New landmarks for the digital economy: on the relationship between economic complexity and material well-being

Mikhail Afanasiev*

Central Economics and Mathematics Institute of the Russian Academy of Sciences, Moscow, Russia

Abstract. The results are obtained that develop the instrumental basis of the digital economy and the methodology for choosing priority areas of diversification. Estimates of the economic complexity of 80 Russian regions and 82 sectors of the economy were obtained. It is shown that regions with developed sectors of the extractive industry have relatively low estimates of economic complexity. According to the data of 2019, the regions are divided into two groups with high and low estimates of economic complexity. For each group, a significant relationship between estimates of the economic complexity of the regions and indicators of per capita income was revealed. The increment of the average per capita income as a result of the increase in the economic complexity of the region is estimated. Information about the impact of economic complexity on well-being is one of the possible forms of digital support for strategic decision-making. It can be used to set priorities in the implementation of regional development projects aimed at increasing the number of jobs in the region and increasing material well-being.

1. Introduction

Modern ideas about economic complexity are associated with an increase in economic well-being and a decrease in income inequality [7]. Countries exporting more "sophisticated" goods usually have a higher level of per capita material well-being than countries exporting simple goods. Moreover, a structural transformation of the economy and a transition from simpler forms of production to more complex ones is possible. Relatively recently, a procedure has been developed that allows measuring the economic complexity of exported products and the structure of the economy as a whole [8,10,11,12]. The proposed measure of economic complexity has earned attention because it has a high significance in forecasting models of economic growth. However, the method used for calculating economic complexity does not take into account the volume of domestic consumption of manufactured products. Further, in contrast to the traditional approach to assessing economic complexity, according to which the concept of identified comparative advantages [6] is applied to exported products, the emphasis is on the study of the economic sectors of the region. The description of the

* Corresponding author: mi.afan@yandex.ru

structures of regional economies is given on the basis of data on tax revenues by economic sectors, which makes it possible to characterize the structures of regional economies, including sectors focused on both external and domestic markets. The analysis of the relationship between the index of economic complexity and indicators of material well-being of Russian regions is carried out. Estimates of their correlation relationship are obtained for two groups of regions, one of which includes mainly regions with developed sectors of the extractive industry,

The relevance of this study is determined by the fact that the development of measures to improve the material well-being and quality of life of the population is among the tasks aimed at achieving the strategic goals of economic development of the Russian Federation. The solution of these problems is possible on the basis of expanding the scope of practical application of the concept of economic complexity when choosing the directions of structural transformation of regional economies.

2 Research methodology

To describe the structure of strong sectors of the region's economy, the concept of identified comparative advantages is used [6]. Let's determine the indicator RCA_{cp} of the revealed comparative advantages:

$$RCA_{cp} = \left(y_{cp} / \sum\nolimits_{p} y_{cp} \right) / \left(\sum\nolimits_{c} y_{cp} / \sum\nolimits_{c,p} y_{cp} \right), \quad (1)$$

where y_{cp} is the volume of production of sector p of the economy of region c; RCA_{cp} — the ratio of the share of production from sector p in the total volume of production from all sectors of the economy of region c to the share of production of sector p for all regions in the volume of production from all sectors of the economy of all regions. In accordance with [10], to identify comparative advantages in economies, an indicator RCA_{cp}, is used for which a condition of the type of restriction from below is checked. If the value RCA_{cp} exceeds one, it is assumed that the economy of region c has identified comparative advantages in the output of sector p; otherwise, there are no identified comparative advantages:

$$a_{c,p} = \begin{cases} 1, \text{ if } RCA_{cp} \geq 1; \\ 0, \text{ if } RCA_{cp} < 1. \end{cases}$$

The matrix $\mathbf{A} = \left(a_{c,p} \right)$ contains data on the sectors of the economy that are developed in different regions at the level of the identified comparative advantages determined using the expression (1). The rows of this matrix correspond to regions, the columns correspond to sectors of the economy. We will call the vector $\left(a_{c,p_1}, \ldots, a_{c,pm} \right)$ a structure of strong sectors of the region 's economy c. Thus, the structure of the regional economy is characterized by a set of its strong sectors.

To calculate the economic complexity index, the approach presented in [3, 8, 12] and its author's modification based on the use of data on tax revenues by economic sectors were used. The concept of "economic complexity of a region" is considered as a characteristic reflecting the level of its technological development, which, in turn, is determined by strong sectors in the structure of its economy: the economic complexity of a region is proportional

to the average level of economic complexity of strong sectors in the structure of its economy. Similarly, the "economic complexity of the sector" depends on the level of technological development of the regions: the economic complexity of the sector is proportional to the average level of economic complexity of the regions in the structure of the economies of which this sector is strong. A detailed description of the method for calculating the index of economic complexity of regions and the index of economic complexity of sectors is presented in [5].

As a characteristic of the diversification of the region's economy, the number of strong sectors whose products the region produces at the level of the identified comparative advantages is considered. To assess the relationship between economic complexity and material well-being, the regions are divided into two groups. The first group includes regions whose economic structures include strong sectors of the extractive industry. A list of these sectors is given in table 1.

Table 1. Extractive industry sectors in accordance with data on tax revenues by economic sectors (nalog.ru).

Sector code	Sector name
1046	mining of hard coal
1047	mining of lignite
1055	crude oil and petroleum gas production
1060	extraction of natural gas and natural gas liquids
1075	mining of iron ores
1080	extraction of non-ferrous metal ores
1081	other mining and quarrying
1084	support activities for petroleum and natural gas extraction

Many regions of this group are characterized by high specialization in the extractive industry and a small number of strong sectors in the structure of the economy. In [1], these regions are classified as a cluster of "extractive" according to the GRP structure. But in this group there are also regions with a high level of diversification. The second group includes regions with relatively high estimates of economic complexity.

Rosstat indicators "per capita monetary incomes of the population" and "gross regional product per capita" for 2019 are used as indicators of well-being [4]. Correlation coefficients of the index of economic complexity and indicators of material well-being are calculated for each group of regions.

3 Research Results

The matrix of revealed comparative advantages characterizing the structure of strong sectors of 80 regions, the index of economic complexity of regions, the index of economic complexity of 82 sectors are calculated on the basis of data on tax revenues by economic sectors for 2019 [5].

Based on the matrix of identified advantages, the number of strong sectors in its economy is determined for each region. The point in Fig. 1 characterizes the region in the space "number of strong sectors" (abscissa axis) – "assessment of the economic complexity of the region" (ordinate axis). There is a strong nonlinear relationship between the number of strong sectors and estimates of the economic complexity of the regions. At the same time, the correlation coefficient of the characteristics of the diversification of regional economies and estimates of the economic complexity of the regions is quite high and is equal to 0.635. The

regions in the lower left part of the figure are characterized by high specialization in the extractive industry. These are the Orenburg Region (6 strong sectors), the Tyumen Region (8), the Astrakhan Region (9), the Tomsk Region (10), the Republic of Sakha (Yakutia) (11).

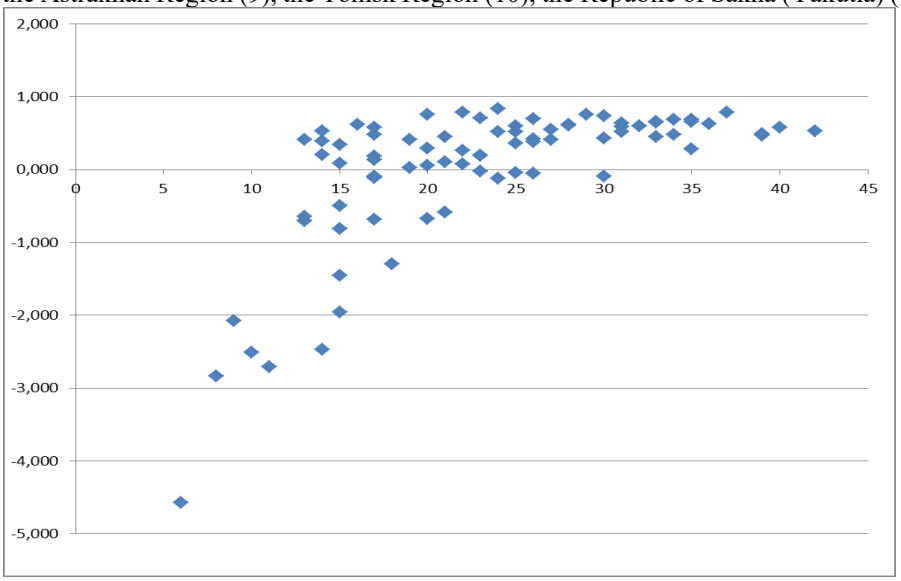

Fig. 1. The abscissa shows the number of strong sectors in the region, the ordinate shows the assessment of economic complexity.

Table 2 shows the regions of the first group, ordered by increasing estimates of economic complexity. The columns of table 2 indicate: (1) – the number of the region in order; (2) – the number of the region in accordance with the order of the regions in the statistical book "Regions of Russia"; (3) – the name of the region; (4) – the number of the cluster according to the GRP structure; (5) – the number of strong sectors in the structure of the region's economy; (6) – assessment of the economic complexity of the region (the calculated index of economic complexity is normalized with an average of 0 and a standard deviation of 1); (7) – the average per capita monetary income of the population in rubles.

Table 2. Regions of the first group.

(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	51	Orenburg region	2	6	-4.569	24483
2	58	Tyumen region	2	8	-2.833	48335
3	72	Republic of Sakha (Yakutia)	2	11	-2.71	45458
4	71	Tomsk region	2	10	-2.509	28381
5	20	Komi Republic	2	14	-2.469	35356
6	32	Astrakhan region	1	9	-2.076	24971
7	66	Krasnoyarsk Krai	1	15	-1.955	31739
8	67	Irkutsk region	1	15	-1.456	26306
9	78	Sakhalin region	2	18	-1.298	59015
10	53	Samara region	1	15	-0.818	29421

Continuation of table 2.

11	45	Republic of Tatarstan	2	13	-0.707	35707
12	42	Republic of Bashkortostan	1	17	-0.689	30567
13	48	Perm Krai	1	20	-0.678	30588
14	80	Chukotka Autonomous Area	2	13	-0.645	83385
15	75	Khabarovsk region	1	21	-0.586	41459
16	46	Udmurt Republic	2	15	-0.496	25066
17	18	Moscow	1	24	-0.122	75084
18	25	Murmansk region	2	17	-0.11	44237
19	76	Amur region	1	17	-0.092	33304
20	74	Primorsky Krai	1	26	-0.05	36883
21	77	Magadan region	1	23	-0.023	65357
22	21	Arkhangelsk region	2	20	0.058	36693
23	73	Kamchatka region	1	23	0.194	52674
24	28	St. Petersburg	1	23	0.197	47169
25	10	Moscow region	1	39	0.464	47201

In Table 2, regions with numbers 1-23 have relatively low estimates of economic complexity (the index of economic complexity of regions is normalized with an average value of 0 and a standard deviation of 1.), since these regions have strong extractive industries with low estimates of economic complexity in their structure (The index of economic complexity of sectors is normalized with an average value of 0 and a standard deviation of 1.). Estimates of the economic complexity of the extractive industry sectors are given in table 3.

Table 3. Estimates of the economic complexity of extractive industry sectors

Sector code	1046	1047	1055	1060	1075	1080	1081	1084
Assessment of economic complexity	-0.866	-1.445	-0.801	-4.981	0.129	-1.871	-0.578	-2.861

When describing the specifics of the two groups of regions, we will take into account the author's results of clustering of regions presented in [1]. According to the data on the industry structure of GRP, the regions are divided into five clusters: 1) "uniformly developed", 2) "mining", 3) "processing", 4) "agricultural", 5) "developing". The cluster number is specified for each region in column 4 of Table 2. The first group of regions included 11 "mining" regions. It also includes 12 regions from the cluster evenly developed with strong sectors of the extractive industry. The first group also includes two equally developed regions with a high level of diversification, relatively high estimates of economic complexity and indicators of per capita monetary income of the population exceeding 36,000 rubles: St. Petersburg and the Moscow region. Pearson's correlation coefficient of estimates of economic complexity and per capita monetary incomes of the population is 0.346; Spearman's rank correlation

coefficient is 0.442. For the regions of the first group, there is a significant correlation of economic complexity and average per capita income at the 10% level. The regression coefficient of per capita income for estimates of economic complexity is 4367.146, the standard error is 2473.572. Thus, the expected growth of the average per capita incomes of the regions of this group with an increase in economic complexity by 0.1 and excluding inflation is 437 rubles. This is 1% of the average per capita income of the regions of the first group. In Fig. 2, the regions of the first group are represented in the space: "assessment of economic complexity" (abscissa axis) – "average per capita income" (ordinate axis).

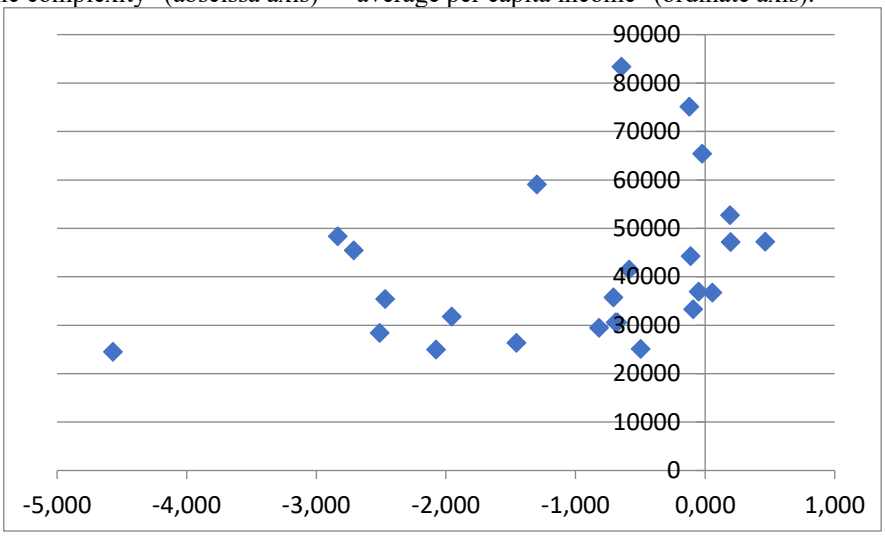

Fig. 2. On the abscissa axis is an assessment of the economic complexity of the region, on the ordinate axis is the average per capita income.

The second group includes 55 regions presented in table 4. The regions are ordered in descending order of estimates of economic complexity. The structure of table 4 coincides with the structure of table 2. All regions are characterized by a relatively high level of diversification (column 5) and economic complexity (column 6). In this group there are 25 "evenly developed" regions; 12 "processing"; 11 "agricultural" and 8 "developing" regions. The average per capita income for the region of the second group does not exceed 36,000 rubles.

Table 4. Regions of the second group.

(1)	(2)	(3)	(4)	(5)	(6)	(7)
26	60	Altai Republic	5	30	-0.092	20256
27	61	Republic of Buryatia	4	25	-0.042	25268
28	65	Zabaykalsky Krai	1	19	0.027	25750
29	29	Republic of Adygea	4	22	0.077	29115
30	36	Republic of Ingushetia	5	15	0.082	16614
31	54	Saratov region	1	21	0.101	22757
32	70	Omsk region	3	17	0.131	26967
33	62	Republic of Tyva	5	17	0.187	16618

Continuation of table 4.

34	39	Republic of North Ossetia - Alania	5	14	0.202	24495
35	63	Republic of Khakassia	1	22	0.266	22689
36	59	Chelyabinsk region	3	35	0.284	25425
37	68	Kemerovo region	1	20	0.294	24886
38	23	Kaliningrad region	1	15	0.342	28952
39	55	Ulyanovsk region	1	25	0.359	23698
40	56	Kurgan region	4	26	0.385	21304
41	30	Republic of Kalmykia	5	14	0.387	18508
42	38	Karachay-Cherkess Republic	1	27	0.407	18821
43	40	Chechen Republic	5	13	0.409	24138
44	35	Republic of Dagestan	5	19	0.413	27408
45	19	Republic of Karelia	1	26	0.424	30854
46	57	Sverdlovsk region	3	30	0.429	36000
47	7	Kostroma region	1	33	0.446	25285
48	79	Jewish Autonomous region	5	21	0.446	26602
49	33	Volgograd region	1	17	0.475	24158
50	4	Voronezh region	4	34	0.483	32022
51	69	Novosibirsk region	1	39	0.492	30559
52	17	Yaroslavl region	3	25	0.514	28658
53	50	Nizhny Novgorod region	3	24	0.519	33817
54	43	Mari El Republic	1	31	0.522	20864
55	24	Leningrad region	1	14	0.526	32306
56	15	Tver region	3	42	0.531	27211
57	31	Krasnodar Territory	4	27	0.552	35673
58	37	Kabardino-Balkarian Republic	1	17	0.574	21474
59	47	Chuvash Republic	1	40	0.574	20162
60	2	Bryansk region	1	31	0.591	28371
61	26	Novgorod region	3	32	0.595	26003
62	22	Vologda region	3	25	0.596	28334
63	14	Tambov region	4	28	0.61	28154
64	12	Ryazan region	1	16	0.614	26886
65	5	Ivanovo region	1	28	0.617	25794
66	9	Lipetsk region	3	36	0.628	32479
67	13	Smolensk region	1	31	0.639	27388

Continuation of table 4.

68	34	Rostov region	4	33	0.643	30752
69	64	Altai Territory	4	33	0.653	23937
70	49	Kirov region	1	35	0.654	23604
71	27	Pskov region	4	35	0.687	25524
72	16	Tula region	3	34	0.69	28557
73	52	Penza region	4	26	0.693	22969
74	41	Stavropol Territory	4	23	0.707	24366
75	11	Oryol region	1	30	0.735	26064
76	6	Kaluga region	3	29	0.751	31394
77	44	Republic of Mordovia	1	20	0.754	19748
78	3	Vladimir region	3	37	0.783	25358
79	8	Kursk region	1	22	0.785	29149
80	1	Belgorod region	1	24	0.83	32352

For the regions of the second group, the Pearson correlation coefficient of estimates of economic complexity and per capita monetary incomes of the population is 0.309; Spearman's rank correlation coefficient is 0.281. For the regions of the second group, there is a significant correlation of economic complexity and average per capita income at the 5% level. The regression coefficient of per capita income for estimates of economic complexity is 6202.021, the standard error is 2625.511. Thus, the expected growth of the average per capita incomes of the regions of this group with an increase in economic complexity by 0.1 and excluding inflation is 620 rubles. This is 2.3% of the average per capita income of the regions of the first group. In Fig. 3, the regions of the first group are represented in space: assessment of economic complexity (abscissa axis) – average per capita income (ordinate axis).

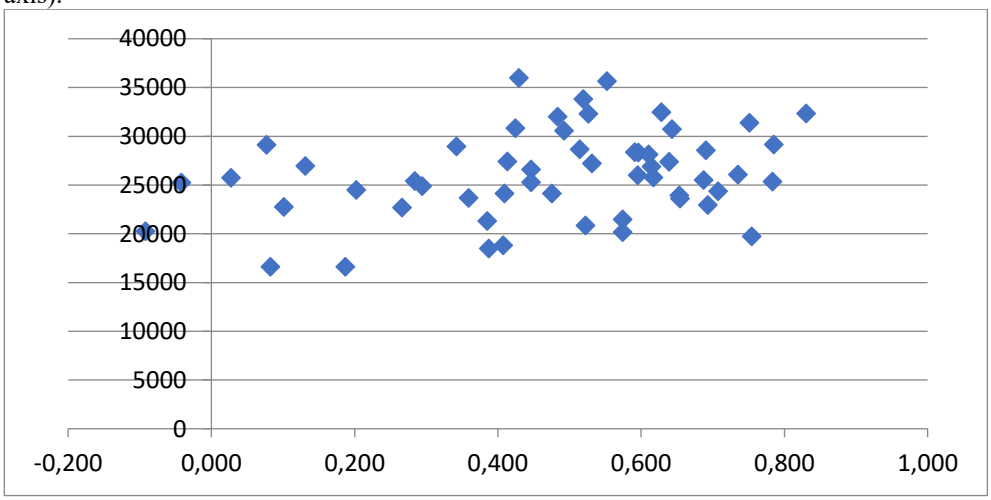

Fig. 3. On the abscissa axis – the assessment of the economic complexity of the region, on the ordinate axis – the average per capita income.

For the regions of the second group, the Pearson correlation coefficient of 0.302 of estimates of economic complexity and the indicator "GRP per capita" is also significant at the 10% level. For the regions of the first group, there is no significant relationship between these characteristics. The reason for this may be natural rent, which is part of the GRP structure of some regions specializing in the extractive industry. According to the estimates presented in [2], the natural rent of the regions of the Tyumen Region, the Republic of Sakha (Yakutia), the Sakhalin Region, the Chukotka Autonomous Okrug, not explained by the characteristics of economic differentiation, ranges from 43.7 to 60.0% of GRP.

4 Conclusion

For Russian regions, based on the concept of revealed preferences, the structure of economies in the context of 82 sectors is described. Estimates of the economic complexity of regions and sectors of the economy are obtained. It is shown that regions with developed sectors of the extractive industry have relatively low estimates of economic complexity. The regions are divided into two groups with high and low estimates of economic complexity. For each group according to the data of 2019 a significant relationship between estimates of the economic complexity of regions and indicators of per capita income has been revealed. The increment of the average per capita income as a result of the increase in the economic complexity of the region is estimated. The results obtained can be used to select priority areas for the development of regional economic structures, taking into account the concept of economic complexity. Information about the impact of economic complexity on well-being is one of the possible forms of digital support for strategic decision-making. It can be used to set priorities in the implementation of regional development projects aimed at increasing the number of jobs in the region and increasing material well-being.

References

1. S.A. Ayvazyan M.Yu. Afanasyev A.V. Kudrov, Economics and Mathematical Methods **54(1),** 43 (2018)
2. M.Yu. Afanasyev, A.V. Kudrov, *Methodology for assessing the socio-economic development of the subjects of the Russian Federation*, Current trends and methods of analysis of economic systems, ed. M. V. Gracheva, 308 p. (M.: Faculty of Economics of Moscow State University named after M. V. Lomonosov, 2020). ISBN 978-5-906932-47-1.
3. I.L. Lyubimovm, M.A. Gvozdeva, M.V. Kazakova, K.V. Nesterova, J. of the New Economic Association **2(34)**, 94 (2017)
4. Regions of Russia. Socio-economic indicators. 2020: P32 Stat. book / Rosstat. Moscow, 2020. 1242 p. ISBN 978-5-89476-502-0
5. M.Yu. Afanasiev, A.V. Kudrov, Montenegrin J.of Economics **16(4)**, 43 (2020). DOI: 10.14254/1800-5845/2020.16-4.4
6. B. Balassa, Lafayrade Liberalization and “Revealed” Comparative Advantage, The Man-chester School **33**, 99 (1965)
7. D. Hartmann, World Development **93**, 75 (2017)
8. R. Hausmann, C. Hidalgo, S. Bustos, M. Coscia, A. Simoes, M.A. Yildirim, The atlas of economic complexity: Mapping paths to prosperity. Cambridge: Center for International Development, Harvard University (MIT, 2011)
9. R. Hausmann, J. Hwang, D. Rodrik, J. of Economic Growth **12(1)**, 1 (2006)

10. R. Hausmann, B. Klinger, CID Working Paper **128**, (2006)
11. R. Hausmann, D. Rodrik, J. of Development Economics **72(2)**, 603 (2003)
12. C.A. Hidalgo, R. Hausmann, Proceedings of the National Academy of Sciences **106(26)**, 10570 (2009)
13. C.A. Hidalgo, B. Klinger A.-L. Barabasi, R. Hausmann, Science **317 (5837)**, 482 (2007)