the impact of human capital on growth to be verified is the direct influence of knowledge and skills increase on productivity of work. Equation 1 in Table 5 indicates that this phenomenon largely explains the differences in the rate of subregional growth. If we adopt the share of the population with higher education as an indicator of human capital resources, increased knowledge capital has the coefficient 0.21, with statistical relevance under 1%. This means that, *ceteris paribus*, a 10% difference in the increase of human capital in the period 1988 and 2002 corresponds to an over 2% difference in the value of the variable describing income increase between 1995 and 2003.[4] When we relate this to an average Polish subregion and take into account the constructionof both these variables (see note under Table 5), we can expect that a 0.3 percentage point increase in the share of the population with higher education would be accompanied by an increase of GDP per capita (in fixed prices) by 2.6 percentage point throughout the entire period in question (1995-2003).

Table 5. Human capital as a growth factor (1). Estimation results

Variables	Equation 1
Intercept	**4.611 (19.17)**
$\ln \Delta h$ (% of population with higher education)	**0.214 (3.04)**
$\ln \Delta h$ (% of population with higher education)	**-0.184 (-2.55)**
$\ln \Delta k$	**0.044 (2.40)**
$\ln \Delta u$ *	-0.040 (-1.19)
N	38
R^{2}^	0.43

* unemployment rate.
Endogenous variable: $\ln((100*((y_t - y_{t-1})/y_{t-1}))+100)$
Δk – increase in gross value of fixed assets in enterprises between 2000 and 2003.
Δu – increase in official unemployment rate between 1998 and 2003.
The values in bold denote significance at 5%.

Unlike in the case of higher education, the change of the share of people with a diploma of secondary education in the subregion's population is negatively correlated with the GDP increase.

It should be observed that in the period 1988-2002 increases in the share of people with secondary and tertiary education were negatively (although not very strongly) correlated

[4] Education data for 1995 are not available. In Poland, the national census was conducted in 1988 and 2002; for this reason, and out of necessity, human capital increases measured by the share of well-educated people in the population, are calculated for the 1988-2002 time interval.

at the subregional level. Where the population of secondary school leavers grew faster, the number of people with higher education increased relatively more slowly. This reflects the division into metropolitan areas, particularly those with an academic function, and provincial regions, which is more and more acutely visible in Poland. In the former category, also owing to migration of educated individuals or those who want to get university education, the number of university graduates is growing relatively quickly as compared to the increase in the number of secondary school leavers. On the other hand, outside metropolitan areas the growing demand for education is especially manifested by a rapid increase of the share of people with secondary education.

These observations lead usto simple classification of subregions based on the generation and application of human capital in the economy.

Table 6. Classification of subregions based on the role of human capital

Type of subregion	**Characteristics of subregion**	**Examples of subregions**
Large producers and consumers of human capital	Metropolitan area, large academic centre, economy dominated by the service sector	Warsaw, Wrocław, Lublin
Local producers of human capital	Big or medium-sized city with its surroundings, academic centre, industry and service-based economy	Częstochowa, Białystok-Suwałki, Szczecin
Areas of negative migration of human capital	Areas with medium-sized cities with poorly developed academic function, industrial and agricultural area	Nowy Sącz, Piła, Jelenia Góra, Ełk

The research findings indicate that the areas where the increase of human capital at the tertiary level is the highest tend to have a higher rate of growth than the rest of the country. They are at the same time the wealthiest regions, which means that in this way growth is polarised even further. Reducing the positive impact of human capital on growth to the category of higher education is consistent with the findings of studies looking at the European dimension. Let us recall at this point that Badinger and Tondl (2002) obtained similar results when they analysed a sample of NUTS-2 regions located in 10 ‘old’ Member States. There, also regions which had a relatively high increase in the number of well-educated people recorded a fast rate of economic growth, whereas the varied potential of people with secondary education did not have any significant impact on development. In the Polish situation, the latter type of human capital even tends to be negatively correlated with the rate

of growth, and can be seen as a proof of more acute polarisation processes than in other countries, which include migration of well-educated individuals and those wishing to improve their educational attainment.

Table 7 shows the role of human capital on economic growth according to the Nelson-Phelps approach. The analysis looks at the interrelationship between initial human capital resources in the subregions and economic growth in the period that follows. Human capital increase is included in the survey (Equations 3 and 4) as a control variable. Theoretically, it is therefore possible to state which mechanism of the influence of human capital on growth is the dominant one in the case of Poland. It should be added however that such an assessment is extremely difficult for the analysed sample because the indicators which define the initial value of human capital and its increase are strongly mutually correlated. In other words, regions with the largest initial capital are those which recorded the fastest increase of such capital in the recent years (cf. Fig. 7).

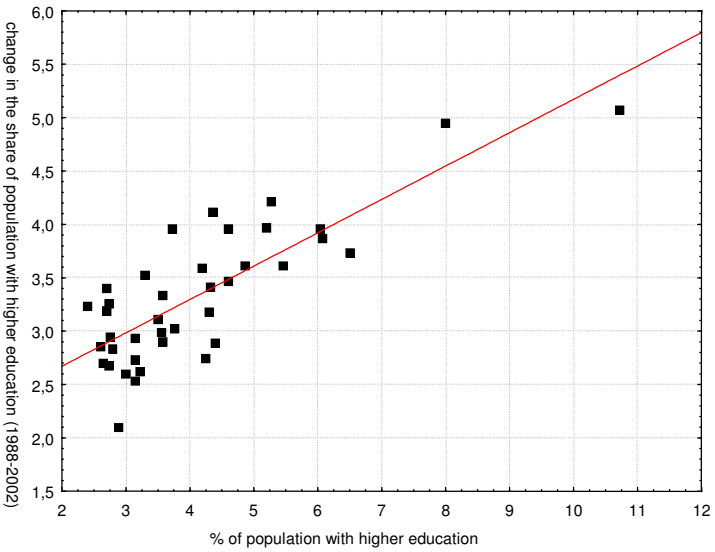

Fig. 7. Population with higher education by subregions in 1988 and its increase in the period 1988-2002.

In such a situation, an attempt to include both the impact of human capital in the initial period and the increase of human capital on economic growth in a research study leads to co-linearity between variables, which in turn hampers the accuracy of estimations. It can be expected therefore that a study using regression will help identify basic regularities in the relationships between individual variables rather than produce precise measurements of the existing correlation.

The results of the estimation indicate that initial human capital resources are strongly correlated with economic growth at a later period. As can be seen from the estimations

provided (Table 7, Equations 1-3), a 10% difference in the initial knowledge resources is translated, *ceteris paribus*, into the difference reaching 1.8-2.3 percentage point in the rate of economic growth calculated for the whole period between 1995 and 2003.

Table 7. Human capital as a growth factor (2). Results of estimation

Variables	Equation 1		Equation 2		Equation 3		Equation 4	
Intercept	**4.348**	**(28.91)**	**4.237**	**(27.68)**	**4.204**	**(23.78)**	**7.223**	**(18.58)**
$\ln \Delta h$ (% of population with higher education)					0.040	(0.39)	0.291	(1.30)
$\ln h_{t-1}$ (% of population with higher education)	**0.188**	**(5.22)**	**0.175**	**(5.01)**	**0.156**	**(2.70)**	**0.532**	**(4.18)**
GAP* $\ln h_{t-1}$ (% of population with higher education)			**0.158**	**(2.08)**	**0.161**	**(2.07)**	- 0.276	(-1.62)
$\ln \Delta k$	**0.044**	**(2.50)**	**0.049**	**(2.87)**	**0.048**	**(2.84)**	**0.128**	**(3.40)**
$\ln \Delta u$ *	-0.071	(-2.16)	-0.050	(-1.51)	-0.045	(-1.28)	0.056	(0.72)
N	38		38		38		38	
R^{2}^	0.48		0.52		0.51		0.72	

* unemployment rate
Endogenous variable in equations 1-3: $\ln((100*((y_t - y_{t-1})/y_{t-1}))+100)$.
Endogenous variable in equation 4: $\ln(y_t - y_{t-1})$
Δk – increase of the gross value of fixed assets in enterprises per capita in 2000-2003.
Δu – increase of the registered unemployment rate in 1998-2003.
The values in bold denote significance at 5%

In Equations 2 and 3, the initial value of human capital in interaction with the technological backwardness of a given region proves an important determinant of growth. This means that knowledge resources in certain less developed regions can generate a relatively high rate of growth owing to absorption of innovation, technology and inward capital. Does the 'catch-up' effect mean an opportunity for the convergence of regional development due to investment in human capital? Finding an answer to this question is difficult because, firstly, development depends on some other factors, including primarily physical capital resources, the increase of which is a significant variable in each of the equations estimated in Table 7. Secondly, the comparison of the parameters of Equations 3 and 4 indicates that we can only speak about the equalising effect in the context of a relative measurement of economic growth. These equations have similar specifications but differ in the way the explained variable is constructed. In Equation 3, it is the natural logarithm of the regional rate of growth in the period 1995-2003, calculated for the entire period in the relation to the initial value of the region's income. We can say therefore that what we see in effect is

the relative measure of growth. In Equation 4, the dependent variable refers to the natural logarithm from the simple increase of per capita income in the region, measured in Polish zloties (PLN). This is an absolute indicator, which does not have any reference to the initial value of income. Equation 3 implies that the increase of human capital in a backwarded region can facilitate faster economic growth. The variable GAP* $\ln h_{t-1}$ is included into the equation with positive sign and is statistically significant. However, the higher rate of growth in less developed regions with a high potential of human capital does not have to imply convergence in absolute terms. In equation 4 the variable GAP* $\ln h_{t-1}$ has negative sign and is statistically insignificant, at a level of 5%.

The problem of convergence/divergence in regional development is very frequently discussed in the context of policy making and public finance. In Poland, a new stimulus to this discussion has been provided by the structural funds and ways of their distribution among regions. Many empirical studies, mainly those conducted in Europe and the US, have dealt with the issue of economic convergence and divergence of regions. The findings presented in this chapter indicate that, similarly to many other countries, the convergence/divergence processes in Poland are strongly influenced by human capital resources in the regions. The next stage of our analysis looks at this problem in more detail.

DOES CONVERGENCE /DIVERGENCE OF DEVELOPMENT DEPEND ON THE LEVEL OF HUMAN CAPITAL?

Convergence, that is equalising the incomes and standards of living in countries and regions, is one of majors goals of economic policy, both local and international. Large income disparities lead to social tensions and conflicts, not to mention the fact that they are quite unacceptable from the humanitarian point of view. However, the answer to the question whether convergence takes place in real life and what factors can stimulate it is extremely complicated, which is partly due to the fact that the term itself has a number of definitions. First and foremost, the tenet that underdeveloped regions will develop faster than wealthy ones does not in itself guarantee that they will ever manage to close the development gap. Despite lower income increases measured in relation to the initial period, wealthy areas can develop faster in terms of absolute values. The literature of the subject has many references to the difference between beta-type and sigma-type convergence (R. Barro and X. Sala-i-Martin 1995).

The first type refers to the specification of the regression equation where the rate of growth of a given economy in a given period represents the following variable explained:

(7) $y_{i,t} = \alpha + \beta y_{i,t-1} + \varepsilon_{i,t}$

Parameter B, which is also known as the convergence coefficient, defines the rate of growth of a given economy in relation to income in the initial period. We speak about convergence when B is negative; with the positive sign, we will have a divergence of income.

On the other hand, sigma-type convergence is measured in relation to absolute income values at the beginning and at the end of the analysed time interval. It may be expressed by the standard deviationof income within a given group of countries or regions. It can also be estimated using the regression model; in such a case, the endogenous variable should describe the absolute increase in income over a given time interval.

The difference between the two types of convergence using the example of Polish subregions is shown in Fig. 8. On its left-hand side, we can see the sigma-type convergence, i.e. changes in income expressed in absolute terms. As we can see, there is a distinct, positive correlation between the initial value and the changes in income in 1995-2003 (correlation coefficient of 0.64). We can say therefore that a strong divergence in the subregional incomes has taken place. The comparison between standard deviation values for the beginning and the end of the period in question leads to similar conclusions. In 1995, this value was approximately PLN 1,800, as compared to nearly PLN 3,000 in 2003 (fixed prices).

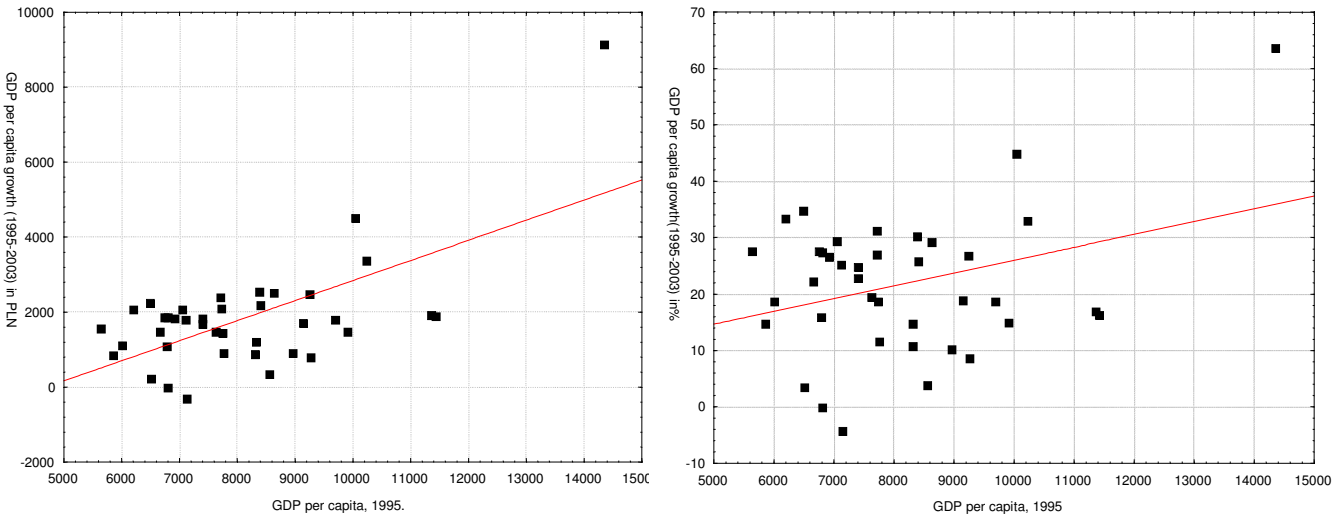

Fig. 8. Divergence of per capita income in the subregions (NTS3) (1995-2003).

The right-hand side of the diagram proves that also there is no beta-type convergence of Polish regional economies. The linear convergence between per capita income in 1995 and the rate of economic growth in the subsequent years is relatively weak (with the correlation coefficient of 0.33), but nevertheless positive.

Table 8. Unconditional and conditional convergence/divergence in the subregions[5].

Variables	Equation 1		Equation 2		Equation 3		Equation 4	
Absolute term	-1.377	(-1.11)	1.789	(1.44)	**3.742**	**(5.27)**	**5.594**	**(7.86)**
$\ln y_{t-1}$	**1.189**	**(8.64)**	**0.779**	**(5.31)**	0.117	(1.48)	-0.122	(-1.47)
$\ln h_{t-1}$ (% of population with higher education)			**0.383**	**(4.37)**			**0.224**	**(4.48)**
N	39		39		39		39	
R^{2}^	0.66		0.77		0.03		0.36	

Endogenous variable in equations 1-2: $\ln(y_t - y_{t-1})$

Endogenous variable in equations 3-4: $\ln((100 * ((y_t - y_{t-1}) / y_{t-1})) + 100)$.

These observations are corroborated by the results of convergence coefficients (Table 8). The first two equations in this table refer to the sigma-type convergence. Here, the variable explained is the natural logarithm of the subregions' absolute increase in per capita income (in current prices) between 1995 and 2003. As we can see, the income level in the initial period is strongly and positively correlated with the rate of economic growth in the following years. This is true for both simple regression (Equation 1) and regression in which, in addition to the income from the initial period, initial human capital resources were included. In the latter case, the convergence coefficient is slightly lower but nevertheless remains both positive and statistically highly significant. This means that in the analysed period neither unconditional nor conditional sigma-type convergence took place in the Polish subregions. Conversely, a considerable divergence of the regional economies could be observed.

The estimation results for the beta-type convergence (Equations 3 and 4) should be interpreted differently. Its convergence coefficient is positive but statistically insignificant at 5% level. Therefore, no distinct divergence between the subregions can be ascertained for the analysed period. In Equation 4, with human capital controlled, coefficient B becomes negative

[5] In this case, conditional convergence also denotes convergence between the levels of per capita income in the economies, which is 'revealed' in the regression equation only when the model takes into account the differentiation of specific resources (such as human capital) in the regions.

but remains statistically insignificant. We can therefore find traces of the beta-type conditional convergence with the controlled level of human capital in the subregions, although such a result is not statistically credible.

The above analyses indicate that in the last decade a close correlation could be observed at the subregional level between human capital resources and increase on the one hand, and the level of income and rate of economic growth on the other. The regions which in the mid-1990s had a strong human capital potential were able to achieve relatively high rates of growth in the subsequent years. Those regions where the level of knowledge and skills was relatively lower were also developing at a slower pace. Moreover, in the analysed period, we could observe a distinct divergence in terms of regional per capita income as well as human capital resources. Both these values grew at the fastest rate in metropolitan areas, that is in those regions where they were already the highest at the beginning of the period in question. This means that the dynamics of human capital increase does not contribute in any way to equalising the disparities in regional development. An important question that follows is whether such equalising role is at all possible. Provided the less developed regions made bigger investment in human capital, would they diminish the income gap between them and metropolitan areas? The results of our analyses do not confirm such a view. The most that human capital can achieve is stimulate the beta-type convergence, that is the relatively fast growth of poorer regions measured in relation to the initial value of income. Nevertheless, the actual disparities in development tend to be increasing.

The analyses do not allow for any clear conclusions concerning the way in which human capital influences subregional economic growth. We can observe a strong correlation between the rate of growth with the initial level of human capital, and with its increase over the analysed period. This would suggest that human capital directly affects productivity of labour and overall factors productivity. However, if we analyse the simultaneous impact of the level and the increase of knowledge resources, we will see that only the former factor has certain influence upon the rate of regional development. However, a full explanation of this phenomenon is impossible due to the strong correlation between the initial level and the increases of human capital in the Polish subregions, which lowers the reliability of the results of the modelling exercise.

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