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Analysis and modeling of indicators of sustainable development of regions in the Republic of Kazakhstan

Sustainable development management includes three major components: environmental, social, economic. This paper is focused mainly on environmental part.The article includeseconometric modeling approach in the analysis of environmental governance in the Republic of Kazakhstan on the way to sustainable development. We estimate regions in the Republic of Kazakhstan according to their economic and environmental development. Based on the above-mentioned we proposed 4 clusters. According to the analysis of environmental situation we found out that there is a need to minimize ecological consequences, future externalities for new generations. Public authorities need to understand it in the process of implementation of long-term social and economic strategy in the Republic of Kazakhstan. The prediction of the transition to «sustainable» development made by our macroeconomic model is very favourable for the Republic of Kazakhstan from economic, environmental and social points of view. In our model, it was shown that «sustainable development» not only leads to the economic development of the country as a whole, but also provides a higher GRP growth rate, smoothes uneven regional progress, and guarantees «development» itself - one of the key indicators of the country's well-being.

Keywords: sustainable development, management, economic sphere, social sphere, ecological sphere, Kuznets curve, Kazakhstan model, cluster, indicators of sustainable development, regions.

System of indices and indicators, which includes various components, is used to assess the level of sustainable development both at the regional and national level, as well as its modelling. In view of the availability of a huge variety of "sustainable development" definitions in the interpretation of domestic and foreign scientists, involved in the management of sustainable development, by sustainable development we understand a model of governance that will ensure a decent standard of welfare and dynamic development of economic and social system with the environment. A.A. Shalmuev in relation to socio-economic system defines "sustainability" in the most general form as the ability of the system to return relatively quickly to its original state or reach a new and higher point on the path of its development [1].

One of the most complete systems on coverage of sustainable development indicators was developed by the United Nations Commission on Sustainable Development. The indicators are divided into main groups:

– indicators of social aspects of sustainable development,

– indicators of economic aspects of sustainable development,

– indicators of the environmental aspects of sustainable development (including the characteristics of the water, land, air, other natural resources and waste),

– indicators of institutional aspects of sustainable development (programming and policy planning, research and development, international legal instruments, information technology, strengthening the role of major population groups) [2].

In this work we have attempted to analyze the relationship between the level of environmental pollution and the volume of GDP in Kazakhstan (in the whole country). In the basis we used the Environmental Kuznets Curve [3, 4] proposed by D. Grossman and A. Krueger [5].

Simplified Environmental curve regression equation is as follows:

$$Y_{it} = \beta_0 + \beta_1 \text{ВВП}_{it} + \beta_2 \text{ВВП}_{it}^2 + \beta_4 \overline{\text{ВВП}}_{it} + \beta_5 \overline{\text{ВВП}}_{it}^2 + u_{it},$$

where Y_{it} – the level of pollution; ВВП_{it} – the volume of gross domestic product; $\overline{\text{ВВП}}_{it}$ – three-year moving averages of gross domestic product volumes.

In this case, the moving averages are usually included in model for smoothing short-term fluctuations and highlighting fundamental trends or cycles. Mathematically moving average is one type of fold, and it can, therefore, be regarded as a low pass filter used in processing signals [6].

Estimation of coefficients of the regression equation we will produce by the least squares method. As a result of fitting the data on the volume of GRP and emissions of air pollutants by 16 regions of Kazakhstan for the period from 2006 to 2015, was obtained the following equation:

$$Y_{it} = 81{,}47 + 0{,}13\text{ВРП}_{it} - 0{,}00004\text{ВРП}_{it}^2 + 0{,}03\overline{\text{ВРП}}_{it} - 0{,}000005\overline{\text{ВРП}}_{it}^2,$$

wherein: Y_{it} – emissions of pollutants from stationary sources, thousand tons; ВРП_{it} – the volume of gross regional product, blntenge; $\overline{\text{ВРП}}_{it}$ – three-year moving averages of gross regional product volumes, blntenge.

Since the coefficient $\beta_2 = -0{,}00004 < 0$, and the coefficient $\beta_1 = 0{,}13 > 0$, we obtain a convex upward curve (∩-shaped) changing its direction with respect to the inflection point from growth to fall.

Differentiating the equality in terms of GRP, and equating the result to zero, we have calculated the amount of GDP on average in Kazakhstan for which the amount of pollution reaches its maximum value. And have found that the contamination peak occurs at the level of the GRP = 1677, 05 billion tenge. A further increase in this indicator in the Republic of Kazakhstan leads to pollutants emissions reduction.

However, this trend is not observed for a longer period. As a result of the data processing on the volume of GRP and emissions of air pollutants by 16 regions of Kazakhstan for the period from 2000 to 2016, we obtained the following regression equation:

$$Y_{it} = 119{,}8 - 0{,}07\text{ВРП}_{it} + 0{,}00001\text{ВРП}_{it}^2 + 0{,}15\overline{\text{ВРП}}_{it} - 0{,}00003\overline{\text{ВРП}}_{it}^2.$$

In the equation, the coefficient $\beta_2 = 0{,}00001 > 0$, and the coefficient $\beta_1 = -0{,}07 < 0$, therefore, downward convex curve (U-shaped) changes its direction with respect to the inflection point fromdropto the growth.

In this equation using the moving averages of gross domestic product, which are typically included in a model for smoothing short-term fluctuations and highlighting major trends or cycles, we observe a slightly different picture, analyzing long trend. This may be connected to the cyclical development of the economy in the long term, which in itself, does not contradict the principles of sustainable development.

Since economic growth reflects the quantitative changes (in the form of gross domestic product); and sustainable development reflects the positive qualitative changes aimed at growth, the transformation and the transition from one state to another.

Cyclic recurrence of the economy development can be defined as a form of its development, as a movement from one to the other macroeconomic equilibrium, i.e. the transition from one state to another. In this context, the U-shaped curve represents, on one hand, the economic cycle phases. But, since cycle recurrence itself is a form of economy development, the crisis (manifested in decline point), in turn, appears as a form of economic development.

Further research is of practical interest of the impact of economic development on the level of pollution in different regions of Kazakhstan. At first, in order to do this we held clustering of all regions by the two indicators - the number of air pollutants emissions from stationary sources (thousand tons), and gross regional product (blntenge) using data for 2015 [7].

For the classification of regions we used cluster analysis, allowing carrying out decomposition of objects into homogeneous groups or clusters on a number of grounds. Homogeneous objects are considered as objects,observable signs of which are in close proximity to each other. The norm of proximity is the metric distance. To solve the problem we used the usual Euclidean metric, according to which the distance between observations is calculated as follows:

$$d_{i,j} = \sqrt{\sum_{k=1}^{p}(x_{ki} - x_{kj})^2}.$$

On the basis of the Euclidean metric, the distance between the regions 1 and 2 is:

$$d_{1,2} = \sqrt{(83{,}8 - 125{,}4)^2 + (942{,}2 - 1816{,}3)^2} = 875.$$

It is evident that $d_{1,2} = d_{2,1}$, a$d_{1,1} = 0$.

Similarly we find the distance between all the 16 regions and build a matrix of distances.

From this the distance matrix it follows that the regions 5 and 10 are closest to each other $d_{5,10} = 38$, so we combine them into a single cluster and move to the next partition.

The distance between the clusters is defined by the principle of "distant-neighbour", which is described by the formula:

$$d_{r,q} = \frac{1}{2}d_{l,q} + \frac{1}{2}d_{m,q} + \frac{1}{2}|d_{l,q} - d_{m,q}|,$$

Inwhich $d_{l,q}$; $d_{m,q}$ — geometric distances between relevant clusters.

Thus, the distance between the region 2 and the cluster (1 + 8) is:

$$d_{1,(5+10)} = \frac{1}{2}d_{1,5} + \frac{1}{2}d_{1,10} + \frac{1}{2}|d_{1,5} - d_{1,10}| =$$
$$\frac{1}{2}\cdot 904 + \frac{1}{2}\cdot 938 + \frac{1}{2}|904 - 938| = 938.$$

Carrying out similar calculations, we obtain a new matrix of distances.

We find again the minimum distance between objects $d_{11,14} = 70$, combine them into a cluster and on the principle of "distant-neighbour" define the distance between the clusters. Thus, re-construct a matrix of distances.

Calculations are continued for so long as one does not get the final cluster. The sequence of clusters join is represented in the form of the scheme:

{1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16}
↓
{1,2,3,4,5+10,6,7,8,9,11,12,13,14,15,16}
↓
{1,2,3,4,5+10,6,7,8,9,11+14,12,13,15,16}
↓
{1,2+(5+10),3,4,6,7,8,9,11+14,12,13,15,16}
↓
{1+6,2+(5+10),3,4,7,8,9,11+14,12,13,15,16}
↓
{1+6,2+(5+10),3,4,7,8+9,11+14,12,13,15,16}
↓
{(1+6)+13,2+(5+10),3,4,7,8+9,11+14,12,15,16}
↓
{(1+6)+13,(2+(5+10))+3,4,7,8+9,11+14,12,15,16}
↓
{(1+6)+13,((2+(5+10))+3)+(11+14),4,7,8+9,12,15,16}
↓
{(1+6)+13,((2+(5+10))+3)+(11+14),4+15,7,8+9,12,16}
↓
{((1+6)+13)+(8+9),((2+(5+10))+3)+(11+14),4+15,7,12,16}
↓
{((1+6)+13)+(8+9),(((2+(5+10))+3)+(11+14))+12,4+15,7,16}
↓
{((1+6)+13)+(8+9),(((2+(5+10))+3)+(11+14))+12,(4+15)+7,16}
↓
{(((1+6)+13)+(8+9))+((((2+(5+10))+3)+(11+14))+12),(4+15)+7,16}
↓
{((((1+6)+13)+(8+9))+((((2+(5+10))+3)+(11+14))+12))+((4+15)+7),16}
↓
{((((((1+6)+13)+(8+9))+((((2+(5+10))+3)+(11+14))+12))+((4+15)+7))+16}

On the basis of a schematic representation of the results of the cluster analysis, we can conclude that all regions of the Republic of Kazakhstan by ecological and economic development are divided into four clusters:

1) Akmola region (1), Zhambyl region (6), Kostanay region (8), Kyzylorda region (9), North-Kazakhstan region (13);

2) Aktobe region (2), Almaty region (3), West-Kazakhstan region (5), Mangystau region (10), South-Kazakhstan region (11), Pavlodar region (12), East-Kazakhstan region (14);

3) Atyrau region (4), Karaganda region (7), Astana city (15);

4) Almaty city (16).

The results of cluster analysis can be represented as a dendrogram, which is presented in Figure.

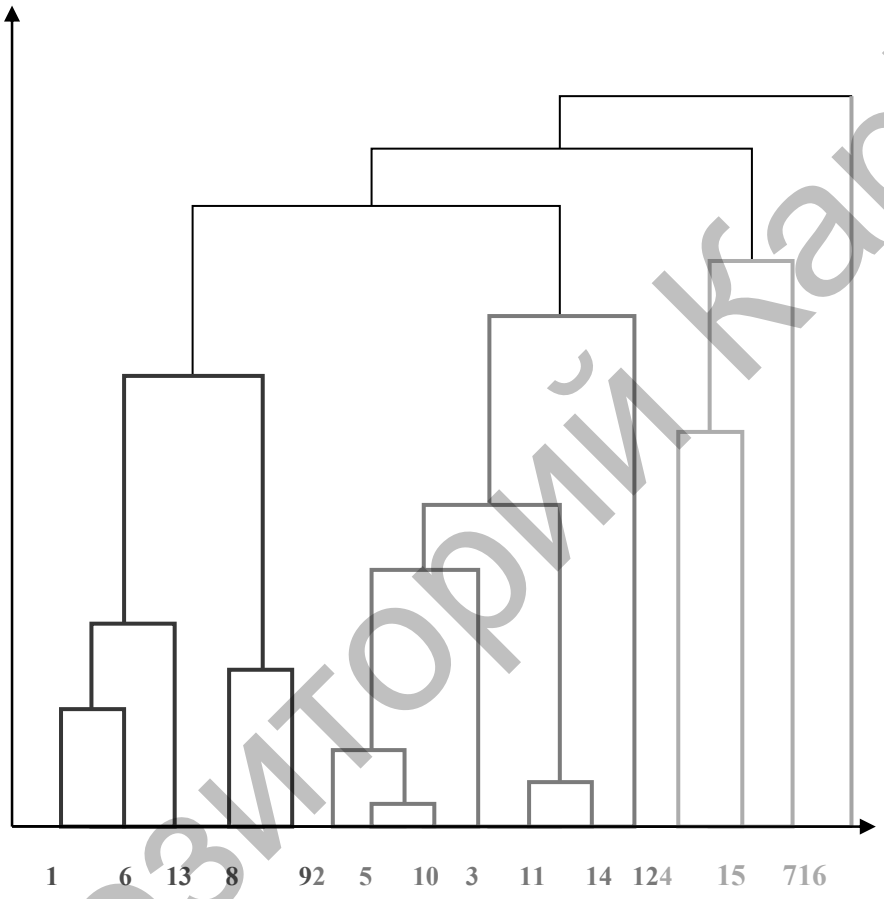

Figure. Cluster analysis of ecological and economic development of regions of the Republic of Kazakhstan.

After dividing all the regions of Kazakhstan on four clusters we carried out a regression analysis according to the level of contamination from the economic development of the regions; and as a result of which we obtained the following equation:

For cluster 1:

$$Y_{it} = 192{,}7 - 0{,}206\text{ВРП}_{it} + 0{,}000075\text{ВРП}_{it}^2.$$

For cluster 2:

$$Y_{it} = 109{,}4 + 0{,}151\text{ВРП}_{it} - 0{,}000076\text{ВРП}_{it}^2.$$

For cluster 3:

$$Y_{it} = 70{,}2 + 0{,}419\text{ВРП}_{it} - 0{,}00012\text{ВРП}_{it}^2.$$

For cluster 4:

$$Y_{it} = 13{,}3 + 0{,}0002\text{ВРП}_{it} - 0{,}00000008\text{ВРП}_{it}^2.$$

So, the first cluster is represented by the most prosperous regions in terms of ecology — Akmola, Zhambyl, Kostanay, Kyzylorda and North-Kazakhstan. For this cluster Kuznets curve does not work - there is no maximum point, but we have minimum one, i.e. before it with the increase of GRP the emissions reduce, and after that point with increasing GRP the emissions will increase.

The second cluster is represented by less favourableregions from an environmental point of view: Aktobe, Almaty, West Kazakhstan, Mangystau, South Kazakhstan, Pavlodar, East Kazakhstan regions.

The third cluster is represented by Atyrau region, Karaganda region, Astana city; and the city of Almaty - stands out as an independent fourth cluster.

For all these regions ∩-shaped curve, i.e.there is a point of maximum GRP, after which emissions are reduced. That is, according to the environmental Kuznets curve, along with economic development the pollutants emissions into the environment reduce.

Why forthe first most prosperous cluster in the ecological sense in Kazakhstan Kuznets curve does not work?

This can be explained by the fact that the growth of economic activity has a negative impact on the quality of the environment; in contrast to changes in GNP income per capita, the impact on the environment of which is positive and linear, and this contradicts the results of Grossman and Krueger. Variable measuring the impact of trade is not significant in the regression equations, as it may have contradictory effects on the ecology. Researchers make the following conclusion: the level of contamination increases if the country has a surplus of capital (as in this case capital-intensive and environmentally dirty industries are developing), and decreases with growing labour-intensive industries.

In general, countries with low GNP income per capita generate polluting products, and the society is not so concerned about the condition of the environment that the government will realize conservation activity. With the growth, pollution reaches a critical point. Then the state under public pressure, on the one hand, begins to form a system of environmental management, and on the other - with the help of macroeconomic tools to stimulate economic shift away from polluting industries to high-tech ones, in which modern technology and the human factor play an important role. As a result, environmental pollution begins to decrease.

So, the prediction of the transition to «sustainable» development made by our macroeconomic model is very favourable for the Republic of Kazakhstan from economic, environmental and social points of view. In our model, it was shown that «sustainable development» not only leads to the economic development of the country as a whole, but also provides a higher GRP growth rate, smoothes uneven regional progress, andguarantees «development» itself — one of the key indicators of the country's well-being.

At the present stage of its development, the Republic of Kazakhstan has not yet reached the point of the maximum on the Environmental Kuznets Curve, which explains the environmental degradation and worsening of environmental situation.

A number of ministries, departments, committees, NGOs and other organizations responsible for addressing these issues in Kazakhstan practice the management of «sustainable development». The main government body, in our opinion, is the Ministry of Environment and Water Resources.

The transition to sustainable development and its management – is a very long process, as it requires the solution of unprecedented by scale social, economic and environmental objectives. As we move towards sustainable development the very notion of it will be changed and updated, the needs of people - rationalize in accordance with environmental constraints, and means to meet these needs - improve. Therefore, the implementation of the principles of sustainable development should be considered in stages. Moreover, only for relatively early stages appropriate software and forecast documents can be developed. For example, the Strategic Plan of the Ministry of Environment and Water Resources of the Republic of Kazakhstan for 2014 - 2018 years. This strategic document is a plan, which outlines the main objectives, indicators, events and measures to achieve the goals on the path to sustainable development in the Republic of Kazakhstan. But, unfortunately, many of the indicators of the Plan are not amenable to analysis and should be specified [8].

The transition of the Republic of Kazakhstan to sustainable development is predetermined by the need to address pressing environmental, economic and social problems. At the same time, programs of the environment improvement should be developed in the areas of ecologic crisis and begin their systematic execution; also outline comprehensive measures to normalize the situation in environmentally disadvantaged areas

and prepare the organizational basis of these measures realization. Minimizing adverse environmental impacts, future externalities for the next generations is necessary. The problem of environmental constraints, compromise between current and future consumption should become the main in the elaboration of socio-economic development strategy for the long term outlook for any country.

In the next step should be carried out major structural changes in the economy, technological innovation, and significant greening process of socio-economic development. At this stage, environmental well-being of the country is provided primarily through the rationalization of the use of the rich natural potential of Kazakhstan, the use of new technologies, the development of human capital and management.

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Н.К. Емелина, М.А. Асанова, Д.А. Ситенко

Қазақстан Республикасы аймақтарының тұрақты дамуының көрсеткіштерін талдау және үлгілеу

Тұрақты дамуды басқарудың үш негізгі құраушысы бар: экология, әлеуметтік сала, экономика. Мақалада эконометриялық үлгілеудің көмегімен тұрақты даму жолындағы Қазақстан Республикасының экологиялық басқаруына талдау жасалған. Біз ҚР аймақтарына олардың экономикалық және экологиялық дамуына сәйкес баға бердік. Жоғарыда айтылғандар негізінде біз 4 кластер ұсындық. Экологиялық жағдайдың талдауына сәйкес жаңа буын үшін сыртқы факторлар болатын экологиялық салдарларды минимумге әкелу қажеттілігі бар екенін анықтадық. Мемлекеттік билік мекемелері Қазақстан Республикасының ұзақ мерзімді әлеуметтік-экономикалық стратегиясын жүзеге асыру үрдісінде осыны түсіну қажет. Біздің макроэкономикалық үлгімен жасалған «тұрақты» дамуға өту болжамы Қазақстан Республикасы үшін экономикалық, экологиялық және әлеуметтік жағынан да өте оңтайлы. Біздің модельде «тұрақты даму» елімізді жалпы экономикалық дамуға әкеліп қана қоймай, ЖІӨ өсу екпінін жоғарылататыны, аймақтық дамудағы біртекті еместікті тегістейтіні, сонымен бірге еліміздегі молшылықтың негізгі көрсеткіштерінің бірі – «дамудың» өзін қамтамасыз ететіні көрсетілген.

Кілт сөздер: тұрақты даму, басқару, экономикалық сала, әлеуметтік сала, экологиялық сала, Кузнец қисығы, Қазақстан моделі, кластер, тұрақты даму көрсеткіштері, аймақтар.

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Анализ и моделирование показателей устойчивого развития регионов в Республике Казахстан

Управление устойчивым развитием включает в себя три основных компонента: экология, социальная сфера, экономика. В статье освещена главным образом экологическая составляющая. С помощью эко-

нометрического моделирования проведен анализ экологического управления в Республике Казахстан на пути к устойчивому развитию. Дана оценка регионам РК в соответствии с их экономическим и экологическим развитием. На основании упомянутого выше предложено 4 кластера. Выяснено, что гласно анализу экологической ситуации существует необходимость свести к минимуму экологические последствия, будущие внешние факторы для новых поколений. Отмечено, что органы государственной власти должны понимать это в процессе реализации долгосрочной социально-экономической стратегии в Республике Казахстан. Сделанное нашей макроэкономической моделью предсказание перехода к «устойчивому» развитию очень благоприятно для Республики Казахстан и с экономической, и с экологической, и с социальной точек зрения. Показано, что «устойчивое развитие» не только приводит к экономическому развитию страны в целом, но и обеспечивает более высокие темпы роста ВРП, сглаживает неравномерность в региональном развитии, а также обеспечивает само «развитие» – один из основных показателей благополучия страны.

Ключевые слова: устойчивое развитие, управление, экономическая сфера, социальная сфера, экологическая сфера, кривая Кузнеца, казахстанская модель, кластер, показатели устойчивого развития, регионы.

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