

## The integral indicator of the sustainable development of the regional socio-economic systems: the structure, the methodology of the formation, the direction of the application

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**Abstract:** The article suggests a methodology of a quantitative estimation of the sustainability of the regional socio-economic systems (RSES). The special attention is paid to the role of the information, communication and innovation factors in these processes. To solve the objective of a *quantitative* estimation of the RSES sustainability the methodology of the calculation of the general integral index in the context of the following blocks was selected: 1) economic relations; 2) the social situation; 3) the institutional environment; 4) the innovative potential. The formation of the index was made on the basis of the methodology of the calculation of the HDI UNDP. The data of the statistical collections “Regions of Russia. Socio-Economic Indicators” for the period from 2003 till 2012 were used as the information source of the calculations. The selection includes 80 subjects of the Russian Federation. The data processing was performed with the help of the Microsoft Excel programme analysis package. The international practice and the frame of the multivariate correlation and regression analysis were used at the selection of the indicators for the calculation of the subscripts included in the general integral index of sustainability. The integral indexes of the sustainability for 80 subjects of the Russian Federation for the period from 2003 till 2012 were calculated according to the suggested methodology. The estimation of the received results has allowed drawing a conclusion that the sustainable development of the majority of the Russian regions has increased during the analyzed period. Also it is established, that the greatest contribution to process of the development was made by the economic (the average partial coefficient was 0.445) and institutional components (0.402); the low level of a social subsystem development (0.260) and the innovative activity (0.032) were noted.

[Anna Chub. **The integral indicator of the sustainable development of the regional socio-economic systems: the structure, the methodology of the formation, the direction of the application.** *Life Sci J* 2014;11(8):177-183]. (ISSN:1097-8135). <http://www.lifesciencesite.com>. 23

**Key words:** the integral sustainability index, the regional system, the dynamic balance, the sustainable development, the correlation and regression analysis

### 1. Introduction

This article represents a methodology, which helps to estimate quantitatively a sustainability degree of the development of the regional formations, and also to reveal the factors, which influence on the process the most strongly way.

Before proceeding directly to the description of the methodology, we shall give a brief definition of the main terms and concepts used in this work.

The analysis of the approaches of foreign (Isard, 1960; Deutsch, 1981) and the Russian (Gootman, 1996; Granberg, 2006; Doroshenko, 2010) authors to the concept of the region has allowed to define it as a complex dynamic system, which is a relatively autonomous local, institutionally and economically integral formation, within the framework of which the processes of the extended reproduction of the gross regional product and the labour workforce are provided.

On the basis of the provisions of the informational concept of the systems' development (Arucev, 1999) and the concept of the evolutionary economics (Doroshenko, 2010), the conclusion was drawn that the sustainability of the region should be

defined as “the preservation in the variation”, that is the ability of the regional socio-economic system to maintain a dynamic balance, providing by means of the information exchange an adaptive consolidation of useful characteristics for the survival in this environment. Thus, the regional formation will develop sustainably only if, on the one hand, it has a socio-economic and institutional integrity, and on the other hand, if it is be capable for some period of time of becoming unsustainable under the influence of the disturbances leading to the appearance of its new characteristics.

As an element of the regional system ensuring the sustainability of its structure the institutional environment is allocated. It should be noted that, despite a significant number of studies on the role of the institutions in the processes of a social development (North, 1990; Klein 1999; Williamson, 1996; Inshakov, 2001) currently the established definition of this term is absent. Within the frame work of this article, by a regional institutional environment we shall mean an ordered set of institutions, organizations and their interrelations forming an institutional space of the region, which is

formed under the influence of both the internal integration of the economic entities and the external factors, where on the basis of the system of the incentives and the enforcement mechanisms the overcome of the functional and information dissociation between the elements of a regional system is ensured, as well as the orientation of its movement towards a sustainable development.

In its turn on the basis of the works of Kondratiev (1914); Shumpeter (1939); Mensh (1975), Glaziev (1986) the disturbances, unbalancing the RSES and promoting its transition to a new, higher stage of the development are considered to be innovations.

Thus, the process of a sustainable development of the RSES is influenced fundamentally by the following groups of factors:

- 1) the economic relations;
- 2) the social situation;
- 3) the institutional environment;
- 4) the innovation potential.

## 2. Materials and methods

### 2.1. The formation of a general formula of the integral index of a sustainable development

As an information source of the calculations, the statistical data of the collection "Regions of Russia. Socio-Economic Indicators", characterizing the results of the development of the Russian Federation subjects during the period from 2003 till 2012 were used. The selection included 80 subjects of the Russian Federation.

The data processing was performed with the help of the Microsoft Excel programme analysis package.

The development of the formula of the integral index of the development sustainability of the regional system was developed on the basis of the methodology of calculating the HDI UNDP (Human Development Index - HDI) according to the following formula:

$$Ks_{it} = \frac{1}{N} \sum k_{ij}^t \quad (1.1), \text{ where}$$

$Ks_{it}$  is the integral index of the sustainability for  $i$  region in the year  $t$ ;

$N$  is the number of the subscripts ( $N \in [1;4]$ );

$k_{ij}^t$  is the subscript of  $j$  indicator in  $i$  region in the year  $t$  ( $j \in [1;N]$ ).

Thus, the calculation of the subscripts is exercised according to the formula:

$$k_{ij}^t = \frac{\left( k_{ij} - \min_{i=1, \dots, 80} k_{ij} \right)}{\left( \max_{i=1, \dots, 80} k_{ij} - \min_{i=1, \dots, 80} k_{ij} \right)} \quad (1.2),$$

where

$k_{ij}^t$  is the index of  $j$  indicator in  $i$  region ( $i \in [1;M]$ , where  $M$  is the number of the considered regions);

$k_{ij}$  is the value of  $j$  indicator for  $i$  region.

Thus, having formed the general formula of the calculation let us turn to the issue on the methods of the selection of the partial indicators for each four above-mentioned units.

### 2.2. The formation of the subscript for the economic block

As an indicator reflecting the results of functioning of the regional economic subsystem the gross regional product (GRP) is taken. The similar approach is used in the following works (Keynes, 1936; Harrod, 1939; Domar, 1946; Fedorenko, 1989).

It should be noted that when calculating the subscripts of the GRP for getting more accurate results formula 1.3 is transformed by using the decimal logarithms in accordance with the principle of the diminishing income utility (1.4).

$$k_{ij}^t = \frac{\left( \log k_{ij} - \log(\min_{i=1, \dots, 80} k_{ij}) \right)}{\left( \log(\max_{i=1, \dots, 80} k_{ij}) - \log(\min_{i=1, \dots, 80} k_{ij}) \right)} \quad (1.3)$$

### 2.3. The formation of the subscript for the social block

Currently, the indicator characterizing the part of the output (in this case, the regional) aggregate, directed to the satisfaction of the public needs is the budgetary expenditures for the social and cultural arrangements. This indicator is used in the official databases of the Federal State Statistics Service, including in the regional context [1], and also in the international practice, as evinced by, in particular, the data of the collection "Russia and the Countries of the World. 2012", where in the section "The Level and the Conditions of Living of the Population" there is a comparative analysis of the expenditures for the education and the health care in the Russian Federation and other countries, formed according to the UNESCO data, the World Health Organization (WHO) and the National Research University "Higher School of Economics" [2].

The check of the possibility of including the indicator “The Volume of the Budgetary Expenditures for the Social and Cultural Arrangements” into the general integral indicator was exercised on the basis of the provision that according to the HDI methodology the partial indicators included in the general integral index must have a high influence degree on each other.

In order to verify the correlation level the frame of the multivariate correlation and regression analysis was used, which enables:

- to justify the correlations of the factors influencing on the analyzed indicator;
- to quantify the closeness of the relation between the effective characteristic and the factors;
- to determine the influence degree of each factor on the effective characteristic by building a

model-equation of the multiple regression, which allows establishing in what direction and by what value the effective indicator will change at the change of each factor included in the model.

Thus, proceeding from the thesis that the real sector creates the material basis for the maximum full satisfaction of the needs of the population, living on the territory of the region, the volume of the budgetary expenditures for the social and cultural arrangements ( $c$ ) was taken as an effective indicator. In its turn the volume of the GRP ( $y$ ) was considered as a factorial (influencing) characteristic.

During the analysis performed for each year of the analyzed period the pair correlation coefficient was calculated and the regression equation of the correlation of the studied factors was built. The obtained results are summarized in table 1.

Table 1. The results of the correlation and regression analysis of the interrelation between the GRP and the volume of the budgetary expenditures for the social and cultural arrangements

	The correlation coefficient	The approximation accuracy value ( $R^2$ )	The calculated value of Fisher's F-test	The tabular value of Fisher's F-test	The regression equation
2003	0,96	0,92	916,00	2,00	$c=0,0481y+4126,6$
2004	0,96	0,92	892,27	2,00	$c=0,0471y+5376,1$
2005	0,88	0,77	276,91	2,00	$c=0,0403y+8517,4$
2006	0,90	0,81	345,68	2,00	$c=0,0468y+9864,8$
2007	0,73	0,54	93,35	2,00	$c=0,0289y+17457$
2008	0,60	0,36	44,48	2,00	$c=0,0504y+10885$
2009	0,93	0,86	517,06	2,00	$c=0,065y+12360,1$
2010	0,94	0,88	590,97	2,00	$c=0,612+13569,3$
2011	0,94	0,88	576,90	2,00	$c=0,0661+15523,32$
2012	0,93	0,88	596,11	2,00	$c=0,0770+16317,31$
The average value	0.89	0.81	-	-	-

The data analysis shown in table 1 has allowed drawing the following conclusions.

1. The interrelation between the effective and factorial characteristics was considered essential, as during the studied period the correlation coefficient was ranging in the interval from 0.60 to 0.96. The average value amounted to 0.87, what indicates to a strong dependence between the analysed factors.

2. Proceeding from the regression equation the dependence between  $c$  and  $y$  was recognized as directly proportional.

3. According to the theory of the correlation and regression analysis the comparison of the calculated and tabular values of Fischer's F-test allows to judge about the accuracy of the built models. In case the first one exceeds the second one, the model is considered to be significant, if there is a

reverse situation, it is not considered to be significant. As during all years of the studied period the calculated value exceeds the tabular one, it is possible to draw a conclusion on the significance of the built model.

4. The performed calculations has shown that the variation of the GRP factor defines 81% (the average  $R^2 = 0.81$ ) of the variation of the effective characteristic of the expenditures for the social and cultural arrangements. This means that the social subsystem expenditures are by 81% dependent upon the industrial operational effectiveness of the region. In addition, this approximation accuracy value also confirms the conclusion on the significance and correctness of the built model.

5. We connect the fact that the indicators calculated according to the statistics of 2007 and

2008 are below the results of the remaining years (especially in 2008) with the influence of the global economic crisis. At that the indicated deviations are in general within the framework of the identified general trends, and fundamentally do not influence on the total average results.

Thus, in the result of the analysis of the volume of the regional expenditures for the social services to the population and the size of the GRP during the period from 2000 till 2012 it was established that, in general, between the studied indicators there was a high directly proportional dependence. The indicated circumstance allows considering "The Volume of the Budgetary Expenditures for the Social and Cultural Arrangements" index as the social unit subscript for the calculation of the general integral index of the sustainability of the development of the regional system.

#### 2.4. The subscript formation for the innovative block

The selection of the indicator on the basis of which the subscript of the innovative development should be calculated is based on the hypothesis, that if the real sector creates the material basis for the implementation of the RSES main function, the maximum full satisfaction of the needs of the population living on the territory of the region, then, it is necessary to identify the innovative factors rendering the most significant influence on the final effectiveness of the operation of the economic complex. Thus, as an effective factor  $y$  for further calculations the GRP indicator was taken as well.

At the same time as the factorial characteristics  $x_1, x_2, \dots, x_k$ , characterizing the innovative activity of the subjects of the Russian Federation, the indicators shown in table 2 were selected.

Table 2. The factorial and effective indicators for the correlation and regression analysis of the interrelation of the development of the GRP and the RSES innovative potential

Conventional symbols	Indicators
$x_1$	The number of the organizations, which carried out the research and the developments
$x_2$	The number of the personnel engaged in the research and the developments
$x_3$	The domestic expenditures for the research and the developments
$x_4$	The number of the created advanced technologies
$x_5$	The number of the used advanced technologies
$x_6$	The innovative activity of the organizations
$x_7$	The expenditures for the technological innovations
$x_8$	The volume of the innovative products, works, services
$y$	The gross regional product

In accordance with the theory of the correlation and regression analysis, the main condition for including the factors in the model of the multiple regression is the absence of a correlation connection between the factorial characteristics and the presence of a strong relation between the effective and

factorial indicators. The problem of the exclusion of the multicollinear factorial indicators was solved by building a correlation matrix. For example, the correlation matrix, built according to the values of  $x_1 - x_8$  indicators in 2012, was as follows (table. 3).

Table 3. The correlation matrix (2012)

	$x_1$	$x_2$	$x_3$	$x_4$	$x_5$	$x_6$	$x_7$	$x_8$	$y$
$x_1$	1								
$x_2$	0,9859416	1							
$x_3$	0,9810251	0,9960546	1						
$x_4$	0,9147503	0,9250001	0,9071793	1					
$x_5$	0,4308893	0,4396412	0,4312193	0,3740194	1				
$x_6$	0,5552659	0,5406639	0,5121137	0,5499261	0,7237879	1			
$x_7$	0,8608319	0,4430321	0,4218316	0,4931107	0,2543888	0,3813475	1		
$x_8$	0,2172155	0,2380497	0,2228102	0,2143308	0,1544856	0,2467223	0,2124633	1	
$y$	0,9011726	0,7118264	0,5271221	0,804204	0,424344	0,4862775	0,5426728	0,1885091	1

The data given in table 4 show that the factorial indicators  $x_1 - x_3$  are multicollinear (the pair correlation coefficients are more than 0.8), and  $x_8$  factor has an extremely low correlation degree (0.2) with the effective indicator  $y$ . Thus,  $x_1, x_2, x_3$  and  $x_8$  factors were excluded from further analysis, in the result of which the updated correlation matrix was formed (table. 4).

Table 4. The correlation matrix after the exclusion of the multicollinear factors (2012)

	<i>x4</i>	<i>x5</i>	<i>x6</i>	<i>x7</i>	<i>y</i>
<i>x4</i>	1				
<i>x5</i>	0,3740194	1			
<i>x6</i>	0,5499261	0,7237879	1		
<i>x7</i>	0,4931107	0,2543888	0,3813475	1	
<i>x8</i>	0,2143308	0,1544856	0,2467223	0,2124633	
<i>y</i>	0,804204	0,424344	0,4862775	0,5426728	1

Further, the degree of the influence of each of the remaining factors on the total value of the GRP was checked by the method of a step-by-step regression. It was found that for the period from 2003 till 2012 the volume of the GRP by an average 60% depends on the number of the created advanced technologies (factor *x4*). The influence of other indicators was considered as not significant.

Thus, to calculate further the subscript characterizing the innovative potential of the region, the statistical data for the indicator “The number of the created advanced technologies” were used.

#### 2.5. The formation of the subscript for the institutional unit

The difficulty of selecting the indicators for the calculation of the subscript for the block “Institutional environment” was in the fact that, as mentioned above, currently the established definition of the institutional environment has not been established in science. This circumstance resulted in the significant differences in its criterion estimations.

For example, within the framework of the global competitiveness index (GCI), in the structure of one of the 12 components characterizing “The Quality of Institutions” the following ones are analysed: the degree of the accountability of the civil society bodies to the government; the independence of the judicial system in the country; the respect for the property rights; the level of the state interference in the activities of the private sector of the economy; the

corruption of the public officials; the quality of the budget policy; the level of the personal and public safety in the country; the effectiveness of the activity of the police and special security services; the level of the corporate ethics and the transparency of the companies’ activity [3].

The central base of the statistical data of the Federal State Statistics Service of the Russian Federation keeps account of the institutional transformations in the economy according to the following directions: small and medium enterprises, legal entities, the privatization, the demography of organizations [4].

In view of the indicated circumstances, the selection of the indicators for the calculation of the subscript of the institutional environment was based on:

- the definition of the institutional environment, formulated in the first part of this article, therefore, the statistical indicators, which, in our opinion, reflect its characteristics quantitatively were selected (table 5);

- the results of the analysis of the international experience, which allowed establishing that the effective operation of communication channels is provided by the way of the development and improvement of the transport infrastructure inclusively (Myrdal, 1990).

Table 5. The factorial and effective indicators for the correlation and regression analysis of the interrelation of the development of the GRP and the RSES institutional environment

Conventional symbols	Indicators
<i>z1</i>	The number of the employees of the state power and the local self-government
<i>z2</i>	The unemployment level
<i>z3</i>	The number of the registered crimes
<i>z4</i>	The expenditures for the communication and information technologies
<i>z5</i>	The share of the organizations, which used the information and communication technologies in the total number of the inspected organizations of the subject of the Federation
<i>z6</i>	The number of the privatized assets of the state and municipal unitary enterprises
<i>y</i>	The gross regional product

The identification of the factors of the institutional environment rendering the most significant influence on the development of the GRP, was conducted by the method of a step-by-step regression analysis according to the scheme, similar to the selection of the partial indicator of the innovative unit.

Finally the conclusion was drawn that such indicator as “The share of the organizations, which used the information and communication

technologies in the total number of the inspected organizations of the subject of the Federation” has the strongest influence on the development of the gross regional product (about 43%).

### 3. Results

The selected indicators, which values were the basis for the calculation of the partial coefficient for each unit are presented in table 6.

Table 6. The components of the integral index of a sustainable regional development

The significant direction of the regional development	Indicators
Economic relations	The volume of the gross regional product per capita.
The social situation	The volume of the expenditures for the social sphere per capita.
The institutional environment	The share of the automobile roads with a firm covering in a total length of the public roads The share of the organizations, which used the information and communication technologies in the total number of the inspected organizations of the subject of the Federation
The innovative potential	The number of the created advanced technologies

Further, the subscripts for each of 80 subjects during the period from 2003 till 2012 were calculated according to formula 1.2. In conclusion, the overall integrity indexes of the sustainability were calculated according to formula 1.1 (table 7 – because of the

limitations of the scope of the article the integral indexes and subscripts of the subjects of the Central Federal District for 2003 and 2012 are represented in the table).

Table 7. The calculated values of the subscripts and the integral indexes of the sustainability

Субъект Федерации	2003					2012				
	Kd	GRP	Social	Inst.	Innov.	Kd	GRP	Social	Inst.	Innov.
Belgorod region	0,298	0,469	0,147	0,436	0,138	0,388	0,525	0,503	0,464	0,060
Bryansk region	0,241	0,350	0,114	0,502	0,000	0,310	0,304	0,408	0,474	0,054
Vladimir region	0,279	0,405	0,131	0,497	0,083	0,343	0,397	0,459	0,517	0,000
Voronezh region	0,305	0,420	0,096	0,521	0,183	0,349	0,402	0,447	0,489	0,060
Ivanovo region	0,233	0,309	0,131	0,494	0,000	0,292	0,247	0,451	0,459	0,012
Kaluga region	0,301	0,428	0,164	0,500	0,110	0,327	0,450	0,489	0,229	0,139
Kostroma region	0,214	0,423	0,165	0,259	0,009	0,274	0,353	0,460	0,284	0,000
Kursk region	0,260	0,434	0,098	0,481	0,028	0,311	0,417	0,430	0,396	0,000
Lipetsk region	0,292	0,564	0,187	0,418	0,000	0,354	0,519	0,473	0,422	0,000
Moscow region	0,372	0,507	0,236	0,479	0,266	0,451	0,566	0,587	0,367	0,283
Oryol region	0,283	0,469	0,158	0,495	0,009	0,298	0,342	0,439	0,406	0,006
Ryazan region	0,265	0,439	0,123	0,499	0,000	0,337	0,399	0,459	0,482	0,006
Smolensk region	0,281	0,459	0,140	0,497	0,028	0,340	0,391	0,453	0,504	0,012
Tambov region	0,250	0,404	0,120	0,475	0,000	0,316	0,374	0,419	0,470	0,000
Tver region	0,272	0,443	0,146	0,453	0,046	0,344	0,427	0,513	0,431	0,006
Tula region	0,283	0,452	0,142	0,499	0,037	0,348	0,412	0,461	0,519	0,000
Yaroslavl region	0,305	0,548	0,200	0,446	0,028	0,309	0,463	0,511	0,233	0,030
Moscow city	0,807	0,867	0,394	0,965	1,000	0,883	0,904	0,726	0,901	1,000

The estimation of the received results has allowed drawing a conclusion, that during the studied period the sustainability of the development of the majority of the Russian regions has increased. Also it is established, that the greatest contribution to the development process has been made by the economic (the average partial coefficient was 0.445) and institutional components (0.402); the low level of the

development of the social subsystem (0.260) and the innovative activity (0.032) was noted.

### Discussions.

It should be noted, that the suggested methodology of the selection of the indicators is imperfect and is currently being further modernized and improved.

At that the methodology can be applied in the context of a separate subject of the Russian Federation, too. So, using it on the example of Vladimir region has allowed establishing, that the volume of the GRP of the region is by 93% dependant on the share of the organizations, which used the information and communication technologies in the total number of the inspected organizations of the subject of the Federation, and is by 4% determined by the influence of the “the unemployment level” factor. As we see, the regularities revealed on the example of Vladimir region, confirm the conclusion on the biggest importance of the information resources for the economic development of the regions, which has been received during the inspection of 80 subjects of the Russian Federation. The fact of the non-coincidence of the second factor does not deny the significance and accuracy of the conducted research, as, firstly, the methodology of the correlation and regressive analysis allows the deviations of the partial results from the general regularities, and, secondly, the established difference allows identifying the factors which are relevant for each particular region. Such information will allow the regional authorities to obtain additional sources of the regional development.

### Conclusions

Overlaying the results obtained by the theoretical means on the modern economic realities of the development of the Russian Federation it is possible to speak about the fact, that they reflect quite correctly the trends and problems of the development of the Russian society.

As the analysis of the calculated sustainability indexes shows, in general the development of the majority of the subjects of the Russian Federation cannot be considered sustainable, because in the indicated period the value of the integral indexes of the majority of the subjects was below the level of 0.500. The cities of the Federal significance, such as Moscow and Saint-Petersburg and Tyumen region are the regions, which have overcome this barrier. The Chukotka Autonomous District and Sverdlovsk region have come close to this mark and have occupied the 4<sup>th</sup> and the 5<sup>th</sup> places, respectively.

Conducting the estimation in the context of the partial components, it is necessary to note, that the greatest contribution to the general integral index is

made by the component of the GRP per capita, what can be explained by the redistribution of the income at the Federal level.

The work of the transport communication units should be recognized to be relatively satisfactory, however, the low level of the maintenance of the equipment of the majority of the RF subjects for the data transmission services, as well as an extreme irregularity of its distribution reduce the value of the subscript of the institutional infrastructure almost by half.

The most complex situation is observed in the spheres of the social maintenance of the population and the innovation development, where the indicators of the majority of the subjects do not rise above the level of 0.200 and 0.100, respectively.

Also, the performed calculations confirm the conclusion on the extremely low influence of the innovation component on the level of the economic development of Russia and reflect the misbalance between the demand and the innovation supply in favour of the latter, as the indicator “The number of *the created* advanced technologies” became the most powerful factorial characteristic in the final model.

In conclusion it should be noted, that the transition to the economy of the knowledge in the framework of which the determining factors of the social development are the human capital and innovations, while these trends are preserving, is extremely difficult.

### Reference

1. The Regions of Russia. Social and Economic Indicators. 2013: [The electronic resource]. – The access mode: [http://www.gks.ru/bgd/regl/b10\\_14p/IssWWW.exe/Stg/d03/23-05.htm](http://www.gks.ru/bgd/regl/b10_14p/IssWWW.exe/Stg/d03/23-05.htm)
2. Russia and Countries of the World. 2012.: Statistic collection / Rosstat. - M., 2012. - P. 130-131.
3. Rogatnykh E.B. The Global Competitiveness Index: the Issues of the Construction and Estimation Methodology [The electronic resource] / E.B. Rogatnykh. - The access mode: [http://www.vavt.ru/journal/id/3E808A/\\$File/13-19.pdf](http://www.vavt.ru/journal/id/3E808A/$File/13-19.pdf)
4. The central base of the data of the Federal State Statistics Service [The electronic resource]. - The access mode: <http://www.gks.ru/dbscripts/Cbsd/DBInet.cgi#1>.