

# **Taxonomic analysis of the demographic situation in Poland in the context of regional economic development in sub-regional system in the years 2004-2012**

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## **Abstract**

Population, both in terms of quantity and quality, is one of the factors that play a significant role with regard to the economic prosperity of a country. The demographic situation in many European countries, especially the changes in its size and the age structure are not optimistic. Economically developed countries are faced with a growing problem of aging populations, also in Poland this issue is becoming increasingly important. The main goal of this article is to analyze the demographic situation in Poland in the context of the country's economic development. The article sets a taxonomic measure of development depicting the demographic situation as well as a measure of economic development for 66 sub-regions (NUTS-3) on the basis of selected diagnostic variables in the period 2004-2012. This allowed to assess the demographic situation in Poland in relation to the level of economic development of individual regions. The analysis attempts to verify the hypothesis that demographic phenomena have a positive impact on the economic development and are a significant factor in supporting Polish regional development.

*Keywords:* population, demography, taxonomic measure of development, population aging

*JEL Classification:* C43, R23

## **1. Introduction**

The aim of the article is to analyze the demographic diversity of sub-regions in Poland classified within the NUTS-3 system in relation to the level of economic development. This paper attempts to verify the hypothesis that in individual Polish sub-regions there is a positive correlation between the demographic situation and the level of economic development. The assessment of the demographic situation, as well as the level of economic development was based on the use of a taxonomic measure of development. In order to construct indicators used in the diagnosis of the analyzed demographics and economic phenomena relevant variables were applied, which are an expression of quantitative indicators describing the quantity and population structure as well as the level of economic development in Poland in the period considered. On the one hand, this allowed, to put the sub-regions in order in terms of the achieved level of the synthetic measure reflecting their demographic situation, and on the other hand, to make a corresponding arrangement with regard to their level of economic

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development. Furthermore, we have made an attempt to isolate groups of sub-regions that are similar with regard to the two designated measures.

The analysis of the distribution within the sub-region groups that are similar in the studied areas and determination of the correlation between them, were used in the verification of the hypothesis of existence of a positive relationship between the demographic potential and economic development and precisely that demographic potential is a factor that positively affects the regional development of Polish sub-regions.

## **2. The demographic situation and the level of regional development in Polish sub-regions**

One of the basic elements of regional policy is to stimulate economic development, and the production factors that affect it or whose low values could restrict it. In the era of alarming signals regarding the aging of the Polish society one should pay attention to the impact of the demographic situation on economic development, including in particular the development of individual regions. It is emphasized that the current population changes, especially the aging of European population is the major problem not only in the area of demographics (Szukalski, 2007). The consequences of population aging brings a wide range of changes in the society functioning and directly affects the condition of the economy (Kubanova, 2014). Furthermore there are other demographic challenges. Low fertility rate in Poland as in all the European countries only in short run will increase income per capita but in long term it will decrease income per capita (Bloom et al., 2010).

The synthetic measure calculated in relation to the selected variables defining the demographic situation the individual sub-regions will in this paper be referred to as the demographic potential. Such nomenclature is used in the literature in different contexts, whereas here it is adopted in accordance with the established hypothesis that demographic potential is the ability of human resources to ensure further development and the possibility to have an effect on numerous social and economic areas through its size and structure (Mazowiecki Ośrodek Badań Regionalnych, 2013). The proper definition of demographic potential from the point of view of this consideration is provided by Kurpowicz (2008), according to who it is a: “general capabilities, capacity and power inherent in the population (its conditions, structure and intensity of population processes) of a given region”. The higher the value of the demographic potential in a given sub-region the higher expected level of its economic development. According to Rosner (2012) research, there is a direct correlation between the demographic processes and the level of socio-economic development. In

addition, attention is drawn to the trend towards the deepening of differentiation in this regard and the tendency towards depopulation of low population density regions (Pomanek, 2014).

### **3. Material and method of analysis**

The analysis was conducted based on data from the Local Data Bank of the Central Statistical Office ([http://www.stat.gov.pl/bdr\\_n/app/strona.indeks](http://www.stat.gov.pl/bdr_n/app/strona.indeks)). Among the potential diagnostic variables the authors selected a set of such variables that most clearly reflect the analyzed phenomenon. The said variables were selected in such a way as to be, on the one hand, the most representative of the phenomenon being analyzed, while on the other, to ensure that the information contained therein does not duplicate. The selection was carried out both in terms of content and formality, also taking into account the availability of data on the Polish division into the 66 sub-regions and comparability of demographic data and economic indicators in time and the study space.

All of the variables selected for the study were characterized by high volatility, for which the coefficient of variation was above 0.1. The demographic variables included the following variables:  $X_1$  – birth rate per 1,000 population,  $X_2$  – the balance of internal migration for permanent residence per 1,000 inhabitants,  $X_3$  – the balance of international migration for permanent residence in general,  $X_4$  – total fertility rate,  $X_5$  – population density,  $X_6$  – the demographic burden rate (calculated as the ratio of the number of people at the retirement age per 100 people of working age) and  $X_7$  – the number of working age population.

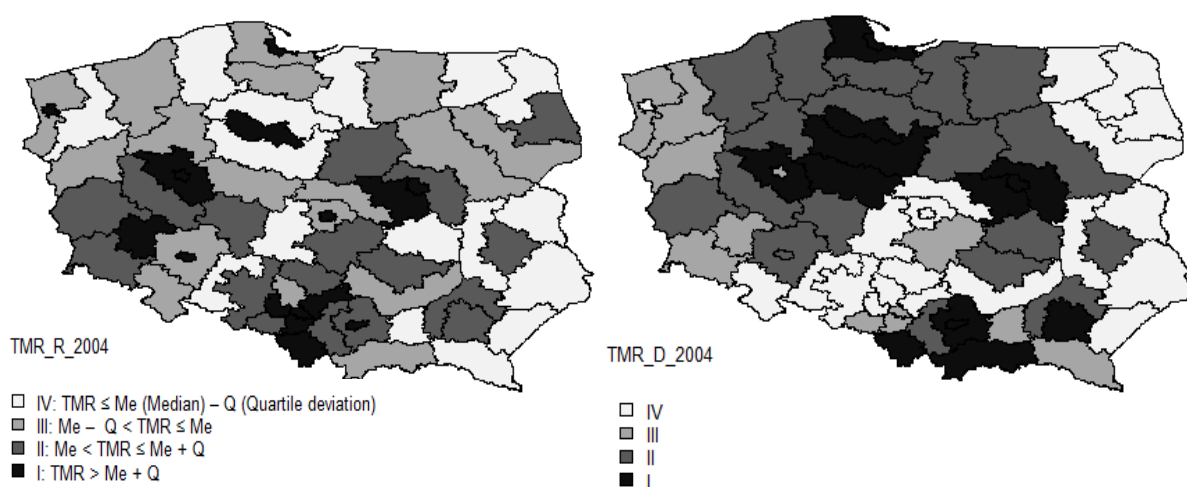
The variables describing the economic development include the following indicators:  $X_1$  – gross domestic product per capita,  $X_2$  – investment in enterprises per 1 inhabitant,  $X_3$  – entities of the national economy in general,  $X_4$  – the unemployment rate in %,  $X_5$  – the share of registered unemployed among the number of the working age population and  $X_6$  – the average monthly gross salary. The unemployment rate and the demographic burden rate was considered as destimulants, while other variables were treated as stimulants.

The analysis of the spatial differentiation in the taxonomic measure of development for both characteristics and comparisons in this area led to preliminary assessment of the similarity between the demographic situation and economic development in the Polish sub-regional system.

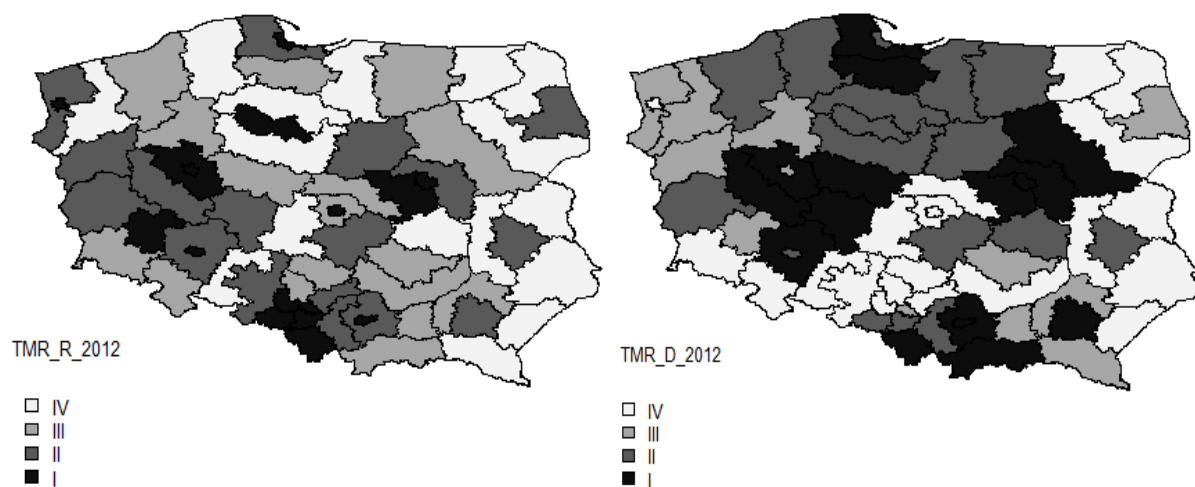
#### 4. The results of the study – the classification of Polish sub-regions with regard to the taxonomic measure development

The analysis of the spatial differentiation in the taxonomic measure of economic development (TMR\_R), and demographic potential (TMR\_D) allowed in the first place to assess individual sub-regions with regard to each synthetic variable separately, and then compare them with each other in different years of analysis.

Within a structured set of taxonomic measures of development of the objects considered a classification was performed in order to identify similar sub-regions using the positional measures criterion.



**Fig. 1.** TMR distribution in 2004 for economic development (left) and demographic potential (right).



**Fig. 2.** TMR distribution in 2012 for economic development (left) and demographic potential (right).

By comparing the formation of the designated measures by sub-regions it should be noted that the sub-regions that are specific centers of economic development in Poland coincide with the sub-regions characterized by the highest level of demographic potential in each year – which is also visible in the first and the last audited years (see Fig. 1 and 2). At the same time a high level of demographic potential is observed in the sub-regions lying near those characterized by the highest economic development.

Taking into consideration both the values of particular variables characterizing the demographic situation of sub-regions and the results for the calculated and parsed taxonomic measure of development of the demographic potential, the 66 Polish sub-regions can be divided into 4 groups, according to the above division into statistical positional measures. The first group, both in the first and last analyzed year included the following sub-regions: the Warsaw city, Eastern Warsaw, Poznań and Gdańsk. Despite the changes in the order of sub-group IV its composition remained the same. More significant changes, however, have occurred in the sequence amidst the second and third group.

Name	D_ '04	Rank	Name	D_ '12	Rank
M. Warszawa	0.362	1	M. Warszawa	0.420	1
Warszawski wschodni	0.322	2	Warszawski wschodni	0.403	2
Poznański	0.311	3	Poznański	0.372	3
Gdański	0.308	4	Gdański	0.364	4
Nowosądecki	0.304	5	Warszawski zachodni	0.354	5
...	...	...	...	...	...
Sandomiersko-jędrzejowski	0.041	62	Bytomski	0.061	62
Gliwicki	0.032	63	Nyski	0.058	63
Bytomski	0.020	64	Łomżyński	0.054	64
Łomżyński	0.017	65	M. Łódź	0.019	65
Opolski	0.002	66	Opolski	0.005	66

**Table 1.** Values of the taxonomic measure of development of demographic potential in the years 2004 and 2012 for selected sub-regions.

Table 1 provides for comparison the calculated values of the taxonomic measure of development regarding the demographic potential in the first and last year of the analysis, limited (due to the requirement of a limited volume of this study) to the calculated values of

only the first and last five sub-regions in the classification. There were no significant changes in the TMR in relation to the arrangement of subsequent sub-regions in the entire analyzed period. The values of the defined synthetic variable in the period 2004-2012 indicate that the differences in the potential between the different demographic sub-regions remain substantially unchanged.

The calculated values of the TMR of economic development indicate a high level of dispersion in the regional development of Polish sub-regions. The analysis in the period 2004-2012 showed no significant changes in this respect. The sub-regions which since 2004 were characterized by a very high or low economic growth in the majority remained in the group without major changes noted also in 2012. Table 2 contains the TMR values of economic development in the first and last year of the analysis, limited (as in Table 1) to the values calculated only for the first and last five sub-regions in the standings.

Name	R_ '04	Rank	Name	R_ '12	Rank
M. Warszawa	0.991	1	M. Warszawa	0.981	1
M. Poznań	0.548	2	M. Poznań	0.521	2
M. Kraków	0.470	3	Trójmiejski	0.490	3
Trójmiejski	0.466	4	M. Wrocław	0.471	4
M. Wrocław	0.444	5	M. Kraków	0.469	5
...	...	...	...	...	...
Bialski	0.147	62	Włocławski	0.141	62
Nyski	0.143	63	Bialski	0.137	63
Elbląski	0.141	64	Radomski	0.127	64
Stargardzki	0.127	65	Przemyski	0.122	65
Ełcki	0.086	66	Ełcki	0.109	66

**Table 2.** Values of the taxonomic measure of economic development in the years 2004 and 2012 for selected regions.

We can say that since Poland's accession to the European Union there are still considerable differences in the development of particular Polish sub-regions. Leaders remained in their positions, while the sub-regions starting from a lower development level still remain at the end of the ranking. The first group characterized by a very high level of economic development in the years 2004-2012 with regard to the calculated taxonomic measure of development invariably included the city of Warsaw and Poznań. The subsequent regions in

the first group, with minor changes in the arrangement, included: the Tricity region, the city of Wrocław and the city of Cracow. The last place in Group IV with the lowest level of economic development included the Ełk sub-region, and, slightly above, the Elbląg, Stargard, Bielsko-Biała and Przemyśl regions.

In order to determine the degree of compliance in the distribution of sub-regions in the period 2004-2012 for the designated synthetic indicators of economic and demographic potential the concordance coefficient by Kendall and Babington-Smith (Kendall, Smith, 1939) was applied with the use of the following equation:

$$W = \frac{12S}{T^2(n^3 - n)} \quad (1)$$

where  $W$  – coefficient of concordance,  $S$  – the sum of the squares of the differences between the sum of ranks after periods and their mean value,  $n$  – the number of objects and  $T$  – the number of periods.

The calculation of the concordance coefficient for the taxonomic measure of development and demographic potential provided the respective results of 0.977 and 0.973. The value of this coefficient close to 1 may prove a very high degree of compliance in the ordering of Polish sub-regions in the analyzed period. In order to assess the significance of this factor the chi-squared statistics was used as (Legandre, 2005):

$$\chi^2 = \frac{12S}{Tn(n+1)}. \quad (2)$$

The critical value for the  $T-1$  degrees of freedom and a level of significance of  $\alpha = 0.05$  was 23.68. The calculated values of the chi-square statistics were higher than the critical value (amounted to 571.82 and 569.55 respectively), indicating the statistical significance of both concordance coefficients, which means a compatibility in the ordering of the sub-regions in terms of the demographic potential and economic growth in the analyzed period.

In order to examine the similarity of orderings of sub-regions on the basis of each synthetic variable in the extreme years of the analysis, the author additionally applied the Kendall's tau coefficient, in the following formula (Szmidt and Kacprzyk, 2011; David et al., 1951):

$$\tau = \frac{C - D}{\frac{1}{2}n(n-1)} \quad (3)$$

where  $C$  – the number of concordant pairs,  $D$  – the number of discordant pairs and  $n$  – number of observations.

Based on the calculated coefficients of concordance of the orderings gamma convergence evaluation of demographic potential was performed, as well as the same type of economic convergence of sub-regions, i.e. it was examined whether the sub-regions with a lower ranking in terms of the studied traits managed to overtake the sub-regions that were “better” in the initial period of the study.

In the present study, the correlation coefficients had positive values. At the same time, a statistical significance of these factors was found. Polish sub-regions did not significantly change their position in the rankings in terms of the demographic potential and economic development. Thus, the phenomenon of gamma convergence in the analyzed phenomena in the sub-regions in the period in question was not confirmed.

### **5. The results of the correlation study between the demographic potential and economic development**

For the analyzed period 2004-2012 the correlation between the designated synthetic measures of the demographic potential and economic development was examined with the use of the Kendall rank correlation coefficient expressed by formula (3). Kendall values presented in Table 3 oscillate between 0.16 and 0.24, which indicates a low positive correlation between the analyzed statistical variables. The analysis of the results for individual years, however, allows observing that the demographic potential increase may be a factor that will in the future have a positive effect on the economic development of Polish sub-regions.

The highest value of the correlation coefficient was achieved between the taxonomic measure of demographic potential in  $t$  year, and the taxonomic measure of economic growth in the  $t + 2$  period and onwards. The correlation between the analyzed synthetic variables for the same years, 2004-2005, and 2011-2012 amounted to less than 0.2, which confirms that the demographic phenomena reveal their delayed impact on the economic development. Based on the obtained results it can be concluded that the favourable demographic situation may have a positive impact on the economic development in future years. The results also indicate the need to remain vigilant with regard to the demographic situation of the country and its individual regions in the light of further quantitative data and forecasts, for the purpose of further analysis verifying significant relationships of the studied phenomena. It could contribute to drawing greater attention of the policy makers sensitive to the need of greater economic development of individual Polish regions, to the necessity to intensify efforts to improve the demographic situation, including minimization of effects resulting from the aging



of population, influencing the achievement of higher levels of fertility rate, or minimization of foreign migrations.

TMR	D_'04	D_'05	D_'06	D_'07	D_'08	D_'09	D_'10	D_'11	D_'12
R_'04	0.182	0.202	0.187	0.173	0.162	0.183	0.161	0.163	0.164
R_'05	0.180	0.194	0.187	0.173	0.166	0.183	0.166	0.165	0.164
R_'06	0.203	0.215	0.209	0.195	0.188	0.207	0.185	0.187	0.182
R_'07	0.210	0.222	0.219	0.207	0.201	0.219	0.196	0.193	0.190
R_'08	0.216	0.230	0.224	0.212	0.205	0.228	0.202	0.202	0.197
R_'09	0.225	0.241	0.234	0.223	0.216	0.237	0.213	0.213	0.208
R_'10	0.223	0.239	0.228	0.218	0.210	0.230	0.204	0.207	0.207
R_'11	0.208	0.226	0.215	0.207	0.201	0.219	0.194	0.198	0.192
R_'12	0.219	0.236	0.229	0.219	0.211	0.227	0.203	0.203	0.198

**Table 3.**  $\tau$  Kendall's rank correlation for the years 2004-2012 ('04-'12) between the TMR of demographic potential (D\_) and the TMR of economic development (R\_).

## Conclusion

The article considerations were related to the examination of the relationship between the demographic situation and economic development of Polish sub-regions. The scope of the study involved formulation of sub-regional taxonomic measures of development for the years 2004-2012. The analysis of changes in the diversity of synthetic indicators in the analyzed period led to the conclusion there were no significant changes in both the economic development and demographic potential not only with regard to the position of various sub-regions in the designated rankings, but also in the obtained values. The calculated correlation coefficients between the designated synthetic measures indicate the existence of a weak positive correlation between the demographic potential and economic development of regions. On this basis, it can be concluded that the initially formulated hypothesis on a certain impact of the demographic situation (demographic potential) of Polish sub-regions on economic development is valid. Due to the specificity of the analyzed demographic phenomena the said impact is delayed. On the other hand, the results of the verification of the hypothesis concerning the gamma convergence allow us to conclude that Polish sub-regions do not become similar to each other in terms of the considered phenomena.

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