Spatial Modeling of Social Expenditure in EU Countries

Monika Miśkiewicz-Nawrocka* and Katarzyna Zeug-Żebro

University of Economics in Katowice, Department of Statistics, Econometrics and Mathematics, Poland

ARTICLE INFO

Keywords:

*Forecast of social
expenditure
Spatial analysis
Spatial lag model
Social security*

ABSTRACT

The age structure of EU countries has changed significantly in recent years. These changes are mainly due to longer life expectancy, low fertility rates, and population migrations. Countries are trying to cope with the consequences of demographic changes by reforming the social care system, extending the retirement age, introducing additional social benefits promoting parenthood and supporting large families. Social security programs in EU countries are very diverse. The financial aspect plays an important role in social security systems. Social security is based on the redistribution of income between persons receiving remuneration from work and persons who, due to reaching retirement age, poor health, lack of employment or having many children receive social benefits. In view of the changing demographic situation, social security functions such as health care, pensions and benefits for large families require Member States to take immediate structural and financial change. In the study will carry out spatial analysis of social care system development in the European Union and will research the impact of social spending on the unemployment rate, household structure, birth rate or poverty level. In addition, the forecast of social expenditure in the EU will be designated. The use of spatial analysis will allow to determine the existing relations between the studied countries due to the level of development of the studied phenomenon. The analysis will be carried out on the basis of actual data from Eurostat.

1. Introduction

In recent years, the analysis of economic phenomena has been increasingly carried out based on methods and tools of spatial statistics or spatial econometrics. These tools allow the assessment and comparison of phenomena in terms of spatial relationships, i.e. similarity and diversity of objects located at a certain distance from each other. Spatial methods are used in such issues as demographic phenomena, analysis of the labor market, study of the standard of living of the population, economic and trade concentration, analysis of electoral support, real estate valuation, analysis of industrial structures (Pietrzykowski, 2011; Pośpiech, 2015). The ongoing process of population aging around the world leads to significant changes in the structure of societies, and thus to changes in the volume of demand and supply for basic social services related not only to the proper functioning of the health service, care institutions, education but also the social security system (disability and retirement benefits, benefits for large families, unemployment benefits).

The aim of the study is to examine the spatial relationships between EU countries in terms of the development of the social care system. The article analyzes the development of the social care system in EU countries and builds an econometric model explaining the impact of social

* Corresponding Author E-Mail Address: monika.miskiewicz@ue.katowice.pl

spending on, among others, the unemployment rate, household structure, birth rate or the level of poverty.

2. Social Protection in the EU

The first legal regulations on social policy in the EU Community appeared more than 60 years ago (Treaty of Rome (1957)). At that time, Member States were to improve both the economic and social situation of the poorest social groups, as well as to protect workers against the effects of adverse and unfortunate accidents and life events. Initially, EU social policy was not a priority for Member States and focused mainly on creating appropriate social, economic and legal conditions on a Community and national scale. These conditions concerned equal treatment of men and women on the labor market, pensions, mobility of the labor force on the EU labor market and improvement of the working and living conditions of the citizens of the community. Intensive growth of interest in social issues occurred only in the 70s, when on the Conference in Paris in 1972 highlighted the social dimension of economic and political integration. A year later, the First Social Program on European labor law was developed. In 1975, the European Regional Development Fund was created, which deals with the regional policy of the member states. The Single European Act (1986) introduced further changes in the social dimension of the single market. As a consequence, the Community Charter of Fundamental Social Rights of Workers was adopted at the Strasbourg summit (1989). These rights included, among others, the improvement of living and working conditions, social protection, health protection, protection of children and young people, protection of the disabled and protection of the elderly. Amendments introduced by the Maastricht Treaty (1992) to implement this policy in accordance with the principle of subsidiarity are essential for EU social policy. On its basis, in subsequent years, the European Commission formulated strategies assuming, among others ensuring a high level of health protection for residents of EU countries, improving living conditions and hygiene, promoting a healthy lifestyle. In 2000, the Charter of Fundamental Rights was adopted to guarantee respect for human rights, which was attached in the form of a declaration to the Treaties on European Union (Treaty of Maastricht since 1993) and the Treaty establishing the European Community (1993-2009), later the Treaty on the Functioning of the European Union (from 2009) (Głabicka, 1997; Ulman, Eichengreen, Dickens, 2010).

At present, total expenditure on social benefits in the EU amounts to EUR 8388.39 per capita and is almost 80% higher than in 1995. These expenses cover seven areas: sickness / health care, disability, old age, family/children, unemployment, housing and social exclusion. In addition, social expenditure also covers administrative and other costs, representing around GBP 1.1%. Fig. 1 presents the distribution of spending on social objectives in the EU in the years 1995-2017. Total expenses for social benefits are expressed as% GBP, while the remaining data as purchasing power standard (PPS) per inhabitant.

Based on the data in Fig. 1, it can be seen that total social spending is systematically growing. The disorder of the upward trend is 2007, in which two countries Bulgaria and Romania joined to the community. The largest percentage of social expenditure is old age spending (about 40% of total expenditure), which is understandable in the light of an aging society. The largest percentage of social expenditure is old age expenditure (about 40% of total expenditure), which is understandable in the light of an aging society. Expenditure on health care comes second (about 30% of total expenditure). In addition, an increase in old age expenditure by 3.3 pp and health care expenditure by nearly 2 pp can be observed during the period under review. In the case of expenditure on unemployment, in 2017 there was a decrease of 3.7 percentage points compared to 1995, which may indicate an improvement in the situation on the EU labor market and a decrease in the level of unemployment.

Figure 1. Expenditure on social purposes in the EU in 2008-2017 (Source: own elaboration)

3. Spatial Modeling

Spatial modeling has become an important research area when the first law of geography was formulated by W. Tobler in 1970 (Tobler, 1970), which says that everything is related, but near objects are more related than distant ones. The construction of the spatial model is aimed at improving the quality of the econometric model. Inclusion of spatial relationships within a given area as well as within neighboring areas can have a positive influence on the translation of the variability of the features under consideration. The following basic groups of spatial models are distinguished: spatial lag models, spatial error models, cross-regression models and mixed variants. In paper the first two models were considered.

2.1 Spatial Lag Model

The spatial lag model includes the spatially delayed endogenous variable Wy , ie it is an autoregressive model (the basis of the model is spatial dependence). The general form of this model is described by formula (Arbia, 2006; Suhecki, 2010):

$$y = \beta X + \alpha Wy + \varepsilon, \quad \varepsilon \sim N(0, \sigma^2 I) \quad (1)$$

Where: α – spatial autocorrelation coefficient, W – spatial weight matrix, β – vector of model coefficients, X – matrix of exogenous variables, ε – model error.

The model tests if $\alpha = 0$ ie the significance of the dependent variable which is spatially delayed. Spatial delay Wy is interpreted as the level of the dependent variable y in neighboring regions. If this is significant, then the level of y in the i -th region can be explained by the level of the phenomena in the neighborhood and other factors represented by the remaining explanatory variables.

2.2 Spatial Error Model

The spatial error model contains spatially delayed error. This model assumes the spatial autocorrelation of the rest of the model. The general form of the model is given by the formula (Kopczewska, 2006; Suhecki, 2010):

$$y = \beta X + \varepsilon \quad (2)$$

where:

$$\varepsilon = \mu W \varepsilon + \varphi, \quad \varphi \sim N(0, \sigma^2 I) \quad (3)$$

μ – spatial autocorrelation coefficient, other signs as above.

$W\varepsilon$ is a spatially delayed error, which should be interpreted as the average error from neighboring locations, and φ is an independent error of the model. In the model we test whether $\mu = 0$ ie lack of spatial autocorrelation.

4. Empirical Analysis

The subject of the study were 28 EU countries in 2008 and 2017. The data used for the analysis come from the Eurostat database. MS Excel and R-Cran were used for calculations and graphic presentation of data.

In the first stage of the study, countries were compared by level of spending on social benefits. Figure 2 shows the division of EU countries according to the amount of social benefits into 4 groups according to the following rules: class I (high levels of the studied phenomenon), class II (medium levels of the studied phenomenon), class III (low levels of the studied phenomenon), class IV (very low levels of the studied phenomenon). The results of obtained classes spatial distribution for Europe territorial division into countries in 2008 and 2017 due to the social expenditures is shown in the following table (Fig. 2).

The first group (dark green color) includes the countries with the highest social benefits, while the fourth group (light yellow color) - the lowest social benefits. Analyzing the data in Fig. 2, it can be seen that in 2008 the highest social benefits (group I) were paid by: France, Denmark, Sweden, Austria, Germany, Italy and Belgium, while the lowest (group IV): Latvia, Romania, Bulgaria, Estonia, Slovakia and Lithuania. In 2017 the situation changed. Group I was joined by Finland and Netherlands, while Belgium and Sweden fell to group II. However, Ireland were additionally included in group IV, while Slovakia and Malta moved to group III. In the analyzed years 20 countries did not change or improved their position in the ranking, which may indicate on improving the social situation in these countries. The largest changes were recorded for Ireland (decrease in the ranking by 10 positions) and Finland (increase in the ranking by 7 positions).

Figure 2. The classification of EU countries due to the value of social expenditures in years: 2008 and 2017 (Source: own elaboration)

Analyzing social expenditure in individual countries, 6 areas mentioned in point 1 were taken into account, i.e. sickness/health care, disabled, old age, family/children, unemployment, housing, social exclusion. Table 1 presents the ranking of EU countries by each of the above areas.

Table 1.

Ranking of EU countries for social spending in years 2008 and 2017

	sickness/ health care		disability		old age		family/ children		unemployment		housing	
	2008	2017	2008	2017	2008	2017	2008	2017	2008	2017	2008	2017
Belgium	8	9	8	7	11	9	6	6	1	3	12	12
Bulgaria	27	27	28	26	28	28	27	21	27	24	28	28
Czechia	17	14	19	19	17	16	12	11	18	18	18	13
Denmark	11	10	3	1	6	3	2	2	10	7	4	5
Germany	4	1	7	6	9	10	7	7	8	11	5	7
Estonia	23	20	23	12	22	23	15	9	25	22	22	17
Ireland	3	6	18	15	19	18	10	14	4	6	7	6
Greece	15	24	17	21	12	13	20	27	12	14	17	24
Spain	13	15	14	13	16	14	18	20	3	8	14	16
France	5	4	10	9	7	6	8	8	7	4	2	3
Croatia	20	19	12	14	25	27	23	19	26	25	24	25
Italy	12	13	13	11	4	8	25	24	11	9	20	22
Cyprus	19	25	26	25	15	17	9	26	14	13	3	10
Latvia	26	28	27	23	27	26	19	17	22	19	16	19
Lithuania	24	21	20	18	24	24	16	18	23	17	27	18
Luxembourg	1	2	1	2	3	2	1	1	2	1	11	4
Hungary	22	22	16	24	20	21	11	10	17	27	10	10
Malta	18	16	24	28	18	19	22	23	20	21	15	15
Netherlands	2	3	5	5	5	7	14	16	9	10	8	8
Austria	7	5	6	8	1	1	5	5	6	5	13	14
Poland	25	23	22	20	21	20	26	12	24	26	19	21
Portugal	16	17	11	16	13	12	28	28	15	15	26	27
Romania	28	26	25	27	26	25	21	22	28	28	23	26
Slovenia	14	12	15	22	14	15	24	25	21	16	25	23
Slovakia	21	18	21	17	23	22	17	15	19	20	21	20
Finland	10	11	4	4	10	5	4	4	5	2	9	2
Sweden	6	7	2	3	2	4	3	3	13	12	6	9
United Kingdom	9	8	9	10	8	11	13	13	16	23	1	1

Source: own elaboration.

By far the best situation in terms of social security can be seen in Luxembourg, which ranks 1-2 in the ranking in almost every category. However, the worst situation is observed for Bulgaria and Romania, occupying the last positions in the ranking in each of the areas.

In the next stage of the study, statistical analysis of the impact of demographic and socio-economic factors on the level of social expenditure was carried out for 28 countries of the European Union. The study began with the selection of variables based on which two regression models will be estimated. The dependent variable (Y) characterizing the level of social spending was total social spending in EUR million / inhabitant. For the set of potential explanatory variables, 14 indicators were selected: payments for social purposes in total EUR million / inhabitant (X1), percentage of active population (X2), people at risk of poverty or social exclusion (X3), life expectancy (X4), birthrate(X5), infant mortality rate (X6), total fertility rate (X7), young-age dependency ratio (population aged 0-14 to population 15-64 years) (X8), old dependency ratio (population 65 and over to population 15-64 years) (X9), structure of households by number of children – 1 (X10), structure of households by number

of children – 2 (X11), structure of households by number of children – 3 (X12), structure of households by number of children – 4+ (X13), Gini coefficient of equivalised disposable income (X14).

Using the Hellwig parametric method (Hellwig, 1981), variables strongly correlated with other features were eliminated, i.e. variables which are carriers of similar information. This allowed to identify central and satellite variables. As a result, eight features were included in the final set of diagnostic variables: X3, X4, X5, X7, X8, X10, X12, X14.

Next, linear econometric models were estimated, which were developed for 2008 and 2017. Table 1 presents the results of estimation of the econometric models. The symbol "-" means that the parameter wasn't statistically significant.

Table 2.

Estimation results of linear models

Variables	Coefficient values	
	Model (2008)	Model (2017)
	Y_2008	Y_2017
const	-72.6265	-66.2119
X3	-	-0.3822
X4	0.8028	0.7492
X5	-3.7709	-
X7	-	-
X8	0.7871	-
X10	-	-
X12	0.1707	0.7514
X14	-	0.5040
R²	0.6778	0.6444

Source: own elaboration.

Each model contains only four statistically significant explanatory variables. The coefficient of determination for both models is at the medium level, which is why model matching is sufficient, i.e. the model only explains about 60% of the variability of the dependent variable. In the next step of the analysis, spatial autocorrelation of errors was examined. For this purpose, Moran I test (Moran, 1950) was used for the residuals of the estimated models. The test results are presented in Table 3.

Table 3.

Moran I statistics values for the residuals of the linear model

Model (2008)		Model (2017)	
<i>I</i>	<i>p value</i>	<i>I</i>	<i>p value</i>
-0.0083	0.3435	0.1660	0.0500

Source: own elaboration.

Only in one model (2017) Moran I statistic is positive and statistically significant. This situation indicates the presence of spatial autocorrelation, i.e. no randomness in the distribution of model residues. The value of this statistic for the model estimated on the basis of data from 2008 is not statistically significant, which indicates the lack of spatial autocorrelation.

Continuing the model diagnostics, the LM test was used and it was checked which of the models, spatial lag or spatial error would be better. The results of this analysis are included in Table 4.

Table 4.

Selection of the spatial model

Model	Test LM				Spatial model type
	LM _{error}	p value	LM _{lag}	p value	
Model (2008)	0.0021	0.9636	4.4771	0.0344	Spatial lag model
Model (2017)	0.8342	0.3611	5.2170	0.0224	Spatial lag model

Source: own elaboration.

The LM_{error} tests for the estimated models are irrelevant, so it can be assumed that it is better to use spatial lag models.

In addition, table 5 presents the values of information criteria: Akaike (AIC) and logLik. Obtained results allow comparison of the linear model with spatial models (SEM - spatial error model, SLM - spatial lag model). The best model is the one for which the AIC criterion takes the lowest value, while the logLik criterion takes the highest value.

Table 5.

Information criteria values

Model	Criteria values	
	AIC	logLik
2008 SLM	128.0118	-57.0059
2008 SEM	135.8746	-60.9373
2008 CLS	133.8821	-60.9411
2017 SLM	150.1967	-68.0984
2017 SEM	156.2931	-71.1465
2017 CLS	156.9131	-72.4566

Source: own elaboration.

The information criteria values for models (2008 and 2017) clearly indicate the spatial lag model. The results of the estimation of the parameters of the suggested spatial model are given in Table 6.

Table 6.

Results of the spatial lag model estimation

Variables	Coefficient values	
	Model (2008) Y_08	Model (2017) Y_17
const	-56.6691	-53.3735
X3	-	-0.2182
X4	0.6017	0.58381
X5	-2.5550	-
X7	-	-
X8	0.6916	-
X10	-	-
X12	-0.0010	0.4747
X14	-	0.3721
α	0.4678	0.39304

Source: own elaboration.

In both cases, model coefficients and autocorrelation coefficients proved to be statistically significant. According to all criteria of information, spatial lag models are definitely better than linear models. The smallest impact on the dependent variable adopted for analysis has a birthrate (model 2008) and poverty level (model 2017); while the largest impact in the 2008 model has young-age dependency ratio, and life expectancy in the 2017 model.

In the next step of the study, based on the estimated spatial models, the forecast was determined and the quality of the forecast (RMSE) was determined. The obtained results are presented in Table 7.

Table 7.

Forecast results and RMSE values

Country	Total social spending in EUR million / inhabitant			
	Model 2008		Model 2017	
	CLS	SLM	CLS	SLM
Austria	7.8306	6.7067	10.7052	8.7622
Bulgaria	-0.6897	-0.0517	-1.1734	0.3552
Cyprus	8.3605	5.4069	9.7528	5.9428
Czech Republic	1.9713	2.9205	6.2179	6.1610
Belgium	9.7694	10.3176	11.0110	12.9472
Germany	6.6112	7.3884	9.9154	11.0084
Denmark	10.3006	10.3903	10.9744	11.6986
Estonia	1.9298	1.3145	5.5174	3.8061
Greece	5.4647	4.2195	5.2924	3.9802
Spain	5.5632	6.2365	8.0229	9.0221
Croatia	4.0838	4.2061	5.3185	4.3085
Hungary	2.5934	2.5666	1.6408	2.2198
Finland	9.0469	9.9871	11.5143	12.9131
France	11.3138	11.6998	12.1029	12.6097
Ireland	7.6117	8.4936	14.1389	13.0402
Lithuania	1.0168	1.1003	3.2471	2.6547
Luxembourg	8.8724	10.0049	9.5644	11.1353
Latvia	-0.3954	-0.4487	2.5224	2.0393
Malta	6.3163	4.0238	6.1885	3.4361
Netherlands	10.2625	10.1305	11.7741	12.1569
Italy	7.3052	7.8102	6.7397	8.8119
Portugal	6.7228	6.8287	6.0553	6.3729
Romania	3.1629	2.5257	-1.3507	-0.6259
Poland	2.5754	2.5539	5.2737	4.7613
Sweden	10.2846	10.4885	11.2072	12.4378
Slovakia	2.3349	2.5667	1.9712	2.2756
United Kingdom	9.1492	9.6243	10.5589	10.7203
Slovenia	3.4751	3.8326	6.3420	6.0943
RMSE	2.1329	1.7889	3.2181	2.6151

Source: own elaboration.

In this model, the spatial specification is better than, linear, because RMSE is smaller for the spatial model. However, too high a value of this error indicates that the forecast is not very accurate.

To improve the quality of forecasts, you can perform parametric bootstrapping for the parameters of the estimated model and on this basis forecast

5. Conclusion

The study carried out an analysis of the development of the social care system in EU countries in the years 2008-2017, and also examined the spatial relationships between variables affecting the size of social expenditure in these countries. During the study, the spatial dependence of spending on social purposes on the socio-economic environment was proved. Particularly significant turned out to be variables: people at risk of poverty or social exclusion by age and sex, life expectancy, birthrate, young-age dependency ratio, structure of households by number of children – 3 and Gini coefficient of equivalised disposable income i.e. Based on the conducted research, it can be seen that the progressing aging process of societies causes changes in the social care system.

References

- Arbia G. (2006), *Spatial Econometrics: Statistical Foundations and Applications to Regional Convergence*, Springer-Verlag, Berlin.
- Głabicka K. (1997), Polityka socjalna w Unii Europejskiej, *Studia Europejskie* 4/1997.
- Hellwig, Z. (1981). Wielowymiarowa analiza porównawcza i jej zastosowanie w badaniach wielocechowych obiektów gospodarczych. In W. Welfe (Ed.), *Metody i modele matematyczno-ekonomiczne w doskonaleniu zarządzania gospodarką socjalistyczną*, 46-68. Warszawa: PWE.
- Kopczewska, K. (2006). Ekonometria i statystyka przestrzenna z wykorzystaniem programu R CRAN. Warszawa: Cedewu.pl.
- Moran, P. A. P. (1950). *Notes on Continuous Stochastic Phenomena*. *Biometrika* 37 (1), 17–23.
- Pietrzykowski, R. (2011). Wykorzystanie metod statystycznej analizy przestrzennej w badaniach ekonomicznych. *Roczniki Ekonomiczne Kujawsko-Pomorskiej Szkoły Wyższej w Bydgoszczy*, 4, 97-112.
- Pośpiech, E. (2015). Analiza przestrzenna bezrobocia w Polsce. *Studia Ekonomiczne*, (227), 59-74.
- Sucheckie, B. (Ed.) (2010). *Ekonometria przestrzenna. Metody i modele analizy danych przestrzennych*. Warszawa: Wydawnictwo C.H. Beck.
- Tobler, W. (1970). A computer Model Simulating Urban Growth in Detroit Region. *Economic Geography*, 46(2), 23-240.
- Ulman L., Eichengreen B., Dickens W.T. (eds.) (2010), *Labor and an Integrated Europe*, Brookings Institution Press.
- [www] <https://ec.europa.eu/eurostat/data/database> (available: 15.04.2019).