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Local development toward permanently sustainable low emission economy

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**Local development toward permanently sustainable low
emission economy**

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Local development toward permanently sustainable low emission economy

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Abstract

Research background: This article presents issues of rational management of energy throughout the Lubuskie province. The starting point was the idea of permanently sustainable development. The authors focused on the problem of reducing emission of polluting gases in the context of sustainable development. The results obtained were collated with other provinces and a comparative analysis was made.

Purpose of the article: The aim of the article is to evaluate the changes of emission of pollutants as well as the factor affecting emission and also to indicate the directions of its reduction. Such an approach is connected with both a long and short-term horizon, which follows from the necessity of securing clean air and “healthy atmosphere” at present as well as for future generations, taking into consideration, however, the economical, social and environmental context. In that sense, we are looking for an alternative which would secure permanent sustainability of development throughout the province.

Methodology/methods: The paper analyzes different solutions to decrease the use of coal to achieve the aims of CO₂ emission reduction throughout the Lubuskie province by means of an econometric model. The authors used a fixed effects model and selected statistical tests serving to evaluate and chose the right model. For evaluating the levels of penetration of different technologies considering their

economical, technical and environmental characteristics, a probabilistic approach and historical data were used.

Findings & Value added: Even though air pollution with gases has been dropping in the Lubuskie province since 2011, still the actions taken at the regional level are of great significance. The policy pursued by the region should include promotion of renewable sources of energy, spatial planning, or changes in the lifestyle. In the context of sustainable development, variables such as forestation, wages, number of plants, poverty threshold and population density have proven to be important.

Introduction

The concept of sustainable development combines economic and social aspects, taking at the same time into consideration respect for the natural environment, and concerns both the contemporary and future generations. The environmental element play a more and more significant role in modern world on account of the range of transformations taking place, as a result of development paths implemented so far, which were mostly determined by economic factors. The paper relates to the narrow approach and the problem of carbon dioxide emission to the atmosphere. The research was carried out for the territory of Poland with particular attention paid to the Lubuskie province. The objective of the paper is to assess the changes in air pollutant emissions and their economic, social and environmental factors. Such an approach is connected both with the short-term and long-term horizon, which follows from the necessity for satisfying the needs of the contemporary and future generations for fresh air and “healthy atmosphere”. In this meaning, we are looking for a permanent sustaining of development in the Lubuskie province on the background of other provinces. The article analyses the mechanism of CO₂ emission reduction in the Lubuskie province by means of an econometric model. A panel regression model with fixed effects and selected test statistics were employed. Innovative actions, which play a more and more significant role in enhancing CO₂ reduction, undertaken at the regional level, such as spatial planning, promotion of renewable energy sources and changes in the lifestyle, were presented.

Research Methodology

A statistical analysis of CO₂ emission in individual Polish provinces was performed. Minimum and maximum values, the mean, the median, standard deviation, the coefficient of variation, the average rate of changes and average level of the phenomenon under investigation were estimated. The

model of panel regression with fixed effects was used for the estimation of the impact of individual factors on the level of emissions. The analytic form of this model is expressed by the equation:

$$y_{it} = \alpha_i + \delta_t + \beta'x_{it} + \varepsilon_{it},$$

where:

i – index of the entity (province),

t - time (year),

α_i – individual effect, fixed in time, different spatially for individual provinces in the panel,

δ_t – fixed time effect, having the same value for all entities in the panel at the same time, but different at any another time, i.e., changing over time,

β' - vector of variable coefficients,

x_{it} – cross-sectional variables.

The model included economic, social and ecological variables which affect CO₂ emission. They included the number of enterprises particularly detrimental to the atmosphere, relative poverty threshold, the efficiency of devices and systems to reduce pollution, average level of wages and forestation. They constituted a representation of the basic components of sustainable development. Thus, the model hypothesis assumed the following form:

$$CO_2\text{emission} = \alpha_0 + \alpha_1 \text{No.of enterprises} + \alpha_2 \text{relative poverty threshold} + \alpha_3 \text{wages} + \alpha_4 \text{forestation} + \beta' DU + \lambda' DV,$$

where

β – vector of zero-one variable parameters for individual effects (Dt),

λ – vector of zero-one variable parameters for time T.

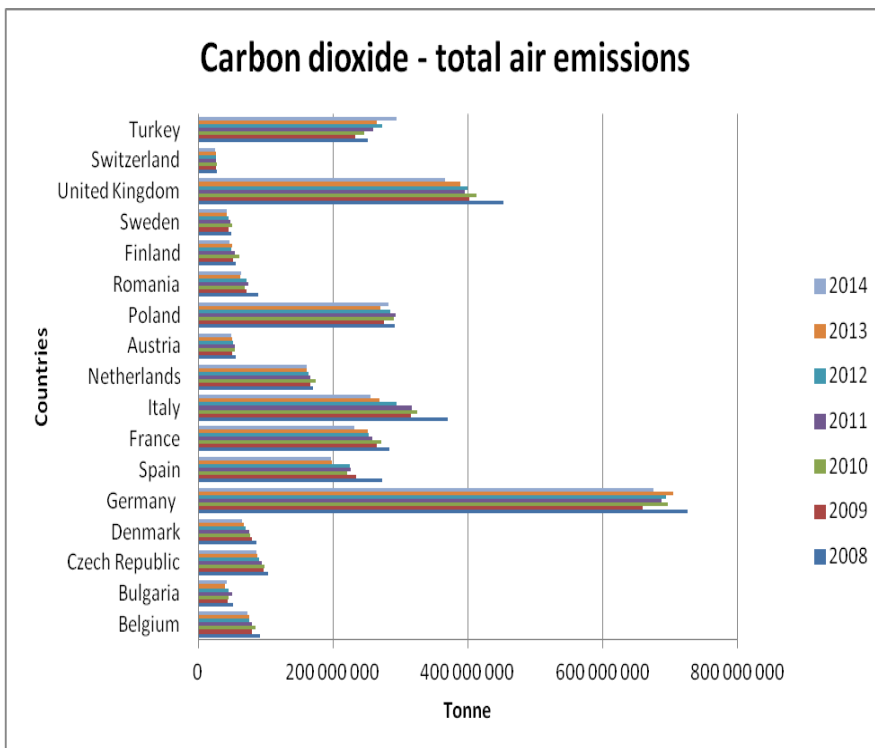
The choice of the method was dictated by the Breusch-Pagan test that was performed, in which the assumption of the null hypothesis substantiates the use of the Least Squares Method [Najbar, 2016, p. 219] (statistic LM 366,883 with the p-value equal to 8,92869e-082). The low value of p parameter allows rejection of H_0 and acceptance of an alternative hypothesis that a panel model with fixed/random effects will be more appropriate. Then the Hausman test was performed, for which H_0 means the reasonability of accepting the model with random effects and rejecting the alternative hypothesis on the reasonability of accepting the model with fixed effects [Najbar, 2016, s.220]. The H statistic was 13,1775 at the p-value equal to 0,021771, and this made it possible to reject the null hypothesis in favour of the alternative hypothesis. An estimation of the least squares panel was performed using 128 observations including 16 cross-sectional units (tab.1) and 8 time series.

Atmospheric pollution - problems with CO₂

The concept of sustainable development is extraordinarily broad and it covers numerous principles, objectives, rules and measures. Taking into consideration the objective of this paper, we focused only on these elements which are connected with atmospheric pollution due to CO₂ emissions. Air pollution, next to water pollution, water deficit, electromagnetic and ionizing radiation, limited resilience of biological life, spatial barriers, noise, vibrations, depletion of natural resources, is one of the factors hazardous to life on the Earth [Kozłowski, 1994, p. 16]. Air is a mixture of gases which surround the Earth and build up its atmosphere. It is composed in a substantial part of nitrogen (78,03%), oxygen (20,99%), argon (0,93%), carbon dioxide (0,03%) and remaining gases which constitute about 0,02% of the volume of air [Deszczka, Dworakowska et al., 2011, pp. 41-42]. According to Wnuk, air pollution occurs when harmful quantities of natural and synthetic compounds are introduced into the atmosphere as a consequence of direct and indirect activities of man. Pollution is a complex problem on account of the fact that a pollutant may be in a gaseous, liquid or solid form, and pollutants can be introduced into the atmosphere directly or they can form in the atmosphere from other pollutants through solar radiation¹ [Wnuk, 2010, p. 74]. The most frequent air pollutants include gaseous pollutants in the form of carbon dioxide, nitrogen oxides and solid particulates which occur in the form of volatile dust and fly ash [Deszczka, Dworakowska, et al., 2011, p. 42]. According to the OECD estimations, since the accession to the European Union in 2004, Poland has recorded an impressive economic growth. It allowed the improvement of the standard of life and environmental protection. However, as pointed out by Kozłowski, the Polish environment is exceptionally polluted with dust and gaseous emissions [Kozłowski, 1994, p. 16]. In 2012, Poland had the highest level of air pollution with fine dust particles in Europe. It is worth mentioning that Polish power plants are included among the largest contributors of *health and environmental damage* costs in the EU. In 2010, approximately 25 000 deaths were related to air pollution. This is one of the highest levels in the OECD [Environmental Performance Reviews 2015, p. 3-5]. The highest air pollution in Poland is still related to CO₂ emissions. According to Eurostat data Poland is one of the leading countries with the highest CO₂ emission in Europe (Fig.1).

Figure 1. CO₂ emission in Poland and some European countries in 2008-2014.

¹ Such a pollutant is called secondary.



Source: developed on the basis of eurostat data

Climate changes and their impact on life on the earth is reflected by including them as one of the PSR (Pressure – State - Response) indexes by international organizations.

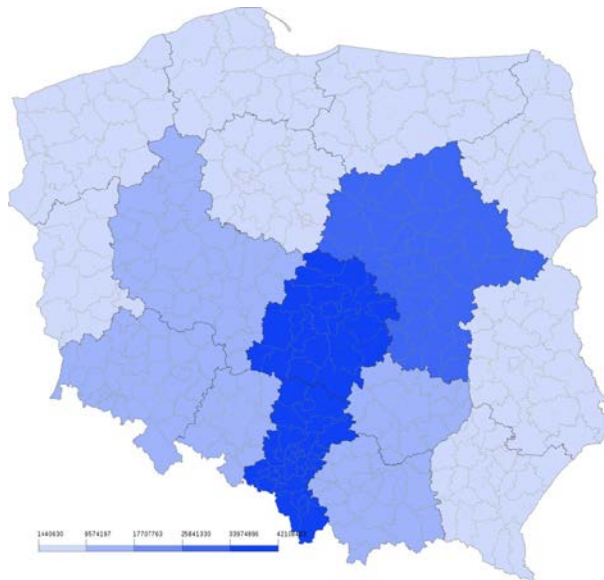
Sustainable development and CO₂ in the Lubuskie province

The premises of sustainable development in the Lubuskie province are included in the Strategy of the Development of the Lubuskie province 2020 (SRLW). Initially the document contained basic guidelines for the regional policy of the local government, and its implementation was expected to guarantee stable and sustainable development of the region. According to the strategy, the Lubuskie region was to be perceived as a place of healthy life style and gain the name of the ‘green area of modern technology’.

The realization of the plan is to be supported by the use of natural capital, which constitutes the major asset of the Lubuskie province, and includes the values of the natural environment, as well as its diversity. High rate of forestation and clean air are of particular significance. This creates an opportunity for the improvement of the life quality of local residents as well

as development of tourism. A lot of attention was paid to natural resources such as deposits of brown coal or natural gas, which in future may influence the development of the Province and constitute its competitive advantage. In the context of stable and sustainable development of the province, the need to maintain a high standard of the natural environment and simultaneous social and economic development, as well as highly specialized agriculture, remain major challenges. This is one of the challenges of the Strategy, which aims at assuring sustainable development and optimum utilization of resources. The primary goal of the attempts is to take advantage of the location of the Lubuskie province in Europe, the positive aspects of the environment as well as communication accessibility [Strategia Rozwoju...,2012, pp. 4-30]. In 2015 the emission of CO₂ in Poland totalled at 209961550 t/y. To a larger or lesser extent each of the provinces contributed to the increase in the volume of emission from particularly noxious companies.

Figure 2. A map of CO₂ emission in particular provinces in 2015



Source: developed on the basis of BDL data and <http://mapy.easysoftware.pl/> website

Recently, in Poland the highest emission of gases from particularly noxious companies was observed in central and south-western part of the country, and in particular in the Mazowieckie, Łódzkie and Śląskie provinces.

The issue of CO₂ emission can be considered by means of search for mutual dependencies in the econometric model. Various economic, social and environmental factors are analysed in the background literature. The publications of Xu and Lin (2016, p. 1462), Du Wei, Cai (2012, p. 378) Kemplinger, Templ, Upadhyaya, (2013, p. 757) Xu i in (2017, p. 3063) include the level of GDP per capita, the level of urbanization, the number of private cars, energy consumption, the level of the use of coal, export, the structure of energy production, import, the level of consumption per capita and investment. Regional, sector or combined approaches prevail in the papers. The constellation of assessed factors indicates that the problem of stable sustainable development is stressed to a lesser extent.

In the analyzed period, the highest level of emission measured by the average level of the phenomenon was observed in Łódzkie, Śląskie and Mazowieckie provinces. The high level of emission in the aforementioned provinces is additionally confirmed by high values of the observation of maximum, minimum and average levels. The average level of emission in the Lubuskie province was one of the lowest in the analyzed period. In order to specify the impact of selected economic, social and ecological factors on CO₂ emission, a model of panel regression with fixed effects was used (Table 1).

Table 1. Estimation of model parameters for the dependent variable: CO₂ emission

List	Coefficient	Mean error	t-distribution	P value	
Const	-4,16482e+07	1,39527e+07	-2,9850	0,0093	***
No. of companies	50252,9	16619,3	3,0238	0,0085	***
Wages	12682,9	3400,02	3,7302	0,0020	***
Relative poverty threshold	109969	54736,6	2,0091	0,0629	*
Pollution reduction	-2,43741	1,17148	-2,0806	0,0550	*
Forestation	-4,48497	3,35023	-1,3387	0,2006	
Kujawsko-pomorskie	2,81446e+06	1,70435e+06	1,6513	0,1018	
Lubelskie	-1,03599e+06	1,22519e+06	-0,8456	0,3998	
Dolnośląskie	2,58206e+06	2,84781e+06	0,9067	0,3668	
Łódzkie	3,15042e+07	2,14055e+06	14,7178	<0,0001	***
Małopolskie	-59682,2	2,6912e+06	-0,0222	0,9824	
Mazowieckie	5,46343e+06	6,00437e+06	0,9099	0,3651	
Opolskie	5,44696e+06	2,87273e+06	1,8961	0,0608	*
Podkarpackie	56750,6	795081	0,0714	0,9432	
Podlaskie	-2,34622e+06	947654	-2,4758	0,0150	**
Pomorskie	-3,79132e+06	2,31199e+06	-1,6399	0,1042	
Śląskie	1,49586e+07	6,48096e+06	2,3081	0,0231	**

Świętokrzyskie	5,92941e+06	2,40853e+06	2,4618	0,0155	**
Warmińsko-mazurskie	66382,7	1,00484e+06	0,0661	0,9475	
Wielkopolskie	9,18687e+06	1,89466e+06	4,8488	<0,0001	***
Zachodniopomorskie	3,31443e+06	1,43168e+06	2,3151	0,0227	**

Legend: * $p < 0,1$; ** $p < 0,05$; *** $p < 0,01$.

Source: author's data processed by Gretl 2016d.

Due to collinearity, the time variable for 2015 was omitted

Table 2. Matching evaluation and statistical tests of the estimated model

Arithmetic mean of the dependant variable	13265837	Standard deviation of the dependant variable	12084811
Sum of square remainders	1,28e+14	Standard deviation of remainders	1132754
LSDV square R	0,993082	Within square R	0,211507
Likelihood logarithm	-1950,166	Crit. Akaike inform.	3956,332
Crit. bayes. Schwarz	4036,189	Crit. Hannana-Quinna	3988,778
Remainder autocorrelation - rho1	0,478127	Stat. Durbin-Watson	0,902184

Source: author's data processed by Gretl 2016d.

On the basis of the analyses, several significant regularities can be observed, particularly in the context of permanent differences. The volume of emission obviously depends on the number of subjects generating pollution. From the point of view of the hereby considerations concerning the mechanism of shaping the balance, corrective factors are of particular significance. Increased tendency to approve the level of carbon dioxide emission was partly compensated by the level of remuneration (economic sphere), which had a positive influence on its amount. At the same time it has to be noticed, that in accordance with the theoretical assumptions, increased number of people living below the threshold of poverty contributes to higher CO₂ emission.

This constitutes a social element in the analyzed system of sustainability. A similar approach applies to actions connected with the amount of means designated for the investment undertaken by private subjects and aimed at the decrease of the emission. This is a social and legal element resulting from changes in regulations as well as the impact of the community at the local level (yet such influence cannot be explicitly narrowed) on the decisions of economic subjects and costs borne by them in respect of pro-environmental activities. The environmental aspect is perceived in the form of broadly understood green areas. In this context, higher levels mean correction of emission and a different direction of the allocation of resources. This constitutes both a direct effect (CO₂ absorption), as well as decisions

concerning the area development plan of the province in the long term perspective.

Summary

The statistical data as well as the results of the estimation of the model of panel regression presented above, indicate a low impact of the Lubuskie province on CO₂ emission. Although Lubuskie province, only to a limited extent, contributes to the emission of CO₂ at the national level, there is a need to undertake further action aimed at further reduction of the emission. Despite the decrease in the emission of gas pollution in the Lubuskie province since 2011, actions at the local level as well as promotion of renewable sources of energy, area development planning or changes in the life style remain significant.

In the context of sustainable development, such variables as forestation, remuneration, number of companies, the level of poverty and density of population occurred to be important. All these factors significantly explained the impact on the sustainable social, economic and environmental development. To a certain extent, this constitutes the choice between shaping the available area (among others green areas) and economic and social effects, which form specific substitutes for the consequences of choices in respect of the level of emission in particular provinces.

The panel analysis demonstrates the occurrence of individual effects confirming the significance of the analysis of CO₂ emission at the regional level, at which the level of emission is influenced by its specific characteristics connected with geographical location and the assumed level of sustainability. However, spatial dependencies confirm the conclusions resulting from the laws of Tobler's geography concerning the interaction between regions and mutual impact of some regions on other areas.

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