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Improving the Decoupling Analysis of the Regions' Eco-Economic Development (by the examples of the Southern Federal District regions of Russia)

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***Abstract* — The key aspect of sustainable development is decreasing the ecological problems and risks in order to promote the society's welfare. The systems of indicators are elaborated to characterize sustainable development. These systems allow to evaluate the tools being used and results, to monitor and manage the regions' eco-economic policy. The world's best practice relies on the decoupling-analysis, based on calculating the decoupling index. Such analysis helps evaluate the economic processes' influence on the environment. However, the calculation of the decoupling index does not make a profound analysis of the "decoupling" effect (does not show whether the effect is absolute or relative). The research authors suggest an advanced model of analyzing a region's eco-economic condition, based on the updated decoupling index. This will provide an opportunity to substantiate the financial measures more rationally, promote the "green" economy projects and achieve the regions' sustainable development goals.**

The article presents the Southern Federal District regions' eco-economic development decoupling analysis, based on the suggested decoupling-analysis model. The research also gives the calculation of region's "eco-economic attractiveness' rating, based on the updated decoupling index. Such a rating is essential for monitoring the effectiveness of integrating the eco-saving technologies and evaluating a region's risks. As a result, the rating will allow ranging the regions by their eco-economic development level and making conclusions on the effectiveness of the region's policy.

Keywords*— *"green" economy, sustainable growth, regional economy, ecological and economic effect, the effect of "decoupling"

I. INTRODUCTION

The eco-economic development of a region is determined by the environment and is characterized by the degree to which the humankind affects it. The understanding of this interdependence serves as the basis for sustainable development and the "green growth" theory, which is now a core for making managerial decisions both on the state and companies' levels.

The UN's General Assembly Resolution of September 25th, 2015 "The 2030 Agenda for Sustainable Development" contains 17 goals and 169 objectives in the sustainable development sphere. The resolution emphasizes the importance not only of the economic development, but of the sustainable ecological development either: We are determined to ensure that all human beings can enjoy prosperous and fulfilling lives and that economic, social and technological progress occurs in harmony with nature" [2]. Setting the goals and objectives demands elaborating the sustainable development indicators for monitoring and assessing the managerial decisions' efficiency.

The Moscow State University Professor S. Bobylev notes the importance of elaborating the sustainable development indicators: "A set of such indicators (indexes and criteria) should play the key role in describing (diagnosing) the condition of the "nature – economy – population" system. So far it is too early to speak of the sustainable development indicators completeness, accurateness and calculation…" [3].

Evaluating the effect from introducing the tools and mechanisms of stimulating the "green" economy and defining a region's eco-economic attractiveness level is possible through the "decoupling index" indicator [4]. The decoupling effect is characterized with "splitting" and "disconnecting" the economic growth rates (GDP and GRP) and the growth rates of natural resources' consumption, production and wastes production and consumption. The presence of the "decoupling" effect is the requirement for the "green" economy's development.

The research authors calculate the decoupling effect for the following Russian regions:

- Murmansk Oblast (by the indicators of emissions from stationary pollution sources and by the GRP), Belgorod Oblast (by the indicators of emissions from stationary pollution sources and the surface water chemical composition0, Krasnodar Krai (by the industrial production indicators and atmospheric emissions) 5], The Republic of Tatarstan [6] – the analysis has confirmed the decoupling effect;

- Rostov Oblast (environmental pollution growth despite the industrial production reduction) [5], Kemerovo Oblast (by the coal-mining industry) [7] – negative decoupling effect

- The republic of Karelia [8] – the positive effect by the "emissions from stationary pollution sources" indicator and the negative effect - by the long-term perspective forecast;

- Vologda Oblast [9] – positive decoupling effect in the metallurgical sector and the insignificant effect in the chemical sector.

Ye. Yakovleva has calculated the decoupling effect by Russian Federation region. Her investigation has shown that some regions present either absolute or relative decoupling effect [10].

The researchers point out the topicality of analyzing the decoupling effect: "using the decoupling coefficient for evaluating a regions development sustainability allows further methodic working: suggestions on classifying the decoupling indicators for various ways of natural resource use will facilitate developing the methodology of evaluating the sustainability on the regional level" [7, c.133].

It is worth noting, that the traditional calculation of the decoupling index tells whether the decoupling effect really takes place, but it is impossible to tell whether the effect is relative or absolute. A. Dumnov, N. Rybalskii and D. Boriskin underline the drawbacks of the traditional decoupling index calculation [11]. The current article's authors suggest a model of analyzing a region's eco-economic condition, based on calculating an updated decoupling index in order to eliminate the drawbacks.

The research goal is to find out the dependence between the enterprises' economic activity results and a region's environmental change. The authors have analyzed the "decoupling" effect in the Southern Federal District using the advanced decoupling-analysis model by the "stationary pollution sources emissions indicator". Additionally, the study presents the rating of the Southern Federal District regions' eco-economic attractiveness, based on the suggested decoupling-analysis model.

The suggested model and results can be used for monitoring a region's eco-economic state, developing and correcting the regions' eco-economic development programmes.

II. Materials and Methods (Model)

The conception of sustainable development and the "green" economy theory served as the theoretical and methodological scientific support. The decoupling method has been applied in order to analyze the regions eco-economic efficiency [12]. In return, the method allows discovering whether the "decoupling' effect takes place, what is more it helps find out the extensity or intensity of the economy's development in relation to the natural resources use and environmental conditions.

The decoupling index is calculated as a relative variation (growth coefficient) of a consumed resource or pollution emission over a certain period in respect to the resulting indicator variation (generally the GDP, GRP and etc.) over the same period. The decoupling index calculated this way shows whether the "decouplig" effect takes place, but it does not reflect whether it's absolute or relative. Moreover, there is no opportunity for profound conclusion on a region's eco-economic state.

The research authors elaborated an updated "decoupling" effect analysis model, which helps eliminate the above-mentioned drawbacks. The model is based on comparing the growth coefficients of the resources and/ or pollution and the economic growth indicators. This model enables defining six sectors, which characterize various effectiveness degrees of a region's eco-economic state.

The traditional calculation of the decoupling indicator has several disadvantages – it doesn't tell whether the effect is relative or absolute. The updated decoupling index of a new calculation model is calculated with the following formula (2):

$$DI/ = TR/ – TY/, \quad (1)$$

where: DI/ is the updated decoupling index, reflected in relative units;

TR/ is the consumed resource or pollution emission growth coefficient over a certain period in relative units;

TY/ is the resulting indicator growth coefficient in relative units.

There are six sectors which are defined depending on the correlation of the TR / and TY /. These sectors characterize various efficiency levels of a region's eco-economic state (Table 1). The first three sectors show whether the decoupling effect takes place, whereas sectors IV to VI reflect the absence of the decoupling effect. At the same time, diverse economic and ecological situations' correlations can be discovered within these sectors.

TABLE I. **Decoupling analysis sectors characteristics**

No decoupling effect	Decoupling effect
Sector VI. TR/ (+) > TY/ (+), DI/ > 0.	**Sector I.** TR/ (–; 0,0) < TY/ (+,0,0), DI/ ≤ 0,0.
Sector V. TR/ (–) < TY/ (–), DI/ > 0.	**Sector II.** TR/ (+; 0,0) < TY/ (+,0,0), DI/ ≤ 0,0.
Sector VI. TR/ (+) > TY/ (–), DI/ > 0.	**Sector III.** TR/ (–; 0,0) > TY/ (–; 0,0), DI/ ≤ 0,0.

Resource: authors' model.

Sector I is characterized with an "absolute decoupling" effect and reflects the most favourable condition for a region.

Sector II characterizes the presence of the "relative decoupling" effect and a "normal" variant of a region's eco-economic development, when the economy's growth is followed by the growing environmental stress, although the economy grows faster.

Sector III also reflects the "relative decoupling" effect, but a region's eco-economic situation is different: the economic results decrease in case the environmental pollution decreases faster.

Sector IV – the "decoupling" effect is absent, the situation in a region faces rapid economic growth, when the environment is subject to a negative influence, which is not compensated by the growing economic rates.

Sector V – the "decoupling" effect is absent, the ecological situation improves, but the economy does not grow.

Sector VI - the "decoupling" effect is absent, the economy does not grow, though growing environmental stress rises.

The researchers suppose that the suggested model will help discover the ecological and economic problems and risks in a timely manner. This model has been applies to calculate the advanced decoupling index in the Southern Federal District regions (see Table 2).

It considered reasonable to rate the regions by their "eco-economic attractiveness" using the advanced decoupling index (formula 2):

$$Reea = \sum r_i * f_i / \sum f_i \quad (2)$$

where: Reea is a region's "eco-economic attractiveness" rate; Reea = [1 ÷ 6];

r_i – the decoupling analysis sector, r_i = [1, 2, …6];

f_i – the frequency of r_i in a period being analysed, f_i = [1, 2, …n];

n – the number of periods analyzed.

This rating can be applied by investors for evaluating the regional risks when investing in regional ecological projects.

III. Results and Discussion

Russia's current ecological situation is considered unsafe, what is noted in the Russian Federation's Ecological Safety Strategy through to the year 2025: "Russian Federation's environment on the territories, where the most population, industrial facilities and productive agricultural farmlands are concentrated (around 15% of the country's territory), is rated unfavourable by the ecological parametres. Experts say that annual economic loss, determined by the worsening environment and corresponding economic factors, reaches 4-6% of Russia's GDP, let alone the harm done to the population's health" [13].

The Russian Federation Ecological Safety Strategy through to the year 2025 was adopted in 2017, which was proclaimed the year of ecology, what emphasizes the urgency of ecological issues in Russia.

The researchers carried out the decoupling analysis of the Southern Federal District regions in order to evaluate their eco-economic state and rate the regions by their "eco-economic attractiveness" (see Table 2).

The Southern Federal District comprises the following regions: the Republic of Adygea, Astrakhan Oblast, Volgograd Oblast, the Republic of Kalmykia, Krasnodar Krai, Rostov Oblast. The Republic of Crimea and the city of Sevastopol entered the District in 2016, what explains the absence of long-term data on these regions. That is why they were excluded from the analysis.

The researchers have analyzed the regions' National ecological rating, made up by the "Green Patrol" public organization, in order to compare the results [14].

The national ecological rating has been carried out since 2008 four times a year. Monitoring and evaluation of the most significant ecological situations, accidents and problems lie at the core of this rating. The rating's results are relative and depend on the indicators of all regions participating in the evaluation process. This rating is being formed a the new information on a region's ecology comes from various sources, including "the mass-media, authority bodies, public organizations, expert organizations, economic entities and initiative groups. The information data is considered to contain topical reports, publications or documents, which describe the regions and processes' state, as well as situations, events and news in the ecological and environmental protection spheres in the online mode" [14]. An expert group gives its marks to an ecological situation (+1 – if it's positive, -1 – of it's negative) in three spheres, which are the ecosphere (environmental protection index), the technosphere (industrial and ecological index) and the public (the socio-economic index). The correlation of rates is converted into the 100% scale in order for the regions to be compared. Then, the composite ecological rating is made up for each region. The higher the rate is, the better the ecological situation in a region is. The figures on the changes in the National ecological rating for the Southern Federal District regions from 2007-2017 are given in Table 3.

The regions' "eco-economic attractiveness" and the regions' national ecological ratings can complete each other. Thus, the regions' eco-economic attractiveness rating is based on the statistical data and shows the regions' eco-economic policy's effectiveness in the long-term period, whereas the regions' national ecological rating is made up by means of expert evaluations and reflects the contemporary reaction of regional authorities to ecological problems.

IV. Conclusion

A) The results allow the authors to speak of the decoupling effect in all Southern Federal District regions in most of the analyzed periods. The analysis by the advanced decoupling analysis model enabled the researchers to specify the traditional decoupling indicator's data and range the regions by their eco-economic attractiveness. The authors have analyzed the 2005- 2016 period with the help of the traditional decoupling-analysis methodic and the advanced decoupling-analysis model, suggested in the article. The results of both analyses do not contradict each other. The analysis has allowed defining the following tendencies of the Southern Federal District regions' development:

TABLE II. **the decoupling effect characteristics (Southern Federal District regions example)**

Indicators	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
The Republic of Adygea , Reea = 3,54											
R, thousands of tons	1,62	2,84	3,06	3,31	3,61	4,24	6,29	8,59	10,12	10,65	10,92
R/, relative units	0,00	-0,138	0,753	0,077	0,082	0,091	0,175	0,483	0,366	0,178	0,052
TY/, relative units	0,070	0,160	0,140	0,061	0,044	0,056	0,059	0,027	0,038	0,008	0,019
Sector (by R)	**I**	**IV**	**II**	**IV**	**IV**	**IV**	**IV**	**IV**	**IV**	**IV**	**IV**
Astrakhan Oblast, Reea = 2,64											
R, thousands of tons	117,31	128,8	125,13	103,3	124,93	131,52	134,38	130,48	118,15	118,63	126,76
R/, relative units	-0,107	0,098	-0,028	-0,174	0,209	0,053	0,022	-0,029	-0,094	0,004	0,069
TY/, relative units	0,078	0,085	0,080	-0,106	0,021	0,078	0,113	0,162	0,005	-0,009	0,028
Sector (by R)	**I**	**IV**	**I**	**III**	**IV**	**II**	**II**	**I**	**I**	**VI**	**IV**
Volgograd Oblast, Reea = 2,64											
R, thousands of tons	221,3	226,9	221,4	194,9	201,1	178,2	170,9	172,8	153,5	160	161,4
R/, relative units	0,000	0,025	-0,024	-0,120	0,032	-0,114	-0,041	0,011	-0,112	0,042	0,009
TY/, relative units.	0,020	0,070	0,057	-0,130	0,037	0,033	0,028	0,014	0,047	-0,062	-0,014
Sector (by R)	**II**	**II**	**I**	**V**	**II**	**I**	**I**	**II**	**I**	**VI**	**VI**
The Republic of Kalmykia, Reea = 2,91											
R, thousands of tons	8,06	5,55	4,27	2,21	3,5	3,57	3,66	6,71	4,54	3,42	2,19
R/, relative units	1,838	-0,311	-0,231	-0,482	0,584	0,020	0,025	0,833	-0,323	-0,247	-0,360
TY/, relative units	0,031	0,034	0,022	0,014	-0,036	0,022	0,000	0,026	0,047	-0,041	-0,019
Sector (by R)	**IV**	**I**	**I**	**I**	**VI**	**II**	**VI**	**IV**	**I**	**III**	**III**
Krasnodar Krai, Reea = 3,09											
R, thousands of tons	152,14	142,99	146,69	150,15	138,97	161,34	215,74	205,17	188,89	190,83	242,25
R/, relative units	0,348	-0,060	0,026	0,024	-0,074	0,161	0,337	-0,049	-0,079	0,010	0,269
TY/, relative units	0,107	0,103	0,088	-0,018	0,062	0,076	0,037	0,039	0,007	-0,016	0,001
Sector (by R)	**IV**	**I**	**II**	**VI**	**I**	**IV**	**IV**	**I**	**I**	**VI**	**IV**
Rostov Oblast, Reea = 2,45											
R, thousands of tons	173,75	163,27	185,28	175,24	175,84	153,96	200,2	192,63	194,05	164,91	169,12
R/, relative units	0,187	-0,060	0,135	-0,054	0,003	-0,124	0,300	-0,038	0,007	-0,150	0,026
TY/, relative units	0,122	0,124	0,102	-0,108	0,064	0,068	0,025	0,029	0,032	0,040	0,032
Sector (by R)	**IV**	**I**	**IV**	**V**	**II**	**I**	**IV**	**I**	**II**	**I**	**II**

Note: TY/ – The GRP volume growth rate in relative units; R – emissions from stationary pollution sources, thousands of tons; R/ –stationary pollution sources' emissions growth rate R, in relative units.; sector (by R) – a sector which characterizes the decoupling effect according to the decoupling analysis model; Reea - the regions eco-economic attractiveness rating.
Resource: authors' calculations according to the data [15].

TABLE III. **Southern Federal District regions National ecological rating**

Years	The Republic of Adygea	Astrakhan Oblast	Volgograd Oblast	The Republic of Kalmykia	Krasnodar Krai	Rostov Oblast
2017	48	49	47	43	54	54
2016	43	44	45	41	50	53
2015	42	43	44	40	49	51
2014	43	42	48	41	49	50
2013	48	43	43	39	45	49
2012	50	43	47	39	44	50
2011	49	45	48	37	51	49
2010	51	50	50	41	49	53
2009	51	51	52	52	50	56
2008	50	43	49	52	50	57
Average rate	**47,5**	**45,3**	**47,3**	**42,5**	**49,1**	**52,2**

Resource: composed by authors according to [14].

TABLE IV. **Southern Federal District regions ranking**

Regions	Ranking №1	Ranking №2
Rostov Oblast	1	1
Volgograd Oblast	2/3	3
Astrakhan Oblast	2/3	6
The Republic of Kalmykia	4	4
Krasnodar Krai	5	2
The Republic of Adygea	6	5

Note: ranking №1 – the regions are rated by their “eco-economic attractiveness”; ranking №2 - the regions are rated by the “regions’ national ecological rating) indicator.

Resource: authors’ calculations.

- the decoupling effect in Rostov Oblast is registered in 63,6 % of observations, absolute decoupling effect – in 36,4 % of observations, the decoupling effect is absent in 27,3 % of observations and is characterized by a pollution level, which is higher than the economic growth level;
- the decoupling effect in Volgograd Oblast is registered in 72,3 % of observations, absolute decoupling effect – in 36,4 % of observations. These figures are almost equal to those in Rostov Oblast. However, when during the periods, when the decoupling effect was absent, the GRP’s volume growth was decreasing with growing environmental stress (sector 6 of the decoupling-analysis model);
- the decoupling effect in Astrakhan Oblast takes place in 63,6 % of observations, absolute decoupling effect - 36,4 % of observations. The decoupling effect is absent in 75 % of observations, what is characterized by a pollution level, which is higher than the economic growth level, in 25 % of observations the economic growth is absent, while the pollution emissions are increasing;
- the decoupling effect in the Republic of Kalmykia is present in 63,6 % of observations, where two observation periods (18,2 %) are characterized by the worst eco-economic situation (sector 6 of the decoupling-analysis model);
- the absolute decoupling effect in Krasnodar Krai takes place in 36,4 % of observations with the pollution level, which is higher than the economic growth level. At the same time, the regional authority bodies and the public reacts to ecological problems quickly.
- the Republic of Adygea is characterized by low absolute emissions figures, although they grow very fast (the average growth rate over the period analyzed is 1,21), whereas the Republic of Kalmykia shows approximately the same absolute emissions figures, but there the average growth rate is 0,84. In 81,8 % of observations the Republic of Adygea presents he pollution level, which is higher than the economic growth level.

B) Therefore the main academic and practical results comprise: 1) the decoupling-analysis model, containing 6 qualitatively different sectors, which characterize the regions’ eco-economic situation and 2) the authors have calculated and submitted the regions’ eco-economic attractiveness rating. The suggested models and indicators can be applied in ecological and regions’ socio-economic monitorings.

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