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Spatio-temporal Analysis of Unemployment Rate in Poland

Abstract

The aim of this paper is to present results of spatio-temporal analysis of unemployment rate in Poland, with the usage of advanced spatial econometric methods. The analysis was done on data collected for 'powiat' level between 2006 and 2010. GIS and ESDA tools were applied for visualization of the spatio-temporal data and identification of spatial interactions between polish counties on labor market. Multi-equation spatial econometric models were used to describe unemployment rate in relation to selected social-economic variables.

1. Introduction

For a long time now unemployment has aroused interest among economists, sociologists and psychologists as, due to its consequences, it constitutes a serious socioeconomic problem. It produces adverse effects being of importance to both the unemployed and the entire economy. A rise in unemployment means not only a drop in the population's standard of living (loss of means of livelihood, growing social discontent, increased social pathologies and crime) but also the workforce not being fully utilized, and thus actual production being lower than the potential one (Milewski 2000, p. 532).

Poland's high unemployment rate has generated widespread interest in that issue. Specialist literature offers numerous studies whose authors try to find reasons for high values of that variable in Poland. Those studies, however, do

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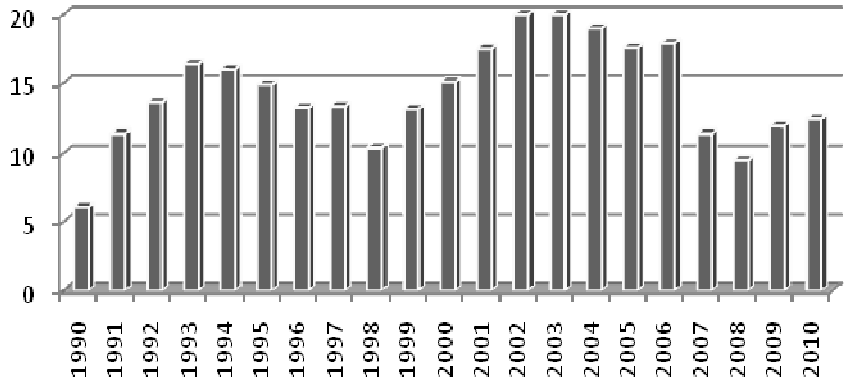
not include spatio-temporal analyses applying multi-eguation spatial econometric models.

The objective of the study is to analyse the unemployment rate in Poland from a spatio-temporal perspective, with the usage of advanced spatial econometric methods. The research uses GIS and ESDA tools for visualization of variables and identification of spatial interactions occurring among studied territorial units in the country's labour market. Seemingly Unrelated Regression models with spatial effects are employed to describe the impact of selected macroeconomic variables on the level of unemployment rate in Poland in specific poviats from 2006 to 2010.

2. Unemployment in Poland

There were considerable fluctuations in the unemployment rate in Poland after 1990. Figure 1 shows clearly two cycles in that variable with the first occurring in the 1990-1998 and the other – in the 1999-2008 period. The inflection point of the first cycle was observed in 1993 when unemployment hit 16.4%. As for the other, its inflection point was in 2002 and 2003 when unemployment reached a record high of 20%.

Figure 1. Unemployment rate in Poland in the 1990-2010 period



Source: own work based on statistical data of the Central Statistical Office.

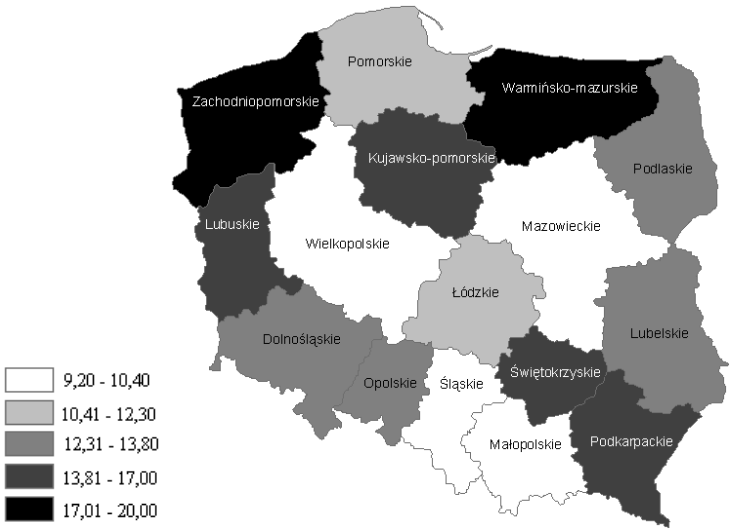
The first stabilization in the labour market appeared in 1994. The situation improved thanks to a high economic development rate and the slowing down of restructuring processes in some sectors of the economy. After 1998

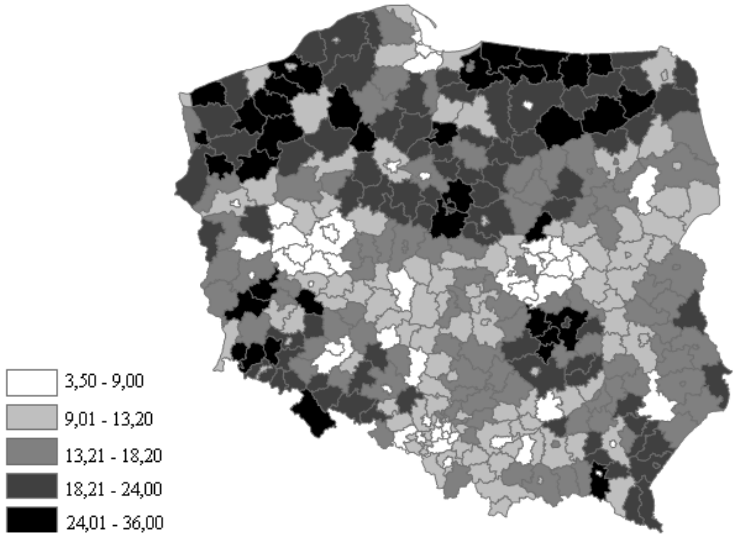
unemployment started to rise again due to expired undertakings contained in privatization agreements of the mid-1990s. They obligated companies to maintain employment at specified levels. When they were no longer valid, companies began mass lay-offs. In consequence, the unemployment rate soared to as much as 20% in 2002 and 2003.

The second stabilization period lasted from 2004 to 2008. Mass emigration for economic reasons and rapid economic growth had a considerable impact on the fall in the unemployment rate. In 2008 the unemployment rate reached 9.5%, thus being the lowest since 1990. In 2009 the situation in the labour market everely deteriorated; the economic crisis caused a rise in the unemployment rate to almost 12% to subsequently hit 12.4% in 2010.

The unemployment rate in Poland is considerably spatially diversified. Figure 2 shows that in 2010 the highest level of the studied variable was noted for the Warmian-Masurian voivodship (20%), while it was the lowest for the Greater Poland (9.2%) and Masovian (9.7%) voivodships.

Figure 2. Unemployment rate in Poland in specific voivodships and poviats in 2010



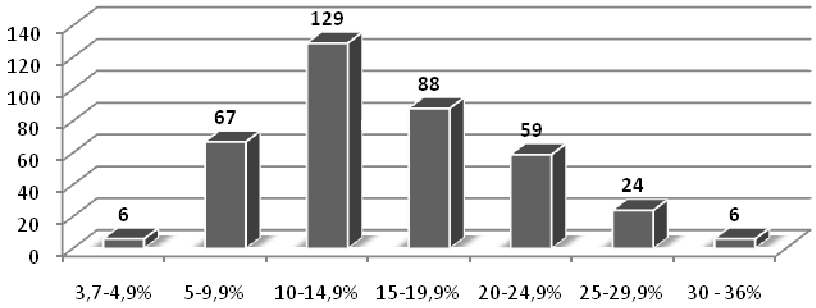


Source: own work based on statistical data of the Central Statistical Office.

The highest unemployment rate was observed for the following poviats: Szydłowiecki 36% (Masovian voivodship), Piski 31.5% (Warmian-Masurian voivodship) and Braniewski 30.9% (Warmian-Masurian voivodship). The lowest level of the variable occurred in the following poviats: Poznański 3.5% (Greater Poland voivodship), Warszawski 3.5% (Masovian voivodship) and cities with poviat rights – Poznań 3.6% (Greater Poland voivodship), Katowice 3.6% (Silesian voivodship) and Sopot 3.9% (Pomeranian voivodship). It should also be noted that the difference in unemployment rates between poviats with the lowest and highest levels of the variable accounted for as much as 32.5 percentage points.

Figure 3 presents results of the clustering of poviats according to their unemployment rates. In 2010 the lowest unemployment rate (below 5%) was noted for six poviats with a majority of those being cities with poviat rights, i.e. Poznań, Katowice, Sopot and Cracow. The largest cluster is formed by poviats with values of the variable ranging between 10% and 14.9%. It consists of one hundred and twenty-nine objects. Unemployment rates exceeding 20% were observed in as many as eighty-nine poviats, of which six showed levels of the variable above 30%.

Figure 3. Poviats clustered according to unemployment rates in 2010



Source: own work based on statistical data of the Central Statistical Office.

3. Determinants of unemployment

Unemployment is a multidimensional phenomenon determined by complex factors and mechanisms. There are numerous theories offered by specialist literature that specify variables causing an increase or decrease in the unemployment rate. The most frequently mentioned factors include, among others:

1. **Average Wages** – according to the concept by A. W. Phillips, higher unemployment rates are accompanied by a slower rise in nominal wages, while a fall in unemployment coincides with an increase in nominal wages.
2. **Gross Domestic Product** – A. Okun's law says that every drop by 2% in the real GDP as compared with the potential GDP results in a rise in the unemployment rate by 1 percentage point. The unemployment rate is very strongly connected with the GDP. When employment increases, the GDP rises, and thus economic growth occurs with a simultaneous fall in the unemployment rate.
3. **Investments** – the number of created jobs is largely dependent on the volume and type of investments. New development-oriented investments contribute to increased demand for labour. On the other hand, current investments aimed at property replacement allow to maintain existing jobs. It should be emphasized that not all investments contribute to creating or maintaining jobs as they increase the productivity of workforce (Bremond, Couet, Salort 2005, p. 134). However, greater workforce productivity enables enterprises to operate more effectively, hence, making them more competitive, which improves employment situation in the long run.

4. **Socioeconomic Position of Adjacent Areas, Migrations** – the economic situation of the area of origin is among important factors affecting the level of migration. The most frequently mentioned motives behind migration include high unemployment rates, low wages and high costs of living in the place of residence. Migration is encouraged by better socioeconomic conditions of adjacent areas – higher standard of living, employment opportunities (a greater number of offered jobs), higher wages, better working conditions. According to the world-systems theory[1] migrations result from an economic imbalance between the core, i.e. developed areas (countries, voivodships) and peripheries, i.e. developing ones that constitute workforce reserves for the core ones (Kuciński 2009, pp. 102-105). Since Poland's accession to the European Union over one million people have left the country, which resulted in the steadily declining unemployment rate from 2004 to 2008 (Figure 1). It ought to be emphasized, however, that the unemployment rate depends not only on external migrations but also, in large measure, on internal, temporal ones connected e.g. with commuting to another town every day.

The level of unemployment is also dependent on conditions in a specific labour market, for example, the number of people at the working age, economic activity of the population, number of registered economic entities and number of offered jobs.

4. Statistical database

The unemployment rate in Poland was analysed from a spatio-temporal perspective based on statistical database built on the basis of information available at the Local Data Bank of the Central Statistical Office published on the official website of the office. Statistical data were collected for 379 poviats of Poland in the 2006-2010 period. Major determinants of creating the database were both reasons pertaining to the subject matter (see Section 3) and availability of data at the time of carrying out the study.

Regrettably, not all variables needed for the analysis of the unemployment rate are available for specific poviats. Such variables include inflation and the GDP. Due to the fact that the GDP variable that describes economic

[1] It is a concept of social development in which the erstwhile analysed units, i.e. the state, economy, society, have been replaced by historical systems. The world is considered a spatio-temporal whole (Kuciński 2009, p. 105).

development is crucial for the study, it was replaced with one of local development measures, i.e. budgetary revenues of poviats per capita.

5. Preliminary Analysis of Statistical Data

Spatial data are characterised by a more complex structure than time series. When examining spatial objects (countries, regions, voivodships, povits), it should be kept in mind that they are not isolated in space and may be affected by other units. That may result in the spatial clustering of similar values of localized variables or their dispersion.

The first stage of the study used Exploratory Spatial Data Analysis tools in order to identify interactions occurring among unemployment rates in poviats. A spatial weight matrix **W** (row standardized) was generated based on a first degree contiguity matrix, in the queen configuration. Next, values of global Moran's *I* measure were calculated, being $I_{2006} = 0.5342$, $I_{2007} = 0.5198$, $I_{2008} = 0.5124$, $I_{2009} = 0.5022$ and $I_{2010} = 0.4514$ respectively. The received results allowed to conclude that there are certain spatial relationships concerning unemployment rates in Poland.

Apart from the need to examine global spatial autocorrelation, literature indicates that, in order to obtain a detailed picture of a studied phenomenon, it is necessary to perform the analysis of local spatial autocorrelation (LISA). The high value of global Moran's *I* is confirmed by the LISA analysis, that indicates positive spatial autocorrelation in all the periods (as high – low - values of unemployment rate adjacent to high - low - values of the variable in polish poviats). High unemployment rates are characteristic of poviats situated in the North of the country in the Warmian-Masurian and West Pomeranian voivodships. Low unemployment rates occur for central and Southern poviats located in the Masovian, Greater Poland and Silesian voivodships.

The carried out analysis led to conclusions being of the utmost importance from the point of view of econometric modelling. It was proved that there are certain spatial relationships concerning unemployment rates in Poland. It may be inferred that a rise (fall) in unemployment rate in poviats defined in the weight matrix as adjacent results in a rise (fall) in the level of the studied variable in poviat *i* in all the studied periods. Therefore, an econometric model ought to contain a variable that takes into account those relationships.

6. Modelling of Unemployment Rate

Three multi-equation models were applied to describe the impact of the selected socioeconomic variables on the level of the unemployment rate in Poland in specific poviats from 2006 to 2010 (Suchecki 2012, pp. 157-158).

1. Seemingly unrelated regression model (no spatial interactions).
2. Seemingly unrelated regression model with spatially lagged dependent variables.
3. Seemingly unrelated regression model with spatially lagged dependent variables and additionally introduced selected spatially lagged independent variables.

The multi-equation spatial econometric models used in the study were characterised by better goodness-of-fit and lower errors than the model not taking into account spatial interactions. They also allowed to eliminate the impact of spatial autocorrelation from the analysis. Therefore, it may be stated that spatial econometrics models are a better tool to analyse spatio-temporal data than models that do not consider spatial relationships among the studied geographical units, i.e. poviats. It was also observed that the Log-likelihood test value is the highest for the spatial model that additionally took into account spatial lags of selected independent variables (Table 1). The model exhibits lower root mean squared error (RMSE) values and higher significance of parameters; hence it explains the studied phenomenon in the most detailed manner. The received estimations are also consistent with the economic theory.

Table 1. Results of goodness-of-fit test

Model	Log-Likelihood
SUR (no spatial interactions)	-1070,74
SUR with spatially lagged dependent variables	- 653,29
SUR with spatially lagged dependent and selected independent variables	- 577,48

Source: own calculation.

The multi-equation unemployment model with spatially lagged dependent and selected independent variables takes the following form:

$$
\begin{aligned}
U_{06} &= \alpha_{01} + \rho_1 \mathbf{W}\_U_{06} + \lambda_{11} \mathbf{W}\_W_{06} + \lambda_{21} \mathbf{W}\_RE_{06} + \beta_{11} W_{06} + \beta_{21} BR_{06} + \\
&+ \beta_{31} I_{06} + \beta_{41} SA_{06} + \beta_{51} RE_{06} + \beta_{61} OJ_{06} + \beta_{71} IM_{06} + \beta_{81} FM_{06} + \varepsilon_{11} \\
U_{07} &= \alpha_{02} + \rho_2 \mathbf{W}\_U_{07} + \lambda_{12} \mathbf{W}\_W_{07} + \lambda_{22} \mathbf{W}\_RE_{07} + \beta_{12} W_{07} + \beta_{22} BR_{07} + \\
&+ \beta_{32} I_{07} + \beta_{42} SA_{07} + \beta_{52} RE_{07} + \beta_{62} OJ_{07} + \beta_{72} IM_{07} + \beta_{82} FM_{07} + \varepsilon_{22} \\
U_{08} &= \alpha_{03} + \rho_3 \mathbf{W}\_U_{08} + \lambda_{13} \mathbf{W}\_W_{08} + \lambda_{23} \mathbf{W}\_RE_{08} + \beta_{13} W_{08} + \beta_{23} BR_{08} + \\
&+ \beta_{33} I_{08} + \beta_{43} SA_{08} + \beta_{53} RE_{08} + \beta_{63} OJ_{08} + \beta_{73} IM_{08} + \beta_{83} FM_{08} + \varepsilon_{33} \\
U_{09} &= \alpha_{04} + \rho_4 \mathbf{W}\_U_{09} + \lambda_{14} \mathbf{W}\_W_{09} + \lambda_{24} \mathbf{W}\_RE_{09} + \beta_{14} W_{09} + \beta_{24} BR_{09} + \\
&+ \beta_{34} I_{09} + \beta_{44} SA_{09} + \beta_{54} RE_{09} + \beta_{64} OJ_{09} + \beta_{74} IM_{09} + \beta_{84} FM_{09} + \varepsilon_{44} \\
U_{10} &= \alpha_{05} + \rho_5 \mathbf{W}\_U_{10} + \lambda_{15} \mathbf{W}\_W_{10} + \lambda_{25} \mathbf{W}\_RE_{10} + \beta_{15} W_{10} + \beta_{25} BR_{10} + \\
&+ \beta_{35} I_{10} + \beta_{45} SA_{10} + \beta_{55} RE_{10} + \beta_{65} OJ_{10} + \beta_{75} IM_{10} + \beta_{85} FM_{10} + \varepsilon_{55}
\end{aligned} \tag{1}
$$

where:

U – unemployment rate (2006-2010);

W – average wages in zlotys (2006-2010);

BR – budgetary revenues of poviats per capita (2006-2010);

I – investment outlays per capita (2006-2010);

SA – social assistance expenditures per capita (2006-2010);

RE – number of registered economic entities (2006-2010);

OJ – offered jobs per 1 thousand working age individuals (2006-2010);

IM – balance of internal migrations in poviats in Poland (2006-2010);

FM – balance of foreign migrations in poviats in Poland (2006-2010);

$\mathbf{W}$ – spatial weight matrix;

$\mathbf{W}\_SB$, $\mathbf{W}\_WYN$, $\mathbf{W}\_PG$ – spatial lags of U, W and RE variables;

$\alpha, \beta, \rho, \lambda$ – structural parameters;

ε – errors.

Estimations of the model parameters applied the maximum likelihood method (Suchecki 2012, p. 159). Due to the fact that some of them appeared to be statistically insignificant, a part of variables were eliminated from the model. The received results (after sequential elimination of variables) are presented in Table 2.

Table 2. Results of estimations of unemployment model parameters

Independent variables	**Dependent variable -** *U*		
	Coefficient	*t*-ratio	Goodness-of-fit
2006			
Constant	15,945231	(17,31)	$pseudoR^2 = 0{,}5423$ *RMSE* = 2,96655
W_*U*	0,1276212	(19,76)	
W_*W*	-0,0007961	(-10,99)	
BR	-0,0011871	(-3,11)	
I	-0,0001734	(-2,35)	
SA	0,0023427	(2,32)	
2007			
Constant	12,26919	(14,43)	$pseudoR^2 = 0{,}5591$ *RMSE* = 2,73543
W_*U*	0,128756	(16,31)	
W_*W*	-0,0004412	(-8,21)	$pseudoR^2 = 0{,}5591$ *RMSE* = 2,73543
W_*RE*	-0,0003897	(-3,82)	
BR	-0,0007691	(-2,98)	
I	-0,0009192	(-2,21)	
2008			
Constant	9,987221	(16,43)	$pseudoR^2 = 0{,}5381$ *RMSE* = 2,89123
W_*U*	0,123231	(17,98)	
W_*W*	-0,0002971	(-7,44)	
W_*RE*	-0,0004967	(-3,98)	
BR	-0,0006941	(-2,67)	
I	-0,0014848	(-2,23)	
RE	-0,0012221	(-4,37)	
IM	-0,4551298	(-2,93)	
2009			
Constant	14,52855	(11,14)	$pseudoR^2 = 0{,}5131$ *RMSE* = 3,00721
W_*U*	0,137211	(11,51)	
W_*W*	-0,0003907	(-8,21)	
W_*RE*	-0,0004366	(-2,73)	
BR	-0,0007314	(-4,31)	
I	-0,0001141	(-2,51)	
RE	-0,000851	(-2,76)	

2010			
Constant	19,757000	(8,54)	$pseudoR^2 = 0{,}5259$ *RMSE* = 2,93810
W_*U*	0,5798206	(11,88)	
W_*W*	-0,0003996	(-4,19)	
W_*RE*	-0,0012519	(-3,42)	
BR	-0.0006549	(-2,34)	
RE	-0.0048212	(-3,46)	
IM	-0,0011247	(-2,57)	
n	379		

Source: own calculation.

The received results led to the following conclusions:

1. With other factors remaining constant, a rise (fall) in the unemployment rate in poviats defined in the weight matrix as adjacent resulted in a rise (fall) in the unemployment rate in the studied poviat in all the analysed periods. The unemployment rate in Poland is characterised by positive spatial autocorrelation. Thus, the geographic clustering of high and low values of the studied variable is observed. There are spatial clusters of objects with similar values of the variable.
2. It was noted for all the analysed periods that an increase in the poviats' budgetary revenues resulted in a fall in the unemployment rate *ceteris paribus*. Budgetary revenues of poviats per capita are among local development measures. If they rise, economic conditions in a poviat improve. Economic growth occurs and thus investments increase, companies employ more workers and, in consequence, the unemployment rate goes down.
3. With other factors remaining constant, a rise in the investment level caused a fall in the unemployment rate in 2006, 2007, 2008 and 2009. Conditions in the labour market depend in large measure on the level of investments made by enterprises. The number of created jobs is dependent on the volume and type of investments. New development-oriented investments contribute, to a large extent, to increased demand for labour. On the other hand, current investments aimed at property replacement allow to maintain existing jobs.
4. In 2008, 2009 and 2010 an increase in the number of economic entities led to a fall in the unemployment rate *ceteris paribus*. In 2008, when fast economic growth occurred in the country, a substantial increase was noted in the number of economic entities, with the trend continuing in 2009 and 2010 as well. New economic entities create new jobs, hence, their impact on the fall in the unemployment rate is obvious and clear.

5. In 2006 it was observed that, with other factors remaining constant, increased social assistance expenditures resulted in the increased unemployment rate. Unemployment adversely affects the condition of the society, leads to the loss of means of livelihood, loss of qualifications, increased crime and social pathologies. Therefore, the state intervenes in the labour market by using instruments of the so called passive labour market policy. Excessive protectionism, however, does not solve the problems as it may contribute to a further fall in the society's activity in the labour market, which results in increased unemployment.
6. An impact of the increased balance of internal migrations on the fall in the unemployment rate, *ceteris paribus*, was noted in 2008 and 2010. Higher internal migrations mean increased movement of the population within the country. In most cases, population movement is forced by poor economic situation of the area of origin – high unemployment, low wages and poor working conditions. A better socioeconomic position of adjacent areas encourages the so called migration for economic reasons, often even temporary (population movement connected with everyday commuting to another poviat), which causes a fall in the unemployment rate.
7. In all the analysed periods it was observed that, *ceteris paribus*, a rise in average wages in adjacent poviats resulted in a fall in the unemployment rate in the studied poviat. In 2007, 2008, 2009 and 2010 it was also noted that an increase in the number of economic entities in adjacent poviats led to a fall in the unemployment rate in the studied poviat *ceteris paribus*. It was emphasized in the preceding point that a better socioeconomic condition of adjacent areas, including also higher wages or greater demand for labour resulting from an increased number of economic entities, encourages migrations of the population. The movements of the population in search of work contribute to reducing a disproportion between supply and demand in local labour markets, which causes the unemployment rate to fall.

The received results also indicate that average wages, number of offered jobs and balance of foreign migrations did not significantly affect the unemployment rate in the studied period.

7. Conclusions

The study attempted to analyse the unemployment rate from a spatio-temporal perspective.

The carried out research indicates that multi-equation spatial econometric models are a better tool to analyse spatio-temporal data than models that do not

take into account spatial relationships. The spatial SUR models used in the study were characterised by better goodness-of-fit and lower errors than the model not taking into account spatial relationships; they also allowed to eliminate the impact of spatial autocorrelation from the analysis. The models made it possible to obtain a lot of valuable information about the impact of selected macroeconomic variables on the level of unemployment rate in Poland from 2006 to 2010. It was proved that there are spatial clusters of areas with similar values of the unemployment rate in Poland. Neighbouring poviats have an influence on each other. A rise in the unemployment rate in adjacent areas results a rise in that variable in the studied poviat. Moreover an increase in average wages and number of economic entities in neighbouring areas led to a fall in the unemployment rate in the studied poviat. This are very important information for local governments, which should administer their areas in collaboration with each other.

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Streszczenie

PRZESTRZENNO-CZASOWA ANALIZA STOPY BEZROBOCIA W POLSCE

Celem opracowania jest przestrzenno-czasowa analiza poziomu stopy bezrobocia w Polsce, z wykorzystaniem zaawansowanych metod ekonometrii przestrzennej. Badanie przeprowadzono na danych statystycznych zebranych na poziomie powiatu, w latach 2006-2010. Narzędzia GIS i ESDA zostały wykorzystane w celu wizualizacji zmiennych oraz identyfikacji interakcji przestrzennych zachodzących pomiędzy badanymi jednostkami terytorialnymi na rynku pracy. Wielorównaniowe modele o równaniach pozornie niezależnych zastosowano do opisu wpływu wybranych zmiennych makroekonomicznych na kształtowanie się poziomu stopy bezrobocia w Polsce w badanym okresie.