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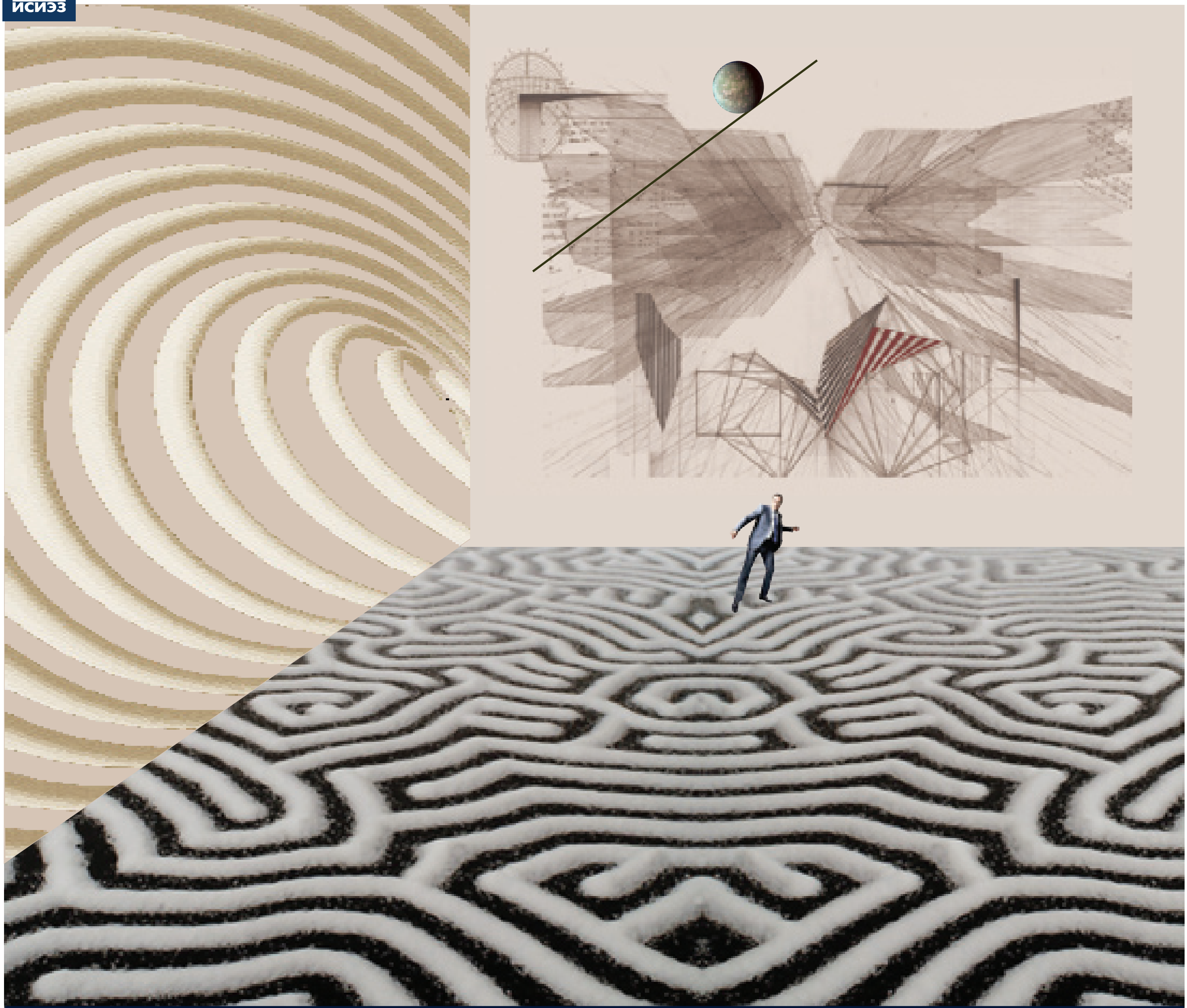

IN THIS ISSUE

Foresight-Russia

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About the journal

Foresight-Russia — a research journal established by the National Research University — Higher School of Economics (HSE) and administered by the HSE Institute for Statistical Studies and Economics of Knowledge (ISSEK), located in Moscow, Russia. The mission of the journal is to support the creation of Foresight culture in Russia through dissemination of the best Russian and international practices of future-oriented innovation development. It also provides a framework for discussing S&T trends and policies. Topics covered include:

- Foresight methods
- Results of Foresight studies implemented in Russia and abroad
- Long-term priorities for social, economic and S&T development
- S&T and innovation trends and indicators
- S&T and innovation policies
- Strategic programmes of innovation development at national, regional, sectoral and corporate levels
- State-of-the-art methods and best practices of S&T analysis and Foresight.

The target audience of the journal comprises research scholars, university professors, policy-makers, businessmen, expert community, post-graduates, undergraduates and others who are interested in S&T and innovation analyses, Foresight and policy issues.

INDEXING AND ABSTRACTING

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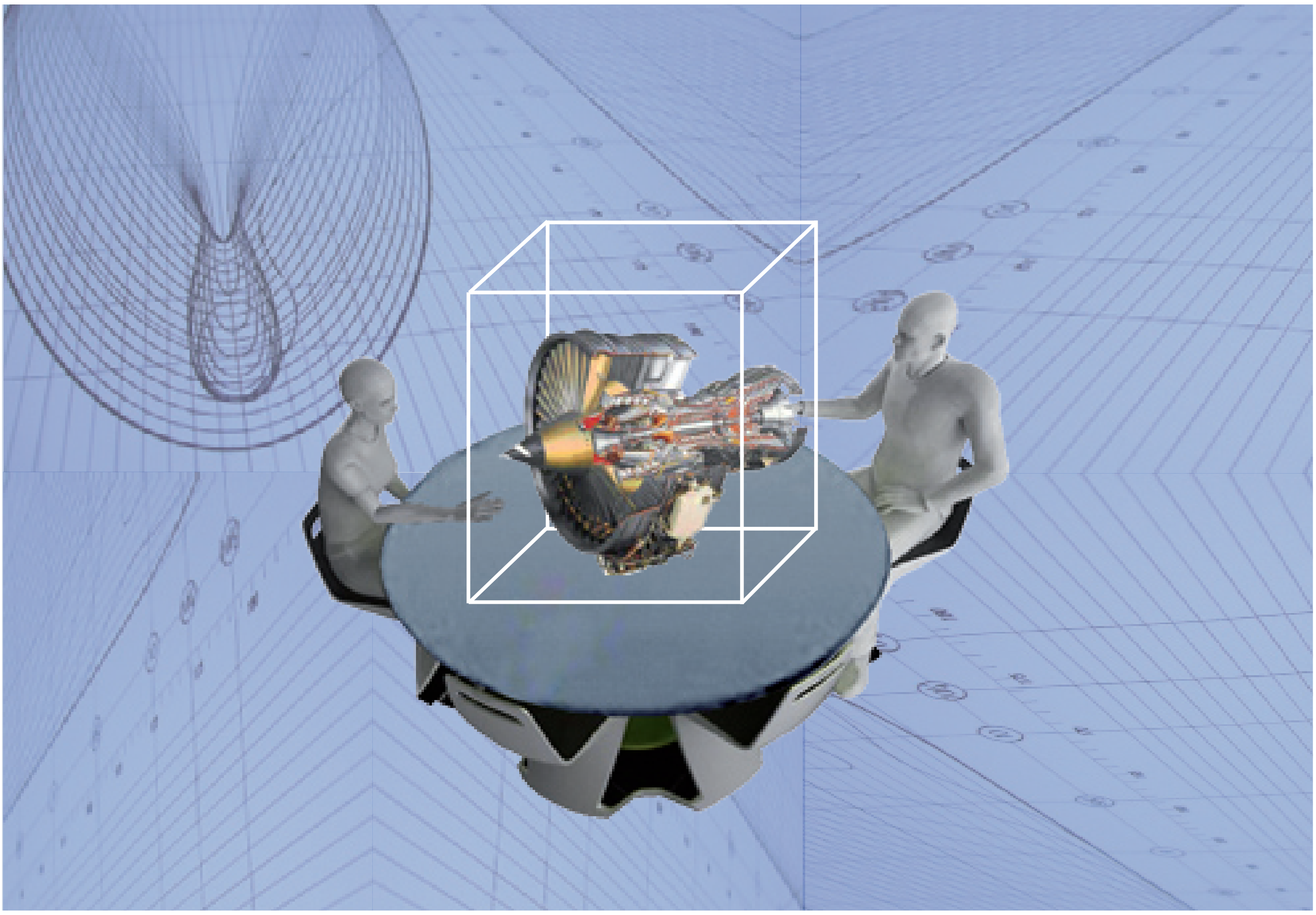
Interactions between Russian Enterprises and Scientific Organisations in the Field of Innovation[1]

Stanislav Zaichenko, Tatiana Kuznetsova, Vitaliy Roud



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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innovation activities;
innovative enterprises;
scientific organisations;
R&D transfer;
innovation;
co-operation.

[1] Research conducted in 2013 within the framework of the NRU HSE Fundamental Research Programme.

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

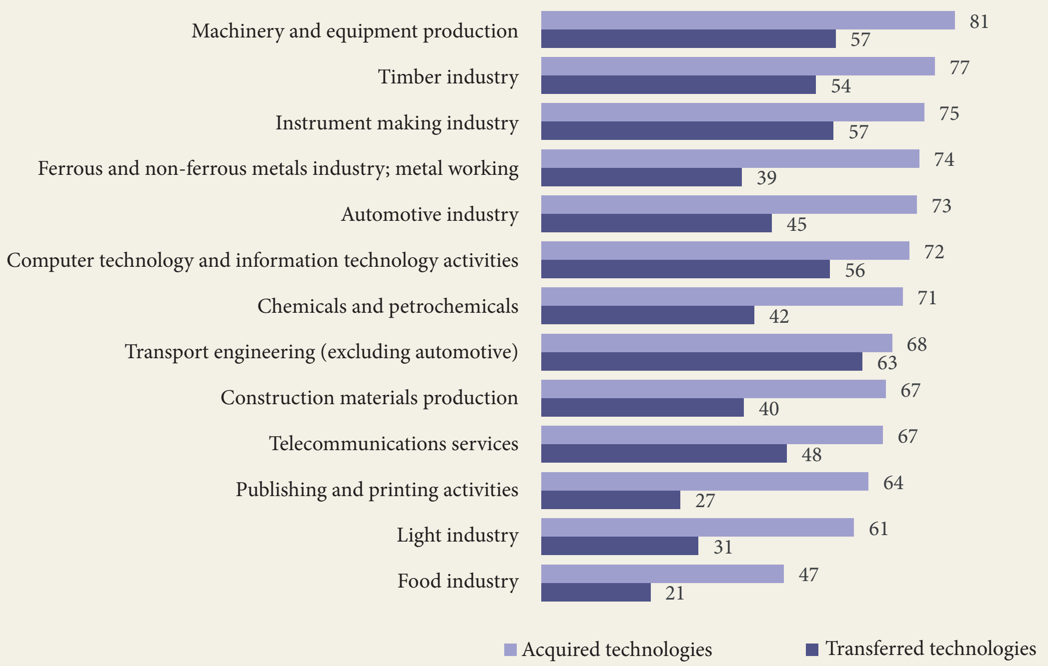
We noted above that innovative development is based on intensive network-focused interaction during which there is some exchange (acquisition and transfer) of knowledge and technologies. The survey carried out enables us to assess the intensity of businesses' involvement in such processes.

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.

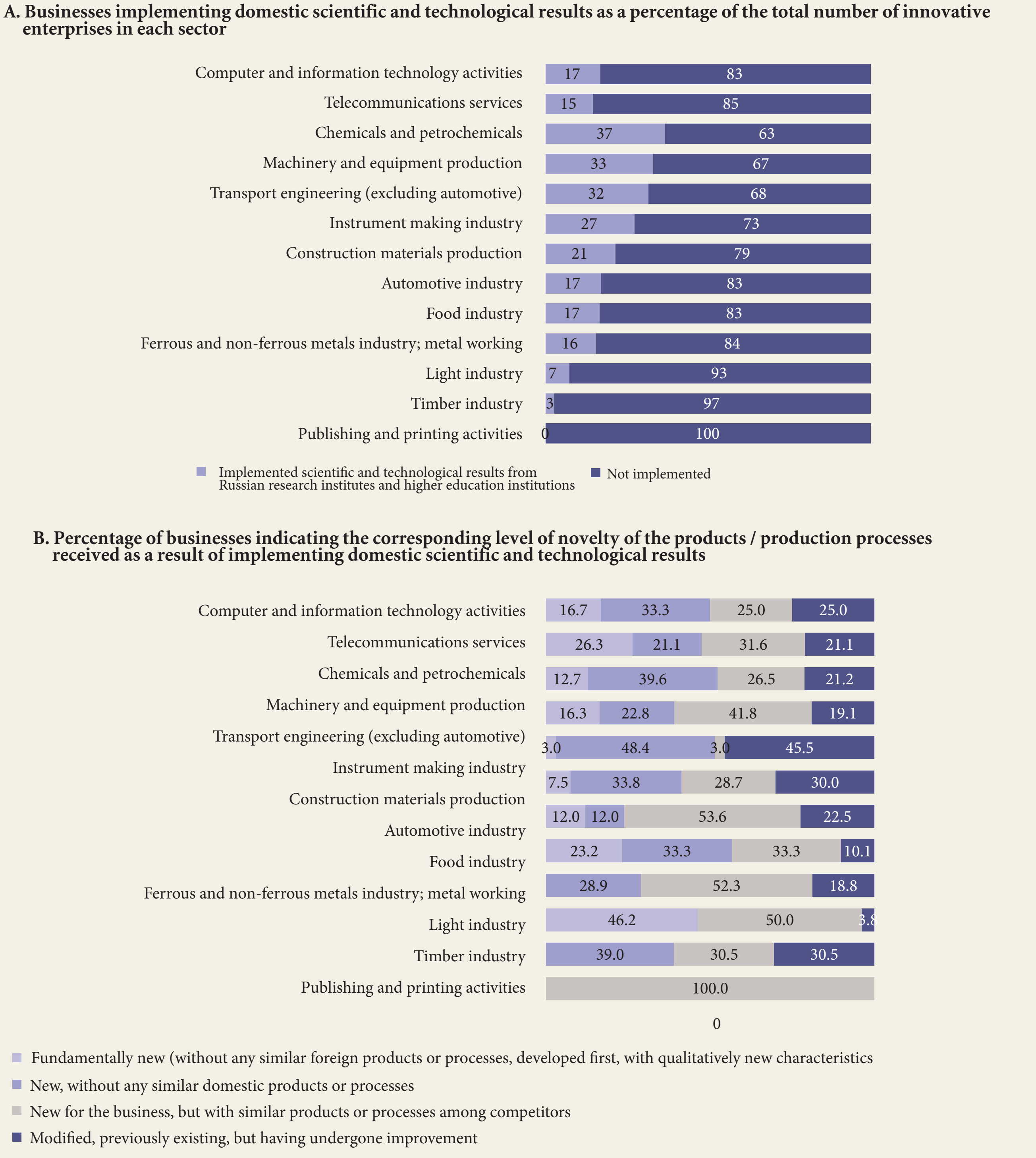
Comparing the intensity with which companies implement Russian scientific and technological developments to the developments' level of scientific novelty makes it possible to group the surveyed sectors according to the impact of the transfer (Fig. 3). We found that the experience of collaboration with 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].

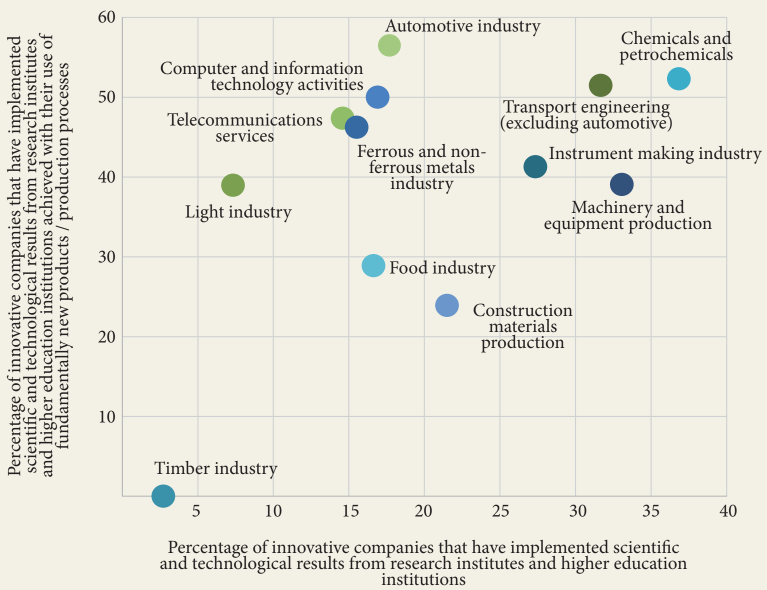
Among the main *problems faced by industries when attempting to implement domestic scientific and technological results*, respondents most frequently mentioned lack of funds (46% of companies) and high economic risk (45%), which reflects the generally hard financial position of Russian industry (Table 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.

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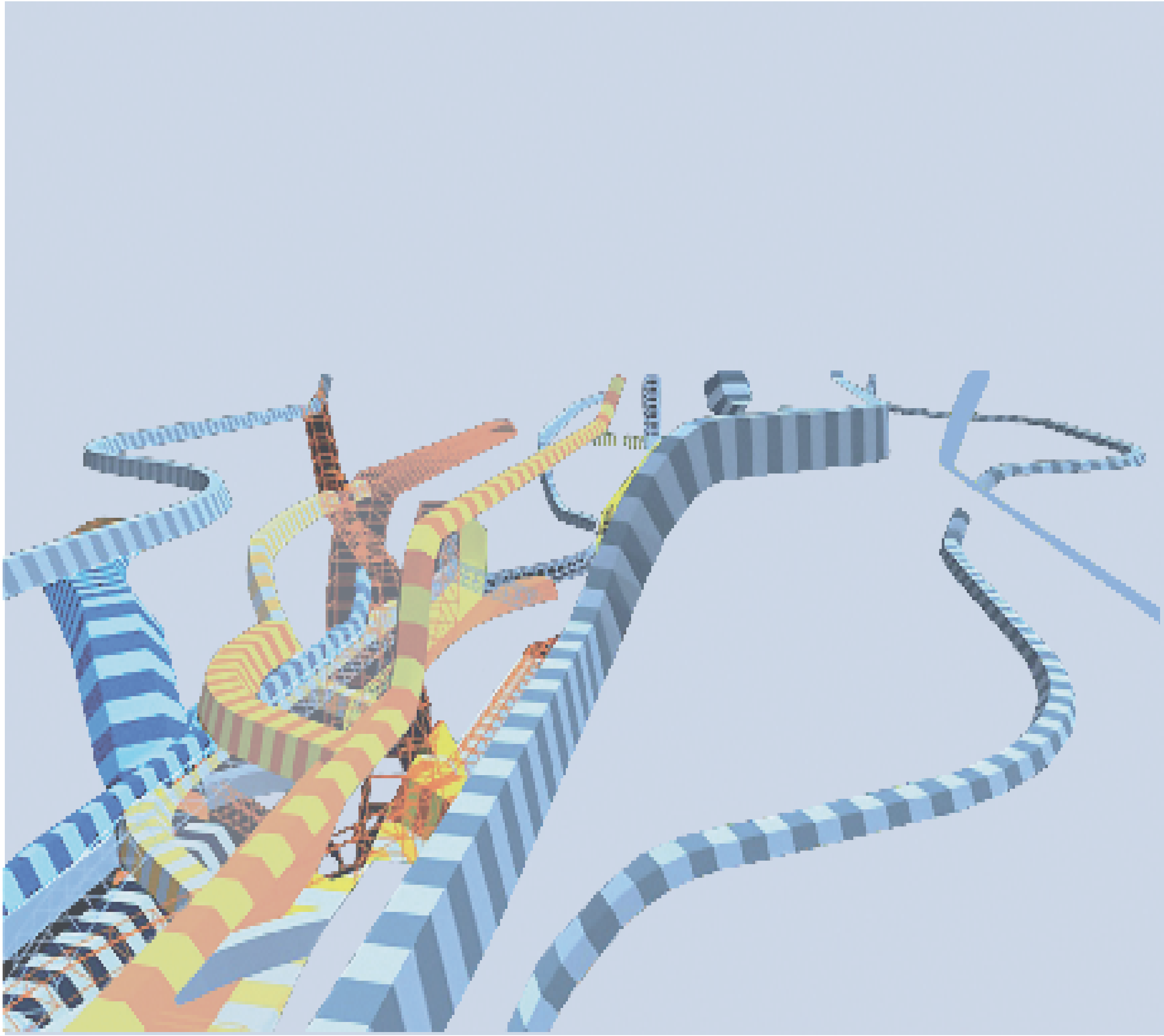
User Communities — Drivers for Open Innovation

Gunnar Prause, Thomas Thurner



This paper discusses the importance of innovation communities for contemporary innovation management. Based on a detailed literature review and corresponding industry examples, this paper suggests that user-driven innovation through tools like virtual communities, communities of practitioners and living labs will be of increased importance for future innovation processes. Of particular importance for integrating dispersed knowledge, such tools also provide very valuable information sources for strategic planning approaches like foresight.

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Role of user communities in developing innovation

Today, innovation is increasingly complex, fast, interactive, and requires the connection of external and internal knowledge bases [*Chesbrough,* 2003]. Examples for such breakthroughs are plentiful, from the light bulb to double helix DNA mapping [*Hargadon, Bechky,* 2006]. Consequently, successful innovation is the result of staged and related sub-processes. Firms acquire knowledge from a variety of sources and actors at various spatial scales, combining it with internal knowledge and competences. For this purpose, firms may maintain and use different types of interactions and transfer channels. Localized knowledge and expertise are crucial for competitiveness as innovation processes rely not only on easily accessible knowledge [*Stuart, Sorenson,* 2003; *Porter,* 2000] but also on the interplay between local and complementary global knowledge [*Gertler, Levitte,* 2005; *Boschma, Ter Wal,* 2007]. Despite the multitude of insights into technology transfer, remarkably little is known about how transfer processes are shaped by the underlying industry and its technical regimes.

The innovation management literature from its beginning started to focus on consumers as a valuable source of knowledge, which could be harvested to inform future innovation. Ultimately, they are the future buyers who could best judge what would lead to commercial success [*Jaworski, Kohli,* 1993]. Hence, more and more firms engaged in customer involvement for new product ideas which would easily be implemented and highly valued by customers [*Kristensson et al.,* 2004]. Most innovation activities focused on a handful of outstanding customers who – due to their economic weight – would be highly influential for the industry as a whole. If a solution could be developed that convinced these big players, the industry was ripe for the harvest.

A reader who engages with the literature on user-driven innovation will inevitably come across the name of one scholar: Eric von Hippel. He studied the appearances of various movements and aspects of user involvement and user innovation from the mid-1970s onwards. His impressive work focused initially on lead users, and later on innovation communities [*von Hippel,* 1976, 1986, 1988, 2005; *von Hippel, von Krogh,* 2003; *Lüthje et al.,* 2005; *Shah,* 2006].

Originally, user innovators were defined as those individuals who develop new products and services based on their own perceived needs without the assistance and involvement of producers [*von Hippel,* 1988]. In his recent research, von Hippel introduces some measures to quantify the importance of users in the innovation process and suggests that billions of dollars are spent annually by users to improve products and make them better suited to their needs [*von Hippel et al.,* 2011, 2012]. With respect to scale, von Hippel's surveys found that millions of users collectively spend billions of dollars every year on developing and modifying consumer products. In the UK, 2.9 million people (6.1% of the population) spend a total of $5.2 billion annually on this activity. In the US, 16 million people (5.2% of the US population) collectively spend $20.2 billion, and in Japan 4.7 million people (3.7% of the population) collectively spend $5.8 billion to create and modify user products for their own use [*von Hippel et al.,* 2012; *Ogawa, Pongtanalert,* 2011]. However, valuable consumer-related knowledge is widely dispersed, so hearing only one voice might in fact be of little relevance. To fully benefit from this diversity, consumers in large numbers need to be integrated which can be very challenging and expensive. Here, the rapid growth in information technology (web 2) opened new opportunities. Of great interest here are online communities.

The latter in particular has now turned into a very fruitful area of research [*Rohracher,* 2005]. Innovation from groups of users within and beyond a community has become a topic of great interest recently [*Hienerth,* 2006; *von Hippel,* 2005]. These studies often focus on user-producer interaction during the various stages of technological development. While earlier works developed well-received tools to allow companies to make use of this valuable resource, this industry focus is also one of the main limitations. This trend toward 'democratizing innovation', as von Hippel calls it, is enhanced substantially by the widespread use of information and communication technology. According to von Hippel, this trend is not only relevant for industries and companies but also for policy makers and various social groups. In 2005, von Hippel compiled this fast-growing cluster of publications in Democratizing Innovation. This is where he introduced the overarching concept of 'innovation community' defined as organized cooperation in the development, testing, and diffusion of user-initiated innovations.

Already earlier, contributions discussed the importance of diversity in innovation communities [*Shah, Tripsas,* 2004]. Colourful multitudes of people are necessary for creative potential to emerge [*Zahay et al.,* 2011]. They benefit from sharing innovation-related information and early assistance and the provision of complementary skills as these help to improve the functionality and quality of the innovations. The increased interest in the last few years to this topic cannot be explained without a deeper understanding of the advancements in mass communication and the Internet. In addition, the entrepreneurship literature discovered user innovators as an interesting starting point [*Hienerth,* 2006]. That literature suggests a certain co-evolvement of user innovation and entrepreneurship [*von Hippel,* 2005]. The emergence phase of user innovation is often spontaneous, contains elements of surprise, and initiated for fun or other non-pecuniary reasons. It can be an individual or collective act. After its birth, innovation diffuses among early-adopters, who are clustered around the inventors (users) themselves. Lead users develop new functionalities that are practical and applicable in a real life setting [*Schreier, Pruegl,* 2008]. Their strong technical expertise makes lead users also well suited to contribute original, creative ideas to new functionalities. Lead users can leverage on expertise that reaches considerably beyond specific products and markets and imaginatively apply it to new contexts [*Morrison et al.,* 2004].

Some of the most outstanding companies of today's high technology manufacturing (such as Microsoft, IBM, BMW, and Nokia) are increasingly investing in virtual communities. Other authors even suggest that more than 80% of firms listed in the S&P 500 index follow suit. Such wide-reaching changes ultimately lead to major adaption processes within the companies. However, these changes did not appear randomly; rather, they were logical developments from open systems and a focus on problem-solving [*Chesbrough*, 2003; *von Hippel*, 2005]. Virtual communities and democratic concepts of innovation also enable the SME sector to participate in open innovation approaches. SMEs usually have fewer resources for R&D relative to larger companies, which results in SMEs patenting less, registering fewer of the other intellectual property rights, and producing fewer technical innovations than larger companies. In other words, we see a positive empirical correlation between innovation activities (including product and process innovations) and company size [*Maaß, Führmann*, 2012].

Nevertheless, the German SME sector, for example, is responsible for about 20% of all German patents. By participating in virtual innovation processes, German SMEs can access open and cheap innovations activities by involving key customers and taking a global perspective [*Simon*, 2007]. SMEs rely on well developed and effective innovation processes due to the high dependency on a small number of products, especially in close cooperation between the company and its customers. With structural mechanisms mostly absent, they generate breeding grounds for non-traditional forms of innovation through knowledge sharing [*Perry-Smith*, 2006]. Faraj et al emphasize the ways in which online communities can lead to dynamic changes, such as shortening reaction times and discussing a wide variety of ideas [*Faraj et al.*, 2011]. These requirements are a strong argument for producers to adopt these innovations instead of creating them independently. However, more likely than an 'either, -or' decision, the skill lies in choosing between the right options and not to miss great ideas. The digitization of content and virtualization of interactions between firms and their user communities changes the definition of boundaries between the two, and may even modify their respective identities.

The reasons why consumers become members of these online communities and engage so actively are plentiful. First, these communities often thrive when users share developments they made largely for their own use. User-to-user sharing might not have even been intended at the time of creation. The connection here has often been analysed in the field of open source software [*Osterloh, Rota*, 2007; *Lerner, Tirole*, 2005]. Second, people are willing to join and actively participate in online communities – places to exchange ideas with like-minded enthusiasts – because it gives them a positive reputation in their community and provides a way to show their exceptional potential to prospective employers. One's standing in your community is of great interest. Both extrinsic motives (such as peer recognition) and intrinsic motives (including fun, curiosity, or support for others) can play roles. Hosting firms should however balance these motives carefully because a shift might negatively affect customer participation. In fact, studies showed that offering financial rewards might discourage many participants.

Mostly, users feel the need to advance these products to adapt them for alternative use or users (both firms and individuals), who in turn are frequently the first to develop and use prototype versions (e.g. Living Labs). Research studies have discussed how these developments could ultimately become commercially successful new products [*Baldwin et al.*, 2006; *Urban, von Hippel*, 1988; *von Hippel*, 1976, 1978, 1986, 1988]. The literature in the last two decades has seen growing evidence of successful user-driven innovation from **industrial products** [*Morrison et al.*, 2004; *Riggs, von Hippel*, 1994; *Urban, von Hippel*, 1988; *von Hippel*, 1976; *von Hippel*, 1988], **consumer products** [*Baldwin et al.*, 2006; *Franke et al.*, 2006; *Hienerth*, 2006; *Jeppesen, Frederiksen*, 2006; *Lüthje*, 2004; *Lüthje et al.*, 2005], or **new service development** [*Alam*, 2006].

Here, tacit knowledge can be generated and transmitted in virtual communities via commonly used tool kits [*Füller, Matzler*, 2007]. Von Hippel suggests firms break down innovation tasks into individual smaller tasks which the firm reassembles again [*von Hippel*, 1994]. To allow firms to harvest this innovative potential, they actively engage in creating the rules of behavior and set the stage for the exchange of ideas [*Sawhney, Prandelli*, 2000] in assisting other group members to freely share their innovations with others [*Füller, Matzler*, 2007; *Jeppesen, Frederiksen*, 2006]. The connection is two-way, as companies also provide members of their communities with their latest products and services for test purposes such as manuals or access to databases about product-related information [*Zahay et al.*, 2011]. One of the major challenges is to decide if the network should stay open or be closed. Niebuhr's results about the relationship between cultural variety and innovation present a strong argument for open networks since her research revealed a significant positive correlation between cultural varieties on innovation power [*Niebuhr*, 2010]. Open networks have the advantage of being able to access feedback from fringe groups which might not currently be in focus but which might be the upcoming mainstream, making the virtual innovation process independent of social and economic restrictions [*Prause, Hunke*, 2012]. In the case of closed networks, companies can of course pick the raisins but they also face the need to qualify as innovators [*Shah*, 2006]. Many diverse skills and previous experiences may help them to better identify potential flaws in product design.

Meanwhile, we notice a change in emphasis from the regional aspect of knowledge and innovation networks towards virtual collaboration concepts in innovation. Virtual collaboration means when ICT – supported networks of companies and institutions co-operate virtually to deploy new innovation potential by integrating third parties like external experts, suppliers, customers or user groups in the innovation process earlier in the process [*Kretschmer et al.*, 2010]. The link of virtual collaboration with virtual communities represents a many-to-many relationship for open innovation processes. Successful examples for such concepts exist in the IT sector. Such examples still have a regional link, such as the 'Living Lab BWe' case which brings together a regional knowledge and innovation network of institutions for electro mobility with current and future user groups. Interestingly, while the lead user approach maintains the boundaries between communities and firms, online communities create more fluent environments, which greatly influence knowledge production. Firms create interfaces like discussion areas for exchanging opinions and ideas and for giving advice on products or services. These interfaces allow companies to become aware of new needs and to integrate potential new uses and new ideas at the design phase. In addition, face-to-face meetings with community leaders may happen in the production processes.

Important tools for visualisation and knowledge creation are semantic knowledge maps with pointers to sources, 'tag clouds' that depict the most popular content, and advanced search functionalities to encourage knowledge creation [*Antioco et al.*, 2008]. Computer based tools like Concept Cloud, Concept Web and Correlation Wheel represent powerful methods to gain new knowledge from user feedback based on modern text analytics [*Wahl, Prause*, 2013]. One of the main criticisms which have been raised recently concerns the efficiency of user-driven innovation. The large number of infrequently participating users brings the risk of redundant information.

Industry examples

Software engineering has a strong history of user-driven innovation. Of great importance are open source communities. Here, research discussed various concepts like private collective innovation [*von Hippel, von Krogh*, 2003], commons-based peer production, as well as community-based software development [*Shah*, 2006]. One of the early examples of consumer-driven innovation is the development of software for music composition [*Jeppesen, Frederiksen*, 2006]. The architecture of such programs and applications is strongly modular, allowing users to modify, enlarge or forward source code. Central organizational units (such as Linux, Apache or Perl) ensure standardization of the development processes.

Users in the field of video games, however, have been much more active. After Atari's success in the 1970s, the introduction of cheap hardware allowed students to write their own games. Later developments like scripting language and game-oriented interfaces allowed for the development of virtual worlds such as Second Life. Here, opportunities for user-driven innovation – and virtual entrepreneurship – were endless. Second Life resembles that of the 'real world' user innovators and entrepreneurs [*Shah and Tripsas*, 2004; *von Hippel*, 2005]. This is consistent with the concept of user innovation and entrepreneurship [*Shah, Tripsas*, 2004; *von Hippel*, 2005] and the notion of consumers-as-international-entrepreneurs.

There are few examples of innovation in the more expensive and knowledge-intensive hardware sector. One remarkable project in the Dutch college town of Leiden, where a group of residents managed to develop a town wide wireless infrastructure, is illuminating. The original idea was to offer free communication for everybody. Its technical solution was unique. The initiative was so successful that in 2005 it spread to other cities, including cities in Turkey.

User-driven innovation is also becoming more important for the construction industry. Innosite, an initiative of Realdania in collaboration with the Danish Energy Agency, establishes an active innovation environment within Denmark's construction industry to enable exchange of ideas across professions and industries. The platform allows access to players from all aspects of construction, allowing property developers and companies to invite tenders for development assignments, share ideas and provide inspiration for new innovation methods. Companies can set up competitions with the help of Innosite. The users of Innosite can subsequently submit their proposals and ideas. People with ideas can register as users, put forward proposals for solutions to particular problems, and comment on other users' ideas. The company setting up the competition awards a prize to the best proposal. The main advantage of the platform lies in its potential for cost-savings by collecting and selecting ideas and solutions online rather than in a more traditional way. Moreover, problems and solutions are taken beyond their usual subject and organization-specific contexts. Open innovation platforms facilitate the involvement of users and experts in the development processes. Indeed, some of the ideas are very interesting: For example, take note of the coloured ice bricks for igloos or summer feelings in the winter city!

Examples of user-driven innovation can be found in large numbers in sports. Here, groups of enthusiasts have developed the equipment for their favourite hobby, whether kite surfing, mountain biking or rodeo kayaking [*Hienerth*, 2006]. This is particularly true for activities outside the well-funded professional activities (such as handicapped sports). For work on user communities producing innovations in sporting equipment see [*Hienerth*, 2006; *Lüthje et al.*, 2005].

For example, the snowboard was the invention of winter sport aficionados who had simply become bored with skiing. Skiing was, and remains so, desperate for new ideas to revitalize the market. The Austrian company Edelwiser, which provides personalization of skis, is a good example. After selecting the technical aspects of your equipment, you can choose the colour and design. The service is in great demand: in January 2014, their skis were sold out for the season. The same is true for skateboarding or kite surfing. In the 1990s, only about 5000 individuals participated in white-water paddling. Due to user-driven innovation, the outdoor industry participation study [Outdoor Foundation, 2009, p. 44] found around 1.2 million people paddling in white-water in 2008, representing about 15% of all paddling activities.

The sports-equipment provider Nike integrated the user-generated network niketalk (www.niketalk.com) into their strategic decision-making. The users of the platform discuss existing products of Nike and possible opportunities for improving them. The over 40,000 registered users generate millions of postings. Not only can Nike get very valuable ideas about the user behaviour, it also allows them to identify lead users.

Another area of innovation driven by lead users is medical equipment. The machinery for neuronal surgery, for example, has largely been inspired by doctors who conceived of better solutions for their precise work. Most importantly, though, are user-driven innovations applied in pharmacological substances. For example, doctors discovered that botalium-toxin could reduce muscle spasms. Users later found that it can be used to ease wrinkles. Prior research demonstrated that parents successfully engage in the development and commercialization of baby-related products [*Shah, Tripsas*, 2004]. Such users have started many international start-ups in knowledge-based industries.

Living Labs have often been established to allow user–oriented application in the context of new technologies into innovation processes, starting from the business idea to the launch of the product. The innovation process in this case was strengthened by including third party institutions and the public sector. The sustainability of these activities, product success rate, socio-economic acceptance and efficiency of innovations could improve significantly. Benefits of the living lab approach are not restricted to future users and consumers; the SME sector also gains by getting enhanced access to R&D infrastructure and integration in national and international innovation networks. The living lab for e-mobility in southwestern Germany ('Livinglab-BWe') is one example. It comprises a regional collaborative innovation network running 40 projects in e-mobility which includes about 100 companies, institutions and associations on one side, and a virtual and real community of practitioners on the other side. The involvement of users is coordinated by a special Internet platform (http://www.e-mobilbw.de) to implement low-emission and market-driven mobility with a focus on the strategic fields of market and costs, handling and comfort, and interlinked mobility. The user groups and external experts are integrated into the innovation process in regional seminars and workshops as well as by virtual links via the Internet platform.

Fashion and design are also areas of strong user involvement in innovation processes. The fashion branch above all has to renew its products at least twice a year, and hence trend scouting and the anticipation of future outfits are crucial. Polyvore is the web's largest fashion community site allowing its members to mix and match fashion items from various websites and share newly-created fashion collections ('sets') on the social network. The Polyvore community consists of trendsetters, shoppers and aspiring stylists, who create more than 30,000 sets daily, with over 6 million unique visitors and 140 million page views per month. This makes Polyvore the largest fashion community site in the world. The proposed sets of the Polyvore community can be used by SMEs working in fashion as business models by offering their own products and fashion items from other stores or websites according to the trendy outfits from Polyvore. Another option is to open your own Polyvore profile and offer the Polyvore community a chance to create outfits based on your products i.e. to use the virtual innovation power of the Polyvore community in fashion. Such a business model offering the creative power of virtual communities based on the large sale of standard products has already been realised by larger companies as well as by new start-ups. The largest European mail order trading company 'OTTO Versand' from Hamburg tried to establish its own Fashion Community, based on their own product; so far, it has had only limited success because only around 700 members are linked to the community. The furniture company IKEA has been more successful, with its own community of fans who bring innovative solutions and make proposals for further development of IKEA products. Besides the direct activities of the large retail company IKEA, many new start-ups were created which offer applications and modifications to existing IKEA standard products such as fancy cushions for sofas or add-ons for standard IKEA tables and boards. In this sense, the products and creations offered play the same role as the well-known 'Apps' in the smart phone business.

Conclusions

Developments in communication technology have enabled new forms of user integration into innovation processes. Virtual communities, communities of practitioners and living labs are examples of how to integrate the dispersed knowledge of users into strategic decision making. In the field of complex and dynamic socioeconomic technologies in particular, the use of virtual communities is a powerful tool to safeguard user oriented and accepted new technologies. New developments show that blended solutions combining living lab concepts with virtual communication, seminars and workshops allow for new levels of open innovation activities. The classical one-to-many approach where one company involves a group of users in the innovation process is changing towards a many-to-many situation where collaborative innovation networks of companies and institutions are trying to involve virtual communities into the innovation process. This development recognises cluster aspects as well as the complexity and interdisciplinarity of new R&D fields related to sustainability and multimodality. Collaborative innovation approaches also enable the SME sector to be integrated into the complex open innovation concepts which is of specific relevance for economic development.

The knowledge generation of inputs from virtual communities is facilitated by new analysis and data mining tools which make it easy to visualise and detect structures in virtual communication. Computer based tools like Concept Cloud, Concept Web and Correlation Wheel gain new knowledge from user feedback based on modern text analytics.

Increasing man-machine interactions promise much innovation potential if companies succeed in better integrating real life conditions into technical innovations. Early integration of user needs into technical innovations can make people accept and want new products and services more, especially when mobility is complex and dynamic. F

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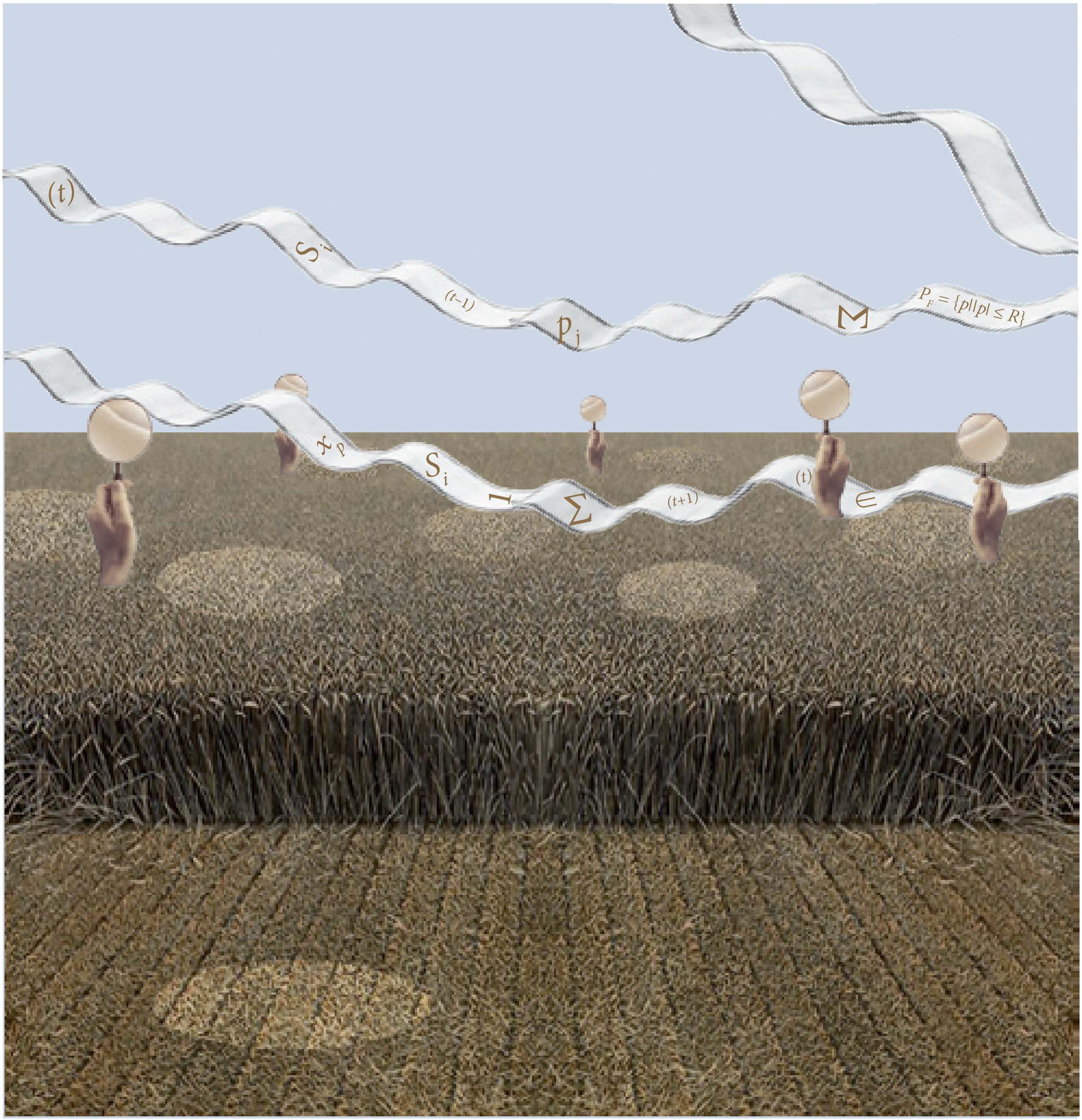
Patent Activity in Biotechnology

Ekaterina Streltsova



The significance of biotechnologies for solving global problems and making social and economic progress is recognized in many countries, including Russia. Managing this field requires up-to-date and reliable information about technological trends and the emergence and diffusion of innovations.

This paper examines the possibility of applying a patent-based methodological approach to the study of biotechnologies in Russia, and assesses its explanatory potential.

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patent classification;
patent analysis;
patent activity.

Today developing biotechnologies, expanding the market for biotechnological products, and increasing demand for biotechnologies are among government priorities in many countries. For example, in the United States, which represents the largest market for biotechnologies in the world – both in terms of the volume of investments as well as the scale of production [Ernst&Young, 2013] - the federal and local governments are stimulating scientific research and production in this field, for years establishing special tax treatment for biotechnology organizations, promoting the creation of technology parks and venture funds, and providing guarantees for loans [*Butcher*, 2009]. Canada has taken a number of measures to attract venture capital (including foreign venture capital) for developing biotechnologies [*Gwynne, Page,* 1999]. In European countries, six of which (France, Spain, Germany, Great Britain, Switzerland, and the Netherlands) are among the ten global leaders in terms of the number of biotechnology organizations [OECD, 2011], strategic significance is now given to building bioeconomics, based on a more rational and efficient utilization of resources, with the application of biotechnologies [European Commission, 2012; Horizon 2020].

In Russia, individual groups of biotechnologies are included in the list of critical technologies (bioengineering technology; genetic, proteomic, and postgenomic technologies; biocatalytic, biosynthetic, and biosensor technologies)[1], and the overall development strategy is given in Program "BIO – 2020" [BIO – 2020, 2012].

Such attention to the field of biotechnology is associated with its role in solving large-scale challenges in ecology, energy, and public health. Biotechnological innovations have a revolutionary impact on the development of pharmaceuticals and medicine, particularly methods to prevent and treat such socially significant illnesses as Alzheimer's, tuberculosis, diabetes, cancer, and HIV [*Rao*, 2012]. The use of biotechnologies makes it possible to raise crop yields, animal productivity, and food production, which are especially important in a context of constant global population growth. The development of biotechnology also favorably influences the environment, reduces the negative effects of humans on the environment, and helps eliminate the consequences of manmade disasters and pollution of the soil, water, and atmosphere.

The realization of these biotechnology possibilities as well as the impressive investments in their development require the creation of a well-grounded approach to regulating this field and adoption of balanced management decisions, which is impossible without complete and reliable information about its current state, particularly the factors preventing further progress. Two questions inevitably arise when addressing this matter. First, how can we best define the object of analysis? Second, what are appropriate methods to study the object of analysis? This paper proposes potential answers to these questions: it attempts to outline the boundaries of the biotechnology field and describe a methodology for its study using patent analysis. As a result, it has become possible to assess the technological trends that reflect the long-term picture of the biotechnology field in Russia.

The biotechnology field: what is it?

The starting point for the development of a methodology to analyze the state of this field is a clear understanding of the term "biotechnology," which in turn serves as a criterion for a subsequent survey of observations and the assignment of objects (organizations, scientific research results, goods and services) to biotechnology categories. This procedure is a matter of principle: Research conducted by Canada's national statistics agency (*Statistics Canada*) has shown that the results of statistical surveying of the biotechnology field change dramatically even with insignificant changes in the definition being used [*Chaturvedi*, 2003].

The concept of "biotechnology", encountered everywhere today and repeated in many publications and government documents, has a multitude of meanings (Table 1). A basic definition understandable to readers who are not experts in the field can be found in any encyclopedic dictionary: biotechnology is the

Modern biotechnologies and the method of recombinant DNA

The phase of active development of modern biotechnologies began in 1973 after the development of recombinant DNA technology by Herbert W. Boyer and Stanley N. Cohen [*Demaine, Fellmeth,* 2002]. Its main purpose - to transfer to a host organism characteristics that are inherent to a donor organism by isolating a gene from the donor's DNA and recombining it in vitro in the host organism's DNA and then integrating it in its cells [*Hughes,* 2001]. The creation of insulin was the earliest achievement of recombinant DNA technology: previously diabetes patients were treated with insulin extracted from the pancreases of cows or pigs; the recombinant technology made it possible to isolate the insulin gene from human DNA, transplant it into plasmids, and then introduce the altered plasmids into microorganisms capable of producing insulin. This made it possible to obtain a large amount of insulin from colonies of such microorganisms at a significantly reduced cost. Other achievements of recombinant DNA technology include the creation of several types of interferons required to treat cancer and leukemia, the synthesis of human growth hormone to treat pituitary dwarfism, etc. It is worth noting that the use of recombinant DNA technology is not limited to the medical and pharmaceutical fields – it also finds application in agriculture and industry [*Ko,* 1992].

[1] List of Critical Technologies of the Russian Federation (approved by Order No. 899 of the President of the Russian Federation of July 7, 2011).

Table 1. **Basic definitions of biotechnologies**

Biotechnology is a collective noun for the application of biological organisms, systems or processes to manufacturing and service industries.
• Integrated use of biochemistry, microbiology, and engineering sciences in order to achieve technological (industrial) application capabilities of microorganisms, cultured tissue and parts thereof
• A technology using biological phenomena for copying and manufacturing various kinds of useful substances
• The application of scientific and engineering principles to process materials by biological agents to provide goods and services
• The science of the production processes based on the action of microorganisms and their active components and of production processes involving the use of cells and tissues from higher organisms. However, biotechnology is not a separate scientific field. Rather it combines the effects of microbiology, biochemistry, molecular biology, cellular biology, phytobiology, immunology, protein engineering, enzymology, mammalian cell culture, and other sciences
• Really no more than a name given to a set of techniques and processes
• The use of living organisms and their components in agriculture, food and other industrial processes
• The deciphering and use of biological knowledge
• The application of our knowledge and understanding of biology to meet practical needs

Source: [OECD, 2005].

application of biological processes for industrial and other purposes, chiefly to perform genetic manipulations with microorganisms during the production of antibiotics, hormones, etc. [*Stevenson, Waite*, 2011]. The term "biotechnology" is often used as a synonym of genetic engineering, which is an unqualified error. In reality, it encompasses an entire array of methods and processes associated with the use of biological material (amino acids, peptides, proteins, fats, fatty and nucleic acids, cells, and microorganisms) for various purposes [*Rudolph*, 1996].

Consequently, many experts assert that the concept of "biotechnology" does not exist and that the only correct solution is to use the plural form of the word – "biotechnolog*ies*". To speak of the biotechnology industry as a separate sector is also erroneous – biotechnologies find application in various fields: food production, pharmaceuticals, forestry, and more.

Obviously, the basic definition we have considered is inadequate for analytical purposes because it does not allow us to separate biotechnological developments and products from objects belonging to other fields. This problem is solved by internationally-accepted single and list-based conventional definitions of biotechnologies recommended by the Organization for Economic Cooperation and Development (OECD) for conducting statistical surveys [*Gokhberg*, 2012]. According to the single definition, biotechnologies are the sum total of the approaches and methods of applying science and technology to living organisms as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services [*OECD*, 2005]. This definition has been intentionally expanded. It encompasses not only all modern forms of biotechnologies but also many types of activities - traditional and transitional - that are gradually transforming under their influence. The list-based definition supplements the general definition, unfolding the field's subject matter and detailing it based on groups of biotechnologies (Table 2). Such an approach allows us - in a first approximation - to mark out the boundaries of the biotechnology field and operationalize the basic definition for the purpose of statistical measurement and analysis [*Gokhberg et al.*, 2013].

Statistical surveying in the biotechnology field

The first attempts at economic and statistical analysis of the development of biotechnologies took place in 1980, when scientific and technical investigations in this field were undertaken [*Gokhberg et al.*, 2013]. Ten years later, the national statistics agencies of Canada, New Zealand, and France conducted special investigations of industrial organizations whose activities were related to the development and use of biotechnologies [*Ibid.*]. At present the most widespread practice (in many countries including Australia, Great Britain, Germany, Israel, Italy, and Canada) is statistical inquiry, using a methodology developed by the OECD. The methodology's units of observation are biotechnology firms[2] that provide information about all aspects of their activities: specializations within the biotechnology field; the amount of internal expenditures on research and development related to biotechnologies; the productivity, number, and structure of employees, scientific and industrial collaboration, etc.

Statistical inquiry requires significant resources of time and money. Above all, this is a result of the search for and selection of biotechnology firms, which are extremely difficult challenges because they are not assigned to an independent category in existing classifications of business activities: biotechnologies may be developed and used by organizations belonging to different sectors, and identifying them is a methodological problem that lacks a concrete solution due to the very nature of biotechnologies as an inter-industry and interdisciplinary ("horizontal") technological field. Additionally, biotechnology companies are often small firms, many of which are startups and not included in standard statistical measurements. These circumstances greatly complicate the search for and

[2] Biotechnology firms («biotechnology-active firms») are enterprises and scientific organizations whose activities include the development and/or use of at least one biotechnology (according to the list-based definition considered above) to produce goods and/or provide services and to perform scientific research and development [*OECD*, 2005].

Table 2. **List-based definition of biotechnologies**

Biotechnology group	Subject matter
DNA/RNA	Genomics, pharmacogenomics, gene probes, genetic engineering, DNA/RNA sequencing/synthesis/amplification, gene expression profiling, and use of antisense technology
Proteins and other molecules	Sequencing/synthesis/engineering of protein and peptides (including large molecule hormones); improved delivery methods for large molecule drugs; proteomics; protein isolation and purification, signaling, identification of cell receptors
Cell and tissue culture and engineering	Cell/tissue culture, tissue engineering (including tissue scaffolds and biomedical engineering), cellular fusion, vaccine/immune stimulants, embryo manipulation
Process biotechnology techniques	Fermentation using bioreactors, bioprocessing, bioleaching, biopulping, biobleaching, biodesulfurization, bioremediation, biofilteration, and phytoremediation
Genes and RNA vectors	Gene therapy, viral vectors
Bioinformatics	Creation of databases of genomes, protein sequences; modeling complex biological processes, including systems biology
Nanobiotechnology	Applies the tools and processes of nano/microfabrication to build devices for studying bio systems and application in drug delivery, diagnostics, etc.

Source: [OECD, 2005].

sampling of responding organizations. In a number of countries belonging to the OECD, special registries of biotechnology firms are being created, which are periodically updated and added to. They are based on different sources of information, including materials from foundations and programs supporting science and innovation, tax agencies, business associations, etc. However this does not guarantee completeness, relevance for the purposes of the statistical survey (possession of the characteristics of a biotechnology firm), or representativeness (representation of all groups and categories of such organizations).

In Russia, efforts to develop registries of biotechnology firms began relatively recently and are fragmented and uncoordinated. The cost of these efforts justifies a search for other ways to investigate the field. One such alternative approach is patent analysis, which makes it possible to assess the present state of biotechnologies in Russia and the direction of their technological development.

Methodological principles of patent analysis in the biotechnology field

Analysis of data about patent activity has traditionally been used as one of the most important approaches to evaluating the level of technological development, both overall as well as in individual areas [*Schmoch, Rammer, Legler*, 2006]. As a type of document granted to protect the results of scientific and technical activities, a patent secures for its holder the priority, authorship, and exclusive right to use the corresponding object of intellectual property, thus guaranteeing the opportunity to receive a reward for the investments made in creating the asset. Neither can we disregard the significance of patents as a unique source of technical information [*Gokhberg*, 2003]. Thus, patent statistics (for example, the number of patent applications or patents granted) may be considered a reflection of the actual level of inventive activity in various segments of the technology market. In view of several circumstances, such an approach is entirely justified to assess trends in the development of biotechnologies.

Due to the very nature of biotechnological innovations, the most widely used method of protecting the associated intellectual property is specifically by securing a patent; alternative strategies are not widely employed here. For example, a significant portion of inventions in biotechnology relate to medicine; as a result releasing products requires a detailed list of their ingredients, which makes it impossible to maintain a trade secret. Rapid production is not effective either: in many instances such products are experimental and are produced in small batches, which in the event of premature disclosure of information allows competitors to release an identical product in a short period of time. Advertising, which in other sectors helps increase trust in the manufacturer and gives it a certain advantage over its competitors, by no means always produces the desired result here: groups of consumers of biotechnological products (especially in such narrow fields as cosmetics, maritime biotechnologies, and bioenergy) are highly specific and rely not so much on brand trust as on technical knowledge and product quality.

Analyzing the state of the biotechnology field in Russia using patent analysis undoubtedly has both merits and shortcomings. First, the use of patent documents not only makes it possible to receive aggregated quantitative data that characterizes the overall level of inventive activity but also to explore its qualitative characteristics. Integrating quantitative and qualitative methods makes it possible using public information to identify the most active players in the biotechnology market. Such information is of fundamental importance here: a patent establishes a monopoly on individual strands of DNA, genomes, and testing methods, which will be required to realize much future research and many innovations in biotechnology (above all in medicine). In particular,

Transformation of the intellectual property protection system under the influence of the development of biotechnologies

The classical system of level protection of intellectual property, which arose back in the 19th century, excluded the ability to patent the results of scientific and technical activities created using living organisms [*Demaine, Fellmeth,* 2002]. However, the fast-paced development of biotechnologies in the 20th century led to a significant transformation of the system, resulting in the fact that today most countries (including Russia) provide for protection of objects created using biotechnologies.

The system was created in three stages. In the first, which began in the 1930s, inventors gained the ability to patent the genomes and DNA chains of plants. In the second stage, whose beginning is linked with the Diamond vs. Chakrabarty trial [*Ko*, 1992], legal protection was extended to the genomes and DNA sequences of bacteria, animals, and other living organisms, which triggered research into DNA replication. Only relatively recently did scientists gain the ability to patent human DNA sequences, while maintaining the prohibition on patenting the entire human genome or any other anthropomorphic being.

in the United States several hospitals have abandoned researching mucoviscidosis (cystic fibrosis) because the cost of payments to the private company that holds the patent on the gene that determines this disease is too high [*Demaine, Fellmeth*, 2002]. A similar situation occurred with the perinatal test for Down Syndrome because the size of the royalty to the patent holder for the "trisomy 21" gene far surpassed the amount of expected compensation from Medicaid program [*Ibid.*]. Thus, the degree of monopolization of the market and the determination of the main players acquire special importance when analyzing the development trends and prospects of the biotechnology field.

Additionally, analyzing the content of patent documents identifies areas of active technological development and - at least indirectly - makes it possible to assess the quality of the innovations produced using information about the patenting of domestic inventions abroad and the proceedings to transfer the corresponding rights to foreign organizations.

The most significant shortcoming of focusing exclusively on patent information when studying Russia's biotechnology field stems from the quality of available patent information. The public registries of the Federal Service for Intellectual Property (Rospatent)[3] were designed primarily for patent search and identifying technological niches; they are poorly suited to analytical research. The registries can only be searched based on one of three criteria - registration number, publication date, and the International Patent Classification (IPC) code. The information system does not provide the ability to combine them. Search results are presented as a list. Each item is contained in a separate file, so processing the information requires a significant amount of time and effort, including calculating all the quantitative indicators by hand.

Many commercial databases, which aggregate information from the world's major patent offices, provide access to the original patent documents for content-based analysis and - simultaneously - provide the ability to automatically calculate the required indicators. We used one of them, Orbit[4] (formerly "QPat") for our empirical research. The Orbit database enables targeted searching thanks to the ability to combine more than ten search criteria. It also has built-in descriptive statistics tools. However, the filters applied by the system have serious defects as they produce search results with invariably items unrelated to the specified criteria. As a rule, these errors represent at least 40% of the search results, which necessarily affects the quality of the output.

The most reliable source of quantitative data is the World Intellectual Property Organization's (WIPO) database, which contains aggregated data from all national, regional, and international patent offices.[5] However, it lacks access to the actual patent documents and the database itself is updated quite slowly (information about countries' patent activity in 2012 was only added in early 2014).

The need to simultaneously use several sources due to the shortcomings of each has a negative effect on the comparability of the resulting information and calculations. In order to minimize this effect, resources from multiple databases and registries were used simultaneously when sampling and analyzing the information. For an objective assessment of the overall level of patent activity in the biotechnology field in Russia, we relied on data from Rospatent and WIPO resources. Rospatent's public registry of inventions and the Orbit database served as the empirical foundation for content-based analysis targeted at studying more detailed, high-quality attributes.

Besides the problems with the access and the quality of the patent information, another shortcoming of the proposed methodology is that it does not allow other indicators typical of the biotechnology field to be assessed such as attributes related to the personnel, material, technical, and financial resources of biotechnology organizations, production volumes, exports, etc. As mentioned above, because organizations can also use other methods to protect created technologies, the statistical information obtained in the patent database about the volume of intellectual property created will be incomplete. Finally, the ad-

[3] Available at: http://www1.fips.ru, accessed 27.01.2014.

[4] Available at: http://www.orbit.com, accessed 15.01.2014.

[5] Available at: http://ipstatsdb.wipo.org, accessed 07.12.2013.

opted methodology makes international comparisons hard. Nevertheless, we believe that by acknowledging the indicated limitations the selected approach satisfies the goals of our research.

When studying the state of the biotechnology field using patent analysis, the ability to identify patents (and consequently, inventions) related to this area of technology plays a paramount role. The classifications used by the world's major patent offices (EPO, USPTO, JPO) do not have a unified category or class for biotechnologies.[6] Selecting relevant patents requires consulting the *Technology Concordance Table* developed by WIPO for cross-country comparisons.[7] The classification serves as a kind of intermediate key, dividing the IPC classes and groups into areas of technology (the Technology Concordance Table identifies, among others, areas such as "Audiovisual technologies", "Telecommunications", "Microstructural and nanotechnology", etc.)

While aiming to create a unified and generalized classification, technological categories and classes in which biotechnological methods might have taken place were identified. According to the Technology Concordance Table, items registered under the following IPC technology groups belong to "Biotechnology":

- C07G "Compounds of unknown structure"
- C07K «Peptides»
- C12M «Devices for working with enzymes and microorganisms»
- C12N «Microorganisms or enzymes; compositions thereof»
- C12P «Enzymatic or fermentative methods to synthesize chemical compounds or compositions or the separation of a racemic mixture into optical isomers»
- C12Q «Methods of measuring and testing that use enzymes or microorganisms»
- C12R «Encoding scheme for subclasses of C12C-C12Q or C12S, related to microorganisms»
- C12S «Methods using enzymes or microorganisms to isolate, separate, or purify a previously obtained compound or composition».

When submitting an application for a protective document, the applicant may indicate several technology groups (IPC codes) to which the invention being patented belongs. "Biotechnology" overlaps pharmaceuticals considerably (approximately 30%). To avoid any possible bias in the data, the OECD excluded inventions with IPC code A61K "Preparations for medical, dental, or toilet purposes" from this area [*Schmoch*, 2008].

A similar approach was taken in our research but a definite limitation arose because individual subclasses unrelated to biotechnologies are included in these groups (for example, C12P 3/00 "Preparation of elements or inorganic compounds except carbon dioxide"). However, the reliability of the assets is sufficiently high: When screening the objects to analyze which had been selected from the Technology Concordance Table less than 10% of patents were excluded for being irrelevant.

The next step in the research was to perform content analysis of the inventions published by Rospatent in the selected area of technology in 2012 [*Rospatent*, 2013a, 2013b]. The patent activity of Russian applicants abroad was not evaluated, although for each invention included in the research subject an additional search of patent families (protective documents related to the same invention) was conducted at foreign and international patent offices. Therefore our results relate only to the domestic biotechnology market.

In the first stage of the content analysis we conducted a search of patent documents in Rospatent's public registry of inventions based on the following formal criteria: IPC code = C07G-K, C12M-S; patent publication date = 2012; patent publication country = RU (Russia). All patents published in Russia were considered, regardless of the patent holder's status (resident/nonresident) and the document's status (active/expired/expired but renewable/potentially invalid). Then to exclude documents unrelated to the biotechnology field from the resulting body of documents, the selected patents were screened using the following algorithm:

1. Removed patents whose bibliographies indicated IPC code A61K from the list of documents (nearly 20% of the selected documents included codes for both "Biotechnology" and "Medical technology").
2. Searched the «Field of the Invention» section of abstracts using the following keywords: «biotechnologies», «molecular biology», «microbiology», «diagnostic methods», «biochemistry», and others listed in the conceptual part of this paper. If at least one of the keywords appeared in this section of the abstract, then the invention was deemed to relate to «Biotechnology».
3. If the abstract did not indicate the field of the invention, then the «Description» or «Claims» sections were searched for the keywords indicated in the list-based definition of biotechnologies given above (Table 2). Documents for which the search did not detect at least one match with the list of keywords were removed from the set.

The total number of items after the screening was 359. All of the aforementioned steps to select items ensured that the results were representative, thanks to the high level of conformity of the selected documents (the degree to which the examined document possesses the attributes of interest to the researcher i.e. the degree to which the document corresponds to the subject of research).

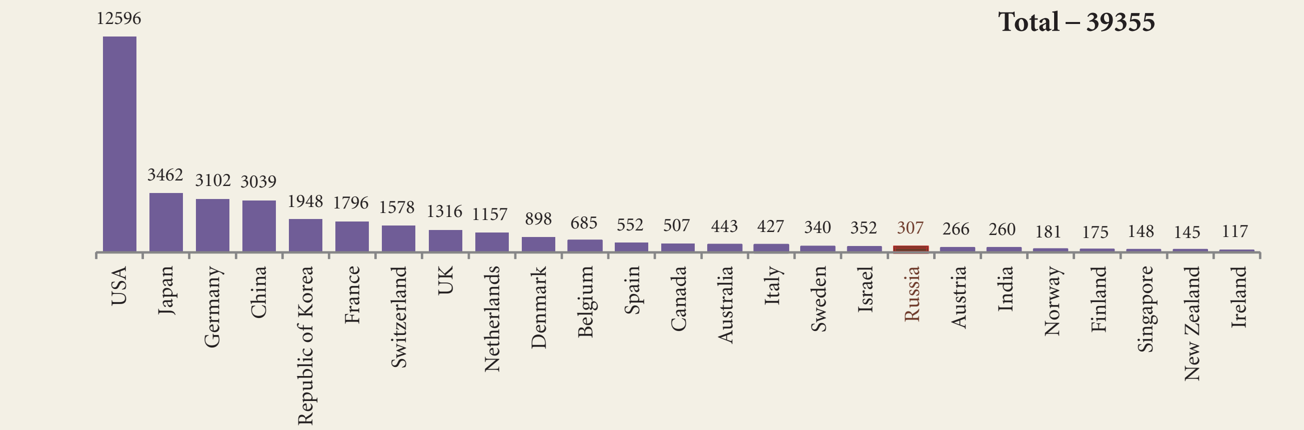
All of the selected documents were assessed using the following criteria during the analysis:

- applicant status (resident/nonresident);
- applicant country (for patents issued to nonresidents);

[6] EPO – European Patent Office. USPTO – United States Patent and Trademark Office. JPO – Japan Patent Office

[7] IPC – Technology Concordance Table. Available at: http://www.wipo.int/ipstats/en/statistics/technology_concordance.html (accessed 01.11.2013).

Figure 1. **Number of patents published for inventions in «Biotechnology» by country of applicants (with more than 100 applicants) for 2012***



*Includes patents granted to applicants in domestically and abroad.

Source: WIPO database.

- applicant type (based on sector membership): state organization, business, institution, non-profit organization, individual;
- IPC codes;
- area of biotechnology (based on the content of the abstract): biomedicine, biopharmaceuticals, bioenergy, industrial, agricultural, forestry, food production, conservation (environmental), biotechnology, aqua-biotechnology;
- field of invention (based on the content of the abstract);
- scope of possible application (based on the content of the abstract);
- existence of patents from foreign patent offices (or filed patent applications);[8]
- for inventions in medicine and pharmacology – which diseases the proposed invention is designed to treat.

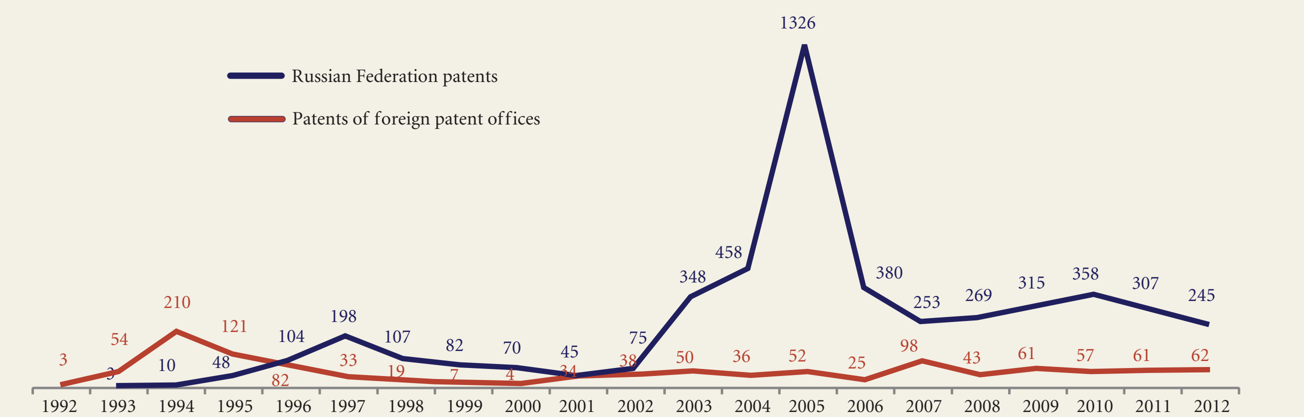
In the next stage the resulting information was encoded and entered into a content-analysis matrix. After the encoding, comprehensive data analysis was performed using the SPSS statistical package. A discussion of the research results is given below.

Russian applicants' patent activity in the biotechnology field

Russia's contribution to global patent activity in the biotechnology field is extremely small. In 2012, out of nearly 40,000 patents published by all the patent offices[9] for inventions in this area, Russian applicants accounted for less than 1%. Russia falls far behind the leading countries, taking 18th place globally for this indicator (Figure 1).

For many years the Russian Federation's documents have dominated the makeup of patents granted to Russian applicants for inventions in "Biotechnology"

Figure 2. **Number of patents for inventions in «Biotechnology» issued to applicants from Russia***



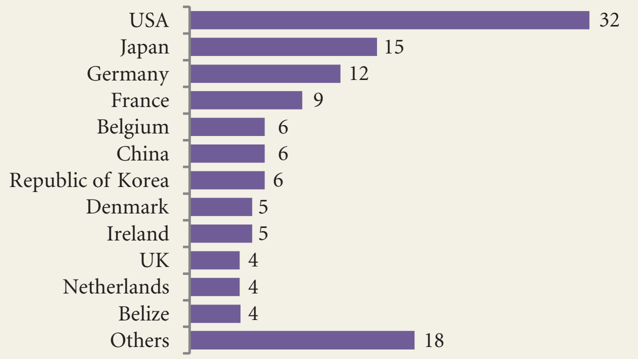
* by patent publication year.

Source: WIPO database.

[8] This was accomplished by searching by number for each patent in the commercial Orbit database. The database supports the ability to obtain information about all patents (and patent applications) related to a single invention and issued at more than 90 patent offices around the world, including the EPO, JPO, USPTO.

[9] When studying the actual level of patent activity, the "number of (filed) patent applications" indicator has traditionally been used. Considering the limitations of available information sources, we have examined here published patents (patent publications). In accordance with the sequence of stages to obtain the protected document and accounting for the average duration of each of them, the assessments presented represent the inventive activity of applicants in the selected area of technology in 2010-2011.

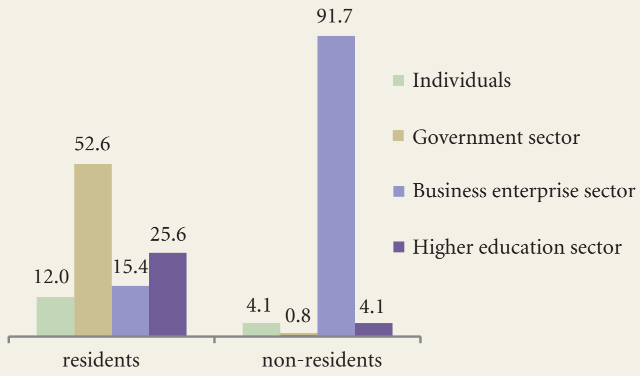
Figure 3. **Number of patents published in the Russian Federation for inventions in «Biotechnology», by applicant country: 2012**



* patents issued to nonresidents.

Source: author's estimates based on Rospatent data.

Figure 4. **Percentage distribution of patents published in the Russian Federation for inventions in «Biotechnology», by applicant type: 2012**



Source: author's estimates based on Rospatent data.

(Figure 2). In the crisis years of the 1990s domestic organizations and inventors actively patented innovations abroad: in 1992-1997 they received nearly as many foreign patents for inventions related to biotechnologies as in the next 15 years (including in countries such as Canada, Germany, Finland, Latvia). Beginning in 1996 we can speak of the realignment of domestic inventors to the internal market: the number of patent applications filed to foreign patent offices shrank, although the circle of countries to which they were submitted expanded slightly. Overall, the level of Russian applicants' patent activity abroad in the biotechnology field remained low over the entire period examined, which may be a result of various factors: the focus on the national technology market as the overriding business strategy; the lack of resources (above all, financial) required to obtain grants at foreign offices; and low competitiveness of domestic inventions.

In contrast to the global situation, internal Russian patent activity in biotechnology over the past twenty years has grown substantially - from 3 patent publications in 1993 to 245 in 2012. However, the relative weight of inventions related to biotechnology in the overall structure of patent publications (1.4%) shows that the area is not a priority for domestic inventors. The fraction of biotechnology inventions have slowly decreased for several years now, and this trend is becoming stable.

Patent assignees

An analysis of the makeup of patent holders testifies to the prominent role that organizations from other countries play in the Russian market for biotechnological innovations. Admittedly, this corresponds with a general trend of growing patent activity in Russia by foreign applicants in other areas of technology as well. Among patents in "Biotechnology" published by Rospatent in 2012, 33.7% are attributable to nonresidents. The remaining two thirds are patents granted to Russian applicants (65.2%). Another 1.1% are documents received jointly by Russian and foreign organizations.

Approximately one quarter of patents for inventions in biotechnology granted to foreign applicants pertain to the United States (Figure 3). Other highly notable countries in this regard are Japan, Germany, and France. For most countries the Russian market is not a priority: out of 121 foreign inventions in the selected set, only 6 were registered exclusively at their applicants' own national patent offices before a patent application was filed in Russia, while the rest already had patents of several (usually more than 10) offices. Furthermore, 91 of the inventions were triadic patent families (they were patented simultaneously at the EPO, JPO, and USPTO). On the whole in 2012, foreign applicants received patents in Russia for inventions that had already been registered at the national level in most cases for more than five years.

According to our calculations, in 2012 patents for inventions related to biotechnologies were issued to 127 domestic and 96 foreign organizations in Russia. The contribution of individuals was relatively small: 9.2% of these patents versus 27.0% of patents across all areas of technology. One can assume that the reason for this is the complexity and high cost of scientific research related to biotechnologies.

As for the assignees of biotechnology patents, businesses are in the lead (42.1%); the relative weight of the government sector is 34.3%. The dominating position of business is the sole result of the makeup of holders of patents granted to foreign organizations, the majority of which are business (Figure 4). In contrast, among resident patent assignees the undisputed leader is the government sector, represented chiefly by the Russian Academy of Sciences, the Russian Academy of Medical Sciences, the Russian Academy of Agricultural Sciences, and state research centres. Among patent assignees for biotechnological inventions issued to Russian applicants, organizations in the government sector accounted for more than half (52.6%), while businesses are patent holders of only

Table 3. **Most active patent-holding organizations in «Biotechnology» (more than three patents)**

Organization name	Number of patents*	Area of biotechnology
State Scientific Research Institute of Genetics and Breeding of Industrial Microorganisms (GosNIIgenetika)	12	industrial biotechnology, biomedicine, biopharmaceuticals
State Research Center of Applied Microbiology and Biotechnologies	9	biomedicine, agricultural biotechnology
Shemyakin-Ovchinnikov Institute of Bioorganic Chemistry of the Russian Academy of Sciences	9	biomedicine, general methods for developing biotechnologies
Gorsky State Agricultural University	6	food production, agricultural biotechnology
ZAO Scientific Research Institute Ajinomoto-Genetika	6	industrial biotechnology
State Scientific Research Center of Virology and Biotechnology 'Vektor'	5	biomedicine
Pasteur Saint Petersburg Scientific Research Institute of Epidemiology and Microbiology	4	biomedicine
Kursky State Medical University	4	agricultural biotechnology
Gabrichevsky Moscow Scientific Research Institute of Epidemiology and Microbiology	4	biomedicine, biopharmaceuticals
OOO SKARABEY	4	agricultural biotechnology

* Includes patents for inventions in "Biotechnology" that were published by Rospatent in 2012.

Source: author's estimates based on Rospatent data.

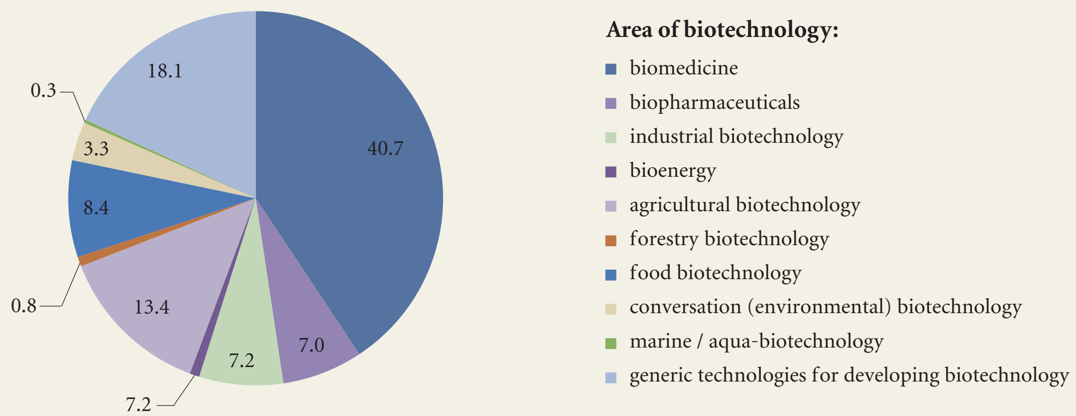
one sixth of protective documents. The level of companies' activity presents the most significant difference in the structure of patenting biotechnological inventions in Russia by residents and nonresidents.

Based on the results of the patent analysis, the most productive Russian organizations on the domestic market for biotechnologies seem to be the State Scientific Research Institute of Genetics and Breeding of Industrial Microorganisms (GosNIIgenetika), the State Research Center of Applied Microbiology and Biotechnologies, and the Institute of Bioorganic Chemistry of the Russian Academy of Sciences (Table 3). These research organizations were the leaders amongst applicants in the IPC class C12 "Biochemistry; beer; alcoholic beverages; wine; vinegar; microbiology; enzymology; mutations; genetic engineering" in the period 1993-2011 [*Rospatent*, 2013a], which makes it possible to treat them as the key agents of biotechnology development in the country. Several universities were in the group of organizations that received several patents in "Biotechnology" in 2012: Gorsky State Agricultural University, Kursky State Medical University, and Kazansky (Privolzhsky) Federal University. The majority of organizations were granted only one patent, most of these were businesses. It is worth noting that, according to the Orbit database, the number of patents granted to the Russian leaders in this field lags considerably behind the world's leading biotechnology companies (for example, Amgen (USA) receives an average of 75 patents annually). However, even these achievements secure a place for them on the list of leading Russian applicants in the biotechnology field.

Areas of inventive activity in the biotechnology field

Analysis of the topical distribution of patents (according to IPC codes), which is traditionally used to

Figure 5. **Percentage distribution of patents published in the Russian Federation for inventions in «Biotechnoogy»: 2012**



Source: author's estimates based on Rospatent data.

study the structure of scientific and technical activities, is not practical in our case because the structure of the set of patents based on IPC class does not give a clear picture of what exactly was invented and patented. For example, three quarters of inventions belong to the IPC group C12N “Microorganisms or enzymes; compositions thereof”, which encompasses a significant number of diverse areas and fields of application for the results obtained. On the other hand, studying the distribution of patents by IPC groups and subgroups (“deeper” levels of classification, such as C12N 15/85 “Ti-plasmid” or even C12N 15/861 “Adenoviral vectors”) would more likely be of interest to professional biotechnologists by demonstrating detailed subjects and methods for conducting scientific research. As our purposes are different, here we wish to consider the structure of patent activity by analyzing the distribution of inventions based on areas of biotechnology (Figure 5).

As was shown above, biotechnology is a rather heterogeneous field of knowledge which produces results that can be applied in various sectors. Our assessments indicate that inventions related to biomedicine are currently being patented particularly intensively in Russia. Moreover, these technologies hold a leading position in the makeup of patents granted to both resident (44.0%) and foreign (35.5%) applicants. Furthermore, 7.0% of the patents in the selected set were related to biopharmaceuticals.

Judging by the indicators of patent activity with regard to technological priorities in health care, the most numerous group consists of inventions related to the diagnosis and treatment of infectious diseases, including widespread illnesses - tuberculosis, pseudotuberculosis, viral diseases (above all, influenza and hepatitis A and B) - and illnesses that are encountered less commonly in developed countries today (melioidosis, plague). 48 inventions in the selected set targeted treatments for these illnesses. Such attention in Russia to a multitude of diseases that have long been known is primarily the result of a consistently large number of reported cases of these diseases. For example, according to the World Health Organization, in 2010 in Russia there were 120,000 reported cases of tuberculosis [WHO, 2013].

21 patents in biomedicine and biopharmaceuticals (one seventh of the total), were granted for inventions concerning methods to diagnose and treat oncological diseases, including methods designed for specific cancers (breast, stomach, and bladder cancers) as well as general methods for treating malignant tumours. Considerable attention is also being given to the development of methods for preventing and treating diseases of the circulatory and cardiovascular systems (8 and 7 patents, respectively) although it should be noted that in this case the level of inventive activity falls far short of what the problem’s importance should merit: these very diseases are the main cause of death from non-infectious diseases both in Russia and around the world [WHO, 2013].

Other less represented groups in the selected set include methods for treating diseases of the endocrine (diabetes) and immune systems (production of immunoglobulins and immunomodulators); illnesses caused by genetic mutations (cystic fibrosis, Huntington’s disease); skin lesions, musculoskeletal system, and the reproductive system. Several inventions relate to preventing the development of diseases during pregnancy and the neonatal period. A small number of inventions (3 patents) concern general methods for raising the effectiveness of diagnostic methods.

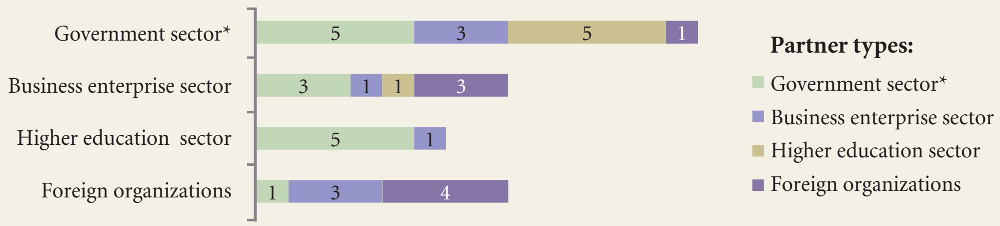
The second largest group in the selected set consists of inventions that may be considered universal methods and technologies applicable in a broad range of fields and generally used to develop biotechnologies. This group, which encompasses 65 patents, relates to methods for DNA sequencing, recombinant DNA technology, the culturing of cells, issues, and microorganisms, and genome analysis. Such inventions are patented to a larger degree by nonresidents: 28.9% of their inventions are in these technologies (for Russian applicants, they account for 12.8%). This distribution, especially if it becomes a consistent trend, may negatively affect the future development of domestic biotechnologies: monopolization of technologies by foreign assignees limits opportunities for their practical application by domestic inventors and manufacturers.

Patents in agricultural biotechnology, which form the third largest group, on the contrary, were granted in most cases (74.5%) to Russian applicants, who developed and patented methods for diagnosing livestock diseases, ways to protect plants from diseases, and new types of fertilizers. Plant cell sequencing and breeding transgenic varieties of plants with specific traits (larger yield, controlled height, etc.) are not areas of active development in Russia: in the selected set such inventions account for only 7 patents, and all of them belong to foreign organizations.

Roughly 7% of patents were granted for inventions in industrial biotechnology. These patents include new ways to get and produce microbial metabolites (above all, amino acid), chemical substances obtained from renewable sources of raw materials (particularly, n-Butanol, which is used in many industrial fields from the paint and varnish industry to the medical industry), enzymes (amylases, lipases, etc.), and new biomaterials. In this case, the definitive leader is the State Scientific Research Institute of Genetics and Breeding of Industrial Microorganisms: it owns one quarter of all patents issued in 2012 in this group.

Inventions in more rare and specialized areas of biotechnology (bioenergy, forestry, environmental, and marine biotechnology) are patented extremely rarely. Their share of the overall markup of patents published in the biotechnology field in 2012 was not more than 5%. Only three inventions were patented in the bioenergy field in 2012 for new types of biofuels. Moreover, they all belong to foreign applicants. Russian organizations dominate among patent assignees for inventions in environmental biotechnology. Inventions patented in this area involve methods to clean waste water, air and industrial waste, and the

Figure 6. **Number of joint patents published in the Russian Federation for inventions in "Biotechnology", by applicant type: 2012**



* Including executive agencies acting as the patent holder on behalf of the Russian Federation.

Source: author's estimates based on Rospatent data.

interior of trunk pipelines used to transport natural gas and oil products.

Cooperation in the biotechnology field

The level of cooperation in the biotechnology field may be measured by the number of joint patents held by several organizations or individuals. 40 items in our selected set fit into this category, four of which are patents received jointly by Russian and foreign organizations, and the same number are joint patents held by several foreign organizations (Figure 6).

In 13 patents the Russian Federation was one of the indicated assignees, as represented by various ministries and agencies. These joint patents should certainly not be viewed as an indication of cooperative relations; they are more likely an indication of the distribution of state and municipal contracts to perform work in the biotechnology field for state or municipal needs. As stipulated in the Civil Code of the Russian Federation (art. 1373), as part of such contracts the ordering party may receive the exclusive right to the created results, which means becoming the patent assignee, either solely or jointly with the organization that fulfilled the contract. All such patents in the selected set relate to biomedicine and provide legal protection for strains of cells, and methods for diagnosing and treating various diseases.

According to our calculations, organizations in the government sector are more frequently involved than others in joint projects in the biotechnology field: five patents were issued for inventions created jointly by several state organizations and the same number belong simultaneously to organizations in the government sector and Russian universities, which are far rarer but have nevertheless been involved in joint research and development. The business enterprise sector also has a small number of joint patents in the biotechnology field (Figure 6).

Several patents belong simultaneously to Russian and foreign inventors; nearly all of them are joint patents of an organization registered in Japan with a subsidiary that is a resident of Russia. Therefore, we may conclude that domestic scientific, educational, and industrial organizations are virtually uninvolved in joint projects with foreign partners in the biotechnology field, which is most likely a negative factor in the development of this area of technology in the country. International cooperation is a necessary condition for technological progress. It encourages the exchange of information and professional experience, which is especially important for the advancement of biotechnologies in Russia, which lags behind many countries in terms of the number of biotechnology organizations, the scale of research activities, and the volume of biotechnology products produced and exported. Factors stifling international cooperation include tax and customs policies, financial reporting procedures, and execution of monetary transactions [NRC, 2013].

Conclusion

One of the current priorities for the modernization of the Russian economy is to take a leading position in the development of biotechnologies and increase the production and consumption of biotechnological products. Biotechnologies as a field of knowledge were developed during the Soviet period [*Rabinovich*, 2007]. However the active phase of state incentives for their development began relatively recently with the adoption of a national program entitled "Development of Biotechnologies in Russia in 2006-2015". Nonetheless, technologies related to living systems have been one of the strategic areas for the development of science and technology since 1996. Despite this fact, Russia's share of the global market for biotechnologies is less than 0.1% [*BIO 2020*, 2012].

The results of our patent analysis presented here are evidence that Russia has not yet accumulated a critical mass of inventions that will subsequently serve as a resource for the active development of the biotechnology field. Despite the fact that the makeup of patents related to "Biotechnology" is dominated by patents granted to residents, the share of foreign organizations' inventions is quite high – indicating that the Russian market for biotechnology remains dependent on foreign technologies. Considering that non-residents are actively patenting general methods and techniques for working with biomaterials in Russia, which makes it possible to "close" certain fields and areas of scientific research, this trend may not only be perpetuated but also intensified in the future.

Among Russian organizations, government sector scientific organizations have demonstrated the most activity in patenting inventions related to biotechnology. At present they may be considered the primary driving force behind the development of biotechnologies in the country. Companies patent the results of research and development in this area of technology less often than other types of organizations. This distribution of roles may become a serious barrier to introducing inventions to production because the majority of applicants in the government sector are organizations that largely lack productive infrastructure.

Patent analysis has made it possible to identify specific trends that may negatively impact the future development of biotechnologies in Russia. The dependence on foreign technologies, the business enterprise sector's low level of inventive activity, the lack of serious cooperative relations, the inadequate level of development in such relevant areas of biotechnology as bioenergy, environmental and marine biotechnologies - all these problems require more in-depth investigation and the preparation of a well-grounded and effective approach to solving them. F

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