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FIRM-LEVEL EVIDENCE ON THE COOPERATIVE INNOVATION STRATEGIES IN RUSSIAN MANUFACTURING

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This paper focuses on revealing the heterogeneous impact of firms' specificities and the environment on the sophistication of the cooperative innovation strategies. We use the firm-level data on innovation strategies of over 800 innovation-active manufacturing enterprises in Russia to model the networking strategy as a simultaneous choice of the range of cooperative linkages (within and beyond the value chain and knowledge production sectors) with a special respect to geography of partners. The determinants comprise the internal factors (as absorptive capacity) and the external conditions (e.g. technological opportunities, appropriability and competition regimes). Revealed effects prove the initial heterogeneity hypothesis thus challenging the wide-spread simplified perception of 'openness' of the innovation strategy as a one-dimensional characteristic.

Keywords: Innovation cooperation; open innovation; firm-level; Russia; manufacturing; innovation strategy; econometric analysis

Thematic area: Applied economics

JEL: L2, O3

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1. Introduction

For the recent decades the cooperative behavior has been considered as one of the central topics in the innovation studies. The importance of engaging external knowledge sources was formally emphasized in the central conceptual models (e.g. the chain-link model of innovation (Kline and Rosenberg, 1986)) and reflected in the statistical measurement frameworks (Oslo Manual, 2005). These theoretical considerations were fully supported by the emerging base of empirical evidence that has greatly improved our understanding of different patterns of cooperative innovation strategies. However, few researchers focused on the empirical analysis of the determinants for the cooperative innovation strategies, addressing the full range of heterogeneities of motivations for the different configurations of collaborative networks.

This study employs the firm-level data on the innovation activities of the Russian manufacturing enterprises to address the major research question: what are the key determinants (including the internal firm specificity and the characteristics of the external environment) that define a cooperative strategy in innovation activities: partner choice and geographical patterns of networking.

To address this question we use the results of the specialized survey entitled "Monitoring the innovation activity of actors of the innovative process", which the Institute for Statistical Studies and the Economics of Knowledge of the National Research University Higher School of Economics has undertaken in 2014-2015 and provides data for 805 innovation-active manufacturing enterprises.

We analyze nine possible types of innovation cooperation chosen by firms: cooperation with customers, suppliers of raw materials, competitors, providers of services, related value-chain members, consulting firms, universities, research organizations and public authorities. We control for six dimensions determining cooperative strategies: firm-specific characteristics, level of competition, technological opportunities, absorptive capacity, appropriability conditions and public support as explanatory variables. The estimation of a multivariate probit model and multinomial logit model provides a measure of factors determining firm's decision on cooperation and its geographical pattern.

The rest of the paper is structured as follows. Section 2 provides a brief overview of the theoretical and empirical literature on innovation cooperation, focusing on innovation cooperation strategies and factors that may either contribute or prevent cooperative behavior. Section 3 shifts the focus to the dataset description, variables construction and estimation methodology. An econometric analysis of the cooperative behavior is delivered in Section 4. Section 5 presents main results and concludes with possible directions for future research.

2. 2. Background

2.1. Cooperation as a core of innovation strategy

Business environment is characterized by widespread circulation of knowledge, rise in venture capital, short product and innovation life cycles and other. Driven by these changes companies are forced to place on the same level of importance both internal and external knowledge resources. Moreover, firms' awareness that they are unable to hold in-house all knowledge and competencies they require, forces them to open up their research and innovation process (Powell and Grodal, 2005; Pavitt, 2005).

Firms obtain various benefits from innovation cooperation by attracting external knowledge, competences, human resources, tangible assets and intellectual property objects. Further each cooperation type has its particular benefits contributing to a multi-partner cooperation.

A cooperative buyer-supplier relationship allows firms to reduce production and operating costs and project development lead times (Clark, 1989), because suppliers have high position in the knowledge chain and operate in the same in the same industry segment, having close contextual knowledge distance to the company (Un, Asakawa, 2015). Suppliers support innovation process, helping to overcome shortcomings in markets, technical resources and capabilities (Zhang and Li, 2010) and providing an opportunity to involve in planning and operation (Fritsch, Franke, 2004). Cooperation with suppliers is essential for marketing and organizational innovation (Sánchez-González, 2013).

An innovation cooperation with clients also help firms to gain the competitive advantages. Customers act as a source of information about user needs (Tether, 2002), market trends and opportunities (Von Hippel et al. 1999) and competitors' offers (Padmore, Schuetze, Gibson, 1998), allowing the company to reduce the risk of uncertainty associated with market introduction. These linkages are especially beneficial when the nature of innovation project is novel and complex or the final market is poorly understood.

Science-industry linkages hold a unique position among all cooperation types. Being a source of fundamental knowledge important to innovation, technology and economic growth (Cohen, Nelson, Walsh, 2002; Mansfield, 1998) and upstream in the knowledge chain of the industry (Un, Asakawa, 2015), collaboration with universities and research organizations enables to realize radical innovations (Kaufmann, Tödtling, 2001), to receive public support for innovation activity and to accelerate the return on investments through shorter innovation cycles and costs reduction (Veugelers and Cassiman, 2005). Moreover, such cooperative agreements increase the mobility of employees and researches across both sectors (Hackett, 2008), allowing

enterprises to trainee employees and to offer highly qualified and expert researches (Schmidt et al., 2007). Nonetheless, this type of cooperation is characterized by the divergence of respective objectives related to the lack of complementarity between scientific studies and business function (Fiaz, Naiding, 2012; Garcia et al., 2015), high uncertainty, communication and trust issues connected to transmission of information.

Many companies are in close coordination with public authorities that provide a legal framework for cooperative agreements, on the one hand, and financial support, on the other. It is an effective tool to support direct investment in various sectors of the economy, to harmonize sectoral legislation and to strengthen the company's market power. Consulting firms, for its part, could provide a variety of inputs to the innovation process (e.g. specialist skills and market information) and stimulate new innovative ideas (Tether, 2002), concerning changes in organization or marketing strategies (Garcia et al., 2015).

Collaboration with competitors differs from all previous types significantly, because they belong to the same industry sector (Miotti and Sachwald, 2003) and have common goals and problems and pursue common innovation projects (Tether, 2002). These linkages are valuable in long complex innovation projects, allowing partners to improve their knowledge, skills and absorptive capacity through the cooperation. The basic problem is the possibility of opportunistic behavior resulting in coordination, communication and trust problems (Edwards-Schachter et al., 2013; Wu, 2014). The lack of a strong intellectual property management and regulation can cause a non-cooperation.

Broadly, firms pursue different objectives when enter into cooperation with external entities, i.e. value chain actors, market players, knowledge producers and other. Nevertheless, they are often forced to delay or even abandon their collaborative projects due to various external and internal hindering factors.

2.2. Determinants of cooperative strategies

The variety of cooperative strategies implies the heterogeneity of motives behind the particular choices of collaborative partners. Numerous surveys of innovation activities (e.g. CIS) have been conducted over the last decades, providing information on innovation behavior of firms. It has led to an increase of empirical studies, including research on:

— Motives leading to innovation and R&D cooperation (e.g. Bayona, García-Marco and Huerta 2001; Segarra-Blasco and Arauzo-Carod 2008; De Faria, Lima and Santos, 2010; Arvanitis 2012),

— Patterns of cooperative innovation and R&D strategies (e.g. Hagedoorn 2002; Tether 2002; Dachs, Ebersberger and Pyka 2008; Franco and Gussoni 2010),

— Factors affecting the choice of partners and the likelihood to enter into a cooperation agreement (e.g. Cassiman and Veugelers 2002, 2005; Miotti and Sachwald 2003; Belderbos et al. 2004; De Faria and Schmidt, 2012; Abramovsky et al., 2008; Badillo and Moreno 2016; Srholec 2014), and

— The impact of cooperation on firm innovativeness and performance (e.g. Kaiser 2002; Becker and Dietz 2004; Fritsch and Franke 2004; Jaklic, Damijan and Rojec 2008).

All papers investigating various R&D and innovation cooperation strategies and analyzing factors that affect the decision to cooperate and key finding of these studies are presented in Table A1 (see Appendix 1). Pursuant to the literature review determinants of firms' innovation cooperation strategies can be arranged into six groups (see Table 1).

Table 1 Determinants of cooperative strategies

Category	Definition
Firm-specific characteristics	Background characteristics of the firms, e.g. size, age, form of ownership, sector of activity
Level of competition	The potential existence of comparative advantages at the industry and firm level
Technological opportunities	Firm innovativeness: the suitability of the currently existing and exploitable external resources
Absorptive capacity	The link between the external stock of technological opportunities and the in-house capabilities
Appropriability conditions	An ability to obtain the benefits from innovation by protecting innovations from imitation
Public support	Public financial support from local and national administrations

Most studies show that firms' strategic decisions rely heavily on firm-specific characteristics, such as industry affiliation, size, age and other. Large companies have sufficient financial, human and technological resources and its own knowledge base needed for innovation activity (Bayona, García-Marco and Huerta, 2001). Firms with foreign participation are more likely to cooperate with customers and universities (Tether, 2002), while a general belonging to a group increases innovation cooperation with customers and suppliers (Belderbos et al., 2004).

Another group of factors relates to the playing field. On the one hand, an increase of competition in the market encourages firms' willingness to engage in innovation partnership, because it enables to broaden the value chain and to strengthen the competitive position (Arvanitis, 2012). On the other hand, a high degree of intensity in competition attended by a risk of leaking knowledge prevent the cooperation (Dachs, Ebersberger and Pyka, 2008).

In general, innovation capabilities of firms depend on the balance between the ability to conduct and expand internal R&D (technological opportunities) and to seize the opportunities offered by external environment (absorptive capacity). Technological opportunities could be assessed as the share of expenditures for R&D and innovation activities (Castellacci, 2007),

importance of different types of innovation and the length of their establishment. Absorptive capacity characterizes the "ability of a firm to identify, assimilate and exploit knowledge from the external environment" (Cohen, Levinthal, 1990), expressed in staff qualification, corporate culture, access to outside sources of information (incoming spillovers) in relation to the development and implementation of innovation.

Outgoing spillovers in turn are resources that can be used by external partners for their personal interest (Becker and Dietz, 2004). Confidence in a steady return on implemented innovations is provided through effective intellectual property protection mechanisms, otherwise the probability of free-riding problem related to innovation investments increases (Belderbos et al., 2004). Alternatively, low appropriability conditions enable intra-firms knowledge diffusion (Castellacci, 2007), with a possible beneficial effect on the productivity growth. Empirically, firm's ability to appropriate returns from innovations has a positive significant effect on the probability of innovation cooperation of any kind (Lhuillery and Pfister, 2009; Veugelers and Cassiman, 2005 among other).

Considering that innovation is a costly and uncertain process, various direct and indirect measures of financial support from public authorities affect cooperation decisions significantly. Availability of public support has a particular effect on science-industry interaction in the process of innovation (Arranz and Fdez. De Arroyable, 2008; Miotti and Sachwald, 2003).

Previous studies have shown that firm-specific characteristics and high level of absorptive capacity play a key role in the propensity for R&D and innovation cooperation regardless of cooperation type. Sustainable competitive advantages encourage firms to engage in innovation cooperation with knowledge producers and competitors. At the same time there is no effect on the cooperation within the supply chain. Firm's technological opportunity that refers to ease the achievement of innovations and technical improvements is especially important for vertical and institutional cooperation. Appropriability conditions contribute to better likelihood of vertical and institutional cooperation. The impact of public support on the probability of innovation cooperation is very strong, especially for cooperation with customers, suppliers and knowledge production sector.

Nevertheless, most of the existing literature focuses on R&D cooperation and not on patterns of cooperative arrangements for innovation. Researchers often consider different cooperation strategies as independent, regardless of possible interdependence among them due to complementarities and substitutability (Belderbos et al., 2004). Moreover, they combine several partners in a single cooperation strategy: vertical (suppliers and consumers), horizontal (competitors) and institutional (universities and research organizations) cooperation. Only a small number of studies are focused on factors determining geographical patterns in the choices

of cooperation partners, while what defines the duration of collaboration is entirely unexplored. In this paper we take into account all these shortcomings and drawbacks.

3. Data and Method

3.1. General information on data source

The empirical work is based on the results from a specialized survey entitled "Monitoring the innovation activity of actors of the innovative process", which the Institute for Statistical Studies and the Economics of Knowledge of the National Research University Higher School of Economics has undertaken on a regular basis since 2009[3]. The aim of the project is to develop empirical studies and to accumulate empirical knowledge about the innovation nature and types of interaction between various actors in the national innovation system.

The monitoring of the manufacturing and services industries adapts techniques from integrated European Manufacturing Survey – research into technology levels and innovative activity in industry (organized by a consortium of 18 research centers and universities and coordinated by Fraunhofer ISI, Germany[4]) and international standards on statistical measures of innovation. It expands the original framework with a number of specialized modules that ensure the methodological compatibility with CIS, but also provide a basis for assessing the respondents' experience of participating in the official innovation surveys.

The survey in 2014-2015 focuses on the innovation activities of the manufacturing and service sector companies. The sample includes more than 1300 firms, data are weighted by population characteristics derived from the Federal State Statistics Service (Rosstat) that include information on the number of enterprises in each industry sector and size group. The present analysis is based on a sample of 805 innovation-active firms representatively reflecting innovation cooperation patterns in Russian manufacturing sector. The brief sample characteristics are presented in Table A2 in Appendix 2.

3.2. Variables definition

We consider nine types of innovation cooperation partners: customers, suppliers of raw materials, competitors, providers of services, related value-chain members, consulting firms, universities, research organizations and public authorities. For each partner we account for three degrees of the geographical proximity: regional (less than 100 km), national (more than 100 km) and abroad.

Potential determinants of cooperative behavior patterns (explanatory variables) are divided into six categories pursuant to the review of theoretical empirical studies. Table A3 in Appendix 3 summarizes definitions of the variables.

[3] https://www.hse.ru/en/monitoring/innproc/
[4] http://www.isi.fraunhofer.de/isi-en/i/projekte/fems.php

Firm-specific characteristics: SIZE variable captured by the log of average number of employees and included in the model as a continuous variable, AGE is a dummy variable with value 1 if there are less than 5 years since registration, ownership variables on whether the firm is STATE- or FOREIGN-owned, variables assessing the operating results as a rate of changes in the staffing level (GROWTH) and as a return on sales index (ROS). Sectoral differences are monitored by a set of INDUSTRY dummies based on NACE Rev 1.1.

Competitive environment: Complex indicators to capture the level of competition: market structure - MONOPOLY (less than two direct competitors) and OLIGOPOLY (from 2 to 5 rivals), potential markets for future development (REGIONAL, NATIONAL and/or FOREIGN), different types of advantages acquired by competitors over the firm in PRICE, QUALITY and/or NOVELTY of products, adaptation of products according to customers' requirements (CUSTOMIZATION), short time of DELIVERY, additional customer SERVICES and OTHER strengths of competitors.

Technological opportunity: The level of investment intensity is derived from the question on what is the share of total innovation expenditures in the total turnover: LOW (less than 2.5%), MEDIUM (from 2.5% to 10%) and HIGH (more than 10%). There are three dummy variables for strategically important for business development types of innovation: REGULAR R&D, development and/or implementation of significantly improved or fundamentally new types of PRODUCT and PROCESS. Moreover, PERIOD variables represent the long-term process (more than 3-5 years) of development and/or implementation of product and process innovation, respectively.

Absorptive capacity: STAFF_HIGH represents the share of employees with a high education qualification and/or doctor degree. CULTURE variables capture the company management attitude towards the involvement of external partners at various stages of development and implementation of innovations (EXTERNAL), independent exchange of idea among the various units of the company (INTERNAL) and the presence of developed standard procedures for interaction with the implementing partners of research and development (PROCEDURES). Catching the variable OWN EFFORT, we consider if the majority of implemented innovations were developed predominately by firms own. Moreover, there are five dummy variables that account for the IMPORTANCE of various internal sources of information for development and implementation of new products, manufacturing processes and services. OUTBOUND knowledge flow dummy accepts value 1 for firms that acquire and/or transfer technologies associated with development and implementation of innovations.

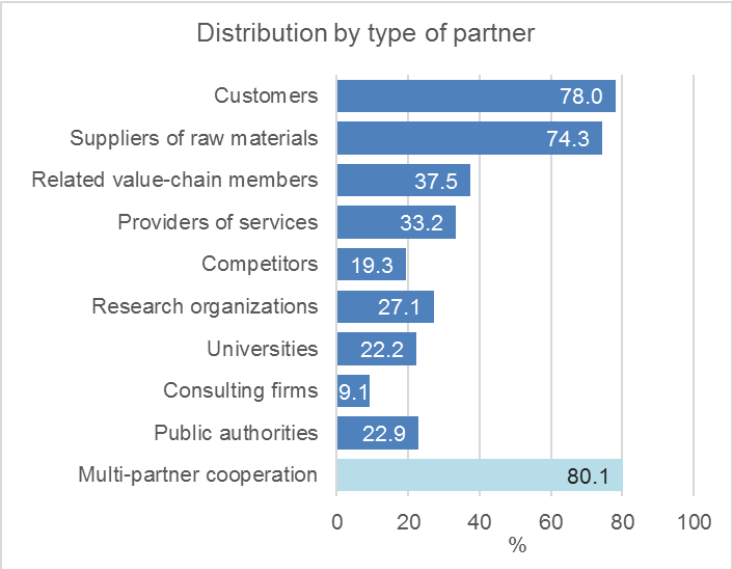
Appropriability conditions: Methods of intellectual property protection used to protect the rents from the firms' innovation activity: FORMAL including patenting of inventions,

industry designs and utility models, registration of trademarks and information units, copyright, and INFORMAL such as confidentiality agreements with the company's personnel or commercial confidentiality ("know-how"), elaborating product design and other.

Public support: Three dummy variables taking the value 1 if the company has used on of state support measures in 2011-2014: HORIZONTAL such as tax remissions and preferences; depreciation bonuses; subsidizing of interest rates on loans; NETWORKING for instance, technology platforms and regional innovation clusters creation and TARGETED including contracts within federal target programs, state grants and targeted support for training innovation managers.

Distribution of surveyed firms by the fact of innovation cooperation and its geographical pattern are presented in Table A4 Appendix 4. The means and standard deviations for each group of determinants are presented in Table A5 in Appendix 5. The vast majority (98.1%) of innovation-active firms in Russian manufacturing are engaged in innovation cooperation, while about 80% prefer to cooperate with several types of partners simultaneously (see Figure 1). Cooperation within the supply chain is the most common among innovative firms, while only a quarter interact with universities and research organizations that could be important strategic partners.

Figure 1 Population of the alternative cooperation modes in relative terms



Notes: Decision-making process among innovation-active manufacturing firms

We undertake a latent class analysis to identify five typical patterns of cooperation with regard to partner type and geographical location (see Table 3). Firms may engage in cooperation with clients and suppliers located anywhere (Cluster 1), within a regional value-chain (Cluster 2) or within a global value chain building on the resources of local universities and research organizations (Cluster 3). Also we can distinguish a cooperation on the national level with

various partners (Cluster 4) and a broad networking with different external actors and frequent interaction with national public-sector R&D (Cluster 5).

Table 3 Profiles of innovation cooperation strategies derived using latent class analysis

		Clusters				
		1. Clients and suppliers	2. Regional value-chain	3. Global value chain and local knowledge providers	4. National networking	5. Broader networking and national knowledge base
Cluster Size		38.2%	33.1%	12.7%	10.9%	5.1%
Indicators: Innovation cooperation with						
Customers/ Clients	regional	**0.343**	**0.715**	**0.801**	0.157	**0.839**
	national	**0.546**	0.001	**0.749**	**0.640**	**0.879**
	foreign	0.126	0.000	**0.213**	0.148	**0.375**
Suppliers of raw materials	regional	**0.173**	**0.724**	**0.654**	0.178	**0.888**
	national	**0.521**	0.005	**0.865**	**0.537**	**0.997**
	foreign	0.162	0.013	**0.382**	**0.319**	**0.531**
Related value-chain members	regional	0.045	**0.351**	**0.502**	0.178	**0.505**
	national	0.153	0.026	**0.406**	**0.334**	**0.640**
	foreign	0.028	0.000	0.078	0.062	0.069
Providers of services	regional	0.069	**0.289**	**0.688**	0.087	**0.848**
	national	0.066	0.002	**0.300**	**0.251**	**0.797**
	foreign	0.020	0.000	0.068	0.091	**0.239**
Competitors	regional	0.023	0.103	**0.405**	0.042	**0.207**
	national	0.039	0.006	**0.382**	**0.204**	**0.372**
	foreign	0.000	0.000	0.005	0.001	0.007
Research organizations	regional	0.054	0.110	**0.213**	**0.299**	**0.853**
	national	0.097	0.017	0.004	**0.775**	**0.829**
	foreign	0.013	0.000	0.006	0.128	0.026
Universities	regional	0.080	0.078	**0.265**	**0.260**	**0.772**
	national	0.019	0.006	0.000	**0.585**	**0.568**
	foreign	0.002	0.000	0.000	0.038	0.049
Consulting firms	regional	0.000	0.052	0.126	0.042	**0.305**
	national	0.018	0.002	0.029	0.121	**0.256**
	foreign	0.013	0.000	0.010	0.046	0.000
Public authorities	regional	0.081	0.146	**0.264**	0.333	**0.631**
	national	0.031	0.007	0.060	**0.392**	**0.409**
	foreign	0.000	0.000	0.000	0.034	0.000

3.3. Estimation methodology

To investigate the factors that lead firms to cooperate we estimate a multivariate probit model (Cappellari, Jenkins, 2003) with nine binary equations, each one representing a pattern of innovation cooperation on the assumption that it is possible to cooperate with several partners simultaneously and that various cooperative strategies are interdependent. The model provides unbiased, asymptotically normal and efficient estimations. To address the question of possible interdependence of partner selection strategies we test values of non-diagonal cross-equation correlations (*rhos*) and test the hypothesis that all contemporaneous correlations among error terms across equations are equal to zero based on the likelihood ratio test.

To assess the factors influencing the geographical breadth of the cooperation networks we estimate a multinomial logit model (Greene, 2012, 803-805). It includes same explanatory variables and uses maximum likelihood estimation (MLE) to calculate probability of cluster membership.

4. Estimation results

The results are presented in two steps. First, we estimate a multivariate probit model to identify factor that influence the probability of engaging in cooperation. Second, we analyze what defines the geographical pattern of cooperation for innovation using multinomial logit model.

In line with previous studies, the multivariate probit estimation results show that small and young firms rarely cooperate with knowledge production sector (see Table 4). Cooperative activity of high- and medium high-tech companies is substantially higher, especially when a firm collaborate across the supply chain, with related value-chain members and science partners. Orientation on national and foreign markets has significant positive effect on cooperation with competitors, universities and public authorities, while the lack of competitive advantage in quality of products and price stimulate firms to cooperate with suppliers of raw materials and consulting firms.

The crucial role is played by absorptive capacity and incoming spillovers. Efficient management and corporate culture (encouragement of in-house ideas exchange and external partners' involvement in innovation process, existence of standard procedures for cooperation) are keys to an extensive cooperation network. This is in line with the finding by Dachs et al. (2008) and Badillo and Moreno (2016). However, only while cooperation with knowledge producers and consultants, firms highly appreciate their efforts and trust them to develop the majority of innovations.

Moreover, the results support the assumption of simultaneity of innovation partner choice. Positive correlation coefficient ranging from 0.146 to 0.673 show that firms rather consider them as complementarities than alternatives. These finding are consistent with other scientific studies, e.g. Belderbos et al. (2004) and Baddilo & Moreno (2012) for the case of the Netherlands and Spain respectively. Nevertheless, another reason for this are omitted factors affecting cooperative strategies jointly (Srholec, 2014).

Table 4 Determinants of cooperation strategies for innovation (multivariate probit model)

	Customers	Suppliers of raw materials	Related value-chain members	Providers of services	Rival firms	Research org.	University	Consulting firms	Public authorities
Form-specific characteristics									
Log_size	-0.0277	0.0255	-0.0127	0.0256	-0.0243	**0.0967****	**0.0971****	0.0412	0.0463
	(0.0431)	(0.0406)	(0.0384)	(0.0386)	(0.0440)	(0.0453)	(0.0455)	(0.0591)	(0.0426)
Age_less 5	**-0.497****	-0.0312	0.0392	-0.0398	0.281	**-0.545***	**-1.187*****	-0.131	-0.0100
	(0.217)	(0.222)	(0.211)	(0.219)	(0.232)	(0.317)	(0.420)	(0.367)	(0.255)
High_tech	0.310	**0.321***	**0.569*****	0.227	0.230	**0.745*****	**0.967*****	0.196	-0.115
	(0.191)	(0.181)	(0.168)	(0.172)	(0.189)	(0.197)	(0.192)	(0.240)	(0.183)
Medium_high_ tech	**0.310****	**0.244***	**0.251***	0.0810	0.137	**0.493*****	**0.497*****	-0.153	-0.0565
	(0.154)	(0.145)	(0.137)	(0.139)	(0.156)	(0.165)	(0.164)	(0.207)	(0.152)

Table 4 continued

	Customers	Suppliers of raw materials	Related value-chain members	Providers of services	Rival firms	Research org.	University	Consulting firms	Public authorities
Medium_low_ tech	0.128	0.178	**0.378*** **	0.189	0.0623	0.267	-0.0156	**-0.471** **	**-0.304***
	(0.150)	(0.141)	(0.134)	(0.136)	(0.154)	(0.168)	(0.176)	(0.238)	(0.160)
Foreign	-0.324	**-0.472** **	-0.134	-0.223	0.0757	-0.367	-0.107	0.238	-0.102
	(0.202)	(0.195)	(0.197)	(0.201)	(0.223)	(0.239)	(0.231)	(0.266)	(0.212)
State	-0.184	**-0.294***	**0.327** **	0.0966	-0.0282	**0.374** **	0.205	0.0490	**0.337** **
	(0.172)	(0.163)	(0.155)	(0.157)	(0.182)	(0.174)	(0.175)	(0.209)	(0.162)
Growth_1 (>30%decrease)	0.0100	0.0768	-0.0128	0.255	0.429	**0.606***	-0.0519	-0.705	0.102
	(0.356)	(0.306)	(0.288)	(0.302)	(0.327)	(0.348)	(0.361)	(0.698)	(0.321)
Growth_2 (10-30%decrease)	0.00763	**0.340***	-0.0909	**0.472** **	0.235	**0.563** **	0.0264	-0.147	-0.175
	(0.219)	(0.199)	(0.188)	(0.197)	(0.217)	(0.225)	(0.216)	(0.304)	(0.210)
Growth_3 (+/- 10%)	-0.0862	**0.257***	-0.191	**0.376** **	0.167	0.0502	**-0.294***	0.122	-0.224
	(0.168)	(0.152)	(0.149)	(0.162)	(0.177)	(0.185)	(0.172)	(0.233)	(0.161)
Growth_4 (10-30% increase)	0.0277	0.285	0.128	**0.348***	0.184	0.289	-0.237	-0.0222	-0.116
	(0.212)	(0.195)	(0.185)	(0.198)	(0.215)	(0.219)	(0.212)	(0.286)	(0.203)
Growth_5 (>30% increase)	-0.447	**-0.453***	-0.213	0.306	0.321	**0.630** **	**-0.794** **	0.282	-0.367
	(0.295)	(0.273)	(0.283)	(0.283)	(0.300)	(0.308)	(0.353)	(0.378)	(0.308)
ROS2 (0-2%)	-0.0729	0.0287	**0.713*** **	0.221	0.304	-0.427	**-0.555** **	0.144	-0.0806
	(0.262)	(0.229)	(0.238)	(0.227)	(0.263)	(0.263)	(0.258)	(0.345)	(0.234)
ROS3 (2-5%)	-0.0835	-0.0923	**0.415***	0.149	0.188	-0.0256	-0.385*	-0.0351	-0.100
	(0.245)	(0.212)	(0.225)	(0.212)	(0.244)	(0.237)	(0.232)	(0.319)	(0.216)
ROS4 (5-10%)	-0.233	-0.0404	**0.597*** **	0.127	0.169	-0.131	**-0.402***	-0.0835	-0.305
	(0.249)	(0.216)	(0.228)	(0.214)	(0.248)	(0.240)	(0.236)	(0.319)	(0.222)
ROS5 (> 10%)	**-0.454***	-0.0365	0.348	0.0316	0.0416	-0.0485	0.0145	-0.0819	-0.145
	(0.256)	(0.227)	(0.237)	(0.226)	(0.262)	(0.251)	(0.246)	(0.330)	(0.232)
Level of competition									
C_monopoly	-0.193	-0.190	0.0881	-0.103	**-0.310***	0.0936	-0.235	-0.0474	-0.0605
	(0.152)	(0.143)	(0.140)	(0.142)	(0.167)	(0.161)	(0.165)	(0.218)	(0.157)
C_oligopoly	-0.00685	-0.0111	0.00277	-0.0341	-0.0866	-0.00326	0.0693	0.0162	-0.0777
	(0.128)	(0.121)	(0.113)	(0.114)	(0.127)	(0.132)	(0.132)	(0.174)	(0.126)
M_regional	0.175	-0.223	0.0864	-0.0800	**0.555** **	0.0282	0.179	-0.156	**0.422***
	(0.210)	(0.200)	(0.193)	(0.191)	(0.258)	(0.275)	(0.338)	(0.313)	(0.241)
M_national	0.101	-0.121	-0.0218	-0.137	**0.681*** **	0.337	**0.666** **	0.0139	**0.515** **
	(0.202)	(0.192)	(0.184)	(0.184)	(0.251)	(0.257)	(0.318)	(0.290)	(0.231)
M_foreign	0.203	-0.191	-0.179	-0.293	**0.588** **	0.398	**0.566***	0.270	**0.504***
	(0.240)	(0.224)	(0.214)	(0.214)	(0.278)	(0.280)	(0.338)	(0.321)	(0.259)
A_price	-0.202	**0.213***	-0.0540	-0.0309	0.119	0.0735	-0.00901	-0.000699	-0.114
	(0.126)	(0.122)	(0.114)	(0.115)	(0.125)	(0.132)	(0.135)	(0.171)	(0.127)
A_quality	0.137	**0.365***	0.246	0.183	0.286	-0.293	-0.110	**0.859*** **	-0.0190
	(0.206)	(0.202)	(0.178)	(0.180)	(0.191)	(0.218)	(0.214)	(0.225)	(0.196)
A_novelty	0.0840	0.0971	**0.217***	0.104	0.0210	0.129	-0.174	-0.108	-0.0186
	(0.146)	(0.139)	(0.129)	(0.128)	(0.144)	(0.152)	(0.159)	(0.193)	(0.143)
A_customization	**-0.478** **	-0.00928	0.0374	-0.211	-0.0133	-0.151	-0.0938	0.247	-0.221
	(0.203)	(0.210)	(0.191)	(0.191)	(0.207)	(0.222)	(0.227)	(0.250)	(0.212)
A_delivery_times	0.437	0.0512	**0.698*** **	-0.193	**0.623*** **	-0.0566	0.138	-0.315	**-0.791*** **
	(0.308)	(0.242)	(0.233)	(0.241)	(0.236)	(0.273)	(0.256)	(0.338)	(0.304)
A_services	-0.0538	-0.0620	0.0379	0.0646	-0.0358	-0.143	0.0302	0.0333	0.126
	(0.190)	(0.181)	(0.168)	(0.165)	(0.193)	(0.195)	(0.189)	(0.250)	(0.182)
A_other	0.162	0.133	0.235	0.152	0.0890	0.0885	-0.00360	0.281	0.0982
	(0.246)	(0.220)	(0.212)	(0.210)	(0.237)	(0.253)	(0.246)	(0.304)	(0.231)
Technological opportunity									
High_int	0.124	0.0841	-0.116	-0.137	-0.157	0.0253	0.0574	-0.319	-0.219
	(0.189)	(0.178)	(0.172)	(0.172)	(0.196)	(0.199)	(0.204)	(0.258)	(0.191)
Medium_int	0.208	**0.256***	0.101	-0.0764	0.00721	0.0288	**0.273***	0.110	-0.0446
	(0.147)	(0.140)	(0.134)	(0.136)	(0.157)	(0.160)	(0.163)	(0.195)	(0.149)
Low_int	0.0489	0.0255	0.0946	-0.0578	0.171	0.0327	0.0966	-0.119	-0.0827
	(0.147)	(0.138)	(0.136)	(0.136)	(0.155)	(0.162)	(0.166)	(0.211)	(0.150)

Table 4 continued

Regular R&D	**-0.265****	-0.155	0.108	-0.105	0.150	-0.0169	-0.142	0.229	0.172
	(0.124)	(0.115)	(0.109)	(0.110)	(0.123)	(0.128)	(0.131)	(0.166)	(0.121)
Product_inn	0.0988	0.129	-0.181	0.126	**0.310***	-0.153	-0.0668	-0.285	-0.0638
	(0.151)	(0.143)	(0.140)	(0.145)	(0.172)	(0.165)	(0.169)	(0.212)	(0.156)
Process_inn	0.128	0.134	**0.305****	**0.322****	0.0462	-0.0192	-0.128	0.266	0.0790
	(0.148)	(0.140)	(0.140)	(0.144)	(0.163)	(0.165)	(0.161)	(0.220)	(0.155)
Product_long	0.138	0.106	-0.116	0.0944	0.254	0.121	-0.111	-0.0957	0.226
	(0.159)	(0.148)	(0.142)	(0.141)	(0.159)	(0.156)	(0.162)	(0.212)	(0.149)
Process_long	-0.0445	-0.0952	-0.158	0.214	-0.177	0.196	**0.284***	0.294	**0.272***
	(0.163)	(0.152)	(0.149)	(0.148)	(0.169)	(0.164)	(0.165)	(0.209)	(0.158)
Absorptive capacity									
Staff_high	-0.00251	-0.00202	0.000377	-0.00188	0.00149	0.00327	0.00103	0.00221	0.00284
	(0.00238)	(0.00222)	(0.00215)	(0.00221)	(0.00249)	(0.00253)	(0.00254)	(0.00316)	(0.00238)
Culture_coop_ external	**0.323****	-0.00962	**0.182***	**0.262****	0.0776	**0.296****	0.209	**0.349****	0.174
	(0.128)	(0.119)	(0.110)	(0.111)	(0.125)	(0.126)	(0.129)	(0.167)	(0.123)
Culture_coop_ procedures	-0.00924	0.117	0.0566	-0.0285	**0.259****	0.169	-0.170	-0.0847	-0.0750
	(0.127)	(0.120)	(0.111)	(0.113)	(0.125)	(0.126)	(0.132)	(0.171)	(0.124)
Culture_coop_ internal	**0.365*****	**-0.239****	-0.0276	**-0.260****	**-0.299****	-0.0777	-0.0337	-0.00526	-0.122
	(0.119)	(0.110)	(0.104)	(0.106)	(0.119)	(0.120)	(0.120)	(0.152)	(0.114)
Own_effort	-0.0237	0.0335	**-0.194***	-0.141	-0.181	**-0.685*****	**-0.412*****	**-0.257***	0.0177
	(0.114)	(0.108)	(0.103)	(0.103)	(0.115)	(0.115)	(0.119)	(0.145)	(0.114)
Imp_internal_ R&D	-0.322	0.169	0.0569	0.157	**-0.388***	-0.0891	**-0.584****	0.310	0.240
	(0.202)	(0.193)	(0.182)	(0.185)	(0.222)	(0.225)	(0.238)	(0.257)	(0.199)
Imp_manuf_ departments	0.0580	-0.128	**0.316***	**0.325***	**0.587*****	0.215	0.191	0.0889	0.0511
	(0.206)	(0.191)	(0.182)	(0.184)	(0.210)	(0.227)	(0.232)	(0.258)	(0.199)
Imp_marketimg _ client	-0.167	0.0946	0.0952	**-0.254****	-0.151	-0.173	-0.0353	-0.287	-0.174
	(0.134)	(0.128)	(0.120)	(0.124)	(0.139)	(0.141)	(0.141)	(0.189)	(0.138)
Imp_manag_ stakeholders	0.111	-0.0338	**-0.334****	-0.0561	-0.143	0.0374	0.0802	0.273	0.0192
	(0.156)	(0.143)	(0.147)	(0.144)	(0.169)	(0.169)	(0.171)	(0.210)	(0.156)
Imp_informal	**0.301****	0.00359	-0.0285	**0.270****	0.0107	**-0.270***	-0.0469	-0.265	-0.0740
	(0.130)	(0.120)	(0.116)	(0.116)	(0.131)	(0.145)	(0.143)	(0.195)	(0.131)
Outbound Knowledge flow	-0.147	0.0282	0.0105	0.116	-0.139	0.111	**-0.238***	**0.380****	-0.0979
	(0.113)	(0.108)	(0.104)	(0.105)	(0.119)	(0.121)	(0.125)	(0.156)	(0.117)
Appropriability conditions									
App_formal	-0.176	0.118	0.0407	0.0780	0.0379	**0.393*****	0.137	**0.373****	0.0457
	(0.121)	(0.112)	(0.110)	(0.111)	(0.127)	(0.133)	(0.132)	(0.187)	(0.121)
App_informal	**0.332*****	0.112	**0.202***	**0.365*****	0.0782	**0.255***	**0.486*****	0.187	**0.242****
	(0.121)	(0.114)	(0.109)	(0.111)	(0.122)	(0.130)	(0.133)	(0.170)	(0.121)
Constant	**0.678***	0.0675	**-1.334*****	**-1.557*****	**-2.113*****	**-2.139*****	**-1.644*****	**-2.440*****	**-1.557*****
	(0.403)	(0.374)	(0.377)	(0.378)	(0.453)	(0.450)	(0.477)	(0.569)	(0.405)
	Rho1	Rho2	Rho3	Rho4	Rho5	Rho6	Rho7	Rho8	
Rho /2	**0.261*****								
	(0.0694)								
Rho /3	**0.146****	**0.368*****							
	(0.0683)	(0.0693)							
Rho /4	**0.255*****	**0.511*****	**0.510*****						
	(0.0722)	(0.0765)	(0.0675)						
Rho /5	**0.581*****	**0.525*****	**0.378*****	**0.595*****					
	(0.106)	(0.0950)	(0.0737)	(0.0786)					
Rho /6	0.0416	0.0968	**0.187*****	**0.202*****	**0.258*****				
	(0.0809)	(0.0763)	(0.0716)	(0.0706)	(0.0802)				
Rho /7	**0.295*****	**0.191****	**0.181****	**0.274*****	**0.277*****	**0.762*****			
	(0.0906)	(0.0837)	(0.0726)	(0.0749)	(0.0832)	(0.0906)			
Rho /8	-0.0110	0.121	**0.287*****	**0.454*****	**0.309*****	**0.393*****	**0.541*****		
	(0.102)	(0.105)	(0.0952)	(0.0966)	(0.109)	(0.106)	(0.120)		
Rho /9	**0.169****	**0.144***	0.108	**0.231*****	**0.376*****	**0.418*****	**0.673*****	**0.546*****	
	(0.0784)	(0.0765)	(0.0669)	(0.0672)	(0.0795)	(0.0798)	(0.0894)	(0.111)	
* significant at 10%; ** significant at 5%; *** significant at 1%									
Standard errors in parentheses									
Number of observations = 805									
Likelihood ratio test of rho21 = rho31= rho41= rho51= rho61= rho71= rho81= rho91= rho32= rho42= rho52= rho62= rho72= rho82= rho92= rho43= rho53= rho63= rho73= rho83= rho93= rho54= rho64= rho74= rho84= rho94= rho65= rho75= rho85= rho95= rho76= rho86= rho96= rho87= rho97= rho98 = 0: chi2(36) = 566.706 Prob > chi2 = 0.0000									

The analysis of factors determining the geographical pattern of cooperation (see Table 5) revealed that state-owned high-tech firms prefer to develop national and global cooperative networks, while young companies with low operating profit margins companies that implement most of innovations on their own and recognize the importance of internal R&D have small cooperation networks and collaborate mostly with clients and suppliers.

Absence of competitive advantage in price and timely delivery discourage firms to develop national networking, but subject to the availability of public support and effective mechanisms of IP protection. Enterprises performing innovation activity on a regular basis motivates cooperate within a global value chain while taking full advantage of the potential offered by local universities and research organizations.

Table 5 Determinants of innovation cooperation geographical scope (marginal effects)

	Regional value-chain	Global value chain and local knowledge providers	National networking	Broader networking and national knowledge base
Base outcome	vs clients and suppliers			
Firm-specific characteristics				
Log_size	0.00219	0.00365	0.0111	**-0.00652**
	(0.0453)	(0.0375)	(0.00997)	(0.304)
Age_less 5	**-0.143**	0.0990	**-0.0738**	0.0114
	(0.189)	(0.272)	(0.0991)	(0.527)
High_tech	**0.283**	-0.0864	**0.0856**	0.000786
	(0.411)	(0.119)	(0.133)	(0.0396)
Medium_high_tech	**0.159**	-0.0493	0.0331	0.00773
	(0.318)	(0.0429)	(0.0862)	(0.360)
Medium_low_tech	0.0765	-0.0653	-0.0139	0.0175
	(0.281)	(0.0320)	(0.0440)	(0.810)
Foreign	-0.0314	-0.00137	-0.0235	0.00364
	(0.0526)	(0.0548)	(0.0355)	(0.170)
State	0.0210	**0.0931**	**0.0467**	0.00293
	(0.0716)	(0.170)	(0.0889)	(0.138)
Growth_1 (>30%decrease)	-0.0379	0.0686	-0.00403	-0.00494
	(0.111)	(0.114)	(0.0625)	(0.233)
Growth_2 (10-30% decrease)	0.0117	-0.0170	0.0566	-0.00314
	(0.0556)	(0.0638)	(0.0813)	(0.148)
Growth_3 (+/- 10%)	-0.0237	-0.0340	0.00135	0.0114
	(0.0641)	(0.0462)	(0.0506)	(0.530)
Growth_4 (10-30% increase)	-0.0115	0.0113	-0.0118	0.00579
	(0.0555)	(0.0760)	(0.0307)	(0.270)
Growth_5 (>30% increase)	0.0931	0.0460	-0.0639	0.0300
	(0.490)	(0.331)	(0.0725)	(1.360)
ROS2 (0-2%)	**-1.171**	-0.132	-0.0692	0.997
	(0.0787)	(0.0653)	(0.0379)	(0.478)
ROS3 (2-5%)	-0.167	-0.133	-0.0680	0.999
	(0.0706)	(0.0709)	(0.0474)	(0.526)
ROS4 (5-10%)	-0.166	-0.150	-0.0673	0.999
	(0.0627)	(0.0538)	(0.0414)	(0.453)
ROS5 (> 10%)	-0.151	-0.132	-0.0731	0.998
	(0.0710)	(0.0622)	(0.0368)	(0.451)
Level of competitiveness				
C_monopoly	-0.0257	-0.0193	-0.0141	-0.0115
	(0.117)	(0.101)	(0.0606)	(0.539)
C_oligopoly	-0.00147	-0.0243	0.00624	-0.0118
	(0.0924)	(0.109)	(0.0401)	(0.552)
M_regional	**0.0789**	0.0733	**0.0133**	**0.0637**
	(0.734)	(0.654)	(0.270)	(2.829)

Table 5 continued

M_national	**0.189**	**0.0457**	**0.0399**	**0.0576**
	(0.864)	(0.442)	(0.284)	(2.622)
M_foreign	0.259	0.00974	**0.0230**	0.0610
	(1.395)	(0.406)	(0.292)	(2.708)
A_price	0.0157	-0.0394	**-0.00390**	0.0289
	(0.245)	(0.103)	(0.0958)	(1.327)
A_quality	-0.0841	-0.00480	0.0209	0.00439
	(0.109)	(0.0507)	(0.0620)	(0.205)
A_novelty	-0.00720	0.0156	-0.0306	0.00767
	(0.0575)	(0.0822)	(0.0305)	(0.356)
A_customization	-0.0542	0.0164	-0.0389	0.0242
	(0.0607)	(0.200)	(0.0241)	(1.104)
A_delivery_times	0.0891	-0.0968	-0.0430	0.0753
	(0.981)	(0.0355)	(0.0630)	(3.247)
A_services	-0.00927	0.0829	-0.0315	-0.0111
	(0.0999)	(0.0592)	(0.0746)	(0.525)
A_other	-0.0536	-0.00692	0.0429	0.0000
	(0.0897)	(0.0576)	(0.0811)	(0.0182)
Technological opportunity				
High_int	0.0123	-0.0420	-0.0141	-0.00546
	(0.0575)	(0.0940)	(0.0453)	(0.256)
Medium_int	**0.0888**	-0.0390	0.0152	0.0102
	(0.225)	(0.0332)	(0.0660)	(0.475)
Low_int	0.0527	-0.00937	-0.0260	**0.0290**
	(0.324)	(0.166)	(0.0542)	(1.329)
Continuous R&D	-0.0547	**0.0620**	0.00835	0.00634
	(0.0454)	(0.135)	(0.0402)	(0.296)
Product_inn	0.00458	-0.00981	-0.0298	0.0158
	(0.125)	(0.0978)	(0.0406)	(0.742)
Process_inn	-0.0414	0.0359	-0.00362	**0.0234**
	(0.141)	(0.182)	(0.0835)	(1.105)
Product_long	0.00363	0.0639	0.0169	0.00559
	(0.0602)	(0.145)	(0.0535)	(0.261)
Process_long	-0.00933	0.0333	**0.0593**	-0.00812
	(0.0801)	(0.0455)	(0.0540)	(0.381)
Absorptive capacity				
Staff_high	0.000415	-0.00001	0.000494	0.000105
	(0.00148)	(0.000869)	(0.00114)	(0.00490)
culture_coop_external	0.0309	0.0205	**0.0322**	0.00611
	(0.0953)	(0.0753)	(0.0730)	(0.285)
culture_coop_procedures	0.0153	-0.0220	0.0189	0.0122
	(0.117)	(0.0518)	(0.0767)	(0.568)
culture_coop_internal	0.0118	-0.0189	-0.0223	-0.00524
	(0.0365)	(0.0660)	(0.0532)	(0.245)
Own_effort	**-0.0911**	0.0538	**-0.0831**	-0.00121
	(0.142)	(0.0734)	(0.125)	(0.0573)
imp_internal_R&D	**-0.0845**	0.0320	0.00495	**-0.0230**
	(0.236)	(0.133)	(0.0842)	(1.086)
imp_manuf_dep	-0.0329	0.0469	0.0288	**0.0499**
	(0.258)	(0.473)	(0.275)	(2.231)
imp_marketimg_client	-0.0209	-0.0464	0.00608	-0.00919
	(0.0988)	(0.123)	(0.0335)	(0.430)
imp_manag_stakeholders	0.0488	0.00623	-0.0223	-0.00405
	(0.0575)	(0.0424)	(0.0504)	(0.190)
imp_informal	**-0.0630**	-0.0134	-0.00579	0.00820
	(0.0515)	(0.0430)	(0.0293)	(0.381)
has_outbound_knowledgeflow	-0.00842	-0.0166	-0.00602	-0.0105
	(0.0926)	(0.0945)	(0.0497)	(0.491)
Appropriability conditions				
App_formal	0.0280	-0.0268	**0.0467**	-0.00514
	(0.0307)	(0.0786)	(0.0542)	(0.240)
App_informal	**0.0537**	0.0135	**0.0545**	-0.00294
	(0.0639)	(0.0289)	(0.0707)	(0.137)

Table 5 continued

Public Support				
PS_horizontal	0.0228	**0.0467**	0.0212	0.0107
	(0.122)	(0.152)	(0.0779)	(0.494)
PS_targeted	-0.0407	**0.125**	0.000470	-0.00835
	(0.115)	(0.108)	(0.0354)	(0.392)
PS_networking	0.0291	0.0139	**0.0852**	-0.00401
	(0.0567)	(0.0478)	(0.105)	(0.188)
Number of observations = 805 Standard errors in parentheses Statistically significant estimated multinomial logistic regression coefficients are marked in bold				
chi2(200) = 475.61 Prob > chi2 = 0.0000 Pseudo R2 = 0.2137				

The findings also highlight a strong positive impact of the effectiveness of protection mechanisms for appropriating the benefits of successful innovations on firms' cooperative behavior. Availability of effective appropriability mechanisms, especially informal, increases the probability of innovation cooperation and contributes to the cooperation with knowledge producers, related industry actors and public authorities on the national level.

The availability of public support also facilitates the expansion of the cooperative linkages. Results achieved underscore the findings of previous studies (i.e. Veugelers and Cassiman (2005), Arranz and Fdez. De Arroyabe (2008), Badillo and Moreno (2016)). Networking measures, such as programs for creation and support of technology platforms and regional innovation clusters, are especially important for an intensive long-term cooperation with universities and research organizations and the development of national networking.

5. Conclusion

This article provides evidence for the ongoing discussion on the factors influencing firm's cooperative strategy in innovation activities: decision to cooperate (or not) and geographical pattern, and employs the firm-level data on the innovation activities of the Russian manufacturing enterprises.

To keep pace with changes in the global business environment, that is characterized by a high degree of dynamism, global and fierce competition, rapidly growing value and availability of knowledge and other, companies are forced to align their innovation strategy and corporate culture, and also to build external innovation networks.

Firms engage in cooperative relations with many different partners such as customers and suppliers, related value-chain members, competitors, providers of services, universities, research organizations, consulting firms or public authorities, each of which contribute in accordance with their capacity and competences. The choice of cooperative innovation strategy depends on a variety of factors, that could be divided into several categories based on the review of theoretical and empirical studies: firm-specific characteristics, level of competition, technological

opportunities, absorptive capacity, appropriability conditions and the availability of public support.

Innovation-active enterprises in Russian manufacturing cooperate with various external actors along the whole innovation process quiet frequently, especially preferring to interact with several partners simultaneously. However, the specific degree of participation of each party in innovation development and implementation is non-observed.

The results indicate strong differences in determinants of innovation cooperation strategy across different types of partners. Large incumbent companies in high-tech sectors prefer long-term cooperation with R&D sector. Firms, in cooperation with universities and research organizations, are mostly oriented towards foreign markets, have an adequate intellectual protection system and receive public support. The availability of government support (i.e. networking measures) facilitates expansion of the cooperative linkages, especially with knowledge production sector promotes the development of national networking. Most importantly, firms highly appreciate the contribution made by universities and research organizations in innovation development and implementation process.

Focus on process innovation stimulates collaboration with providers of services and related value-chain members. Such companies develop broader networking and rely on a national knowledge base. At the same time, focus on product innovation and orientation on national and foreign markets has a positive effect on cooperation with competitors. The lack of competitive advantage in quality of products and price stimulate firms to cooperate with suppliers of raw materials and consulting firms. Availability of effective appropriability mechanisms contributes to cooperation with knowledge producers, related industry actors and public authorities on the national level.

The obtained results are broadly consistent with other studies and confirm that, besides general firm-specific characteristics, company's capacity to identify, assimilate and apply valuable external knowledge (absorptive capacity) affects most of their cooperative strategies in innovation activities. Young companies that implement most of innovations on their own and find internal R&D as important sources of information have small cooperation networks and collaborate mostly only within the supply chain.

The revealed heterogeneity of the impact of endogenous and exogenous conditions for the cooperation with different actors challenges the wide-spread simplified perception of 'openness' as a one-dimensional characteristic of the innovation strategy. This should be taken in mind as a framing consideration in the theoretical modelling of the innovation processes as well as the practical policy development aimed at intensified networking.

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Appendix 1

Table A1

Review of empirical studies on R&D and innovation cooperation

Authors, Year of publication	Title	Country, Survey Years	Dependent Variables	Independent Variables	Methodology	Key Findings
Faria and Schmidt, 2012	International cooperation on innovation: Firm-level evidence from two European countries	Germany and Portugal, 1998-2000	Cooperation types: Domestic partner Foreign partner	Export status, part of a group, absorptive capacity (in-house R&D activities, the skill level of firms' employees), innovation intensity, incoming and outgoing knowledge spillovers, size, industry, public funding	Bivariate probit model	Statistically significant variables: 1. Domestic partner: size (+), industry (+), part of a group (+), absorptive capacity (+), public funding (+), outgoing spillovers (+) 2. Foreign partner: size (+), export status (+), part of a group (+), absorptive capacity (+), public funding (+), outgoing spillovers (+)
Veugelers and Cassiman, 2005	R&D cooperation between firms and universities. Some empirical evidence from Belgian manufacturing	Belgium, 1993	Cooperation with universities	Size, ownership, constraints (risk and cost), own R&D capacity, public funding, vertical cooperation, appropriability conditions (strategic and legal), incoming spillovers, export intensity, cooperation with universities at industry level	Instrumental probit model	Statistically significant variables: 1. Cooperation with universities: const (-), size (+), foreign (-), cost (-), risk (+), cooperation with universities at industry level (+), public funding (+), vertical cooperation (+) 2. Cooperation with universities (correction for endogeneity for the complementary strategies): const (-), risk (-), cooperation with universities at industry level (+), public funding (+)
Kaiser, 2002	An empirical test of models explaining research expenditures and research cooperation: evidence for the German service sector	Germany, 1995	Binary choice between cooperation and non-cooperation	Horizontal and vertical spillovers, research productivity, the generality of the research approach, market demand	Nested multinomial logit (NMNL) and Multinomial logit model (MNL)	Statistically significant variables: 1. Mixed cooperation: R&D generality-approach (>3) (+), strong decrease in sales (+), increase in sales (+), eastern German firms (+) 2. No cooperation: size (-), transport sector (-), R&D generality-approach (>3) (-), R&D productivity science (-), horizontal spillovers (-)

Table A1 continued

Miotti and Sachwald, 2003	Co-operative R&D: why and with whom? An integrated framework of analysis	France, -	Cooperation types: horizontal, vertical, institutional	Size, part of a group, industry, public funding, market share, permanent R&D, constraints (risk and cost), lack of information (market and technological)	Logit regression model	Statistically significant variables: 1. Vertical cooperation: const (-), size (+), part of a group (-), lack of market information (+) 2. Cooperation with public institutions: const (-), size (+), public funding (+), permanent R&D (-), science (+), cost (-) 3. Horizontal cooperation: const (-), size (+), public funding (+), high-tech industry (+), cost (+)
Dachs, Ebersberger and Pyka, 2008	Why do firms cooperate for innovation? A comparison of Austrian and Finnish CIS3 results	Finland and Austria, 1995	1) Innovation activity; Product innovation, Process innovation 2) Cooperative behavior: any partner, suppliers, customers, competitors, universities and research institutions	Size, part of a group, industry, export status, innovation expenditure, diversification of the innovative efforts, hampering factors (internal and economic), internal knowledge flow, basicness of R&D, appropriability conditions (strategic and formal), public funding, incoming spillovers, innovation type, speed of technological development, labor productivity	Multivariate logit model	Statistically significant variables (ex. Finland): 1. Collaboration with suppliers: const (-), public funding (+), diversification of the innovative efforts (+), process and product innovation (+), internal knowledge flow (+), appropriability conditions (strategic and formal) (+), incoming horizontal and vertical spillovers (+) 2. Collaboration with customers: const (-), public funding (+), appropriability conditions in industry (-), process and product innovation (+), diversification of the innovative efforts (+), appropriability conditions (strategic and formal) (+), incoming horizontal and vertical spillovers (+) 3. Collaboration with competitors: const (-), public funding (+), labor productivity (+), process innovation (+), innovation expenditure (+), horizontal incoming spillovers (+) 4. Collaboration with universities and research organizations: const (-), public funding (+), labor productivity (+), continuous of R&D (+), product innovation (+), diversification of the innovative efforts (+), internal knowledge flow (+), appropriability conditions (+), incoming horizontal (-) and vertical (+) spillovers, basicness of R&D (+)

Table A1 continued

Badillo and Moreno, 2016	What drives the choice of the type of partner in R&D cooperation? Evidence for Spanish manufactures and services	Spain, 2006-2008	Cooperation types: horizontal, vertical, institutional Group cooperation	Size, part of a group, sector, public support, R&D intensity, appropriability conditions (legal), incoming spillovers, constraints (risk and cost), lack of qualified personnel, export intensity	Multivariate probit model	Statistically significant variables: 1. Vertical cooperation: const (-), incoming spillovers (+), legal protection (+), R&D intensity (+), subsidies (+), part of a group (+), size (+) 2. Cooperation with public institutions: const (-), incoming spillovers (+), R&D intensity (+), risk (-), subsidies (+), part of a group (+), large size (+), industrial sector (-) 3. Horizontal cooperation: const (-), incoming spillovers (+), R&D intensity (+), subsidies (+), part of a group (+), size (+), industrial sector (-) 4. Group cooperation: const (-), incoming spillovers (+), legal protection (+), risk (-), public finding - subsidies (+), size (+), industrial sector (-), part of a group (+)
Franco and Gussoni, 2010	Firms' R&D cooperation strategies: the partner choice	Italy, 2002-2004	Cooperation types: market, science, mixed	Incoming spillovers, appropriability, size, sector, export status, costs of innovation, subsidies - public funding, participation in a multinational group, permanent R&D	Multinomial logit model	Statistically significant variables: 1. Market vs Mixed cooperation: const (+), size (-), subsidies (-), incoming spillovers (-), appropriability conditions (-), permanent R&D (-), export status (+), manufacturing industry (+) 2. Science vs Mixed cooperation: const (-), incoming spillovers (-), export status (+), manufacturing industry (+) 3. Market vs Science cooperation: const (+), size (-), subsidies (-), appropriability conditions (-), permanent R&D (-)

Table A1 continued

Belderbos, Carree, Diederen, Lokshin and Veugelers, 2004	Heterogeneity in R&D Cooperation Strategies	Netherlands1996 and 1998	Cooperation types: horizontal, vertical, institutional	Incoming spillovers (vertical, horizontal, institutional), industry outgoing spillovers, R&D intensity, size, industry, ownership, part of a group, constraints (organizational capability, risk, cost), speed of technological change, internal knowledge flows, R&D subsidy	Multivariate probit model	Statistically significant variables: 1. Vertical cooperation: const (-), horizontal (-), vertical (+), institutional (+), incoming spillovers, R&D intensity (+), R&D intensity squered (-), size (+), organizational capability constraint (+), risk constraint (+), service (+), part of a group (+), R&D subsidy (+) 2. Cooperation with public institutions: const (-), institutional incoming spillovers (+), R&D intensity (+), size (+), organizational capability constraint (+), speed of technological change (+), R&D subsidy (+) 3. Horizontal cooperation: const (-), institutional incoming spillovers (+), size (+), industry average firm size (+), risk constraint (+), speed of technological change (+), service (+), foreign multinational (-)
Arranz and Fdez. de Arroyabe, 2008	The choice of partners in R&D cooperation: An empirical analysis of Spanish firms	Spain, 1997	Cooperation types: horizontal, vertical, institutional	Size, part of a group, industry, permanent R&D, incoming spillovers (science), external R&D, obstacles (risk and cost), lack of market information and technological information, public funding	Logit regression model	Statistically significant variables: 1. Vertical cooperation: const (+), size (+), part of a group (+), high-tech, medium-high-tech industry (+), public funding (+), lack of market and technology (+) 2. Cooperation with public institutions: const (+), part of a group (+), high-tech, medium-tech industry (+), external R&D (+), public funding (+) 3. Horizontal cooperation: const (+), size (+), permanent R&D (+), high-tech industry (+), cost (+), risk (+), public funding (+)

Table A1 continued

De Faria, Lima and Santos, 2010	Cooperation in innovation activities: The importance of partners	Portugal, 1998-2000	1) Cooperation decision in innovation activities 2) Importance of cooperation partners	Size, Industry; Export share; Part of a group; Engagement R&D; Employees education; Innovation intensity; Incoming knowledge spillovers; Appropriability; Cooperation within the same group, suppliers, clients or customers, competitors, consultants, commercial labs or R&D labs, universities and government research institutions	1) Selection probit model 2) Probit model	Statistically significant variables: 1) Const (-); Size (+), Export share (+); Part of a group (+); Engagement R&D (+); Employees education (+); Innovation intensity (+); Appropriability (+) 2) Const (-); Engagement R&D (+); Innovation intensity (+); Cooperation within the same group (+), suppliers (+), High-tech (+)
Abramovsky, Kremp, Lopez, Schmidt, Simpson, 2008	Understanding co-operative innovative activity: evidence from four European countries	France, Germany, UK, Spain, 1998-2000	Cooperation types: research base; suppliers or customers; competitors	Incoming spillovers; Appropriability; Industry-level legal protection; Constraints; Public support; R&D intensity; Size; Industry	OLS regression	Statistically significant variables: Incoming spillovers (+); Public support (+); Appropriability (+); Industry-level legal protection (-); Constraints (+); R&D intensity [with the research base] (+); Size (+); Industry (+)
Srholec, 2014	Persistence of cooperation on innovation: Econometric evidence from panel micro data	the Czech Republic, 5 waves of CIS: 1999-2001; 2008-2010	Cooperation types: suppliers, customers, competitors, consultants, research institutes, universities	Past cooperation on innovation (1-3 lags); characteristics of the firm: continuous R&D activity; part of a group; age; size; industry; period of observations;	Multivariate Probit Model	Statistically significant variables: past cooperation on innovation (+); continuous R&D activity (+); part of a group (+); size (+)

Table A1 continued

Tether, 2002	Who co-operates for innovation, and why. An empirical analysis	United Kingdom, 1997	Cooperation types: customers, suppliers, competitors, universities, consultants, other	Size, ownership, part of a group, sector, R&D intensity, type of innovation, obstacles (risk, cost, internal, regulations), lack of information on market and technology, lack of qualified personnel	Logistic regression	Statistically significant variables: 1. Cooperation with suppliers: const (-), size (+), utilities (+), low-tech-services (-), R&D at least on an occasional basis (+), continuous and high intensity R&D (+), lack of customers responsiveness to innovation (+), lack of technology (-), obstacles risk and finance (+) 2. Cooperation with customers: const (-), foreign (+), high-tech manufacturing and services (+), R&D at least on an occasional basis (+), continuous R&D (+),'new to the market' innovations (+), lack of customers responsiveness to innovation (+), lack of information on markets (+) 3. Cooperation with competitors: const (-), size (+), utilities (+), high and low-tech services (+), R&D at least on an occasional basis (+), continuous R&D (+), 'new to the market' innovations (+), lack of customers responsiveness to innovation (+) 4. Cooperation with universities: const (-), size (+), part of a group (+), utilities (+), high-tech manufacturing (+), low-teck services (-), R&D at least on an occasional basis (+), continuous R&D and high intensity (+) 5. Cooperation with consultants: const (-), size (+), foreign (+), utilities (+), high and low-tech services (+), R&D at least on an occasional basis (+), continuous R&D (+), obstacles risk and finance (+) 6. Other cooperation types: const (-), new firm (+), size (+), utilities (+), medium-tech manufacturing (+), high-tech services (+), obstacles risk and finance (+)

Appendix 2

Table A2

Sample characteristics

Manufacturing sector	Innovation-active	Has at least one cooperation partner
Food and Beverages	83	81
Textiles, clothing and shoes	58	58
Wood and paper	50	47
Printing and Publishing	47	46
Petrochemistry, coal and nuclear fuel	21	20
Rubber, plastics and nonmetallic goods	55	53
Chemical production	54	53
Pharmaceuticals	41	40
Metallurgy	51	50
Metallic products	60	60
Machinery and Equipment	94	93
Precision instruments and computers	44	44
Railway transport and shipbuilding	43	43
Automobiles	27	27
Aircraft and space	23	22
Other manufacturing	54	53
Total	**805**	**790**

Appendix 3

Table A3

Construction of the explanatory variables

	Variable	Type	Construction
Firm-specific characteristics	Size	Continuous	Log of the average number of employees in 2013 (at least 10)
	Age_less 5	Dummy	One, if a firm was established after 2010
	Industry		
	High-tech	Dummy	One, if a firm belongs to high technology manufacturing based on NACE Rev. 1.1 codes
	Medium-high-tech	Dummy	One, if a firm belongs to a medium-high technology industry based on NACE Rev. 1.1 codes
	Medium-low-tech	Dummy	One, if a firm belongs to a medium-low technology industry based on NACE Rev. 1.1 codes
	Base level: Low-tech	Dummy	One, if a firm belongs to a low technology industry based on NACE Rev. 1.1 codes
	Ownership		
	Foreign	Dummy	One, if a firm has foreign ownership
	State	Dummy	One, if a firm has state ownership
	Rate of business growth		
	> 30% decrease	Dummy	One, if the average annual changes in the number of employees (in the past 3 years) are more than 30% decrease
	10-30% decrease	Dummy	One, if the average annual changes in the number of employees (in the past 3 years) are 10-30% decrease
	minor variation (+/- 10%)	Dummy	One, if the average annual changes in the number of employees (in the past 3 years) are in interval +/- 10%
	10-30% increase	Dummy	One, if the average annual changes in the number of employees (in the past 3 years) are 10-30% increase
	> 30% increase	Dummy	One, if the average annual changes in the number of employees (in the past 3 years) are more than 30% increase
	Base level: Ambiguous changes	Dummy	One, if One, if the average annual changes in the number of employees (in the past 3 years) were ambiguous
	Profitability of sales		
	0-2%	Dummy	One, if the return on sales in 2013 (before tax) was 0-2%
	2-5%	Dummy	One, if the return on sales in 2013 (before tax) was 2-5%
	5-10%	Dummy	One, if the return on sales in 2013 (before tax) was 5-10%
	>10%	Dummy	One, if the return on sales in 2013 (before tax) was more than 10%
	Base level: Negative	Dummy	One, if the return on sales in 2013 (before tax) was negative
Level of competition	Market structure		
	Monopoly	Dummy	One, if a firm has no direct competitors or has less than 2
	Oligopoly	Dummy	One, if a firm has 2-5 principal competitors
	Base level: Competition	Dummy	One, if a firm has more than 5 principal competitors
	Markets for future development		
	Regional	Dummy	One, if prospects for company development are associated with regional markets
	National	Dummy	One, if prospects for company development are associated with national markets
	Foreign	Dummy	One, if prospects for company development are associated with foreign markets
	Base level: Local market	Dummy	One, if prospects for company development are associated with local markets

Table A3 continued

Level of competition	Competitors' advantages		
	Price	Dummy	One, if prices of products are the most explicitly represent advantages of competitors
	Quality	Dummy	One, if quality of products are the most explicitly represent advantages of competitors
	Novelty	Dummy	One, if novelty of products are the most explicitly represent advantages of competitors
	Customization	Dummy	One, if adaptation of products according to customers' requirements are the most explicitly represent advantages of competitors
	Delivery	Dummy	One, if prices of products are the most explicitly represent advantages of competitors
	Services	Dummy	One, if prices of products are the most explicitly represent advantages of competitors
	Other	Dummy	One, if competitors have other advantages
Technological Opportunities	Investment intensity in innovation		
	High	Dummy	One, if the share of total expenditure on innovation activities in the total turnover in 2013 is less than 2.5%
	Medium	Dummy	One, if the share of total expenditure on innovation activities in the total turnover in 2013 is from 2.5 to 10%
	Low	Dummy	One, if the share of total expenditure on innovation activities in the total turnover in 2013 is more than 10%
	Base level: Lack of investment	Dummy	One, if there were no costs for implementation of new products in 2013
	Importance of innovation types for business success		
	Regular R&D	Dummy	One, if regular research and development is important for firm's business success
	Product innovation	Dummy	One, if product innovation are important for firm's business success
	Process innovation	Dummy	One, if process innovation are important for firm's business success
	Long_product innovation	Dummy	One, if the period of product innovation development / implementation is more than 3-5 years
	Long_process innovation	Dummy	One, if the period of process innovation development / implementation is more than 3-5 years
Absorptive Capacity	Staff_high	Share	Number of graduated employees and employees with a Candidate of Sciences, Doctor of Sciences (or PhD) degree
	Culture_coop external	Dummy	One, if executives and the management welcomes the involvement of external partners and cooperation at various stages of development and implementation of innovations
	Culture_standard procedures	Dummy	One, if the enterprise has developed standard procedures for interaction with the implementing partners of research and development (including the regulatory framework, the criteria for assessing the quality of results, etc.)
	Culture_coop internal	Dummy	One, if an exchange of ideas is practiced among the various units of the company without the direct involvement of the management
	Own effort	Dummy	One, if the majority of implemented innovations were developed predominately by firms' own
	Importance of information sources		
	Internal R&D	Dummy	One, if internal R&D are important sources of information
	Manufacturing departments	Dummy	One, if manufacturing departments are important sources of information

Table A3 continued

Absorptive Capacity	Marketing and/or client services	Dummy	One, if marketing departments and/or client services are important sources of information
	Management team and/or stakeholders	Dummy	One, if company's management team and/or stakeholders are important sources of information
	Informal sources of information	Dummy	One, if informal sources of information (ex. scientific literature, patent information, trade fairs and other professional events) are important sources of information
	Outbound knowledge flow	Dummy	One, if the company performed technology acquisition/transfer in 2011-2013
Appropriability Conditions	Formal methods of IP protection	Dummy	One, if the firm uses formal methods of intellectual property protection
	Informal methods of IP protection	Dummy	One, if the firm uses informal methods of intellectual property protection
Public Support	Horizontal	Dummy	One, if the firm received horizontal public support between 2011-2014
	Targeted	Dummy	One, if the firm received targeted public support between 2011-2014
	Networking	Dummy	One, if the firm received networking public support between 2011-2014

Appendix 4

Table A4

Distribution of surveyed firms by the fact of innovation cooperation and its location (%)

Cooperation partner		Consumers/ Clients	Suppliers of raw materials	Related value-chain members	Providers of services	Competitors	Research organizations	Universities	Consulting firms	Public authorities
Cooperation [a]	No	22.0	25.7	62.5	66.8	80.7	72.9	77.8	90.9	77.1
	Yes	78.0	74.3	37.5	33.2	19.3	27.1	22.2	9.1	22.9
Location [b]	Regional	67.8	61.0	64.6	79.0	56.8	59.2	70.9	58.9	79.3
	National	53.7	56.5	50.0	39.7	55.5	62.8	45.8	41.1	37.5
	Foreign	14.2	23.7	8.3	11.6	17.4	7.8	3.4	12.3	1.6

[a] Percentage of the total innovation active firms operating in the manufacturing sector (N = 805)

[b] Percentage of the total innovation active firms in the manufacturing sector involved in innovation cooperation

Appendix 5

Table A5

Descriptive statistics for dependent variables

	Total sample	
	Russia N[a]=805	
	Mean	**SD**
Firm-specific characteristics		
Log_Size	5.4383	1.4881
Age_less5	0.0547	0.2274
Industry		
High-tech	0.1491	0.3564
Medium-high-tech	0.2584	0.4380
Medium-low-tech	0.2286	0.4202
Ownership		
Foreign	0.0696	0.2546
State	0.1304	0.3369
Rate of business growth (Number of employees)		
> 30% decrease	0.0335	0.1801
10-30% decrease	0.1329	0.3397
Minor variation (+/- 10%)	0.5081	0.5002
10-30% increase	0.1528	0.3600
> 30% increase	0.0398	0.1955
Profitability of sales		
0-2%	0.1652	0.37161
2-5%	0.3019	0.45935
5-10%	0.2708	0.44465
>10%	0.1925	0.39455
Level of competition		
Market structure		
Monopoly	0.1963	0.3974
Oligopoly	0.3081	0.4619
Markets for future development		
Regional	0.2435	0.4294
National	0.4745	0.4997
Foreign	0.1913	0.3936
Competitors' advantages		
Price	0.29	0.452
Quality	0.09	0.284
Novelty	0.19	0.394
Customization	0.07	0.259
Delivery times	0.05	0.217
Services	0.09	0.293
Other	0.06	0.235
Technological Opportunities		
Investment intensity in innovation		
Low	0.3081	0.4619
Medium	0.3193	0.4665
High	0.1354	0.3424
Importance of innovation types for business success		
Regular R&D	0.7466	0.4352
Product_innovation	0.9217	0.2687
Process_innovation	0.9876	0.1108
Long_product innovation	0.2261	0.4186

Long_process innovation	0.1888	0.3916
Absorptive capacity		
Staff_high	33.5202	23.5879
Culture_coop external	0.4236	0.4944
Culture_standard procedures	0.3863	0.4872
Culture_coop internal	0.4273	0.4950
Importance of information sources		
Internal R&D	0.1615	0.3682
Manufacturing departments	0.1578	0.3647
Marketing and/ or client services	0.3404	0.4741
Management team and/ or stakeholders	0.2522	0.4345
Informal sources of information	0.2870	0.4526
Outbound knowledge flow	0.4733	0.4996
Own effort	0.6373	0.4811
Appropriability conditions		
The firm uses formal methods of IPP	0.6112	0.4878
The firm uses informal methods of IPP	0.5988	0.4904
Public support		
Horizontal measures	0.2435	0.4294
Networking measures	0.0944	0.2926
Vertical measures	0.2708	0.4446