

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

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**Abstract:** The article 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 [1-4], their correlation relation with the Gross Regional Product (GRP) – in the work [5], 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 [6,7], the comparative analysis of publication activity of the Russian leading universities conducted on the basis of Web of Science and Scopus databases was carried out in the work [8].

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 [9,10], 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 [5-7], and in this work we will operate the data for 2014.

### METHODOLOGY

From the point of view of empiric basis and preparation of initial data on all indicators, we will rely on the abovementioned works [1-8], the databases according to objects of regional innovation infrastructure [9,10], 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 ( $N_{um2015}$ ) calculated according to Webometrics database [6,7]. To a second, stricter, approximation, we will propose to take into account the national Webometric rankings of universities in this work. 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

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

Then the regional university potential  $I_j$  can be calculated based on the formula (1)

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

We will take the data according to Webometric rankings of universities for July 2015 [6,7].

In this case,  $\max_{ij} R_{ij} = 1482$ ,  $\min_{ij} R_{ij} = 1$ , then we will

re-write the formula (2) as follows:

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

where  $j = \overline{1, 27}$

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 to 13 October, 2016 (there was taken the cumulative data and data for 2015).

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 [9] and second [10] database of these objects,  $N_{scj}$  is the total number of Scopus-publications in universities of a region,  $N_{scj_{2015}}$  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.

**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	$N_{scj_{2015}}$	$N_{scj}$	№	Russian Regions	University	$N_{scj_{2015}}$	$N_{scj}$
1	Belgorodskaya oblast	Belgorod State University	340	1866			Moscow University of Finance and Law	8	19
		Belgorod State Technological University VG Shukhov	131	588			St. Tikhon's Orthodox University	5	19
		Belgorod State Agricultural Academy	2	18			Moskovskij Gosudarstvennyj Universitet Kult'ury i Iskusstv	1	17
	<b>Total</b>		<b>473</b>	<b>2472</b>			State Academic University for Humanities GAUGN	8	11
2	Bryanskaya oblast	Bryansk State Technical University	27	434			Moskovskaja Mezdunarodnaja Vyssaja Skola Biznesa	1	6
		Bryansk State University Academician I G Petrovskii	7	185			Sovremennaja Gumanitarnja Akademiya	0	5
		Bryansk State Engineering-Technological Academy	27	434			Institute of International Business Education, Moscow	0	4
	<b>Total</b>		<b>61</b>	<b>1053</b>			Moscow Academy of Labour Market and Information Technology	2	4
3	Vladimirskaya oblast	Vladimir State University	137	1190			Moscow Institute of Economics, Management and Law	0	4
		<b>Total</b>		<b>137</b>	<b>1190</b>			Pushkin State Russian Language Institute	3
4	Voronezhskaya oblast	Voronezh State University	344	4895			Moscow P. I. Tchaikovsky Conservatory	0	2
		Voronezh State Technical University	55	1115		<b>Total</b>		<b>13542</b>	<b>190053</b>
		Voronezh State Pedagogical University	0	25	<b>11</b>	Orlovskaya oblast'	State University ESPC (Orel State Technical University)	1	137
		Voronezh State Agrarian University	0	362			Orel State University	17	202
	Voronezh Institute of Ministry of Interior of Russia	3	17			Oryol State Institute of Economy and Trade	0	0	

		Voronezh State Medical Academy	12	342		<b>Total</b>		<b>18</b>	<b>339</b>
		Voronezh State Forest Technical Academy	15	178	<b>12</b>	Ryazanskaya oblast	Ryazan State University S A Esenin	17	233
		Voronezhskaja Gosudarstvennaja Tehnologiceskaja Akademija	<b>0</b>	<b>362</b>			Ryazan State Medical University IP Pavlov	14	465
		Voronezh Institute of Russian Ministry of Internal Affairs	<b>2</b>	<b>21</b>			Ryazan State Radioengineering University	87	500
						<b>Total</b>		<b>118</b>	<b>1198</b>
		Voronezh Military Institute of Aircraft Engineering	<b>0</b>	<b>5</b>	<b>13</b>	Smolenskaya oblast	Smolensk Humanities University	0	6
	<b>Total</b>		<b>431</b>	<b>7322</b>			Smolensk State University	7	124
<b>5</b>	Ivanovskaya oblast	Ivanovo State University of Chemistry and Technology	165	2611		<b>Total</b>		<b>7</b>	<b>130</b>
		Ivanovo State University	57	769	<b>14</b>	Tambovskaya oblast	Tambov State Technical University	72	476
		Ivanovo State Power University	14	131			Tambov State University	37	401
		Ivanovo State Medical Academy	11	320		<b>Total</b>		<b>109</b>	<b>877</b>
		Ivanovo State Medical Academy	11	320	<b>15</b>	Tverskaya oblast	Tver State University	102	1302
	<b>Total</b>		<b>258</b>	<b>4151</b>			Tver State Medical Academy	10	262
<b>6</b>	Kaluzhskaya oblast	Obninsk State Technical University for Nuclear Power Engineering	1	139			Tver State Technical University	54	362
		Kaluga State Pedagogical University	0	34		<b>Total</b>		<b>166</b>	<b>1926</b>
	<b>Total</b>		<b>1</b>	<b>173</b>	<b>16</b>	Tulskaya oblast	Tula State University	91	839
<b>7</b>	Kostromskaya oblast	Kostroma State University N A Nekrasov	3	17			Tula State Pedagogical University	12	223
		Kostroma State Technological University	51	386		<b>Total</b>		<b>103</b>	<b>1062</b>
	<b>Total</b>		<b>54</b>	<b>403</b>					
<b>8</b>	Kurskaya oblast	Southwestern State University Kursk	144	904	<b>17</b>	Yaroslavskaya oblast	Yaroslavl State University	111	1642
		Kursk State Medical University	38	440			Yaroslavl State Medical Academy	20	254
	<b>Total</b>		<b>182</b>	<b>1344</b>			Yaroslavl State Pedagogical University	15	158
<b>9</b>	Lipetskaya oblast	Lipetsk State Technical University	41	321			Yaroslavsky Pedagogical Institute	0	3
	<b>Total</b>		<b>41</b>	<b>321</b>			Yaroslavl Polytechnic Institute	0	153
<b>10</b>	Moskva	Lomonosov Moscow State University	6018	111581			Yaroslavl State Technical University	28	350
		Russian State Social University	127	344		<b>Total</b>		<b>174</b>	<b>2560</b>
		Moscow Institute of Physics and Technology	1416	8675	<b>18</b>	Sankt-Peterburg	САИКТ- Saint Petersburg State University	3046	33305
		Bauman Moscow State Technical University	590	6904			Saint Petersburg National Research University of Information Technologies, Mechanics and Optics University ITMO	1618	6549
		National University of Science & Technology MISIS	765	6755			Sankt-Peterburgskij Gosudarstvennyj Elektrotehniceskij Universitet	377	2883
		Sechenov First Moscow State Medical University	319	6420			Pavlov First State Medical University of St. Petersburg	49	2252

	Pirogov Russian National Research Medical University RNRMU	295	5723			Herzen State Pedagogical University of Russia	106	1363
	D.Mendelev University of Chemical Technology of Russia	263	5580			Saint Petersburg Mining University	215	1088
	National Research University Higher School of Economics	1,146	5293			North-Western State Medical University named after I.I. Mechnikov	53	1031
	Peoples' Friendship University of Russia	306	4495			Military Medical Academy, Saint Petersburg	33	936
	M.V. Lomonosov Moscow state university of fine chemical technologies	186	3937			Saint-Petersburg State Chemical Pharmaceutical Academy SPCPA	6	917
	National Research University Moscow Power Engineering Institute	333	3063			St. Petersburg State Institute of Technology	107	2343
	Moscow State Pedagogical University	128	2471			Saint-Petersburg State University of Aerospace Instrumentation	113	872
	Moscow State University of Medicine and Dentistry	82	2206			St. Petersburg State University of Technology and Design	52	532
	Rossijskij Gosudarstvennyj Universitet Nefti i Gaza im. I.M. Gubkina	157	2091			Institute for Problems of Mechanical Engineering, Russian Academy of Sciences	177	1769
	Moscow Power Institute	4	1719			Baltic State Technical University "VOENMEH"	30	516
	Moscow State University of Design and Technology	22	1428			Rossijskij Gosudarstvennyj Hidrometeorologiceskij Universitet	52	392
	Moscow Technological University MIREA	110	1397			St.Petersburg Sanitary and Hygienic Medical Institute	0	311
	MIET National Reserch University of Electronic Technology	32	853			Saint Petersburg State Forest Technical Academy	24	308
	Plekhanov Russian University of Economics	156	720			Saint-Petersburg State University of Architecture and Civil Engineering	72	280
	Moscow State University of Civil Engineering	148	708			Saint-Petersburg State University for Civil Aviation	23	198
	Moscow State Technological University Stankin	144	595			St. Petersburg State Technological University of Plant Polymers	11	151
	Timiryazev Agricultural Academy	22	586			European University at Saint Petersburg	17	133
	Independent University of Moscow	17	466			Saint Petersburg State Pediatric Medical Academy	2	107
	Moscow State Aviation Technological University	56	443			Sankt-Peterburgskij Gosudarstvennyj Universitet Telekomunikacij imeni professora Bonch-Bruevicha	23	87
	Moscow Automobile and Road Construction State Technical University MADI	19	437			St.Petersburg State University of Film and Television	4	74
	Moscow State University of Mechanical Engineering	98	414			Sankt-Peterburgskij Gosudarstvennyj Morskoj Tehniceskij Universitet	4	52

Moscow State University of Mechanical Engineering	98	414			Sankt-Peterburgskij Gosudarstvennyj Morskoy Tehniceskij Universitet	4	52
Moscow State Mining University	12	406			Severo-Zapadnyj Zaocnyj Tehniceskij Universitet	0	26
Financial University under the Government of the Russian Federation	100	357			Sankt-Peterburgskij Gosudarstvennyj Universitet Ekonomiki i Finansov	2	21
Russian Presidential Academy of National Economy and Public Administration RANEPA	98	326			Sankt-Peterburgskij Gosudarstvennyj Inzenerno-Ekonomiceskij Universitet	2	8
Moscow Region State University	27	288		<b>Total</b>		<b>6218</b>	<b>58504</b>
Rossijskij Gosudarstvennyj Gumanitarnyj Universitet	47	285	<b>19</b>	Vologodskaya oblast	Vologda State Technical University	40	281
Moskovskij Gosudarstvennyj Industrialnyj Universitet	24	271		<b>Total</b>		<b>40</b>	<b>281</b>
Moscow State Geological Prospecting Academy	8	253	<b>20</b>	Arkhangelskaya oblast	Northern (Arctic) Federal University (Arkhangelsk State Technical University)	93	473
Moscow State Open University	0	216			Northern State Medical University Arkhangelsk	10	325
Moscow State University of Food Production	36	216			Arkhangelsk State Technical University	0	2
Moscow State Institute of International Relations MGIMO	19	214		<b>Total</b>		<b>103</b>	<b>800</b>
Moscow Evening Metallurgical Institute	0	192	<b>21</b>	Kaliningradskaya oblast	Immanuel Kant State University of Russia (Kaliningrad State University)	165	1178
Moskovskij Gosudarstvennyj Universitet Prirodobustroistva	2	189			Kaliningrad State Technical University	29	240
Moscow State University of Psychology and Education	26	158			Baltic Fishing Fleet State Academy	0	51
Russian State University of Tourism and Service	32	158		<b>Total</b>		<b>194</b>	<b>1469</b>
Moskovskij Gosudarstvennyj Universitet Lesa	11	147	<b>22</b>	Respublika Komi	Syktivkar State University	39	412
Gosudarstvennyj Universitet Upravlenija	10	130			Ukhta State Technical University	23	85
Moskovskij Tehniceskij Universitet Svjazi i Informatiki	17	128		<b>Total</b>		<b>62</b>	<b>497</b>
Moskovskaja Gosudarstvennaja Akademiya Nefti i Gaza	0	125	<b>23</b>	Murmanskaya oblast	Murmansk State Technical University	19	203
Moscow State University of Geodesy and Cartography	21	98		<b>Total</b>		<b>19</b>	<b>203</b>
Moscow State University of Printing Arts	16	87	<b>24</b>	Pskovskaya oblast		<b>0</b>	<b>0</b>
Moskovskij Gosudarstvennyj Universitet Inzenernoj Ekologii MGUIE	0	83	<b>25</b>	Respublika Kareliya	Petrozavodsk State University	109	1076
Sholokhov Moscow State University for the Humanities	23	80			Karelian State Pedagogical University	0	40
Moskovskij Gosudarstvennyj Tehniceskij Universitet Grazdanskoj Aviacii	6	70			Petrozavodsk State University, Faculty of Medicine	0	15
Russian New University	4	56		<b>Total</b>		<b>109</b>	<b>1131</b>
Moscow State University of Technologies and Management	10	43	<b>26</b>	Novgorodskaya oblast	Yaroslav-the-Wise Novgorod State University	57	549
Moskovskij Gosudarstvennyj Universitet Putej Soobscenija	1	37		<b>Total</b>		<b>57</b>	<b>549</b>
Russian Foreign Trade Academy	5	23	<b>27</b>	Nenetskiy avtonomnyy okrug		<b>0</b>	<b>0</b>
Moskovskij Gosudarstvennyj Universitet Prikladnoj Biotehnologii	0	19					

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.

**Table 2**  
Initial data for the regression-correlation analysis

№	Russian Regions	$N_{scj_{2015}}$	$N_{scj}$	GRP, 2014, Million Rubles	GRP per capita, 2014, Million Rubles	$N_{un_{2015}}$	$I_j$	$N_{in}^1_{2014}$	$N_{in}^2_{2014}$	$P_j$ , Population (thous. people), 2014	$\rho_j$ , Population density, people /km <sup>2</sup>
1	Belgorodskaya oblast	473	2472	619388.1	400.6	10	5.2	17	14	1548	57.1

2	Bryanskaya oblast	61	1053	243026.0	196.3	9	4.4	9	9	1233	35.3
3	Vladimirskaya oblast	137	1190	327885.3	232.6	7	3.2	7	6	1406	48.3
4	Voronezhskaya oblast	431	7322	709068.3	304.3	24	12.5	34	27	2331	44.7
5	Ivanovskaya oblast	258	4151	151047.0	145.2	12	6.6	6	9	1037	48.5
6	Kaluzhskaya oblast	1	173	324940.7	322.5	11	3.8	12	25	1011	33.9
7	Kostromskaya oblast	54	403	146311.2	223.2	3	2.1	2	3	654	10.9
8	Kurskaya oblast	182	1344	297435.6	266.0	11	5.8	5	7	1117	37.2
9	Lipetskaya oblast	41	321	395700.1	341.5	8	3.4	3	6	1158	48.3
10	Moskva	13542	190053	12808573.4	1053.9	309	168.4	224	429	12197	4691.2
11	Orlovskaya oblast'	18	339	179740.4	234.2	7	3.6	3	11	765	31.0
12	Ryazanskaya oblast	118	1198	297333.9	261.2	17	6.7	5	5	1135	28.7
13	Smolenskaya oblast	7	130	234732.0	242.9	15	6.2	7	3	965	19.4
14	Tambovskaya oblast	109	877	275820.7	258.8	7	4.0	10	12	1062	30.8
15	Tverskaya oblast	166	1926	307376.7	232.8	11	3.8	13	12	1315	15.6
16	Tul'skaya oblast	103	1062	408485.0	269.2	11	4.3	15	10	1514	58.9
17	Yaroslavl'skaya oblast	174	2560	388135.5	305.2	18	8.5	14	12	1272	35.1
18	Sankt-Peterburg	6218	58504	2652050.3	513.8	110	60.9	52	83	5192	3708.6
19	Vologod'skaya oblast	40	281	388402.8	325.8	8	4.3	6	7	1191	8.2
20	Arkhangel'skaya oblast	103	800	356433.8	311.5	5	2.4	9	8	1140	2.8
21	Kaliningrad'skaya oblast	194	1469	306232.8	317.0	11	4.8	11	10	969	64.2
22	Respublika Komi	62	497	480862.7	553.8	9	3.6	4	10	864	2.1
23	Murmanskaya oblast	19	203	320275.7	416.7	12	5.1	9	12	766	5.3
24	Pskov'skaya oblast	0	0	121303.1	185.5	8	3.5	3	4	651	11.8
25	Respublika Kareliya	109	1131	185640.4	293.1	4	1.9	7	13	633	3.5
26	Novgorod'skaya oblast	57	549	205930.1	331.8	3	1.3	8	6	619	11.4
27	NeNETSKIY AVTONOMNIY OKRUG	0	0	183699.8	4252.48	0	1.0	0	0	43	0.2

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**  
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)

	$N_{scj_{2015}}$	$N_{scj}$	GRP,2014, Million Rubles	GRP per capita, 2014, Million Rubles	$N_{un_{2015}}$	$I_j$	$N_{in,}^1$ 2014	$N_{in,}^2$ 2014	$P_j$ , Population (thous. people), 2014	$\rho_j$ , Population density, people /km <sup>2</sup>
$N_{scj_{2015}}$	1									
$N_{scj}$	0.9906	1								
GRP,2014, Million Rubles	0.9688	0.9927	1							
GRP per capita, 2014, Million Rubles	0.8752	0.8812	0.8932	1						
$N_{un_{2015}}$	0.9920	0.9979	0.9879	0.8815	1					
$I_j$	0.9937	0.9983	0.9872	0.8799	0.9997	1				

$N_{in, 2014}^1$	0.9653	0.9879	0.9933	0.8794	0.9852	0.9843	1			
$N_{in, 2014}^2$	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	
$\rho_j$ , Population density, people /km <sup>2</sup>	0.9682	0.9258	0.8776	0.8141	0.9346	0.9381	0.8757	0.8710	0.9372	1

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 Figure. 1 – 3.

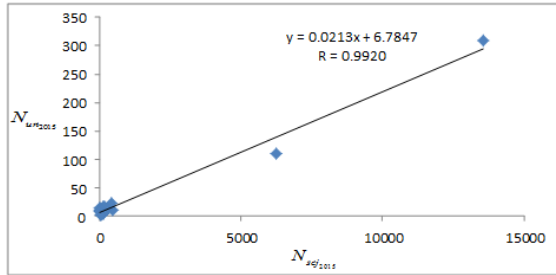


Figure 1. Linear Regression Equation between  $N_{scj2015}$  and  $N_{um2015}$

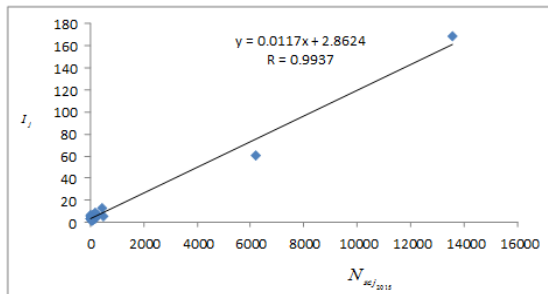


Figure 2. Linear Regression Equation between  $N_{scj2015}$  and  $I_j$

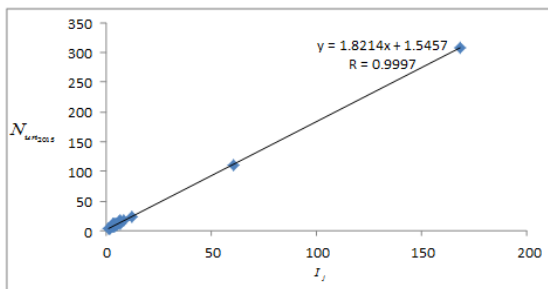


Figure 3. Linear Regression Equation between  $I_j$  and  $N_{um2015}$

If we take out points corresponding to Moscow and Saint-Petersburg coordinates from the obtained linear equations, so for the Figure 1 we will obtain the equation  $N_{um2015} = 0.0209 N_{scj2015} + 7.2026$ ,  $R = 0.4938$ , for the Figure 2 the equation  $I_j = 0.0121 N_{scj2015} + 3.0722$ ,  $R = 0.6094$ , for the Figure 3 the equation  $N_{um2015} = 2.036 I_j + 0.5186$ ,  $R = 0.9529$

**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 article. 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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