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Correlation Relationship Between Scientific-Innovation and Macroeconomic Indicators in the Selected Russian Regions

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Abstract: The study presents a matrix of pairwise correlations for 26 regions of the Central and North-West Federal Districts of Russia between ten scientific-innovation and macroeconomic indicators comprising a number of objects of the innovation infrastructure according to two databases, a number of universities, university potential which had been calculated based on webometric rankings of universities, a number of scopus-publications in universities of the regions during the year 2015 and in general, the gross regional product, a number of population, the gross regional product per capita, population density. In all cases there were obtained high values of pearson's correlation coefficient. It has been concluded that a high level of scientific-innovation development of regions is based on a high degree of social-economic development of their urbanized territories that is the gross regional product and a number of population, rather than the reverse.

Key words: Correlation relationship, scientific-innovation indicators, macroeconomic indicators, Scopus publications, gross regional product, population, webometrics, Russian regions, Central Federal district, North-West Federal district, cross correlation matrix, regional innovation infrastructure

INTRODUCTION

Dynamics of the Russian regional innovation infrastructure objects was studied in the works (Moskovkin and Krimsky, 2007a, b, 2008; Moskovkin *et al*., 2015) their correlation relation with the Gross Regional Product (GRP) in the work (Munenge, 2016), the correlation relation between regional macroeconomic indicators (the gross regional product, a number of population) and a number of universities according to the Russian regions was studied in the works (Moskovkin *et al*., 2015), the comparative analysis of publication activity of the Russian leading universities conducted on the basis of Web of Scienceи Scopus databases was carried out in the work (Moskovkin *et al*., 2015).

Together with the gross regional product and a number of population there will be used in this work the gross regional product per capita and population density as macroeconomic indicators and a number of objects of regional innovation infrastructure according to two databases (Fgbnu, 2016) a number of universities in the Russian regions according to Webometrics database, the total and current (2015) number of scopus-publications according to universities of regions and an indicator of regional university potential calculated specially according to Webometrics database as scientific-innovative indicators. It should be noted that the Federal State Statistics Service (ROSSTAT) data on the macroeconomic indicators were taken for 2013 in the works (Moskovkin *et al*., 2015) and in this research we will operate the data for 2014.

MATERIALS AND METHODS

From the point of view of empiric basis and preparation of initial data on all indicators, we will rely on the abovementioned works (Moskovkin and Krimsky, 2007, 2008; Moskovkin and Munenge, 2015a, b; Moskovkin *et al*., 2015), the databases according to objects of regional innovation infrastructure (Fgbnu, 2016; NDP, 2016), the database according to macroeconomic indicators of the Federal State Statistics Service (ROSSTAT), the database according to Webometrics rankings of universities and Scopus database according to university publication activity. It is obvious that the regional university potential may be calculated by various ways. To a first approximation, it may be the total number of universities in a region (N_{un2015}) calculated according to Webometrics database

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(Moskovkin *et al*., 2015). To a second, stricter, approximation we will propose to take into account the national Webometric rankings of universities in this researcch. Let us set the national (country) ranking (rank, place of a university in the national Webometric ranking) of an i university in a j region by R_{ij}. For each j it is taken its own numeration from i = 1 to i = n_j number of universities in the j region. In order to transform R_{ij} values into a unit interval we will use a standard rate setting procedure:

$$r_{ij} = \frac{\max_{ij} R_{ij} - R_{ij}}{\max_{ij} R_{ij} - \min_{ij} R_{ij}} \quad (1)$$

Then the regional university potential I_j can be calculated based on Eq. 1:

$$I_j = \sum_{i=1}^{n_j} r_{ij} = \sum_{i=1}^{n_j} \left(\frac{\max_{ij} R_{ij} - R_{ij}}{\max_{ij} R_{ij} - \min_{ij} R_{ij}} \right) \quad (2)$$

We will take the data according to Webometric rankings of universities for July 2015 (Moskovkin *et al*., 2015; Munenge, 2016). In this case, $\max_{ij}R_{ij}$, $\min_{ij}R_{ij}$ = 1, then we will re-write the Eq. 2 as follows:

$$I_j = \sum_{i=1}^{n_j} \left(\frac{1482 - R_{ij}}{1481} \right) \quad (3)$$

where, j = 1.27. Data according to two innovation and four macroeconomic indicators was taken as of the end of 2014. Data on Scopus-publication activity of universities was taken from Scopus database within the period from 5-13 October, 2016 (there was taken the cumulative data and data for 2015).

About 27 regions of the bordering Central and North-West Federal districts were taken as the Russian regions. The last region (the Nenets Autonomous district) we determined as an statistical outlier and excluded it from the further regression-correlation analysis.

Upon the preparation and calculation of all initial data, we conducted the regression-correlation analysis using the standard Microsoft Excel opportunities. Finally, we calculated a cross-correlation matrix for ten macroeconomic and scientific-innovation indicators of regions of the Federal Districts under consideration.

RESULTS AND DISCUSSION

The distribution of Scopus-publications according to universities of regions of the Central and North-West Federal Districts of Russia is shown in Table 1 and all initial data for the regression-correlation analysis is shown in Table 2 in which N_{in}^1 and N_{in}^2 is a number of objects of the regional innovation infrastructure, respectively, according to the first (Fgbnu, 2016) and second (NDP, 2016) database of these objects, N_{scj} is the total number of Scopus-publications in universities of a region, $N_{scj2015}$ is a number of Scopus-publications in universities of a region during 2015 (the value of both indicators is taken from Table 1). In Table 1 the first 17 regions relate to the Central Federal district and the rest 10 regions relate to the bordering North-West Federal district.

From Table 1 we see that the apparent leaders in Scopus-publication activity are Moscow and St., Petersburg which have respectively 67 and 28 universities, in turn, correspondingly, 13542 and 6218 Scopus publications in 2015.

In the further calculations the data for the Nenets Autonomous District (region No. 27) was excluded from the analysis as there was observed the abnormally high gross regional product per capita for it due to the high gross domestic product (oil-and-gas-bearing region) and very low number of population. The matrix of pairwise correlations for ten macroeconomic and scientific-innovation indicators for 26 regions of the Central and North-West Federal districts of Russia is shown in Table 3.

Table 3 contains the value of Pearson's correlation coefficient (R). As we see from this table, there was throughout obtained very high values of the correlation coefficient. Selected linear equations of regression are shown in Fig. 1-3.

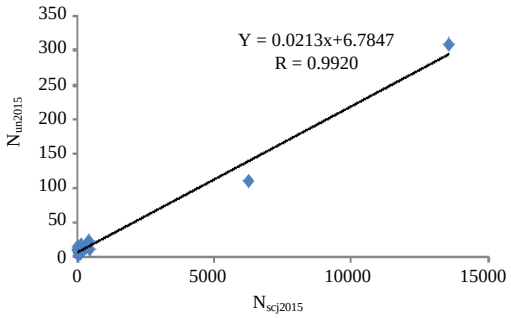

Fig. 1: Linear regression equation between $N_{scj2015}$ and N_{scj}

Table 1: The distribution of Scopus-publications according to universities of regions of the Central and North-West Federal districts of Russia

Russian regions	University	$N_{sci2015}$	N_{sci}
Belgorodskaya Oblast	Belgorod State University	340	
	Belgorod State Technological University VG Shukhov	131	
	Belgorod State Agricultural Academy	2	
	Total		473
Bryanskaya Oblast	Bryansk State Technical University	27	
	Bryansk State University Academician I G Petrovskii	7	
	Bryansk State Engineering-Technological Academy	27	
	Total		61
Vladimirskaya Oblast	Vladimir State University	137	
	Total		137
Voronezhskaya Oblast	Voronezh State University	344	
	Voronezh State Technical University	55	
	Voronezh State Pedagogical University	0	
	Voronezh State Agrarian University	0	
	Voronezh Institute of Ministry of Interior of Russia	3	
	Voronezh State Medical Academy	12	
	Voronezh State Forest Technical Academy	15	
	Voronezskaja Gosudarstvennaja Tehnologiceskaja Akademija	0	
	Voronezh Institute of Russian Ministry of Internal Affairs	2	
	Voronezh Military Institute of Aircraft Engineering	0	
	Total		431
Ivanovskaya Oblast	Ivanovo State University of Chemistry and Technology	165	
	Ivanovo State University	57	
	Ivanovo State Power University	14	
	Ivanovo State Medical Academy	11	
	Ivanovo State Medical Academy	11	
	Total		258
Kaluzhskaya Oblast	Obninsk State Technical University for Nuclear Power Engineering	1	
	Kaluga State Pedagogical University	0	
	Total		1
Kostromskaya Oblast	Kostroma State University N A Nekrasov	3	
	Kostroma State Technological University	51	
	Total		54
Kurskaya Oblast	Southwestern State University Kursk	144	
	Kursk State Medical University	38	
	Total		182
Lipetskaya Oblast	Lipetsk State Technical University	41	
	Total		41
Moskva	Lomonosov Moscow State University	6018	
	Russian State Social University	127	
	Moscow Institute of Physics and Technology	1416	
	Bauman Moscow State Technical University	590	
	National University of Science and Technology MISIS	765	
	Sechenov First Moscow State Medical University	319	
	Pirogov Russian National Research Medical University RNRMU	295	
	D.Mendeleev University of Chemical Technology of Russia	263	
	National Research University Higher School of Economics	1,146	
	Peoples' Friendship University of Russia	306	
	M.V. Lomonosov Moscow state university of fine chemical technologies	186	
	National Research University Moscow Power Engineering Institute	333	
	Moscow State Pedagogical University	128	
	Moscow State University of Medicine and Dentistry	82	
	Rossijskij Gosudarstvennyj Universitet Nefti i Gaza im. I.M. Gubkina	157	
	Moscow Power Institute	4	
	Moscow State University of Design and Technology	22	
	Moscow Technological University MIREA	110	
	MIET National Reserch University of Electronic Technology	32	
	Plekhanov Russian University of Economics	156	
	Moscow State University of Civil Engineering	148	
	Moscow State Technological University Stankin	144	
	Timiryazev Agricultural Academy	22	
	Independent University of Moscow	17	
	Moscow State Aviation Technological University	56	
	Moscow Automobile and Road Construction State Technical University MADI	19	
	Moscow State University of Mechanical Engineering	98	
	Moscow State Mining University	12	
	Financial University under the Government of the Russian Federation	100	

Table 1: Continue

Russian regions	University	$N_{sci2015}$	N_{sci}
	Russian Presidential Academy of National Economy and Public Administration RANEPA	98	
	Moscow Region State University	27	
	Rossijskij Gosudarstvennyj Gumanitarnyj Universitet	47	
	Moskovskij Gosudarstvennyj Industrialnyj Universitet	24	
	Moscow State Geological Prospecting Academy	8	
	Moscow State Open University	0	
	Moscow State University of Food Production	36	
	Moscow State Institute of International Relations MGIMO	19	
	Moscow Evening Metallurgical Institute	0	
	Moskovskij Gosudarstvennyj Universitet Prirodoobustroistva	2	
	Moscow State University of Psychology and Education	26	
	Russian State University of Tourism and Service	32	
	Moskovskij Gosudarstvennyj Universitet Lesa	11	
	Gosudarstvennyj Universitet Upravlenija	10	
	Moskovskij Tehniceskij Universitet Svjazi i Informatiki	17	
	Moskovskaja Gosudarstvennaja Akademija Nefti i Gaza	0	
	Moscow State University of Geodesy and Cartography	21	
	Moscow State University of Printing Arts	16	
	Moskovskij Gosudarstvennyj Universitet Inzenernoj EkologiiMGUIE	0	
	Sholokhov Moscow State University for the Humanities	23	
	Moskovskij Gosudarstvennyj Tehniceskij Universitet Grazdanskoj Aviacii	6	
	Russian New University	4	
	Moscow State University of Technologies and Management	10	
	Moskovskij Gosudarstvennyj Universitet Putej Soobscenija	1	
	Russian Foreign Trade Academy	5	
	Moskovskij Gosudarstvennyj Universitet Prikladnoj Biotehnologii	0	
	Moscow University of Finance and Law	8	19
	St. Tikhon's Orthodox University	5	19
	Moskovskij Gosudarstvennyj Universitet Kul'tury i Iskusstv	1	17
	State Academic University for Humanities GAUGN	8	11
	Moskovskaja Mezdunarodnaja Vyssaja Skola Biznesa	1	6
	Sovremennaja Gumanitarnja Akademiya	0	5
	Institute of International Business Education, Moscow	0	4
	Moscow Academy of Labour Market and Information Technology	2	4
	Moscow Institute of Economics, Management and Law	0	4
	Pushkin State Russian Language Institute	3	3
	Moscow P. I. Tchaikovsky Conservatory	0	2
	Total	13542	190053
Orlovskaya Oblast'	State University ESPC (Orel State Technical University)	1	137
	Orel State University	17	202
	Oryol State Institute of Economy and Trade	0	0
	Total	18	339
Ryazanskaya Oblast	Ryazan State University S A Esenin	17	233
	Ryazan State Medical University IP Pavlov	14	465
	Ryazan State Radioengineering University	87	500
	Total	118	1198
Smolenskaya Oblast	Smolensk Humanities University	0	6
	Smolensk State University	7	124
	Total	7	130
Tambovskaya Oblast	Tambov State Technical University	72	476
	Tambov State University	37	401
	Total	109	877
Tverskaya Oblast	Tver State University	102	1302
	Tver State Medical Academy	10	262
	Tver State Technical University	54	362
	Total	166	1926
Tulskaya Oblast	Tula State University	91	839
	Tula State Pedagogical University	12	223
	Total	103	1062
Yaroslavskaya Oblast	Yaroslavl State University	111	1642
	Yaroslavl State Medical Academy	20	254
	Yaroslavl State Pedagogical University	15	158
	Yaroslavsky Pedagogical Institute	0	3
	Yaroslavl Polytechnic Institute	0	153
	Yaroslavl State Technical University	28	350
	Total	174	2560

Table 1: Continue

Russian regions	University	$N_{sci2015}$	N_{sci}
Sankt-Peterburg	CaHkT Saint Petersburg State University	3046	33305
	Mechanics and Optics University ITMO		
	Saint Petersburg National Research University of Information Technologies,	1618	6549
	Sankt-Peterburgskij Gosudarstvennyj Elektrotehniceskij Universitet	377	2883
	Pavlov First State Medical University of St. Petersburg	49	2252
	Herzen State Pedagogical University of Russia	106	1363
	Saint Petersburg Mining University	215	1088
	North-Western State Medical University named after I.I. Mechnikov	53	1031
	Military Medical Academy, Saint Petersburg	33	936
	Saint-Petersburg State Chemical Pharmaceutical Academy SPCPA	6	917
	St. Petersburg State Institute of Technology	107	2343
	Saint-Petersburg State University of Aerospace Instrumentation	113	872
	St. Petersburg State University of Technology and Design	52	532
	Institute for Problems of Mechanical Engineering, Russian Academy of Sciences	177	1769
	Baltic State Technical University "VOENMEH"	30	516
	Rossijskij Gosudarstvennyj Gidrometeorologiceskij Universitet	52	392
	St.Petersburg Sanitary and Hygienic Medical Institute	0	311
	Saint Petersburg State Forest Technical Academy	24	308
	Saint-Petersburg State University of Architecture and Civil Engineering	72	280
	Saint-Petersburg State University for Civil Aviation	23	198
	St. Petersburg State Technological University of Plant Polymers	11	151
	European University at Saint Petersburg	17	133
	Saint Petersburg State Pediatric Medical Academy	2	107
	Sankt-Peterburgskij Gosudarstvennyj Universitet Telekommunikacij imeni professora Bonch-Bruevicha	23	87
	St.Petersburg State University of Film and Television	4	74
	Sankt-Peterburgskij Gosudarstvennyj Morskoj Tehniceskij Universitet	4	52
	Severo-Zapadnyj Zaocnyj Tehniceskij Universitet	0	26
	Sankt-Peterburgskij Gosudarstvennyj Universitet Ekonomiki i Finansov	2	21
	Sankt-Peterburgskij Gosudarstvennyj Inzenerno-Ekonomiceskij Universitet	2	8
	Total	6218	58504
Vologodskaya Oblast	Vologda State Technical University	40	281
	Total	40	281
Arkhangelskaya Oblast	Northern (Arctic) Federal University (Arkhangelsk State Technical University)	93	473
	Northern State Medical University Arkhangelsk	10	325
	Arkhangelsk State Technical University	0	2
	Total	103	800
Kaliningradskaya Oblast	Immanuel Kant State University of Russia (Kaliningrad State University)	165	1178
	Kaliningrad State Technical University	29	240
	Baltic Fishing Fleet State Academy	0	51
	Total	194	1469
Respublika Komi	Syktyvkar State University	39	412
	Ukhta State Technical University	23	85
	Total	62	497
Murmanskaya Oblast	Murmansk State Technical University	19	203
	Total	19	203
	Pskovskaya Oblast	0	0
Respublika Kareliya	Petrozavodsk State University	109	1076
	Karelian State Pedagogical University	0	40
	Petrozavodsk State University, Faculty of Medicine	0	15
	Total	109	1131
Novgorodskaya Oblast	Yaroslav-the-Wise Novgorod State University	57	549
	Total	57	549
	Nenetskiy avtonomnyy okrug	0	0

Table 2: Initial data for the regression-correlation analysis

Russian regions	$N_{sci2015}$	N_{sci}	GRP, 2014 (Million rub.)	GRP per capita, 2014 (Million rub.)	N_{im2015}	I_i	N_{in}^1 (2014)	N_{in}^2 (2014)	P_j, population (thousand people, 2014)	P_j, population (thousand density/km^2)
Belgorodskaya Oblast	473	2472	619388.1	400.6	10	5.2	17	14	1548	57.1
Bryanskaya Oblast	61	1053	243026.0	196.3	9	4.4	9	9	1233	35.3
Vladimirskaya Oblast	137	1190	327885.3	232.6	7	3.2	7	6	1406	48.3
Voronezhskaya Oblast	431	7322	709068.3	304.3	24	12.5	34	27	2331	44.7
Ivanovskaya Oblast	258	4151	151047.0	145.2	12	6.6	6	9	1037	48.5
Kaluzhskaya Oblast	1	173	324940.7	322.5	11	3.8	12	25	1011	33.9
Kostromskaya Oblast	54	403	146311.2	223.2	3	2.1	2	3	654	10.9
Kurskaya Oblast	182	1344	297435.6	266.0	11	5.8	5	7	1117	37.2

Table 2: Continue

Russian regions	$N_{scj2015}$	N_{scj}	GRP, 2014 (Million rub.)	GRP per capita, 2014 (Million rub.)	N_{un2015}	I_j	N_{in}^1 (2014)	N_{in}^2 (2014)	P_j, population (thousand people, 2014)	P_j, population (thousand density/km^2
Lipetskaya Oblast	41	321	395700.1	341.5	8	3.4	3	6	1158	48.3
Moskva	13542	190053	12808573.4	1053.9	309	168.4	224	429	12197	4691.2
Orlovskaya Oblast	18	339	179740.4	234.2	7	3.6	3	11	765	31.0
Ryazanskaya Oblast	118	1198	297333.9	261.2	17	6.7	5	5	1135	28.7
Smolenskaya Oblast	7	130	234732.0	242.9	15	6.2	7	3	965	19.4
Tambovskaya Oblast	109	877	275820.7	258.8	7	4.0	10	12	1062	30.8
Tverskaya Oblast	166	1926	307376.7	232.8	11	3.8	13	12	1315	15.6
Tulskaya Oblast	103	1062	408485.0	269.2	11	4.3	15	10	1514	58.9
Yaroslavskaya Oblast	174	2560	388135.5	305.2	18	8.5	14	12	1272	35.1
Sankt-Peterburg	6218	58504	2652050.3	513.8	110	60.9	52	83	5192	3708.6
Vologodskaya Oblast	40	281	388402.8	325.8	8	4.3	6	7	1191	8.2
Arkhangelskaya Oblast	103	800	356433.8	311.5	5	2.4	9	8	1140	2.8
Kaliningradskaya Oblast	194	1469	306232.8	317.0	11	4.8	11	10	969	64.2
Respublika Komi	62	497	480862.7	553.8	9	3.6	4	10	864	2.1
Murmanskaya Oblast	19	203	320275.7	416.7	12	5.1	9	12	766	5.3
Pskovskaya Oblast	0	0	121303.1	185.5	8	3.5	3	4	651	11.8
Respublika Kareliya	109	1131	185640.4	293.1	4	1.9	7	13	633	3.5
Novgorodskaya Oblast	57	549	205930.1	331.8	3	1.3	8	6	619	11.4
Nenetskiy Avtonomnyy okrug	0	0	183699.8	4252.48	0	1.0	0	0	430.2	

Table 3: The matrix of pairwise correlations for ten macroeconomic and scientific-innovation indicators (26 regions of the Central and North-West Federal districts of Russian Federation)

Russian regions	$N_{scj2015}$	N_{scj}	GRP, 2014 (Million Rub)	GRP per capita, 2014 (Million Rub)	N_{un2015}	I_j	N_{in}^1 (2014)	N_{in}^2 (2014)	P_j, population (thousand people, 2014)	P_j, population (thousand density/km^2
$N_{scj2015}$	1	-	-	-	-	-	-	-	-	-
N_{scj}	0.9906	1	-	-	-	-	-	-	-	-
GRP, 2014, Million rub.	0.9688	0.9927	1	-	-	-	-	-	-	-
GRP per capita, 2014, (Million rub.)	0.8752	0.8812	0.8932	1	-	-	-	-	-	-
N_{un2015}	0.9920	0.9979	0.9879	0.8815	1	-	-	-	-	-
I_j	0.9937	0.9983	0.9872	0.8799	0.9997	1	-	-	-	-
$N_{in}^1$2014	0.9653	0.9879	0.9933	0.8794	0.9852	0.9843	1	-	-	-
$N_{in}^2$2014	0.9647	0.9908	0.9982	0.8842	0.9856	0.9846	0.9941	1	-	-
P_j, Population (thous. people), 2014	0.9888	0.9865	0.9785	0.8716	0.9922	0.9927	0.9834	0.9742	1	
P_j, population density, people/km^2	0.9682	0.9258	0.8776	0.8141	0.9346	0.9381	0.8757	0.8710	0.9372	1

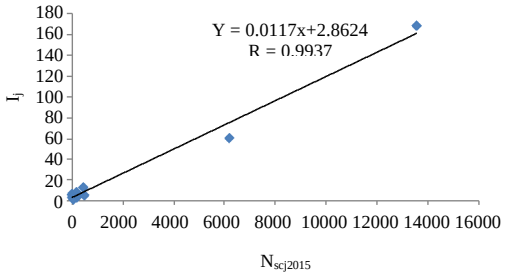

Fig. 2: Linear regression equation between $N_{Scj2015}$ and N_{scj}

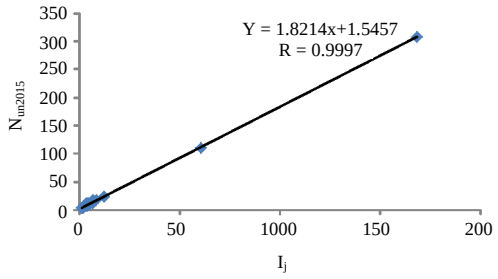

Fig. 3: Linear regression equation between $N_{Scj2015}$ and N_{scj}

If we take out points corresponding to Moscow and Saint-Petersburg coordinates from the obtained linear equations, so for Fig. 1 we will obtain the equation N_{un2015} = 0.0209 $N_{scj2015}$+7.2026 = 0.4938, for Fig. 2 the equation I_j = 0.0121 $N_{Scj2015}$+3.07220, R = 0.6094, for Fig. 3 the equation N_{un2015} = 2.036 I_j+0.5186, R = 0.9529.

CONCLUSION

Thus, based on the example of 26 regions of the Central and North-West Federal districts of Russia there was studied the mutual correlation between ten scientific-innovation and macroeconomic indicators in the

study. Two indicators of innovation infrastructure and four indicators of university infrastructure and their activities, including Scopus-publication activity were taken as scientific-innovation indicators. The gross regional product and a number of population as well as their specific indicators (the gross regional product per capita, population density) were taken as macroeconomic indicators. There was obtained a high pairwise correlations of all indicators between each other. It is obvious that the social-economic potential of urban regions determines their high scientific-innovative potential, rather than the reverse.

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