Artículo de investigación

Opportunities and Risks from Cooperation among Companies within the Production Sphere and the Sphere of Services in Russia in the Context of Industry 4.0

Возможности и риски кооперации компаний производственной сферы и сферы услуг в России в соответствии с концепцией Индустрия 4.0

Oportunidades y riesgos de la cooperación entre empresas en los sectores de producción y servicios en Rusia de acuerdo con el concepto Industria 4.0

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Abstract

Between 2015 and 2016, an international study was conducted to determine just what Industry 4.0 meant to companies from various countries, how vital cooperation in the area among companies from various countries was, and how this cooperation could be best organized. The survey featured no companies from Russia. Between 2018 and 2019, a similar study was carried out by the authors of this work among Russian companies, its purpose being to identify some of the key common and specific traits in existing approaches to cooperation in Industry 4.0 among Russian and foreign companies. To obtain comparable results, the study relied on a research methodology developed by the National Academy of Science and Engineering (Germany), which employed it in its survey engaging 150 company executives from six

Аннотация

В 2015-2016 гг. проведено международное исследование с тем, чтобы выяснить, что означает для компаний из разных стран Индустрия 4,0, насколько необходимо сотрудничество компаний из разных стран в этой области и как это сотрудничество лучше организовать. Среди участников опроса не было компаний из России. В 2018-2019 гг. проведено такое же исследование авторы статьи провели среди российских компаний, цель исследования – выявить общие и специфические черты в подходах к сотрудничеству в Индустрии 4,0 российских и зарубежных компаний. Для получения сравнимых результатов наше исследование опирается на исследовательскую методологию Национальной академии наук и инжиниринга Германии, в рамках которого

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different countries. In Russia, a total of 50 interviews were conducted of executives of Russian companies of varying size and sector, with data gathered via in-depth interviews, one-on-one questionnaire-based interviews, and online surveys. Based on the survey results, many Russian companies, just like their foreign counterparts, are perfectly aware of the opportunities and risks of Industry 4.0 and of the need to adopt common standards and address issues related to fostering cooperation, but their assessments are rather polarized, with some highly excited about the potential it offers, and others somewhat wary of the risks it may be fraught with – which may be due to differences in the level of their technological development. Prior research did not produce comparative assessments based on a single methodology on senior management's take on the opportunities and risks of the cooperation of Russian and foreign companies in Industry 4.0. The findings could be utilized in developing appropriate measures for bolstering the cooperation, which could be mutually beneficial for companies representing various countries and sectors.

Keywords: complex economic systems, mechanisms for integration and cooperation, Industry 4.0, opportunities and risks.

были опрошены 150 руководителей компаний в шести странах. В России проведено 50 интервью с руководителями российских предприятий разного размера и из разных отраслей, сбор данных проводился с помощью глубоких интервью, личного интервью по анкете и онлайн опроса. Российские компании так же, как и зарубежные, оценивают возможности и риски Индустрии 4,0, необходимость общих стандартов и проблемы развития сотрудничества, но их оценки более поляризованы: одни более высоко оценивают возможности Индустрии 4,0, другие – риски в силу различий в уровне свое технологического развития. В предыдущих исследованиях не проводилась сравнительная оценка по одной методологии позиций топ-менеджмента относительно возможностей и рисков сотрудничества российских и зарубежных компаний в рамках Индустрии 4,0. Полученные результаты позволяют разработать меры по укреплению сотрудничества, взаимовыгодные для компаний из разных отраслей и стран.

Ключевые слова: сложные экономические системы, механизмы интеграции и сотрудничества, Индустрия 4.0, возможности и риски.

Resumen

En 2015-2016 Se realizó un estudio internacional para averiguar qué significa para las compañías de diferentes países, Industria 4.0, cuánta cooperación se necesita de las compañías de diferentes países en esta área y cómo está mejor organizada esta cooperación. Entre los participantes de la encuesta no hubo empresas de Rusia. En 2018-2019 se realizó el mismo estudio; los autores del artículo realizado entre las compañías rusas, el propósito del estudio es identificar características comunes y específicas en los enfoques de cooperación en la Industria 4.0 de compañías rusas y extranjeras. Para obtener resultados comparables, nuestro estudio se basa en la metodología de investigación de la Academia Nacional de Ciencias e Ingeniería de Alemania, en la que se entrevistó a 150 ejecutivos de empresas en seis países. En Rusia, se realizaron 50 entrevistas con gerentes de empresas rusas de diversos tamaños y de diferentes industrias, la recolección de datos se realizó mediante entrevistas en profundidad, entrevistas personales en el cuestionario y encuesta en línea. Las empresas rusas, así como las extranjeras, evalúan las oportunidades y los riesgos de la Industria 4.0, la necesidad de estándares comunes y los problemas para desarrollar la cooperación, pero sus evaluaciones están más polarizadas: algunas aprecian más las capacidades de la Industria 4.0, otras consideran los riesgos debido a las diferencias en Su desarrollo tecnológico. En estudios anteriores, no se realizó una evaluación comparativa utilizando la misma metodología de los cargos de alta dirección en relación con las oportunidades y los riesgos de la cooperación entre empresas rusas y extranjeras dentro de la Industria 4.0. Los resultados obtenidos nos permiten desarrollar medidas para fortalecer la cooperación, mutuamente beneficiosas para empresas de diferentes industrias y países.

Palabras clave: sistemas económicos complejos, mecanismos de integración y cooperación, Industria 4.0, oportunidades y riesgos.

Introduction

The Russian economy, which over the last 25 years has experienced a deep transformational slump and a swift recovery, is currently witnessing a radical transformation that is predicated on Industry 4.0 technology and is aimed at ensuring sustainable economic growth in the country in turbulent conditions (*Datasheet for the 'Digital Economy of the Russian Federation',* 2018; *The 'Digital Economy of the Russian Federation" Program,* 2017; Frolov, Kaminchenko, Kovylkin, Popova, & Pavlova, 2017). The new transformations have to do with the development of networks of products, processes, and items of infrastructure, which should have a profound, comprehensive effect on business processes, business models, technologies, jobs, and people's daily life (OECD, 2019; Sniderman et al., 2016). It has been acknowledged that a key innovation is the digitalization of the economy, with networked interaction and cooperation expected to play a decisive role in deploying Industry 4.0.

The integration of companies, which, by their nature, are complex economic systems (Zakharov et al., 2018), into systems of a higher order – value chains, digital platforms, and ecosystems, is a highly complex issue which has the following key aspects to it: technological, organizational, economic, and social. The dynamic nature of the development of digital technology requires new forms of cooperation, so that networks created by them could be flexible, capable of continual adaptation and transformation, and capable of overcoming the borders (barriers) between sectors, regions, and countries. There is a need to develop corporate, sectoral, intersectoral, national, and global rules, regulations, and standards that would help create a reliable investment environment and strengthen the trust among network participants, expanding their potential and reducing risk inherent in the production of integrated value added.

Depending on their size, resources, and place in the market and their strategy for development, companies have different attitudes toward the development of networks and digitalization, with some being more active than others and others just keeping an eye out, waiting for the right moment. It is important to get an idea of how company executives perceive digital cooperation, what they are wary about, and what measures they are prepared to back. This is especially significant for Russia, as, based on estimates by experts from McKinsey, Russia has a unique chance to actualize its creative potential during the digital revolution and occupy a worthy place among the leaders (Aptekman et al., 2017).

Between 2015 and 2016, the National Academy of Science and Engineering (Germany) conducted a study across six different countries in an attempt to determine just what Industry 4.0 means to companies from various countries, how vital cooperation in this area among companies from various countries is, and how this cooperation can be best organized. The survey featured no companies from Russia, so the authors found it necessary to fill this gap.

The paper provides the findings from a study conducted in Russia by a team from the Lobachevsky State University of Nizhny Novgorod between 2018 and 2019. The study's purpose was to identify some of the key issues in and areas of opportunity offered by cooperation between Russian and foreign companies as part of the process of digitalization of the economy and reveal some of the key common and specific traits in existing approaches to the digitalization of Russian companies.

Methods

The authors' own study relies on a methodology for investigating the risks and opportunities associated with the development of Industry 4.0 developed by the National Academy of Science and Engineering (Acatech) (Kagermann et al., 2016; Schuh et al., 2017), which has made an immense contribution to the development of a common understanding of Industry 4.0, with its approach to the topic regarded as one of the most advanced at the moment. The authors adapted Acatech's methodology employed in its 'Industrie 4.0 in a Global Context' study (Kagermann et al., 2016) by reference to the objectives of their own study and the current situation regarding the study subject in Russia.

The German study was based on 150 interviews and conversations with experts from Germany, China, Japan, South Korea, the UK, and the US, conducted between September 2015 and June 2016. The Russian study, exploratory by its strategy, was based on 50 interviews and conversations with Russian experts, conducted between March and November 2018. The sample incorporated companies of varying size and sector involved, to one degree or another, with the processes of development of networks and digitalization both in Russia and overseas.

To gather data, the authors employed in-depth personal interviews conducted using a set of flexible methodologies (semi-structured

interviewing, prompted interviewing, and interviewing using key questions), which made it possible, on the one hand, to adjust the course of an interview in accordance with what and how much an expert knew about the topic, and, on the other hand, to introduce into the analysis quantitative parameters. The results from personal interviews were supplemented with data obtained via an online questionnaire.

The survey addressed the technical, financial, and business aspects of standardization and cooperation in the area of Industry 4.0. It sought to elicit answers to the following questions: (1) Are there any common, majority-shared notions of Industry 4.0 based on which it would be possible to build cooperation among companies in the area of digitalization of the economy? (2) To what degree must Russian companies cooperate with their partners in the area of regulations and standards in order to be able to gain competitive advantage? (3) What problems, opportunities, and risks do the companies associate with this kind of cooperation? (4) What are some of the best ways to build mutually beneficial cooperation?

Results and Discussion

The present-day understanding of Industry 4.0 in various countries. Based on answers given by the representatives of Russian companies to the open-ended question as to what they made of Industry 4.0, in Russia, just like in most developed industrial countries (key suppliers of Industry 4.0 solutions), Industry 4.0 is viewed today as an integral conceptual foundation (Figure 1).

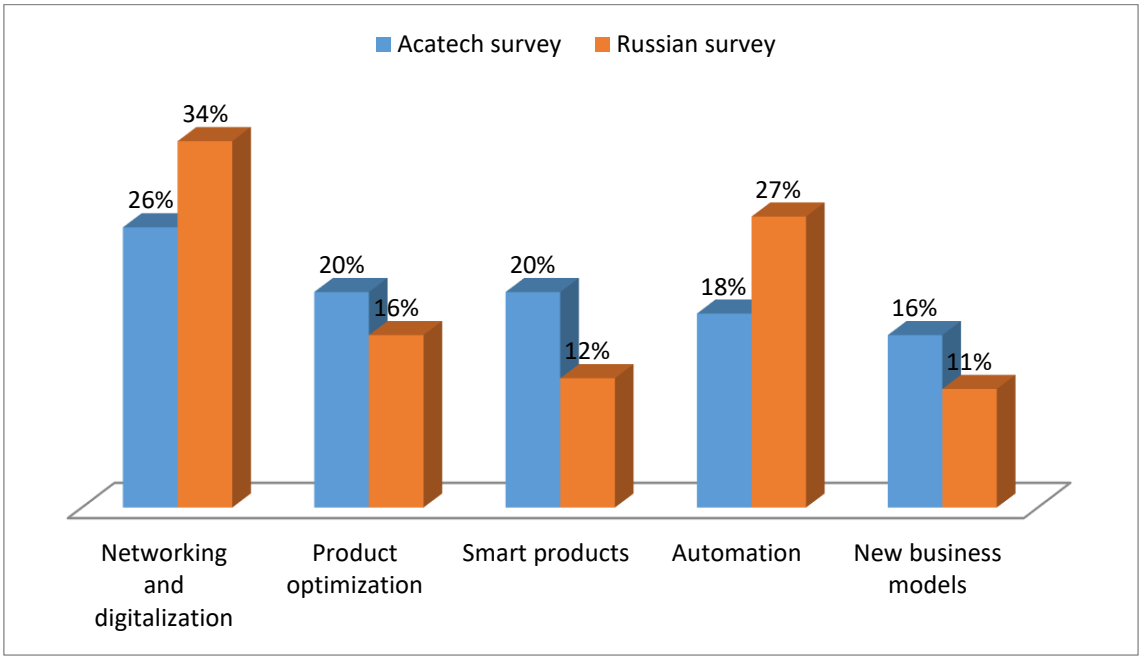

Figure 1. Understanding of Industry 4.0. Data from Kagermann et al. (2016, p. 19) and the authors' Russian survey.

As one can see, experts from all the countries linked Industry 4.0 to, above all, the development of networks and digitalization. However, there were some differences in focus, with Russian companies pointing more often to the need for the development of networks and digitalization as key areas for cooperation (34% versus 26%), as well as the automation of production, which may provide benefits (OECD, 2019a) in terms of productivity, help boost competitiveness, and help strengthen the manufacturing industry (27% versus 18%). It is these elements that are believed to have the potential to help boost the pace of development of Industry 4.0 in an integrated fashion in Russia, and thereby help improve the well-being of its citizens.

Most companies are believed to be keen on implementing Industry 4.0 primarily because of the economic potential it offers. Figure 2 displays the answers provided by the Russian experts to the question as to what economic opportunities Industry 4.0 can offer to companies.

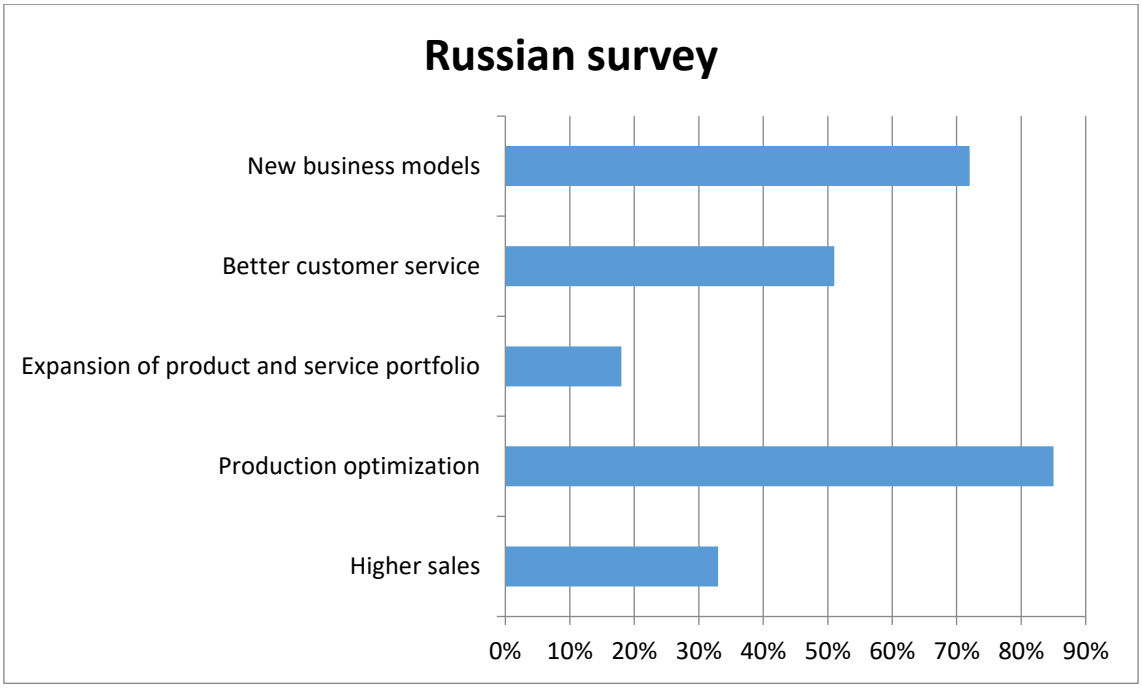

Figure 2. The most significant areas of opportunity offered by Industry 4.0 in Russia. Data from the authors' Russian survey.

The Russian experts cited production optimization as a key economic benefit from Industry 4.0, suggesting that it is production optimization (using the Internet of Things) that will have the greatest effect on the efficiency of activity by Russian companies. This assessment reflects the concept's major production orientation, also highlighted by the experts from Germany, the US, South Korea, and the UK (see Table 1).

Table 1. The Most Significant Areas of Economic Opportunity Offered by Industry 4.0 (across a set of countries).

Areas of economic opportunity offered by Industry 4.0	Russia		Germany		USA		China		South Korea		Japan		UK	
	place	%	place	%	place	%	place	%	place	%	place	%	place	%
Better customer service	3	51	4	38	3	54	4	51	2	55	4	29	2–4	33
New business models	2	72	2-3	50	2	62	3	54	3-4	36	1	50	5	0
Expansion of product and service portfolio	5	18	2-3	50	4	31	1	67	3-4	36	3	38	2–4	33

Production optimization	1	85	1	79	1	62	2	60	1	73	2	41	1	67
Higher sales	4	33	5	17	5	15	5	19	5	18	5	24	2–4	33

Note. Data from Data from Kagermann et al. (2016, p. 20) and the authors' Russian survey.

The experts were unanimous in believing that the greatest economic potential from Industry 4.0 lay in the optimization of production from a standpoint of quality, price (costs), flexibility, and financial results, which had been substantiated by the findings from a number of other studies (OECD, 2017; Institute for Manufacturing, 2018). This is especially relevant for Russia, with its relatively low productivity levels compared with other major economies (cited by 85% of the Russian experts). In a more detailed study conducted recently in Russia, over 60% of the respondents noted such major results from the implementation of digital solutions as accelerated and simplified production processes, greater accuracy and better quality, reduced labor and resource intensity, more flexible processes, and processes that were aimed at specific client needs (Medovnikov, 2018).

In Germany, a major focus is on integrating information, communication, and production technologies within intellectual self-organizing plants. In the US, Japan, and (increasingly) China, Industry 4.0 is closely linked to intellectual products, Internet platforms, and business models that are based on them. China's fast-growing domestic market helps generate the new products required for its future global expansion, so the experts from China placed goods and services portfolio expansion first on the priorities' list (Kagermann et al., 2016, p. 20).

The development of Industry 4.0 can create both new opportunities and new risks. The biggest concern with the Russian experts is risks associated with technology implementation and data security (Figure 3).

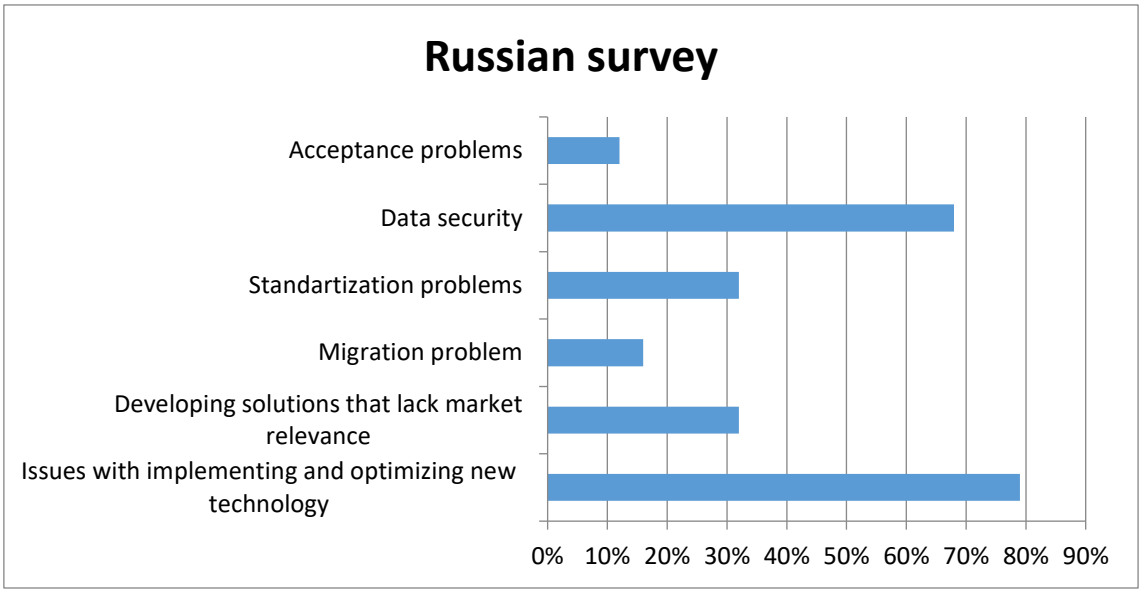

Figure 3. The most significant risks associated with Industry 4.0 in Russia. Data from the authors' Russian survey.

In all of the countries under examination (except for the US), the biggest concern is data security (Table 2).

Table 2. The Most Significant Economic Risks Associated with Industry 4.0 (across a set of countries).

Economic risks of Industry 4.0	Russia		Germany		USA		China		South Korea		Japan		UK	
	place	%	place	%	place	%	place	%	place	%	place	%	place	%
Acceptance problems	6	12	5	20	1-2	50	4	21	3–5	25	5	15	2–4	25
Developing solutions that lack market relevance	3-4	32	2	40	1-2	50	5	19	3–5	25	3	24	2–4	25
Migration problems	5	16	3-4	25	5	13	3	26	3–5	25	4	18	5	0
Standardization problems	3-4	32	3-4	25	3-4	38	2	47	2	63	2	47	2–4	25
Data security	2	68	1	55	3-4	38	1	77	1	75	1	65	1	75
Issues with implementing and optimizing new technology	1	79												

Note. Data from Kagermann et al. (2016, p. 22) and the authors' Russian survey.

The experts expressed a concern that low data security levels may lead to the loss of key competencies, which may become common knowledge. In Russia, just like in other countries, data security is the biggest concern primarily among small and medium-sized enterprises.

In Germany and the US, the world's top suppliers of Industry 4.0 solutions, they are particularly concerned about the risk of development of solutions that lack market relevance, which may result in companies being unable to refinance their investments. Similar concerns were cited by the Russian experts regarding a decline in return on investment in new digital technologies due to increased expenditure on adapting third-party solutions and a lack of domestic solutions geared toward the needs of Russian companies, sectors, and markets.

Another issue that, in the experts' view, requires keen attention and swift action is work on putting in place common standards with a view to ensuring the compatibility of existing systems.

On the whole, the experts acknowledged the topicality of Industry 4.0 and the need to incorporate it into their company's strategy for development, with 42% of the experts from countries that supply solutions and 50% of the experts from Russia noting that their companies would like to take an active part in shaping the future of Industry 4.0. Plus, an additional 8% of the representatives of Russian companies stated their willingness to become number one in the area (compared with 1% of the companies from other countries). Due to the high technological inhomogeneity of the national economy, Russian companies appear to be more polarized in their aspiration for digital transformation, with there being both many staunch proponents of Industry 4.0 and many who are skeptical about its relevance. For instance, 19% of the experts from advanced countries confessed that their companies preferred to postpone the

implementation of Industry 4.0 technology until major solutions became available to them, while 38% of the Russian experts stated that Industry 4.0 had yet to be of real value to their companies.

Standardization. Standardization is a key to the compatibility of different digital technologies. The experts have converged on the view that to achieve a breakthrough in Industry 4.0 it will help to galvanize intersectoral, national, and international efforts on standardizing existing systems. When asked if open standards are crucial to the development of Industry 4.0, the overwhelming majority of the experts (9 of 10) acknowledged the need to employ open standards in order to ensure the compatibility of different existing and future systems (Figure 4)

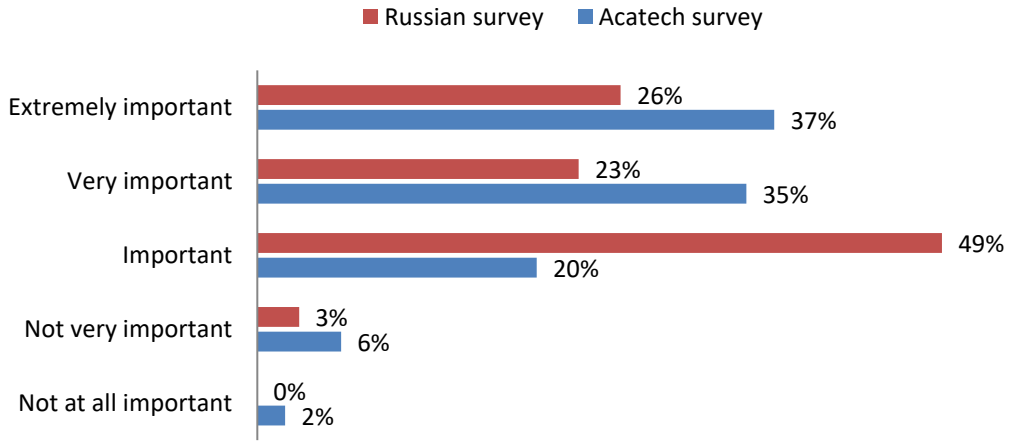

Figure 4. The significance of open standards to the development of Industry 4.0. Data from Kagermann et al. (2016, p. 25) and the authors' Russian survey.

As evidenced by the surveys, most experts are of the view that particular production modules and elements must be governed by uniform standards, which would enable the flexible construction of production facilities from components made by different manufacturers. Open standards may help create affordable solutions for a wide range of users, reduce development costs, and minimize investment risk, especially among small and medium-sized enterprises.

At the same time, many experts from different countries pointed to the risks associated with large American companies putting in place platforms and digital ecosystems that are capable of dominating all new digital markets.

Figure 5 displays the answers provided by the Russian experts to the question as to whether it is possible to preserve closed ecosystems at companies and in sectors.

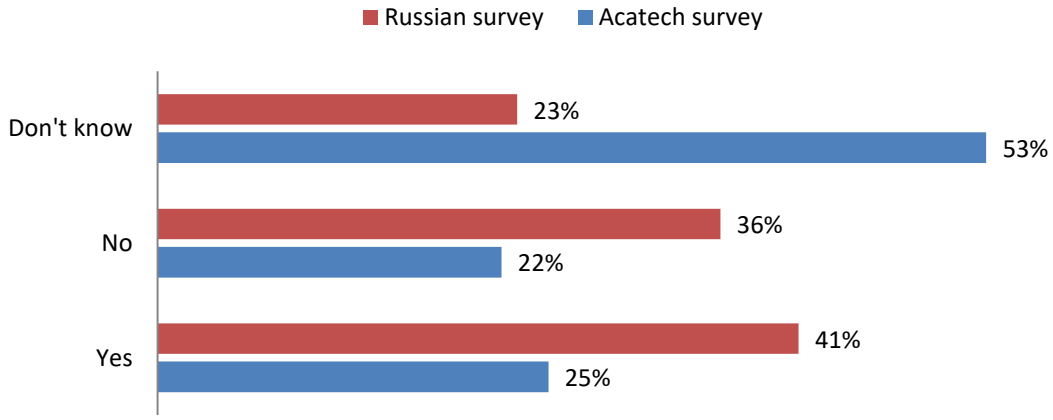

Figure 5. The potential for closed ecosystems to be preserved at companies and in sectors. Data from Kagermann et al. (2016, p. 27) and the authors' Russian survey.

Over half of the experts from countries that lead the way in digitalization were unable to express a clear-cut opinion regarding whether or not industrial companies were going to develop and maintain their own closed (bunker) solutions in the future (53% of the experts in Acatech's survey were undecided, more than twice the number of experts from Russia – 23%). There was a roughly even split between affirmative and negative answers to the above question among the rest of the experts.

Based on the expert assessments, by pace of development of standardization in the sphere of digital technology the countries can be split into two major groups:

1) countries where standardization, as per the majority of experts (70%–90%), is developing too slowly (Germany and South Korea);
2) countries where standardization, as per the majority of experts (50%–75%), is developing at the right pace (the US, China, Japan, and the UK).

The Russian experts were divided on this, with 53% claiming that standardization was developing in Russia too slowly, and 45% stating that the pace was adequate.

The experts warned against making hasty decisions in the area, stressing that, on account of the highly complex nature of Industry 4.0 and the need for extensive discussion and coordination, standardization processes appeared to be more complex and took more time than expected. Most of the experts, especially those from Russia, converged on the view that there would be no uniform standards on Industry 4.0. There is a belief that in the next few years there will emerge quite a large number of standards.

Cooperation. The study helped identify a set of technical areas and related spheres the need for cooperation in which is the greatest. These include learning and professional development, R&D, business models, access to venture capital, and access to talent (Figure 6).

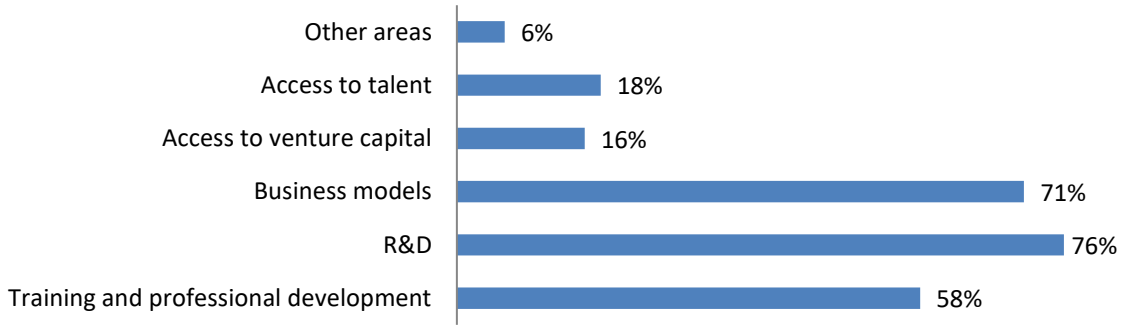

Figure 6. Adjacent areas that are characterized by a need for cooperation among companies and further organization. Data from the authors' Russian survey.

With all the countries involved with the Industry 4.0 survey, the experts identified two major adjacent areas where there is a significant need for cooperation: (1) R&D and (2) creation of innovative data-oriented business models, followed by learning and professional development.

According to the experts, cooperation in R&D should not be confined to companies' R&D departments – it ought to move from a sectoral to an intersectoral, academic, and national level. There is a need to seek out new methods for protecting intellectual property to prevent the loss of know-how in working with outside partners. Small and medium-sized enterprises, especially in Russia, are concerned the most about losing their competitive edge enjoyed owing to their own platforms as a consequence of working with a partner using new business models (Kagermann et al., 2016, p. 30).

The need for professional development is commonly believed to be felt especially acutely at the level of managing the company, at which there takes place the creation and support of unique strategic positions. Protecting a company's competitive edge (e.g., in know-how and technology) is of fundamental strategic significance to each of the partners in the context of any cooperation agreement, while the cooperation ought to be mutually beneficial.

The development of international experimental testing platforms for intersectoral integration was cited by all the participant nations as an effective tool for future cooperation. For instance, test trials make it possible for digital innovations to quickly turn into commercially effective solutions. The study revealed significant differences in attitude towards these tools among startups, small and medium-sized enterprises, and large companies.

When asked the question as to what benefits and risks cooperation in Industry 4.0 development may offer, most experts from different countries were found to share similar views on the matter, with the way led by a focus on compatibility and innovation-related benefits (16%), followed by synergy, economic gain (reduced costs), and speed (13-14%). The experts stressed the need to stimulate various ways of cooperating, including sectoral and intersectoral cooperation, cooperation with suppliers and with competitors, and cooperation with global corporations and innovation-focused startups.

Figure 7 displays the assessments of risks associated with the cooperation provided by the Russian experts.

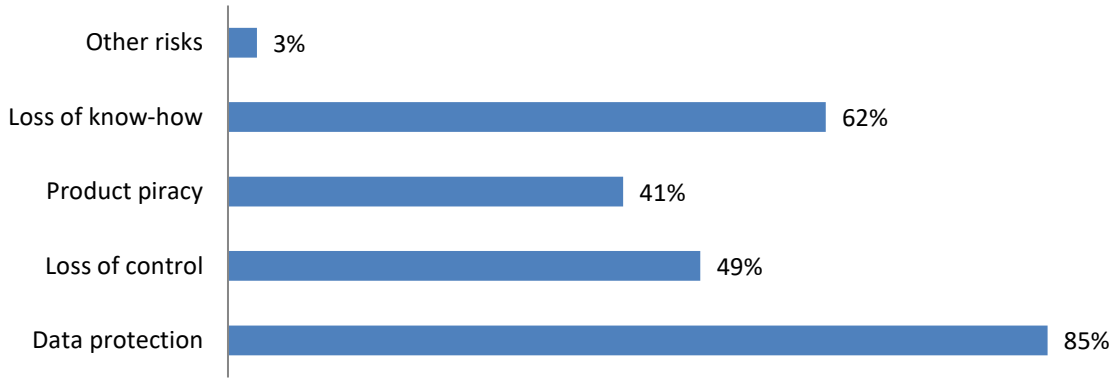

Figure 7. Risks of cooperation in Industry 4.0 for Russian companies. Data from the authors' Russian survey.

As one can see, the biggest challenge for Russian companies is risk associated with data theft or loss. What is typical for all the countries that took part in the survey is that over two-thirds of the experts (60–70%) regarded risk related to data protection as a key risk associated with the cooperation, a view voiced by the majority of experts from Russia (85%) as well. This risk is followed by the risk of potential loss of know-how during the process of cooperation, which was cited by about half of the experts. The risk was found to be a major concern with companies from Germany (75%), the US, and Russia (62%). Product piracy was identified as a secondary concern in all the countries (Table 3). With Japanese companies, the biggest risk was found to be loss of control, with a significant portion of the experts from Japan being of the view that these risks might actually be a reason not to take part in international cooperation altogether.

Table 3. *Risks of Cooperation (across a set of countries)*

Risks of cooperation	Russia		Germany		USA		China		South Korea		Japan		UK	
	place	%	place	%	place	%	place	%	place	%	place	%	place	%
Data protection	1	85	1-2	75	1	69	1	71	1	70	2	61	1	60
Loss of control	3	49	3	45	3	46	4	30	2	50	1	64	4-5	0
Product piracy	4	41	4	35	4	31	3	43	4-5	0	4	24	3	20

Loss of know-how	2	62	1-2	75	2	62	2	51	3	20	3	52	4-5	0
Other risks	5	3	5	0	5	0	5	2	4-5	0	5	0	2	40

Note. Data from Kagermann et al. (2016, p. 34) and the authors' Russian survey.

The experts stressed the need to exercise caution in the choice of contractor. The success of any company in the market is largely governed by their competitive advantage in know-how and technology. A loss of know-how as a consequence of cooperation with other companies is, above all, a threat to the survival of small and medium-sized enterprises.

Even when potential users *are* interested in Industry 4.0 solutions, they may still be reluctant to invest in them. The primary reason behind this is that there have yet to be introduced international standards or universal solutions that would help ensure the compatibility of different systems, which may threaten companies with technological isolation. If they create or acquire standalone or bunker solutions, there is danger that in the mid-term they may become dependent on technology from a certain individual supplier (Kagermann et al., 2016, p. 33). It has been observed that in most countries small and medium-sized enterprises with limited resources are exposed to investment risks the most.

On the whole, some of the key benefits companies expect from cooperation include expanded know-how, especially in terms of protection of data and business models, reduced timeframes for the development and implementation of technology, and prevention of superfluous solutions, which has been substantiated by the findings from a number of other research studies (Kane et al., 2015).

According to the experts, such agreements must be regulated based on a set of fundamental principles (28%) and rules set out in a contract (33%), as well as by trust between the parties, for it is impossible to put together contracts that lend themselves to no dual interpretation whatsoever (28%). Trust is more significant for companies from China, South Korea, and Japan. The respondents unanimously rejected oral agreements as a basis for successful cooperation. The survey revealed the need for dynamic, modular, and standard contracts. It was suggested that contracts needed capture specific obligations and responsibilities for each of the parties (Kagermann et al., 2016, p. 35).

Conclusions

In expanding further on the conclusions from the international study by Acatech and by reference to the findings from the Russian survey of experts, it will be possible to formulate a set of recommendations for Russian companies with regard to fostering cooperation in the area of Industry 4.0.

The study has helped identify several areas in which it is worth galvanizing the efforts of Russian companies, sectoral associations, research centers, and government authorities with a view to ensuring the long-term successful development of Industry 4.0 in Russia.

Russian companies need to take more active part in shaping the future of Industry 4.0 on an international level. This should help bolster the reputation of Russian companies in industrially developed countries. High-tech Russian companies are capable of passing along their unique experience as part of an intensive international effort on putting in place appropriate regulations and standards on Industry 4.0 based on which it will be possible to build flexible value-creating networks. This will require new forms of cooperation that will be supported by Russian government authorities and sectoral associations and international organizations in the area of standardization.

Taking part in the activity of international organizations in the area of standardization will enable Russian companies to familiarize themselves with Industry 4.0 solutions in other countries and enter the market at the right time. This kind of joint activity provides a great opportunity to acquire valuable know-how.

Large Russian high-tech companies ought to devote more attention to the development of compatible, modular products with open interfaces which make it possible to integrate them with solutions from several suppliers. Russian manufacturers of equipment and software products ought to take part in the development of sectoral programming platforms for Industry 4.0, which should help take advantage of network effects for more lucrative interaction with Internet companies.

The growing role of small and medium-sized enterprises in the creation of key Industry 4.0 innovations is still something that is being underestimated in Russia at this time.

In implementing new digital technologies and creating ecosystems based on the Industry 4.0 platform, Russian companies are faced, from the very beginning, with the need to implement new business models. Only the joint development of technologies and business models can help ensure success in this respect.

Russia, just like any other nation, will implement an approach to Industry 4.0 that incorporates two major components. On the one hand, it is following an integrated strategy on Industry 4.0, which includes the development of reference architectures, regulations, and standards. On the other hand, the nation will also develop pragmatic, specialized (field-specific) solutions that should help ensure specific gains for Russian business.

In Russia, the role played by the government in the development of Industry 4.0 is particularly significant due to the nation's poor institutional development level. Russian companies (just like companies in other countries) view threats to the security of their data as a key risk associated with Industry 4.0. The Russian government ought to work closely with the business community and government of partner nations so that it could put in place an appropriate regulatory-legal framework designed to help protect one's intellectual property and data security.

Additional effort will be needed in Russia to foster digital learning in educational institutions and companies. It may be worth drawing all initiatives on digital learning together into a single roadmap for development in the area of Industry 4.0.

Bolstering mutually beneficial economic ties with large ecosystems in industrially developed countries is a vital condition for the successful development of Industry 4.0 in Russia. There is a need for further large-scale international and domestic research with participation from Russian companies, with a focus on deepening the understanding of the opportunities and risks in the development of Industry 4.0.

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