PRACE NAUKOWE UNIWERSYTETU EKONOMICZNEGO WE WROCŁAWIU
RESEARCH PAPERS OF WROCLAW UNIVERSITY OF ECONOMICS AND BUSINESS

2020, vol. 64, nr 4

ISSN 1899-3192
e-ISSN 2392-0041

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THE CONVERGENCE OR DIVERGENCE OF LABOUR RESOURCES IN POLAND?

DOI: 10.15611/pn.2020.4.07
JEL Classification: C22, J11, R11

Quote as: Krupowicz, J. (2020). The convergence or divergence of labour resources in Poland? *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu*, *64*(4).

Abstract: Eurostat's projections indicate that by 2050 Poland will see a significant reduction in and ageing of its labour resources. The country is experiencing a strong polarization of demographic phenomena and disproportions in population structure. The goal of the study was to determine whether Poland's labour resources are undergoing convergence or divergence. The occurrence of beta, sigma and gamma-convergence in the country's individual provinces (voivodeships) in the period 2012-2018 was verified. Three models were created (working age population ratio, young-age dependency ratio and old-age dependency ratio). The results indicate the occurrence of absolute (unconditional) beta-convergence of the variables that characterise labour resources. No unambiguous confirmation of sigma-convergence, i.e. a significant reduction in the diversification of the provinces in terms of the studied variables, was obtained. Similarly, the occurrence of gamma-convergence, i.e. a significant change in the positions of the provinces in terms of labour resources, was not unambiguously confirmed.

Keywords: social convergence, regional convergence, labour resources.

1. Introduction

Since the 1990s, the EU Member States have recorded a shortage of labour force resulting from the low total fertility rate and the low population growth rate. The working-age population has been decreasing noticeably, which is affecting economic growth and the competitiveness of many European regions. The ageing of Europe's population will affect the community's territorial development by 2050 (ESPON, 2014; Kupiszewska and Kupiszewski, 2014).

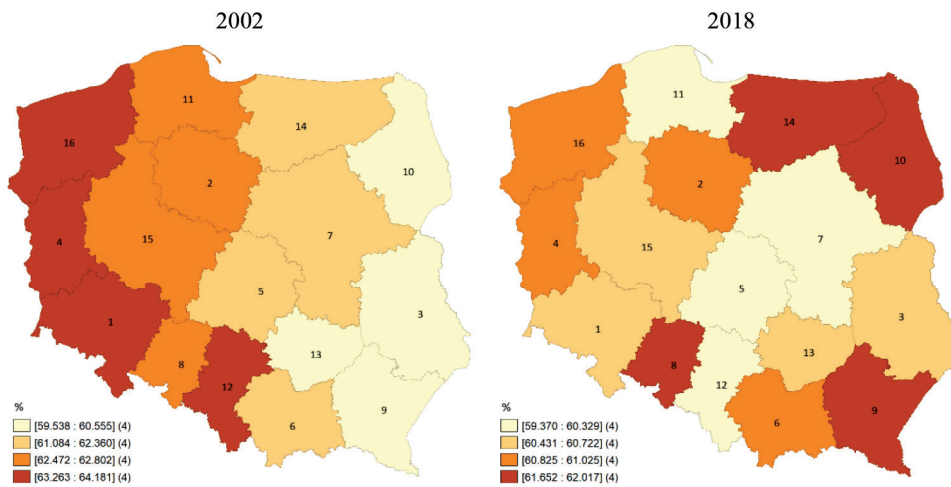
The labour supply phenomena in Poland fall into this megatrend, observed in the other EU and OECD countries. The entering into the period of activity in the labour market of less populous age groups will bring about a reduction in the number of working people. According to demographic projections, Poland will be among the EU countries with the largest declines in the working age population. In the medium term, by 2030 the population aged 20-64 will decrease by 2.3 million, and by 2050 by 6.0 million (Eurostat, 2019). As a result, in Poland, by around 2050 there will only be two working age persons (15-64 years) per each person aged 65 or above, while in 2018 the ratio was one to four in Poland and one to three in the EU. According to the Institute for Structural Research, the expected increase in the employment rate will not be sufficient to set off the negative impact of demographic factors on Poland's employment figure (Magda, Baran, Lis, and Miazga, 2014). Changes in population size and structure have specific consequences related not only to the labour market, but also to the operation of the national insurance system in the future. Poland's dependency ratio is rising dynamically, which will have the biggest impact on the country's old-age pension spending in the entire EU (European Commission, 2015, p. 87).

In the European countries, spatial development and settlement structures are polarised. In 2018, 76% of the population lived in towns and cities, with the Northern Europe being the most urbanised, and the urbanisation process will increase. In 2050, 89% of the community's population will be living in towns and cities, as a result of which rural and less urbanised areas will be losing their labour resources. In Eastern Europe, urbanisation towards bigger towns and cities will be more intensive than in Western Europe (ESPON, 2014), while in Poland the lack of equilibrium in the territorial distribution of the population and its age structure will affect the innovativeness and dynamism of social and economic processes.

The falling number of young people and the growing number of older people means an increase in the percentage of the latter in the entire population, i.e. a steep rise in its ageing. Such transformations of the population processes are typical of the second demographic transition (Kotowska, 1999). Poland is experiencing a strong polarization of demographic processes. There exist noticeable disproportions in the population structure by age and sex, caused by a historically-based varying intensity of births, deaths and migrations (Śleszyński, 2018). Changes in the course of natural and migration movements are leading to population structure transformations both in terms of the entire country and its individual provinces (Hrynkiewicz, Witkowski, and Potrykowska, 2018).

Poland has been experiencing unfavourable changes in the population structures by economic age group since the 1990s. The share of the elderly population has increased, while that of the young population has dropped. Although over a longer period of time, the share of the working age population has grown, in the first two decades of the 21st century the percentage of that age group has fallen (from 62.2% in 2002 to 60.6% in 2018). Similar observations have been made about the population structures in the economic age groups and their mutual relations

in Poland's provinces. These are presented in the quartile groups on Maps 1 to 3. In the period 2002-2018, the median of the ratio of the working age population in the provinces fell from 62.45% to 60.75%. The indicator varied depending on the province (Map 1). In 2002, the provinces in the western and south-western part of the country had high rates of working age populations (in the third and fourth quartile groups, i.e. above the median). On the other hand, the provinces in the eastern and north-eastern parts of the country had relatively low rate values (in the first and second quartile groups, i.e. below the median). In 2018, the composition of the quartile groups was different from that in 2002. Although the median of the percentage of the working age population fell in the respective years, two provinces (*Podlaskie* and *Podkarpackie*) recorded an unusual improvement, i.e. a growth in the indicator, which shifted them from the first to the fourth quartile group.

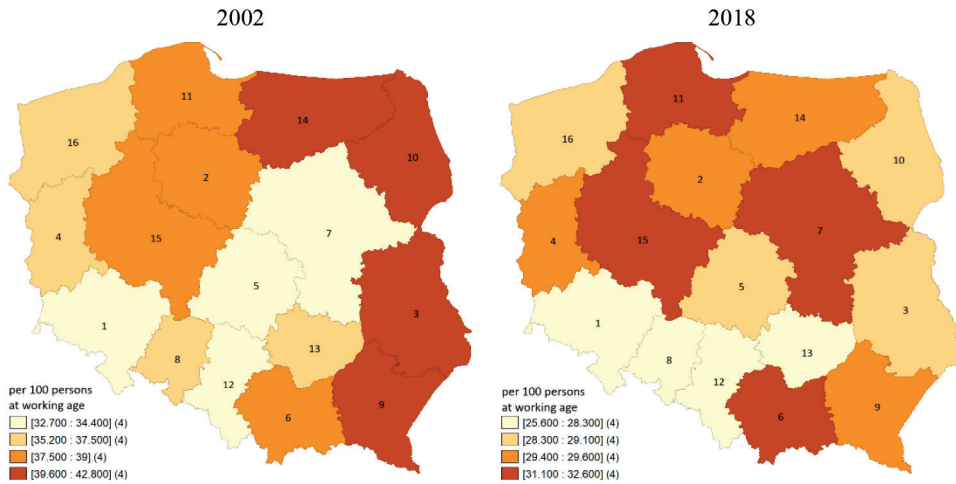


Legend: 1 – Dolnośląskie; 2 – Kujawsko-Pomorskie; 3 – Lubelskie; 4 – Lubuskie; 5 – Łódzkie; 6 – Małopolskie; 7 – Mazowieckie; 8 – Opolskie; 9 – Podkarpackie; 10 – Podlaskie; 11 – Pomorskie; 12 – Śląskie; 13 – Świętokrzyskie; 14 – Warmińsko-Mazurskie; 15 – Wielkopolskie; 16 – Zachodnio-pomorskie.

Map 1. Share of the working age population in Poland's provinces in 2002 and 2018

Source: own compilation on the basis of (The Central Statistical Office, GUS, 2020).

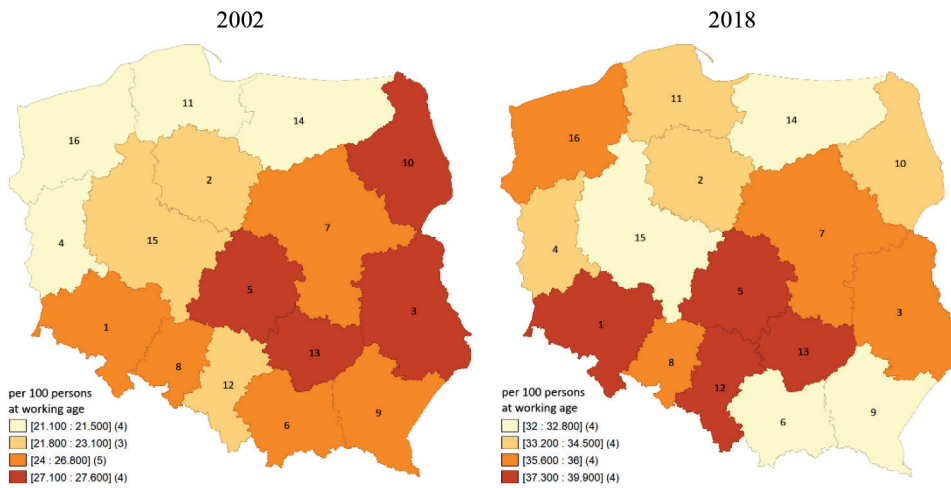
Changes in the age group proportions led to changes in the population's economic dependency. The country's youth dependency ratio dropped (from 36.5 in 2002 to 29.8 in 2018). During the period, there was also a drop in the median of the youth dependency ratio in the provinces, from 37.5 to 29.3. In 2002 the provinces in the country's eastern and north-eastern parts were characterised by high values of the youth dependency ratio (the fourth quartile group). In 2018, the indicator was high in Poland's central provinces (*Mazowieckie*, *Wielkopolskie*) – Map 2.



Legend: 1 – Dolnośląskie; 2 – Kujawsko-Pomorskie; 3 – Lubelskie; 4 – Lubuskie; 5 – Łódzkie; 6 – Małopolskie; 7 – Mazowieckie; 8 – Opolskie; 9 – Podkarpackie; 10 – Podlaskie; 11 – Pomorskie; 12 – Śląskie; 13 – Świętokrzyskie; 14 – Warmińsko-Mazurskie; 15 – Wielkopolskie; 16 – Zachodniopomorskie.

Map 2. Youth dependency ratio in Poland's provinces in 2002 and 2018

Source: own compilation on the basis of (GUS, 2020).



Legend: 1 – Dolnośląskie; 2 – Kujawsko-Pomorskie; 3 – Lubelskie; 4 – Lubuskie; 5 – Łódzkie; 6 – Małopolskie; 7 – Mazowieckie; 8 – Opolskie; 9 – Podkarpackie; 10 – Podlaskie; 11 – Pomorskie; 12 – Śląskie; 13 – Świętokrzyskie; 14 – Warmińsko-Mazurskie; 15 – Wielkopolskie; 16 – Zachodniopomorskie.

Map 3. Old-age dependency ratio in Poland's provinces in 2002 and 2018

Source: own compilation on the basis of (GUS, 2020).

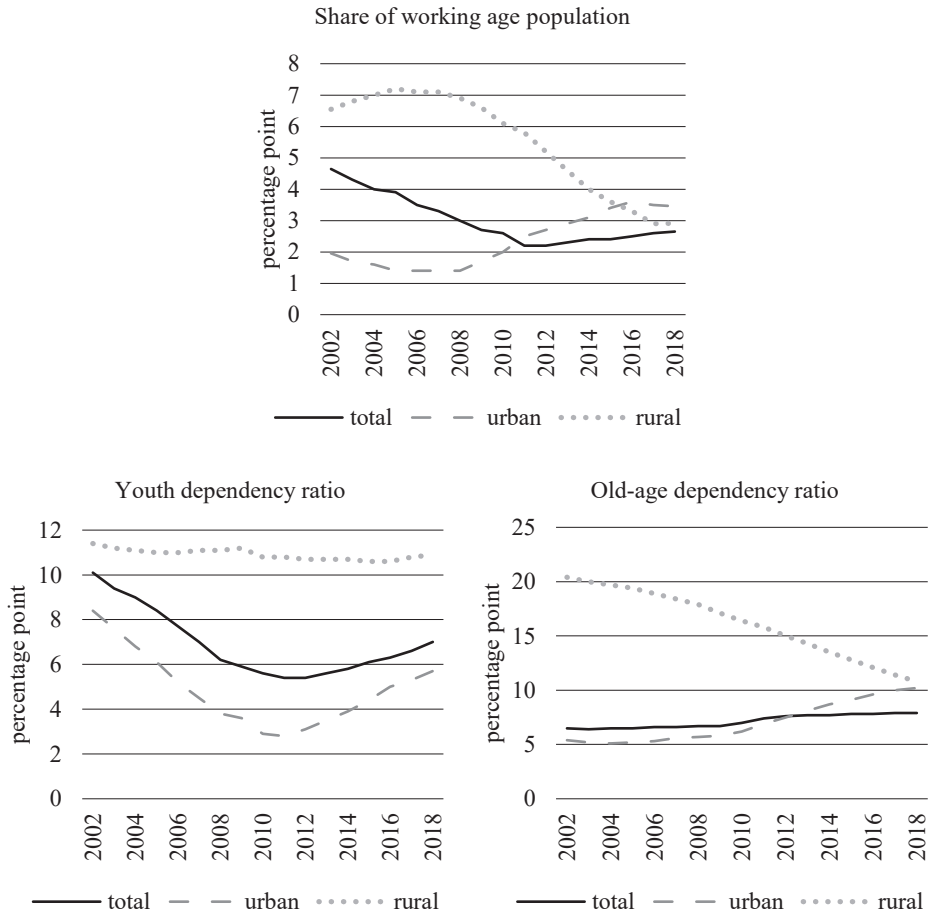


Fig. 1. Range of the studied variables in Poland's provinces in the period 2002-2018

Source: own calculations on the basis of (GUS, 2020).

In turn, Poland's old-age dependency ratio grew (from 24.2 in 2002 to 35.3 in 2018). Between the compared years, the median of the ratio increased from 24.0 to 35.1. In 2002 the old-age dependency ratio was relatively low (below the median) in the country's northern and north-western provinces, and in 2018 the indicator was also low in the south of Poland (*Małopolskie*, *Podkarpackie*) – Map 3. In terms of economic dependency ratios, a particularly unfavourable situation was in *Podlaskie* province. The youth dependency ratio fell by 12.5 percentage points, and the old-age dependency ratio rose by 6.5 percentage points, which shifted the province from the fourth to the second quartile group.

The ratio and quartile group changes in the years 2002 and 2018 were not only analysed by provinces as a whole, but also in relation to the urban-rural division.

Figure 1 shows changes in the ratios in individual provinces, taking account of the urban-rural division. The differentiation was measured by range, i.e. the difference between the largest and the smallest values of the ratio. In the period 2002-2018, there occurred multi-directional changes in the dispersion of the ratios that characterise labour resources and their dependency ratios. The changes in both the make-up of the quartile groups and in value differentiation inclines one to check whether there is any internal (i.e. within provinces) convergence or divergence of labour resources in Poland.

The goal of the study was to examine whether the province subpopulations are becoming alike in terms of the structure and dependency of labour resources. Three variables were used: the share of the working age population in the total population (ratio of population at working age, in %), the youth dependency ratio (dependency ratio of pre-working age population per 100 persons at working age) and the old--age dependency ratio (dependency ratio of post-working age population per 100 persons at working age). The study covered the period 2002-2018, as during that time some unfavourable changes in Poland's population age structures became more pronounced. The urban-rural division was taken into account. Three detailed research questions were asked: (1) Did the studied variables level off in the provinces in 2002-2018? (2) Did the disparity between the values of the studied variables in the provinces decrease during the time? (3) Did the ranking of the provinces during the time in question change?

2. Previous studies

The implementation of the European Union's cohesion policy is conducive to examining the economic, social and territorial convergence of the community's countries and regions. Of the three, economic convergence has been most intensely explored, with its most popular measure – GDP per capita[1]. Social convergence is studied in terms of human capital, social order and labour markets, and to measure them the following metrics were applied: unemployment rate, participation rate (i.e. employment indicator), and quality of life (e.g. Human Development Index, synthetic development measures).

Beta, sigma and gamma- (and less frequently club) convergence were examined. Beta-convergence refers to processes related to the evening up of development levels between various regions. This type of convergence occurs in two variants: absolute and conditional. Absolute beta-convergence assumes that regions become alike irrespective of initial conditions, and conditional one assumes that regions with similar structural factors become alike. Sigma-convergence refers to a reduction in the disparities between regions over time. Gamma-convergence determines

[1] GDP per capita is universally used as a measure in examining convergence and is referred to as 'income convergence'.

convergence based on the position in the region ranking in time. Club convergence occurs between regions with a similar structure and similar initial conditions. The models of the considered convergence types are described in Section 3 of this article. The applied approaches have both their strong and weak points (Bernardelli, Próchniak, and Witkowski, 2017; Furceri, 2005; Quah, 1993), and researchers tend to measure convergence rather than assess it (Plümper and Schneider, 2009). Studies also make use of alternative techniques and methods, such as the Markov processes, a transition matrix (Tyrowicz and Wójcik, 2007; Wójcik, 2008), measures of analogy (Kudrycka, 2014), DEA (Kosmalski, 2016), and models with spatial effects (Folfas, 2016). Both single indicators and synthetic measures are used as variables. The spatial dimension of convergence particularly applies to the EU Member States, their regions or Poland's regions (provinces/voivodeships, counties/powiats, communes/gminas). Cohesion analyses cover time slots of varying lengths, frequently connected with periods (perspectives) of financing or the community's implemented development strategies.

In one of the directions of studies into the cohesion of European regions, income convergence is combined with social convergence. The division into new and old community members and periods before and after the financial crisis were taken into account. The conclusions depend on the duration of the examined period. Marelli (2007) examined 25 EU countries and regions (NUTS2), divided into new and old EU members in terms of GDP per capita, employment and productivity. He found beta-convergence for most of the divisions (except for the new Member States) and sigma-convergence, i.e. a reduction in the disparity between the countries and regions in the long term. In turn, Pastuszka and Skrzypek (2017) focused on the convergence (divergence) of Italian regions in terms of GDP per capita, gross remuneration and unemployment rate before and after the financial crisis. They showed that the unemployment rate converged in Italy as a whole and in its individual macroregions. Baer-Nawrocka and Markiewicz (2012) analysed labour productivity convergence in agriculture in 212 regions (NUTS2) of European Union countries in the period 2000-2008. They found inter-regional sigma-convergence. Using the same territorial division (NUTS2) of the EU countries in 2002-2010, absolute beta-convergence of the regions was identified (without statistical testing) in terms of GDP per capita, household income, investment per capita and unemployment rate (Mroczek, 2015). It was shown that the distance between the EU regions was closing the fastest with regard to household income, with unemployment rate and GDP per capita following. The differences between regions that were disappearing at the slowest rate regarding the level of investment per inhabitant. It was noted that although in terms of economic development the Polish provinces were at the periphery of the European Union, the distance between them and the regions of the richest economies was closing.

In studies into social convergence understood as the regions becoming similar to one another in terms of development level and the standard of living, absolute beta-convergence and sigma-convergence of various country groups during a period

of over 30 years were verified (Jordá and Sarabia, 2015; Mazumdar, 2002). In Polish literature, social convergence has been examined for single metrics or synthetic variables. In an analysis of household spending on groceries, absolute and conditional convergence of provinces in 1999-2010 was confirmed (Müller-Frączek, Muszyńska, and Pietrzak, 2013), while no economic convergence of the provinces in the same period was found. When using a synthetic measure of the standard of living, beta-convergence of the provinces in 1999-2012 was established, while no unambiguous confirmation for sigma or gamma-convergence in that respect was obtained (Muszyńska and Müller-Frączek, 2014). Kowerski and Bielak (2019) confirmed beta and sigma-convergence of the synthetic metric of the standard of living in Poland's provinces in the period 2006-2016.

Of special nature are studies designed to determine whether convergence or divergence is occurring as regards socio-economic development at the lowest level of territorial division, i.e. NUTS5. Kołodziejczyk (2014) identified the character of convergence (divergence) of Poland's communes in 2005 and 2012, by dividing them into four groups based on the synthetic metric of Hellwig's development. Nearly one half of the communes were lagging in economic development, i.e. they had a low level of development and low economic growth. Kiczek (2015) confirmed the beta-convergence of the synthetic measure of socio-economic development in the communes of *Podkarpackie* Province in 2007-2012. He determined that the more rural a commune was, the faster the beta-convergence effect. Studies limited to rural communes indicated the occurrence in the period 2004-2014 of slow beta-convergence processes in terms of synthetic metrics characterising the labour market, living conditions, health and social issues, care, education, demographics and culture, i.e. the areas of socio-economic development (Wojewódzka-Wiewórska and Dudek, 2016).

Attention is also drawn to labour market cohesion in Poland. Tyrowicz and Wójcik (2007) confirmed beta-divergence of the unemployment rate in Poland's counties in the period 1999-2006, and proved the lack of sigma-convergence in that respect. Misiak, Tokarczyk and Włodarczyk (2014) found no sigma-convergence of labour productivity, real wages and unemployment rate in the provinces and counties in 2002-2009. They confirmed beta-convergence of the unemployment rate, and determined sigma-divergence of the variable in 2006-2008 and sigma-convergence in 2008-2009, which the researchers linked to the economic situation. Kusideł (2013b) used social order measures, including those characterising access to the labour market, to study the provinces in the period 1995-2011. By analysing the indicators (e.g. long-term unemployment rate, employment rates of women, disabled persons, young persons and elderly persons, and designing a synthetic measure on their basis), she discovered absolute beta-convergence of that area of a social order. She also determined that in comparison with the other areas that aspect was characterised by the highest speed of convergence (4.5%). The results were not unambiguous, because no statistically significant differentiation in access

to the labour market was established, and no gamma-convergence was found, i.e. any significant change in the position in the province ranking in terms of the synthetic metric (Kusideł, 2013b).

The influence of the divergence of economic development (measured as GDP per capita) on the regional labour markets in Poland was examined by Guzikowski (2016). He described the labour markets by means of: unemployment rate, activity in the labour market, long-term unemployment rate and employment rate, and showed that in the long term the demographic diversity of the provinces determines the structure and changes in the regional labour markets, resulting in a divergence of provincial development. In examining regional labour market cohesion, Kusideł and Gajdos (2016) used shares of the employed by education, profession and specialisation. They determined that in the period 2005-2014 Poland's provinces were characterised by a stronger convergence in terms of occupational structure than that of other EU countries.

The literature on labour market modelling and forecasting presents a supply and demand approach (European Centre for the Development of Vocational Training [CEDEFOP], 2010; Kryńska, Suchecka and Suchecki, 1998). The most frequently predicted are absolute values that describe the magnitude of supply (number of employees, number of persons employed, often taking account of occupation, qualifications, sectors or regions), and less frequently – relative values (employment rate). Analyses and forecasts relate rather to domestic labour markets (CEDEFOP, 2010; Kupiszewska and Kupiszewski, 2014; Lewandowski and Magda, 2014) rather than regional labour markets (Batóg, Batóg, Mojsiewicz, and Rozkrut, 2016). The supply approach exposes the past and future demographic situation of labour resources, particularly their ageing. Analyses indicate the dwindling of labour resources and a risk of a skills gap in the future (Król, 2016). The intensification of the ageing of the working age population after 2020 will limit the propensity for spatial and occupational mobility of the subpopulation. Labour resources in rural areas will be relatively younger and more mobile (Rossner and Stanny, 2008). Changes in labour resources will have a direct impact on GDP (both in absolute terms and per capita), which will affect the quality of life of successive generations (Janicka, Kaczmarczyk, and Anacka, 2015). In turn, the use of a synthetic labour market development measure and GDP per capita to classify the provinces indicates the considerable diversity of the development potential of regional labour markets in terms of demand for labour, which determines their competitiveness (Gawrycka and Szymczak, 2010).

A review of the studies into income and social convergence provides evidence that a low level of territorial division does not translate into a convergence or divergence of the division units. Furthermore, analysis of the demographic conditions for labour supply connected with changes in population number and structure by economic age group usually covers an entire country, and that is why it was decided to check for convergence or divergence of labour resources in Poland's provinces. The findings

are important, for instance because disparities in labour resources in individual provinces may deepen regional differences in economic development.

3. Applied research approach

In order to check for convergence of labour resources in Poland's provinces three absolute beta, sigma and gamma-convergence models were used (Barro and Sala-i--Martin, 1992; Boyle and McCarthy, 1997; Sala-i-Martin, 1996). Initially, the models were used to examine income convergence, and with time they started to be used for examining social convergence.

Absolute beta-convergence was verified by means of the cross-sectional regression model in the form:

$$\ln\left(\frac{y_{iT}}{y_{i0}}\right) = a + b \cdot \ln\left(y_{i0}\right), \tag{1}$$

where: $\ln\left(\frac{y_{iT}}{y_{i0}}\right)$ – speed of changes in the examined variable between the final and the initial study periods; y_{iT} – value of the studied variable in the final period of analysis; y_{i0} – value of the studied variable in the initial period of analysis; a, b – model parameters; i – object of study, $i = 1, \ldots, N$.

The model parameters (1) were estimated by the method of least squares[2]. In order to check for absolute beta-convergence (divergence) relevant hypothesis sets were verified:

H_0: $b = 0$ (lack of beta-convergence and divergence),

H_1: $b < 0$ (beta-convergence occurs) or

H_{1a}: $b > 0$ (beta-divergence occurs).

The significance of parameter b was checked by means of Student's t-test. A statistically significant negative value of parameter b means that beta-convergence occurs. On the other hand, a statistically significant positive value of the parameter indicates beta-divergence. Parameter b from model (1) was used to calculate the coefficient of convergence β:

$$\beta = \frac{-\ln(1+b)}{T}, \tag{2}$$

where: T – interval between the final and initial periods of the analysis.

[2] Equally frequently, researchers use the method of least squares (MLS), as a generalized method of moments (GMM). From the methodological perspective, the latter is a more appropriate estimation method, because MLS requires that the assumption of the lack of auto-correlation of a random component should be met. Because the assumption was met and the number of objects in the study was small, MLS was applied to estimate the parameters.

A positive value of coefficient β indicates convergence and its medium-term tempo of change (expressed as a percentage). It is not possible to determine the coefficient of convergence if parameter b obtained by using the absolute beta-convergence model equals –1 or less. The half-life metric is an indicator complementary to the coefficient of convergence – it specifies the time needed to cut the existing differences in the variable by half:

$$hl = \frac{\ln 2}{\beta}. \tag{3}$$

The occurrence of beta-convergence should trigger a search for the other types of convergence, i.e. gamma and sigma-convergence. It is worth noting that if in the absolute beta-convergence $b \leq -1$, then gamma-convergence may be expected. The catch-up effect, a propensity to reach a steady-state, which is typical of beta--convergence, turns then into a leapfrogging effect with high values of the variable by objects that initially had low values of the variable.

The requisite – although not sufficient – condition for the occurrence of sigma-convergence is the presence of beta-convergence (Furceri, 2005; Quah, 1993). At the same time, sigma-convergence is a sufficient but not requisite condition for beta-convergence (Kusideł, 2013a, p. 45). That means that the lack of sigma--convergence does not warrant the claim that objects with low initial values do not show a higher growth than others. Consequently, one should not limit examination to a selected type of convergence or one measurement method. While in order to identify beta-convergence one statistical test was used, to check for sigma and gamma-convergence a confirmation test was applied. This is connected with the fact that convergence measurement can take account of observations made during a period of time or only at the ends of the period, which may lead to disparate conclusions as to the occurrence of convergence.

Sigma-convergence was verified using a model of regression of a measure of dispersion in relation to time in the following form (Friedman, 1992):

$$v_t = a + b \cdot t, \tag{4}$$

where: v_t – coefficient of variation of the examined variable in period t; a, b – model parameters; t – study period, $t = 1, \ldots, n$.

The coefficient of variation was determined as a relation of the standard deviation of logarithm values of the studied variable to the arithmetic mean of the logarithms of the variable. The model parameters (4) were estimated by the method of least squares. In order to check for sigma-convergence (divergence), relevant sets of hypotheses were verified:

H_0: $b = 0$ (lack of sigma-convergence and divergence),

H_1: $b < 0$ (sigma-convergence occurs) or

H_{1a}: $b > 0$ (sigma-divergence occurs).

The significance of parameter b was checked by means of Student's t-test.

Sigma-convergence (divergence) was confirmed by means of another statistical test. Where sigma-convergence was assumed, the significance of the fall in variance in the initial period ($t = 0$) and the final period ($t = T$) was tested. On the other hand, an assumption regarding sigma-divergence was tested by checking the significance of the increase in variance in the compared periods. The sets of hypotheses were as follows:

H_0: $\hat{\sigma}_0^2 = \hat{\sigma}_T^2$ (no sigma-convergence or divergence),
H_1: $\hat{\sigma}_0^2 > \hat{\sigma}_T^2$ (sigma-convergence occurs) or
H_{1a}: $\hat{\sigma}_0^2 < \hat{\sigma}_T^2$ (sigma-divergence occurs).

To checking F statistics was done in the form:

$$F = \frac{\hat{\sigma}_0^2}{\hat{\sigma}_T^2}, \tag{5}$$

where: $\hat{\sigma}_t^2 = \frac{1}{N}\sum_{i=1}^{N}\left(\ln(y_{it}) - \overline{\ln(y_{it})}\right)^2$ – variance of the variable in period t.

Where a presumed variance increase is tested, F statistics is the reverse of the relation expressed with formula (5). Empirical F statistics has the Fisher-Snedecor distribution with $n_1 = N - 1$ and $n_2 = N - 1$ degrees of freedom. A statistically significant F value confirms sigma-convergence (divergence).

It should be emphasized that a test of significance of parameter b in sigma-convergence model (4) provides information about changes in the diversity of the variable value in the examined period of time, while a test of variance changes checks the significance of such changes only in the extreme periods (the initial and final ones). When the test results are contradictory, conclusions about the occurrence of convergence (divergence) may be ambiguous.

The check for gamma-convergence was based on an analysis of changes in object ranking in various periods of the study. Agreement of rankings is measured by means of a coefficient of concordance (Kendall's coefficient of concordance). The occurrence of gamma-convergence was tested as proposed by Kusideł (2013a). Gamma-convergence was determined by means of a model of regression of a coefficient of concordance to time:

$$RC_t = a + b \cdot t, \tag{6}$$

where: $RC_t = \frac{\operatorname{var}\left(\sum_{t=0}^{T} AR(y_{it})\right)}{\operatorname{var}\left((T+1)\cdot AR(y_{i0})\right)}$ – coefficient of concordance in period t; $AR(y_{i0})$ – rank of object i in the first period of study; $AR(y_{it})$ – rank of object i in period t; a, b – model parameters.

Hypothesis H_0: $b = 0$ (no gamma-convergence) was verified against H_1: $b < 0$ (gamma-convergence occurs). The significance of parameter b was checked by means of Student's t-test. A statistically significant negative parameter b of model (6) tentatively indicates the presence of gamma-convergence.

A test of significance of parameter b in gamma-convergence model (6) has a filtering nature here. A reduction in the value of coefficient RC over time does not necessarily mean that there have occurred any significant changes in the object rankings, particularly if the values of the coefficient of concordance are close to 1. Considering the possible range of values of the coefficient of concordance – [0;1] and the fact that the measure close to 1 reflects the stability of the ranking in time, it should be concluded that the value of the rate of gamma-convergence close to 1 indicates the lack of such convergence (Bernardelli, Próchniak, and Witkowski, 2017). In such a situation, confirmation by means of another test is recommended (Kusideł, 2013a, pp. 68-71). As the testing of parameter b from model (6) is tentative in nature, confirmation of gamma-convergence should also be sought when a coefficient of concordance has low values close to 0 (indicating the lack of agreement of rankings). In the study, a test of Spearman's rank correlation coefficient was used.

A negative value of Spearman's rank correlation coefficient means that an opposing change in object rankings in terms of the variable value has taken place, i.e. gamma-convergence occurs. The occurrence of such convergence is also signalled by a correlation coefficient amounting to 0. The lack of concordance of ranking also means that the initial ranking in terms of a given variable is different – random – from that in the final period under study (Kusideł, 2013a, pp. 70-71). In such situations no confirmation test was used. A positive correlation coefficient reflects an agreement of object rankings in the compared periods, and only then was its statistical significance tested. The following hypothesis H_0 was formulated: $r_s = 0$ (gamma-convergence occurs), against H_1: $r_s > 0$ (lack of gamma-convergence). A test was carried out by means of empirical statistics in the form:

$$t_{r_s} = \frac{r_s \sqrt{N-2}}{\sqrt{1-r_s^2}}, \tag{7}$$

where: r_s – Spearman's rank correlation coefficient.

Empirical statistics has Student's t-distribution with $N - 2$ degrees of freedom (Aczel and Sounderpandian, 2018, p. 624). A statistically insignificant value means that gamma-convergence occurs.

As in the case of confirming sigma-convergence, verification of a gamma--convergence hypothesis by means of various measurement methods may lead to contradictory results. In such situations the conclusions are not unambiguous, although – because of the filtering nature of the test of significance of parameter b from model (6) – one might be inclined to accept the conclusion arising from Spearman's rank correlation coefficient test.

4. Study findings

4.1. Beta-convergence

Based on data regarding three variables characterising labour resources and their dependency ratios in Poland's provinces, regression models of absolute beta-convergence were built, taking account of the division by place of residence. The results of the model parameter estimation and their verification by means of Student's t-test are presented in Table 1.

The obtained values of parameter *b* in the absolute beta-convergence models were negative (Table 1). At the significance level of 0.05, the parameters significantly differed from 0, which indicates the existence of such convergence for nearly all of the studied indicators in the examined sections. Statistically insignificant was the parameter in the model for the youth dependency ratio in rural areas; in this case there is no confirmation of occurrence of absolute beta-convergence. In general, the constructed models adequately or sufficiently adequately matched the data.

Table 1. Values of parameters of absolute beta-convergence models and their verification for the studied variables in Poland's provinces in 2002-2018

Specification	Model parameters			Empirical statistics t_{emp}	*p*-value	β coefficient	Half-life *hl*
	b	*a*	R^2				
Share of population of working age							
Total	–1.1684	4.8026	0.8347	–8.4068	0.0000	–	–
Urban	–2.1153	8.7376	0.7026	–5.7515	0.0000	–	–
Rural	–0.7154	2.9748	0.8094	–7.7097	0.0000	7.9%	8.8
Youth dependency ratio							
Total	–0.8209	2.7309	0.5427	–4.0762	0.0006	10.7%	6.4
Urban	–1.0009	3.3425	0.6740	–5.3795	0.0000	–	–
Rural	–0.2644	0.6374	0.0884	–1.1650	0.1317	1.9%	36.1
Old-age dependency ratio							
Total	–0.6849	2.5551	0.5965	–4.5497	0.0002	7.2%	9.6
Urban	–0.4648	2.0071	0.3429	–2.7030	0.0086	3.9%	17.7
Rural	–0.5025	1.7572	0.8636	–9.4143	0.0000	4.4%	15.9

Source: own calculations on the basis of (GUS, 2020).

The speed of convergence of indicators describing labour resources and their dependency ratios expressed as a coefficient of convergence β in the analysed period of time in Poland's provinces differed. The value of parameter *b* lower than –1 means that it was impossible to determine coefficient of convergence β reflecting the speed of convergence of the share of the population of working age (total and urban areas)

or the youth dependency ratio (urban areas) in the provinces. This in turn attests to the very high speed at which the provinces are becoming alike, and indicates that the catch-up process is turning into a leapfrogging of areas with high values of the indicators by areas that initially had low values.

Gamma-convergence may be expected in three cases. In total provinces the old--age dependency ratio had a lower speed of convergence than the youth dependency ratio (7.2% as opposed to 10.7%). With those speeds, in order for the provinces to reach a steady-state in terms of those two metrics in which the differences in their values are cut by half, 9.6 and 6.4 years were required, respectively. In turn, the share of population of working age and the youth dependency ratio was changing faster in urban areas than in rural areas. The findings mean that Poland's provinces were becoming alike in terms of indicators characterising labour resources and their dependency ratios.

4.2. Sigma-convergence

The occurrence of sigma-convergence depends on the presence of beta-convergence. In order to determine whether sigma-convergence of indicators characterising labour resources and their dependency ratios occurs, a coefficient of variation of each of the indicators in the provinces was calculated for the period 2002-2018. The estimated parameters of the models of regression of sigma-convergence of the three indicators in the examined territorial sections of the provinces are presented in Table 2.

In most cases, the values of the coefficient of variation tended to fall which was attested to by the negative values of parameters *b* in the sigma-convergence models. The parameters were statistically significant, with a significance level of 0.05 (Table 2). This means sigma-convergence of the share of population of working age, the youth dependency ratio and the old-age dependency ratio in Poland's provinces in 2002-2018 in the studied territorial sections. The diversity of the provinces in terms of metrics characterising labour resources in the examined time interval was diminishing, which indicates convergence in that respect. Only in two sigma-convergence models (for the share of population of working age in urban areas and the youth dependency ratio in rural areas) were statistically significant positive values of parameters *b* obtained. This means sigma-divergence, i.e. in the urban areas the diversity of the share of population of working age was increasing over time, while in the rural areas the dispersion of the youth dependency ratio was growing.

The conducted test of statistical significance of the coefficient of variation of indicators characterising labour resources was supplemented by testing the significance of the increase (or decrease) in variance in the initial period (2002) and the final period (2018) of the examined time interval. The verification results are shown in Table 3.

Table 2. Values of parameters of sigma-convergence models and their verification for the studied variables in Poland's provinces in 2002-2018

Specification	Model parameters			Empirical statistics t_{emp}	*p*-value
	b	*a*	R^2		
Share of population of working age					
Total	–0.0002	0.0056	0.8607	–9.6261	0.0000
Urban	0.0001	0.0011	0.8782	10.3976	0.0000
Rural	–0.0003	0.0093	0.9424	–15.6699	0.0000
Youth dependency ratio					
Total	–0.0004	0.0229	0.8476	–9.1354	0.0000
Urban	–0.0004	0.0192	0.4949	–3.8338	0.0008
Rural	0.0002	0.0200	0.7631	6.9514	0.0000
Old-age dependency ratio					
Total	–0.0010	0.0342	0.9701	–22.0543	0.0000
Urban	–0.0005	0.0259	0.9791	–26.5198	0.0000
Rural	–0.0021	0.0704	0.8883	–10.9198	0.0000

Source: own calculations on the basis of (GUS, 2020).

Table 3. Values of variance and empirical statistics of sigma-convergence (divergence) for the examined variables in Poland's provinces in the years 2002 and 2018

Specification	Variance		Test for decrease		Test for increase	
	2002	2018	Empirical statistics *F*	*p*-value	Empirical statistics *F*	*p*-value
	σ_0^2	σ_T^2				
Share of population of working age						
Total	0.0006	0.0002	3.3473	0.0126	–	–
Urban	0.0001	0.0002	–	–	3.1375	0.0169
Rural	0.0013	0.0002	6.3953	0.0004	–	–
Youth dependency ratio						
Total	0.0065	0.0039	1.6669	0.1665	–	–
Urban	0.0056	0.0027	2.0634	0.0861	–	–
Rural	0.0063	0.0073	–	–	1.1578	0.3901
Old-age dependency ratio						
Total	0.0103	0.0043	2.4007	0.0502	–	–
Urban	0.0060	0.0042	1.4277	0.2494	–	–
Rural	0.0404	0.0111	3.6479	0.0085	–	–

Source: own calculations on the basis of (GUS, 2020).

In the majority of the considered situations, variance in the final period was lower than in the initial period in each of the examined territorial sections. At the assumed significance level of 0.05, a statistically significant drop in variance of the share of population of working age was found in total provinces and in rural areas. A statistically significant reduction in variance was also recorded for the old-age dependency ratio in the provinces as a whole. If the requirements are slightly relaxed, i.e. assuming $\alpha = 0.1$, it may be observed that the diversity of the youth dependency ratio diminished statistically significantly in urban areas and the old-age dependency ratio decreased statistically significantly in total the provinces in the compared years of 2002 and 2018. At the same time, urban areas experienced a statistically significant growth of the variance of the share of population of working age. In rural areas, the variance of the youth dependency ratio grew in the compared years. However, the growth was statistically insignificant, and so there are no grounds for rejecting the hypothesis concerning the lack of divergence of the youth dependency ratio in those areas.

4.3. Gamma-convergence

The provinces were ranked by the values of indicators characterising labour resources, and subsequently coefficients of concordance of rankings for successive periods were calculated. Low values of coefficients of concordance (not exceeding 0.3) mean that over time the rankings of the provinces changed. In the constructed gamma-convergence models, statistically significant ($\alpha = 0.05$) negative values of parameters b (Table 4) were obtained. Tentatively, this indicates the existence of gamma-convergence in total the provinces and in the urban-rural division, i.e. there were changes in the rankings of the provinces in terms of indicators characterising labour resources and their dependency ratios.

In line with the description of the verification procedure in Section 4, also a check for gamma-convergence was carried out by testing significance of Spearman's rank correlation coefficient. The values of the correlation coefficients and empirical statistics for the examined sections are shown in Table 5.

The change in the rankings of the provinces in 2018, as compared to 2002, was evidenced by the negative value of the rank correlation coefficient of the share of population of working age for urban areas and the provinces as a whole (Table 5). Thus, without any statistical verification, one may conclude that gamma-convergence of the indicator occurred in the provinces and in urban areas. As a result, the presumption of the occurrence of that convergence type was confirmed, when the leapfrogging of urban areas and the provinces as a whole was observed in respect of the share of population of working age (cf. Section 4.1). In urban areas and total provinces there existed a very small positive agreement of rankings of the provinces in terms of the youth dependency ratio, and Spearman's rank correlation coefficient was not statistically significant (0.05). This indicates that also in the case of those territorial

sections, there are no grounds for rejecting the hypothesis concerning the occurrence of gamma-convergence of that dependency ratio in the period 2002-2018.

Table 4. Values of parameters of gamma-convergence models and their verification for the studied variables in Poland's provinces in 2002-2018

Specification	Model parameters			Empirical statistics t_{emp}	*p*-value
	b	*a*	R^2		
Share of population of working age					
Total	–0.0055	0.2779	0.8286	–8.2274	0.0000
Urban	–0.0071	0.2433	0.8637	–9.4204	0.0000
Rural	–0.0009	0.2519	0.7722	–6.8888	0.0000
Youth dependency ratio					
Total	–0.0032	0.2604	0.9494	–16.2125	0.0000
Urban	–0.0050	0.2664	0.9439	–15.3412	0.0000
Rural	–0.0020	0.2568	0.8853	–10.3932	0.0000
Old–age dependency ratio					
Total	–0.0027	0.2537	0.9476	–15.9188	0.0000
Urban	–0.0006	0.2524	0.5344	–4.0087	0.0006
Rural	–0.0005	0.2515	0.9355	–14.2516	0.0000

Source: own calculations on the basis of (GUS, 2020).

Table 5. Values of Spearman's rank correlation coefficient and empirical statistics for the studied variables in Poland's provinces in the years 2002 and 2018

Specification	Spearman's rank correlation coefficient r_s	Empirical statistics t_{rs}	*p*-value
Share of population of working age			
Total	–0.2912	–1.1388	0.1369
Urban	–0.3265	–1.2924	0.1086
Rural	0.6147	2.9160	0.0056
Youth dependency ratio			
Total	0.3456	1.3780	0.0949
Urban	0.2574	0.9965	0.1680
Rural	0.4912	2.1099	0.0267
Old-age dependency ratio			
Total	0.4338	1.8016	0.0466
Urban	0.6353	3.0780	0.0041
Rural	0.9132	8.3867	0.0000

Source: own calculations on the basis of (GUS, 2020).

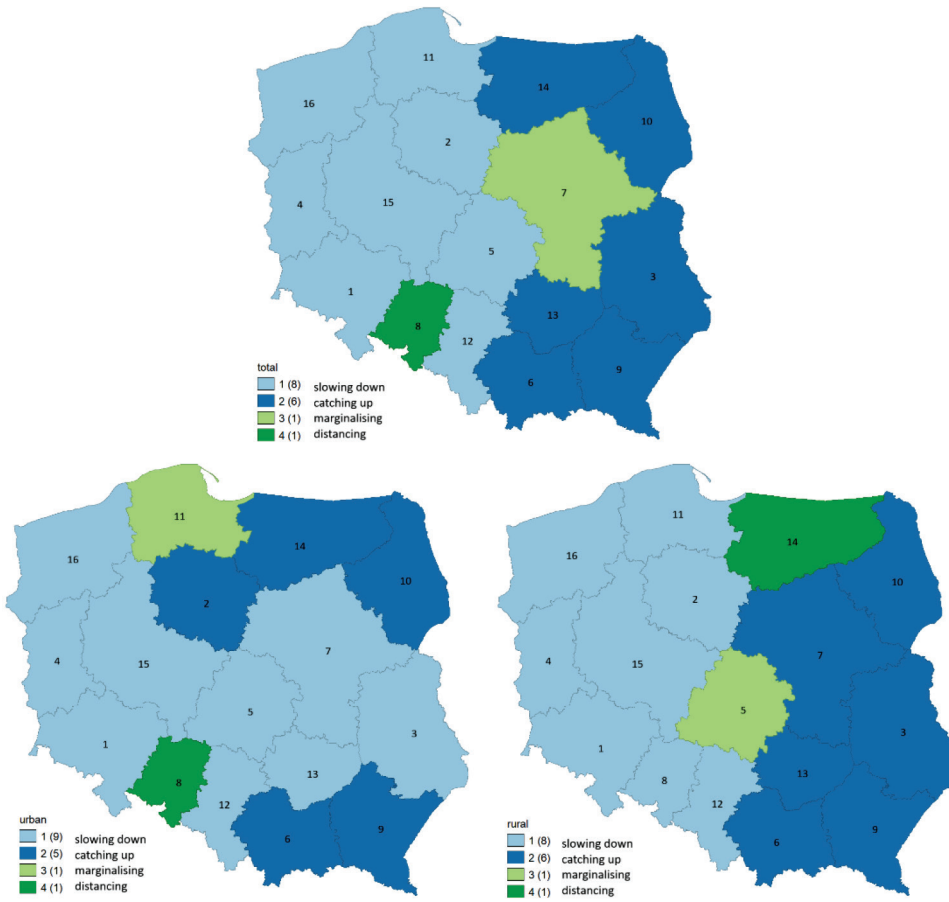
In other situations, the values of the rank correlation coefficients calculated for the agreement of rankings were positive. These indicate at least a moderate agreement of the province rankings in terms of the analysed indicators in the final and initial periods of the interval 2002-2018. The positive sign of Spearman's rank correlation coefficient and its statistical significance ($\alpha = 0.05$) indicates the lack of gamma-correlation of the old-age dependency ratio in the examined territorial sections. Similar conclusions may be drawn in relation to rural areas; there are no grounds for rejecting the hypothesis concerning the occurrence of gamma-convergence of the youth dependency ratio or the share of population of working age in 2002-2018. Thus, unambiguous conclusions regarding changes in the rankings of counties in terms of two indicators (the share of population of working age and the youth dependency ratio) may only be drawn in respect of urban areas and the provinces as a whole.

4.4. Identification of the nature of convergence

Section 4.1 stated that absolute beta-convergence of labour resources was found, so it had been possible to identify the nature of the convergences occurring in the provinces. The basis for assigning a given province to a group was the value of the variable in it in the initial period, i.e. the year 2002 (specifically, a logarithm of the variable value), and the dynamism of the changes in the variable in the studied time interval of 2002-2018 in relation to the mean (specifically, a logarithm of the quotient of the variable value from the final and initial periods).

Convergence may consist in catching up or slowing down, while divergence – in marginalising or distancing. The results of the grouping for the share of population of working age in the examined territorial sections are presented in Map 4. The produced classification indicates that during the first two decades of this century, in nearly all of Poland's provinces there occurred beta-convergence of the share of population of working age. That was true of entire provinces as well as their urban and rural areas.

Convergence was found in 14 provinces – in six it was a catch-up process, while in eight it was a slow-down (Map 4, upper panel). Catch-up convergence occurred in the following provinces: *Lubelskie*, *Małopolskie*, *Podkarpackie*, *Podlaskie*, *Świętokrzyskie* and *Warmińsko-Mazurskie*. In 2002, the provinces had a share of population of working age lower than the average for all of the provinces, but because the speed of the changes in them was higher than the average, their situation improved when compared to the mean. It is worth noting that catch-up convergence occurred in the provinces in the east of the country. A slow-down convergence was found in the provinces in the western part of the country: *Dolnośląskie*, *Kujawsko-Pomorskie*, *Lubuskie*, *Łódzkie*, *Pomorskie*, *Śląskie*, *Wielkopolskie* and *Zachodniopomorskie*. In those provinces which had above-average values of the indicator in the initial period, the speed of changes was lower than the average dynamism of the share of population of working age.



Legend: 1 – Dolnośląskie; 2 – Kujawsko-Pomorskie; 3 – Lubelskie; 4 – Lubuskie; 5 – Łódzkie; 6 – Małopolskie; 7 – Mazowieckie; 8 – Opolskie; 9 – Podkarpackie; 10 – Podlaskie; 11 – Pomorskie; 12 – Śląskie; 13 – Świętokrzyskie; 14 – Warmińsko-Mazurskie; 15 – Wielkopolskie; 16 – Zachodniopomorskie.

Map 4. Classification of the provinces in terms of the value and speed of changes in the share of population of working age in 2002-2018

Source: own compilation.

Divergence processes were identified in two provinces. *Mazowieckie* province had a high share of population of working age at the beginning of the studied period and an above-average dynamism of growth of the indicator, and so it was gradually distancing itself from the other regions of the country. *Opolskie* province was experiencing a marginalising divergence, because the gap between it and the other provinces was increasing. In 2002, the share of population of working age in the province was lower than the average for all of the provinces, while the speed of the changes was lower than the average.

In the urban areas, slow-down convergence was occurring in nine provinces, while catch-up convergence – in five (Map 4, left panel). As regards rural areas, convergence was identified in 14 territorial division units: in eight of them it had a slow-down nature, and in six – a catch-up one (Map 4, right panel) Distancing divergence was discovered in the urban areas of *Opolskie* province and in the rural areas of *Warmińsko-Mazurskie* province, while marginalising divergence – in the urban areas of *Pomorskie* province and in the rural areas of *Łódzkie* province. As regards the other indicators, i.e. the youth dependency ratio and the old--age dependency ratio, the identified characters of convergence and divergence corresponded to those of the share of population of working age in each of the examined territorial sections. No graphical presentation of the identified characters of the changes in the indicators has been included here.

5. Conclusion

The obtained results of the study of convergence of labour resources in Poland's provinces provided the answer to question (1) posed in Section 1 above – the provinces were becoming similar to one another by equalising the values of the examined variables characterising labour resources and their dependency ratios. This is indicated by a confirmed absolute beta-convergence of the variables, not only for the entire provinces, but also – nearly always – for the urban/rural division (Table 6). Furthermore, taking account of the urban/rural division, one may observe that the speed of convergence was higher in urban areas than in rural areas, or the leapfrogging effect was observed in the former.

The answer to question (2) asked in Section 1 is not unambiguous. During the first two decades of this century the structures of labour resources and their dependency ratios in Poland's provinces were becoming increasingly less diverse, and so were the provinces. Only the shares of population of working age in urban areas were found to have been growing different. Furthermore, as regards the dependency ratios in various sections, neither convergence, i.e. becoming alike, nor divergence of the provinces have been determined (Table 6). This multidirectionality of the results does not allow for the formulation of any definitive conclusions about convergence or divergence of the provinces in terms of variables characterising labour resources dependency. Usually, the conducted tests did not confirm sigma-convergence or sigma-divergence. This ambiguity of conclusions could be linked to the fact that the applied tools for measuring sigma-convergence enable assessment of diversity in an established time interval or exclusively in its extreme periods. The study often found that over time the diversity of the values of a variable diminished (increased) in a statistically significant manner, but the change in the diversity between the initial and final periods covered by the study proved insignificant.

The answer to question (3) asked in Section 1 is also not unambiguous. A change in the rankings of the provinces, i.e. ranking instability, was confirmed with reference

to two variables: the labour resources structure and the youth dependency ratio. The conclusion refers to the provinces as a whole and urban areas. A change in the province rankings was confirmed the most infrequently, although tentatively tests indicated such a change (Table 6).

Table 6. Confirmed types of convergence of the studied variables in the provinces in 2002-2018

Specification		Type of convergence				
		Absolute beta	Sigma		Gamma	
		test 1	test 1	test 2	test 1	test 3
Share of population of working age	t	yes	yes	yes	yes	yes
	u	yes	(yes)	(yes)	yes	yes
	r	yes	yes	yes	yes	–
Youth dependency ratio	t	yes	yes	–	yes	yes
	u	yes	yes	yes	yes	yes
	r	–	(yes)	–	yes	–
Old-age dependency ratio	t	yes	yes	yes	yes	–
	u	yes	yes	–	yes	–
	r	yes	yes	yes	yes	–

Legend: t – total; u – urban; r – rural; test 1 – test of significance of parameter *b*; test 2 – test of variance; test 3 – test of Spearman's rank correlation coefficient; yes – confirmed convergence; (yes) – confirmed divergence; – lack of confirmation.

Source: own compilation.

The review of the literature showed that it is not possible to compare the study findings with any other findings in terms of the examined variables. However, the conclusions regarding convergence of labour resources are consistent with the results confirming beta-convergence and not confirming sigma-convergence of the unemployment rate in Poland's provinces, although for the shorter period of 2002--2009 (Misiak, Tokarski, and Włodarczyk, 2011). The produced classification of the provinces in terms of the rate and the speed of changes in the characteristics of labour resources also confirms the division of regions in terms of labour market development and economic development (Gawrycka and Szymczak, 2011). The distance between the labour market in *Mazowieckie* province and the other labour markets in Poland is pronounced. The changing structure and quantity of labour resources lead to gradually growing shortages on the labour market, as a result of which it is becoming impossible to find appropriately skilled employees (Strzelecki, 2012). Quantitative shortages (a general lack of a sufficiently numerous group of people willing and capable of being employed) and qualitative inadequacy (in terms of knowledge and skills sought) are particularly noticeable on local labour markets. The trends may

grow stronger by an outflow of younger labour resources from less attractive local labour markets, increasing the depopulation of rural areas and towns. Thus, studies of convergence (or divergence) of labour resources should focus on determining the intensity of such processes in the counties.

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KONWERGENCJA CZY DYWERGENCJA ZASOBÓW PRACY W POLSCE?

Streszczenie: Prognozy Eurostatu wskazują, że do 2050 r. Polska doświadczy znacznego ubytku zasobów pracy oraz ich starzenia się. W kraju widoczna jest silna polaryzacja zjawisk demograficznych i dysproporcje w strukturze ludności. Celem badania było ustalenie, czy występuje wewnętrzna konwergencja czy dywergencja zasobów pracy w Polsce. Weryfikowano występowanie konwergencji beta, sigma i gamma w województwach w latach 2012-2018. Zbudowano modele dla 3 zmiennych (udział osób w wieku produkcyjnym, obciążenie ludnością w wieku przedprodukcyjnym i obciążenie ludnością w wieku poprodukcyjnym). Wyniki wskazują, że wystąpiła beta-konwergencja absolutna zmiennych charakteryzujących zasoby pracy. Jednoznacznie nie potwierdzono sigma-konwergencji, tj. istotnego zmniejszania się zróżnicowania województw pod względem badanych zmiennych. Również nie potwierdzono w sposób jednoznaczny występowania konwergencji typu gamma, czyli istotnej zmiany pozycji województw pod względem zasobów pracy.

Słowa kluczowe: konwergencja społeczna, konwergencja regionalna, zasoby pracy.