Interactions between Russian Enterprises and Scientific Organisations in the Field of Innovation[1]

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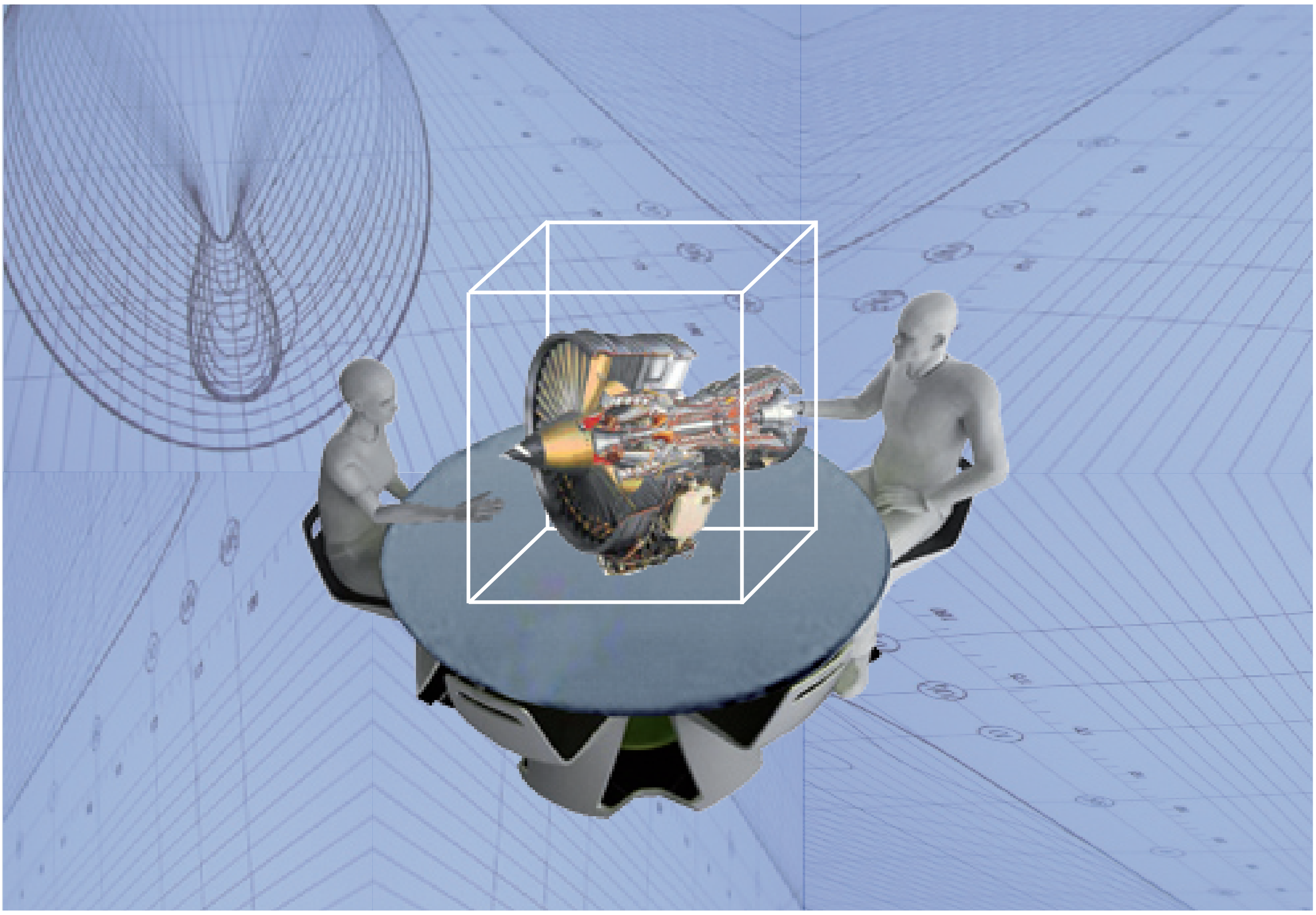

An essential element of modern economic models on the development and implementation of innovation is the various forms of interaction between stakeholders engaged in innovative activities with a view toward exchanging knowledge and technologies. The intensity and quality of this interaction becomes all the more important when assessing the level of development of innovation systems, while the embeddedness of certain organisations and enterprises in a network of such contacts shapes the long-term effectiveness and impact of their work.

This article assesses the degree of involvement of Russian innovative enterprises and scientific organisations in processes to create, transfer, and acquire technologies (including the purchase and sale of ready-made machines and equipment, and various methods to transfer intangible scientific and technological results).

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Economic theory, since its beginnings, has conceptualised national innovation systems (NIS) in various ways and focused attention on various different stakeholders or processes [*Etzkowitz, Leydesdorff,* 2000; *Arundel, Hollanders,* 2005; *Godin,* 2006; *Kline, Rosenberg,* 2006, and others]. One of the promising areas for the development of NIS (and related research in) is linked to the intensive circulation of intellectual capital in the overall production and demand system for economic and other benefits. Such circulation also directly affects subjective, institutional, functional and other measures of innovation systems (Table 1). According to current views, the efficiency of innovative development depends not only on the extent to which the actions of individual innovative stakeholders are productive when considered separately, but also on the quality of the interactions between stakeholders. The existence of developed and far-reaching networks of contacts between large- and medium-sized companies, small firms, research centres, universities, authorities, not-for-profit organisations, and others guarantees, supports and stimulates the emergence of new ideas, the generation and dissemination of knowledge, the realisation of technological opportunities, and makes it possible to count on improvements in the efficiency of knowledge transfer (circulation), the level of innovative activity, and the receptiveness of economic stakeholders to knowledge and technologies.[2]

Recent research agrees that producers and consumers of new knowledge in the real sector of the economy are emerging as stakeholders[3] in innovative activities. The primary stakeholders include:

- **Specialised structures** (research centres, higher education institutions) directly involved in R&D and providing economic actors with research, scientific and technological results (in the form of patents for inventions, know-how, ready-made technical solutions, standards, etc.) and other required data;
- **Companies** collating information on potential growth areas and engaging in innovative activity based on this in practice (production). These (directly or indirectly) provide a stimulus for R&D to be carried out (and often themselves come to carry out or participate in the R&D) and generate real demand for new knowledge.

The challenge of effectively coordinating key NIS actors – organisations and businesses engaged

Table 1. **The distribution of key NIS stakeholders in Russia according to their duties and institutional affiliation**

Type of activity / field of interaction	Institutional sectors			
	State	Market (real)	University	Intermediaries
Infrastructure / services	Elements of infrastructure supported by the state (for example, technology platforms)	Technology transfer centres (TTC), innovative technology (production) centres (ITC), coaching centres, venture funds	Affiliated common use centres (CUC) for equipment, technology cluster residents, tech cities, science and technology information organisations, etc. Innovation division, basic laboratories, technology clusters, business incubators, etc.	State organisations offering intermediary roles
Science / research and development (R&D)	Public sector science Administrative authorities regulating activities in the fields of science, technology and innovation Administrations (departments) of state special programmes	Research, project, design divisions (laboratories) at enterprises; business sector science	Higher education science sector (universities carrying out R&D) Laboratories, higher education centres which are part of research organisations and enterprises, R&D and training centres	Research associations, groups, networks
Business activity	State government bodies Public-private partnership (PPP) institutes Administrations (departments) of state special programmes	Enterprises engaged in innovative activities	Small innovative firms at research organisations and higher education institutions	Commercial intermediaries
Education and training	State government bodies, administrations (departments) of state special programmes	Corporate research institutes and training centres	Departments and centres of research organisations at higher education institutions, research and training centres Higher education institutions engaged in innovative activities (innovative educational programmes, R&D, application etc.)	
Commercialisation of knowledge	State bodies which are clients of scientific and technological results, training services etc.	Businesses engaged in the application of new technologies and innovations	Research organisations, higher education institutions involved in the transfer, commercialisation of scientific and technological results	Intermediaries in the transfer (commercialisation) chain for scientific and technological results

Source: HSE ISSEK.

[2] See: [IMEMO, SI HSE, 2008; *Drucker,* 1985; *Farina, Preissl,* 2000; OECD, 2010; OECD, 2011a; OECD, 2011b; *Gokhberg, Kuznetsova,* 2011, and others].

[3] We are talking specifically here about key stakeholders (with all the conventionalities of this term) with numerous other interested players.

[4] Of all organisations and businesses, production and processing industries and those involved in the production and distribution of electricity, gas and water accounted for 4.2%.

in R&D – is pressing for all countries. In Russia this problem is particularly acute, which is confirmed in particular by official statistical data. In 2011, 35% of Russian firms engaged in technological innovation were involved in joint R&D[4]. Of those, 46% collaborated with research centres and 28% with higher education institutions. A perceptible proportion of projects (a little less than half) were conducted in conjunction with suppliers of equipment, materials, parts, software and other counterparties. On-going interaction with research organisations was maintained by 45% of innovative companies and by 26% of higher education institutions. Closer contact on a regular basis has been seen with affiliates, consumers and suppliers of goods and services, as well as with competitors. Out of the total number of joint R&D projects carried out in the business world, 24% approached research organisations and 7% higher education institutions [NRU HSE, 2013, p.192, 204, 2013, 222, 229].

Even the low level of demand demonstrated by real sector companies for R&D results (new technologies) is not, as a rule, fully met. One reason lies in the fact that business structures either express no interest in innovative activities or are forced to implement highly ineffective imitating activities, characterised by a weak flow of generated knowledge, relatively low levels of cooperation with research structures, and an orientation primarily toward purchasing tangible technologies. Such behaviour of companies means a preponderance of non-innovative companies and 'irregular' imitators in the economy. As a result, there has been an expectedly dramatic increase in the technological dependence of Russia on foreign countries (including on direct economic competitors) and growing threats to national security [*Gokhberg et al.,* 2010].

As noted above, the behaviour of innovative stakeholders, among other things, is viewed in economic theory in the context of their involvement in the generation, application and use of new technologies and the production, based on these innovations, of modern products demanded by the markets. The present article will investigate the intensiveness and forms of involvement of Russian enterprises and research organisations in these processes, the existing factors and limitations, technology exchange strategies, and the specific features of using knowledge and technology transfer channels [*Nelson,* 1959; *Pavitt,* 1984; *Freeman, Soete,* 1997; *Marsili,* 2001; *Cohen et al.*, 2002; *Monion, Waelbroeck,* 2003; OECD, 2011a; *Gokhberg et al..,* 2010; *Zaichenko,* 2012].

Data and Analytical Approaches

We undertook our analysis using the results from a specialist survey entitled *'Monitoring the innovation activity of actors of the innovative process'*, which the Institute for Statistical Studies and the Economics of Knowledge (ISSEK) of the National Research University Higher School of Economics (NRU HSE) has undertaken on a regular basis since 2009 (as part of HSE's Fundamental Research Programme). The survey alternates between investigating research organisations engaged in technology transfer and innovative companies every two years[5].

The monitoring of the manufacturing industry and services businesses adapts techniques from integrated European research into technology levels and innovative activity in industry (the European Manufacturing Survey) and international standards on statistical measures of innovation. The survey samples more than 2,000 domestic companies [OECD, 2005; *Gracheva et al..*, 2012; *Brödner et al.,* 2009; *Kirner et al.,* 2009; *Kinkel, Maloca,* 2009].

Additionally, ISSEK-HSE has developed a unique approach to monitor the innovative activity of research organisations. Part of this research focuses on the strategies of research organisations as entities providing innovative services (resources, assets, and expertise)[6]. Despite its simplicity, similar foreign approaches are considered to be relatively fruitful [*Hales,* 2001; *Zaichenko,* 2012]. They make it possible to structure empirically observable results on activity, and to highlight and explore patterns of organisational involvement in innovative processes such as independent use of an open research base, data, libraries, R&D activity, and provision of integrated services (design, production, adaptation of means of production, trial production, etc.).

The survey covers approximately 1,000 research organisations belonging to the business science sector [*Gokhberg,* 2003], of which more than 60% have actually transferred scientific and technological results to businesses in the real sector of the economy, with roughly 39% being guided by some clearly set out (formal) strategy in a plan on innovation and demand for transferable results.

When comparing the involvement of research organisations and real sector businesses in technology exchange, significant trends have been taken into account which arise as a result of factors such as the structure and efficiency of existing development institutions, global position, the specific nature of the activities, and regulatory initiatives by the state. We note, in particular, the following:

- in each country there is a unique structure for the knowledge (technology) markets and their participants, and we see the broadening and diversification of these markets;
- traditional challenges to science and ways for clients and contractors to interact on scientific and technological work and innovation are undergoing constant and profound changes; integrated forms of interaction and network structures have been actively developed to help formulate rele-

[5] In 2009, 2010 and 2012 the survey was conducted among companies, and in 2010 and 2011 among organisations in the business science sector. The results of the research are published in [*Gracheva et al..*, 2012; *Zaichenko*, 2012; *Gokhberg et al.*, 2012; *Gokhberg et al.*, 2013].

[6] The innovative activity associated with research organisations includes operational activity (research consultancy, knowledge-intensive services, including expert appraisals, certification, trials, forecasting, etc.), engineering, the selection and maintenance of ready-made technological equipment, the creation of 'public benefits' in the form of fundamental and applied research, scientific and innovative infrastructure, small innovative firms, and others [*Oerlemans,* 2010].

vant demands and obtain ready-made solutions aligned with the market;
- there is on-going large-scale structural and functional expansion of the knowledge-based services sector making it possible to increase interaction between R&D organisations and real sector businesses to an entirely new level;
- although perceptible inter-country structural, qualitative and quantitative differences exist, general frameworks are being developed for the functioning of NIS institutions defining a universal set of typical problems (challenges, constraints) in the field of technology transfer and approaches to finding solutions.

The harmonisation of the tools used in the two surveys in terms of the generation, transfer and use of new knowledge and technologies has made it possible to identify and confirm certain factors based on empirical data giving rise to serious imbalances in Russia between supply and demand for innovations.

Innovation active enterprises

Involvement in technology exchange

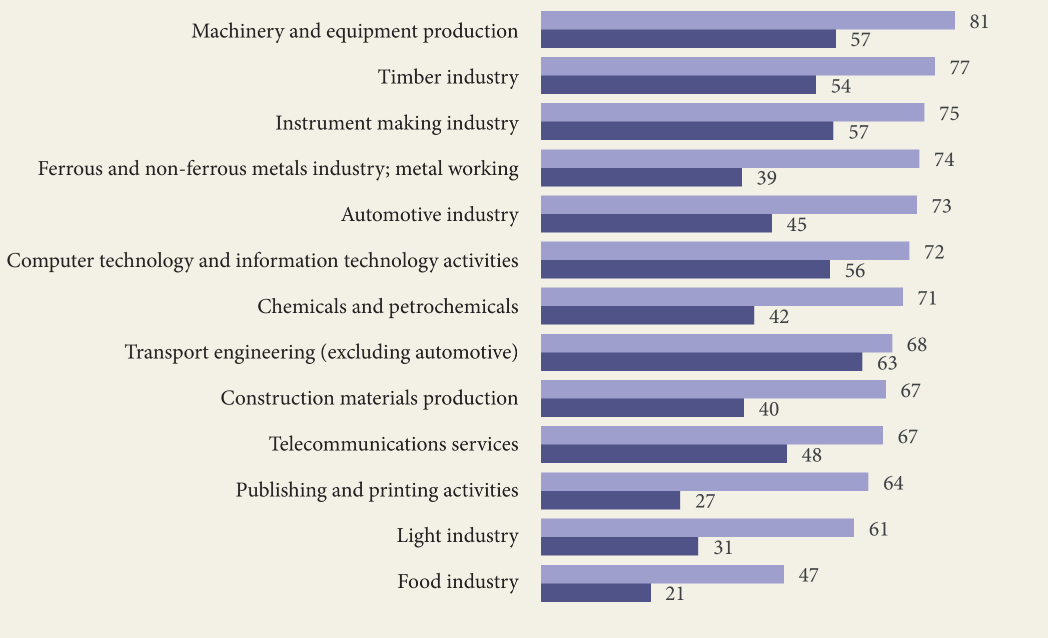
We noted above that innovative development is based on intensive network-focused interaction during which there is some exchange (acquisition and transfer) of knowledge and technologies. The survey carried out enables us to assess the intensity of businesses' involvement in such processes.

The data that we have obtained for 2012 suggest that during the development of innovations, 68% of innovative businesses in the manufacturing industry and 70% in the information and communication technology (ICT) sector turned to various forms of technology acquisition[7]. As for technology transfer, 43% of respondents in industry and 53% from the ICT sector declared outbound knowledge flows.

We found the greatest intensity in technology acquisition in machinery and equipment engineering, timber and instrument-making industries, and the lowest intensity in food, light industry, and printing industry (Fig. 1). Outbound flows of technology take place on a large scale in the transport engineering, instrument making, machinery and equipment industries. Companies in the food, light, and printing industries exhibit minimal activity here. Such a distribution can most likely be explained by the common technological and innovative level of certain sectors, the intensity of ongoing modernisation processes, the dominance of certain types of innovative behaviour, and research potential. The most balanced involvement in technology exchange is arguably seen in transport engineering, instrument making and ICT companies. These companies single out, primarily, the completeness of the innovative process (the scale and structure of the innovations) and their commitment to more modern innovative behaviour models [*Gokhberg et al.*, 2010].

Analysing the forms of scientific and technological results acquisition makes it possible to highlight certain universal patterns for all sectors. In industry two types of technology transfer are most popular – the acquisition of ready-made equipment and commercial agreements, including agreements to carry out R&D (40% of all cases of technology acquisition).

Figure 1. **Enterprise involvement in technology exchange (enterprises which acquired/sold technologies as a percentage of the total number of enterprises engaged in technological innovation by sector)**



Source: HSE ISSEK.

[7] The quaternary services sector was included in the survey. For clarity, this article will provide data on two sectors only: services using computer technologies and information technologies, as well as telecommunications. In a number of instances these two sectors have been merged together under the common designation ICT in diagrams.

Table 2. **Forms of technology acquisition**
(enterprises which used the corresponding form of technology acquisition as a percentage of the total number of enterprises engaged in technology transfer, by sector)

Forms of technology acquisition	ICT sector	Manufacturing industry	Industry with the most frequent use of this form of technology acquisition, with % of enterprises in that industry which stated use
Commercial agreements, including:			
research and development contract	33.7	40.3	Transport engineering (excluding automotive) – 79.8
invention patent	3.6	8.5	Chemicals and petrochemicals – 21.0
free acquisition	1.2	2.8	Food industry – 4.4
utility model	3.6	9.3	Food industry – 20.2
invention patent licence	2.4	3.9	Chemicals and petrochemicals – 8.3
know-how	2.4	3.8	Chemicals and petrochemicals – 13.8
trademark	10.8	9.7	Food industry – 31
industrial sample	10.8	22.8	Light industry – 35.3
engineering services	13.3	14.7	Transport engineering (excluding automotive) – 30.8
Other forms of technology exchange			
Collaboration contract	31.0	31.0	Transport engineering (excluding automotive) – 43.9
Joint research projects	13.3	13.1	Transport engineering (excluding automotive) – 36.4
Collaborative research centres	1.2	1.6	Chemicals and petrochemicals – 4.4
Technology platforms	15.7	5.3	Ferrous and non-ferrous metals industry; metal working – 20.6
Sale/purchase of ready-made equipment	37.3	40.2	Automotive industry – 72.2
Focused exchange by qualified specialists	6.0	6.0	Publishing and printing activities – 10.8
Informal means to transfer results	38.6	25.0	Timber industry – 46.3
Other	0.0	0.7	Timber industry – 2.8

Source: HSE ISSEK.

Табл. 3. **Forms of technology transfer**
(enterprises which used the corresponding form of technology transfer as a percentage of the total number of enterprises engaged in technology transfer, by sector)

Forms of technology transfer	ICT sector	Manufacturing industry	Industry with the most frequent use of this form of technology transfer, with % of enterprises in that industry which stated use
Commercial agreements, including:			
research and development contract	28.6	32.6	Instrument making industry – 57.5
invention patent	1.6	4.1	Transport engineering (excluding automotive) – 12.2
free acquisition	0.0	1.3	Ferrous and non-ferrous metals industry; metal working – 6.1
utility model	3.2	6.6	Food industry – 39.7
invention patent licence	3.2	4.0	Chemicals and petrochemicals – 11.2
know-how	1.6	3.8	Transport engineering (excluding automotive) – 12.2
trademark	1.6	2.0	Light industry – 7.2
industrial sample	11.1	14.4	Light industry – 44.5
engineering services	7.9	9.4	Transport engineering (excluding automotive) – 19.8
Other forms of technology exchange			
Collaboration contract	29	36	Transport engineering (excluding automotive) – 55.6
Joint research projects	4.8	14.0	Transport engineering (excluding automotive) – 25.9
Collaborative research centres	1.6	2.0	Food industry – 7.8
Technology platforms	17.5	4.7	Telecommunications services – 21.7
Sale/purchase of ready-made equipment	33.3	24.2	Food industry – 45
Focused exchange by qualified specialists	1.6	17.5	Ferrous and non-ferrous metals industry; metal working – 29
Informal means to transfer results	27.0	23.8	Chemicals and petrochemicals – 50.8
Other	1.6	1.2	Telecommunications services – 4.3

Source: HSE ISSEK.

For 31% of respondents these solutions were accompanied by collaboration contracts and for 23% by an obligation to develop industrial samples. 25% of respondents turned to informal methods of transfer (Table 2). Informal exchanges of results are common throughout in the ICT sector (accompanying transfer in 39% of cases). Acquisition of ready-made equipment (37%), R&D contracts (34%) and collaboration contracts (31%) are almost at the same level.

Technology transfer is provided for, primarily, by R&D contracts (33% of instances in the manufacturing industry, 29% in the ICT sector) and collaboration contracts (36% and 29% respectively), as well as sales of ready-made equipment (24% and 33%). A significant proportion of outbound knowledge flows are accompanied by exchanges of qualified specialists and informal contracts (Table 3). It is significant that, overall, during technology exchanges commercial agreements rarely include specifically formalised rights to intellectual property or provide engineering or other production-related services. In short, the timeframe for actual implementation of knowledge and technology is significantly drawn out, and the innovative process is often such that it is never completed.

The implementation of domestic scientific and technological results

We discussed above the relatively low intensity of implementation of research results in the real sector of the economy. The survey showed that 23% of innovative industry businesses and 16% of ICT sector companies have experienced successful collaboration with research centres. The leaders here are chemical industry companies (37% of which have used domestic scientific and technological results during innovative development), machine and equipment manufacturing companies, and transport engineering and instrument-making companies (Fig. 2A). The timber industry (3%) and light and printing industries are least inclined to adopt such collaborative approaches (Fig. 2A).

In describing the aims of the collaboration and the quality of the scientific and technological results obtained, industry respondents classed the level of innovation of the product and resulting production processes as follows:

- Fundamentally new, without any similar foreign products or processes – 12%;
- New and without any similar domestic products or processes – 29%;
- New for the implementing firm, but with similar products or processes among competitors – 36%;
- Improved or modified – 23%.

Telecommunications services companies described 26% of transferred results as fundamentally new, 21% as new for the domestic market, 31% as new for the business itself, and 23% as improved and modified (Fig. 2B). The metal works industry highly commended domestic scientific and technological results (with 46% seeing them as fundamentally new technologies), alongside the telecommunications industry (26%) and automotive industry (23%).

We note that in those industries where collaboration with research bodies is more intensive (chemical and petrochemical industries, transport engineering) directors' assessments were more reserved. The 'technologies without similar Russian technologies' point was picked slightly more frequently, but the majority of respondents (more than 50% in all sectors) used the results obtained to modify or improve technologies already existing in the business (or to implement technologies which were new to the business but where competitors had similar technologies). Metal work, food and light industries made minimal demands regarding the novelty of the transferred results.

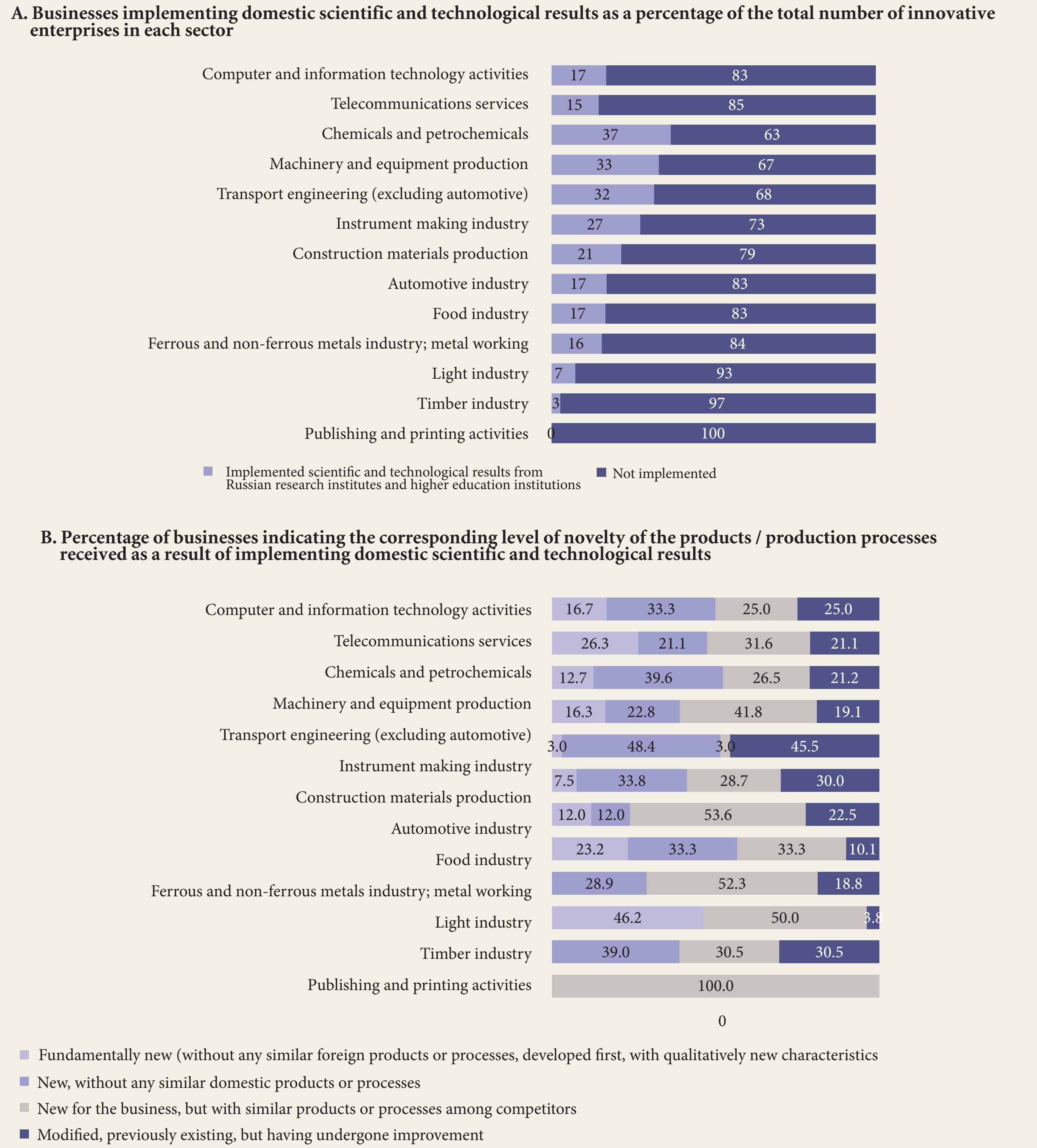
Comparing the intensity with which companies implement Russian scientific and technological developments to the developments' level of scientific novelty makes it possible to group the surveyed sectors according to the impact of the transfer (Fig. 3). We found that the experience of collaboration with research institutions has been productive for companies in sectors such as chemicals, transport engineering, machine or equipment production and instrument making. Many of these companies collaborate with research centres to obtain and implement high quality (competitive) technologies.

Companies in the food industry and building materials production industry are characterised by intensive collaboration with research which however is largely limited to orders and the acquisition of modernised imitation developments. This exhibits a combined interest in regular R&D and positive relations with domestic research organisations. Under these conditions, key constraints to dissemination are insufficient readiness of research results for implementation, inability to guarantee the claimed properties of experimental samples in real production processes, and the lack of novelty in the proposed solutions (even at the level of adaptation or modification).

A third group of companies is of interest that has relatively weak overall collaboration intensity and demands results of the very highest level. This group includes automotive, ICT, metal working and telecommunications businesses. The group could also include light industry but an excessively low level of collaboration with research bodies takes this sector outside the boundaries of the group. Companies in these sectors single out dynamic development, often based on their own designs. Traditional contact with research groups has become common. These firms value investment in R&D highly, although respondents are often convinced that they already collaborate with the most competent Russian research organisations in the relevant area. Having exhausted opportunities within Russia they are more interested – and are either already engaged in or plan to do so in the future – in searching for foreign research partners.

Companies in the timber and printing industries, the least dependent on Russian research achievements, complete the proposed ranking. These businesses do not consider it worthwhile to carry out R&D, mainly due to the long-term return on investment in such

Figure 2. **Intensity and impact of collaboration with Russian organisations engaged in R&D**



Source: HSE ISSEK.

projects. It is likely that they lack the required expertise for R&D projects. Such firms are inclined to ignore other forms of innovative behaviour except for purchasing ready-made equipment, do not link business success to innovation, and have no interest in collaborating with Russian research centres.

The results obtained strongly correlate with the intensity assessments of the dominant forms of technology exchange, as well as with earlier findings on innovation behaviour patterns in various sectors [*Gracheva et al.*, 2012].

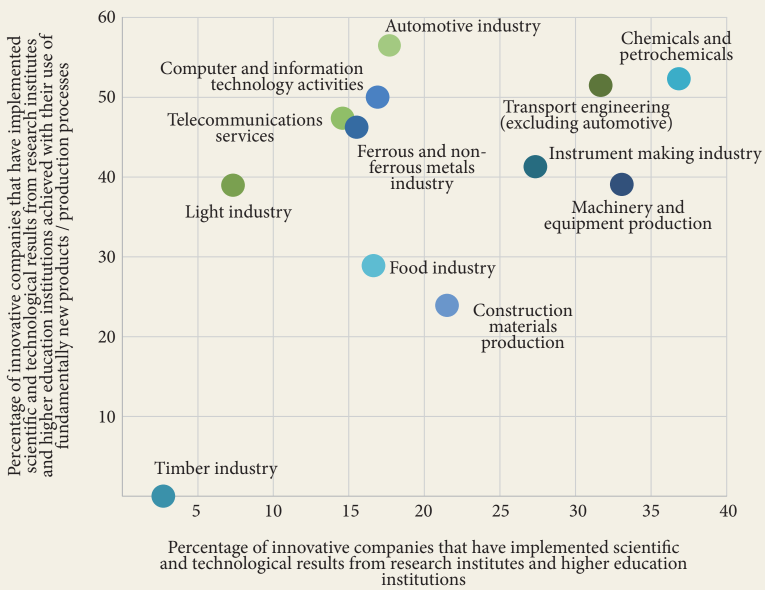
Among the main *problems faced by industries when attempting to implement domestic scientific and technological results*, respondents most frequently mentioned lack of funds (46% of companies) and high economic risk (45%), which reflects the generally hard financial position of Russian industry (Table 4). Financial constraints were noted by 74% of instrument making businesses, which have had to overcome serious domestic and foreign competition (while being heavily dependent on state support). The economic risks of implementing innovations were greatest for the metal

Table 4. **Constraints in applying domestic scientific and technological results (enterprises that highlighted the significance of the constraint as a percentage of the total number of enterprises engaged in the application of domestic scientific and technological results,** *percentage of total number of respondents*)

Question: 'Specify the main constraints to the implementation of scientific and technological results developed by Russian research organisations and higher education institutions'	ICT sector	Manufacturing Industry	Most affected sector
Inadequate management quality in research organisation	16.7	10.4	Building material construction – 34.4
Inadequate management quality in business	5.2	8.1	Food industry – 18.8
Insufficient readiness of scientific and technological results from the developing organisation for practical implementation	23.1	22.7	Automotive industry – 46.5
Lack of guarantees regarding uninterrupted operation of production based on the scientific and technological results obtained	26.6	8.1	Telecommunications services – 28.6
Inconsistency between the level of trial and experimental work at the research organisation with the latest scientific and technological achievements	5.3	10.8	Light industry – 61.0
High economic implementation risk	15.8	45.6	Ferrous and non-ferrous metals industry; metal working – 77.0
Lack of financial resources at the business for implementation	20.4	46.6	Instrument making industry – 73.8
Higher competitiveness of foreign developments	31.6	20.9	Telecommunications services – 42.9
High competition from other domestic producers of finished goods, work, services	14.8	12.5	Chemicals and petrochemicals – 20.1
High competition from new goods, work, services imported from abroad	31.3	13.1	Telecommunications services – 42.3
Legal and administrative barriers to the transfer and implementation of scientific and technological results	17.1	13.6	Building material construction – 27.2
Shortage of qualified specialists to guarantee the transfer of scientific and technological results (economists, legal specialists, manager, etc.)	0.0	9.4	Chemicals and petrochemicals – 16.0
Shortage of qualified staff (engineers, technology specialists) at business	11.5	21.7	Instrument making industry – 31.3
Lack of information on new technologies at business	25.3	6.1	Telecommunications services – 57.1
Lack of collaborative links with research organisations	10.5	4.0	Light industry – 30.5
Lack of development of innovation infrastructure	21.1	14.5	Ferrous and non-ferrous metals industry; metal working – 34.6
Legal problems relating to innovation activities as a whole	9.3	2.9	Transport engineering (excluding automotive) – 14.3
Other	4.3	10.6	Light industry – 39.0

Source: HSE ISSEK.

Figure 3. **Intensity of technology transfer and the novelty of resulting innovations**



Source: HSE ISSEK.

working industry due to its perceptible dependence on the external state of affairs. Approximately 23% of companies (46% in the automotive industry) with experience collaborating with the Russian R&D sector came up against the problem of the scientific and technological results not being sufficiently ready for practical implementation. More than 21% of respondents chose to favour competitive foreign developments (this factor is significant for 42% of firms in the telecommunications sector, 30% in light industry and 26% in the food industry). One fifth of companies (21%) cited the unavailability of qualified engineers at their businesses as a major constraint (the problem is most serious in the instrument making industry – 31%). In certain sectors dissatisfaction with the novelty of proposed technological solutions was more pronounced than average (primarily in light industry – 61%, the automotive sector – 46%, and chemistry – 28%).

The assessment of collaboration with Russian research bodies in the ICT sector was different. Here, the main constraints continue to be the high competitiveness of foreign technologies and ready-made products (significant for 31% of firms), the lack of any guarantees regarding uninterrupted production based on these technologies (26%), and the lack of awareness and information among businesses of new technologies offered by research organisations (25%).

The survey results clearly demonstrate that domestic businesses – when searching for and implementing innovative ideas – are predominantly guided by their own capabilities and internal sources of information. That has a negative impact on the quality and impact of innovation activities. Market channels relaying consumer preferences play a substantial role here. In general, the communications resources used by companies are fundamentally limited by the lack of development of the corporate research sector and the lack of a critical mass of successful innovators, in particular strategic ones. The assessments received confirm the statistical data and parameters of the innovative behaviour module for industrial companies constructed on the basis of these data [*Gokhberg et al.*, 2010]. Russian businesses show a preference for their own research divisions, whereas external research centres are assigned the role of supplying engineering and localisation services for technological innovations obtained through other channels (often through the acquisition of equipment from foreign partners). Such relationships are a clear challenge to the state regulation system. To guarantee effective interaction with companies, the questions of management and the capabilities of the research organisation to provide duly formulated research results, among other things, are of increasing critical importance.

Research organisations involved in science and technology transfers

Most research organisations involved in technology exchanges are part of the business science sector (63%). This is perhaps one of the few similarities between the Russian results transfer model from the sciences to the real sector of the economy and the model that has evolved in leading industrial nations. The prevailing organisations among these are budgetary institutions (31%) and open joint-stock companies, including those with a significant public share-holding (29%). The majority of these fall under the federal form of ownership (58%), which cannot fail to impose certain constraints on the possibilities and incentives for transferring the scientific and technological results obtained by these organisations. Organisations both involved and not involved in technology transfer do not differ significantly for the majority of parameters. The only exception is the group of organisations under joint private and foreign ownership. Here the proportion of stakeholders engaged in technology transfer is much higher – 9.2% compared with 0.9% respectively. In many ways, foreign shareholdings explain the technology transfer [*Gokhberg, Kuznetsova*, 2011; *Gokhberg et al.*, 2011].

However, what are the main factors contributing to or, conversely holding back, greater technology transfer among organisations? Here it is important to take several contrasting trends into account. First, there are the specific features governing the functioning of the research organisations themselves and the external conditions relating to technology transfer.

The organisation of knowledge transfer processes

Organisational opportunities to participate in technology transfer were assessed, among other ways, according to the presence of specialised 'innovative' divisions[8] and according to the intensity of the involvement of external structures with appropriate profiles in technology transfer. Such divisions could indeed significantly improve the conditions and effectiveness of science and technology results transfer. However, the survey showed that respondents are actively creating and using only some of their own 'innovation' divisions in the transfer process – science and technology information centres (65% of respondents), test facilities (61%), legal services (46%), scientific and training centres (43%), and patent and licensing offices (39%). There are practically no organisational units such as technology transfer centres (TTC) (less than 5% of positive responses), business incubators (2%) and others. A quarter of respondents did not have any specialised divisions to transfer the obtained scientific and technological results.

With the clear weakness of internal innovation departments, research organisations could have actively sought to involve external partners in knowledge transfer. However, here we see exactly the same set of external specialised structures involved: scientific and training (39% of positive responses), patent and licensing (35%) and information (38%) centres. The services of TTCs, business incubators, technology clusters, and engineering and marketing departments are not popular.

[8] The survey also took into account internal and external innovation infrastructure such as test facilities (test and experimental production facilities), technology transfer centres, innovative technology centres (ITCs), business incubators, small innovative businesses, common use centres (CUCs), engineering, marketing and legal services, and information, patent and licensing divisions.

An essential prerequisite for achieving competitive scientific and technological results and their dissemination across the economy is solid interaction between research organisations and other actors involved in the innovation process, as well as clear forms and channels for interaction. Implementing projects with a complex network of collaboration and within the framework of a strict formal administrative and hierarchical structure – characteristic of research in the USSR and, in part, modern Russia – has numerous obstacles. The networks themselves are not notable for their great flexibility, inherent to NIS in countries with developed market economies: 80% of respondents had collaborated with implementing businesses directly without involving intermediaries. Isolation from such networks has impeded their ability to effectively collaborate with partners and clients when developing and transferring technology. Based on the results of our survey, more than half of the respondents were completely isolated from any external network. Approximately one sixth of respondents fall under a group working on a contractual basis and just as many work as part of informal associations. Only 17% of organisations were integrated into international networks and associations.

The transfer of scientific and technological results was, in many cases, determined by their specific circumstances. Certain forms of knowledge are easier to implement in practice than others. For example, results such as publications and patents are more claims to an innovation and do not constitute suitable knowledge for transfer into the economy. In addition, scientific, technological and related services can be regarded as transfer objects. The bulk of these consist of scientific and technological information services (49%), production services (45%) and training services (42%). The proportion of technological innovative projects carried out by research organisations at real sector businesses carried out accounts for a little less than 40% of the total value of work and services, with projects linked to radical innovations representing less than 20%.

Regarding the form of technology transfer, overall, 65% of organisations in the sample lacked any administrative or organisational links with clients and conducted transfers on the basis of contracts or as part of long-term joint projects. In more than a quarter of cases, the transfer takes place between institutionally connected (affiliated) organisations. Approximately the same proportion of respondents reported interaction with external independent organisations based on one-off contracts. In 16% of cases the ties were established based on informal networks and associations.

In addition to the quality of the scientific and technological results, other factors that impact a company's decision whether or not to acquire a technology include the cost of the technology, R&D timeframe, the level of readiness for practical implementation, and the potential (where applicable) for after-sales service. Ultimately, even the most advanced scientific and technological results can prove to be uncompetitive due to high implementation costs, special requirements regarding the qualifications of engineers and technology specialists, and other reasons. To assess such situations within the context of the survey, instances were specifically analysed where there were setbacks or refusals by the implementing organisations to transfer the technologies. Such cases were reported by 18% of respondents, of which almost two thirds were caused by client refusal in connection with choosing another partner (most frequently due to lower prices) [9].

Real sector companies and research organisations engaged in technology transfer were asked to choose the most significant *constraints on the development and transfer of scientific and technological results*. It is hard to overestimate the importance of this data in terms of making management decisions on all levels. According to the respondents, four main factors interfere with knowledge development – R&D staff shortage (40% of respondents reported this), low demand from potential clients and consumers (41%), lack of modern research equipment (35%), and an inadequate experimental base (22%). It is interesting that only low demand is an external factor (and at that only in part)[10], with the rest characterised as purely internal factors. It is significant that research organisations are concerned specifically by an overall shortage of specialists and not, for example, the more private issue of their level of training. Also among the common reasons are unclear objectives from clients (15%). Evidently, these problems take on greater importance during systematic production of knowledge for transfer and close cooperation with real sector companies.

The frequency with which certain negative factors are mentioned differs according to the economic sector in which the technologies developed by the research organisation are implemented (Table 5). In particular, compared with the ICT sector, the development of new technologies for manufacturing industries is accompanied by larger-scale projects, capital-intensive and labour-intensive R&D, and so here the effect of lacking research equipment, research staff shortages and low business demand is felt much more. The ICT sector however sees a higher level of competition, intensive scientific and technological collaboration, and smaller-scale and less resource-intensive projects. The ICT market is more sensitive to factors such as the lack of development of research infrastructure, communication problems with clients and partners, and low levels of qualification among specialists.

The range of factors hindering the transfer and implementation of knowledge is considerably wider. These include various qualitative characteristics of

[9] It is significant that this reason applies only to refusals in favour of domestic partners. Where foreign competing research organisations were chosen, brand reputation was generally cited as the reason. It is possible that this is more due to an objective assessment of the situation by the respondent than due to the real motives of the client. See also Table 5.

[10] This could be due to low quality results, sub-optimal quality-price balance, depreciation, etc.

Table 5. **Constraints to the development of scientific and technological results (only for research organisations engaged in technology transfer,** *percentage of total number of respondents***)**

	Manufacturing industry	ICT sector
Shortage of R&D staff at research organisation	38.6	29.0
Insufficient level of staff training at research organisation	11.5	16.1
Shortage of modern research equipment at research organisation	35.2	25.8
Insufficient level of experimental base at research organisation	23.7	16.1
Inadequate management quality at research organisation	8.1	14.5
Low demand for scientific and technological results from potential clients, consumers	39.9	33.9
High competition from other Russian developers	8.4	17.7
High competition from foreign developers	16.8	12.9
Lack of information on new technologies	6.2	4.8
Lack of information on latest global research	4.7	8.1
Weak collaboration with co-contracting and subcontracting research	9.7	11.3
Underdeveloped research infrastructure (research information centres, common use centres for equipment, technology clusters, etc.)	14.0	25.8
Lack of clear-cut requirements from clients	17.4	25.8
Other	18.4	12.9

Source: HSE ISSEK.

the proposed technologies, as well as the activities of those demanding the technologies. One way or another, the prevailing factors reflect the specific feature of demand for scientific and technological products.

If the development of knowledge is predominantly hindered by internal problems within organisations, then the source of difficulties when it comes to knowledge transfer is as a rule, external and linked to deficiencies in clients' work and the unfavourable institutional and economic environment, among other factors. Among the main barriers (Table 5), respondents noted the lack of client funds (49%), the high economic risks associated with implementing technology (22%)[11], administrative obstacles (25%), and the ineffective nature of legal regulation (23%).

A detailed analysis (Table 6) enables us to verify that technology transfer in the ICT sector is increasingly vulnerable to a wider variety of risks compared with the manufacturing industry. In particular, ICT companies are significantly more likely to suffer from poor innovation infrastructure, innovation stimulation expenses, technological regulation, licensing, certification and other legal and administrative barriers. Moreover, in this sector there is the more acute problem of 'raw' development – a lack of readiness for implementation and a lack of guarantees for reliable after-sale operation of new products and processes.

Based on the results of the survey, a typical picture of research organisations that are involved in innovation activity comes to light, but at the same time these organisations are isolated from the outside world and have weak links with partners and competitors. Such structures do not show any interest in professional exhibitions and fairs for innovative technological achievements, are indifferent to the activities of real and potential competitors, as well as to the opportunities offered by infrastructure networks (in particular, consulting services).

Strategies and frameworks for the transfer of scientific and technological results

Approximately 70% of the surveyed organisations have an approved development strategy. The majority of these strategies involve target indicators, meaning that they are not simply aspirational documents but concrete plans for development. In this context, any announcement that R&D results are to be transferred as part of several strategic priorities (which is reflected in 41% of cases) suggests that involvement in technology transfer is perceived as a real competitive advantage and an important factor for further growth. The temporal horizon of most strategies is 4–10 years, which suggests that the goals are realistic and the approach to strategic guidelines is serious. Further analysis shows, however, that the presence alone of such strategies does not guarantee a high impact of any technology transfers.

We chose to examine using the survey data the novelty of the results transferred by businesses and research organisations for subsequent implementation. Only 12% of research organisations transferred fundamentally new (i.e. new to the market) technologies. Such a technology transfer model could conditionally be referred to as innovative (in a similar way to industry innovative frameworks [*Gokhberg et al.*, 2010]). 62% of respondents reported that they transferred R&D results allowing the business to obtain an innovation which was new for that business, while 65% mentioned technology transfers to develop modified products. These respondents form the 'imitation and adaptation' group which use an imitation framework for scientific and technological results transfers.

[11] Note that these two factors prevail in businesses too.

The transfer chain for scientific and technological results can differ in terms of the degree of complexity, can involve a varying number of links and can provide for a range of ways to link the chain together. Thus, only in 11% of cases did the client not implement the received technologies but instead transferred them to third-party organisations. The exception to this is 2% of cases when the technologies transferred to the client were not used at all.

As such, the empirical data and selected criterion (novelty) make it possible, with a certain degree of conditionality, to identify innovation and imitation approaches to the transfer of scientific and technological results. Hence the research organisations themselves can be divided accordingly into 'innovator' and 'imitator' groups. The tools used in the survey enable us to describe these groups in more detail (Table 7). The parameters for comparison were the forms of interaction with the client, the channels through which the results were transferred, the specifics of the contractual obligations, competition factors, and demand for public support and incentive mechanisms.

We should stress that the characteristics of the 'innovators' and 'imitators' are not evaluative judgements. Interest in modification technologies from Russian and foreign businesses is not lower, and sometimes there is actually more demand for totally new technological solutions. This must be satisfied by research organisations of the appropriate scales which are no less effective.

Conclusions

Summing up the analysis of the intensity and effectiveness of Russian businesses' and research organisations' involvement in the transfer of scientific and technological results, we note that both are involved in technology exchange processes in an extremely non-uniform manner. Against a relatively modest overall backdrop, it is possible to single out segments and specific organisations whose innovative activities and forms of innovation are approaching the practices of the most successful countries. The positive examples, however, do not reduce the generally acute state of affairs in technology transfer in Russia. The formation of successful enclaves in fact enhances the various imbalances of the Russian economy in areas such as the integration of research and production, product competitiveness, the labour market (pro-

Table 6. **Constraints to the transfer and application of scientific and technological results (only for research organisations engaged in technology transfer, *percentage of total number of respondents*)**

	Manufacturing industry	ICT sector
Inadequate management quality at research organisation	8.7	14.5
Inadequate management quality at implementing organisation	8.4	9.7
Insufficient level of readiness of a research organisation's scientific and technological results for practical application (need for further adjustments and modifications)	13.1	22.6
Lack of guarantees regarding reliable operation of production based on the scientific and technological results of a research organisation	11.8	16.1
Inconsistency between the level of trial and experimental work with the latest scientific and technological achievements	9.7	6.5
High economic risks of implementation	26.5	25.8
Lack of financial resources at the implementing organisation	50.5	41.9
Low innovative potential of the implementing organisation (underdeveloped innovation culture)	19.6	16.1
High competition from other Russian developers	7.2	8.1
High competition from foreign developers	17.1	16.1
High competition from other domestic producers of finished goods, work, services	5.6	4.8
High competition from new goods, work, services imported from abroad	14.6	14.5
Legal and administrative barriers to the transfer and implementation of scientific and technological results	21.8	33.9
Shortage of qualified specialists to guarantee the transfer of scientific and technological results (economists, legal specialists, manager, etc.)	11.2	9.7
Shortage of qualified staff (engineers, technology specialists) at implementing organisation	16.2	9.7
Lack of awareness among clients and/or implementing organisations about new technologies	16.8	21.0
Lack of information at research organisation on the requirements of the market in terms of new technologies	8.1	6.5
Lack of collaborative links with clients and/or implementing organisations	12.8	12.9
Lack of development of innovative infrastructure (networks of organisations offering engineering, computer, legal, consultation, intermediary, banking and other services)	14.6	24.2
Inefficiency of export, import and customs regulation (high customs tariffs on imported components and technologies, complex customs procedure, etc.)	11.5	11.3
Problems relating to legislation on technological regulation, licencing, certification	16.2	21.0
Inefficiency of legislative, regulatory and legal mechanisms to regulate and stimulate innovation activity	23.1	32.3
Other	7.2	3.2

Source: HSE ISSEK.

Table 7. **Summary characteristics of key sub-groups of research organisations according to the specifics of the technology transfer**

	Innovators	Imitators
Nature of contact with implementing organisations	Inclination for direct (without intermediaries) contact with implementing firm where there is often an independent structure (company) linked to the research organisation by means of long-term contracts. Low probability of refusal to implement.	Often work like a "conveyor belt", they do not receive any information on the future of the transferred results. As a rule, they provide results which are only new to a certain business or which are modified according to the needs of a specific client.
Form of scientific and technological results transfer	Prefer patents and know-how; actively use informal channels to transfer technology (research activities, personal contacts in research communities, etc.).	Do not transfer technologies for radically new products and services. The transfer object is often not technology, but engineering services to adapt the scientific and technological results to the circumstances and needs of a specific business.
External funding	Due to higher risks linked to creating fundamentally new technological products, they experience some difficulty in obtaining funding from the client at the pre-competitive stage of R&D.	Work with proven, 'old' technologies; risk less when carrying out R&D, which attracts clients to provide funding, including in the early stages of R&D.
Market positions	The uniqueness of designs and high quality often require organisations to have a monopoly in certain scientific and technological fields, including internationally. Often use international quality standards.	Forced to exist in harsher competitive environments, independently reach out to potential clients.
Reasons for refused collaboration	The high cost and complexity of the technological solutions to be transferred give rise to a higher proportion of clients refusing to implement the received results. However, finding a more profitable equivalent technology from a client's competitor is, as a rule, not easy and therefore refusals to implement the results on the grounds of choosing other contractors are relatively rare. Russian innovations often lose out to competitors in terms of costs, especially to overseas competitors.	The most common reason for refusal is lower price or higher quality offered by another contractor, with the quality issue often being the decisive factor. This is true for both Russian and foreign competitors.
Attitude towards public regulations and policies	Noticeably more active use of the entire range of available incentive and support mechanisms when engaging in transfer projects, which can be explained by the urgent need to offset the risks associated with developing fundamentally new technologies and a low degree of willingness on the part of the client to fund the initial phases of R&D. The most attractive are mechanisms which offset these risks as much as possible.	Support mechanisms which minimise the risks of new R&D do not offer as great an interest. The development of research and innovative infrastructure could become an urgent measure.
Involvement in networks	Inclination to technological exchange within informal networks; often transfer scientific and technological results to independent external organisations.	Involvement in network interactions is less evident.
Quality control of the scientific and technological results to be transferred	A fairly typical situation is that of a client not being in a position to monitor the quality of the results due to the fundamentally new nature of the technologies; the quality control duties shift either to the contractor or to an external expert structure.	Less inclined to apply international standards, suggesting the relatively low quality of the scientific and technological results being transferred, as well as the lack of demand for work with foreign clients.

Source: HSE ISSEK.

ductivity, salary levels), including skilled labour. The presence of organisations and businesses which are actively involved in the innovative process and which are developing, transferring and using knowledge and technologies with a high degree of novelty, as such, does not result in improved sustainability and economic growth in Russia. The effects of their activities are severely limited in terms of scale: the number of actual innovators, staff resources, and the volume of products produced and services provided are just a few of the limitations.

The empirical findings that we have obtained suggest the dominance, on the Russian markets, of technologies and high-tech products under competition frameworks which do not directly stimulate the transfer of scientific and technological results. Such frameworks also do not give rise to short- and medium-term encouragement mechanisms for all those involved in the innovative process, including research organisations and businesses. Under such circumstances, the main constraints on the development of innovative activities in industrial companies and in the services sector are the inadequacy of resources, low internal research potential, and the lack of qualified engineering staff. Only 14% of innovative industrial companies have experience in implementing domestic research results, of which 12% created – on the basis of these developments – fundamentally new products and production processes without any similar products and processes elsewhere in the world. A further 29% engaged in collaboration which enabled them to obtain a new innovative product for the domestic market.

In research spheres, alongside the lack of resources, constraints included the lack of solvent demand for R&D results, the presence of competitive foreign developments, and the low level of readiness of the developed technologies for market implementation. F

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