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Research and Business Cooperation: International Practice and Siberian Experience

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The paper discusses possibilities and directions for bridging the gaps between academic research and business by reducing barriers and strengthening incentives for the development of partnership interactions between participants of the regional innovation ecosystem. Many researchers from developed and developing countries focus on the problems of interaction between universities and companies in order to find ways to increase academic research effectiveness and make the results relevant to the business sector's real demand. Development of partnership relations is known to be a factor which accelerates creation and dissemination of innovations. Improvement of such relationship favours academic researchers' possibilities, educational programs adjustment, and regional economy development. Basing on international experience review, the paper determines the main tendencies and perspectives of research – business cooperation as well as key directions of partnership cooperation support. The empirical part of the paper deals with the results of original pilot survey which uses data from a number of research, educational organizations and high tech companies from Novosibirsk region. The aim of the survey was to analyze success factors and main obstacles for sustainable research – business cooperation. Qualitative methods including case studies, interviews, and surveys were used within the research. It is shown that, although all representatives of science and business recognize the need to develop partnership relationships, differences in motivations and conflicting goals of participants still remain. Besides well known barriers (lack of financial and other resources, personnel etc.) some other factors turned to be important. Low level of confidence and negative cooperation experience impede cooperation development. Personal issues and previous successful experience help to develop and improve partnerships. Such cases could be found. State support (especially at the regional level) is quite necessary; it is not limited to financial instruments. Support of communications which helps to increase the level of confidence and to decrease “attrition costs” of cooperation is also of great importance.

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Introduction

Transition to knowledge economy and digital transformation of economy and society determine the growth of research and innovation costs in most developed and developing countries.

According to the US National Science Foundation (NSF, 2018), in 2015, the volume of global expenditures on research and development (R&D) amounted to 1.918 trillion US dollars compared to 1.415 trillion dollars in 2010 and 722 billion dollars in 2000. In their aggregate fifteen countries with research and development costs exceeding 20 billion dollars in each of them form 85 % of the global value of R&D costs. The USA and China are world leaders in this indicator.

Business sector is both the research and development provider and the main source of their funding. However, its interests are mostly concentrated in the field of applied research and experimental development. Fundamental research is carried out in major universities and federal research centres and is funded primarily by the state.

Almost all the R&D funding in the USA business sector (98 % in 2015) was directed to research and development in the business itself. Small amount was directed to higher education R&D performers, other nonprofit organizations, and federal research centres. Research and development conducted by American enterprises are mainly carried out in five sectors: production of chemicals (pharmaceutical industry in particular); production of computers and electronics; production of transport equipment (particularly in automobile and aerospace industries); information and communications sector; and professional, research and technical services. In 2015, these five business sectors accounted for 83 % of total R&D.

Russia ranks 11th in the world in terms of the research and development costs that amount for 38.135,5 million dollars in PPP (NSF, 2018) and 4th in the world in the

number of researchers, but only 45th in terms of the use of knowledge and technology use (GII, 2017).

Similar to other countries, the bulk of research and development costs in Russia are borne by enterprises and organizations of the business sector of the economy (58.7 % in 2016). Public sector organizations bear 32 % of the costs, whereas higher education organizations bear 9.7 % of the costs (HSE, 2018). However, the structure of the sources financing these costs differs significantly from that of the leading countries. Most of research and development funding (68 %) is provided by the state, whereas business sector covers only 28 % of the costs.

Business sector in Russia carries out less research and development and spends much less on their implementation than in the leading scientific and technological countries. The share of innovatively active Russian companies over the past ten years does not exceed 10 %. It is several times less than in the developed countries.

The offer of research and technological developments on the part of science does not find demand from the entrepreneurial sector; high potential of domestic research finds no implementation in the form of innovative technologies, goods and services. Susceptibility of economy and society to innovations remains low and, thus, prevents practical application of research and development results.

This situation relates to structural features of Russian economy (low share of high-tech and knowledge-intensive industries), low level of entrepreneurial activity, insufficiently favorable business climate as well as to weak interaction of the research and development sector with the real sector of economy, fragmentation of the innovation cycle and the innovation system.

This article aims to justify the opportunities and directions of reducing the gaps between science and business by lowering the barriers and strengthening the incentives for development of partnerships between actors of the regional innovation ecosystem, Novosibirsk region serving the example due to high level of its research and technological development.

Current research review

The problems of increasing the scientific research efficiency and low demand for scientific results from business are in the centre of the researchers' and practitioners' interests in both developing and developed countries. Much research reflecting the growing urgency of the problem regarding the formation of sustainable relationships between various actors of the innovation system as a basis for the country's and/or

region's competitiveness in a rapidly changing environment has been carried out. Review papers (Teixeira, Mota, 2012) show an increasing number of publications since mid-2000s, American and English authors dominating (Agrawal, 2001; Perkmann, Walsh, 2007; Al-Mubarakhi et al., 2013; Mascarenhas et al., 2018).

Most researches can be grouped as follows:

1. Conceptual structuring that analyzes relationships and results achieved through collaboration. The source of this area of research is the conception of innovation systems which is developing and becoming more complex due to involvement of more concerned parties (H. Etzkowitz's "triple helix" (Etzkowitz, Leydesdorff, 2000) and its development into a more complex structure (Miller et al., 2018), multi-agent systems (Kravchenko, Markova, 2018), clusters etc.) as well as due to more complete consideration of the specifics of various research fields and technological modes.

2. Research of various intermediaries' and intermediate actors' role in cooperation processes, such as technology transfer centres, business incubators, technology parks, innovative entrepreneurs, brokers etc. (Al-Mubarakhi et al., 2013; Bercovitz, Feldman, 2008).

3. Research of factors and conditions that affect the processes of interaction as well as various forms of such interactions, which are often grouped according to the ecosystem's hierarchical level (personal, organizational, institutional). Various state and regional initiatives are considered as conditions and possible incentives for the development of cooperation between science and business. The experience gained in implementing the policy aimed at bridging the gap between research and business is summarized in a number of publications based on empirical data. (Cohen et al., 2002; Grilli, Murtinu, 2014).

Most of the researches are based on qualitative methods, mainly the case-study. Yet, recent works apply quantitative research methods.

In this paper, it is worth while giving a more detailed account of recent studies on the analysis and assessment of factors and conditions of cooperation between research and business sectors.

In 2018, the results of the largest and most ambitious project "The State of University-Business Cooperation in Europe", carried out in 2016–2017 for the European Commission, were published (Davey et al., 2018). The project aimed to assess the UBC¹ status and the opportunities of cooperation development. It was the survey data

¹ University Business Cooperation. Most foreign publications regard the universities as research and education centres. This corresponds to the Anglo-American model of organizing the research. Regarding the interaction of research

of 17410 respondents from the universities and enterprises of 33 European countries that served the information basis of the project.

The research proved that most academic and business structures are currently not involved in cooperation; partnerships between universities and business are still fragmented and weak, and support tools are focused on certain elements of the European ecosystem. Yet, the results of the project demonstrate that cooperation between universities and business can be beneficial to all the actors involved. Business is increasingly getting aware of the benefits of partnership with universities as a source of future-oriented innovations and talents attraction. This can become the basis for building competitive advantage. Business is also realizing the role of universities as the leading sources of entrepreneurship development in the region.

Identification of **cooperation barriers and drivers** is an important result of the research. Researchers, university management and business representatives are unanimous in their opinion that lack of funding and lack of resources are the main cooperation barriers. In addition, researchers point to bureaucracy and lack of time, whereas business representatives consider cultural differences and different motivation. It turned out that both groups believe that, compared to other stakeholders, they benefit from cooperation less. Each group of stakeholders has their own motivation for cooperation. The scientists aim to promote their research. The university management's goals are diversified. These are fundraising, their graduates' employment, and research results implementation. Business is interested in the contribution to the innovation process and access to talents. As for the researchers' motivation, it is the least developed UBC mechanism, which can be considered as the politicians' priority.

The typical profiles of possible individual actors in cooperative relations between science and business are of particular interest. They demonstrate a certain similarity of researchers and businessmen who are willing to develop partnerships: they often initiate cooperation, have experience in cooperation, and plan to continue or expand it. They consider mutual commitment, trust, common goals and previous relations to be conditions for successful cooperation. The project results clearly show that the UBC experience stimulates further cooperation.

and business, the authors use the term "university" to refer to all types of public research organizations, including those funded by the government. In addition to the universities, this category usually includes state research laboratories, research institutes and other non-profit or commercial research organizations (Perkmann, West, 2014).

At the individual and institutional levels, the additional factors that affect cooperation opportunities are the following ones:

- University's influence – the longer a researcher works at the university, the less he/she is set up for cooperation with business.
- Insight effect – the longer a researcher works in business, the more bound he/she is for cooperation.
- Experience multiplier – the longer a researcher cooperates with business, the more extensive cooperation is.
- Size effect – large universities and companies are more determined to cooperate.
- “Proximity effect” – the majority of cooperating partners are in the same region (or at least the same country).

Removing the barriers does not necessarily stimulate UBC, development of incentives for cooperation being a more important factor. A review of European countries' policies shows a large diversity of measures used by the governments to support specific UBC initiatives and highlights the gaps and overlapping areas. The authors come to the conclusion that it is necessary to change the focus of the support policy from eliminating barriers to creating drivers for collaboration, as well as to providing conditions for establishing trust and setting common goals.

The report of the London School of Economics (Ranga et al. 2013), carried out with H. Etzkowitz's participation and devoted to the study of cooperation between universities and business in the United States and Canada, provides the data on the goals and motivations of such cooperation as well as its most common forms. It offers recommendations to stimulate the development of integration links. One of the conclusions of this study deserves special attention. It turned out that the decline in public funding of the universities is not an incentive to activate the universities' “entrepreneurial function” and generates no aspiration for partnership with business.

The most important forms of UBC are knowledge sharing and transfer as well as informal interaction. With some gap, they are followed by applied innovations and academic staff and student involvement in solving specific business problems, research partnerships, as well as entrepreneurship trainings. Other forms of cooperation such as staff mobility, student employment and internships, cooperation in training programmes were assessed as average.

According to the OECD, in Russia the share of large innovatively active companies interacting with research organizations and universities is 28 %. This is several times lower than in the developed countries. Empirical works which base on the data of

large-scale surveys of Russian enterprises and research organizations are scarce. The research (Zudin et al., 2017) showed that only half of the innovatively active companies of Russian manufacturing industry cooperate with other actors in the process of promoting developments in general and only 24 % of them interact with research organizations and universities. On the other hand, a considerable part of research institutes and universities perform R&D which are industry oriented. Perspective developments in Russian science are not among the main innovative incentives for enterprises, although many managers recognize the contribution of research and production cooperation in improving competitiveness. Generally, the main actors of cooperation asymmetrically assess current interaction of science and business and differently see the key problems. The analysis showed that the measures of state support (tax, financial, organizational and institutional) don't give a meaningful result yet.

The paper (Gershman et al., 2018) discusses the factors that influence the models of cooperation between science and business and determine their success. The survey covered more than 1300 enterprises of various manufacturing industries. Almost all innovatively active enterprises (98.5 %) cooperate with external partners. Yet, the intensity of interaction with universities and research organizations is low: 27 % of enterprises are involved in cooperation with universities and 22 % – with research institutions. Less than 10 % of enterprises cooperating with universities and research institutes introduce the developments into production process; 17.5 % as a result of partnership get scientific and technological services, which are not related to research and development. The reluctance of business to cooperate with universities in research and development is due to the lack of staff qualification and their poor awareness of the specifics of technological tasks and market condition (Dezhina et al., 2017).

This situation can be partly explained by the Russian business propensity to borrowing rather than creating innovative developments. The analysis proved that forms and models of cooperation between business and research are mainly determined by the company's general profile and industry affiliation. Inconsistency of state policy, remaining high risks and insufficient funding as well as the low level of the developer organization's research and technical results readiness for practical implementation were identified as the most significant problems of interaction (Bychkova, 2016; Yusupova, 2017; Dezhina, 2018).

The Russian researchers' empirical results confirm some global trends:

- Large companies are more willing to establish partnerships with research and educational organizations.

– A higher technological level also raises the companies' interest in cooperation with research organizations.

State ownership as a significant factor that increases the likelihood of companies cooperating with research organizations can be considered a Russian peculiarity.

Thus, the study of the experience gained in the course of research and business cooperation and the assessments of their results allow to make some general conclusions:

1. According to international research, the problems of interaction are known and recognized. They are based on the fact that “companies and universities are not natural partners”, but the institutions with different goals and motivations.

2. Almost all actors of the innovation ecosystem (science, universities, business and government) recognize the importance of partnership development not only for direct actors, but also for regional development. They consider partnership potential to be insufficiently realized.

3. Forms of partnerships, actors' goals and motivations differ in many aspects: individual, organizational, institutional, and success of cooperation results from many factors, including unique and sometimes random.

4. Among the factors that increase the likelihood of establishing and expanding cooperation most researchers highlight the presence of necessary resources, experience in cooperation and joint projects implementation, cooperative culture, as well as individual actors' authority and status.

5. State support of cooperation between business and science is necessary, but the mechanisms used are not always effective.

Opportunities and problems of SB RAS leading institutes' developments commercialization: pilot survey results

Novosibirsk region is one of few territories with all conditions for high-tech companies' dynamic development: high concentration of research and educational organizations, developed innovative infrastructure, and support of regional authorities. However, in Novosibirsk region, there are still problems of weak implementation of existing scientific and technological potential.

In 2016–2018, we conducted a pilot survey of the leading institutes of natural science, the institutes being the members of the Siberian Branch of the Russian Academy of Sciences (SB RAS), and innovative companies (10 research institutes and 10 companies). The main idea was to see and assess the opportunities of converging research and business through cooperation and partnership development.

Structured interviews with the heads of institutes and companies were the main research methods applied.

All institutes carry out top level fundamental research, have breakthrough applied developments with commercialization potential, which are of interest to both domestic and foreign enterprises. In most cases, academic institutions face serious problems in promoting even prospective developments. Some large institutes have their own pilot production, analytical centres, Centres for Collective Usage, and other structures. In most cases, they are unprofitable, covering the costs of their maintenance being a common problem which is extremely difficult to solve. Innovative companies have been created on the basis of many institutes, but most of them are fictitious and in fact do not work. For functioning enterprises, as a rule, there is an urgent problem of distribution of rights and powers between individual developers and the institute as an organization. In addition, there are conflicts of goals between the researchers striving for scientific publications (the publications serve the main criterion for assessing the effectiveness of their research activity) and the employees engaged in the applied developments implementation and commercialization. Within the institute, there may be a conflict between those involved in fundamental research and those who are in technological developments. “Few people are eager to be involved in technology, since the employees believe that writing a project and getting a grant is easier than trying to conclude contracts”.

The most significant problems we have identified are the following ones:

1. Lack or shortage of financing of innovative projects’ final stages (applied developments, pilot production, and engineering works).
2. Difficulties in finding partners and in organization of effective interaction with various actors of the innovation cycle, especially with large industrial enterprises. “Another barrier to the interaction of science with big business is money. Companies sign contracts with research institutes only for the money given by the state. Companies’ money with income tax paid is not invested in R&D”.
3. Difficulties in searching for potential customers which are largely due to a small size of high-tech sector of industry, which is capable to generate the demand for research and development.
4. Insufficiently clearly defined rules of work with intellectual property (its assessment, order of alienation and protection). This problem arises both within the institutes when organizing interaction between individual researchers and the organization as well as when entering foreign markets.

5. Lack of projects' reasonable economic estimates and assessments of the market potential of products or services. Most institutes need a competent economic justification of current projects, research and assessment of potential market.

6. Lack of information on the possibilities of state support.

All institutes note that promotion and commercialization of the developments require coordination of various organizations' efforts and search for industrial partners. Effective schemes and mechanisms of partnerships are a necessary condition for successful implementation of scientific research. In many cases, they are spontaneously formed. The experience of cooperation with enterprises is ambiguous. As regarded by the institutes, some examples of cooperation between institutes and large enterprises (such as Gazprom Neft, for example) within the framework of national projects proved to be ineffective. According to the institutes' management, these are comprehensive plans for scientific researches aimed at interdisciplinary ties formation that can become a perspective form of consolidating the efforts of different actors. Potentially, such plans, the implementation of which should be managed by inter-ministerial committees with the customers' representatives, may play the role of platforms attracting business representatives. It is State Defense Procurement and Acquisition that is currently the most attractive form of interaction between the developer and the customer for many institutes.

Among high-tech companies included in the survey 2 companies are engaged in the field of bio- and medical technologies, 4 companies work in the field of information technology, 3 companies are involved in the field of electronics, and 1 company is in the field of nanotechnologies. All companies are small or medium in terms of the number of employees, but global in scale, they operate in the global market both as consumers and as suppliers. "Even if domestic market is not a priority, their presence in the market is important, since it is easier to enter the world market when having the working experience with similar customers in Russia".

Interviews with **high-tech business** representatives were focused on discussing the development issues, success factors, and partnership opportunities with the representatives of science and universities.

The key success factors identified were the following ones:

- a strong leader, having a clear vision of strategic prospects and capable to build a powerful professional team (balance of managers and specialists),
- high quality of developments and availability of technological solutions having competitive advantages in the global market,

- high qualification and motivation of employees,
- the right choice of a market niche, domestic demand and reduction of international market entry barriers,
- availability of resources (sufficient funds),
- non-interference by the state.

The ability to build communication and create a network of partnerships with other actors is especially important at the stage of business formation. “Close connection between research and business (in the sense of partnership) is the primary factor for the emergence of new companies”.

Companies are unanimous in their assessment of partnership importance. “Due to a very high rate of innovations, pace is often a decisive factor, and cooperation can accelerate the development and implementation of innovative products, allocation of R&D costs being another important advantage”.

Lack of personnel with necessary qualifications becomes the main problem. IT companies note the difficulties of attracting and retaining highly qualified programmers: “Novosibirsk had an advantage in solving the personnel problem. Still, after 2014, the situation got worse”.

The extremely low level of trust, communication failures and lack of coordination of the actors’ actions were identified as a significant barrier to high-tech business development.

Administrative pressure and bureaucracy are large barriers to business growth. Reluctance to grow, preference to companies’ fragmentation, and creation of conglomerates have been emphasized several times. “There is no desire to attract attention”. Although the business climate is improving, but not enough for entrepreneurs to gain confidence in the future. Power pressure is increasing. Two companies moved their production abroad to be closer to consumers and to minimize political risks.

Generally, high-tech companies, established on their own, do not highly assess the possibility of cooperation with academic institutes. “It is especially difficult to work with those who previously worked in academic institutes”. “It is difficult for the representatives of academic science to foster courageous entrepreneurs, the former writing articles and clogging the information space”.

The table below summarizes the noted above key problems of effective interaction between academic institutes and high-tech business, which were identified in the course of surveys.

Undoubtedly, each actor’s motivations and positions are objectively different. However, there seem to be no insurmountable contradictions between them. The results

we have gained confirm the importance of accumulated experience of interactions and partners' reputation, the factors being noted by foreign researchers. Examples of successful cooperation could be the impetus for its large-scale development.

Table. Problems of effective cooperation between academic science and high-tech business

Science	Business
<ul style="list-style-type: none"> – difficulty in achieving high availability developments that can be commercialized; – weakness of financial and economic justification of the possibility to promote the developments; – lack of institutional conditions favouring the development of cooperation between science and business; – general level of development and structure of economy, limiting the demand for innovations; – negative experience of cooperation with business 	<ul style="list-style-type: none"> – low level of trust to potential partners in general; – lack of consistency between motivations and actions; – negative reputation of academic science

Partnership and integration of the actors' resources (and competencies) are necessary conditions for major innovation projects implementation. All survey participants note that commercialization of scientific developments requires coordination of many actors. Major industrial partners, other research organizations and government agencies are considered to be the most important ones. In Novosibirsk region, there are already examples of effective cooperation in the form of multi-agent interdisciplinary projects. Still, these examples are few so far; each of them is unique. Thus, it is too early to talk about the possibilities of transferring and disseminating the experience acquired. The examples which are worth mentioning are the project of "3D Medical systems" ("3D Meditsinskie sistemy") company (Kravchenko, Markova, 2018), the "Aerotomography" project, the project of the establishment of the "National centre for testing and engineering of catalysts". Each of these projects includes a complex system of interactions between the university, research institutes and industrial partners. This system makes it possible to define the goals, determine various actors' motivation and assess their contribution, expected results and distribution of potential synergetic effects at an early stage of cooperation. State support in these cases is not limited to financial instruments (which are definitely very necessary for the projects' sustainability). The interest of regional authorities in obtaining socially significant results is no less important. It is manifested in information support as well as in raising the level of trust and reducing the "costs of friction" between the partners.

Conclusion

Despite its pilot nature, our survey allowed to identify common problems related to the interaction of science and business. Academic institutions have the potential to commercialize their research and technological developments. Yet, its implementation is limited by the action of financial (chronic underfunding of applied and experimental development, obsolescence of instrument base and equipment), structural (a small share of high-tech industry which is the main consumer of research and development results), institutional (strict regulation of institutes, uncertainty of rights and protection of intellectual property) and other factors. The most significant partners for research institutes are other research institutes as well as state structures and corporations. Partnership with the former favours integration of resources and competencies for integration studies, whereas partnership with the latter can provide public procurement and defense order. Small business as an attractive partner in commercialization processes was not mentioned in any interview. As for universities, they are primarily considered by research institutions as educational ones that can provide an influx of personnel. New high-tech companies also attach great importance to integration, partnerships and joint activities. Yet, they are wary of interacting with academic institutions.

The probability of creating successful and sustainable partnerships can be increased through the use of innovation and industrial policy tools such as, for example, financing of consortium's projects, which extends cooperation beyond research into education and commercialization; funding for long-term cooperation, which results in the development of expertise and relationships; promoting the benefits of partnership through various channels (forums, seminars, etc.); strengthening the universities' role in teaching innovative entrepreneurship; creating great opportunities for research and business collaboration through small projects support with an emphasis on the development of relations of trust and cooperation; creating like-minded communities of scientists tuned in for cooperation with business through organizing thematic meetings, special events, etc.; organization and promotion of events that encourage communication between researchers and businessmen.

Other countries' experience proves that cooperation between the participants of the system of creating knowledge and innovation, representatives of science, education, business and government can not only increase their competitive advantages (in their area of interest) but also create synergetic effects, contributing to the employment growth, new high-tech industries development, and regional economy development.

However, similar western experience teaches that there are no ready-made recipes, any success story is unique and is due to many favorable conditions, including random and unpredictable ones.

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Кооперация науки и бизнеса: международная практика и сибирский опыт

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Работа посвящена обоснованию возможностей и направлений сокращения разрывов между наукой и бизнесом за счет снижения барьеров и усиления стимулов для развития партнерских взаимодействий между участниками региональной экосистемы инноваций. Проблемы формирования кооперации между наукой и бизнесом для повышения эффективности и востребованности исследовательских разработок предпринимательским сектором находятся в фокусе интересов исследователей и практиков как развивающихся, так и развитых стран. Исследования доказывают, что развитие партнерских связей ускоряет производство и продвижение инноваций в предпринимательском секторе, расширяет возможности проведения исследований учеными, корректирует образовательные программы, а также способствует региональному развитию. На основе обобщения мирового опыта выделяются основные тенденции и перспективы развития кооперации науки и бизнеса, а также направления поддержки партнерских взаимосвязей. В эмпирической части работы представлены результаты пилотного обследования ряда исследовательских и образовательных организаций и высокотехнологичных компаний Новосибирской области, направленного на оценку факторов успеха и препятствий для формирования устойчивой кооперации науки и бизнеса. В работе использованы качественные методы исследования (case study,

интервью, анкетирование). Показано, что, хотя все представители науки и бизнеса признают необходимость развития партнерских взаимосвязей, сохраняются различия мотиваций и конфликт целей участников как между собой, так и внутри организаций. Кроме известных препятствий (недостаток ресурсов, недофинансирование, дефицит кадров) выделены низкий уровень доверия и негативный опыт предыдущего сотрудничества, препятствующие участию в кооперации. Персонализация отношений участников и предыдущий опыт успешного сотрудничества становятся стимулами для развития партнерств, и такие примеры имеются. Государственная поддержка (особенно регионального уровня) необходима, она не ограничивается финансовыми инструментами, не меньшую важность имеет поддержка коммуникаций, способствующих повышению уровня доверия и снижению «издержек трения» между участниками партнерства.

Ключевые слова: академическая наука, высокотехнологичный бизнес, модели взаимодействия, барьеры развития кооперации.

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