STRUCTURAL EQUATION MODELING OF REGIONAL ECONOMIC DEVELOPMENT IN POLISH VOIVODESHIPS IN THE YEARS 2010-2014

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Abstract

Improving conditions for regional growth and welfare is currently a basic objective of European development strategy given in Europe 2020 plan. Thus, the research concerning the development process at a regional level is an important task both form the academic point of view and from the perspective of socio-economic governance. In this regard, the aim of the article is to quantify the level of economic development in Poland at the voivodeships level (NUTS 2) for the years 2010-2014. The phenomenon of economic development is treated not only as a multivariate problem, but it is also assumed that it should be considered as a latent variable. Thus, in the research Structural Equation Model (SEM) was applied. SEM model is the result of a merger between confirmatory factor analysis and path analysis applied in econometrics. Its advantage in the context of the aim of the research is its high elasticity. Application of the model enabled to verify the usefulness of the observable variables suggested by General Statistical Office of Poland for research on the country regional development. On the one hand, the conducted analysis confirms noticeable progress obtained by Polish regions.

Key words: Structural Equation Modeling, SEM, economic development, regions, Poland

JEL Code:C30, C38

Introduction

Improving conditions for regional development, treated a part of sustainability concept, is an objective of all European governments, which is supported at the European Union level with structural funds. It has been an important aim of Lisbon Strategy and current Europe 2020 plan (Balcerzak, 2015).Reaching sustainable regional development has been also a declared objective of all Polish governments. As a result, the quantitative research concerning the level of regional development is an important issue both from methodological and strictly informative perspective. For these reasons, the aim of the article is to quantify the level of economic development in Poland at the voivodeships level (NUTS 2) in the years 2010-2014.

The research is based on data provided by General Statistical Office of Poland. In this context, the additional aim of the article is to verify the usefulness of the observable variables suggested by the General Statistical Office for research on the Polish regional development.

The article consists of two main parts. First, the methodology of the research is briefly presented. In the second part, the empirical procedure, its results and discussion is given. The paper is ended with conclusions.

1 Structural Equation Modeling Methodology

The subject of the research is a regional development in Poland at the voivodeship level (NUTS 2). It is commonly accepted that the phenomenon of development cannot be measured effectivly with a single factor. The regional developmet is related to the situtaion on the local labour markest (Łaszkiewicz, 2016), effectiveness of local authorities and public services (Adamowicz & Machla, 2016; Lizińska *et al*., 2016), innovation potential of regions (Kondratiuk-Nierodzińska, 2016; Zemstov *et al*., 2016) andmany other factors. Thus, it should be analised as a multidimensional problem (Łyszczarz, 2016; Małkowska & Głuszak, 2016, Jantoń-Drozdowska & Majewska, 2016; Balcerzak, 2016a; 2016b; 2016c). Additionaly, it can be treated as a phenomenon describied with a latent variable (Pietrzak & Balcerzak, 2016). As a result, in order to quantify regional development Stuctural Equation Modeling methodlogy (SEM) can bee applied (see Loehlin, 1987;Kaplan, 2000).

SEM model consists of two submodels: a) an external model; b) an internal model. The external model enables to conduct factor analisis for the latent variable. The internal model is a cause and effect econometric model, which eanbles to analize the relations between the latent variables (Pietrzak& Balcerzak, 2016).

The external model can be given as follow:

$$\mathbf{y} = \mathbf{C}_{\mathbf{y}}\boldsymbol{\eta} + \boldsymbol{\varepsilon}, \tag{1}$$

$$\mathbf{x} = \mathbf{C}_{\mathbf{x}}\boldsymbol{\xi} + \boldsymbol{\delta}, \tag{2}$$

where: $\mathbf{y}_{p\times 1}$ - the vector of observed endogenous variables, $\mathbf{x}_{q\times 1}$ - the vector of observed exogenous variables, $\mathbf{C}_{\mathbf{y}}, \mathbf{C}_{\mathbf{x}}$ - matrices of factor loadings, $\boldsymbol{\varepsilon}_{p\times 1}, \boldsymbol{\delta}_{q\times 1}$ - vectors of measurement errors.

The internal model for one explanatory variable can be given as:

$$\boldsymbol{\eta} = \beta\,\boldsymbol{\xi} + \psi, \tag{3}$$

where: $\boldsymbol{\eta}_{m\times 1}$ - - vector of endogenous latent variables, $\boldsymbol{\xi}_{k\times 1}$ - vector of exogenous latent variables, β - regression parameter, $\boldsymbol{\psi}$ - vector of disturbances.

When the analisis is only limited to the identification and measurement of the latent variable, the SEM model is only used for confirmatory factor analysis. In that case only an external model is proposed. This apprach is taken in the current article.

The parameters of the SEM model can be estimated with application of a maximum likelihood method (MLM), a generalized least squares method (GLSM) and an asymptotically distribution-free (ADF), where the final choice of the method depends on the on the type of dataset, sample size and variables distribution. In the case of normal distribution of the observable variables, one can use MLM method.Otherwise the remaining two methods should be applied.

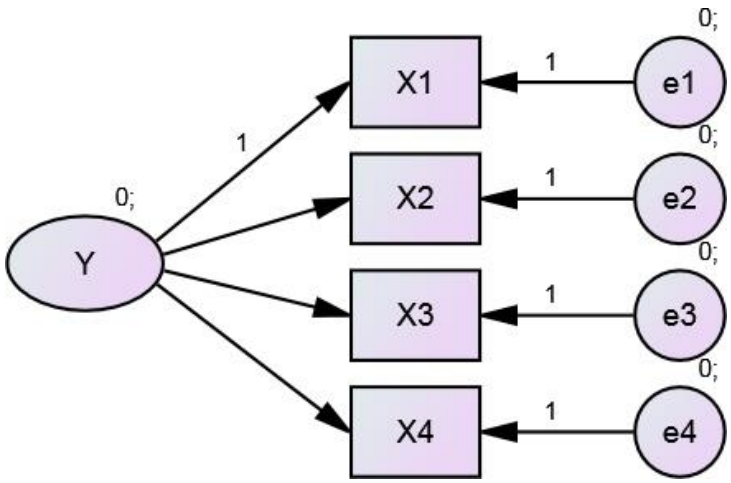
The verification of the quality of the model is usually done with application *IFI* (*Incremental Fit Index*) and *RMSEA* (*Root Mean Square Error of Approximation*). In the case of the first index when the IFI is higher than 0,9, the model is characterized with a sufficient fit to empirical data. In the case of the second measure when the value is below 0,1, it indicates good fit of the model to the empirical data. But it should be stressed that the pointed values were proposed for the models based on the survey data. In the case of data from official national statistics the given limits can be less restrictive (Pietrzak&Balcerzak, 2016).

2 Assessment of sosio-economic regions in Poland

Based on the aim of the research the parameters of the SEM model in the years 2010-2014 were estimated. The specification of the model is given on the figure 1. In accordance to the assumed hypothetic model only confirmatory factor analysis was conducted. Diagnostic variables that were applied for assessing the level of regional development treated here as the latent variable is given in table 1. The set of the potential diagnostic variables was restricted by availability of data at regional level. Additionally, the set of preliminary variables was verified with information quality criteriacommonly applied in taxonomic research, which resulted in limiting the number of final diagnostic variables (see: Balcerzak, 2009). The values of the variables were obtained from the online service: http://wskaznikizrp.stat.gov.pl/.

For all the variable Cronbach's alpha was tested. The obtained assessment of 0,77 for the given variables indicates that the variables can be used for proper description of the latent variable.

Fig. 1: Hypothetic SEM model for estimation of regional development in Poland



Source: own work.

Tab. 1: Variables in the SEM model

Variable	Description of Variables
Y	Latent variable – regional development
X_1	Gross domestic product per capita (PLN per inhabitant)
X_2	Investments outlays per capita (PLN per inhabitant)
X_3	Employment rate by age (%)
X_4	Expenditure on R&D activity in relation to GDP (%)

Source: own work based on General Statistical Office of Poland.

In the next step the parameters of the SEM model were estimated with the application of the model specification given in figure 1. The procedure was conducted in AMOS package. The parameters of the model were estimated with application of ADF method due to the fact that some variables did not fulfil the condition of normal distribution. The results are given in table 2. All the parameters of the external model were statistically significant, which means that the diagnostic variables were properly selected. The verification of the fit of the model to empirical data was conducted with application of *IFI* and *RMSEA* (given in table 2), were IFI value for the obtained SEM model was equal to 0,997 and *RMSEA* 0,148.

Tab. 2: Estimations of parameters of SEM model based on the confirmatory factor analysis

Variable	Parameter	Estimate	Standardized estimate	p-value

X_1	α_1	1.000	0.902	-
X_2	α_2	0.117	0.842	~0,00
X_3	α_3	0.175	0.697	~0,00
X_4	α_4	0.025	0.651	~0,00
Model	**IFI**	**RMSEA**		
Default	0.997	0.148		
Independence	0.000	0.558		

Source: own estimatin.

The obtained standardized values enable to assess the importance of the given variables in forming the latent variable. Based on the obtained factor score weights it was possible to order and propose the ranking of importance of the diagnostic variables in influencing the latent variable (see table 3). GDP per capita and the investment per capita were the most important variable here.

Tab. 3: Factor Score Weights for the SEM model

Latent variable	**Observable variables**			
	X_1	X_2	X_3	X_4
Technological potential	0.461	2.198	0.568	3.087

Source: own estimatin.

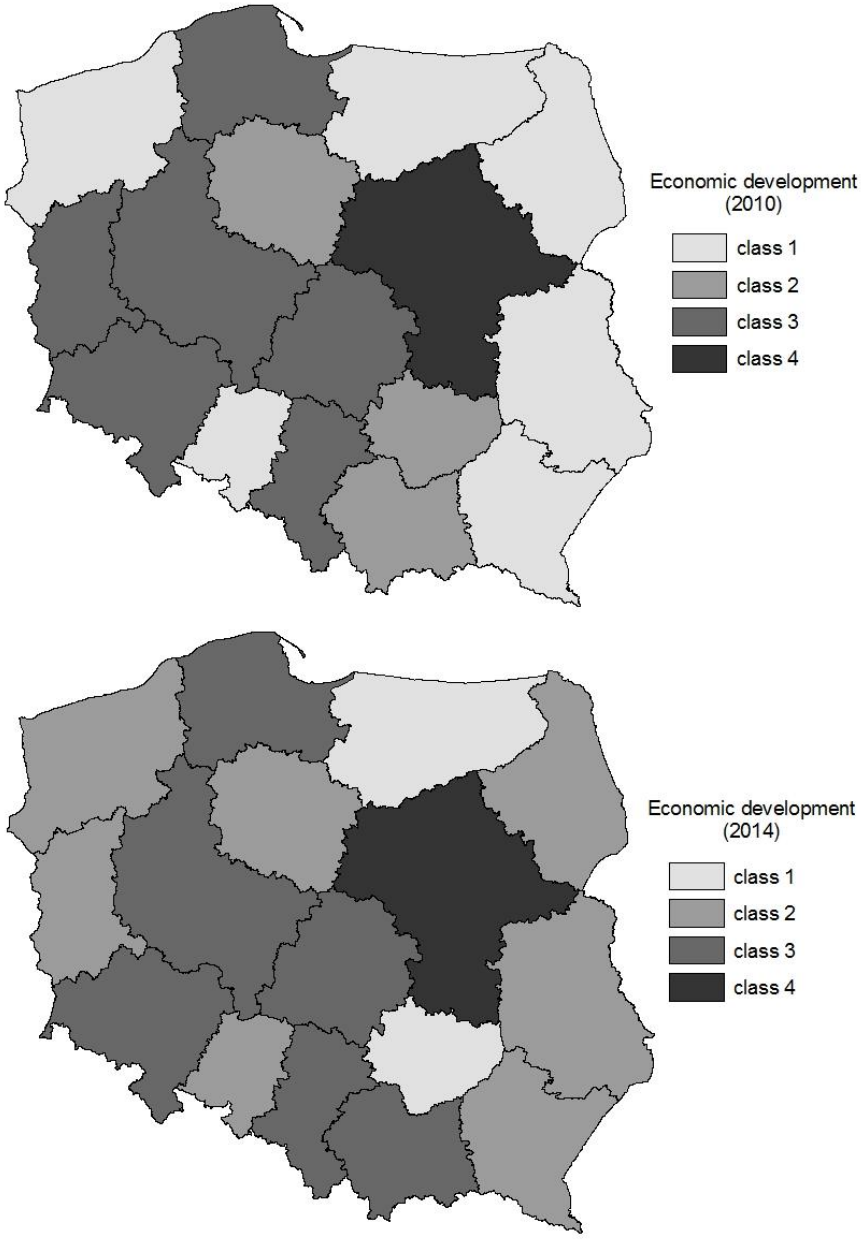
Next based on the values of diagnostic variables the values of the measure of regional development was assessed. The values of the latent variable for the years 2010 and 2014 were estimated based on the sum of product of values of Factor Score Weights and the values of given variables (see table 1). Then, a ranking ofvoivodeships based on their level of development in both years was proposed. Additionally, with application of Natural Breaks method the voivodseships were grouped in four classes. In the 4 class the voivodeships with the highest level of development were found. In the 1 class the once with the lowest level of development were grouped. The result can be seen in figure 2 and table 4.

The obtained results confirm that during the analyzed period the level of development in the case of most of the voivodeships significantly improved. It can be seen in the grouping of the regions in the classes. In the year 2010 in the 1 class one could find five voivodeships, whereas in the year 2014 there were only two of them. Swietokrzyskie voivodeship and lubuskie are exceptions in this regard, as swietkorzyskie has been degraded from the 2 to the 1 class, and lubuskie from the 3 class to the 2.

Mazowieckievoivodeship is the best developed. In both years it is the only voivodeship in the 1 class with the highest level of development. In the 3 class characterized with high level

of development one could find dolnoslaskie, wielkopolskie, pomorskie, lodzkie, slaskie i malopolskie. Among the regions with lower level of development (2 class) one could see zachodniopomorskie, podlaskie, opolskie, kujawsko-pomorskie, podkarpackieandlubuskie.

Fig. 2: The level of economic development Poland in the year 2008-2012



Source: own estimatin.

Tab. 4: Ranking and grouping of voivodeships based on the level of economic development

Level of development						
voivodeships	**2010**	**rank**	**class**	**2014**	**rank**	**class**
mazowieckie	77.772	1	4	91.721	1	4
dolnoslaskie	60.224	3	3	69.309	2	3

wielkopolskie	61.688	2	3	67.581	3	3
pomorskie	58.757	4	3	65.491	4	3
lodzkie	57.754	7	3	64.946	5	3
slaskie	58.645	5	3	64.284	6	3
malopolskie	56.229	8	2	62.666	7	3
zachodniopomorskie	51.421	13	1	58.27	8	2
podlaskie	49.554	16	1	57.666	9	2
opolskie	51.875	11	1	57.525	10	2
kujawsko-pomorskie	54.026	10	2	56.945	11	2
podkarpackie	51.679	12	1	56.236	12	2
lubuskie	58.398	6	3	55.821	13	2
lubelskie	49.996	14	1	55.449	14	2
swietokrzyskie	54.052	9	2	51.981	15	1
warminsko-mazurskie	49.961	15	1	51.664	16	1

Source: own estimatin.

Conclusion

The research was devoted to the analisis of regional development in Poland in the years 2010-2014. The phenomenon of regional devleopment was treated as a multivariate problem described with the latent variable. These factors justified appliation of SEM methodlogy in the research.

The obtained results confirmed that during the analised period a significant improvement of the economic development at the reigonal level was obtained. Though, some signifcant disparities between the regions are still present. Addiotnally, application of the SEM model enabled to verify the usefulness of the observable variables suggested by General Statistical Office of Poland for research on the country regional development. As a result, both objective of the papers were reached.

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