Cooperation between Russian research organizations and industrial companies: factors and problems

Simachev, Yuri and Kuzyk, Mikhail and Feygina, Vera

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COOPERATION BETWEEN RUSSIAN RESEARCH ORGANIZATIONS AND INDUSTRIAL COMPANIES: FACTORS AND PROBLEMS

Yuri Simachev, Mikhail Kuzyk, Vera Feygina*

The study is focused on the cooperation of Russian companies with research organizations in implementing R&D projects during technological innovation. Taking into account behavioral changes, authors carry out a micro-level analysis based on empirical data of executive survey of over 600 Russian industrial firms (2011—2012) and about 350 research organizations and universities (2012). The authors emphasize the key factors of firms' demand for outsourcing R&D reveal the main barriers to the development of university-industry cooperation and their particularities for different cooperation actors.

The analysis shows that there is a positive relation between the size of a company and R&D outsourcing. As for the factor of age, the highest cooperation activity of Russian firms is observed among enterprises founded over 20 years ago. As far as concernes cooperation activity of research organizations, large ones are significantly more likely to cooperate with business. A common prerequisite for research organizations' R&D cooperation with business is sufficient academic ranking.

Business and science evaluate differently various obstacles to effective cooperation. For firms, the main problems are the inflated costs of national R&Ds, insufficient research organizations' orientation at company needs, and low quality of developments. As for representatives of research organizations, they mention as barriers primarily the lack of companies' receptivity to innovation and inadequate information about promising developments. Businesses are more optimistic about cooperation with science if they already have a relevant experience of interaction. In the case of research organizations we observe a different pattern: most problems seem more significant to organizations conducting R&D in business interests.

Keywords*:* innovations, university-industry cooperation, barriers to research and development, firm behavior

JEL Classification*:* L20, O31, O32

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* Interdepartmental Analytical Center

Introduction

Evolutionary growth theory has become noticeably popular among experts and politicians in the past two decades (Metcalfe, 1994; Edquist, 1997). Innovation, according to the theory, is a complicated phenomenon characterized by high risks and requiring broader access to knowledge; hence interaction, cooperation, and partnership among various actors become the most important determinants of innovation processes and technological shifts in economies.

The increased attention to the evolutionary growth model is caused by the fact that terms of performing innovation have changed dramatically. We can point to the following global changes that raise the value of interaction in the innovation field:

(1) complication of technological innovation has significantly elevated the role of external knowledge sources, even for big companies;

(2) the interdisciplinary character of research has become an important factor of successful innovation; moreover, the need to acquire various competences incites cooperation at different levels — corporative and international — creation of technological alliances;

(3) as channels of communication of new knowledge, skills, and technologies diversify, the processes of knowledge transmission and acquisition of knowledge at the personal level become the most important elements of innovation; thus, the role of education increases significantly.

Cooperation between agents of an innovation system creates various positive effects: it improves susceptibility to new knowledge, enhances processes of mutual education, and accumulates economy's intellectual potential in general (Pavitt, 1998; Smith, 1995; Bjerregaard, 2009). Effectiveness of modern innovation is evaluated by a multiple knowledge sources, practices, skills, and channels of information sharing and education. For example, successful distribution of research and development in new industrial countries was based on intensive education; moreover, positive effects of this education accumulate over time (Teubal, 1996, 2002).

From the evolutionary theory perspective, learning failures are critically important (Bach, Mats, 2005) that are interpreted as limitations in learning potential and its use at the level of particular agents and groups of agents. Therefore, problems such as the lack of coordination among agents, underdevelopment of institutions of joint generation and dissemination of knowledge, desynchronized change in institutions undergoing technological upgrading, complexities of codification, etc. come to forefront in innovation policy agenda.

Avoiding the use of rigid hierarchical systems and transition to a horizontal network model of organization at all levels of management has today become a recognized trend. State support of cooperation and partnerships is the most significant factor in increasing efficiency of

an innovation system (OECD, 2011; Goldberg, 2011). Speaking of developing cooperation among companies and research organizations, it is necessary to take into account fundamental differences in their goals and values, priorities, and incentives to cooperate (Ervin et al., 2002; Kodcharat, Chaikeaw, 2012).

The main aim of our study is a micro-level analysis of problems of scince-industry cooperation, key factors and obstacles on the way of interaction of Russian companies and research organizations.

1. Study motivations, special aspects of approach, and limitations

Several obstacles served as a *motivation* for this study.

First. While there are numerous foreign studies on the factors of firms' cooperative behavior, Russian empirical papers analyzing development of science-industry cooperation at the micro level are surprisingly scarce on this background. In Russian empirical studies, issues of science-industry linking have been addressed only superficially in the majority of cases.

Second. Everything related to communication and interaction are hard-to-measure parameters poorly captured by the traditional system of innovation statistics. Development of cooperation and partnerships is mainly related to behavioral changes at the micro level. This determines the critical importance of identifying behavioral effects, both at the business and science levels.

Third. Regarding the problems of university-industry links in Russia, it is necessary to take into account specific character of the Russian R&D sector that is of extremely heterogeneous nature and is undergoing a long, multidirectional transformation. Many decisions in Russian innovation policy are dictated, among other things, by the urge to increase the contribution of R&D to social and economic development and to push the researchers into cooperation with business.

Motivations for this research have largely determined *characteristics of the methodical approach.*

Assessment of the demand for cooperation, barriers to cooperation development, and effects of state innovation policy is performed at the micro level. This allows us to estimate factors of cooperative behavior, especially given the high level of heterogenuity of incentive mechanisms' impact on different segments of business and science.

Notably, the majority of studies in the field evaluate the cooperation effects either from the point of view of business (Fontana, Geuna, Matt, 2004; Laursen, Salter, 2004; Liu, 2009) or the science point of view (Kaymaz, Eryigit, 2011). The key feature of this study is the "two-way" approach to the analysis of cooperation: both from the point of view of public research

institutions and universities, on the one hand, and business, on the other. This determines some possibilities of at least relatively objective assessments.

Empirical base for this study was comprised of data collected in two survey rounds of over 600 Russian company managers held in 2011 and 2012, and polls of heads of over 350 Russian research organizations (institutes and universities) held in 2012. Certainly, these samples are not completely representative, but they were quota sampled: the company sample – by representation of manufacturing industries and by medium and large companies; the research organizations sample – by representation of academic institutions, industrial research institutes and design centers, and universities. Besides, we used results of 2014 executive interviews of 15 companies funding R&D.

For assessing barriers to cooperation, we find it important to take into account the factor of deterring and revealed problems, and the potential of mutual learning on individual issues and generating consensus approaches. Thus we compared estimates of theoretichans (who did not have interaction experience) and practitioners.

Few words on the *limitations* of this research.

First, we confined ourselves to analyzing cooperation between companies and research organizations in their joint realization of R&D projects, although interaction between these actors can be notably more multifaceted. The evaluation of possible positive effects of this interaction and quality changes in formation of innovation-friendly environment is thus significantly limited.

Second, panel data were available on companies only, not on research organizations. Thus, the possibility to evaluate training effects and dissemination of behavioral changes was limited.

Third, the surveys were performed at the level of heads of companies and research organizations. This substantially limits the spectrum of motivations and obstacles to cooperation that we analyze, since opinions of junior and senior management, especially in universities and academia institutes, differ greatly.

Finally, we used a subsample of firms – those who funded R&D – for our analysis, except for individual cases. This allowed us to quite clearly compare two corporate models: the model of entirely intracompany research and the other one combining internal and external R&D. However, consequently, we did not consider effects of companies' possible initiation R&D activities and certain barriers of this initiation due to the insufficiency of potential external partners in conducting R&D.

2. Prevalence of companies' links with research organizations and factors of business demand to ousourse R&D

Science-industry cooperation in performing R&D has an over two-century-old history. International practice shows significantly differing trends in the interaction between universities (and institutes) and companies. There were long periods when firms' cooperation with external partners in carrying out research and development shrinked (e. g., before 1960s, due to dynamic development of intracorporate research), and, to the contrary, when it extended (since 1980s). However, in the 21st century, there is a growing demand for the use of a complex of external knowledge sources: not only universities but also competitors, consumers, and suppliers (Borrell-Damian, 2009).

Cooperation is the most important knowledge-sharing factor that determines innovation. Comparing national data on the prevalence of collaboration in the innovation sphere among companies shows that firms conducting R&D value more the interaction factor compared to those who are not involved in any research activity (OECD, 2013).

In Russia, the share of firms involved in innovation-related collaboration in total of innovatively active R&D funding companies is estimated quite high for 2009—2011: at the level of 58% (compared to up to 30% of businesses not performing R&D), that is, Russia is in among leaders by this indicator (Fig. 1). At the same time, we have to understand that the proportion of innovative R&D-funding companies in the economy is much lower in Russia than in the leading countries: the majority of innovations in fact are of imitational character, and research spending is replaced by acquiring already materialized technologies.

Importantly, the cross-country comparison of business links is not about corporate collaboration with research organizations only: interaction with other actors of the innovation system is no less important for the success of innovation. According to innovation statistics in Russia, contacts with affiliates, consumers, and suppliers are more significant in comparison with links to R&D sector (Zaichenko, et al., 2014).

In particular, innovation in big companies is under major influence of suppliers due to stronger integration within the value added chain formation. This effect of innovation spreading upwards has been also noticed in the case of big Russian industrial companies intergrated in vertical cooperation chains, when suppliers' technological modernization and their transition to the output of materials and components with new properties serves as an incentive to innovate (Simachev et al., 2014).

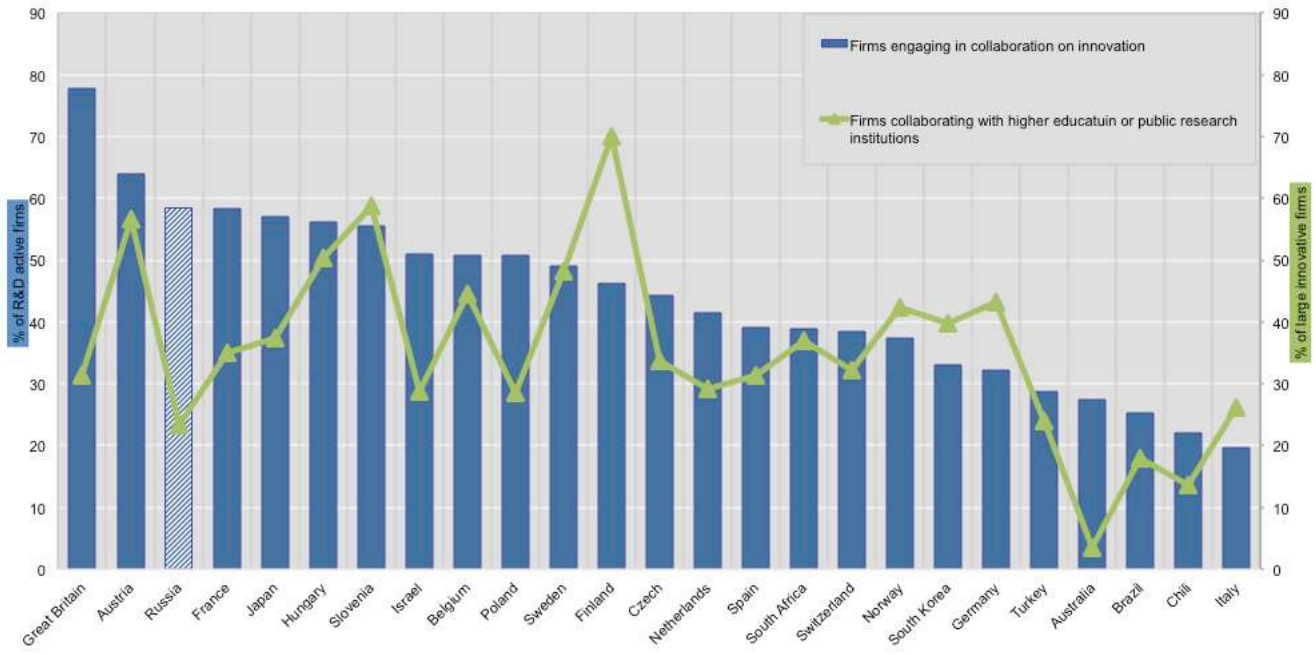

Figure 1. Proportion of enterprises (1) interacting with other innovation actors and (2) interacting with universities and research organizations in the total of enterprises of each category, 2008—2010*

Source: IAC based on OECD Scoreboard data, 2013
** Data on Russia is for 2009—2011.*

At the same time, it is namely the development of cooperation between companies and research organizations that is one of the basic components of the knowledge economy. It is included in all the major indices of competitiveness and innovative development of national economies (Global Competitiveness Index, Global Innovation Index, Knowledge Index, Knowledge Economy Index, etc.)

As for direct cooperation between companies and research institutions (universities and institutes) during innovation, this indicator is significantly lower in Russian economy compared to other countries: such cooperation has been observed only in 23% of big innovative companies (Fig. 1). Typically, according to assessments of development of science and industry relations, Russia lags behind not only top nations in the rating of innovative economies but also analogous countries comparable to it by the general level of economic development[†]. International statistics thus show that there are poorly developed linkages between science and industry in Russian economy, and no positive change has been discerned in recent years.

For all the diversity of studies in the field on intra-corporate science and science-industry

[†] *Data of WEF Global competitiveness Report 2013-2014. Brazil, India, China, South Africa, Malaysia, and Ukraine have been chosen as Russia's analogs according to SEDA methodology.*

cooperation, their rather universal and common result is the evidence of obvious industry heterogeneity due to the differences in the need of knowledge, level of accumulation, productivity, etc. specific for each sector of economy (Ortega-Argiles et al., 2009; Antonelli, Crespi, 2011).

The indicators of the level of research cooperation activity in Russia are close to average in our research sample[‡]. At the same time, companies of oil and gas section and metallurgical engineering are more active in outsourcing their R&D projects (Table 1).

Table 1. Enterprises R&D cooperation in 2011, proportion in the total of industry enterprises

	Companies funding R&D	Including	
		companies spending over 1% of revenue on R&D	companies interacting with research sector in their R&D
Chemical production	55,2%	19,4%	28,4%
Production of electrical machines and systems	50,0%	12,5%	25,0%
Production of transport vehicles	47,8%	21,7%	26,1%
Production of machines and equipment	46,2%	9,6%	23,1%
Nonferrous metallurgy	43,5%	8,7%	34,8%
Ferrous metallurgy	42,3%	3,8%	26,9%
Oil and gas producction	38,6%	4,5%	36,3%
Manufacture of rubber and plastic products	34,1%	6,8%	22,7%
Production of construction materials	27,3%	6,8%	15,9%
Pulp and paper production	25,7%	0%	2,9%
Textile manufacture	23,7%	2,6%	10,5%
Apparel industry	19,2%	11,5%	5,8%
Wood processing	17,9%	2,6%	7,7%
Food processing, including beverages	16,7%	7,8%	5,9%
Total percentage in the sample	*33,7%*	*9,2%*	*17,5%*
Percentage in the innovative subsample	*49,4%*	*15%*	*28,9%*

Let us consider *factors contributing to cooperation* between industrial enterprises and research organizations in R&D. According to a number of studies, big business is more prone to this cooperation (Mohnen, Hoareau, 2003; Cohen et al., 2002; Arundel, Geuna, 2004; Fontana, Geuna, Matt, 2004; Laursen, Salter, 2004). Big[§] companies have sufficient labor and

[‡]The average share of firms cooperating with scientific organizations in our research sample is comparable to average indicators published in OECD Scoreboard: 29% large innovative companies contact research sector while performing their R&D.

[§] In some studies, not only the total number of employees but also the number of those hired in R&D sector is used as a scale factor (Fontana, Geuna, Matt, 2004).

organizational resources to support their cooperation with R&D organizations.

Analysis based on our sample illustrates that there is an interrelation between the scale of a business (measured by the number of employees) and the presence of counterparties to conduct R&D. The larger the company size, the greater the number: (1) of firms funding research in principle, (2) and also the share of them who cooperate with research institutions.

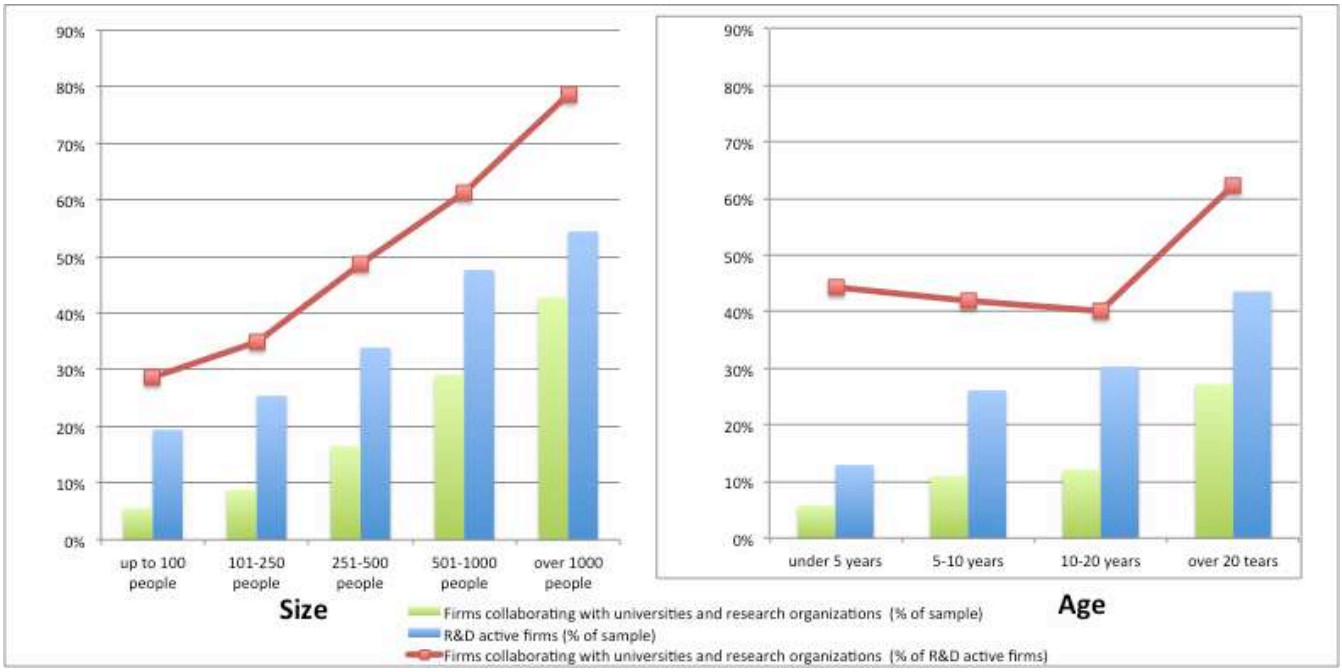

Figure 2. Demand of industrial companies for R&D cooperation: factors of size and age

Although revealing a positive relationship between the probability of R&D outsourcing and business size confirms results of most studies in this field, the nature of relationship with company age does not quite fit into usual foreign research results. The leap in cooperative activity is observed in the older age group – among enterprises founded over 20 years ago whose cooperation with science is based on, among other things, traditions established as early as in Soviet times. Lack of young business's cooperative activity is opposite to the foreign-literature image of startup as the source of generating demand for research and development (Cohen et al., 2002).

To clarify the factors of scientific and industrial cooperation, we have conducted a regression analysis in several specifications (Table 2), whereas the dependent variable is the presence of R&D outsourcing.

Table 2. Outsourcing in R&D field: results of calculation of parameters of binary logistic

regression model (by the sample of R&D-funding industrial enterprises)

		Presence of R&D contractors		
		Model 1	Model 2	Model 3
Age	under 5 years	0,505 (0,909)	0,991 (0,895)	0,555 (0,776)
	over 20 years	**1,156 ***** **(0,384)**	**1,241 ***** **(0,396)**	**0,946 ***** **(0,340)**
Number of employees	up to 250	**-1,007 *** **(0,598)**	-0,691 (0,57)	**-1,172 ***** **(0,349)**
	over 1000	**1,227 ***** **(0,451)**	**1,308 ***** **(0,461)**	
Ownership structure	absence of foreign shareholders	0,205 (0,433)	0,182 (0,431)	0,195 (0,398)
	state participation	-0,125 (0,567)	0,328 (0,575)	0,254 (0,521)
Export		0,161 (0,506)	0,164 (0,507)	-0,312 (0,401)
Financial state	poor	-0,804 (0,62)	-0,916 (0,632)	-0,692 (0,550)
	good	0,121 (0,399)	0,04 (0,395)	0,203 (0,359)
R&D intensity(% of revenue)		**0,446*** **(0,247)**		0,149 (0,217)
New products (to the country or to the world)			**0,807 **** **(0,382)**	
Dynamically developing company**				**0,692** **(0,373)***
Control of sectoral differences		yes	yes	yes
Constant		-1,171 (1,604)	-1,102 (1,318)	1,012 (1,702)
Number of observations		220	220	220
R^2 (Nagelkerke)		0,314	0,387	0, 204

Note: The maximum value of the variance inflation factor (VIF) – 2,64.

Here and below:
signs of significant coefficients are used;
**** significance at the 1% level,*
*** significance at the 5% level,*
** significance at the 10% level.*

The positive effect of company size and age is confirmed in all specifications. Besides, we have identified several more factors that affect the probability of linking with research organizations.

For example, the R&D intensity significantly affects the explanatory variable. The same observation is confirmed in a number of foreign empirical studies (Schartinger et al., 2001; Arundel and Geuna, 2004). Apparently, the mechanism operating here is the following: the more the organization invests in R&D, the more seriously it treats innovation, the more actively it monitors the market for the emergence of advanced products and technologies, the more susceptible to the influx of external knowledge it becomes.

** Dummy variable that takes the value 1 if at least one of the two indicators – the amount of revenue or share of investment in fixed assets – has increased over the last year by more than 20%.

Another important factor of cooperation in R&D area is the level of novelty of a manufactured product. Since R&D intensity correlates with the indicator of radicality (novelty) of innovative activity, we introduce into the model the second specification. We have received the following result: companies creating products new to their country, or to the world are more likely to outsource R&D compared to those who make products new only to their own enterprise. Business is disposed to attract research organizations as partners in implementation of projects in the forefront of science and requiring the use of the newest and breakthrough technologies (Hall et al., 2001).

In the third specification, we have added an explanatory variable demonstrating the rapidly growing and developing business. This factor of firms' cooperative activity is identified in a number of empirical studies whose authors show that companies constantly increase value at the phase of their growth, they turn to external sources of technologies and employ them for production (Mohnen, Hoareau, 2003; Fontana, Geuna, Matt, 2006). Our analysis shows that the coefficient of this variable is significant at the ten-percent level, which can be interpreted with some caution in favor of the assumption that fast-developing business does not have time to build its own commensurate research infrastructure and provides for its growing needs for the development and adaptation of technologies by contracting external organizations.

Similarly, we have performed regression analysis on research organizations database (Table 3) to identify factors determining cooperation of research organizations with companies or their inclination for such interaction in future[††].

Table 3. Interaction of research organizations with business: results of calculation of binary logistic regression model parameters (by the sample of research organizations)

		Performing R&D in business interests in the last 3 years	R&D planned in business interests in the next 3—5 years	Extention of research activity in business interests planned in the next 3—5 years
Age	under 10 years	-0,377 (0,433)	**-0,719 (0,437)***	**-0,892 (0,439)****
	over 20 years	-0,123 (0,34)	-0,468 (0,349)	-0,200 (0,327)

[††] The simulation is performed on several explanatory variables: first representing the fact of research organization's cooperation with business in R&D area; second and third variables are related to plans and intentions: to implement such work in future and to orient organization at extending in future its research activities in the interests of business.

Number of employees	up to 50	**-0,797** **(0,368)**	**-0,595*** **(0,352)**	-0,371 (0,351)
	over 1000	**1,813*** **(0,423)**	**1,511*** **(0,446)**	**0,637*** **(0,380)**
Type of organization	university	0,293 (0,317)	-0,226 (0,336)	0,354 (0,301)
	academia institute	**1,320*** **(0,364)**	**0,894** **(0,372)**	**0,560*** **(0,336)**
Regional location	Moscow, St.-Petersburg	**-0,498*** **(0,275)**	**-0,645** **(0,282)**	-0,110 (0,265)
Ownership structure	state-owned	**-0,511*** **(0,308)**	0,036 (0,306)	0,366 (0,288)
Financial state	poor	0,531 (0,420)	0,362 (0,432)	0,492 (0,399)
	good	0,382 (0,346)	-0,118 (0,353)	0,147 (0,336)
Academic ranking (self-scoring)	low	-0,292 (0,311)	**-0,698** **(0,318)**	0,494 (0,301)
	high	**0,906*** **(0,306)**	**0,847*** **(0,326)**	**0,741*** **(0,284)**
Constant		0,01 (0,382)	0,847 (0,326)	-0,727 (0,370)
Number of observations		340	361	361
R2 (Nagelkerke)		0,26	0,24	0,17

Note: The maximum value of the variance inflation factor (VIF) – 2,78.

Just like the industrial companies, large research organizations are significantly more likely to interact in R&D projects. The size of an organization determines its capacity to bear higher costs, e.g., constantly allocating resources to form scientific and technological groundwork and to create, develop, and maintain sustainable relationships with business representatives. Another effect appears to be that external R&D is mainly demanded by rather big business characterized by complex and lengthy decision-making procedures. To withstand bureaucratic costs is feasible for rather large research organizations, as well as institutions having long traditions of interacting with business – it is no coincidence that young research organizations are very unlikely to be oriented at developing cooperation with business.

Notably, private research organizations are more often involved in cooperation with business than public ones. We can suggest that such institutions initially counted less on public funding. It is also interesting that research institutions of Moscow and St.-Petersburg are less oriented at cooperation with business: probably, in the capital cities, there are more opportunities for them to obtain funds without direct business R&D-related contracts.

Finally, a common prerequisite for both research organization's present and prospective R&D cooperation with business is sufficient academic ranking. Therefore, contrary to widespread assertions, business probably has a 'sense of value' of research proposed to it. This apparently also determines a somewhat better position of academic insitutes, of which some have not only preserved but also developed their scientific and scholarly expertise.

In this context, the lack of pronounced dominance of universities, even in the case of their future interaction with business is rather disappointing– and this is despite the fact that one of the major directions of declared R&D sector transformation is associated with increasing universities' involvement in the process of knowledge generation. Perhaps this is because the desire of the state to perform fast transformation prompted significant increase in public funding of universities' R&D activities, but university institutional reforms and building a new functioning model of research university lagged behind, which all weakened universities' motivation to directly interact with business.

3. Barriers to interaction and conditions of mutual compatibility

Goals and values of companies and research organizations differ significantly, and so does their motivation to cooperate. Studies show that science is attracted to linking with business primarily by the exchange of knowledge which facilitates initiation of new directions of research development and enriches research staff scientific potential and opportunities to attract additional funding (Meyer-Krahmer, Schmoch, 1998; D'este, Perkmann, 2011). In addition, cooperation with business involves a number of other (slightly less significant) benefits for universities: creation of new jobs, including provision of internships for students, use of practical experience in teaching, etc. (Lee, 2000).

From the business point of view, cooperation is beneficial by virtue of acquiring wider access to advanced scientific findings and getting help in resolving technical difficulties (Freitas, Verspagen, 2009), the opportunity to improve position in the market if innovative products or technologies are created (Lee, 2000), and, finally, in some sectors (pharmaceutics, biotechnology), facilitation of the commercialization process plays an important role (Zucker, Darby, 2000). Research commercialization can be also the motive to cooperate for research organizations, but this occurs quite rarely (D'este, Perkmann, 2011).

Note that the value of collaboration with universities (institutes) is not at all limited by their role merely as a source of knowledge for business. Moreover, in the Russian situation of transition to the university-based model, other motivations to cooperate with universities become a priority for business: access to research and testing facilities and to research staff (Dezhina, Simachev, 2013).

According to the analyzed samples of Russian companies and research institutions, about each other organization (both in business and research samples) which has spendings on R&D has had a practice of cooperation while conducting them, and 55% of organizations are oriented

at such cooperation in the next 3—5 years.

However, despite the multitude of motivations to collaborate on both sides, in practice many problems arise due to fundamental differences in participants' priorities and principles of their work organization. Difference between goals and motivations, discrepancy in project schedules, and 'cultural incompatibility' are cited by researchers as most common obstacles to research and manufacturing cooperation (Wu, 2000; Casey, 2004). Business approach dictates the importance of practical tasks and the priority of commercial benefit of a project, while scientific approach is based primarily on the urge to broaden one's horizons and on the value of learning effect. Entrepreneurs are interested in performing external research as soon as possible and in the presence of visible commercialized results.

Besides, researchers emphasize such barriers to interaction as the issues of equitable distribution of intellectual property rights (Bowie, 1994) and the opacity of the legal regulation of joint projects (Barnes et al., 2002). This problem is particularly acute in developing economies characterized by multiple imperfections of institutional environment. The multidimensionality of forms of the results of joint scientific and technological activities is largely driven by low demand of scientific organizations for the protection of intellectual property rights and the lack of industry interest in the use of direct contractual instruments (Zasimova et al., 2008).

Effective interaction can also be hindered by ineffective management (Ghani, 1991), lack of knowledge (Schibany et al., 1999), and technical difficulties in transfer and adaptation of new knowledge (Freitas, Verspagen, 2009).

It seems important *to assess the role of these barriers* and to evaluate differences in how representatives of business and science percept these barriers. Since difference in views, ideas, routines, and motivations is pointed to as the main underlying cause hindering the development of R&D cooperation, we have compared in our research sample science and business perceptions of the barriers to interaction, also depending on their having or not a corresponding cooperative experience (Table 4).

Table 4. The significance of barriers to cooperation for industrial companies and research organizations (1) without interaction experience and (2) with interaction experience, percentage in the total of organizations of each category

	Industrial enterprises	Research organizations

	Not cooperating in R&D area	Cooperating in R&D area	Balance evaluation	Not cooperating in R&D area	Cooperating in R&D area	Balance evaluation
No obstacles	24%	28%	*0,08*	10%	7%	*-0,20*
Lack of information on national perspective developments	27%	18%	*-0,19*	18%	29%	*0,22*
Research organizations poorly oriented at customer needs	29%	23%	*-0,11*	21%	14%	*-0,18*
Inflated national R&D costs	24%	25%	*0,02*	23%	11%	*-0,34**
Disagreement between the quality of domestic developments and enterprises' needs	26%	22%	*-0,07*	17%	13%	*-0,13*
Lack of information about competitive domestic research organizations	18%	14%	*-0,12*	14%	22%	*0,23*
Domestic research organizations do not provide the necessary range of services	19%	13%	*-0,18*	10%	21%	*0,33*
Cheaper and quality foreign analogs	8%	10%	*0,11*	22%	18%	*-0,10*
Ineffective management by research organizations	8%	16%	*0,33***			
Negative experience of relations with domestic research organizations	7%	7%	*-0,02*			
Lack of company receptivity to innovation				19%	37%	*0,32***
Companies directly interact with specialists				17%	19%	*0,07*
The system of management of national research organizations is not adapted to interact with companies				12%	19%	*0,22*
Business's distorted view of R&D quality due to mass media bias				9%	15%	*0,26*
Number of organizations	101	121		165	175	

Highlighted are survey categories on which data are not available.
Significance of differences was tested by calculation of regression models. Significance of variable held constant 'presence of R&D contractors' was evaluated in a model where the fact of barrier mentioning by a company or research organization's administrator was used as a dependent variable. The calculation was performed for the subsample of organizations with R&D spending.
*** significance at the 1% level
** significance at the 5% level,
* significance at the 10% level;

Indeed, business and science evaluate differently the significance of various obstacles on the way to effective cooperation. For representatives of business interacting with science, the main flaws of research organizations are the inflated costs of national developments, insufficient orientation at company needs, incongruence of developments' quality and company needs. As for representatives of research organizations, they mention as barriers primarily the lack of companies' receptivity to innovation and inadequate information about promising developments, most often naming among their own drawbacks the absence of necessary range of services and the lack of adaptation of research organizations management system to interaction with companies. Finally, ineffective management in scientific institutions appears to be very important, since the significance of the barrier increases (reveals) in the case of cooperation both

among research institutions and companies.

We hypothesized that, in accordance with the Hall et al. (2001) conception, the pressure of most of the barriers decreases owing to acquisition of relevant interaction experience. This has been partly confirmed for companies: businesses cooperating with science are notably more optimistic, they regard most of the problems as less important, while the main problem "revealed"[‡‡] during interaction is ineffective management in research institutions.

A different pattern occurs in the case of research organizations: most interaction problems seem more significant to organizations conducting R&D in business interests. The main revealed problem for research institutions is the low companies' receptivity to innovation. Therefore, this issue is real (not a phantom) for researchers not to cooperate with business.

Such issues as the weak orientation of research organizations at the customer needs and the incompatibility of national developments quality with enterprise needs are apparently the only ones deterring cooperation. Those without cooperation experience evaluate this problem as more significant, both in business and science.

Information barriers remain significant: namely, the lack of information about promising developments and competitive research organizations. Because of science and business mutual ignorance, potentially successful and fruitful cooperation remains unrealized (Kaymaz, Eryigit, 2011). Interestingly, the change in significance of information barriers for cooperating among business and research organizations is counter-directed. While interacting business representatives pay less attention to information problems, representatives of research institutions who work in the interests of business, by contrast, emphasize these issues much more compared with those not interacting with business. Apparently, scientific sector organizations follow the inherent to them introversive model of behavior by intentionally avoiding advertisement of their research capabilities, causing potential clients' inability to objectively evaluate R&D market supply.

It would be wrong not to go beyond merely generalized and averaged estimates of individual problems in the activities of research organizations that impede their interaction with companies. It is known that the Russian R&D supply has a high degree of heterogeneity. The legacy of the Soviet scientific school is the survived division of science into three main branches: academic science (institutes of the Russian Academy of Sciences), industry science (public research centers, departmental research institutes, design centers, etc.), and, finally, university

[‡‡] Significance of difference in evaluation of this barrier between the group of companies having experience of interaction with research organizations and group without such experience is confirmed by the regression model.

science (high education organizations). The established system of Russian scientific complex is largely imbalanced: contrary to the world practice, fundamental research is performed almost exclusively in academic institutes, while young researchers are concentrated mainly in the walls of universities (Dezhina, Kiseleva, 2008).

Comparing sets of barriers to interaction between business and each category of research organizations makes visible subsectors' specific features (Table 5). Quite expectedly, industrial research institutes look best in terms of cooperation with business: representatives of companies interacting with this category of research organizations often point to no obstacles to cooperation; moreover, they are significantly less troubled by non-conformity of R&D quality and company needs.

Table 5. Perception specifics of cooperation barriers depending on experience of interaction with different research subsectors – frequency of enterprise executive responses

	Enterprise major R&D contractor		
	Academic institutes	Industrial research institutes	Universities
No obstacles	12%	**31%****	23%
Negative history of interaction with national research organizations	11%	5%	7%
Disagrement between quality of national developments and enterprise needs	37%	**17%*****	33%
Inflated prices for national R&D	21%	27%	27%
Cheaper and higher-quality foreign analogs	11%	8%	10%
National research organizations do not provide necessary range of services	11%	13%	20%
Research organizations insufficiently client-oriented	37%	23%	**40%****
Ineffective management in research organizations	**37%*****	15%	10%
Lack of information on promising national developments	26%	21%	27%
Lack of information on competitive national research organizations	11%	19%	13%

Significance of differences by Chi-square criterion

*** *significance at the 1% level*
** *significance at the 5% level*

Business representatives emphasize problems of ineffective management primarily in cooperation with academic institutes: probably, this is mostly due to the gap in mentality between scholar researchers and businessmen and differences in the goals of conducting research. In universities, the most common problem is significantly distorted practical motivation — they are meagerly oriented at client needs.

In this context, it is important to pay attention to a marked increase in negative

evaluations of changes in university sector situation: the panel sample share of enterprise executives who pointed to deterioration in university science reached 37% in 2012 vs. 16% in 2011. We suggest that this is the consequence of excessive overhang of rapid positive change in the university sector in general, while practical business interaction with typical universities has had rather negative demonstration effect.

The ability of business to different sorts of interaction is to a large extent determined by how companies organize *their intracorporate systems of innovation management* and their readiness to undertake specific risks.

Based on factor analysis of possible elements of corporate innovative infrastructure, we can distinguish two basic models of intracorporate innovation system in companies that can be called 'research' and 'innovative' (Table 6). The first model suggests the availability of the office of R&D Director, R&D schedule or budget, and availability of specialized relevant departments for research and development. Another model is less focused on formal R&D-related attributes and more on innovation. In particular, it involves the position of top manager responsible for innovation, approved program of innovative development, and accumulation of innovative ideas.

Table 6. Matrix of factor loadings* of elements of internal organization of corporate innovative activities

Elements of internal organization of corporate innovative activities	Component factor loading		
	1	2	3
Top manager responsible for innovation	0,115	**0,529**	-0,133
Innovation committee	0,452	0,446	-0,095
Programs of innovative development	0,147	**0,509**	-0,006
Financial incentives for innovation activities	0,040	**0,689**	0,077
Collection of innovative ieas	-0,085	**0,539**	*0,355*
R&D Director	**0,701**	-0,072	0,179
R&D schedule	**0,720**	*0,295*	-0,010
Approved R&D budget	**0,661**	*0,372*	0,034
Special R&D departments	**0,707**	-0,017	0,056
Engineering center	0,235	0,014	**0,642**
Industrial design center	-0,033	-0,012	**0,782**

*After varimax rotation

Explained variance proportion – 51%

It would seem that the research model of the intracorporate system should be complementary to the innovative model, but the practice is somewhat different. Perhaps this is a consequence of corporate tendency to interact with various research subsectors, their interest to use different types of R&D results. The analysis shows that when companies interact with

academic institutes, they display more elements of the research model, whereas when they interact with industrial research centers and design bureaus – of the innovative one. Industrial research institutes and design bureaus are better oriented at final needs of companies. They can provide a range of services, while academic institutes are able to offer advanced results which, however, require their understanding and further practical development by companies themselves, in particular, in intracorporate research departments, hence the need of special administration of such cooperation.

4. Conclusion

1. Results of our analysis show that there is an interrelation between the size of a company and the presence of counterparties to conduct R&D. Big companies have sufficient labor and organizational resources to support their cooperation with R&D organizations.

Although revealing a positive relationship between the probability of R&D outsourcing and business size confirms results of most studies in this field, the nature of relationship with company age does not quite fit into usual foreign research results. The leap in cooperative activity of Russian firms is observed in the older age group – among enterprises founded over 20 years ago whose cooperation with science is based on, among other things, traditions established in Soviet times.

Companies' R&D intensity strongly correlates with their cooperation with research organizations. Apparently, the more the firm invests in R&D, the more seriously it treats innovation, the more actively it monitors the market for the emergence of advanced products and technologies, the more susceptible to the influx of external knowledge it becomes.

An important factor of cooperation in R&D area is the level of novelty of a manufactured product: companies creating products new to their country, or to the world are more likely to outsource R&D compared to those who make products new only to their own enterprise.

2. As far as concernes cooperation activity of research organizations, large ones are significantly more likely to cooperate with business in R&D projects. The size of an organization determines its capacity to bear higher costs, e.g., constantly allocating resources to form scientific and technological groundwork and to create, develop, and maintain sustainable relationships with business. Another effect appears to be that external R&D is mainly demanded by rather big business characterized by complex and lengthy decision-making procedures. To withstand bureaucratic costs is feasible for rather large research organizations, as well as institutions having long traditions of interacting with business – it is no coincidence that young research organizations are very unlikely to be oriented at developing cooperation with business.

Private research organizations are more often involved in cooperation with business than public ones. We can suggest that former institutions initially counted less on public funding. It is also interesting that research institutions of Moscow and St.-Petersburg are less oriented at cooperation with business: probably, in the capital cities, there are more opportunities for them to obtain funds without direct business R&D-related contracts.

A common prerequisite for both research organizations' present and prospective R&D cooperation with business is sufficient academic ranking. Therefore, contrary to widespread assertions, business probably has a 'sense of value' of research proposed to it. This apparently also determines a somewhat better position of academic institutes, of which some have not only preserved but also developed their scientific and scholarly expertise.

3. Business and science evaluate differently the significance of various obstacles on the way to effective cooperation. For representatives of business, the main flaws of research organizations are the inflated costs of national developments, insufficient orientation at company needs, and low quality of developments. As for representatives of research organizations, they mention as barriers primarily the lack of companies' receptivity to innovation and inadequate information about promising developments, most often naming among their own drawbacks the absence of necessary range of services and the lack of adaptation of research organizations management system to interaction with companies.

Businesses are more optimistic about cooperation with science if they already have some relevant experience of interaction. In the case of research organizations we observe a different pattern: most interaction problems seem more significant to organizations conducting R&D in business interests. The main revealed problem is companies' low receptivity to innovation.

Ineffective management in scientific institutions appears to be very important, since the significance of the barrier increases (reveals) in the case of cooperation both among research institutions and companies.

Information barriers remain significant: namely, the lack of information about promising developments and competitive research organizations. Interestingly, the change in significance of information barriers for cooperating business and science is counter-directed. While interacting business representatives pay less attention to information problems, representatives of research institutions who work in the interests of business, by contrast, emphasize these issues much more compared with those not interacting with business. Apparently, scientific sector organizations intentionally avoiding advertisement of their research capabilities, causing potential clients' inability to objectively evaluate R&D market supply.

4. The legacy of the Soviet scientific school is the survived division of scientific complex into three main branches: academic, university, and industry science.

Industry science looks best in terms of cooperation with business: research institutes, laboratories and desigh centers significantly less troubled by non-conformity of R&D quality and company needs. Problems of ineffective management in cooperation with academic institutes are primarily emphasized by business representatives: probably, this is mostly due to the gap in mentality between researchers and businessmen and differences in the goals of conducting research. In universities, the most common problem is significantly distorted practical motivation — they are meagerly oriented at client needs.

5. Firms' cooperation ability is to a large extent dependent on their intracorporate systems of innovation management. We can distinguish two basic models of the system that can be called 'research' and 'innovative'. When companies interact with academic institutes, they display more elements of the research model, whereas when they interact with industrial research centers the innovative one is implemented more. Industrial research institutes are better oriented at final needs of companies, while academic institutes are able to offer advanced results which, however, require their understanding and further practical development by companies themselves.

6. In general, there are poorly developed links between science and industry in Russian economy, and no positive change has been discerned in recent years. We can point to particular successes in science and industry cooperation, but they are so far of a local character, and the environment itself is not conducive to their proliferation.

Regarding the problems of science-business cooperation in Russia, it is necessary to take into account specific character of the Russian R&D sector that is of extremely heterogeneous nature and is undergoing a long, multidirectional transformation. Many decisions in Russian innovation policy are dictated, among other things, by the urge to increase the contribution of R&D to social and economic development and to push the research sector into cooperation with business.

Both in business and science, we can observe the signs of a lack of sensitivity to mutual needs. One gets an impression that this is the consequence of bureaucratism of management systems and their excessive vertical linearity.

One of the most significant problems in cooperation between companies and research organizations is the principally different mentality of businessmen and scientists. It is pointless to try to change this contradiction, but it's important to translate it into a state of positive conflict. This requires state support for partnerships. However, there should be no rigid orientation at end results in the form of physical indicators: more important are the qualitative effects, the change in actors' priorities and management models.

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