Comparative Economic Research, Volume 17, Number 4, 2014
10.2478/cer-2014-0037

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Spatial Analysis Of Foreign Migration In Poland In 2012 Using Geographically Weighted Regression

Abstract

Migration has a principal influence on countries' population changes. Thus, the issues connected with the causes, effects and directions of people's movements are a common topic of political and academic discussions.

The aim of this paper is to analyse the spatial distribution of officially registered foreign migration in Poland in 2012. GIS tools are implemented for data visualization and statistical analysis. Geographically weighted regression (GWR) is used to estimate the impact of unemployment, wages and other socio-economic variables on the foreign emigration and immigration measure. GWR provides spatially varying estimates of model parameters that can be presented on a map, giving a useful graphical representation of spatially varying relationships.

Keywords: *emigration,immigration, spatial analysis, GIS, GWR*

1. Introduction

Agreements signed in the scope of the free movement of people, which is one of the fundamental human freedoms, are currently respected almost throughout the whole of Europe[1]. Nowadays the signatories of the Schengen

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[1] http://ec.europa.eu/dgs/home-affairs/pdf/flipbook/ (accessed on 21 May 2014).

Agreement, under which border checks are gradually abolished at the signatories' common borders, are twenty-two European Union countries as well as Iceland and Norway. Switzerland and Liechtenstein are associated with the Schengen group. Cyprus, Croatia, Bulgaria and Romania are seeking membership. The abolishment of institutional barriers has increased migration processes in Europe leading to numerous positive as well as negative consequences. People's migrations affect, to a large extent, the sizes of populations in European countries. Therefore, issues connected with causes, effects and directions of the movements of people are becoming an increasingly frequent topic of political and academic discussions.

Poland joined the European Union in 2004 and became the signatory of the Schengen Agreement in 2007 but it was only in 2011 and 2014 that the last barriers to the free movement of citizens were eliminated[2]. According to unofficial data, as many as 2.7 million Poles may be currently residing abroad[3]. Given the fact that those are usually young people, often having higher education it definitely poses a serious problem to the country. Emigration substantially exceeds immigration. Along with Romania and Bulgaria, Poland is characterized by the lowest share of foreigners in the overall population.

Causes of migration are very complex and difficult to define. Main factors leading to the movements of people include environmental, psychological, political, cultural and economic aspects. It should be emphasized that they can co-occur (Bonifazi, Okólski, Schoorl, Simon 2008, p.13). For Poles the most important ones are socio-economic aspects connected with seeking better living conditions – stability, safety and better working culture. The proximity of the country of migration and historical factors are also important (GUS 2013, p. 1).

The aim of this article is to analyse the spatial distribution of immigration and emigration[4] in Poland. The study was carried out on officially registrered statistical data concerning poviats in 2012, published by the Central Statistical Office. The first part of the study used geographic information systems tools for the purpose of the visualization and preliminary (statistical) data analysis. Then, an attempt was made to specify socio-economic variables that might significantly

[2] As the last EU members, Germany and Austria opened their labour markets to Poles on 1 May 2011, while Switzerland – a signatory of the Schengen Agreement – did that on 1 May 2014.

[3] http://www.fronda.pl/a/kolejna-wielka-emigracja-polakow-w-2013-wyjechalo-z-polski-prawiepol-miliona,34385.html (accessed on 20 May 2014).

[4] According to the Central Statistical Office: immigration – registration for permanent residence of individuals coming from abroad; emigration – de-registration for permanent residence abroad.

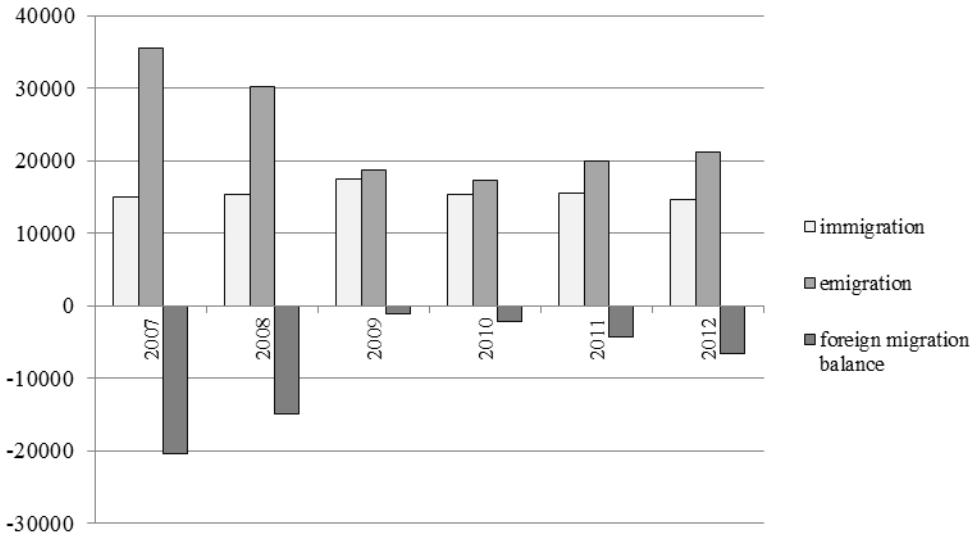
affect migration in Poland. The analysis of impacts of exogenous variables on immigration and emigration applied geographically weighted regression allowing to identify variability of regression coefficients in geographical space.

2. Foreign migration in Poland

Figure 1 shows immigration (inflow of people), emigration (outflow of people) and net migration (difference between immigration and emigration) in Poland in the years 2007-2012. The largest volume of emigration was reported in 2007 and 2008 when over 65000 people emigrated from Poland. In 2009 the volume of emigration markedly decreased; the trend continued in 2010 as well. In turn, in 2011 and 2012, the variable showed a considerable rise again.

The inflow of foreign population ran at about 15000 people per year; it was only in 2009 that a slight increase in that variable was observed. The net migration was negative throughout the study period, which meant that emigration exceeded immigration. The largest differences between the inflow and outflow of people were reported in 2007 and 2008. Those significantly decreased in 2009 to go up again in the final three years of the study, in particular, in 2012. Thus, it can be noted that the first substantial wave of Poles' emigration occurred before the economic crisis, i.e. in the years 2007-2008. At present, when the economic situation of European countries gradually stabilizes and effects of the crisis subside, the second growing wave of Poles' emigration is observed. According to the reports published by the Central Statistical Office, a vast majority of emigrants from Poland reside in the countries of the European Union, especially in the United Kingdom, Germany, Ireland, the Netherlands and Italy. There is also a rise in the number of people emigrating to Scandinavian countries (GUS 2013, pp. 3-4). As for immigrants, most of them are citizens of Ukraine, Vietnam, Russia and Belarus.

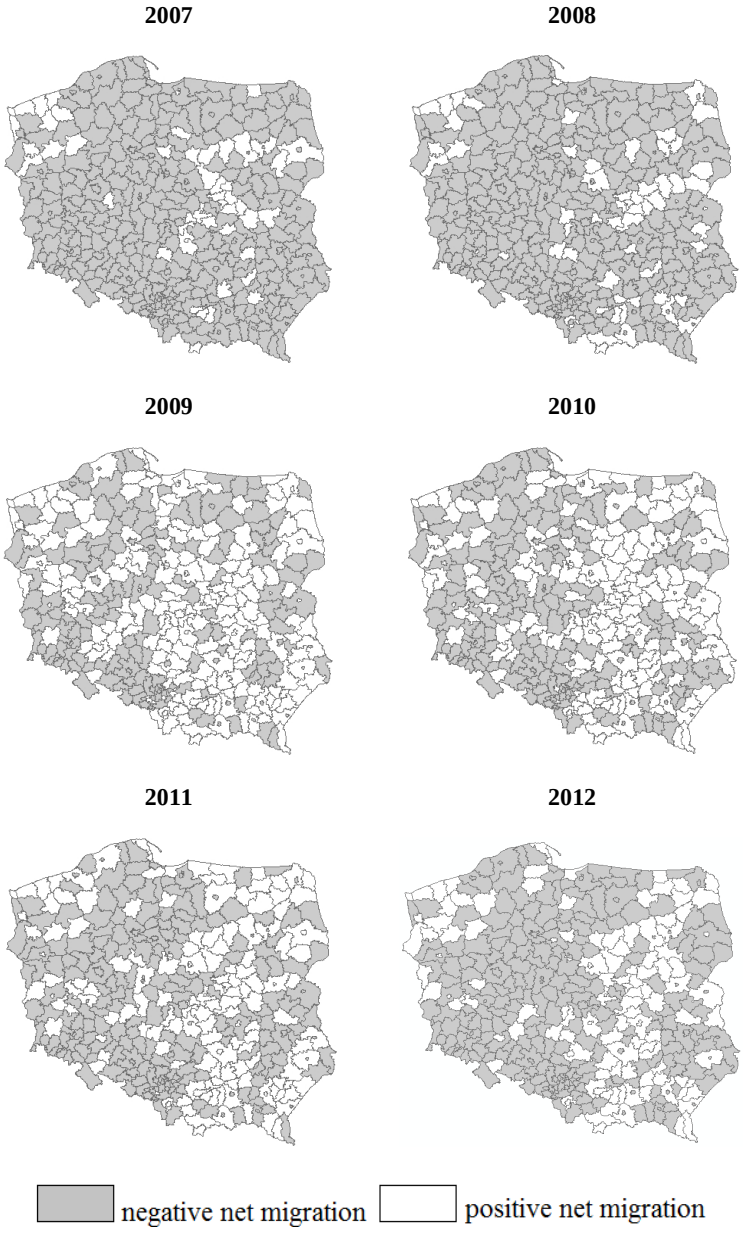
Figure 1. Foreign migration in Poland in the 2007-2012 period



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

Figure 2 shows net migration for specific poviats of Poland between 2007-2012. In the first year of analysis a positive net migration occurred only in 50 poviats. The lowest value of the variable was observed in the Opolski (-650) and Gliwicki (-591) poviats, while the highest – in Warsaw (103) and Cracow (91). In 2008 the number of spatial objects characterized by a positive net migration rose to 61 and in 2009 it was as high as 214. At that time, the highest value of the variable was reported in Warsaw (480) and Wrocław (422). In the years 2010-2012 there was a gradual increase in the share of poviats with a negative net migration. In 2012 a positive net migration occurred in only 133 spatial units. The lowest value of the variable was observed in the Opolski (-361) and Strzelecki (-291) poviats, while the highest – in Warsaw (255) and Cracow (228). A map for 2012 shows a clear division into Western Poland characterized, to a large extent, by a negative net migration, and Eastern Poland where poviats with a positive external net migration are located.

Figure 2. Foreign migration balance in poviats in 2007-2012



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

3. GWR in migration analysis

The conventional approach to the empirical analyses of spatial data is to build a global model that assumes homogeneous (stationary) across-space relationships between dependent and independent variables. It means that the same stimulus provokes the same response in all parts of the study region (countries, voivodeships, poviats). The regression equation can be expressed as:

$$y_i = \beta_0 + \sum \beta_{ik} x_{ik} + \varepsilon_i, \quad (1)$$

where: yi - dependent variable, β i - coefficients, xik – independent variables, εi - error term.

However, in practice, the relationships between variables might be nonstationary and vary geographically (Matthews, Yang 2012, p. 152).

Locally linear regression, introduced to the economic context by McMillen (1996), is a relatively recent modelling technique for spatial data analysis. The technique was extended and relabelled geographically weighted regression by Fotheringham, Charlton and Brunsdon (1996, 1997, 2002). Unlike global regression models, where a single coefficient is estimated for each explanatory variable, GWR allows local variations (over space) in those coefficients to be estimated. This method generates a separate regression equation for each observation, that can be expressed as follows (Brunsdon, Fotheringham, Charlton 1996, p. 284):

$$y_i = \beta_0(u_i, v_i) + \sum \beta_k(u_i, v_i) x_{ik} + \varepsilon_i, \quad (2)$$

where: (ui, vi) - coordinate location of i.

The estimator for this model takes a form of (Charlton, Fotheringham 2009, pp. 5-6):

$$\boldsymbol{\beta}' = [\mathbf{X}^T \mathbf{W}(u_i, v_i) \mathbf{X}]^{-1} \mathbf{X}^T \mathbf{W}(u_i, v_i) \mathbf{Y}, \quad (3)$$

where: $\mathbf{W}(u_i, v_i)$ - square matrix of weights relative to the position of (u_i, vi) in the study area, XTW(ui, vi)X -geographically weighted variance-covariance matrix (the estimation requires its inverse to be obtained), Y - vector of the values of the dependent variable.

The W (ui, vi) matrix contains the geographical weights in its leading diagonal and 0 in its off-diagonal elements.

$$\mathbf{W}(u_i, v_i) = \begin{bmatrix} \mathbf{w_1}(u_i, v_i) & 0 & 0 \\ 0 & \dots & 0 \\ 0 & 0 & \mathbf{w_n}(u_i, v_i) \end{bmatrix} \quad (4)$$

Each equation is calibrated using a different weighting of the observations contained in the data set. The assumption is that observations nearby one another have a greater influence on one another's parameter estimates than observations farther apart. The weight assigned to each observation is based on a distance decay function centred on observation i (Mennis 2006, p. 172).

GWR provides great richness of results that are usually presented on maps. As a minimum, this technigue produces parameter estimates and their standard errors at the regression points. If the regression points are the same as the sample points, GWR also produce fitted values for the dependent variable, residuals and standardised residuals. Some implementations output local goodness-of-fit measures and influence statistics based on the hat matrix (Charlton, Fotheringham 2009, p. 9). Mapping GWR results facilitates interpretation based on spatial context and known characteristics of the study area (Mathews, Yang 2012, p. 155).

GWR is a tool which is more and more often used in demographic as well as socio-economic research. In particular, in analyses related to healthcare – incidence of diseases and access to medical services (Nakaya, Fotheringham, Brunsdon, Charlton M. 2005; Young, Gotway 2010; Comber, Brunsdon, Radburn 2011, Kisiala 2013), environmental protection (Foody 2003; Gilbert, Chakraborty 2011), real estate market (Yu, Wei, Wu 2007, Cellmer R. 2013), population density (Lo 2008), poverty (Benson, Chamberlin, Rhinehart 2005; Partridge, Rickman 2007) and migrations (Byrne, Pezić 2004; Jensen, Deller 2007; Jivraj, Brown, Finney 2013).

In their article entitled Spatial Modeling of the Migration of Older People with a Focus on Amenities, T. Jansen and S. Deller (2007) presented results of an analysis of the impact of selected factors, including amenities connected with natural resources of regions (i.e. access to forests, lakes) and climate conditions, on the migration of the elderly in the United States. The study was conducted on statistical data concerning 3,072 spatial units (districts) in the years 1995-2000. The results of the analysis suggest that older migrants cannot be treated as a homogenous group and amenities (e.g. warmer weather, natural and historical attractions) have a significant impact on explaining their migration decisions. The amenity measures used in that study had distinctly different implications for the dependent variable in individual localities. The GWR estimates were more efficient than those of the OLS for all presented models.

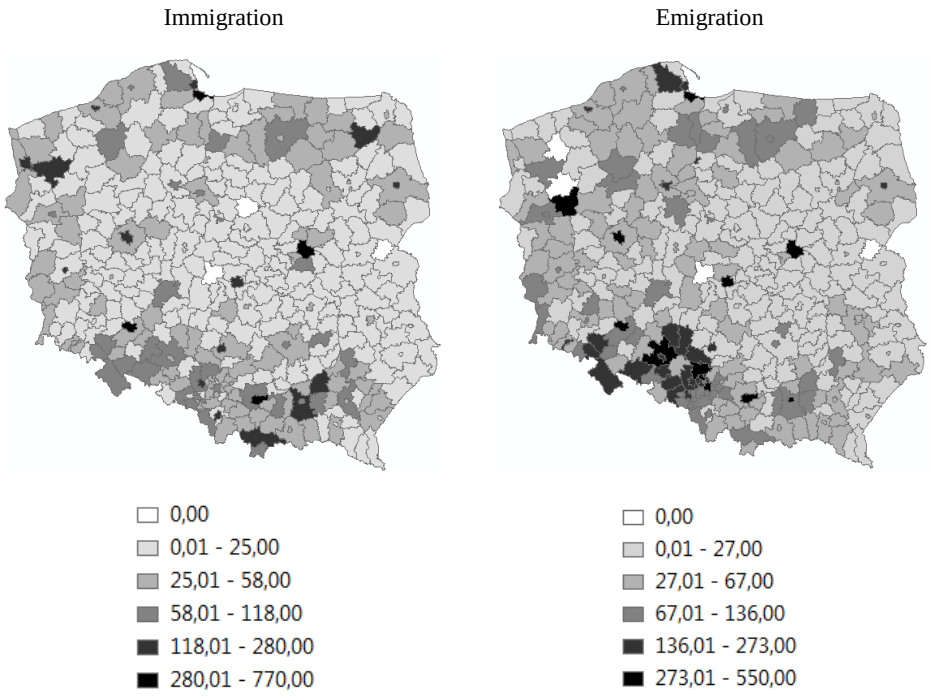
In the article entitled Modelling Internal Migration Drivers with Geographically Weighted Regression, G. Byrne and A. Pezić (2004) described results of the spatial analysis of internal migration in Australia having a major impact on a rise in the country's population. The GWR method was used to estimate the effect of factors such as unemployment, house prices and other socio-economic variables on the internal migration measure. The study was carried out on statistical data concerning 203 statistical local areas in Victoria, with attention restricted to the regional centre of Bendigo in Victoria. The results presented in the article support the view that the effects of internal migration drivers are spatially non-stationary. That is why local model estimates were more efficient than those of the global model. Spatial variations in the model parameters where presented on maps and characterized in detail. The results showed inter alia that high migrant flows are concentrated immediately South, West and North-West of Bendigo, flows from the remainder of Victoria are relatively small.

4. Preliminary Analysis of Statistical Data

The foreign migration (emigration and immigration) in Poland was analysed from the spatial 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 was collected for 379 poviats of Poland in 2012. Major determinants of creating the database were both, reasons pertaining to the subject matter and availability of data at the time of carrying out the study. Regrettably, not all variables needed for the analysis of foreign migration are available for specific poviats (e.g. GDP).

Figure 3 presents immigration and emigration volumes for specific poviats in 2012. Maps clearly show that the greatest number of people who left Poland to permanently reside abroad was reported in the South of the country – in the Śląskie, Dolnośląskie and Opolskie voivodships as well as in Gdańsk, Warsaw and Łódź. On the other hand, no emigration was noted in the Łobeski, Łosicki, Poddębicki and Choszczeński poviats. It can be observed that the population residing in the Western and Northern part of the country is more mobile. The highest number of immigrants settled in big cities, i.e. Warsaw, Wrocław, Cracow, Gdańsk, Gdynia and Białystok. No immigration was reported in the Łosicki, Poddębicki and Sierpecki poviats. Foreigners most willing settle in the Southern and Northern borderlands of the country, less often in Central and Eastern Poland.

Figure 3. Emigration and immigration in Polish poviats in 2012



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

Both variables are characterized by high spatial variability and positive global autocorrelation. In 2012 Moran's statistic for immigration was 0.08, while it was 0.26 for emigration (received results are statistically significant). The local statistic for immigration indicates that low values of the variable group in poviats situated in the Kujawsko-Pomorskie, Mazowieckie and Lubelskie voivodships. As for emigration, the local statistic indicates that low values of the variable group in poviats located in the Mazowieckie and Lubelskie voivodships, and high values – in the Opolskie voivodship.

5. Modelling of Foreign Migration in Poland

The analysis of foreign migration in Poland in 2012 was conducted using two econometric models describing immigration and emigration. The first step in examining the impact of selected socio-economic variables on the values of

dependent variables was to create global models. Final models, whose parameters were estimated using the OLS method, had the following form:

$$\widehat{IM} = -20{,}0619 + 0{,}1460LOP + 0{,}0004LM + 0{,}1976M + 0{,}0051DB$$

(-5,5) (5,8) (14,0) (2,2) (3,3)

$$\widehat{EM} = -319{,}7660 - 0{,}3844M - 4{,}4567PS + 4{,}2662K + 0{,}7811IM - 4{,}7531DG$$

(-3,3) (-2,6) (-4,7) (4,5) (17,9) (-3,4)

where: DB – poviats' budgetary incomes per capita in 2012, DG – number of individuals carrying out business activity per 100 of the working age population in 2012, EM – number of emigrants in 2012, IM – number of immigrants in 2012, K – number of women per 100 men in 2012, LM – number of the population in 2012, LOP – number of job offers in 2012, M – dwellings completed per 10 thousand of the population in 2012, PS – share of the working age population using social assistance in the place of residence in the total number of population of that age in 2012.

All model coefficients are statistically significant. The determination coefficient for the immigration model is 73%, while it is 59.9% for the emigration model. It should be emphasized that there is a spatial autocorrelation of residuals in both models.

As the next step, parameters of local models were estimated having the same forms as for global models. Local regression coefficients descriptive statistics for the immigration model are presented in Table 1. It can be observed that median values for specific parameters are similar to results received for the global model.

Table 1. Local regression coefficients descriptive statistics – immigration model

Variable	Minimum	Median	Maximum
Constant	-74,1470	-24,1943	20,1350
LOP	-0,8078	0,0362	0,8355
LM	-0,0001	0,0004	0,0013
M	-0,8840	0,0652	1,5511
DBM	-0,0109	0,0056	0,0309

Source: own work.

Table 2 shows statistics used to compare the global and local models describing immigration in 2012. All measures indicate the markedly better fit of the local model to empirical data – both the determination coefficient, which is higher in the GWR model, and the Akaike Information Criterion, whose value is lower in the local model.

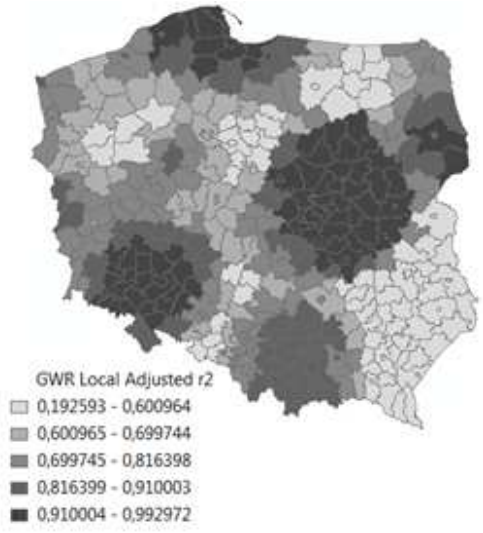
Table 2. Diagnostic statistic for global and local models

	Global model - OLS	Local model - GWR
Akaike Information Criterion	3805.003	3572.464
Coefficient of Determination (R^2)	0.732	0.913
Adjusted R^2	0.73	0.89
Residual Sum of Squares	492370.15	160072.37

Source: own work.

Figure 4 presents local values of the determination coefficient. It can be observed that the model is characterized by insufficient fit to data, particularly for poviats located in the South-Eastern part of the country, whereas the fit is best for the Mazowieckie, Dolnośląskie and Pomorskie vovodships.

Figure 4. Local adjusted R^2 in immigration model

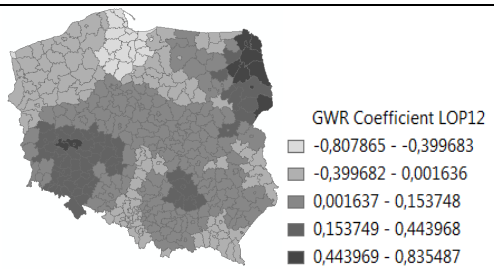
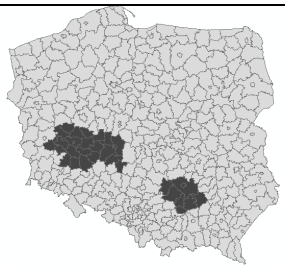
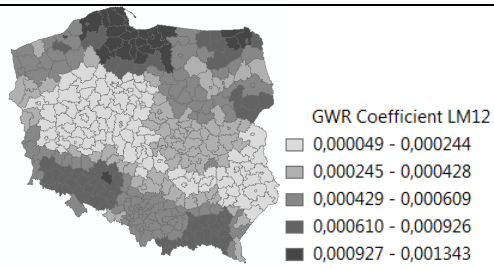
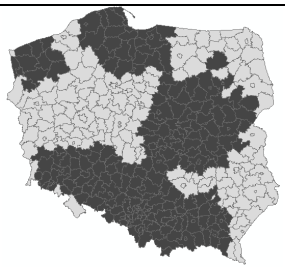
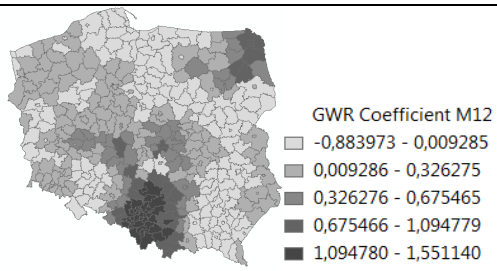
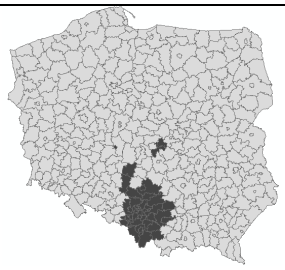


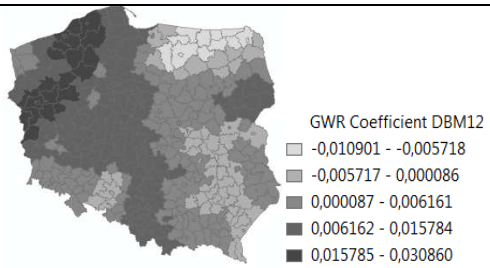
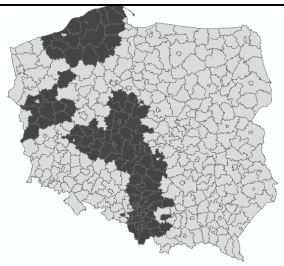
Source: own work in ArcMap.

Table 3 shows local values of coefficients and t-statistics calculated for the immigration model. Maps concerning the significance of parameters clearly show that they are not statistically significant for each locality. All other factors being constant, a rise in the population significantly affects a rise in the number of immigrants for the highest number of poviats. That means that foreigners most willingly settle in big cities where it is easier to find work and dwelling, access commercial and cultural facilities. An increase in the number of job offers affects a growth in the number of migrants in poviats situated in the

Wielkopolskie, Świętokrzyskie and Dolnośląskie voivodships. Economic migration is currently the predominant form of population mobility. Thus, people move to areas where it is easy to find employment. A rise in the number of dwellings significantly affected an increase in immigration mainly in poviats located in the Śląskie and Małopolskie voivodships. In turn, an increase in poviats' budgetary incomes had an impact on a growth in the number of immigrants in poviats situated in the Pomorskie, Zachodniopomorskie, Wielkopolskie and Małopolskie voivodships. That variable is among the measures of local development. If budgetary incomes go up, economic conditions in a poviat improve. That amounts to economic growth, making the area more attractive to potential immigrants.

Table 3. Local values of parameters and t-statistics in the immigration model

Variable	Coefficients	*t* – Statistics
LOP		
LM		
M		

DB		
		not significant significant

Source: own work in ArcMap.

The last step of the study was to estimate parameters of the GWR model describing emigration. Local regression coefficients descriptive statistics for the emigration model are presented in Table 4.

Table 4. Local regression coefficients descriptive statistics – emigration model

Variable	Minimum	Median	Maximum
Constant	-1468,500	-381,611	67,152
M	-1,389	4,490	16,975
PS	-11,748	-2,487	2,115
K	-0,480	-0,257	0,631
IM	-0,053	0,714	1,398
DG	-23,050	-3,958	6,608

Source: own work.

In turn, Table 5 shows statistics used to compare the global and local models describing emigration in 2012. Similarly to the first (immigration) model, all measures indicate the markedly better fit of the local model to empirical data – both the coefficient of determination, which is higher in the GWR model, and the Akaike Information Criterion, whose value is lower in the local model.

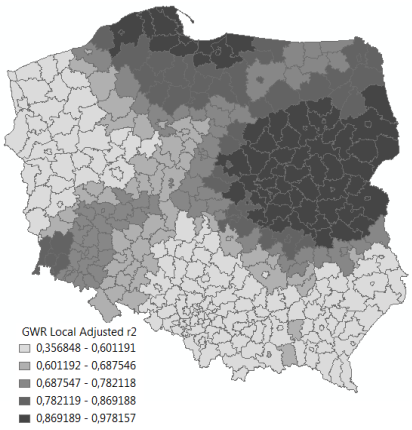
Table 5. Diagnostic statistic for global and local models

	Global model - OLS	Local model - GWR
Akaike Information Criterion	4057,71	3971,561
Coefficient of Determination (R^2)	0,599	0,763
Adjusted R^2	0,595	0,726
Residual Sum of Squares	953868,99	566681,15

Source: own work.

Figure 5 presents local values of the determination coefficient. It can be observed that the model is characterized by insufficient fit to data, particularly for poviats located in the Southern and Western parts of the country, whereas the fit is best for the Mazowieckie, Podlaskie and Pomorskie voivodships.

Figure 5. Local adjusted R^2 in emigration model

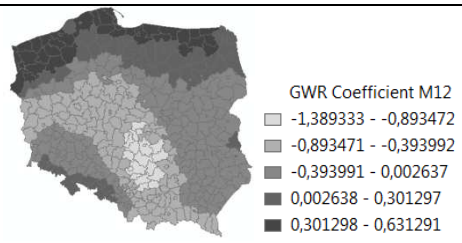
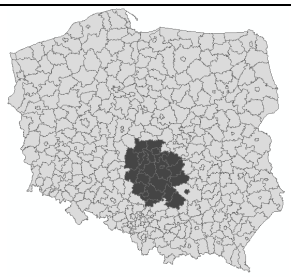
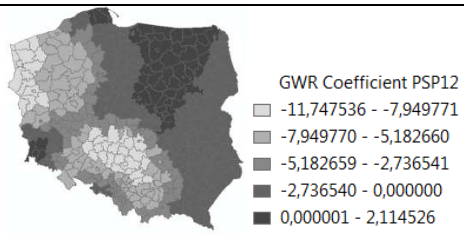
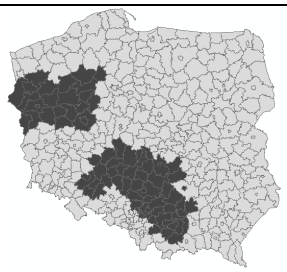
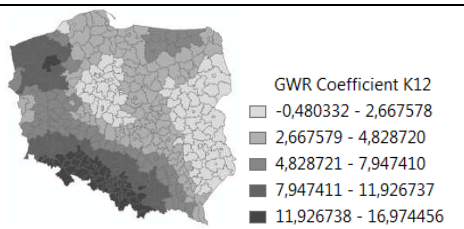
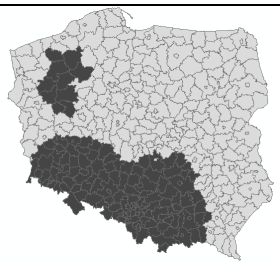
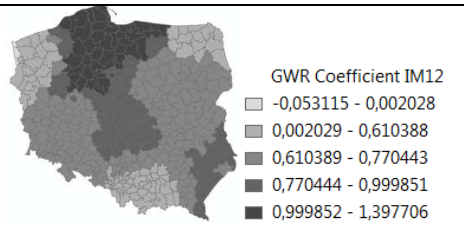


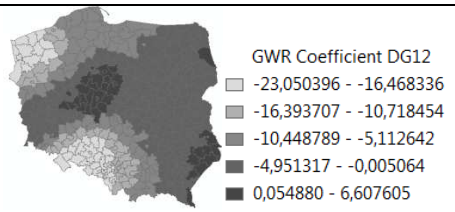
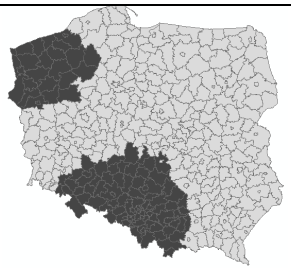
Source: own work in ArcMap.

Table 6 shows local values of coefficients and t-statistics calculated for the emigration model. Also in that case, parameters are not significant for every locality. It can also be observed that variables affect one another with varying intensity. All other factors being constant, a rise in the number of dwellings in poviats located in the Łódzkie, Świętokrzyskie and Śląskie voivodships led to a significant decrease in emigration. As compared to other European countries, housing situation in Poland is very poor. Inability to rent or buy a flat often affects a decision to emigrate, especially among young people. In Southern Poland (Śląskie, Dolnośląskie, Małopolskie voivodships) a rise in the number of women (per 100 men) results in an increase in emigration. That means that it is not only economic factors that determine a decision to leave the country. According to the femininity ratio published by the Central Statistical Office, there are currently 109 women per 100 men in Poland. It is possible that this situation makes women decide to emigrate more often than men. A rise in the working age of population using social assistance significantly affects a fall in emigration in poviats located in the Western and South-Western part of the country. That leads to a conclusion that improvement in social policy could contribute to stopping people's emigration from Poland. A variable that significantly affected emigration in almost the whole country in 2012 was immigration. Immigrants coming especially from countries of the Eastern Bloc tend to take up

jobs with lower salaries, thus causing job offers to be "sucked out" of the labour market. In Western and South-Western Poland, a rise in the number of individuals carrying out economic activity significantly affects a drop in emigration. That variable is among measures of economic development; it generates jobs. Hence, it is negatively correlated with emigration.

Table 6. Local values of parameters and *t*-statistics in the emigration model

Variable	Coefficients	*t* – Statistics
M		
PS		
K		
IM		

DG		
		not significant significant

Source: own work in ArcMap.

5. Conclusion

The opening of borders between European countries ensured free movement of people in Europe. Reasons for emigration are often very complex, with the predominance of economic ones associated with looking for jobs offering fair remuneration. It should, however, be emphasized that various social aspects of migration are increasingly mentioned, too.

Based on the conducted it can be stated that the net migration in Poland was negative in 2012, i.e. emigration exceeded immigration. A positive net migration was observed only in 133 poviats, mainly in big cities, i.e. Warsaw, Cracow, Wrocław, Szczecin and Gdynia.

The analysis of foreign migrations in Poland in 2012 was conducted using two econometric models describing immigration and emigration. An attempt was made to specify socio-economic variables that may fundamentally affect the studied phenomenon and estimate parameters of the geographically weighted regression model. The method proved to be an extremely useful instrument of spatial data analysis. Local models were characterized by a considerably better fit to empirical data than global ones. They allowed to evaluate the significance of parameters of models for specific spatial units. Based on the received results, it was inferred that emigration of people from Poland is affected not only by economic but also social aspects, i.e. desire to find a partner and buy or rent a flat. It was also observed that improvement in social policy related to benefits could limit the movement of population abroad. In turn, immigrants tend to settle in big and highly developed poviats offering better chances of finding employment.

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Streszczenie

PRZESTRZENNA ANALIZA MIGRACJI ZAGRANICZNYCH W POLSCE W 2012 R. Z WYKORZYSTANIEM GEOGRAFICZNIE WAŻONEJ REGRESJI

Migracje ludności w znaczącym stopniu wpływają na kształtowanie się liczby ludności w krajach. Z tego względu zagadnienia związane przyczynami, skutkami i kierunkami ruchów ludności są coraz częstszym przedmiotem politycznych i akademickich dyskusji.

Celem artykułu jest analiza przestrzennego rozmieszczenia poziomu emigracji i imigracji w Polsce w 2012 r. Metody geograficznych systemów informacyjnych wykorzystano w celu wizualizacji i wstępnej (statystycznej) analizy danych. Następnie podjęto próbę specyfikacji zmiennych ekonomiczno-społecznych, które mogą mieć zasadniczy wpływ na kształtowanie się badanego zjawiska oraz estymacji parametrów modelu geograficznie ważonej regresji (GWR). Metoda ta umożliwia identyfikację zmienności współczynników regresji w przestrzenni geograficznej.

***Słowa kluczowe**: emigracja, imigracja, analiza przestrzenna, GWR, GIS*