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Paper Title	Author(s)	Page no
Which Policies can Encourage the Diffusion of new Technologies? A Literature Review	Adele Parmentola, Michele Simoni and Ilaria Tutore	529
Social Outsourcing as a Development Tool for Social Enterprises	Ruslan Pavlov	539
Which Professors are Helping Universities to Transfer Technology by Creating Spin off?	Aura Pedraza, Johana León and Carolina Betancur	546
Customer Value Placed Under Scrutiny: New Perspectives for an Integrative Co-Creation Approach	Sabina Potra and Monica Izvercian	555
Entrepreneurship: A Contemporary Challenge to Sustainable Competitiveness of Thai Rubber Farmers	Suteera Puangpronpitag	561
Input and Output Additionality of R&D Programmes in European SMEs	Dragana Radicic and Geoffrey Pugh	567
Influence of Entrepreneurial Education and Technological Creativity on Entrepreneurial Intentions of Students in Zimbabwe: A Theoretical Perspective	Patient Rambe, Takawira Munyaradzi Ndofirepi and Dennis Yao Dzansi	576
The Dynamics Between Transformational Leadership, Entrepreneurial Orientation and Intrapreneurial Intention Among Employees	Seyed Hadi Razavi and Kamarulzaman Bin Ab Aziz	585
A Study on the Performance of Technology Transfer Units	Fernando Romero and António Rocha	592
Entrepreneurial Learning in Context: An Exploration of Learning Models in Different Domains	Michele Rusk and Pauric McGowan	600
Entrepreneurship in the Development of an Agile Enterprise: Theoretical and Practical Aspects	Maja Sajdak	609
Financing Constraints Faced by Small and Medium Tourist Businesses in India	Navjot Sandhu and Javed Hussain	618
Human Resource Management and Innovation: What Lessons From Italian Social Enterprises?	Daria Sarti and Teresina Torre	626
Crowdfunding in the Context of Traditional Financing for Innovative SMEs	Andreas Schenk	636
Entrepreneurial Marketing in the Last Decade: A Literature Review	Oliver Schuster, Christine Falkenreck and Ralf Wagner	644
When Risk-Neutral and Risk-Averse Entrepreneurs Work Together: A Different Kind of Support	Niousha Shahidi	655
Entrepreneurship in the Gymnasiums Business: Mantras for Success	Krishna Shetty and Bramha Duggal	664
Cooperation and Innovation Activity: Study of the Relationship at the Regional Level	Viacheslav Sirotin and Marina Arkhipova	673
Business Coaching and the Development of Agric-Businesses in Africa	Dzisi Smile, Dza Mawuko and Odoom Franklin	683
International Knowledge Networks in Sustainable Energy Technologies: Evidence From European Projects	Cristina Sousa and Isabel Salavisa	691
Positive Stress and Reflective Practice Enhancing Innovativeness Among Entrepreneurs	Kati Tikkamäki, Päivi Heikkilä and Mari Ainasoja	699
Transitioning Towards Employee-Driven Innovation: Lessons From Pioneers in the ICT Sector	Lia Tirabeni, Paola Pisano and Klas Eric Soderquist	707

Cooperation and Innovation Activity: Study of the Relationship at the Regional Level

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Abstract: Cooperation and partnership are in the focus of the research along with their impact on regional innovation activity. We consider collaboration as a means for the efficiency improvement. Partnership and cooperation create additional possibilities to cope with the various problems of the innovative development. Support to the competitiveness is the other way of fostering innovations. While the former seems to be more important under restrictions concerning lack of the sources for research programs, the latter may be more efficient under the favorable conditions. The contradiction between these points of view is an important issue for many researchers. We try to find is there any significant impact of the collaboration between firms and organizations on the innovation activity of the regions. The methodology of the research is based on using multivariate statistics and econometric modeling. The data set includes a lot of indicators for the Russian regions through the decade. Along with analysis of the reasons that hamper the progress of innovation activity we propose the system of indexes for measuring the level of cooperation and partnership development. The system is based on such variables as the number of joint research and development projects and the number of organizations involved, they are given separately for various types of partners, economic activities and types of cooperation. The regression models for panel data have been considered and compared. They allow estimating the quantitative effect of the cooperation impact on the innovation activity of regions and eliminating the regions peculiarities and the endogeneity bias. The results can be used as information support for the decision makers, government, industry and university in practice of managing the innovative development. The system of integral indicators for various aspects of innovative processes in regions may be used for measuring and fostering the innovative development of the regions. The results of the analysis can also help to raise the competitiveness of the country as a whole.

Keywords: innovative development, cooperation and partnership, panel data, regional innovation activity, integral indicators

1. Introduction

Technological innovations have a great influence on economic, social and political progress of modern society. A lot of factors foster progress of innovative development, and factors of cooperation create an important group of them (Melander, L. et al., 2015). When organizations and firms lack sources for generating innovations, they need help for meeting their goals. Cooperation helps realizing research and development projects and creating innovative products and services. Especially it concerns high-tech industries, where innovations are generated on the base of linked fields of science and knowledge. Partnership provides additional possibilities to cope with the problems of the research and development project diversification. Competition opposes to cooperation in innovative development process in some sense (Boon, J., 2001), (Aghion, P. et al., 2002). So the problem is to define if cooperation and partnership provide real impact on technological progress of the particular country. It is necessary to estimate the significance of the impact. Innovative development varies substantially from region to region in vast countries like Russia, provided the spatial structure of such countries may be substantially heterogeneous. It causes the problem of measuring and modelling innovative activity for regions with specific peculiarities. The problem may be solved by using regression models that allows examining the significance of the factors and obtaining the quantitative estimates of their influence on innovative development. As a source of relevant information data of Russian Federal State Statistics Service and OECD may be used.

2. Literature and data sources review

Innovative economic development is widely discussed issue. In order to create innovation the firm usually needs to combine different types of resources such as product-related knowledge, capability and industrial facilities, market knowledge and efficient distribution system, financial resources among others (Fagdeberg, 2003). A lot of papers are devoted to the mechanism of innovations and impact of various factors on the innovative development and the efficiency of innovations (Chin-Hai Yang et al., Rao, K. et al., 2011).

One of the main aspects of the problem of innovative development is the science and technology interaction (Schmoch, 1993), (Barros, 2011). The quantitative analysis of factors' impact is connected with the problem of relevant information (OECD, 2010).

Although a significant amount of literature devoted to the study of partnerships, international technological cooperation remains relatively underdeveloped in most developing countries (Publications Office of the European Union, 2013).

Processes of innovative development in Russian Federation have national peculiarities because of substantial heterogeneity of the country's regions. From this perspective Russia looks in some sense like a group of countries in a common economic space.

Cooperation and partnership influence on producing of innovations is one of the important points for researchers. Many authors pay attention to the problem (OECD, 2005) and its particular aspects, e.g. contradiction of partnership and competitiveness in modern innovative economy (Aghion, 2002), (Boone, 2001). But some points of the issue need additional attention in order to provide more comprehensive analysis of the innovative development features of the country's regions.

State Statistics Service of Russian Federation (Rosstat) publishes annual report on regional development, which includes a number of indicators of innovative activity and related issues. National Research University Higher School of Economics publishes indicators of innovative activity in cooperation with Russian State Statistics Service, Eurostat, and OECD. These sources are used by scientists researching problems of innovative development of the country and its regions. But it is important to be more specific about measuring the impact of cooperation and partnership. On this way constructing integral indicator of this factor and using it in regression model may be helpful.

3. General descriptions of cooperation and partnership in producing innovations in Russian Federation

Success in innovative development depends not only on own efforts of economic agents but also on efficiency of interaction between them and connections with external sources. In Russia information sources of academic and scientific organizations can hardly be considered as the most important for technological development. It shows the gap between science and real business.

Internal sources, despite of the decreasing of their share, prevail over others to a great extend. From one hand it may be explained by underestimating of the academic and scientific organizations possibilities in applied research area, from the other hand the lack of demand on applied research provides the lack of applied science activity in these organizations. At the same time the share of enterprises considering scientific organizations and academia as the partners in creating technological innovations changes for better along with the total increasing of the cooperative activity level till 2010 and substantial decreasing during the latest period (Table 1).

Table 1: Cooperation of Russian innovative enterprises with various kinds of partners

Year	Organization in the group	Consumers of goods, works and services	Suppliers	Competitors in your industry	Consulting and information company	Scientific organizations	Universities or other higher education institutions
2008	30,3	28,4	45,6	11,5	13,1	37,9	23,4
2010	33,3	26,2	48,1	10,2	14,3	38,5	24,9
2012	11,4	31,9	29,5	4,6	2,7	27,5	7,2
2013	13,8	31,6	28,7	4,8	3,0	24,9	6,9

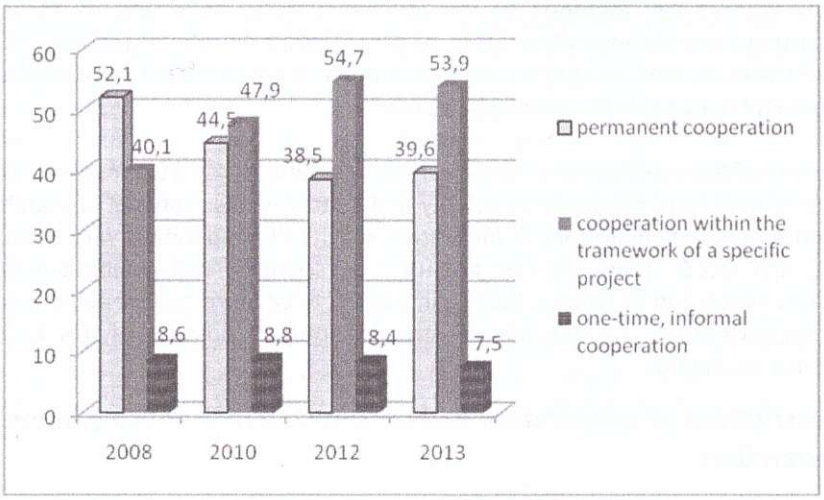
Data Source: Federal State Statistics Service

Since 2008 the numbers of alliances in all groups of enterprises have decreased except the corresponding number for consumers of goods, works and services. Changes in partnership show the way the enterprises react on the economic, social and political environment. A structure of the research and development projects distribution has also changed for the prevalence of partnership in specific projects instead of permanent cooperation with the same partners (Figure 1).

During the latest period the number of joint research and development projects has been increased just linearly (Figure 2) mostly because of the growth of cooperation within the framework of a specific project. The short term decreasing is connected with the crisis in 2008 year.

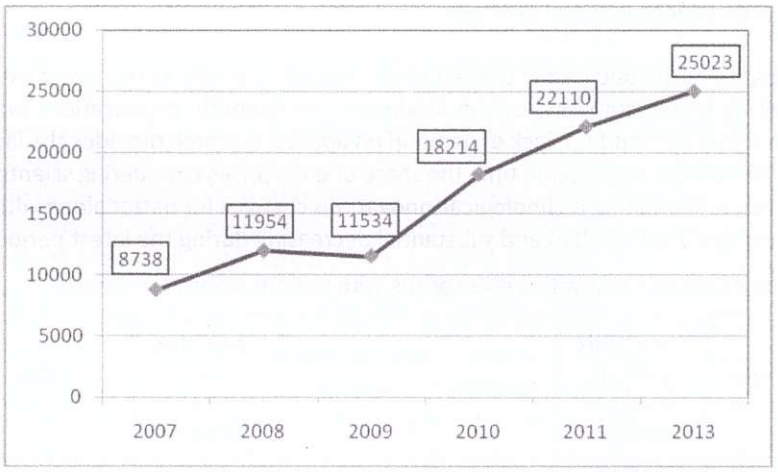
The main role in cooperation within the framework of a specific project play consumers of goods, works and services – 18,2%, scientific organizations - 16,1%, and suppliers - 13,6 %. In permanent cooperation the most active are suppliers (12,6%) and consumers of goods, works and services (11,2%). Academic institutions usually take part in their own R&D projects, and their share in cooperation within the framework of a specific project is about 4% , in permanent cooperation it is even smaller - 2,7%.

During last 6 years, Russian organizations and firms take part in cooperation projects within the country in 91,1% cases. In international cooperation with Russian partners the most active is a group of EU countries, Liechtenstein, Norway, and Switzerland with share of 4% in join R&D projects (Figure 3).



Data Source: own elaboration using Federal State Statistics Service data

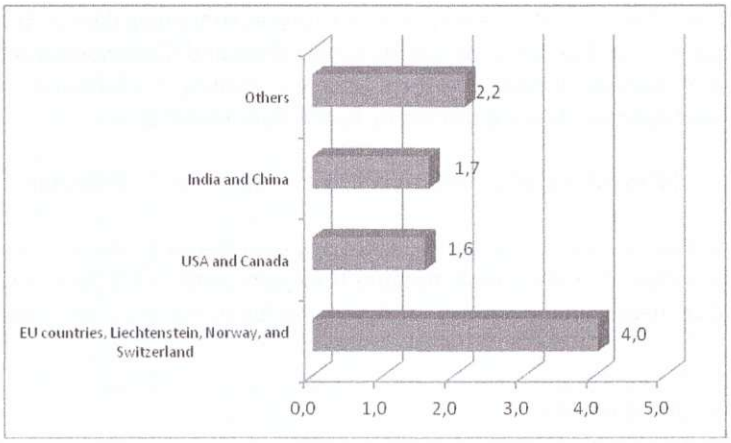
Figure 1: Distribution of joint R&D projects for enterprises producing technological innovations



Data Source: Federal State Statistics Service

Figure 2: Number of joint projects to implement the research and development in 2007 – 2013 years

The level of innovation activity in Russian Federation as a whole is relatively low. In 2013, about 10 percent of the whole enterprises in Russia produce innovative products and services. Some of them are oriented on cooperation within country and especially within groups of enterprises. So we have really great potential in cooperation and partnership development, and it becomes important to estimate the use of it for providing efficient industrial and economic policy. It seems to be important to estimate the impact of the cooperation on innovative activity. For this purpose we have to consider the corresponding indicators.



Data Source: own elaboration on the base of Federal State Statistics Service data

Figure 3: Number of joint projects to implement the research and development in 2007 – 2013 years

4. Data and methodology

Federal State Statistic Survey gathers information on innovations in Russian Federation including various indicators of cooperation activity and development and presents it in datasets separately for big and medium enterprises and for small enterprises. The datasets "Information on innovative activity of the enterprises" of the regular federal statistical observation include specific indicators describing the particular field of the problem for big and medium enterprises:

1. General economic indicators of organization,
2. Innovative activity of the organization,
3. Innovative products and services,
4. Factors interfering with innovations,
5. Expenditure on technological, market and organizational innovations for each type of innovations and source of funding,
6. Results of innovative activity,
7. Number of joint projects and types of partners in R&D,
8. Information sources for forming the innovation policy of organizations,
9. Patents and other methods of copyright protection,
10. Number of purchased and transferred new technologies and software,
11. Organizational and marketing innovations,
12. Environmental innovations.

The first one contains general information concerning innovations. The second one presents indicators of innovative activity. The third one describes the amount of innovative products and services.

One of the most important sections for the research is section 4 presenting factors interfering with innovations. There are three groups of such factors: economic, internal and others (Table 2).

Table 2: Factors interfering with innovations

Factors interfering with innovations		
Economic factors	*Internal factors*	*Other factors*
lack of own funds; lack of state financial support; low level of demand on new products and services; high cost of innovation; high economic risk	low innovation potential; lack of qualified employees; lack of information about new technologies; lack of information on markets; underdevelopment of cooperative ties.	lack of legislative and regulatory norms, regulating and stimulating innovations; underdevelopment of innovation infrastructure; uncertainty of the economic benefits of the intellectual property use

For the factors above the significance of their interfering with innovations are estimated by the management of enterprises in ordinal scale with three levels: "non-significant", "significant", and "important".

Among others the 7-th and the 8-th sections may be interesting as containing data on the topic of research. The 7-th section includes direct quantitative indicators of cooperation and partnership concerning the number of joint projects and types of partners in R&D. The 8-th section is devoted to information sources for forming the innovation policy of organizations. They are divided by four groups (Table 3).

Each kind of sources should be estimated as "non-significant", "significant", "important", or "not used".

Each of Russian regions was used as an observation, and a panel for the particular year included 61 observations. A few regions were not included to the sample because they were outliers for various reasons (extremely high or small, etc). Four such panels form the dataset for the regression modelling. One of the panels is presented in Table 4, where:

y - Innovative Products, million roubles;
TIE - Expenditure on Technological Innovations, million roubles;
RDE - Expenditure on R&D, million roubles;
NJPI - Number of Jointly Created Technological Innovations;
NJPT - Number of Joint R&D Projects in Innovative Organizations;
NOJPI - Number of Innovative Organizations Involved in Joint R&D Projects;
NOCC - Number of organizations involved into cooperation on the regular base;
NOCP - Number of organizations involved into cooperation within frameworks of the specific projects.

Table 3: Information sources for forming the innovation policy of organizations

Information sources for forming the innovation policy of organizations			
Internal sources	Market sources	Institutional sources	Other sources
- internal sources of the organization; - organizations in the group which includes the considering organization	- suppliers of equipment, materials, components, and software; - competitors in the industry of the organization; - consumers of goods and services; -consulting and information companies	- scientific organizations; - universities and other higher education institutions	- scientific and technical literature; - exhibitions, fairs and other promotional tools; Internet; -professional associations (unions); -informal contact; -patent information; -other kinds of sources

Table 4: Panel data on innovative products, expenditure on innovations and R&D, and cooperative activity (fragment)

Region	y	TIE	RDE	NJPI	NJPT	NOJPI	NOCC	NOCP
Altay	5741	1062,9	809,6	16	45	16	14	29
Arkhangelsk	1024,5	549,4	724,5	14	35	5	11	20
Astrakhan	1682,3	1303,2	369,5	13	7	4	3	4
Belgorod	9391,6	3072,3	891,7	20	45	12	11	28
Bryansk	4434,4	929,7	202,7	15	111	14	49	40
Vladimir	4958	2613,1	2478,8	13	78	12	42	33
Volgograd	59594,3	3260,1	2606,6	18	41	15	23	18
Vologda	5570,1	2520,9	286,8	11	45	4	0	45
Voronezh	13431,8	3190,3	5286,9	18	49	13	29	20
Ivanovo	2479,9	2519,5	423,0	8	10	5	3	4

Irkutsk	2282,7	9966	3493,9	13	98	15	66	25
Kabardino-Balkaria	2070,1	215,9	436,2	2	13	5	5	8
Kaliningrad	222,6	176,6	1184,8	3	1	1	1	0
Kaluga	7190,6	5321,5	7301,0	15	84	15	54	30
Kamchatka	34	172,5	1110,6	6	577	3	575	2
Karachaevo-Cherk.	2766,3	129,5	268,5	4	3	1	0	3
Kemerovo	3881,9	1697,2	771,6	11	39	10	21	17
Kirov	7295,6	877,5	849,7	7	24	9	4	19
Kostroma	2159,2	827,6	56,3	10	20	5	4	10
Krasnodar	5033,8	1519,9	3260,3	15	58	11	8	48
Krasnoyarsk	4957,2	14617,7	7087,9	23	212	23	36	176
Kurgan	2517,2	684,1	213,5	15	33	8	11	22
Kursk	1007,7	476,8	2128,9	7	51	6	49	2
Leningrad	9959,2	5847,5	4400,2	14	40	6	33	7
Lipetsk	31511,2	26417,2	66,6	13	37	8	16	12
Moscow reg.	90231,3	12134,5	64980, 6	53	297	40	172	125
Murmansk	792,5	2514,6	200,7	12	48	7	29	19
N. Novgorod	76467,5	18750,3	31361,4	46	671	46	329	280
Novgorod	7037,8	1180,3	708,6	11	17	7	10	7
Novosibirsk	14106,1	3866	12270,4	15	73	16	37	37
Omsk	9783,4	14285	2676,0	17	42	10	9	33
Orenburg	11651,4	6616,3	487,4	18	34	11	12	22
Oryol	5868,9	577	272,5	3	13	4	2	11
Penza	3680,5	2231,2	2497, 3	11	35	8	10	25
Primorie	5381,8	960,4	4100,0	17	25	8	4	4
Pskov	1136,1	166,3	57,1	3	2	2	1	1
Adygheya	1062,9	152,6	59, 7	2	11	2	0	8
Buryatiya	137,8	461,6	467,1	7	12	2	1	10
Daghestan	1542,1	52,2	674,5	2	17	3	6	11
Komi	8830,3	1027	1577, 7	7	13	3	8	3
Mariy-El	1632,2	221,7	124,8	4	4	2	0	4
Sakha (Yakutia)	2184,7	701,2	1651, 7	6	13	5	1	11
Noth.Osetia-Alania	344,3	86,5	231,9	4	14	3	6	8
Rostov	19185	3830,9	6668,4	21	97	21	59	35

Ryazan	4497,5	2725,4	1169,6	8	45	8	21	26
Saratov	17222,1	3315,5	2365,3	14	136	19	29	106
Sverdlovsk	59747,8	22591,8	12712, 0	45	760	43	159	577
Smolensk	2367	1338,8	787,4	11	56	5	12	44
Stavropol	19894,6	6020,7	899,5	5	17	4	6	9
Tambov	2104,6	871,1	805,4	13	32	11	11	21
Tver	14948,3	1565,9	2924,7	7	11	5	5	4
Tomsk	5365,1	2038,5	5869,6	17	195	22	60	125
Tula	8395,6	5308,3	1565,8	16	79	16	22	71
Tyumen	27968	29208,5	7609,5	41	318	32	134	171
Udmurtia	8767,7	2934,5	457,7	30	96	18	44	32
Uliyanovsk	21594,4	1232,9	5154,1	9	58	6	51	7
Khabarovsk	4557	3871,7	1011,4	15	15	7	4	8
Khanty-Mansiysk	17890,2	21002,3	2289,3	14	253	17	115	123
Chuvashiya	9175,6	1834,4	647,8	20	144	24	77	67
Yamalo-Nenetsk	7289,3	7826,9	6,1	5	44	6	14	32
Yaroslavl	21237	11132,6	3179,1	20	87	20	27	56

Data Source: Aggregated from various forms of the Regular Federal Statistical Observation

Initial indicators of cooperation and partnership are significantly correlated. Two of them are considered under logarithm transformation to provide their distribution closer to normal. In order to prevent the multicollinearity effect they have been transformed into the integral indicator of cooperation activity (*coop*) on the base of principle component method which also provides dimension reduction. The same approach have been used for creating an integral indicator of the level of investments to innovations (*invest*).

A lot of factors make an influence on the innovative activity of the regions. As the consequence of using only two factors the problem of the endogeneity may arise. So various models of panel regression along with usual regressions have been created and compared. Fixed effect and random effect models allow eliminating the peculiarities of the objects (regions) from the analyzed relationship without using additional instrumental variables.

5. Modeling results

As a measure of innovative activity the value of shipped innovative products and services innovative activity (y) have been used.

Created integral indicator of cooperation activity is based on the following variables:

NJPI - Number of Jointly Created Technological Innovations;
NJPT - Number of Joint R&D Projects in Innovative Organizations;
NOJPI - Number of Innovative Organizations Involved in Joint R&D Projects;
NOCC - Number of organizations involved into cooperation on the regular base;
NOCP - Number of organizations involved into cooperation within frameworks of the specific projects.

These variables were transformed to the integral indicator of cooperation activity (coop) that explained about 75% of the initial variables variance (Table 5).

Table 5: Total variance explained (Indicator *coop*)

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3,740	74,792	74,792	3,740	74,792	74,792
2	,845	16,894	91,686			
3	,349	6,984	98,670			
4	,065	1,300	99,970			
5	,002	,030	100,000			

Extraction Method: Principal Component Analysis.

The integral indicator of investments to technological innovations (invest) is based on a set of corresponding factors

TIE - Expenditure on Technological Innovations;
RDE - Expenditure on R&D.
Its explanatory power is just the same (Table 6).

Table 6: Total variance explained (Indicator *invest*)

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1,458	72,902	72,902	1,458	72,902	72,902
2	,542	27,098	100,000			

Extraction Method: Principal Component Analysis.

Both indicators allow estimating the development of the corresponding aspects of the technological development fostering. They have been calculated for 61 regions through four years; all the values of indicator are scaled in interval (0;10), where "0" corresponds minimum, and "10" – maximum value of the integral indicator.

For assessment of the impact of the cooperation activity on innovative products a regression models have been created. The results of the model identification for 2010 year are as follows:

$$\ln \hat{y}_1 = \underset{(54,0)}{8,019} + \underset{(2,77)}{0,628}\ invest + \underset{(2,64)}{0,598}\ coop \quad R^2 = 0,503$$

t-statistics are presented in parentheses.

The coefficient of determination seems to be not enough for explaining Innovative Products and Services variance, but the aim of the research was in testing the working hypothesis of the significant role of cooperation in innovative development. The coefficient for cooperation activity indicator is significant at the 0,05 level. It was not so for any other year in the research period that may be explained by the action of various unobserved factors and the endogeneity problem. But what we really were interested in was the influence of the cooperation on producing innovative products and services through the whole analyzing period. For this purpose the regression models with fixed and random effects also have been proposed and estimated. Coefficients in the models are significant at the 0,01 level (Table 7). The model with fixed effects takes into account unobservable peculiarities of the regions and considered to be relevant even when there is correlation between the regressors and the individual effects of the regions.

Table 7: Panel regression model with fixed effects (summary)

Fixed-effects (within) regression		Miaber of obs	244
Croup variable: year		Nuaber of groups	4
K-sq: within = 0.3465		obs per group: ain	61
beteeen = 0.1BOS		avg	61.0
overall = 0.3417			61
		F(Z.238)	63.09
corrfuj. xb) = -0.0000		Prob > F	0.0000

by	Coef.	Std. Err.	t	p> t	[93 Conf.	Interval]
invest	.7DB1716	.0958815	7.39	0.000	.519ZB6B	.6970564
coop	.4401QB2	-095B815	4.59	0.000	.Z51ZZ33	.628993
_cons	B.164735	.0863419	94.56	0.000	7.994703	8.334887
sig*a_u	.ZZ4 62503					
sigma_E	1.348703					
Ни	.0Z6 98988	(fraction of variance due to l|_i}				

F test that all u_i=0: F(3. 238) 1.69 Prob > F = 11.1694

Source: own elaboration

A share of variance explained by individual effects in the whole variance of the dependent variable is about 2.7 percent; individual effects are non-significant, and fixed effect model is very close to pooled model:

$$\ln Y_{pooled} = {}^{8}Д^{65} + {}^{\circ\prime 708}\ invest + 0{,}440\ coop$$

(94,6) (7,42) (4,61)

So we have obtained the relevant model of innovation activity that shows significant impact of cooperation activity along with the investments to innovations through the long-term period.

After proving that the partnership significantly increases the output of innovative products and services, it is worth to look at the factors which affect the propensity to cooperate. The factors interfering with innovations were used as regressors:

Xj - lack of information about new technologies;

x_7 - lack of information on markets;

x_3 - underdevelopment of cooperative ties.

All the regressors are binary variables, the zero value means that most companies in the region consider the corresponding factor as "non-significant", and the unite value if they find it "significant" or "important".

Along with these factors three dummy d_{0_100}, $d_{l0,\_250}$ and й?$_{>1000}$ were used; each of them is equal to "1" if the stuff of scientific department include corresponding number of employees, and "0" otherwise.

So the logit-model has been identified as follows

$$P(F = 1) = \frac{}{1 + e^{z}}$$

$$Z = \underset{(0,8)}{-1{,}55} + \underset{(0,15)}{0{,}22}\ jc, + \underset{(1,05)}{1{,}64}\ x_2 + \underset{(1,05)}{2{,}2}\ x_3 + \underset{(0,35)}{0{,}951}\ d_{0\_100} + \underset{(0,25)}{0{,}7}\ d_{,0,\ 250} + \underset{(1,81)}{2{,}53} d._{>1000}$$

LRstatistics=70,93; R^2(Cox&Snell)=0,583

Most of the advanced companies appreciated the lack of development of cooperative relationships as a significant factor. Those companies that appreciated the lack of information about new markets and technologies, are more likely to cooperate for the purpose of obtaining access to such resources. Moreover, partnerships often take the organization with a high average number of scientific personnel.

6. Conclusion

Panel data regression models allow estimating the relation between innovative activity and its main factors. Each of the factors should be presented as integral indicator based on initial indicators that make comprehensive description of the factor. Estimated quantitative effect of the cooperation impact on innovative activity of regions may provide a reference for the decision makers, government, industry and university in practice of managing the effective innovative development of the enterprises, regions and a whole country. The results of analysis can help to make right strategic decision and to raise the competitiveness of the country.

It is very important to make corresponding research for the particular kinds of technologies and to pay more attention to the international aspect of cooperation and partnership. The problem on this way is gathering corresponding data.

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