Analysis of Innovative Dynamics and Formation of Tools for Assessing the Efficiency of Long-Term Innovative Policy of Russian Regions

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Abstract. The aim of the work is to analyze innovation dynamics and form tools for assessing the effectiveness of long-term innovation policy of Russian regions. Open official data were used to form the metric. They characterize innovative activity in the regions of Russia in the time interval from 2000 to 2018. The paper presents a methodology for the formation of a metric characterizing the innovative development of a region in two projections: long-term in the form of a rating of the severity of the trend of change in indicators of innovative activity and current, in the form of a rating of the level (value) of indicators of innovative activity.

The component of the metric characterizing the current state of innovative detail was calculated as the rank of the average value of the indicator for the period. The component of the metric characterizing the tendencies of change in innovative activity in the region was calculated the rank of the slope of the approximating curve, which was adjusted for the level of approximation reliability. The results of the ranking showed that ten regions with the minimum rating values almost completely coincide, both in terms of dynamics and in terms of the level of innovation activity. Among the leading regions in terms of emerging trends in innovative development, there is a significant proportion of relatively «weak» regions, that is, those with an average level of innovative activity, which can be explained by the «low base» of indicators. Regions with high rates of innovation activity demonstrate a very different level of innovation dynamics, which can be explained by both structural changes in the regions and the phenomenon of the «glass ceiling».

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1 Introduction

Regional innovation policy is a complex set of methods and mechanisms of state influence on economic processes in order to intensify the innovative activity of economic entities. In turn, innovative activity has a number of forms and manifestations, and isn't reducible to relatively simple and transparent indicators, such as the unemployment rate or per capita income. The relative nature of the innovation creates fundamental difficulties in monitoring innovation processes and reflecting them in the system of state statistics. Nevertheless, there are a number of generally recognized indicators, the system of which relatively fully allows us to represent the state of innovation detail in the region. The presence of a set of indicators leads to the fact that synthetic, complex indicators, the so-called metrics, are used to understand the effects of government regulation measures. Metrics are understood as numerical values, which are formed in a certain way that perform the function of quantitative assessment in the area of goal-setting, comparison and control for decision-makers. Metrics can be applied in relation to an individual and in relation to various complex objects (organizations, events) or processes (Volchik 2018).

The widespread using of metrics for the study of economic processes is due to a number of reasons, among which the following ones should be especially noted:

- The presence of significant data sets, which are relatively easy to manipulate, forming their various combinations to varying degrees reflecting objective economic processes with the help of computer technologies (Beer 2016);
- Positively proven at various levels of the management system, which are based on the using of metrics (ranging from various KPI options at the corporate level to ratings of investment attractiveness of regions and the reliability of financial credit institutions, which become the basis for making investment decisions (Muller 2018);
- The systems of metrics correspond to indicative approaches to the impact on the economy associated with a liberal, market discourse and providing for the indirect participation of the state in economic processes, which needs to present in a formalized form the results of its attempts to form a favorable socio-economic environment (Fioramonti 2014);
- The complexity of regulated systems makes it impossible to fix a direct response to the impact and using the deductive method of finding relationships, which are being replaced by inductive decision-making methods (Arthur 1994).

One of the common metrics, which is used in the study of innovation processes, is the compilation of regional ratings of innovation activity and innovation potential. A significant number of publications are devoted to systems for assessing and monitoring the innovative development of Russian regions (Bortnik 2012). These publications analyze existing practices (Mikheeva 2013) and offer original options for the

formation of metrics that characterize innovation processes in the region (Dragun 2017). As rightly noted, (Ryapukhina 2018) almost all these ratings are cumulative indicators, compiled on the basis of publicly available statistical data, differing in the composition of elements and the order in which their weight characteristics are specified in the final assessment. In addition, all the most popular ratings are focused on current indicators, fixing the «instant» picture. The time factor is present in them, only as the movement of the region along the rating levels, and, as a consequence, the impossibility of fixing the general trend. We observe only the movement of regions leading (lagging) from others. Changes made to the rating methodology from time to time (for example, changing the weights in accordance with the significance of factors for decision-makers) only impairs the possibility of temporary comparisons.

The most famous and having the longest horizon of existence are currently two ratings:

- Rating of innovative regions of Russia (AIRR Rating 2019), developed by the Association of Innovative Regions of Russia;
- The rating of innovative development of the constituent entities of the Russian Federation (RIRR 2019), developed by the NRU «HSE».

Both of these ratings correspond to the characteristics, which were discussed earlier.

The paper attempts to form a metric (rating) that would characterize regional innovation processes in two coordinates: the current state (relative level) of manifestation of innovative activity and a long-term trend characterizing the course of the innovation process.

2 Materials and Methods

Open official data (Regions of Russia 2019), which characterize innovative activity in the regions of Russia, were used to form the metric.

The composition of the indicators under consideration (digital designations correspond to the numbering in the statistical book and are further used as conventional designations):

- 19.1. Research and development organizations;
- 19.2. The number of personnel engaged in research and development, people;
- 19.4. The number of researchers with advanced degrees, total, people;
- 19.8.1. Internal current expenditures on research and development by type of work, total, million rubles;
- 19.9.3. Issued patents for inventions, units;
- 19.11. The using advanced production technologies, units;
- 19.12.2. The share of organizations that carried out technological innovations in the total number of surveyed organizations, in percent;
- 19.13.1 Expenses for technological innovations, total, million rubles;

- 19.13.2 Costs for technological innovation, as a percentage of the total volume of goods shipped, work performed, services;
- 19.14.2 The volume of innovative goods, works, services as a percentage of the total volume of goods shipped, works performed, services;
- 19.7. Capital expenditures for research and development (million rubles).

After the calculations, the indicator of 19.7 had to be abandoned, so due to the requirements for the disclosure of statistical information, many regions didn't have open data for many time intervals.

Also, due to the lack of statistical indicators for significant periods of time, the following regions were excluded from consideration: Jewish Autonomous Region; autonomous regions of Chukotka and Nenets; Republics: Crimea, Chechen, Ingushetia; the city of Sevastopol.

The indicators were analyzed for the time interval from 2000 to 2018.

The metric component characterizing the current state of innovation detail was calculated as follows: the average value of the indicator for the period was calculated and each value was assigned a rating, in which the maximum value of the indicator corresponded to the minimum rating value. The final rating was calculated as the average for all indicators, without using of weighting factors.

The component of the metric characterizing the trends in innovation activity in the region was calculated as follows. For the time period under consideration, the values of the approximating linear trend ($y = ax + c$) were calculated for each indicator. The obtained values of the coefficient «a», (the tangent of the slope of the approximating curve) clearly characterize the trend of the indicator (positive - growth, negative - decrease).

The level of reliability of the approximation was estimated by the R2 indicator. The final indicator, by which the rank was calculated, was formed as a product of «R2» and «a». Since R2 is the closer to «0», the lower the approximation reliability, due to this, the weight of the «false trend» was reduced.

The final rank of the «trend» was calculated as the average rank for all indicators, which are included in the rating. If trend indicators couldn't be calculated due to the absence of two or more indicator values, then the region was assigned a minimum rating for this value. The number of such values didn't exceed 10% of the considered sample.

Graphical interpretation of the trend metric calculation for two regions with opposite tendencies and the level of approximation reliability for the indicator 19.14.2 is shown in Fig. 1. The Oryol region shows a negative trend ($a < 0$) with a low level of reliability of the approximating curve ($R2 = 0.5$), while the Tomsk region is a positive trend ($a > 0$) with a high level of confidence ($R2 = 0.8$). Accordingly, the rank of the trend of the Tomsk region by the indicator 19.14.2 will be much higher.

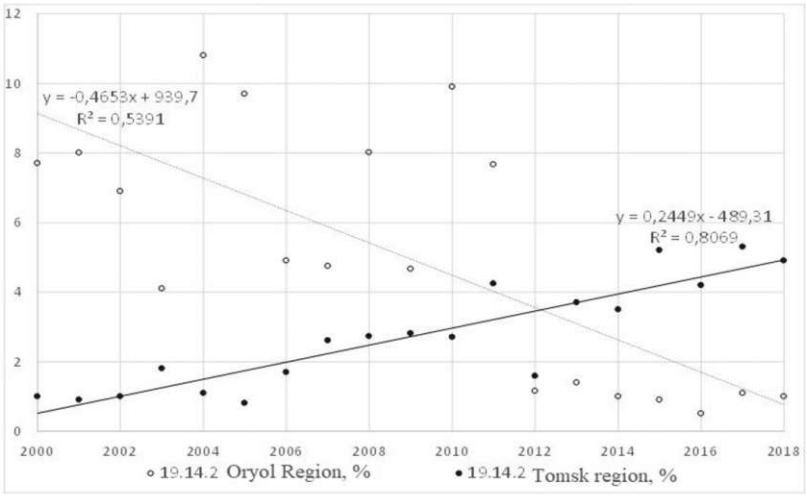

Fig. 1. Graphical interpretation of the trend metric calculation for two regions

3 Results

A fragment of the calculation of the elements of the metric of trends in the course of innovative processes in the regions of the Russian Federation is presented in Table 1. The following symbols are used:

Table 1. Fragment of the calculation of the elements of the metric of trends in the course of innovation processes in the regions of the Russian Federation

Регион	19.1			19.2			19.4			19.8.1		
	AR	AV	TR	AR	AV	TR	AR	AV	TR	AR	AV	TR
CFD-2(Moscow region)	3	241,68	7	2	89120,11	72	3	8275,89	76	3	57167,48	3
CFD-3(Voronezh)	13	60,42	52	12	12785,47	66	16	922,10	41	20	4150,69	19
CFD-5(Kaluga)	25	39,11	25	14	10680,63	57	15	948,63	78	16	5155,33	21
CFD-4(Yaroslavl)	29	33,47	23	20	6965,68	58	22	689,68	7	23	3485,28	23
CFD-7(Vladimir)	33	29,63	71	22	6752,58	71	36	370,52	71	28	2587,04	25
CFD-6(Tula)	40	24,05	62	24	6643,63	76	48	212,21	56	30	2229,61	26
CFD-8(Tver)	27	38,05	77	29	5064,79	63	34	436,31	77	27	2704,02	29
CFD-9(Ryazan)	50	18,95	17	33	2934,95	46	53	174,73	37	39	1055,53	46
CFD-14(Kursk)	49	19,32	74	35	2632,05	7	56	146,10	28	33	2073,10	31
CFD-11(Tambov)	37	26,53	20	39	2082,79	61	52	176,94	51	42	893,54	57

(*continued*)

Table 1. (*continued*)

Регион	19.1			19.2			19.4			19.8.1		
	AR	AV	TR	AR	AV	TR	AR	AV	TR	AR	AV	TR
CFD-15(Bryansk)	45	21,47	54	49	1439,79	59	73	62,36	48	62	361,88	60
CFD-10(Belgorod)	48	20,95	67	50	1439,47	28	42	272,47	8	43	890,57	34
CFD-13(Orel)	51	18,11	65	58	1073,00	51	57	143,73	64	64	310,45	61
CFD-16(Ivanovo)	39	24,95	73	61	955,26	52	40	286,68	60	61	391,41	59
CFD-17(Smolensk)	53	17,68	12	62	923,16	37	74	61,57	68	52	726,35	45
CFD-12(Lipetsk)	66	14,16	24	72	425,84	9	64	114,73	17	73	141,09	69
CFD-18(Kostroma)	75	7,89	61	78	161,63	33	79	25,15	62	77	63,69	75
…												
UFD-1(Sverdlovsk)	6	116,37	72	6	23175,53	74	6	2468,52	14	6	13652,50	6
SFD-6(Novosibirsk)	5	118,63	58	7	22971,58	68	4	5112,26	44	7	11231,60	7
UFD-2(Chelyabinsk)	19	50,79	2	9	16394,95	64	19	738,73	22	9	8114,90	11
SFD-1(Tomsk)	17	56,58	50	16	8641,89	3	8	1666,05	9	15	6008,79	12
SFD-7(Krasnoyarsk)	12	60,68	40	19	7079,16	12	17	815,94	21	10	7870,37	8
SFD-5(Omsk)	23	43,16	69	21	6835,63	75	39	324,57	61	25	2941,90	24
UFD-3(Tyumen)	15	58,05	39	23	6731,68	2	21	712,26	6	13	6878,51	9
FEFD-2(Primorsk)	20	47,21	49	28	5961,63	50	9	1520,63	11	22	3689,51	20
SFD-9(Irkutsk)	22	43,68	15	30	4903,95	44	11	1343,0	69	26	2736,86	27
SFD-10(Altai)	28	36,53	42	34	2716,84	25	31	481,63	4	40	971,88	42
FEFD-3(Yakutia)	41	23,79	36	36	2417,58	48	24	647,10	23	36	1536,00	33
UFD-4(Khanty)	63	14,53	38	42	1952,47	27	54	159,94	67	34	2027,21	38
FEFD-1(Khabarovsk)	26	38,63	18	46	1687,11	13	32	458,10	12	38	1212,08	39
SFD-8(Kemerovo)	30	30,21	59	48	1476,16	38	38	336,05	15	49	773,75	44
FEFD-6(Kamchatka)	58	15,32	43	54	1149,37	31	49	211,63	50	44	874,38	52
FEFD-5(Buryatia)	55	16,89	45	55	1145,68	21	30	486,73	49	57	486,82	53
FEFD-4(Sakhalin)	67	14,00	26	63	878,47	34	65	108,78	54	53	720,11	49
FEFD-8(Amur)	57	15,37	30	64	825,58	39	50	202,57	59	65	289,04	62
FEFD-7(Magadan)	72	8,32	46	68	604,11	18	58	142,0	33	55	574,95	65
FEFD-9 (Transbaikalia)	68	13,89	41	70	535,37	35	70	75,10	53	68	213,55	67
SFD-3(Tuva)	73	8,16	33	74	372,63	11	72	71,15	43	72	148,99	68
SFD-2(Khakassia)	79	5,21	31	77	184,32	14	66	90,15	34	79	50,88	77
SFD-4(Altai)	74	8,05	28	79	138,53	16	77	36,15	66	78	52,79	76
UFD-6(Yamal)	80	4,05	53	80	96,53	22	80	21,11	73	76	76,27	78

The names of the indicators are in accordance with the legend given earlier;
AR - rating of the average value of the indicator (current coordinate of the metric);
TR - trend rating (trend coordinate of the metric);
AV - the average value of the indicator for the period.

For ease of using and presentation of the material, the names of the regions were coded as follows: «Abbreviation of the Federal District - the number of the rank according to the average indicator of innovative activity in the Federal District - the abbreviated name of the region». For example, CFD-13 (Orel) means the Oryol region, which is in 13th position in terms of innovative activity in the Central Federal District.

The final two-dimensional rating is presented in Table 2.

The following conventions are used:

- Cells with gray fill correspond to ten regions that demonstrated the most positive dynamics of innovation detail for the period under review in column «B» and had the highest average rating of values of innovative activity in column «C»;
- Bold type is used to designate regions that are included in the second ten in terms of relevant indicators;
- Italics are used to denote the ten worst regions for both indicators.

We can present the conclusions based on the analysis results:

- «worst» regions are always «worst», that is, ten regions with minimum rating values almost completely coincide in dynamics and in the level of innovation activity (Ivanovo, Kaliningrad, Oryol regions; Republics: Karachay-Cherkess, Adygea, Tyva, Khakassia, Altai, Kalmykia)
- There is a significant share of relatively «weak» regions among the leading regions in terms of emerging trends in innovative development, that is, they have an average level of innovative activity. This can be explained by the «low base» of indicators that these regions had at the beginning of the study period of the Republic: Tatarstan, Chuvash: regions: Tyumen, Tomsk, Moscow, Lipetsk, Yaroslavl, Penza; Krasnoyarsk, Krasnodar and Stavropol Territories);
- Regions with high rates of innovation activity, demonstrating a very different level of innovation dynamics. Thus, the undoubted leader of all ratings in terms of the level of innovativeness, Moscow has hardly entered the twenty most dynamic regions. This can be explained by structural changes in the regions and by the phenomenon of the «glass ceiling», when the growth of the rates of innovative development isn't supported by economic expediency (cities of Moscow and St. Petersburg; regions: Moscow, Rostov, Sverdlovsk, Chelyabinsk, Nizhny Novgorod, Samara, Perm Territory);
- With some reservations, it's possible to draw a conclusion about the harmonious development of innovation processes in cases where the ratings of dynamics and level approximately coincide (Tatarstan is the absolute leader).

Table 2. Rating of long-term trends in innovative activity in the regions of Russia

Region (A)	Dynamic component, rank (B)	Condition component, rank (C)	Region (A)	Dynamic component, rank (B)	Condition component, rank (C)	Region (A)	Dynamic component, rank (B)	Condition component, rank (C)
1	2	3	4	5	6	7	8	9
VFD-2(Tatar)	12,8	7,9	VFD-12(Kyr)	36	43,3	NCFD-5(Oset)	44,8	*69,2*
SFD-7(Krasn)	17,6	**25**	SFD-5(Omsk)	37	29,4	FEFD-6(Kamch)	44,9	59,9
VFD-10(Chuvash)	19	35,9	NCFD-3(Kabard)	37,1	63,8	CFD-5(Kaluga)	45,2	**24**
UFD-3(Tyumen)	23,1	29,4	CFD-9(Ryazan)	37,3	39,6	NCFD-2(Dag)	45,5	46,5
SFD-3(Krasnodar)	23,6	29,5	CFD-11(Tambov)	37,4	41,3	NFD-6(Komi)	46,3	49,6
NCFD-1(Stavr)	25,9	34,3	CFD-7(Vladimir)	37,5	28,4	NFD-10(Pskov)	46,4	63,6
SFD-1(Tomsk)	26,4	**21,5**	CFD-3(Voronezh)	37,8	**19,2**	SFD-8(Kemer)	46,8	47,1
CFD-2(MSK obl.)	26,7	6,5	UFD-2(Chelyab)	38,1	14,6	VFD-14(Mari)	46,9	*64,3*
CFD-12(Lipetsk)	27,1	41,6	SFD-9(Irkutsk)	38,4	31,6	FEFD-9(Transbaikalia)	48,6	*64,8*
CFD-4(Yaroslavl)	27,3	**22,7**	FEFD-4(Sakhalin)	39,1	48,9	FEFD-7(Magad)	48,7	60,1
VFD-7(Penza)	27,5	31,9	SFD-10(Alt. K.)	39,6	36,9	SFD-4(Astr)	49,2	56,4
CFD-10(Belgorod)	**27,8**	40,7	NFD-4(Arkhang)	40,1	47,5	NFD-7(Vol)	51,2	50,5
VFD-5(Bashk)	**28,4**	**19,5**	UFD-4(Khanty)	40,1	48,5	CFD-18(Kostr)	51,5	*63,9*
FEFD-1(Khab)	**28,6**	27,6	NFD-2(Len)	40,4	38,7	NFD-3(Murm)	51,9	44
SFD-1(Rostov)	**30,2**	16,2	FEFD-5(Buryat)	40,5	54,4	UFD-6(Yamal)	52,2	62
VFD-11(Mord)	**30,3**	39,9	VFD-1(Nizh)	40,8	6,5	SFD-2(Volg)	54	**27,4**
CFD-1(Moscow)	**31,4**	5,1	NFD-5(Novgorod)	41	48,1	UFD-5(Kurgan)	*54*	54,7
SFD-6(Novosib)	**31,5**	**22,9**	VFD-6(Saratov)	41,3	**27,2**	NCFD-4(Karach)	*54,1*	*65,1*
NFD-1(SPB)	**31,6**	6,3	VFD-8(Ulyan)	41,4	32,6	CFD-16(Ivanovo)	*54,4*	52,9
VFD-4(Perm)	**33**	13,2	CFD-15(Bryansk)	42,5	51,8	SFD-5(Adygea)	*56,3*	*67,3*
VFD-9(Udmurtia)	**33,2**	35,5	VFD-3(Samar)	42,7	9,9	NFD-8(Kalin)	*57,3*	58,3
VFD-13(Orenburg)	33,8	46,1	CFD-6(Tula)	43	**25,4**	SFD-3(Tuva)	*58,3*	*76,5*
FEFD-2(Primor)	34,6	41	CFD-8(Tver)	43	34,7	SFD-2(Khak)	*58,4*	*71,9*
CFD-14(Kursk)	35,3	45,6	FEFD-3(Yakutia)	44	47,2	CFD-13(Orl)	*61,4*	44,9
FEFD-8(Amur)	35,6	61	CFD-17(Smol)	44,5	56,3	SFD-4(Altai R.)	*61,4*	*64,1*
UFD-1(Sverd)	35,8	9,2	NFD-9(Karel)	44,5	61,1	SFD-6(Kalmyk)	*67,4*	*77,2*

4 Conclusions/Recommendations

Thus, the paper presents a methodology for the formation of a metric characterizing the innovative development of a region in two projections: long-term in the form of a rating of the severity of the trend of change in indicators of innovative activity and current, in the form of a rating of the level (value) of indicators of innovative activity.

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