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**Socio-economic Sustainability in Poland. SEM Analysis
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Socio-economic Sustainability in Poland. SEM Analysis at Regional Level

Michał Bernard Pietrzak¹, Adam P. Balcerzak²

Abstract. Improving conditions for sustainable development has been a major aim of every Polish government since the beginning of transformation process. Thus, the aim of the paper is to analyse the level of sustainable development in Poland at regional level. The research was conducted at NUTS 3 level for the years 2010-2013. The analysis was based on the data from Central Statistical Office of Poland. It was assumed that the phenomenon of socio-economic sustainability at regional level should be considered as a multivariate latent variable. As a result, it was measured with application of Structural Equation Modeling (SEM). The proposed model was based on eight observable variables that are often pointed in the literature as measures of socio-economic development and human welfare. Application of SEM model allowed to verify the usefulness of the observable variables for analysis of the phenomenon of sustainable development in Poland at regional level. The conducted research confirmed serious disparities at regional level in the sphere of socio-economic sustainability that must be the subject of special interest and counteractions of Polish government.

Keywords: Structural Equation Modeling (SEM), regional analysis, sustainable development, Poland.

JEL Classification: Q01, C38

AMS Classification: 90C15

1 Introduction

Creating good conditions for sustainable development has been declared as a formal objective of every Polish government since the beginning of transformation process. It is especially important from the perspective of regional policy as the last two decades have been a period of quick macroeconomic convergence of Poland to EU developed countries, but in the same time significant divergence at regional level, which in the future can be a significant obstacle to long term growth [Pietrzak *et al.*, 2014]. From the short term perspective high degree of regional divergence and socio-economic unsustainability can negatively affect numerous spheres such as labour markets [Balcerzak (Ed.), 2009; Muller-Frączek & Pietrzak, 2011; Balcerzak & Żurek, 2011; Pietrzak & Balcerzak, 2016b; Wilk *et al.*, 2013], bilateral trade [Pietrzak & Łapińska, 2015], quality of human capital and life [Balcerzak, 2011; Hadaś-Dyduch, 2015; Balcerzak, 2016; Balcerzak & Pietrzak, 2016; Pietrzak & Balcerzak, 2016c], effectiveness of institutions [Balcerzak, 2009a, 2009b; Balcerzak & Pietrzak, 2014a, 2014b; Pietrzak & Balcerzak, 2016a] and fiscal stability of the country [Balcerzak *et al.*, 2016; Balcerzak & Rogalska, 2016; Mackiewicz-Łyziak, 2015]. Additionally, implementation of policies supporting socio-economic sustainability cannot be only treated as internal problem of Polish government, but to some extent it can be considered as an commitment to the EU. The sustainable development is considered as major objective of the EU guidelines given in such documents as Europe 2020 [Balcerzak, 2015] and it is supported by the EU structural funds.

As a result, the problem of monitoring socio-economic sustainability at regional level should be a subject of constant scientific research for Polish economists. In this context, the main aim of the paper is to analyse the level of sustainable development in Poland at regional level in the years 2010-2013. The main determinant of the research period was the availability of the data from Central Statistical Office of Poland at regional level (NUTS 3 level). Additional aim of the research is the verification of the usefulness of the data provided by Central Statistical Office of Poland for analysis of the phenomenon of socio-economic sustainability at regional level. As a result, the empirical analysis is conducted with application of Structural Equation Modeling (SEM).

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2 Research methodology

The concept of socio-economic sustainability makes multivariate phenomenon, which to some extent is determined by difficult to measure qualitative factors [Pietrzak & Balcerzak, 2015a; Balcerzak & Pietrzak, 2016a]. Thus, it can be considered as a latent variable in the sense of SEM methodology [Loehlin, 1987, Bollen, 1989; Balcerzak & Pietrzak, 2016b, 2016c]. SEM modeling is the result of a merger between confirmatory factor analysis and path analysis commonly used in econometrics. The main advantage of SEM models in regard to the objective of the paper is their much higher elasticity than the case of regression models. SEM enables to investigate interrelations between complex latent variables, which cannot be subject to direct measuring and are influenced by many factors [Brown, 2006; Byrne, 2010; Kaplan, 2000; Pearl, 2000].

The SEM model includes an external model and an internal model. The external model is used to measure endogenous and exogenous latent variables. It represents the results of the confirmatory factor analysis, which enables to calculate factor loadings for the variables that form the latent variable. It is also called a measurement model, which is given as:

$$\mathbf{y} = \mathbf{C}_y \boldsymbol{\eta} + \boldsymbol{\varepsilon}, \quad (1)$$

$$\mathbf{x} = \mathbf{C}_x \boldsymbol{\xi} + \boldsymbol{\delta}, \quad (2)$$

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

The internal model consists of equations that describe dependencies between latent variables. It is called a structural model, can be given as:

$$\boldsymbol{\eta} = \mathbf{A} \boldsymbol{\eta} + \mathbf{B} \boldsymbol{\xi} + \boldsymbol{\zeta}, \quad (3)$$

where: $\boldsymbol{\eta}_{m \times 1}$ - vector of endogenous latent variables, $\boldsymbol{\xi}_{k \times 1}$ - vector of exogenous latent variables, $\mathbf{A}_{m \times m}$ - matrix of regression coefficients at endogenous variables, $\mathbf{B}_{m \times k}$ - matrix of coefficients at exogenous variables, $\boldsymbol{\zeta}_{m \times 1}$ - vector of disturbances.

3 Analysis of regional socio-economic sustainability in Poland

In the research it is assumed that socio-economic sustainability is a latent variable. In order to measure it an external model based on SEM methodology was estimated. It is assumed that the internal model is not present here, which means that in this case only confirmatory factor analysis was conducted. The analysis was based on the observable variables presented in table 1. The original selection of the variables was based on the literature review on the determinants of sustainable development [Diaz-Chavez, 2014; Garriga & Mele, 2004; Jantón-Drozdowska & Majewska, 2015; Kopnina, 2016; Kuder, 2015; Libertowska, 2014; Richert-Kazmierska, 2015; Shrivastova, 1995; Spoz, 2014; Tureckova, 2015; Wronowska, 2015; Wozniak-Jechorek, 2015]. Before estimation of the model the X_4 variable that is a dis-stimulant was transferred into stimulant.

Variable	Description of the variable	Character of the variable
x_1	GDP per capita in regions	Stimulant
x_2	EU funds of municipalities per 1 inhabitant	Stimulant
x_3	Average monthly gross wages	Stimulant
x_4	Unemployment rate	Dis-stimulant
x_5	Number of registered enterprises in REGON registry per 10 thousand inhabitants	Stimulant
x_6	Investment of enterprises per capita	Stimulant
x_7	Migration balance coefficient for inhabitants in working age	Stimulant
x_8	The number of dwellings per 1000 inhabitants	Stimulant

Table 1 The set of observable variables influencing sustainable development at the regional level

In regard to the objective of the article a hypothetical SEM model was proposed. The model enabled to assess the level of socio-economic sustainability at regional level as a latent variable. The variables x_i $\{i=1,2,\dots,8\}$, represented observable variables that influence the latent variable. The parameters of the model were estimated in AMOS v. 16. The estimation of the parameters was done with maximum likelihood method. The results are presented in table 2. All the parameters of external model are statistically significant, which means a proper selection of observable variables for socio-economic sustainability at regional level. Standardized estimates can be used for assessing the importance of given variables for the socio-economic sustainability. Based on the results they can be ordered as follow: GDP, investment of enterprises, average wages as the variables with the strongest influence; then the number of enterprises, the number of dwellings, unemployment rate as the variables with the average influence; and migration balance and EU funds as the variables with the weakest importance. The classification of the variables was proposed arbitrary by the authors.

Variable	Parameter	Estimate	Standardized estimate	p-value	Factor Score Weights
x_1	α_1	1,000	0,991	-	0,836
x_2	α_2	0,043	0,214	~0,00	0,016
x_3	α_3	2,536	0,855	~0,00	0,016
x_4	α_4	-0,021	-0,646	~0,00	-0,508
x_5	α_5	1,416	0,781	~0,00	0,016
x_6	α_6	9,561	0,889	~0,00	0,006
x_7	α_7	0,086	0,389	~0,00	0,03
x_8	α_8	0,220	0,743	~0,00	0,082

Table 2 Estimated parameters of SEM model based on confirmatory factor analysis

To assess an adjustment of the model to the input data, the Incremental Fit Index (IFI) and Root Mean Square Error of Approximation (RMSEA) coefficients were applied. The value of the IFI coefficient was equal to 0,862. The value of the RMSEA coefficient was equal to 0,204. In the case of survey data IFI value should be higher than 0,9 and the value of RMSEA coefficient should be lower than 0,1. The estimated values of both coefficients did not fulfill these criteria. However, due to the aggregated socio-economic character of the data used in the research, the obtained values of both coefficients could be still accepted. The adjustment of the model to the input data could be considered as proper. The variable describing the level of sustainable development at the regional level in the years 2004-2013 was assessed basing on the sum of product of values of Factor Score Weights (given in table 2) and the values of given variables.

The assessed values of the latent variable for the year 2010 and 2013 are presented in table 3. Based on the value of the variable regions were ordered starting with the once obtaining the highest value of the indicator for socio-economic sustainability. Then, based on the values of average and standard deviation of the latent variable the regions were grouped to one of four classes:

1. The regions with very high level of latent variable, where: $SEM_i \geq \overline{SEM_i} + S(SEM_i)$
2. The regions with a high level of latent variable, where: $\overline{SEM_i} \leq SEM_i < \overline{SEM_i} + S(SEM_i)$
3. The regions with an average level of latent variable, where: $\overline{SEM_i} - S(SEM_i) \leq SEM_i < \overline{SEM_i}$
4. The regions with low level of latent variable, where: $SEM_i < \overline{SEM_i} - S(SEM_i)$

Sub-region	2010			2013			Sub-region	2010			2013		
	SEM _i	Rank	Class	SEM	Rank	Class		SEM _i	Rank	Class	SEM _i	Rank	Class
c. Warszawa	93	1	1	106	1	4	starogardzki	25	37	3	28	37	2
c. Poznan	62	2	1	72	2	4	szczecinski	25	38	3	28	39	2
legnicko-glogowski	56	3	1	56	5	4	oswiecimski	25	39	3	28	40	2
c. Krakow	49	4	1	58	4	4	ciechanowski	25	40	3	28	38	2
c. Wroclaw	49	5	1	58	3	4	bytomski	24	41	3	27	45	2

tyski	47	6	1	48	9	4	slupski	24	42	3	27	44	2
plocki	46	7	1	53	6	4	koninski	24	43	3	28	41	2
trojmiejski	44	8	1	52	7	4	pilski	24	44	3	27	43	2
katowicki	43	9	1	50	8	4	walbrzyski	23	45	3	26	51	2
c. Lodz	39	10	2	45	11	3	radomski	23	46	3	26	49	2
warszawski zachodni	39	11	2	46	10	3	tarnobrzescski	23	47	3	27	46	2
c. Szczecin	38	12	2	42	14	3	ostrolecki	23	48	3	27	42	2
gliwicki	37	13	2	43	13	3	wlclawski	23	49	3	26	53	2
poznancki	36	14	2	43	12	3	inow-roclawski	22	50	3	24	55	2
bydgosko-torunski	34	15	2	37	15	3	swiecki	22	51	3	26	48	2
bielski	31	16	2	36	17	3	gdanski	22	52	3	26	50	2
rybnicki	31	17	2	33	22	2	skierniewicki	22	53	3	26	47	2
sosnowiecki	30	18	2	33	20	3	elblaski	22	54	3	24	57	2
piotrkowski	30	19	2	35	18	3	krakowski	22	55	3	26	52	2
opolski	29	20	2	33	21	3	sandomi-ersko-jedrzejew	21	56	3	22	64	2
wroclawski	29	21	3	36	16	3	tarnowski	21	57	3	24	58	2
lubelski	28	22	3	34	19	3	chojnicki	21	58	3	23	61	2
gorzowski	27	23	3	30	33	2	sieradzki	20	59	3	24	54	2
leszczynski	27	24	3	32	23	2	nyski	20	60	3	23	62	2
koszalinski	27	25	3	30	34	2	lomzynski	20	61	3	23	59	2
bialostocki	27	26	3	30	26	2	grudziadzki	20	62	3	24	56	2
warszawski wschodni	27	27	3	31	25	2	suwalski	20	63	3	23	60	2
czestochowski	26	28	3	30	27	2	nowosadecki	20	64	3	22	65	2
rzeszowski	26	29	3	32	24	2	szcze-cinecko-pyrzycki	19	65	3	22	68	2
zielonogorski	26	30	3	30	30	2	elcki	19	66	3	21	69	2
lodzki	26	31	3	30	31	2	krosnienski	19	67	3	22	67	2
kielecki	26	32	3	29	36	2	bialski	19	68	3	22	66	2
olsztynski	25	33	3	30	35	2	pulawski	19	69	3	23	63	2
jeleniogorski	25	34	3	30	29	2	chelmsko-zamojski	18	70	3	20	71	2
kaliski	25	35	3	30	28	2	nowotarcki	18	71	3	20	70	2
siedlecki	25	36	3	30	32	2	przemyski	17	72	3	19	72	2

Table 3. The values of the latent variable for socio-economic sustainability at regional level

Finally, the regions have been assigned only to first three classes, because there are not any areas that fulfil the criteria given in point 4. This result can be interpreted as a positive one. It means that in Poland there are not any regions that are characterized with extremely low level of value of the measure of sustainable development. However, the analysis still confirms that the highest levels of socio-economic sustainability is present in the major urban centres of western Poland and sub-regions surrounding these centres. These regions were grouped in the first and second class. The third class groups the sub-regions with lower level of the value of socio-economic sustainability. One can find all the sub-regions of eastern Poland in this class, which means that eastern part of Poland is characterized with much lower level of socio-economic sustainability than western part. Due to the growing mobility of main economic factors (especially human capital mobility) the eastern part of the country can suffer additionally from the process of draining the most valuable economic resources. This means that without a proper and effective regional policy, these regions can be doomed to long term deterioration of socio-

economic situation. As a result only a targeted policies separate for the two areas of Poland can take into account the differences in terms of their socio-economic sustainability and support economic development of the whole country

4 Conclusions

The article was devoted to the analysis of the level of sustainable development in Poland at regional level in the years 2010-2013. The level of sustainable development was treated here as a latent variable in the sense of SEM methodology. In regard to the aims of the article the application of the model enabled to verify the usefulness of eight socio-economic variables provided by Central Statistical Office of Poland for assessment of sustainability at regional level.

The conducted research confirmed a serious disparities at regional level in the sphere of socio-economic sustainability, as the first two typological groups of regions characterised with the highest level of the indicator for sustainability were dominated by the regions that are the big agglomeration growth centres in western part of the country. The disparities should be the subject of special interest and counteractions of Polish government. Otherwise, they can become long term growth obstacle.

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