Montenegrin Journal of Economics

Vol. 14, No. 3 (2018), 7-22

Indicators of Regional Development Using Differentiation Characteristics*

SERGEI A. AIVAZIAN[1], MIKHAIL Yu. AFANASIEV[2] and ALEXANDER V. KUDROV[3]

[1] Professor, Central Economics and Mathematics Institute of the Russian Academy of Sciences, Moscow, Russia; aivazian@cemi.rssi.ru
[2] Professor, Central Economics and Mathematics Institute of the Russian Academy of Sciences, Moscow, Russia; miafan@cemi.rssi.ru
[3] Professor, Central Economics and Mathematics Institute of the Russian Academy of Sciences, Moscow, Russia; kovlal@inbox.ru

ARTICLE INFO

Received June 02, 2018
Revised from June 22, 2018
Accepted August 21, 2018
Available online September 15, 2018

JEL classification:

C54, E52, G18.

DOI: 10.14254/1800-5845/2018.14-3.1

Keywords:

regional economy,
econometric modeling,
hypothesis testing,
indicators.

ABSTRACT

On the example of two directions - "production of goods and services" and "welfare", it is developed a methodology for analyzing the interrelationship between various directions of regional development. The novelty of the results is determined by the fact that the direction indicators are constructed using a common basis formed using the characteristics of regional differentiation obtained from theoretically based models. The index for each direction, constructed in the basis, is maximally correlated with the index formed for the corresponding group of indicators. It is shown that for the considered two directions, the basis ensures higher consistency of the indices and ranks of the regions than the first principal components constructed for each group of the indicators separately. The advantage of the approach is that the indices for different directions based on the basis allow a general interpretation in terms of the differentiation characteristics and allow one to assess the change in the level of socio-economic development of the region when these characteristics change. The presented results confirm the significance of the influence of technical efficiency on the indices of regional development and its significance in the indicator composition for the direction of "welfare".

INTRODUCTION

A theoretically grounded approach to the analysis of the interrelationship between various directions of regional development is the construction of indices on the basis of a component analysis of the indicators characterizing these areas. At the regional level, the benefits associated with the use of the principal component method and its modifications are most fully disclosed in the

* **The work was supported by the Russian Science Foundation (project 17-18-01080)**

works (Aivazyan, 2012; Makarov et al., 2014) in analyzing the quality of life. The problem of constructing indices for two directions of regional development - "production of goods and services" and "welfare" and assessing their interrelationship is discussed below. A natural way to solve this problem is the construction index of each direction using principal components analysis and comparison the regions by these calculated indices. Then this method is used for comparison analysis. The novelty of the proposed approach and the obtained results is determined by the fact that the indices are constructed on the basis of a common basis characteristics. The components of the basis are characteristics of differentiation, formed with the use of theoretically grounded models of regional development. In its composition: the scale of the economy, the technical efficiency of production, the index of industry specialization (based on the first principal component of the GRP sector-structure), the index of industrialization (based on the second principle component of the GRP sector-structure), the trend of technical efficiency. The position of the region in the basis of the characteristics of differentiation determines its economic identity. The formation of the index in the basis characteristics is carried out in such a way that it is as much as possible correlated with the set of indicators characterizing the direction in question. The advantage of the approach considered below is that the indices constructed on its basis allow us to quantify the relative change in the level of socio-economic development of the region when the characteristics of differentiation change.

Analysis of the relationship between the technical efficiency of production and the level of regional development is of independent interest. In this paper, there are presented the results confirming the significance in the composition of the basis of the technical efficiency influence on individual socio-economic indicators and its significance as part of the index in the direction of "welfare”. This can help expand the scope of application of technical efficiency not only as one of the characteristics of multifactorial productivity, but as a characteristic of regional differentiation.

1. FORMATION OF THE BASIS

The basis-characteristics $B_t = (\{l_{it}\}_i, \{te_{it}\}_i, \{s_{it}^1\}_i, \{s_{it}^2\}_i, \{dte_{it}\}_i)$ of regional differentiation on the time period $[t-1, t]$ include five components: l_{it} — the scale of the *i*-th region's economy at the time t; te_{it} — a comparable estimator of the technical efficiency; s_{it}^1 — industry specialization index; s_{it}^2 — index of industrialization; dte_{it} — technical efficiency trend, $dte_{it} = te_{it} - te_{it-1}$. Futher it is considered the number of economically active people as the characteristic of the economy scale. Technical efficiency comparable across all regions is considered as a characteristic of the management quality in the long run. The index of industry specialization — the first principle component of the GRP sector-structure and the index of industrialization — the second principle component of the GRP sector-structure. The trend of technical efficiency is a characteristic of the management quality in the short run.

The GRP sector-structure reflects the features of the technological interconnection of resource opportunities and the results of the region's manufacturing activities. The basis-characteristics includes the first and second principal components of the GRP sector-structure. As shown in (Ayvazyan, Afanasyev and Kudrov, 2016a), the first principle component separates regions with high concentration of the mining and other regions, it is further characterized as an index of industry specialization. The second principal component separates the manufacturing regions, evenly developed and developing regions, and is further characterized as the index of industrialization. The first two principle components account for more than 80% of the total variance in the quantitative characteristics of the GRP sector-structure, and the mutual arrangement of regions in the space of the first two principle components is stable in time.

Premise. All regions can be divided into homogeneous groups, each of which is characterized by its own form of GRP dependence from the production factors.

In accordance with the approach proposed by the authors (Ayvazyan, Afanasyev and Kudrov, 2016a), a homogeneous group includes regions that have a close arrangement in the space of the first two principle components of the GRP sector-structure. The homogeneity of the group is controlled by the likelihood function. The whole set of the regions in the Russian Federation is divided into five groups (Ayvazyan, Afanasyev and Kudrov, 2016b). The base group №1 consists of 38 regions with a uniformly developed industry, the group №2 includes 11 "mining" regions, the group № 3 consists of 12 "manufacturing" regions, the group № 4 includes 11 "agricultural" regions and the group № 5 consists of 8 "developing" regions. In the column (1) of Table A1, for each region it is shown the respective group.

For each homogeneous group according to the data for the period 2010-2015 years, it is estimated the production function coefficients, which are assumed to be time-varying and linearly dependent on time:

$$\ln R_{it} = \beta_0 + \alpha_0 t + (\beta_1 + \alpha_1 t)\ln K_{it} + (\beta_2 + \alpha_2 t)\ln L_{it} + v_{it} - u_{it} \quad (1)$$

R_{it} — GRP of the i-th region at the time t; K_{it} — the expenditures of the physical capital for the i-th region at the time t, L_{it} — - the amount of labor for the i-th region at the time t, $v_{it} \in N(0,\sigma_v^2)$; $u_{it} \in N^+(\mu,\sigma_u^2)$. The random component $\varepsilon_{it} = v_{it} - u_{it}$ reflects the effects of uncertainty factors and efficiency factors. In accordance with the concept of a stochastic frontier, an estimate of the technical efficiency of the i-th region production at the time t equals to the conditional mathematical expectation $TE_{it} = E(\exp\{u_{it}\} \mid \varepsilon_{it})$ (Kumbhakar and Lovell, 2004). In Table. 1 it is presented the estimates for the parameters of the model (1) both separately for the regions from each of the five homogeneous groups and for the whole set of 80 regions.

Table 1. Estimates of the parameters of the model (1) for homogeneous groups and for the whole set of regions

Dynamical	*G1 Basic*	*G2 Mining*	*G3 Manufacturing*	*G4 Agricultural*	*G5 Developing*	*all 80 regions*
β_1	.7604*** (.0386)	.8154*** (.0276)	.3659*** (.0401)	.3873*** (.0760)	.3734*** (.0000)	.8590*** (.0342)
β_2	.3323*** (.0477)	.0981*** (.0286)	.6753*** (.0438)	.7465*** (.0817)	.4814*** (.0000)	.1751*** (.0420)
β_0	.0774 (.2858)	1.1958*** (.2536)	3.1638*** (.3102)	2.1853*** (.5071)	4.052*** (.0000)	-.1923 (.2689)
α_0	.0327*** (.0090)		.0733*** (.0075)	.0823*** (.0116)	.0473*** (.0000)	.1690** (.0827)
α_1					-.0292*** (.0000)	-.0226** (.0108)
α_2					.0678*** (.0000)	.0255* (.0133)
μ	-.1219	-.0807	-1.8682	-.7517	-1.9597	-.1427
σ_u^2	.0002	.0704	.0025	.0008	.5428	.0003
σ_v^2	.0453	8.61e-17	.0084	.0160	2.41e-16	.0472
Log likelihood	29.2250	28.7609	69.7292	42.6737	23.1644	51.2145

Premise. Glockalization* creates conditions for the region's access to financial resources and knowledge created by mankind. The relative inefficiency of the region in the homogeneity group is due to the fact that it does not make full use of the available development opportunities.

The technical efficiency estimates for the regions that are part of a homogeneous group are considered as indicators of the effectiveness of regional management, since the difference in the level of technical efficiency of the regions in a homogeneous group is due to the fact that the regions use in a varying degrees affordable, comparable due to homogeneity development opportunities. However, the technical efficiency estimates for regions from different groups are not comparable. To bring them to a comparable kind, the authors proposed and tested a method that allows to correct the technical efficiency estimates obtained on a common for all regions model so that their ranks correspond to the ranks of the estimates obtained from the model constructed for each homogeneous group. The description, theoretical justification, the results of approbation of the method and comparable assessments of technical efficiency are presented in the paper (Ayvazyan, Afanasyev and Kudrov, 2018).

2. THE INFLUENCE OF THE COMPONENTS OF THE BASIS ON ECONOMIC INDICATORS

Based on Russian Statistical Agency data[1], a set of 11 indicators has been formed, characterizing two directions of economic development: "production of goods and services" and "welfare" in the time period 2010-2015 years. The names and designations of the indicators are presented in Table 2. For each indicator from Table 2 for each year t of the considered period, it is constructed regression dependencies in which the dependent variable is the normalized indicator y_{it} for the region i at the moment t (normalized for the whole set of regions, with zero mean and unit variance), and the explanatory variables are the normalized values of the components of the vector basis at the moment $t-1$:

$$y_{it} = \beta_{1t} l_{it-1} + \beta_{2t} te_{2t-1} + \beta_{3t} s_{it-1}^{1} + \beta_{4t} s_{it-1}^{2} + \beta_{5t} dte_{it} + \varepsilon_{it} \quad , \qquad (2)$$

where β_t — parameter vector; ε_{it} — error.

Based on the estimates of the beta coefficients for the five models presented in the Appendix Table A2, for each indicator it is determined the following : the significance of the influence of each component of the basis; direction of the change in the dependent variable with the increase of the component from the basis; the time tendency of the component's influence on the value of the indicator . The results of the analysis are presented in Table. 2.

In Table 2 the values for R^2 are given for 2015 year. The scale of the economy has a significant impact on all indicators, except for w4 and w5. Technical efficiency affects the indicators w1, w2, w4-w6 and w9. The index of industry specialization or the index of industrialization affects all indicators, except w10. The technical efficiency trend affects w2, w3 and w5. The obtained results allow considering the basis of the considered characteristics of regional differentiation as an information basis for constructing indices of various directions of economic development of the Russian Federation regions.

* Glockalization is a combination of global and local factors in the development of territories (Kudryashova, 2008; Robertson, 1992). In the context of the article, the tendency of the unification of mankind, based on the use of information technologies and new means of communication, allows almost instantaneously to receive and use for development of the region resources, created by mankind.

[1] Russian Statistical Agency data: http://www.gks.ru/bgd/regl/b16_14p/Main.htm

Table 2. Influence of the components of the basis on indicators[2]

Indicator	*l*	*te*	*s1*	*s2*	*dte*	*R² 2015*
w1: GRP per capita	*** (+) ↓	** (+) ↑	*** (+) ↑	** (+) ↓	(+) ↑	0,727
w2: Income per capita	*** (+) ↔	** (+) ↔	*** (+) ↔	↔	** (+) ↑	0,601
w3: Population with income below the subsistence level	*** (-) ↔	↔	↔	*** (-) ↔	* (-) ↑	0,444
w4:Infant mortality rate	↔	* (+) ↑	↔	*** (-) ↔	↔	0,363
w5: Average size of pensions assigned	↔	** (+)↔	*** (+) ↔	↔	* (+) ↑	0.574
w6: Migration rate	*** (+) ↔	*** (+) ↓	*** (-) ↓	*** (+) ↔	↓	0,448
w7: Unemployment rate	* (-) ↑	↔	↔	*** (-) ↔	(-) ↑	0,428
w8: Mining	*** (+) ↔	↔	*** (+) ↔	↔	↔	0,437
w9: Manufacturing	*** (+) ↔	* (+) ↓	↔	*** (+) ↓	↔	0,911
w10: Agriculture	*** (+) ↓	↑	↑	↔	↓	0,168
w11:Electricity,gas,water production	*** (+) ↔	↔	*** (+) ↔	↔	↑	0,902

3. FORMATION, BASED ON THE BASIS, OF AN INDEXES FOR A GROUP OF INDICATORS THAT CHARACTERIZE THE DIRECTION OF ECONOMIC DEVELOPMENT

Let $I^s(\gamma_t) = \sum_k \gamma_{tk} y_t^k$ – a linear combination of indicators characterizing the direction S of social and economic development of the Russian Federation regions, where y_t^k – vector of values $\{y_{it}^k\}_i$ of the indicator k of the group S for the whole set of regions i at the moment t, $\gamma_t = \{\gamma_{tk}\}_k$ – vector of parameters. Let $IB^s(\delta_t) = \delta_{1t} l_{it-1} + \delta_{2t} s_{it-1}^1 + \delta_{3t} s_{it-1}^2 + \delta_{4t} te_{it-1} + \delta_{5t} dte_{it-1}$ – be a linear combination of the components of the vector basis. The problem is to estimate the parameters γ_t^*, δ_t^*, such that I^s and IB^s are maximally correlated. That is
$(\gamma_t^*, \delta_t^*) = \arg\max_{(\gamma_t, \delta_t)} corr(I^s, IB^s)$.

As a result of solving this problem, indices $I^s(\gamma_t^*)$ and $IB^s(\delta_t^*)$ for the direction S are constructed. On their basis, two groups of indices of regional development can be constructed for the direction

[2] The notation used in Table. 2.

*** – the significance of the beta coefficient at a level of at least 10% in four or more models;
** – the significance of the beta-coefficient at the level of not less than 10% in three models;
* – the significance of the beta-coefficient at a level of at least 10% in the two models of recent years;
(+) – values of the beta coefficient for each year of the period under consideration have a sign at which the growth of the component of the vector basis leads to an increase in the value of the indicator;
(-) – values of the beta coefficient for each year of the period under consideration have a sign at which the growth of the component of the vector basis leads to a decrease in the value of the indicator
↑ – the influence of increase of the vector basis component in the direction of improving the value of the indicator rises in time;
↓ – the influence of the increase of the vector basis component in the direction of improving the value of the indicator decreases in time;
↔ – there is no tendency to change the influence of increase of the vector basis component in the direction of improving the value of the indicator.

S. The first group of indices is the projection to the index $I^s(\gamma_t^*)$ of the direction S indicators $\{y_{it}^k\}_k$ of direction indicators for each region i. The second group of indices is the projection to the index $IB^s(\delta_t^*)$ of the values of the basis characteristics for each region. With a sufficiently high correlation coefficient $corr(I^s(\gamma_t^*), IB^s(\delta_t^*))$, the regional indices by $IB^s(\delta_t^*)$ can be used as integral characteristics of the development level for the region in macro- and meso-level models, and also for building the ranking of regions by direction S. Thus, the basis vector creates a unified information basis for assessing the interrelationship of various directions of the regional socio- economic development. A feature and advantage of this approach is the ability to assess the impact of relative changes in the characteristics of regional differentiation, the relative level of its socio-economic development.

Description of the method. We denote $B_t^{(i)} = [l_{it}; te_{it}; s_{it}^1; s_{it}^2; dte_{it}]^T$ the value of the basis for the i-th region, $i = \overline{1,N}$, at time t and $Y_t^{(i)} = [y_{it}^1;...;y_{it}^k]^T$ - vector of the indicators values that characterize the direction S of social and economic development of the Russian regions, for the i-th region at time t. Then the solution of the above optimization problem under the assumption of the nondegeneracy of covariance matrices $\text{cov}(B_t^{(i)})$ and $\text{cov}(Y_t^{(i)})$ has the form (for the proof see in H. Hotelling (1936), and F. Waugh, (1942):

$$IB^s(\delta_t^*) = e_1^T[\text{cov}(B_t^{(i)})]^{-1/2} B_t^{(i)} \text{ и } I^s(\gamma_t^*) = f_1^T[\text{cov}(Y_t^{(i)})]^{-1/2} Y_t^{(i)},$$

where e_1 — the eigenvector corresponding to the maximum eigenvalue of the matrix $[\text{cov}(B_t^{(i)})]^{-1/2}\text{cov}(B_t^{(i)},Y_t^{(i)})[\text{cov}(Y_t^{(i)})]^{-1}\text{cov}(Y_t^{(i)},B_t^{(i)})[\text{cov}(B_t^{(i)})]^{-1/2}$, $\text{cov}(B_t^{(i)},Y_t^{(i)}) = \left(\text{cov}(B_t^{(i)},y_{it}^1)\cdots\text{cov}(B_t^{(i)},y_{it}^k)\right)$ — matrix with the dimension $5\times k$, $\text{cov}(B_t^{(i)},y_{it}^j) = \left[\text{cov}(l_{it},y_{it}^j);\text{cov}(te_{it},y_{it}^j);\text{cov}(s_{it}^1,y_{it}^j);\text{cov}(s_{it}^2,y_{it}^j);\text{cov}(dte_{it},y_{it}^j)\right]^T$ — column-cvector, $j=\overline{1,k}$. Wherein $\text{cov}(B_t^{(i)},Y_t^{(i)}) = \left[\text{cov}(Y_t^{(i)},B_t^{(i)})\right]^T$.

And f_1 — eigenvector corresponding to the maximum eigenvalue of the matrix $[\text{cov}(Y_t^{(i)})]^{-1/2}\text{cov}(Y_t^{(i)},B_t^{(i)})[\text{cov}(B_t^{(i)})]^{-1}\text{cov}(B_t^{(i)},Y_t^{(i)})[\text{cov}(Y_t^{(i)})]^{-1/2}$. Note also that the calculations made under the assumption that the covariance matrices $\text{cov}(B_t^{(i)})$, $\text{cov}(Y_t^{(i)})$ and $\text{cov}(B_t^{(i)},Y_t^{(i)})$ do not depend on i.

4. INDICATORS OF REGIONAL DEVELOPMENT AND REGIONAL RATINGS

4.1 Direction №1: "production of goods and services"

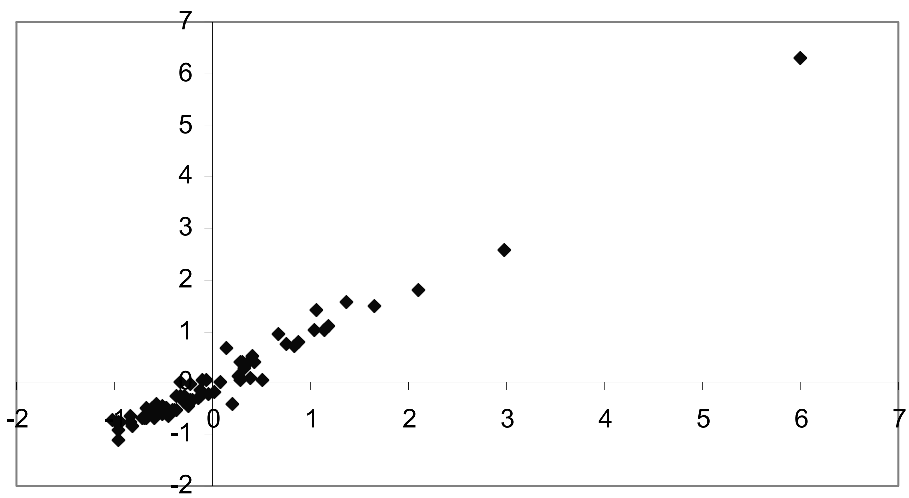
Consider the direction №1 of regional development of "production of goods and services" and five indicators characterizing this direction: w1 - GRP per capita; w8 - mining; w9 - manufacturing; w10 - agricultural products; w11 - electricity, gas, water production. In the following Table. 3 it is shown the estimates of the direction indices constructed on the basis of these indicators and vector basis characteristics for the 2015 year. In the column (1) of Table. 3 – the symbols of indicators characterizing the considered direction № 1. In column (2) – the estimates of the parameters γ_t^* of the index $I^1(\gamma_t^*)$. In column (3) - the correlation coefficients of the index $I^1(\gamma_t^*)$ and respective indicators. In column (4) - the symbols for the vector basis characteristics. In column (5) - estimates of the parameters δ_t^* of the index $IB^1(\delta_t^*)$ constructed on the basis of a vector basis. In column (6) - the correlation coefficients of the of the vector basis characteristics and the index $IB^1(\delta_t^*)$.

Table 3. Indices for the direction "production of goods and services"

I^1	Index of the indicators		IB^1	Index of the basis-characteristics	
(1)	(2)	(3)	(4)	(5)	(6)
w1	-1.462e-07	0.168	I	9.626e-04	0.994
w8	-3.172e-07	0.221	te	1.940e+03	0.211
w9	7.529e-07	0.967	s1	-5.212e-03	-0.192
w10	2.912e-06	0.388	s2	6.136e-03	0.324
w11	6.291e-06	0.931	dte	3.677e+03	0.064

The correlation of indicators w9 ("manufacturing ") and w11 ("electricity, gas, water production") with the index $I^1(\gamma_t^*)$ is above 0.9. Signs of the correlation coefficients of all indicators with the index in column (3) correspond to economic theory. The difference in the signs of the index coefficients in column (2) and the correlation coefficient in column (3) with indicators w1 - "GRP per capita" and w8 - "mining" is explained by the fact that in the regression of the index on indicators of the direction "production of goods and services " indicators w1 and w8 are insignificant. The most significant component of the index $IB^1(\delta_t^*)$ is the scale of the regional economy. The index of industrialization is also an important characteristic.

Figure 1. Regions in the space of indices for the direction "production of goods and services"



In Fig. 1, the dot corresponds to the position of the region in the space of two indices. On the abscissa - the index values for $IB^1(\delta_t^*)$. On the ordinate axis - the values for $I^1(\gamma_t^*)$. The correlation coefficient is 0.982. In the upper right of the figure, there are the following regions: Moscow, Moscow Region, St. Petersburg, Krasnodar region. In the column (4) of Table A1 it is shown the ranks of regions, based on the index $I^1(\gamma_t^*)$, in the column (5) of this table — the ranks constructed on the basis of the indicator $IB^1(\delta_t^*)$. The Spearman coefficient of rank correlation is 0.956, which indicates a high degree of ranks consistency for the index estimated on the basis of the indicators for the direction "production of goods and services" and the corresponding the vector basis characteristics.

4.2 Direction №2: "welfare"

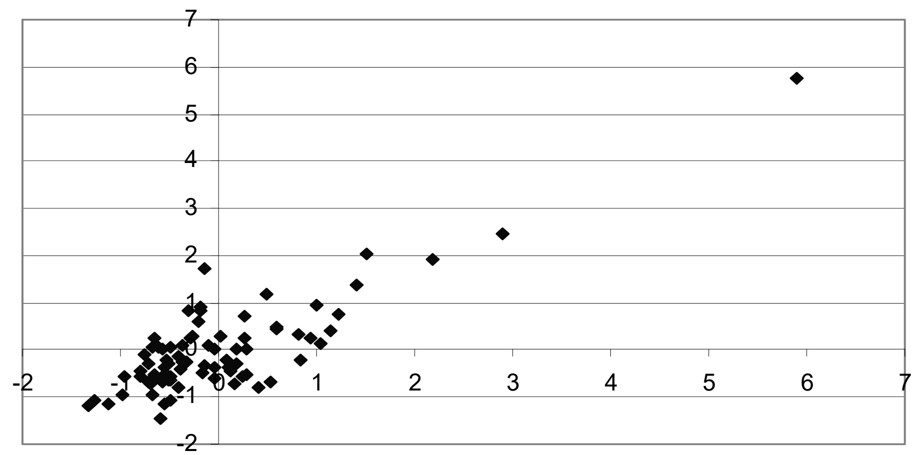
Consider the direction № 2 of regional development from the point of " welfare" and six indicators characterizing this direction: w2 - income per capita; w3 - population with incomes below the subsistence minimum; w4 - infant mortality rate, w5 - average size of pensions assigned, w6 – migration rate; w7 - unemployment rate. In the following Table 4 it is shown the estimates of parameters for indices of this direction, estimated on the basis of indicators and basis characteristics of differentiation according to the data for 2015 year.

Table 4. Indices for the direction "welfare"

I^2	*Index of the indicators*		*IB^2*	*Index of the basis-characteristics*	
(1)	(2)	(3)	(4)	(5)	(6)
w2	0.00016	0.683	l	9.267e-04	0.956
w3	0.07638	-0.153	te	1.147e+04	0.438
w4	-0.05507	-0.293	s1	6.768e-03	0.042
w5	0.00033	0.187	s2	-6.747e-04	0.279
w6	0.00985	0.610	dte	8.758e+03	0.112
w7	-0.03792	-0.415			

The indicators w2, w5 and w6 have a positive correlation with the index $I^2(\gamma_t^*)$, the indicators w3, w4 and w7 - negative, which corresponds to the economic theory. The difference in the signs of the coefficient in column (2) and the correlation coefficient in column (3) at w3 - " population with incomes below the subsistence level" is explained by the fact that this indicator is insignificant in the regression of the index on all indicators of the direction "welfare". In the indicator $I^2(\gamma_t^*)$, w2 is the most significant - income per capita and w6 - the coefficient of migration growth[3]. In the basis-characteristics index $IB^2(\delta_t^*)$ the most significant indicators are the scale of the economy (l) and the technical efficiency (te). The index of industry specialization (s1) and the trend of technical efficiency (dte) are insignificant.

Figure 2. Regions in the space of indices for the direction " welfare"



[3] The significance of the migration growth in the index of material well-being corresponds to the concept of "voting by feet", based on the hypothesis of Ch. Tibu.

In Fig. 2, the abscissa corresponds to the index values for $IB^2(\delta_t^*)$. On the ordinate axis - the values of indices for $I^2(\gamma_t^*)$. The correlation coefficient is 0.839. In the upper right part of Fig. 2 the dominant position is occupied by the same regions as in Fig. 1: Moscow, Moscow Region, St. Petersburg, Krasnodar region. In the column (7) of Table A1 it is shown the ranks of regions constructed for the direction of "welfare" for six indicators based on the index $I^2(\gamma_t^*)$, in column (8) of this table are the ranks estimated on the basis of the index $IB^2(\delta_t^*)$.

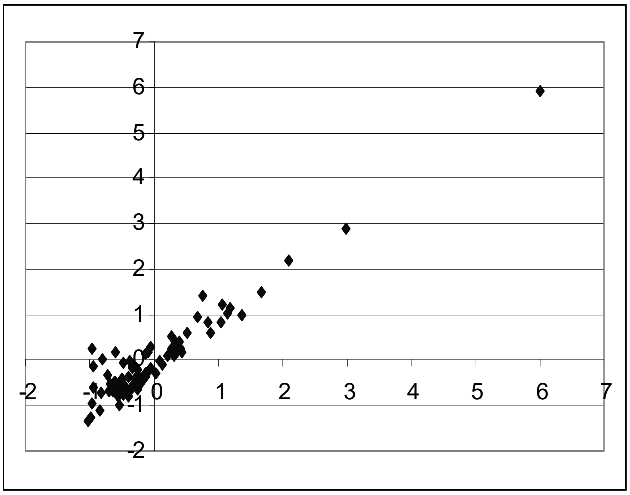


Figure 3a. Regions in the space of indices: the abscissa axis - "production of products and services", the ordinate axis - " welfare"

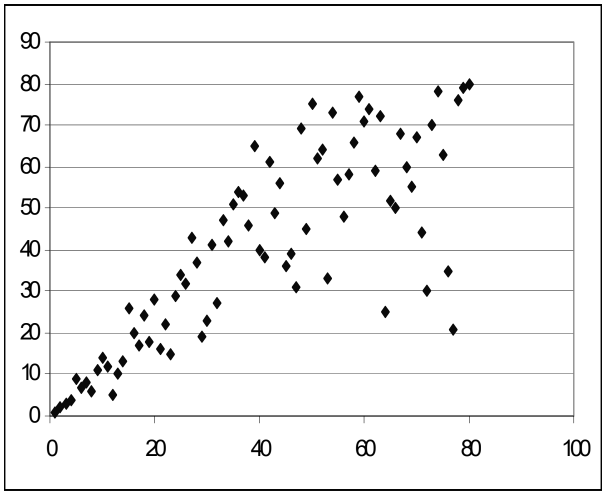


Figure 3b Regions in the space of ranks: the abscissa - "production of products and services", the axis of ordinates - " welfare"

In Fig. 3a on the abscissa - the indices of regions according to the index IB^1 of the direction "production of products and services". On the ordinate axis - the indices of regions according to the index IB^2 of the direction "welfare". The correlation coefficient is 0.953. In Fig. 3b on the abscissa axis - values of ranks in the direction "production of products and services". On the y-axis - ranks in the direction of "welfare". The correlation coefficient is 0.806. The ranks of four regions in the direction of "welfare" coincide with their high ranks in the direction of "production of goods and services": Moscow - 1, Moscow region - 2, St. Petersburg - 3, Krasnodar Region - 4. In the upper right there are two regions: the Jewish Autonomous Region - 79 and the Republic of Kalmykia - 80. In the lower right part of Figure 3b, five regions are distinguished from the total population. These are the Kamchatka Territory, the Republic of Sakha (Yakutia), the Magadan Region, the Sakhalin Region, and the Chukotka Autonomous District. The position of these regions in the ranking for the direction "welfare" is much higher than the position in the rating "production of goods and services". The index in the direction of "production of goods and services" gives an underestimation of the index for the main set of regions, since the industry specialization index is included in the indicator with a negative sign and the natural rent of these regions is not taken into account. In addition, in these regions, in view of climatic features, additional measures of material incentives are used. Without regard to these five regions, the coefficient of rank correlation of the indices for the considered two development directions is 0.911.

Table 5. The first principle components in two directions

g^1	The first principle component for the "production of products and services"	g^2	The first principle component for the "welfare"
(1)	(2)	(3)	(4)
w1	0.404909	w2	0.451720
w8	0.448955	w3	-0.534579
w9	0.532441	w4	-0.337555
w10	0.112927	w5	0.306281
w11	0.581586	w6	0.205685
		w7	-0.510014

For comparison, it is estimated the principal components for the two directions using the normalized values of the indicators (with an average of 0 and a standard deviation of 1). The first principal component g^1 for "production of goods and services" explains 51% of the total variance. The first principle component g^2 for the direction " welfare" explains 44% of the total variance. The signs at the indicators in the first principal component g^1 (column (2) of Table 5) correspond to the economic theory. The most significant in the first principal component g^1, as well as in the indicator I^1, is w9 - the output of manufacturing and w11 - the production of electricity, gas, water. All signs with indicators in the first principal component g^2 of the direction " welfare" correspond to economic theory (column (4) of Table 5). The most significant in the first principal component of g^2 are the indicators w3 - the population with incomes below the subsistence level and w7 - the unemployment rate. On the level of significance indicators, the indicator I^2 and the first principal component g^2 are significantly different. The Pearson correlation of the indices constructed on the basis of the principal components for the two directions g^1 and g^2 is 0.555. Spearman's rank correlation is 0.719. For the directions of regional development considered in this work, the indices in the basis characteristics ensure a higher consistency of the indices and ranks of the regions than the first principal components of the indicator sets.

CONCLUSIONS

It was formed the component composition of the basis characteristics for the formation of indices of socio-economic development of the Russian Federation regions. It includes five characteristics of regional differentiation: the scale of the economy, the technical efficiency of production, the first two main components of the GRP sector-structure (industry specialization index and industrialization index), the trend of technical efficiency. In evaluating these characteristics, theoretically based models of regional differentiation were used.

On the basis of data from the Russian Statistical Agency for the period from 2010 to 2015 years, it is shown that each characteristic of regional differentiation included in the list of basis characteristics is significant in the regression models describing the dependence of the indicators of regional development on the directions "production of goods and services" and "welfare".

Using the method of component analysis based on data for 2015 year, two indices for the direction "production of goods and services" have been constructed. The first is in the space of the five indicators that characterize this direction: GRP per capita; the output of mining; the output of manufacturing industries; the output of agriculture; production of electricity, gas, water. The second is based on the characteristics of differentiation. The regional indices computed from these indicators have a Pearson correlation coefficient of 0.982 and Spearman rank correlation coefficient of 0.956.

Using the method of component analysis based on data for 2015 year, two indices for the direction "welfare" have been constructed. The first - in the space of six indicators: income per capita; population with incomes below the subsistence minimum; migration rate; unemployment rate; infant mortality rate; average size of pensions. The second is in the basis characteristics of differentiation. Pearson correlation coefficient of indices is 0.839, Spearman rank correlation coefficient is 0.611.

Indices for the regions, constructed on the basis of the first principal components for the two groups of indicators, have a correlation coefficient of 0.555. Indices for the regions based on the vector of basis characteristics have the correlation coefficient of 0.953. Spearman's rank correlation coefficients are 0.719 and 0.806, respectively. Thus, for the considered directions of regional development, the vector basis ensures better consistency of the indices and ranks of the regions than the first principal components.

The scale of the economy, technical efficiency and the second principal component of the GRP sector-structure - the index of industrialization - have a significant impact in the indicators of the two directions of regional development based on the basis characteristics. The importance of technical efficiency is of particular interest, as it expands the scope of its application and confirms the validity of its use as a characteristic of regional differentiation. The index of industry specialization and the trend of technical efficiency are insignificant. However, they are significant in regression models of individual indicators. Therefore, it is expedient to use these components in the composition of the basis when constructing indicators in other directions.

REFERENCES

Ayvazian, S. A. (2012), *Analysis of quality and mode of life of the population: econometric approach*, Moscow, Nauka (in Russian).

Aivazian, S., Afanasiev, M., Kudrov, A. (2016a), “Clustering methodology of the Russian Federation regions with account of sectoral structure of GRP”, *Applied Econometrics*, Vol. 41, pp. 24-46.

Aivazian, S., Afanasiev, M., Kudrov, A. (2016b), “Models of Productive Capacity and Technological Efficiency Evaluations of Regions of the Russian Federation Concerning the Output Structure”, *Economics and Mathimatical Methods*, Vol. 52, No. 1, pp. 28-44 (in Russian).

Aivazian, S. A., Afanasiev, M. Yu., Kudrov, A. V. (2018), “The method of comparing the regions of the Russian Federation according to the estimates of technical efficiency, taking into account the structure of production”, *Economics and Mathimatical Methods*, Vol. 54, No. 1, pp. 43-5’1 (in Russian).

Kudriashova, A. I. (2008), *Influence of global globalization on the formation of regional economic policy*, The abstract of Postdoc Dissertation in Economics, M., RGTJeU (in Russian).

Makarov, V., Aivazyan, S., Afanasiev, M., Bakhtizin, A., Nanavyan, A. (2014), “The Estimation Of The Regions’ Efficiency Of The Russian Federation Including The Intellectual Capital, The Characteristics Of Readiness For Innovation, Level Of Well-Being, And Quality Of Life”, *Economica of region*, No. 4, pp. 9–30.

Hotelling, H. (1936), “Relationships between Two Sets of Variables”, *Biometrika*, Vol. 46, pp. 321–377.

Kumbhakar, S., Lovell, K. (2004), *Stochastic Frontier Analysis*. Cambridge U.P..

Robertson, R. (1992), *Globalization: Social Theory and Global Culture*, izdatel’ ???, Gorod ???.

Waugh, F. W. (1942), “Regression between Sets of Variates2, *Econometrica*, Vol. 46, pp. 290–310.

Appendix

Table A1. Ranks of the Russian Federation regions in two directions of development (according to 2015 year).

№ group (1)	№ region (2)	Region (3)	I^1 (4)	IB^1 (5)	g^1 (6)	I^2 (7)	IB^2 (8)	g^2 (9)
1	1	Belgorod region	20	30	22	16	23	10
1	2	Bryansk region	44	43	60	37	49	40
3	3	Vladimir region	33	28	46	53	37	45
4	4	Voronezh region	16	21	24	7	16	9
1	5	Ivanovo region	58	50	69	51	75	50
3	6	Kaluga region	34	42	43	32	61	27
1	7	Kostroma region	49	58	59	56	66	49
1	8	Kursk region	29	46	37	10	39	12
3	9	Lipetsk region	27	31	30	21	41	20
1	10	Moscow region	2	2	3	2	2	3
1	11	Oryol region	50	56	61	72	48	61
1	12	Ryazan region	38	44	49	38	56	32
1	13	Smolensk region	36	48	47	31	69	59
4	14	Tambov region	35	45	50	46	36	24
1	15	Tver region	30	37	38	60	53	38
3	16	Tula region	28	26	32	33	32	21
3	17	Yaroslavl region	41	34	45	22	42	18
1	18	Moscow	1	1	1	1	1	1
1	19	Republic of Karelia	66	66	58	76	50	43
2	20	Komi Republic	59	67	25	73	68	23
2	21	Arkhangelsk region	62	47	31	62	31	28
3	22	Vologda region	31	33	35	50	47	35
1	23	Kaliningrad region	39	41	44	9	38	25
1	24	Leningrad region	14	25	15	28	34	19
1	25	Murmansk region	47	61	33	59	74	14
3	26	Novgorod region	57	49	54	27	45	29
4	27	Pskov region	64	63	70	43	72	64
1	28	St. Petersburg	3	3	4	4	3	2
4	29	Republic of Adygeya	72	70	74	25	67	60
5	30	Republic of Kalmykia	73	80	78	79	80	78
4	31	Krasnodar region	5	4	10	3	4	13
1	32	Astrakhan region	61	62	52	57	59	62
1	33	Volgograd region	17	15	23	70	26	58
4	34	Rostov region	7	6	16	18	7	39
5	35	Republic of Dagestan	46	24	68	40	29	71
5	36	Republic of Ingushetia	76	73	80	69	70	80
1	37	Kabardino-Balkaria Republic	65	57	73	49	58	73

1	38	Karachay-Cherkess Republic	67	74	75	78	78	77
5	39	Republic of North Ossetia-Alania	69	68	72	77	60	68
5	40	Chechen Republic	68	51	76	67	62	75
4	41	Stavropol region	19	18	29	45	24	55
3	42	Republic of Bashkortostan	9	7	11	26	8	37
1	43	Republic of Mari El	55	55	65	55	57	70
1	44	Republic of Mordovia	52	54	64	36	73	54
2	45	Republic of Tatarstan	6	8	6	12	6	8
2	46	Udmurt Republic	37	32	40	52	27	30
1	47	Chuvash Republic	48	39	62	63	65	52
1	48	Permsky Krai	15	16	14	13	20	26
1	49	Kirov region	43	35	55	65	51	34
3	50	Nizhny Novgorod region	11	10	17	15	14	17
2	51	Orenburg region	26	29	20	54	19	51
4	52	Penza region	42	36	57	44	54	33
1	53	Samara region	13	11	12	19	12	22
1	54	Saratov region	18	20	26	47	28	56
1	55	Ulyanovsk region	45	38	56	42	46	48
4	56	Kurgan region	56	59	67	74	77	69
3	57	Sverdlovsk region	4	5	7	8	9	11
2	58	Tyumen region	12	12	2	6	5	7
3	59	Chelyabinsk region	8	9	13	39	11	44
5	60	Altai Republic	74	78	77	58	76	74
4	61	The Republic of Buryatia	60	52	66	30	64	65
5	62	Republic of Tyva	75	75	79	80	63	79
1	63	Republic of Khakassia	53	69	53	64	55	63
4	64	Altai region	25	22	42	61	22	67
1	65	Trans-Baikal region	63	60	63	66	71	72
1	66	Krasnoyarsk region	10	13	9	23	10	46
1	67	Irkutsk region	22	23	19	68	15	66
2	68	Kemerovo region	23	17	18	71	17	57
1	69	Novosibirsk region	24	14	28	17	13	53
3	70	Omsk region	21	19	27	35	18	47
2	71	Tomsk region	51	53	41	48	33	42
2	72	Republic of Sakha (Yakutia)	71	64	8	34	25	31
1	73	Kamchatka region	70	71	48	41	44	15
1	74	Primorsky region	32	27	39	11	43	36
1	75	Khabarovsk region	40	40	36	14	40	16
1	76	Amur region	54	65	51	29	52	41
1	77	Magadan region	78	72	34	20	30	4
2	78	Sakhalin region	80	76	5	5	35	5
5	79	Jewish Autonomous region	77	79	71	75	79	76
2	80	Chukotka Autonomous Okrug	79	77	21	24	21	6

Table A2. Estimates of parameters for the regressions of indicators on the basis characterisitics

		l	te	s1	s2	dte	R2
Gross regional product per capita	2015	0.239***	0.178***	0.760***	0.101	0.113*	0.727
	St. Err	0.064	0.066	0.064	0.064	0.064	
	2014	0.317***	0.157**	0.722***	0.120*	1.03E-01	0.681
	St. Err	0.070	0.069	0.068	0.068	0.066	
	2013	0.355***	0.124*	0.733***	0.126*	3.21E-03	0.697
	St. Err	0.068	0.074	0.067	0.067	0.070	
	2012	0.335***	0.123	0.719***	0.143**	1.32E-02	0.677
	St. Err	0.070	0.074	0.071	0.069	0.069	
	2011	0.332***	0.108	0.723***	0.129*	4.12E-02	0.685
	St. Err	0.070	0.072	0.071	0.068	0.068	
Income per capita	2015	0.443***	0.269***	0.449***	-5.72E-02	0.356***	0.601
	St. Err	0.077	0.080	0.077	0.078	0.077	
	2014	0.485***	0.146*	0.493***	1.59E-03	0.245***	0.512
	St. Err	0.087	0.086	0.085	0.085	0.082	
	2013	0.517***	0.118	0.478***	-2.28E-02	-0.149	0.532
	St. Err	0.084	0.092	0.083	0.083	0.087	
	2012	0.484***	0.188**	0.456***	1.41E-02	-8.56E-02	0.545
	St. Err	0.083	0.088	0.085	0.082	0.082	
	2011	0.506***	0.219**	0.473***	-2.97E-02	1.92E-02	0.566
	St. Err	0.082	0.085	0.083	0.080	0.079	
Population with income below the subsistence lev-el	2015	0.273***	-9.78E-02	-5.39E-02	0.389***	0.314***	0.444
	St. Err	0.091	0.094	0.091	0.092	0.091	
	2014	0.274***	4.95E-03	-8.11E-02	0.466***	0.171*	0.367
	St. Err	0.099	0.098	0.096	0.096	0.093	
	2013	0.269***	-6.18E-02	-9.40E-02	0.452***	-2.69E-02	0.354
	St. Err	0.099	0.108	0.097	0.098	0.103	
	2012	0.251**	-0.133	-7.00E-02	0.402***	-1.07E-02	0.323
	St. Err	0.101	0.108	0.103	0.100	0.100	
	2011	0.271**	0.191*	-7.90E-02	0.325***	-6.46E-02	0.309
	St. Err	0.103	0.107	0.105	0.101	0.100	
Infant mortality rate	2015	-0.193*	0.220**	-0.017	-0.464***	-0.145	0.363
	St. Err	0.097	0.101	0.097	.099	0.097	
	2014	-0.110	0.185*	0.056	-0.477***	0.343***	0.415
	St. Err	0.095	0.094	0.093	0.093	0.09	
	2013	-0.115	0.055	0.006	-0.479***	-0.214**	0.304
	St. Err	0.103	0.112	0.101	0.102	0.107	
	2012	-0.153	0.165	-0.048	-0.497***	-0.121	0.319
	St. Err	0.102	0.108	0.104	0.1	0.101	
	2011	-0.089	0.082	-0.047	-0.547***	-0.160	0.355
Average size of pensions assigned	2015	-0.014	0.266***	0.538***	-0.026	0.435***	0.574
	St. Err	0.08	0.082	0.079	0.081	0.08	
	2014	0.023	0.122	0.578***	0.048	0.246***	0.410
	St. Err	.095	.094	.093	.093	.090	
	2013	0.016	0.093	0.563***	0.049	-0.160	0.401
	St. Err	.096	.104	.094	.094	.099	
	2012	-0.026	0.170*	0.539***	0.104	-0.108	0.428
	St. Err	0.093	0.099	0.095	0.092	0.092	
	2011	-0.036	0.218**	0.551***	0.090	-0.066	0.426
	St. Err	0.094	0.098	0.096	0.092	0.092	

Average size of pensions assigned	2015	-0.014	0.266***	0.538***	-0.026	0.435***	0.574
	St. Err	0.08	0.082	0.079	0.081	0.08	
	2014	0.023	0.122	0.578***	0.048	0.246***	0.410
	St. Err	.095	.094	.093	.093	.090	
	2013	0.016	0.093	0.563***	0.049	-0.160	0.401
	St. Err	.096	.104	.094	.094	.099	
	2012	-0.026	0.170*	0.539***	0.104	-0.108	0.428
	St. Err	0.093	0.099	0.095	0.092	0.092	
	2011	-0.036	0.218**	0.551***	0.090	-0.066	0.426
	St. Err	0.094	0.098	0.096	0.092	0.092	
Unemployment rate	2015	0.190**	-2.84E-02	-3.26E-02	0.401***	0.364***	0.428
	St. Err	0.092	0.096	0.092	0.094	0.092	
	2014	0.188*	8.51E-02	-5.92E-02	0.554***	-0.108	0.384
	St. Err	9.80E-02	0.096	0.095	0.095	9.20E-02	
	2013	-0.158	0.124	-9.53E-02	0.516***	-3.74E-02	0.313
	St. Err	0.102	0.111	0.101	0.101	0.106	
	2012	-0.164	0.116	-6.21E-02	0.502***	0.147	0.319
	St. Err	0.102	0.108	0.104	0.100	0.101	
	2011	-0.138	-3.47E-02	-6.39E-02	0.465***	0.150	0.300
	St. Err	0.104	0.108	0.106	0.101	0.101	

Migration rates per 10 000 population	2015	0.411***	0.182*	0.315***	0.216**	-0.024	0.448
	St. Err	0.091	0.094	0.090	0.092	0.091	
	2014	0.327***	0.188*	0.325***	0.219**	4.34E-02	0.379
	St. Err	0.098	0.097	0.095	0.095	0.092	
	2013	0.414***	0.269**	0.277***	0.171*	5.15E-02	0.440
	St. Err	0.092	0.101	0.091	0.091	0.096	
	2012	0.413***	0.229**	0.229**	0.160*	8.62E-02	0.381
	St. Err	0.097	0.103	0.099	0.095	0.096	
	2011	0.296***	0.232**	-0.173	0.171	0.114	0.255
	St. Err	0.107	0.111	0.109	0.105	0.104	
Mining	2015	0.334***	-0.112	0.629***	8.54E-02	0.026	0.438
	St. Err	0.092	0.095	0.091	0.093	0.092	
	2014	0.310***	-8.52E-02	0.626***	0.101	-3.57E-02	0.440
	St. Err	0.093	0.092	0.091	0.091	0.088	
	2013	0.329***	-9.61E-02	0.631***	0.12165	8.54E-02	0.450
	St. Err	0.092	0.100	0.090	0.090	0.095	
	2012	0.340***	-0.167	0.624***	0.105	3.59E-02	0.398
	St. Err	0.096	0.101	0.097	0.094	0.094	
	2011	0.354***	0.208**	0.649***	9.74E-02	-6.04E-04	0.442
	St. Err	0.093	0.096	0.095	0.091	0.090	
Manufacturing	2015	0.903***	6.26E-02	-0.010	0.113***	3.33E-02	0.912
	St. Err	0.036	0.037	0.036	0.036	0.036	
	2014	0.887***	0.072*	-2.20E-02	0.122***	4.64E-03	0.901
	St. Err	0.039	0.038	0.038	0.038	0.037	
	2013	0.888***	6.80E-02	-5.34E-03	0.133***	-3.50E-02	0.899
	St. Err	0.039	0.042	0.038	0.038	0.040	
	2012	0.838***	0.114**	-3.34E-02	0.183***	2.02E-02	0.876
	St. Err	0.043	0.046	0.044	0.042	0.043	
	2011	0.834***	0.106**	-4.26E-02	0.192***	0.073*	0.883
	St. Err	0.042	0.044	0.043	0.041	0.041	

Agriculture	2015	0.313***	1.20E-01	-0.14884	5.56E-02	-3.85E-02	0.168
	St. Err	0.111	0.115	0.111	0.113	0.111	
	2014	0.333***	0.12196	-0.110	6.07E-02	1.68E-02	0.174
	St. Err	0.113	0.112	0.110	0.110	0.106	
	2013	0.338***	0.140	-0.112	6.21E-02	5.48E-02	0.183
	St. Err	0.112	0.122	0.110	0.110	0.116	
	2012	0.379***	9.42E-02	-6.19E-02	4.67E-02	0.160	0.199
	St. Err	0.110	0.117	0.112	0.108	0.109	
	2011	0.421***	4.44E-02	-7.16E-02	7.05E-02	0.044	0.220
	St. Err	0.110	0.114	0.112	0.107	0.107	
Electricity,gas,water production	2015	0.952***	-0.037	0.172***	0.019	0.073*	0.902
	St. Err	0.038	0.039	0.038	0.038	0.038	
	2014	0.946***	0.073*	0.183***	0.046	0.014	0.881
	St. Err	0.043	0.042	0.042	0.042	0.040	
	2013	0.955***	0.080*	0.187***	0.021	-0.025	0.885
	St. Err	0.042	0.045	0.041	0.041	0.043	
	2012	0.954***	-0.070	0.181***	0.021	-0.049	0.888
	St. Err	0.041	0.043	0.042	0.040	0.040	
	2011	0.962***	-0.054	0.160***	-0.023	-0.013	0.880
	St. Err	0.043	0.044	0.044	0.042	0.042	