ECONOMIC-STATISTICAL ANALYSIS OF REGIONAL DEVELOPMENT AND ENVIRONMENTAL INVESTMENTS DIVERSIFICATION

Viktor Voytsekhovky[1], Viktoriya Voytsekhovska[2], Anastasiya Symak[3]

Apstract: *Article aims at study the interrelations for economics development of polish Voivodships. Those interrelations were found by means of economic mathematic and statistic methods. The problem of investments distribution for environmental investments is developed, taking into account population density and rate of industrial air pollutants emission.*
Key words: *regional development, optimization, Voivodship, statistical analysis.*

INTRODUCTION

The article aims at analysis of regional development on the example of Poland's Voivodeships, in particular, studied by statistical data dependence GDP from fixed assets. Main area of research-defined linear relationship between these factors using the method of least squares.
Appropriate calculation for polish Voivodeships data are following (Table. 2) [4].

Table 2. Voivodships data - 2008.

No.	Voivodships	Gross value of fixed assets, bln. PLN	Gross domestic product, bln. PLN
1	Lower Silesian	179,8	96,7
2	Kuyavian-Pomeranian	93,8	55,3
3	Lublin	99,2	45,4
4	Lubusz	54,7	27,6
5	Łódź	133,5	72,7
6	Lesser Poland	160,4	86,6
7	Masovian	477,8	255,9
8	Opole	59,1	26,6
9	Subcarpathian	97,1	43,7
10	Podlaskie	59,9	27,4

[1] Prof. Viktor Voytsekhovky, Head of Department of finance, Bucovinian University, Darvina 2-A, Chernivtsi-58000, Ukraine, E-mail: viktor.voytsekhovskyy@gmail.com
[2] PhD. Viktoriya Voytsekhovska, Lviv Polytechnic National University, Department of Economics of Enterprise and Investments, Yaroslavenka 47/5, Lviv-79034, vita_voj@yahoo.com
[3] PhD. Anastasiya Symak, Lviv Polytechnic National University, Department of Economics of Enterprise and Investments, St. Bandery, 12, Lviv - 79013, Ukraine, asymak7@gmail.com

No.	Voivodships	Gross value of fixed assets, bln. PLN	Gross domestic product, bln. PLN
11	Pomeranian	122,7	67,1
12	Silesian	268,7	152,7
13	Świętokrzyskie	59,1	30,3
14	Warmian-Masurian	67,5	32,8
15	Greater Poland	200,3	109,1
16	West Pomeranian	93,5	46,9

The results of data processing are shown on Figure 1.

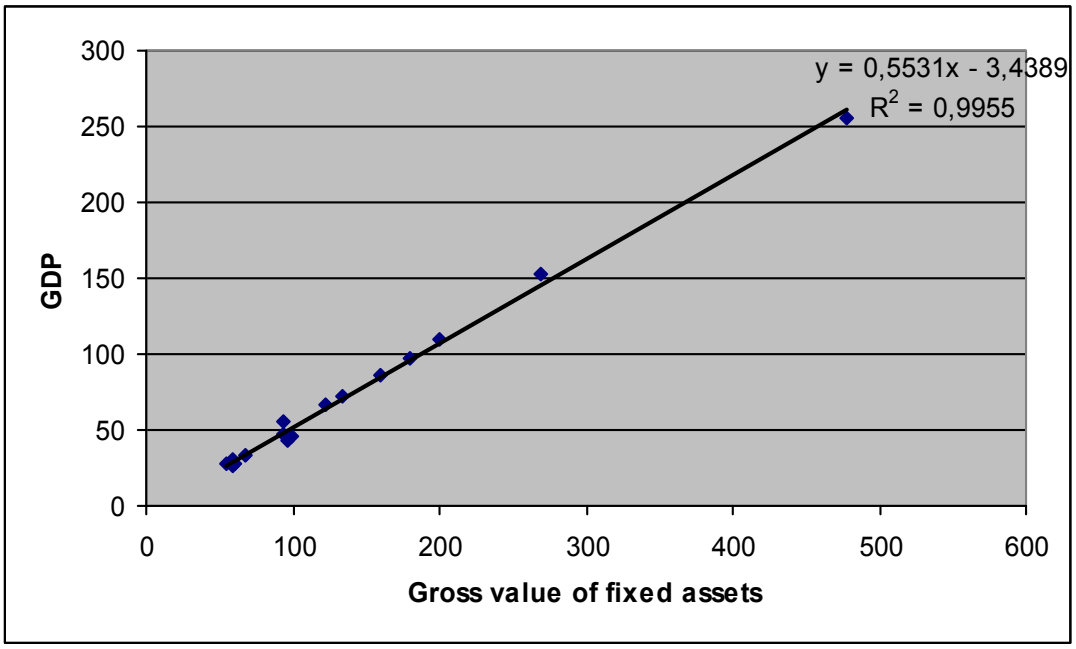

Figure 1 Statistical interrelation in between gross value of fixed assets and GDP, 2008 [4]

Therefore the statistical data processing shows that according to 2008 data, the following strong interrelation between fixed assets gross value and GDP volume exists which tends to be almost functional:

$$P = -3,4889+0,5531F,$$

Where:

P – GDP
F – gross value of fixed assets.

It should be noted, that by means of such interrelation between factors, which is valid for certain time period, the dynamics change and its tendencies for fixed assets and GDP can be found.
Once considering linear interrelation taking into account time factor results:

$P_t=a+bF_t$;

It follows that:

$P_t-a=bF_t$; $P_{t+1}-a=bF_{t+1}$.

For absolute increase P and F following interrelation can be obtained:

$P_{t+1}- P_t =b(F_{t+1}- F_t)$; $\Delta P = b\Delta F$.

The interrelation in between factors and their relative growth will result in following:

$$\frac{\Delta P}{P_t(1-\frac{a}{P_t})} = \frac{\Delta F}{F_t}.$$

The transition to rates of increase will be:

$$\frac{\Delta \eta_P}{1-\frac{a}{P_t}} = \Delta \eta_F ,$$

Where:

$\Delta \eta_P$ - rates of GDP increase,

$\Delta \eta_F$ - rates of increase of fixed assets.

The interrelation of rates of GDP increase and fixed assets results in following equation:

$$\frac{\Delta \eta_P}{\Delta \eta_F} = 1-\frac{a}{P_t},$$

The analysis of this equation shows that symbol of parameter **a** defines the character of GDP and fixed assets dynamics. The following three combinations of such dynamics exist:

1) a<0, $\Delta \eta_P > \Delta \eta_F$;

2) a=0, $\Delta \eta_P = \Delta \eta_F$;

3) a>0, $\Delta \eta_P < \Delta \eta_F$

To summarize, when the sign of parameter a is negative, the rates of increase of GDP exceed rates of increase of fixed assets. Under condition a=0, these rates will be equal. For the option, when sign of parameter a is positive, rates of GDP increase will be lower then rates of fixed assets increase.

Therefore during study period according with obtained statistical interrelation, if constant a has negative sign then should be expected that rates of GDP increase will exceed rates of production capital increase.

We shall stress, that according with statistical data processing of similar data from 2003 [5] obtained correlation resulted in:

P=-4,6154+0,5217F.

The parameters of this interrelation are very similar to ones obtained in 2003. Moreover, the sign of parameter a is as well negative. As was stated above, the analysis showed that rates of GDP increase on the interval 2003-2008, were greater then rates of fixed assets increase (1,50>1,33).

Such economic development tendency must be considered effective, since the results are growing faster then main resource – production capital.

Economics development should also include environmental component, which is linked with reducing pollution of soil, water, air etc. For instance, considering emission of industrial air pollutants, it's observed positive dynamics of clean air. In 2003 emission of industrial air pollutants was 1947 thousand tons in 2008 - 1785 thousand tons, or is decreased about 10% or 162 thousand tons.

In each Voivodeship this dynamics of emissions had individual character. The most significant reduction in gas emissions was reached in Łódź, Masovian and Greater Poland.

Since pollution abatement requires certain investments disposal, therefore the need for investments distribution along territories and regions arises. Diversification of investments can be achieved in different ways. One of the main options to be considered is based on ranking investments on their efficiency in practice of management often called "fair apportionment" of investments in accordance with the object size. But the most rational approach should be considered as such in which

compromise can be achieved between investments performance and pollutions negative impact [5]. The corresponding optimization model is as follows:

$$E = \frac{n_1}{S_1} K_1 + \frac{n_2}{S_2} K_2 + ... + \frac{n_n}{S_n} K_n \to \max ,$$

$$K_1 + K_2 + ... + K_n \le K ,$$

$$\left(\frac{K_1}{Z_1} - \lambda \right)^2 + \left(\frac{K_2}{Z_2} - \lambda \right)^2 + ... + \left(\frac{K_n}{Z_n} - \lambda \right)^2 \le \delta^2 ,$$

$$\lambda = \frac{K_1 + K_2 + ... + K_n}{Z_1 + Z_2 + ... + Z_n} ,$$

$$K_i \ge 0 .$$

This model contains next symbols: E – target function, $\frac{n_i}{S_i}$ - population density by km^2,

K_i- investments targeting air pollution reduction, Z_i- emission of industrial air pollutants,

λ - relation of total investment to total air pollution.

According to problem statement the effect from unit investment depends on population density and territory size. At the same time, the limitation concerning total investments volume, that are used to reduce air pollution is evident. In order not to use all investments for the territories with highest its effectiveness, it is important to add square limitation for relative deviation from average. It ensures in optimal version of the distribution the guarantee for the Voivodships with lower investment performance equitable investment shares.

We use formulated model to optimize the distribution of investments using Voivodships 2008 statistical data [4].

Table 3. Emission of industrial air pollutants by Voivodship - 2008.

Nr	Voivodships	Gross value of fixed assets, bln PLN	Emission of industrial gas pollutants, 1000 t
1	Lower Silesian	179,8	88
2	Kuyavian-Pomeranian	93,8	59
3	Lublin	99,2	33
4	Lubusz	54,7	29
5	Łódź	133,5	144
6	Lesser Poland	160,4	156
7	Masovian	477,8	201,8
8	Opole	59,1	60
9	Subcarpathian	97,1	21
10	Podlaskie	59,9	11
11	Pomeranian	122,7	35
12	Silesian	268,7	571,2
13	Świętokrzyskie	59,1	84
14	Warmian-Masurian	67,5	9
15	Greater Poland	200,2	160
16	West Pomeranian	93,4	43

The optimization problem can be analyzed under condition K=1. In order to obtain quantitative results the computerized version of such algorithm is shown in Table 4.

Table 4. Investments distribution that aim at air pollution decrease.

Nr	Voivodships	Proportional investments distribution	Optimal investments distribution
1	Lower Silesian	0,0490	0,0259
2	Kuyavian-Pomeranian	0,0330	0,0209
3	Lublin	0,0190	0,0142
4	Lubusz	0,0160	0,0127
5	Łódź	0,0810	0,0168
6	Lesser Poland	0,0870	0,0428
7	Masovian	0,0880	0,0144
8	Opole	0,0340	0,0208
9	Subcarpathian	0,0120	0,0103
10	Podlaskie	0,0060	0,0057
11	Pomeranian	0,0200	0,0155
12	Silesian	0,3840	0,7566
13	Świętokrzyskie	0,0470	0,0218
14	Warmian-Masurian	0,0050	0,0047
15	Greater Poland	0,0900	0,0000
16	West Pomeranian	0,0240	0,0164

The calculations show, that according with proportional investments distribution concerning air pollution by Voivodship, the target function will be E = 228,8. In optimal version of investments distribution the target function is bigger - $E_{опт}$= 316,8. Last option shows that the effect from the same amount of investment can be by 1,4 times bigger. In optimal version of investments distribution the amount of 75% focus on Silesian Voivodship where the percentage of gas emission and population density are higher. Therefore the air pollution reduction in this Voivodship results in bigger effect from investment use.

The statistical analysis and results obtained by means of economic-mathematic modeling proves that there is a possibility of quantitative assessment of economics development and its optimal choice. The results obtained can be of practical importance if the found quantitative relations are used during forecasting and planning of the economic development of the regions.

LITERATURE

1. V. Voytsekhovskyy. Optimization of production systems. Наукова думка, Kyiv. - 1991.
2. W. Wojciechowsky., W. Wojciechowska. Economics assessment of innovative fixed assets innovative renovation//Digest of scientific works. Economic sciences. Addition 2: Chernivtzi. „Bukrek", 2006-.38-48p.
3. Rocznik statystyczny Rzeczypospolitej Polskiej 2008, 2009.
4. W.Wojciechowski, W.Wojciechowska. Linear production function in econometrical analysis of production potential of the region/IUS ET FIDES. Towarzystwo Naukowe Katolickiego Uniwersytetu Lubelskiego Jana Pawla II. Prace Wydzialu Nauk Prawnych – 2006, Str. 725-737.
5. W.Wojciechowski, W.Wojciechowska. Ekonomiczno-matematyczne modelowanie a optymalizacja procesów innowacyjnzch/Gaudium in litteris. Towarzystwo Naukowe Katolickiego Uniwersytetu Lubelskiego Jana Pawla II. Prace Wydzialu Nauk Prawnych - 2009, Str. 1093-1105.