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Method and Criteria for Assessing the Sustainable Development

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Abstract

In today's world, to survive, people need to work for a job which they are happy and satisfied. Before choosing their own job, they need to set a career path. When looking at the history about how it has been working for people, we see some factors affecting their orientation to their careers. The world is changing; so is the generation. This paper contains a research study about the career orientation for this new generation in Turkey. This empirical study is conducted with an AHP method with Turkish university students' career orientation, having as main objective to identify the factors which are affecting the new generation about the setting their career orientation and order them in a hierarchical way. The results showed that this new generation is somehow different from the previous ones, especially when it comes to career orientation; some factors affect their way to choose a career path.

Keywords: Countries; Regions and cities; Sustainable development; Evaluation methods and criteria; Comparative analysis.

1. Introduction

The concept of sustainable development has been improving for almost three decades. However, it should be noted that very little progress has been made in theoretical approaches during this period. The theories and models used mainly involve the use of expert methods and simple complex estimates (Abavisani and Sanchooli, 2018).

The generally accepted concept of sustainable development was set out in the UN General Assembly Declaration (Transforming our world, 2018). Sustainable development refers to the development promoting the prosperity and economic opportunity, well-being and environmental protection (Pacheco *et al.*, 2017).

Since 1987, when the first formulation of sustainable development appeared (Report of the World Commission on Environment and Development, 2018), the concept of sustainable development remains a popular and beautiful idea. This concept is set out at a qualitative level without specific details, which would allow creating quantitative models of sustainable development of the analyzed objects (Villalobos Antúnez, 2009).

The aim of this work was to develop a method and criteria for a comprehensive assessment of the development of countries, regions and cities to form ideas about the vector of sustainable development of both individual objects and groups of homogeneous objects.

In recent years, there has been a rapid development in the systematic research, based on the application of natural and physical methods in the economic and social sciences (Albeverio, 2007; Chakrabarti *et al.*, 2006; Meyers, 2009; Naldi *et al.*, 2010). In these methods, data, which determines the entire course of research and model construction, comes first.

1.1. Methodology of Assessment of Complex Objects Development

We assume that the position of each socio-economic object is determined by a set of values of its indices that are formed at a certain time. To describe the position of objects relative to all other objects of a studied class, we used the natural science concept of the state space – an abstract space formed by state variables. As the state variables, we took for socio-econometric analysis indicators that were considered significant among experts and characterized the studied objects in a certain aspect. Suppose that there are statistical data for values of indicators $z_1, z_2, ..., z_n$ for *n* socio-economic objects (countries, regions or cities) considered as state variables. Let us form the *n*-dimensional state space in the form of a Cartesian coordinate system. The main idea of the work is related to the study of the possibility of creating models that differ in the description of geometric points (States) and lines (processes) in multidimensional spaces of States of socio-economic objects on the basis of available statistical information. Modeling is based on the hypothesis of the existence of different measures of similarity of object States $W = W(z_1, z_2, ..., z_n)$

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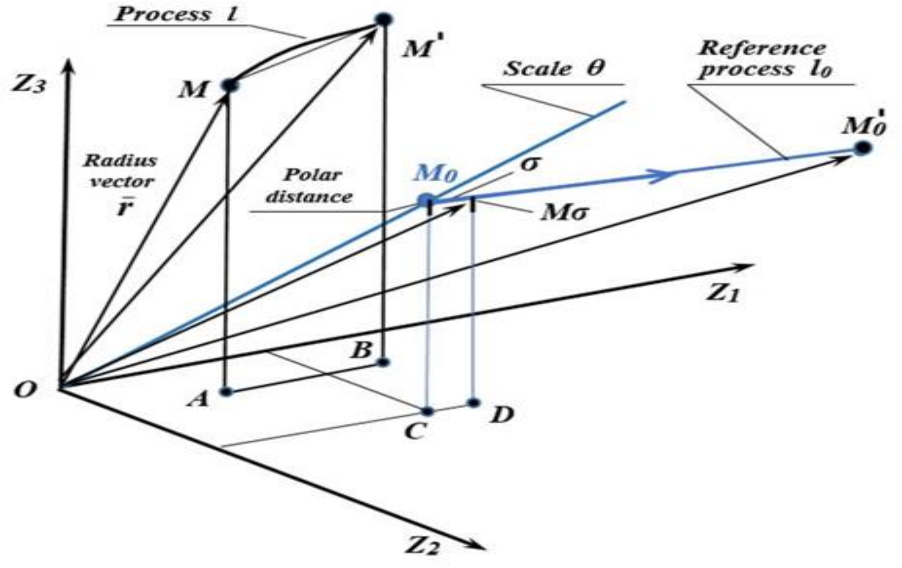
(Averin *et al.*, 2016; Averin and Zviagitrseva, 2017; Averin *et al.*, 2017; Averin *et al.*, 2018; Zviagintseva, 2016). This value is considered as a function of several variables. The construction of models is based on the use of principle of corresponding states (Averin and Zviagitrseva, 2017; Averin *et al.*, 2018; Zviagintseva, 2016). according to which positions of objects in the state space can be described by a single equation of state if you build an effective scale for comparing States with each other and use some of the variables. Typically, the equation of state is represented as $F(z_1/z_{1_0}, z_2/z_{2_0}, ..., z_n/z_{n_0}) = 0$, where z_{k_0} refers to values of indicators for a reference state. In this approach, the modeling object is the state of objects that can be characterized by a general valid equation for the entire multidimensional state space.

A reference object or reference state is selected to construct the equation of state from a group of objects, and all other states are related to the selected point in the state space. The validity of the principle is verified on a case-by-case basis.

The principle of corresponding states allows us to construct a scale for the relative comparison of the position of objects among themselves, in the form of an index θ (Averin and Zviagitrseva, 2017; Averin *et al.*, 2018; Zviagintseva, 2016). In general, the content of method is as follows (Fig. 1.). Select some linear reference process l_0 for some object and mark the reference state on it M_0. On the line of this process, we note the second reference state M'_0. The first reference state may correspond to the start time of statistical data collection, for example, as in the example below, 2012, and the second reference state to the last year of data collection, for example, 2015. The resulting segment is divided into a given number of identical intervals, for example, 100, and set the length of the obtained segments σ, based on the measure of similarity of the States of objects *W*. Next, from the origin of the beam OM_0 and find the length of the segment OM_0 in the accepted system of measurement value *W*. The scale of measurements for the states of objects is formed in the form of an index θ applied to the beam OM_0 with a unit of measurement σ, the length of the segment OM_0 in this scale will be $\theta_0 = OM_0/\sigma$. For certainty, we set the appropriate unit of measure θ as a degree (°G), which is geometrically equal to the length σ.

Using various measures of similarity W, the resulting scale can measure each state in degrees of index θ. Therefore, the index θ, as a whole, characterizes the state of objects and is an empirical measure for their measurement. This is the main criterion for determining the position of countries, regions and cities on a set of different socio-economic indicators in a multidimensional space of States.

Figure-1. System of construction of the index scale θ in relation to the reference state and the reference process Lengths of segments in the state space with the Euclidean metric can be determined based on the Euclidean distance:



$$l_{ab} = \sqrt{(z_{1b} - z_{1a})^2 + (z_{2b} - z_{2a})^2 + ... + (z_{nb} - z_{na})^2}, \quad (1)$$

Where, *a* and *b* are the beginning and the end of a certain segment ab.

To describe the statistical data, we can search for a model of collective behavior of objects in the form of an equation of state (Averin and Zviagitrseva, 2017; Averin *et al.*, 2018; Zviagintseva, 2016).

$$\theta = f\left(z_1/z_{1_0}, z_2/z_{2_0}, ..., z_n/z_{n_0}\right). \quad (2)$$

For different periods of time, it is possible to obtain different values of the complex index θ, as a function of time in the same state space of objects through a common scale of econometric measurements. This will allow you to study not only the state, but also the processes of development of objects.

1.2. Sustainable Development Indicators

247 recommended indicators by the UN, 47 proposed indicators by the world Bank, and 35 recommended national indicators for the use by the state statistics Service of Russia have been used for the sustainable development (The Little Green Data Book, 2006). For instance, 13 indicators were selected from the list of 35 national indicators for integrated assessment of sustainable development of Russian regions which were grouped into two groups. The group, which characterizes the socio-economic stability of the development of regions, include:

- Gross regional product per capita, RUB/person, z_{1s};
- Average per capita income of the population, RUB, z_{2s};
- The average size of assigned pensions, RUB, z_{3s};
- Volume of cargo transportation by rail and road, thousand tons/person, z_{4s};
- The volume of exports, converted at the exchange rate of the dollar, RUB/person, z_{5s};
- Volume of imports converted at the dollar exchange rate, RUB/person, z_{6s};
- Scope of work performed by types of economic activity “Construction”, RUB/person, z_{7s}.

In relation to regions, this group was based on the principle of “the higher the value of an indicator, the better the indicator is”.

The group, which characterizes the environmental sustainability of regions, include:

- investments in fixed capital aimed at environmental protection, RUB/person, z_{8s};
- emissions of air pollutants from stationary and mobile sources, kg/person, z_{9s};
- water intake from natural water bodies, m^3/person, z_{10s};
- discharge of contaminated wastewater into surface water bodies, m^3/person, z_{11s};
- the energy intensity of the GRP, kg of standard fuel/10 thousand RUB, z_{12s};
- infant mortality, the number of children who died before the age of 1 year per 1,000 births, z_{13s}.

The group of indicators of environmental sustainability of regional development was organized according to the principle of “the lower the value of an indicator, the better the indicator”.

Data on the above indicators was collected for a period of 2012–2015 for 80 regions of Russia. The study on features of sustainable development of regions was conducted by the cluster data analysis followed by the construction of socio-econometric scales for comparing states of objects. Clustering was carried out by *k*-means method using the Statistica program separately for groups of indicators characterizing the socio-economic and environmental sustainability of regional development. The clustering technique involved the use of the nearest neighbor method where Euclidean distance was used as a clustering measure. The studied indicators were previously standardized by bringing them to the form: $z_k^{st} = \left(z_k - z_k^{sr}\right)/\sigma_k$, where z_k^{sr} – average *k*-indicator, σ_k – standard deviation.

The above seven indicators, $z_{1s}, ..., z_{7s}$, were used for the analysis of socio-economic sustainability and six $z_{8s}, ..., z_{13s}$ for the analysis of environmental sustainability. The number of clusters was determined by the method of hierarchical clustering in the Statistica software product by building dendrograms.

Clustering of regions according to the observations of the values of socio-economic stability indicators allowed to identify three groups of regions. Table 1 presents characteristics of the clustering areas by standardized indicators.

Table -1. Characteristics of Clustering Areas by Standardized Indicators of Socio-economic Sustainability

Clusters	Statistics	Standardized indicators						
		z_{1s}	z_{2s}	z_{3s}	z_{4s}	z_{5s}	z_{6s}	z_{7s}
The first cluster	Average	2.668	2.433	2.076	0.4	1.737	1.077	2.426
	Standard deviation	1.467	1.077	1.455	1.684	2.782	1.849	1.343
The second cluster	Average	0.128	0.204	0.344	0.700	0.155	0.274	0.249
	Average	0.330	0.644	0.847	1.104	0.403	1.290	0.571
The third cluster	Average	-0.468	-0.475	-0.499	-0.450	-0.344	-0.312	-0.499
	Standard deviation	0.248	0.430	0.271	0.416	0.162	0.221	0.345

The first cluster contained 7 regions, the second 26 and the third 47 regions:

- The first cluster – Moscow and St. Petersburg, Tyumen and Tomsk regions, the Republic of Sakha (Yakutia), Sakhalin region and Chukotka Autonomous Okrug;
- The second cluster – Belgorod, Kaluga, Lipetsk, Moscow regions, Republic of Karelia, Republic of Komi, Arkhangelsk, Vologda, Kaliningrad, Leningrad, Murmansk, Novgorod regions, Republic of Tatarstan, Perm, Samara, Sverdlovsk regions, Republic of Altai, Republic of Khakassia, Krasnoyarsk region, Irkutsk, Kemerovo, Tomsk regions, Kamchatka, Primorsky Krai, Khabarovsk Krai, Amur oblast;
- The third cluster – all remaining regions of Russia.

Table 1 presents that there are high indicators of socio-economic stability for regions of the first cluster since six of seven clustering indicators have the highest average. These regions, in the context of the country as a whole, can be seen as examples of the sustainable socio-economic development.

Clustering of regions according to observations of the values of environmental sustainability indicators also allowed us to identify three groups of regions:

- The first cluster (12 regions) – Lipetsk region, Republic of Karelia, Republic of Komi, Arkhangelsk, Vologda, Murmansk regions, Perm region, Tyumen, Chelyabinsk regions, Krasnoyarsk region, Irkutsk and Kemerovo regions;
- The second cluster (12 regions) – Kostroma, Tver, Leningrad regions, Republic of Dagestan, Republic of Ingushetia, Karachay-Cherkess Republic, Republic of North Ossetia-Alania, Chechen Republic, Republic of Tuva, Republic of Khakassia, Jewish Autonomous region, Chukotka Autonomous region;
- The third cluster (56 regions) – all remaining regions of Russia.

Table 2 presrnts characteristics of clustering areas by indicators of environmental sustainability.

Table-2. Characteristics of Clustering Areas by Standardized Indicators of Environmental Sustainability

Clusters	**Statistics**	**Standardized indicators**					
		z_{8s}	z_{9s}	z_{10s}	z_{11s}	z_{12s}	z_{13s}
The first cluster	Average	1.190	1.656	0.156	1.500	0.934	-0.391
	Standard deviation	1.911	1.496	0.567	1.442	1.564	0.338
The second cluster	Average	-0.506	-0.217	1.133	-0.376	0.602	1.509
	Standard deviation	0.162	0.743	2.158	0.643	1.158	1.439
The third cluster	Average	-0.147	-0.308	-0.276	-0.240	-0.329	-0.240
	Standard deviation	0.560	0.416	0.278	0.601	0.547	0.641

According to the data above, it is clear that included regions in the first and second clusters have low indicators of environmental sustainability. From a large group of regions of the third cluster, 12 regions were selected according to values of environmental indicators and can be considered as regions of sustainable environmental development in the context of the whole country: Belgorod, Voronezh, Ivanovo, Kursk, Tambov, Kirov, Penza, Kurgan, Novosibirsk regions, Republic of Mordovia, Udmurt Republic, and Chuvash Republic.

On the basis of results of cluster data analysis, two control groups of regions were formed and distinguished by indicators of socio-economic and environmental sustainability.

1.3. Integrated Assessment Criteria

Criteria for comparing regions by indicators of sustainable development in a multidimensional state space are based on the choice of support vectors.

If we take two control groups of regions and average their values for 2012 and 2015, then in the state space we can construct vectors characterizing the directions of the most sustainable development for the entire group of 80 regions of Russia for a given period of time.

According to the fact that indicators have different dimensions and values of numbers, the analysis is carried out on standardized values of indicators: $z_k^{st} = \left(z_k - z_k^{sr}\right) / \sigma_k$.

We form a basic vector $\vec{F}_{1s}$ of social and economic stability of the regions. For this vector, the reference state M_0 corresponds to the observed values of the indicators $z_{1s_0},\ldots,z_{7s_0}$ in 2012. The second reference state M'_0 for this vector corresponds to the observed values $z_{1s*},\ldots,z_{7s*}$ of the selected group of 7 regions in 2015. According to this data, we find the vector module $\left|\vec{F}_{1s}\right|$and divide it into 100 identical parts. This allows you to set the length of a line σ as a dimensionless unit socio-economic scale to compare regions among themselves, which amounted to 0.01398.

Similarly, we form the second reference vector $\vec{F}_{2y}$ of environmental sustainability of the regions. For this vector, the first reference state M_0 corresponds to the values of the indicators in 2012 – $z_{8s*},\ldots,z_{13s*}$, and the second reference state for the 2015 data . We find the module of the vector $\left|\vec{F}_{2s}\right|$and divide it into 100 equal parts and set the length of the segment $\sigma = 0.00976$as a unit of socio-econometric scale for comparing regions with each other in terms of environmental sustainability.

Defined vectors of sustainability for selected small control groups of regions, which are considered as examples of sustainable development in the context of the whole country, can be used to form criteria for integrated assessment. The value of a vector module is used as one of these criteria. On its basis, we create an appropriate socio-econometric school. Measurements on this scale allow you to compare regions of Russia with each other.

The index θ, as a measure of similarity of States, is along with the length of the vector characterizing the development of each region in a certain period of time, for example, 2012–2015. This index determines the level of sustainable development of the region in relation to the reference vector, which characterizes the most developed group of regions in this respect.

It should be noted that the vector $\vec{F}_s$ can be characterized not only by the length, but also by the direction of development in the space of object States. Therefore, the second criterion for sustainable development of the region in relation to the most developed group of regions can be the angle φ between the reference vector and the vector of development of the region.

The smaller the angle φ, the more the direction of development of the analyzed region corresponds to indicators of sustainability priority development of the most developed control group.

1.4. Comparison of Russian Regions in Terms of Sustainable Development

We carried out a comprehensive assessment of the socio-economic and environmental sustainability of regions according to indicators of achieving sustainable development goals. We used the method of integrated assessment of the development of socio-economic objects as given earlier. Table 3 presents a comparison of Russian regions by a set of indicators based on the created scales of socio-economic and environmental sustainability.

Table-3. Comparison of Russian Regions in Complex Terms of Socio-Economic and Environmental Sustainability

Subjects of the Russian Federation	Value of the quantities *θ*, °G		Region rank in group	
	Socio-economic sustainability	Environmen-tal sustainability	Socio-economic sustainability	Environmental sustainability
1	2	3	4	5
Sakhalin Region	598.28	64.47	1	33
Belgorod Region	499.37	40.17	2	15
Kaliningrad region	432.99	81.90	3	44
Republic of Altai	262.08	44.70	4	16
Tyumen Region	259.12	312.50	5	77
Moscow	214.16	17.56	6	3
Saint-Petersburg	206.95	61.39	7	30
Kaluga Region	171.79	90.35	8	52
Smolensk Region	141.46	32.22	11	7
Leningrad Region	138.76	89.10	13	51
Irkutsk Region	135.33	79.95	14	41

The rest of the Table 3

1	2	3	4	5
Primorsky Krai	134.48	339.31	15	78
Orenburg region	120.21	90.45	18	53
Krasnodar region	113.41	9.22	20	1
Samara region	85.86	33.25	24	9
Moscow region	81.37	53.90	25	22
Republic of Tatarstan	78.96	58.02	27	25
Rostov region	76.13	54.27	28	23
Voronezh region	70.75	35.40	32	11
Vologda region	70.34	154.75	33	69
Krasnoyarsk region	69.11	93.76	34	55
Arkhangelsk region	68.91	60.22	35	28
Novosibirsk region	68.28	33.26	36	10
Kemerovo region	67.86	107.42	37	59
Volgograd region	65.51	180.31	38	71
Kursk region	60.94	81.05	43	43
Tula region	45.91	80.30	48	42
Saratov region	45.63	82.25	49	45
Nizhny Novgorod region	44.96	10.60	50	2
Vladimir region	39.51	108.49	53	60
Astrakhan region	34.46	132.55	57	66
Altai territory	30.38	36.94	59	14
Perm territory	29.52	292.63	60	75
Ivanovo region	29.26	48.15	61	17
Ulyanovsk region	24.01	60.88	66	29
Stavropol territory	19.75	32.42	72	8
Omsk region	19.69	64.26	73	32
Tomsk region	16.99	115.29	75	61
Ryazan region	16.09	74.56	77	39
Kirov region	13.55	69.06	78	35
Chuvash Republic	11.91	68.16	79	34
Tver region	6.42	273.13	80	74

The value of θ is equal to 100 for reference vectors.

According to the obtained data, five regions with high levels of socio-economic stability in terms of specific indicators (related to the population) were Sakhalin, Belgorod, Kaliningrad regions, the Republic of Altai, and the Tyumen region.

In turn, five regions with high levels of environmental sustainability in terms of specific indicators included the Krasnodar territory, Nizhny Novgorod region, Moscow, Sverdlovsk region and the Kabardian-Balkar Republic. The presence of Moscow in this group is explained by a significant number of the population (12.3 million people) and the fact that the integrated assessment considered specific indicators of environmental sustainability (related to the number of the population).

2. Conclusion and Prospects

The above examples show that the study on features of sustainable development of countries, regions and cities can be performed by the cluster data analysis followed by the construction of econometric scales to compare the States of objects among themselves on a set of indicators. For comparison of objects, it is offered to use a basic vector of development which is under the construction for control group of objects that are the most developed indicators of achievement for achieving the sustainable development.

The present paper proposed socio-econometric scales for assessing the development of regions as well as criteria for characterizing their sustainability based on a relative comparison of development vector of each region with the reference vector of development of control group of regions.

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