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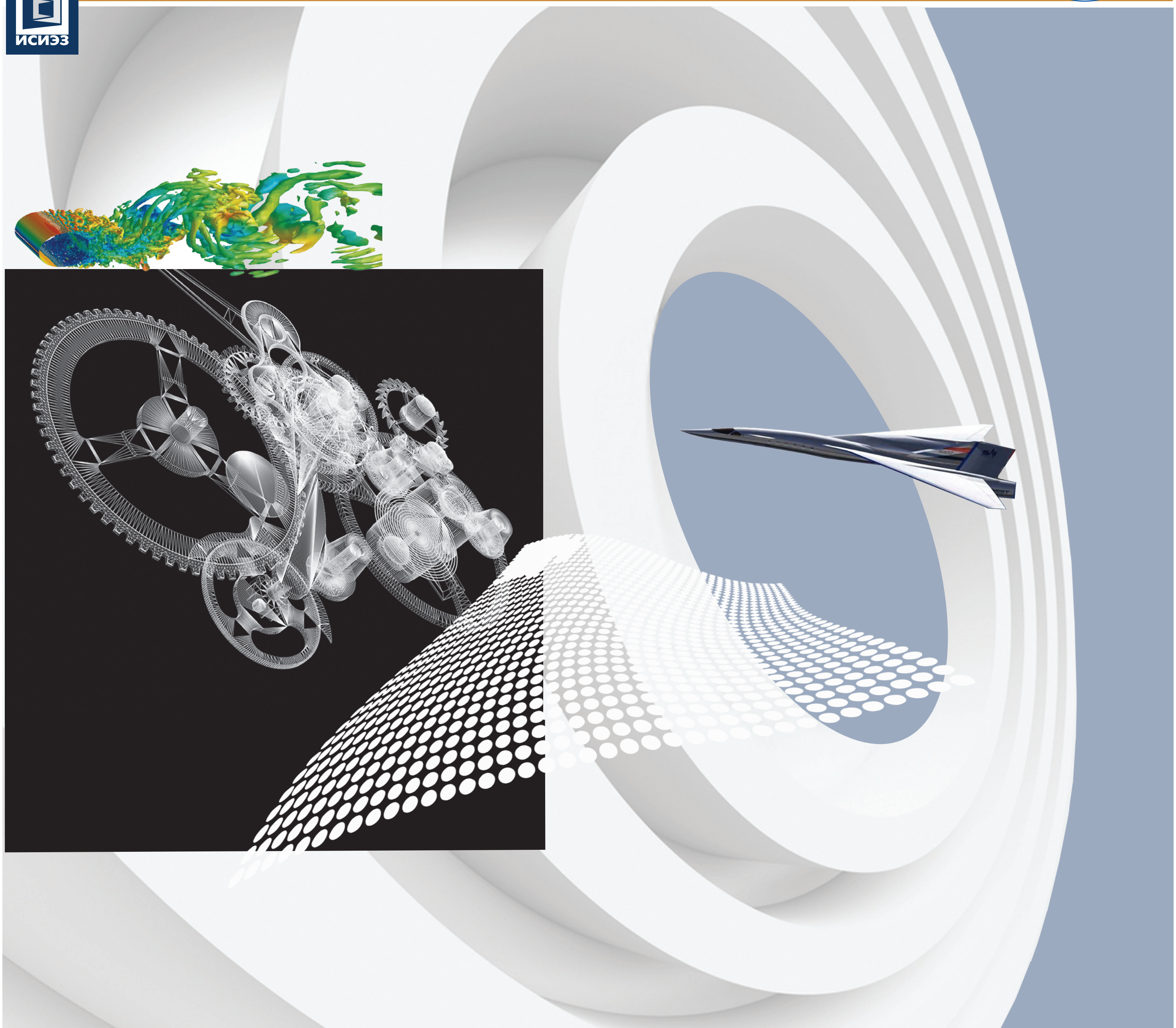

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Foresight-Russia — a research journal established by the National Research University — Higher School of Economics (HSE) and administered by the HSE Institute for Statistical Studies and Economics of Knowledge (ISSEK), located in Moscow, Russia. The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

TOPICAL COVERAGE:

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TARGET AUDIENCE:

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The topical coverage of the journal makes it a unique Russian language title in its field. Foresight-Russia is published quarterly and distributed in Russia and abroad.

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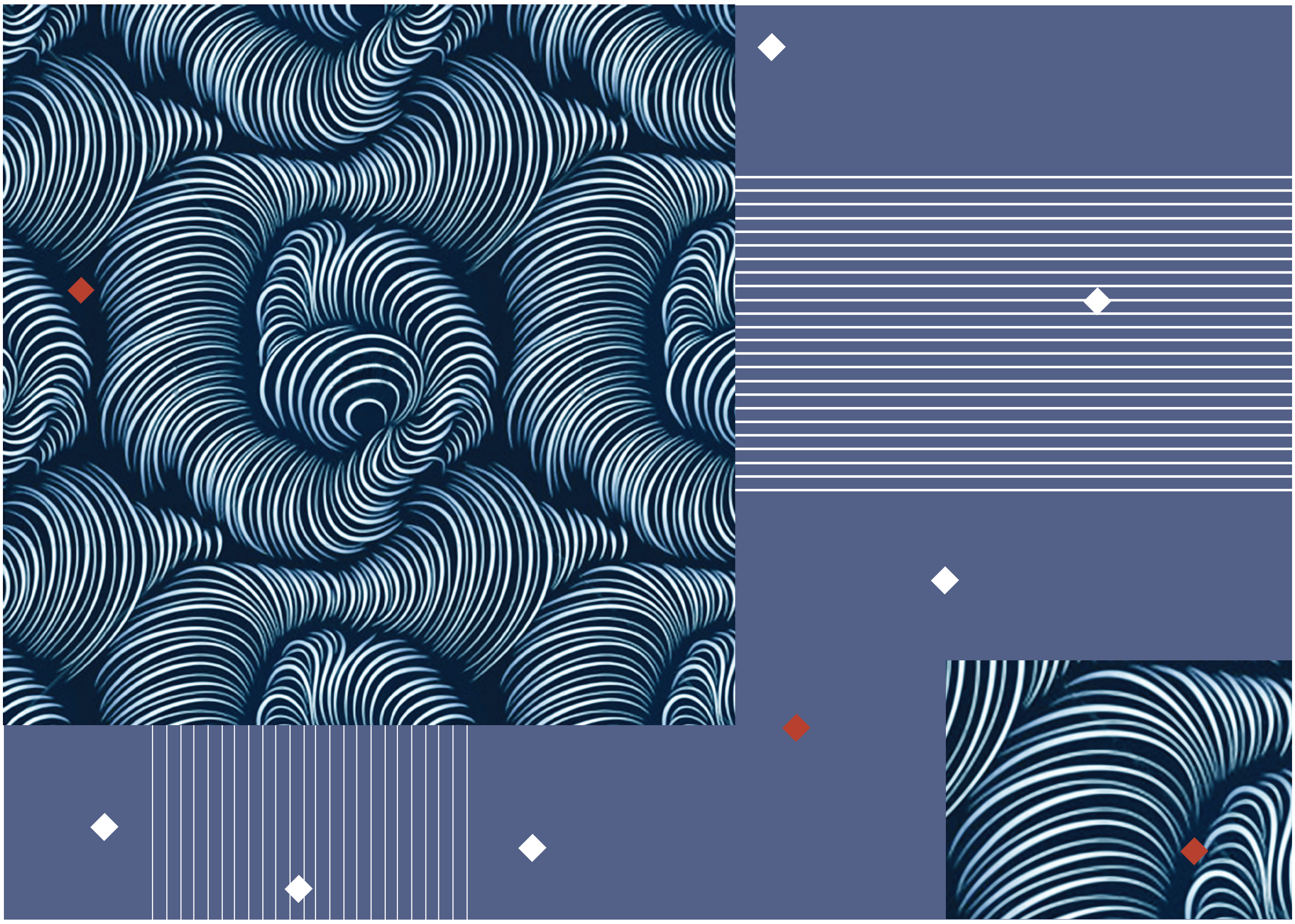
Social Embeddedness of Technology: Prospective Research Areas

Maria Dobryakova, Zoya Kotelnikova



Strategic documents that reflect future S&T priorities are often formulated without sufficiently taking into account the social context of S&T developments. Using the concept of the social construction of technology (SCOT), the paper discusses the capabilities of social sciences for a deeper contextual analysis when setting priorities and, consequently, for helping to make the diffusion of advanced technologies more efficient. It proposes prospective areas of sociological research, whose development may help optimize efforts for the diffusion of new technologies.

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social construction of technology (SCOT); diffusion of innovation; social embeddedness; social sciences; humanities; prospective research areas

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Development in industrial countries is largely based on achievements in science, technology and innovation; indeed, the latter are often considered a key source of economic growth. Ambitious transitional economies strive for this very model. In this respect, planned scientific and technological developments and spontaneous flashes of genius by certain creative groups are thoroughly supported by carefully thought out forecasts and programmes; countries and regions develop these forecasts and programmes taking into account their own interests and circumstances, fixing their developmental priorities and identifying 'critical technologies' and resource opportunities and limitations. In this article, we combine two lines of discussion that are developing in parallel: a social analysis of the relationships between humans and technology on the one hand, and strategic planning, forecasting in prospective technology selection and prospective technology implementation, on the other hand. The aim of this study is to show the opportunities offered by the social sciences and humanities to carry out a more in-depth contextual analysis when formulating country developmental priorities and, ultimately, to raise the effectiveness of policy making in science, technology, and innovation.

Methodological framework: how do innovations take root?

In programme documents on science and technology priorities, science and society have long been viewed as separate entities: it was believed that society is a 'benign recipient' of scientific achievements [*Forsberg et al.*, 2015, p.22]. However, social distrust of certain scientific developments has caused growing concern: a striking example of this is genetically modified foods [*Ibid.*, p.21]. Society has gradually started to see scientific progress as a key reference point in decision making. The analytical document 'Science, society and the citizen in Europe' produced by the European Commission argues for a rethink about the relationship between science, technology and society [CEC, 2000].[1] The concept of 'responsible research and innovation', which proposes taking into account the social and ethical effects of developments, has well and truly taken off [*Stahl*, 2013; *Stahl et al.*, 2014; *Frewer et al.*, 2014; *Bremer et al.*, 2015; *Forsberg et al.*, 2015].

Technology has traditionally been assigned the role of a key driving force, influencing change in social and economic conditions in a certain way. In fact, the latter are rather seen as a resource factor, and the relationship between humans and technology is not broached at all. Recent literature on assessing obstacles to the spread of advanced technology in achieving social and economic goals raises questions about improving scenarios, road maps, methods to identify weak signals and best practices [*Mahroum*, 2012; *Schoemaker et al.*, 2013; *Ram, Montibeller*, 2013; *De Smedt et al.*, 2013; and others] and analyses case studies in specific sectors, for example, bio-products and medical technology [*Wydra, 2015*], energy [*Fortes et al.*, 2015], the 'green' vehicle market in China [*Qian, Soopramanien*, 2015], and institutional conditions for commercializing biotechnologies in Germany and Japan [*Lehrer, Asakawa*, 2004], etc. Social and political measurements are also added to analyses on the effects of technologies and the priority selection process: STEEPV models (*Social, Technological, Economic, Ecological and Public Values*) [*Misuraca et al.*, 2012; *Eerola, Miles*, 2010; *Saritas, Aylen*, 2010] and OCRIO models (*Outcomes, Constraints, Rationale, Intervention, Objectives*) [*Mahroum*, 2012].

Setting aside the numerous differences and various focuses of these studies, it is clear that they are all focused on improving foresight toolkits and techniques, paying virtually no attention to the relationship between the objects chosen by the authors.[2] We propose expanding this branch of the literature to include

[1] For more on the evolution of the European approach to analysing the relationship between science (as a source of technology) and society based on the results of an analysis of projects supported during three framework programmes (1998–2010), see: [*Rodriguez et al.*, 2013]; and on the application of the foresight methodology to identifying science and technology development priorities, see: [*Georghiou, Harper*, 2011].

[2] One unexpected example going against this general trend is an attempt to apply Luhmann's theory of social systems to understand technology [*Herrera-Vega*, 2015]. This is the only study with this analytical perspective in all the literature we reviewed.

a connected theoretical framework: a social analysis of the relationship between humans and technology.

For this, following on from the diffusion of innovations concept, we start by looking at the stages that advanced (innovative) technologies go through before their contribution to a particular field becomes perceptible. We will then set out an additional methodological framework for the analysis: the theory of social construction of technology. With this, we will show how studies in the social sciences and humanities are connected to advanced technologies and could help to maximize their efficient use. In this part of the study, we will describe the corresponding directions of social research that are relevant to Russia in the near future and in the period up to 2030.

The implementation and prospects for mass dissemination of a particular technology resulting in the appearance of innovative products can be described through the diffusion of innovations mechanism. What is the role of the social sciences and humanities in this process? There are two forms of innovation 'implementation': adoption and diffusion. The first is on a micro level, describing the behaviour of individuals: whether they adopt an innovation for themselves, to what extent and why; the second is at a macro level: how the innovation spreads across the whole population over time [*Straub*, 2009, p. 626]. The implementation of technologies is linked to three successive decisions: 1) on using the technology; 2) on the 'depth' of its adoption, i.e., the extent to which the opportunities offered by the technology are realized; and 3) on speed, from replacement of the old with the new [*Åstebro*, 2004, p. 381]. The most important condition for all three of these decisions is that implementing a new technology takes place in a certain social and organizational environment, whether or not this environment is ready to adopt that technology. In other words, assessing the possibility and success of implementing a technology requires an understanding of the social context in which it will be used in future.

The relationship with technology stems from a certain balance in the assessment of risks, benefits and trust in the entity introducing the technology [*Sjöberg*, 2002]. Sociological studies help to analyse sunk costs resulting from a subjective (human or organizational) lack of preparedness for new technologies and their perception.

In his classic work 'Diffusion of Innovation' (1962), Everett Rogers starts with the words of Benjamin Franklin: 'To get the bad customs of a country changed and new ones, though better, introduced, it is necessary first to remove the prejudices of the people, enlighten their ignorance, and convince them that their interests will be promoted by the proposed changes' and formulates this hypothesis in more rigid terms: 'Diffusion is the process by which (1) an innovation (2) is communicated through certain channels (3) over time (4) among the members of a social system' [*Rogers*, 1983, p. 5]. All three of the stages (2–4) not linked to the actual creation of an innovation (1) fall under the remit of the humanities and social sciences.

In fact, these stages do not necessarily occur sequentially. At first glance, the secondary circumstances (which according to Rogers come after creating the innovation) are in fact factors underpinning the formation of the innovation from the very start:

'It is often believed that at the beginning of the process of innovation the problems to be solved are basically technical and that economic, social, political, or indeed cultural considerations come into play only at a later stage... Right from the start, technical, scientific, social, economic, or political considerations have been inextricably bound up into an organic whole. Such heterogeneity and complexity, which everyone agrees is present at the end of the process, are not progressively introduced along the way. They are present from the beginning' [*Callon*, 1987, p. 84].

In the social sciences, several theories have been developed to explain the interaction between humans and technology (and the creation of technological innovations is a special case of these interactions): Actor-Network Theory (ANT)

[*Callon*, 1987]; Social Construction of Technology (SCOT) [*Bijker et al.*, 1987; *Bijker*, 2001]; and Socio-Technical Interaction Networks (SKIN) [*Kling et al.*, 2003]. One of these is rooted in philosophy (ANT), viewing human and material objects symmetrically in relation to one another and analysing the role they plan in designing and reproducing everyday social practices. The others are geared towards a more applied analysis, focusing on the role of social groups in the process of designing technologies (SCOT) or in certain fields, for example information and communication technologies (SKIN).[3] A relatively large number of differences between these approaches exist, all feeding various scientific discussions. For us, however, what is important is that they all arose to counterbalance technological determinism and, each in their own way, make up for its shortcomings.

In the case of innovative technologies, where different social groups have an inherent interest in implementing the results of innovations, it is more appropriate to select the Social Construction of Technology (SCOT) methodology as a framework. This theory identifies the following elements of an analysis, which when examined in series, describe the life cycle of technology in society [*Bijker*, 2001]:

- stakeholders, or relevant social groups (those who are in some way linked to the development or use of the technology);
- interpretative flexibility, or the multiple interpretations of a technology (as perceived by various social groups);
- the technological framework of interaction (between members of relevant social groups);
- ‘closure’ and stabilization (consolidating a particular format of interactions between social groups when using a technology);
- mutual interference, co-creation (continuous interaction between humans and technology and mutual transformation, as a result).

In other words, first the main stakeholders (social groups) are identified, their perception of the technology is reconstructed, together with the perceived pros and cons of the technology, and then the process of coordinating different groups' interests is analysed. After that, the technology is still not yet called into question, but is rather taken as a norm — before the next round of discussion, when new arguments arise for any of the relevant social groups.

Karl Polanyi and Mark Granovetter introduced the notion of ‘social embeddedness of economic action’ to economic sociology [*Polanyi*, 2001; *Granovetter*, 1985]. Granovetter focused on the micro- (individuals), while Polanyi looked at the macro-level (the relationship between the state and the economy).[4] In essence, the concept of social embeddedness lies in the fact that economic actions are carried out not by atomized actors, but are rather built into specific social relationships between living individuals, and these relationships affect which economic results are ultimately achieved. By way of analogy, we suggest viewing ‘social embeddedness of technology’ as a key factor upon which the success of adoption, and at times the very configuration of a technology, depends.

Technology clusters with a high degree of social embeddedness

In virtually all countries which have prepared strategic documents outlining the goals of scientific activity, we see the same societal challenges currently facing humanity. The precise wording and foci may differ, but the material scope of the new technologies remains almost unchanged: medicine, natural resources, energy, the climate, the environment, and security. We are not concerned with analysing specific technologies identified in different countries as priorities to overcome a particular ‘hurdle.’ What is important for us is to show the possibility of bringing together methodological progress in the social sciences with the task of identifying science and technology development priorities. Therefore, for clarity, we have chosen the list of critical technologies in the Russian Federa-

[3] For more on key contemporary social theories explaining the interaction between humans and technology, see: [*Lievrouw*, 2006; *Meyer*, 2007; *Bartis*, 2007; *Pinch, Swedberg*, 2008].

[4] For a detailed review comparing these two classic paradigms, see [*Krippner, Alvarez*, 2007].

tion as the strategic document to be analysed.[5] On the one hand, the example is laconic and is therefore easy to understand, and on the other hand, it is the result of complex expert work.[6] From this list, we have identified 18 of the more ‘socially embedded’ technologies based on an assessment of their potential social and economic effects and have grouped them into four clusters (Table 1). The proposed grouping is not methodologically rigorous. Technologies have been grouped according to industry while their social embeddedness has been identified through expert analysis: the human factor is implied in them, their end ‘customer’ or key consumer is human.

For each cluster, we look at the relevant ‘social’ problems and describe research trends in the social sciences and humanities, which, through a more in-depth understanding of the context and an ability to predict consequences, will contribute to a more effective implementation of certain technologies. In describing the research trends for each cluster, we identify characteristic parameters of the cluster in line with SCOT theory:

- relevant social groups;
- multiple interpretations of the technologies;
- a technological framework for interaction.

The two final parameters — ‘closure’ and mutual transformation — can only be described after the technology has been implemented on a basic level. In addition, we first need to study, from a sociological point of view, how the technologies in question have been (or are) implemented. Moreover, since we will be discussing prospective research directions (i.e. desirable but not yet in progress), in most cases the structure of our reasoning — according to the SCOT format — will become clearer once the studies have been carried out.

Thus, we proceed to describe the desirable research directions for our clusters of technologies.

Prospective directions in research

The research directions that we will enumerate have been selected from a programme of prospective research in the social sciences and humanities. It was developed in 2014 through expert discussions aimed at honing down the most urgent societal challenges for Russia and suggesting a possible role for the social sciences and humanities in overcoming these challenges.[7]

Table 1. **Critical technologies with a high degree of social embeddedness**

Cluster 1. Biomedicine, health	Cluster 2. Energy
1. Biocatalytic, biosynthetic and biosensor technologies. 2. Biomedical and veterinary technologies. 3. Genome, proteome and post-genome technologies. 4. Cellular technologies. 5. Nano-, bio-, information, cognitive technologies. 6. Bioengineering technologies. 7. Technologies to reduce loss from socially important diseases.	1. Nuclear energy, nuclear fuel cycle, safe handling of radioactive waste and processed nuclear fuel technologies. 2. New and renewable energy sources technologies, including hydrogen energy. 3. Technologies to create energy-saving energy transportation, distribution and consumption systems. 4. Technologies for energy-efficient production and transformation of energy from fossil fuels.
Cluster 3. The Environment	**Cluster 4. Transport and travel**
1. Technologies to monitor and forecast the state of the environment and to prevent and eliminate pollution. 2. Technologies to search for, prospect for and develop mineral deposits and extract them. 3. Technologies to predict and eliminate natural and man-made disasters.	1. Technologies to create high-speed means of transport and smart management systems for new forms of transport. 2. Technologies to develop next-generation space rocket and transport technology. 3. Information, control and navigation system technologies. 4. Broadband multimedia service access technologies.

Source: compiled by the authors.

[5] The current list of critical technologies was approved by Order of the President of the Russian Federation no 899 dated 07.07.2011. Available at: http://kremlin.ru/ref_notes/988, accessed 28.01.2015.

[6] The method used to identify critical technologies is set out in the work [*Sokolov*, 2007].

[7] More than 180 Russian and foreign experts took part in the project. In addition to the various forms of expert discussions, the results of a bibliometric analysis based on data from Web of Science and Scopus for 2003–2013 were also used. A detailed report on the results of the project will be prepared for publication in 2015.

Cluster 1: Social research on biomedicine and health technologies

The technologies grouped into this cluster will have a perceptible impact on the health of a nation. Health, while pertaining to the physical world, is largely socially conditioned: aside from genetics, it is linked to lifestyle and everyday habits, but is also connected with whatever quality of life is considered to be the norm in a given society and, consequently, how the health care system is built and the logic governing that system. Therefore, it is appropriate to examine the social prerequisites and consequences of biomedical technologies in two planes: in the context of the health care model and from the perspective of society's readiness (including at the level of certain individuals) to use the results of such developments.

For the technologies to be implemented to such an extent that they are used to their fullest extent (the effective 'depth' of innovation's adoption) [*Åstebro*, 2004], their 'social' parameters must be compatible with existing health care model parameters. We use the term social parameters of technologies to refer to the parameters determined by the social purpose of the development. They are dependent on how the technology will be applied in society: which social groups the technology is geared towards and what the proposed scale of its diffusion and accessibility will be.

Relevant social groups. The development of medicinal products and biomedical technologies affects doctors and patients, members of the pharmaceutical industry, marketing consultants, and regulators.

Multiple interpretations. The notion of a 'safe and effective drug' depends on the views invested in the drug by the various participants in a process, as well as on how these participants solve contradictions arising as a result of conflicts between different reasonings [*Shulgina*, 2014]. For patients, the perception of new drugs can be associated with 'invisible risks.' They are rooted in the 'social unconsciousness', either due to macro- or micro-social mechanisms or as a result of deliberate operations by certain actors [*Stankiewicz*, 2008, p. 56]. This calls for a social and economic analysis of the development of medicinal products, the processes through which they are brought to market and drug prescription practices by Russian doctors. It also calls for monitoring of the state's involvement in controlling and carrying out expert inspections on the pharmaceutical market.

A technological framework for interaction. Starting from the late 2000s, the health care system in Russia has undergone a process of active reform. These reforms set out to solve problems linked not only to raising the efficiency of the system's operations, but also to searching for new health care models, including models based on preventive principles [Government of the Russian Federation, 2008]. These models, geared towards preventing illness and early detection, are more financially advantageous to the state, and in the long-term will undoubtedly help to improve the population's quality of life. Preventive health care, in turn, should take into account the social structure of society and inherent in it forms of inequality.

In relation to the development of a preventive health care model i.e. in defining the focus of new biomedical developments, four major directions of social research can be identified:

- health inequality;
- raising living standards and the population's quality of life;
- mental health;
- the marketization of health care.

Health inequality is a relatively new but extremely pressing issue for Russian society today. It became especially evident during the transitional period, when the economic stratification increased, while access to and the quality of medical care for certain social groups dropped [*Burdyak et al.*, 2008]. Health inequality manifests itself at the level of individuals and at the level of society as a whole. A situation where such inequality starts to be steadily reproduced, giving rise to social polarization, growing tension and increased spending in the social sphere, including on health care, is a major problem. This can have a significant impact on individuals' life chances, cause discrimination on the labour market, intensify the disparity of access to education, lead to growth in relative poverty, reduce productivity in various economic sectors, etc.

To develop preventive health care models, aside from genetics, the social factors of the risk of illness need to be studied. Without such studies, it will not be possible to identify the most vulnerable social groups in this regard. Inequality does not boil down to financial capabilities, but is caused by the effect of the external living environment, cultural practices, and ethical issues raised by treatment [European Commission, 2011; LERU, 2013; ISSC, 2010, 2013].

Studies at the juncture of sociology, demographics (forecasting mortality rates, birth rates, life expectancy) and health economics, on the one hand, and genetics (compiling 'genetic health cards'), neuropsychology, molecular biology and biomedicine, on the other hand, help to conceptualize the notion of health and deviations from the idea of health. They make it possible to improve professional medical practice, by providing doctors with data and instruments which the latter can use to predict the spread of diseases and organize medical support based on preventive principles. They can also help to raise awareness about the importance of creating personalized health cards, conducting genetic testing geared towards the end user, and genetic patient consultation.

Sociological studies of the mechanisms by which epidemiological threats spread will help to develop preventive principles. Amid growing globalization, the increase in migrational flows from developing countries and the expansion of tourism in Russia, citizens' domestic and international mobility is intensifying. As such, analysing potential epidemiological threats is of particular importance. To prevent such threats, we need a comparative assessment of the risk factors and an understanding of the social mechanisms by which illnesses and viruses spread. It is widely recognised that social networks play a fundamental role in the spread of disease [*Granovetter*, 1973], and so it would be advisable to monitor people's spatial movement across Russian territory and abroad, study how tourists communicate with the local population, identify vulnerable social groups from an epidemiological threat perspective, and identify the risk factors (habits, learning models and means of interaction) and mechanisms to reduce their effects. We need to analyse the social aspects of epidemic spread and develop models to increase population immunity. In particular, we need to study how myths about disease arise, devise ideas on the reasons for their spread, and formulate notions of effective treatment, among other things. Social studies will make it possible to elaborate effective measures to prevent epidemiological threats.

Raising living standards and the population's quality of life requires a sociological understanding of the mechanisms by which ideas of health are formed and healthy lifestyle practices made popular. A healthy lifestyle is a controversial and multi-faceted notion, encompassing perceptions of healthy eating, physical activity, the number of hours' sleep, etc. In this respect, it is important to understand the culture of food consumption by various social groups, as well as the link between eating practices and group values, ecological attitudes, consumer competence, religious beliefs, and views on health.

We also need to examine which social circumstances, psychological attitudes and habits interfere with physical activity for certain population groups. Factors having a negative effect on the health of the population also need to be investigated: unhealthy eating, alcohol, tobacco and soft drug consumption, including assessing how accessibility affects consumption levels and models among various social groups, including through monitoring. Special attention should be paid to the younger generations, including teenagers, and the risk behaviour patterns exhibited by them. To work on effective responses, we need to study the role of doctor's practices and medical discourse in shaping people's perceptions of a healthy lifestyle, including in solving problems of excess or insufficient weight. An understanding is needed of which views on healthy lifestyles are formed in a family and passed on to children. It would be worth looking at the limitations and opportunities offered by new technologies and the means of communicating and spreading social perceptions in the popularisation of healthy living models.

Without such research, we will continue to see societies where problems linked to excess or insufficient weight, smoking, consumption of alcohol or harmful foods are not perceived as important; there will be no understanding of their scale or impact on the health of the nation overall, including in the long-term. As a result, resources to develop the corresponding infrastructure and ensure that large swathes of the population are following a healthy lifestyle are insufficient: sports establishments, mass media, including specialist information resources, businesses producing organic food, etc.

Interdisciplinary research on alcohol, drug and tobacco dependence will help to understand the reasons why various social groups are drawn to the consumption of illegal products and are prepared to put their own health at serious risk. This makes it possible to show the impact of education and material welfare on the scale of alcohol, tobacco and drug consumption in society, by providing tools to monitor and assess the effectiveness of state programmes to combat smoking and drug use.

Mental health is an important component of health, and psychological disorders imply high indirect costs: economic and social spending on psychological conditions far exceeds spending on diabetes or cancer treatment [European Commission, 2011; LERU, 2013]. The role of preventive medical technologies is particularly high in this sphere.

Psychological disorders are of course classified as socially important conditions i.e. those which 'are caused predominantly by socio-economic conditions, harm society and require social protection for individuals' [Ministry of Health, 2013]. Of course, in this case we cannot say that social and economic factors are the *primary* cause, but their contribution in terms of preventing or intensifying such conditions is often critical. On a societal level, mental health can affect mass behaviour in general.

Mental health goes beyond the absence of disorders in a strictly medical sense. To a large degree, it is determined by subjective well-being (emotional, human, psychological), which includes life satisfaction, the balance of positive and negative emotions, social attitudes, etc. This gives rise to questions about the social and historical notions of norms and deviations from the norm. From a sociological perspective, it is also important to examine the transformation of psychiatry as a social institution, in particular in terms of dealing with people suffering from psychological conditions.

Mental health (just like subjective well-being) is shaped by a wide range of social, economic, political, and technological factors. Psychological well-being helps to motivate people into long-term activity. It is therefore important to study the link between mental health and employment: phenomena such as tiredness, fatigue, professional burn-out, overtime, occupational safety, mass insanity amid growing information loads, accelerating social processes, the development of ICT, and the increasing complexity of the world around us. Studies that investigate mental health and subjective well-being also make it possible to record increasing depression and growing tension in society in good time, which can have a knock-on effect on the health of the population as a whole, crime, etc. Poor understanding and lack of empirical information impede the identification of widespread psychological deviations, their social causes, and potential consequences, in particular in the workplace.

The marketization of health care is associated with growing dissatisfaction among the population and requires special institutional regulation to eliminate the increasing opposition between morals, technology and the market. These issues are important, for instance, on the growing organ transplant and surrogacy markets. They require both ethical solutions and an examination of institutional reasonings in the health care environment [*Scott*, 2004]. A lack of adequate research prevents regulators from monitoring the effectiveness of health care reforms and promoting the implementation of innovations in this sphere.

The connection between technology, the market, and morals is also considered in health literacy studies. It is important to conceptualize this notion, learn how to measure literacy levels, and identify factors affecting health literacy in modern Russia. This will make it possible to assess the potential and real impact of new digital technologies and means of communication in doctors' practices. Moreover, it will become possible to develop ways to protect personal health care data and to control access to data. Research results will help to reveal Internet behaviour patterns, linked to how people search for information on health and treatment practices.

Cluster 2: Social research on energy technologies

Issues of raising energy efficiency and saving energy occupy an important place on the agenda of Russian state policy. It is believed that the growth seen in recent years in electricity demand could lead to a significant shortfall in the future and could be a major factor stunting the country's economic growth [Government of the Russian Federation, 2010]. We need to transition to sustainable electricity production and increase awareness and the level of end-user involvement in energy development.

Relevant social groups. The problem affects society in general, however the change in electricity consumption behaviour patterns between different social and demographic groups requires further analysis. Everyday electricity consumption culture and practices, peoples' willingness to take responsibility for energy saving and an awareness of civil liability are all pressing subjects in this regard (the latter concerns not only individuals, but businesses too). We need to study consumer literacy in terms of saving energy and the potential impact of new technologies and means of communication on changing behaviour patterns.

Multiple interpretations. Alongside research on reactions and attitudes on an individual level, it is important to assess the probability of and potential resistance points in society. A striking example of such research is the monograph [*Hecht*, 2009], which describes the interweaving of national identity and the development of the nuclear industry in France. In Russia, there are virtually no such studies.[8]

A technological framework for interaction. The prospects of a possible future energy crisis giving rise to the development and use of renewable energy sources is much less intense in Russia than in Western European countries or the US [Government of the Russian Federation, 2010]. The emergence of alternative, cheaper sources of energy will affect the economy, including the labour market. Therefore, it is important to examine the conditions, opportunities, and social and economic consequences of a move from traditional to new forms of electricity production and cheaper sources of electricity, as well as the attitudes of citizens towards renewable energy.

Cluster 3: Social research on natural resource management and environmental protection technologies

Practices in natural resource management and energy consumption are largely shaped by social factors such as value systems and customs.

Relevant social groups. Practices in natural resource management are reflected in the behaviour of both individuals and businesses. Businesses are called upon to decide for themselves whether they will focus only on economic gain or also take into account principles of social responsibility, opting for less profitable, but more environmentally friendly technologies. Indeed, perceptions of technologies can be dependent on ideology [*Plutzer et al.*, 1998]. Of course, in terms of the path that the business selects for itself, a significant role is played by public opinion, which in turn affects the business' reputation.

Multiple interpretations. In the context of attitudes towards the environment, it even makes sense to talk about features of national identity (as a more long-term parameter than transient public opinions). Often, social tolerance is analysed in relation to identity. Usually, this means tolerance towards the 'Other' (conceptualized as representing another culture, religion, etc.) In this case, it

[8] Among the few works are studies carried out in 2007 and 2010 by the ZIRCON group on 'Diagnosing social attitudes in zones of real and potential nuclear energy businesses.' For more information, see: http://www.zircon.ru/about/our-works/2007_2010/, accessed 28.01.2015.

is more about analysing tolerance towards practices that are not conducive to sustainable natural resource management, such as the impact tolerance has on modernization [*Shcherbak*, 2013].

A technological framework for interaction. For this technology cluster, social analysis of interactions between stakeholders should focus on two research directions:

- the societal consequences of climate change;
- the development of eco-mindedness and environmentally friendly behaviour among the population.

Climate change and its social consequences are a global problem, the solutions for which fall largely within the realm of the natural sciences. However, the approaches proposed by natural scientists often prove ineffective, as people simply fall back on social norms and traditions in their behaviour or are guided by another rationale not based on natural scientific reasoning. Empirical studies of social reactions to climate change (both assumed and real) and the perceptions of different social groups to climate trends and cycles are of great interest. No less important are questions of adapting people to climate change, which could have both positive and catastrophic social and natural consequences. In this regard, it is important to study the discourses on climate change, in particular on global warming, and to compare how these discourses are demonstrated indirectly in everyday life with peoples' perceptions. We also need to assess the impact of climate change on the health of the population, including psychologically.

Studies on climate change promote awareness of its potential and real positive and negative effects for society and justify responses to prevent natural disasters. They also bring an understanding of the contextual and local rationale which guides people in their behaviour by reacting to changes in climate conditions, adapting to and surviving catastrophic natural phenomena (for example, drought, forest and peat fires, disruption of the environmental equilibrium, etc.) [*Sobolev*, 2012].

The development of eco-mindedness and the diffusion of environmentally friendly behaviour among the population. To effectively manage a resource-driven economy, there needs to be an adequate understanding of the social history and culture of a territory: how the system of production came to be and how it developed, how producers and consumers adapted to one another, and how they affected the landscape. A vast territory and plenty of natural resources, characteristic of European countries among others, affect the distinct nature of national economies and societies. We therefore need to study the interactions between the size of a country and the practices of managing people and natural resources (land, forests, water, etc.) [*Radkau*, 2000]. The challenge here are the non-market and unlawful means of distributing resources (unauthorized taking by force, poaching, etc.) and the social conflicts caused by these approaches, the consequence of which is social demand for fair, institutionalized distribution of natural resources and conflict settlement.

There is a need to study the extent to which environmental pollution by the population is done consciously and to examine the mechanisms by which eco-mindedness is formed. These include everyday environmental knowledge, attitudes, values, perceptions of 'clean' and 'dirty', the relationship between ideologies and eco-mindedness, the relationship between eco-mindedness and environmentally friendly practices by different social groups, including social surveys of waste management [European Commission, 2011; MRU, 2013], domestic waste processing and recycling technologies and studies of the lives of homeless people and their dealings with waste. We need to analyse mass initiatives to protect the environment and spread environmentally friendly attitudes and behaviour, and examine existing mechanisms to control and distribute natural resources in society from the perspective of 'fairness' and other criteria.

These studies should be compemented by an exploration into the hierarchy of threats in the collective consciousness (physical, material, reputational, etc.).

This would make it possible to conceptualize the contextual and local rationales which guide various social groups in their decision making as to natural resources. Taking these rationales into account, it would then be possible to correct peoples' patterns of behaviour with natural resources (controlling for their social positions, attitudes, and values), develop tools to prevent social tension and political conflict surrounding control over natural resources, and formulate a strategy of awareness-raising on effective natural resource management.

Cluster 4: Social research on transport development technologies

In Russia, domestic migration is currently on the wane. Migration flows have been uneven and are largely becoming uni-directional with large cities being their main destination, active urbanization is continuing. This suggests sociological analysis of city branding, restructuring and reform of city space, and the creation of transport-free zones.

The relevant social groups are city residents, mobile groups of the population, and customers and developers of systems that use geo-data (businesses and municipal authorities). The mechanisms and opportunities to encourage settling in Russian cities and towns, new forms of migration (downshifting, reverse migration, commuting, etc.), and the factors shaping these trends should be of keen interest to the social sciences.

Multiple interpretations. The research agenda involves analysing consumer preferences in terms of transport (their 'environmental friendliness', economy, etc.) and travel methods (public or private transport, or combinations of the two). There is a need to study the consequences for peoples' lives of increased or reduced time spent commuting, as well as the contribution of ICT, distance learning methods and remote working to meet popular demands for less physical travel.

A technological framework for interaction. Geographic information systems are of growing importance for the development of regions, towns and cities. Their widespread application is possible thanks to integration with non-spatial databases and mobile technologies. Geographic information systems in turn could serve sociological purposes too, for instance to map value systems and interests. From a sociological perspective, it is worth paying attention to the growing demand from businesses, the population, and municipal authorities for such geo-data and the contribution of amateur users to data generation.

To change the intensity and directions of domestic travel, we need to study regional mobility and the impact of space management on the lives of people and society. This will make it possible to identify the most dynamic population groups and highlight the factors contributing to or inhibiting domestic mobility. It will also mean that we can develop tools which can help to lock in social imbalances arising as a result of falling public demand for physical travel. Such reduced demand for physical travel is, in turn, due to new technologies or forms of communication (for example, the falling spatial accessibility of cultural sites). Finally, research in these areas will enable us to understand the factors contributing to regional identity crises. The results obtained will help to explain Russian tourism practices and Russians' consumption preferences in terms of holiday destinations, which could in turn serve to develop attractive city brands and implement an effective transport policy.

In the long-term, humanity will more actively develop not only horizontal but vertical space, which will invariably have an impact on the construction sector and on the production of means of transport, etc. [*Utyasheva*, 2014] In this regard, the time has now come for us to seriously consider the possibility of creating 'smart cities', comprising self-sufficiency, integrated management, and electronic government [*Moir et al.*, 2014].

Conclusion

The natural and technical sciences are often contrasted to the social and human sciences: while the former examine natural phenomena in the physical world (*nature-dominated*), the latter are focused on human and social interactions (*human-dominated*). However, the range of problems facing humanity now often requires contributions from both fields. The problem itself might lie in the physical plane and be independent of people in this respect (for example, the state of water basins, the air), yet solving such problems requires both technological efforts and a certain involvement from society through the shaping of attitudes and behaviour patterns which could minimize environmental pollution [*Bastow et al.*, 2014].

We have shown that at the juncture of the physical and the social lie many advanced technologies. Their development plays out in the physical plane, but their effective implementation and use is often inconceivable without the social context for which they were created and in which they exist.

On the list of critical technologies for the Russian Federation (the succinct case study strategic document defining science and technology development priorities), we identified those priorities where the level of social embeddedness potentially reaches its maximum. Realizing these priorities in full will only be possible with an understanding of the associated social attitudes and circumstances. These priorities were broken down into four groups ('clusters'): biomedicine and health, energy, the environment, and transport.

For each 'cluster', we identified prospective research directions in the social sciences and humanities which will make it possible to render the technologies more effective through a more reliable assessment of the context surrounding their development and diffusion. To do this, we applied the methodological framework of the Social Construction of Technology theory, having analysed the composition of social groups affected by these technologies and their potential conflicts of interests.

As this study looks at prospective research, we only considered those elements of social circumstances that, according to SCOT theory, can be foreseen at the technology implementation phase for each cluster: relevant social groups, multiple interpretations of a technology, and the likely types of interaction between groups. Further diffusion of a technology must be accompanied by studies on their 'stabilization' processes for certain social groups and monitoring of the changes that corresponding changes in configuration could entail.

Among such changes are the possible consequences of developing technologies that are hard to assign to one particular field, but which could lead to a fundamental transformation in society. This relates, primarily, to the emergence of 'new subjects' in society, especially in the employment sphere (social robots, personalized virtual agents, etc.) amid the rapid development of artificial intelligence technologies. Studies in this area might start with an analysis of hybridization and autonomous control processes, especially in health care, the education system, large-scale industry and agriculture. However, it is important to examine the negative effects of a technology's diffusion and increasing automation: for example, we see a loss of professional qualifications (including doctors, surgeons, architects, airline pilots, etc.) and at the same time, growing competition between robotic technologies [*Carr*, 2014]. Studying peoples' readiness to interact with technological subjects which carry human values, interests and individuality is linked to this topic [*Smart*, 2014]. The distinction between the virtual environment and the real world is gradually wearing down while the importance of research at the juncture of 'spatial movement — new technologies — anxieties about health' [Skyscanner, The Future Labs, 2014] is increasing.

Thus, we contend that many prospective technologies, which are material in nature, prove more effective if their implementation and, potentially, elements of their development are accompanied (and often anticipated) by the results from corresponding studies in humanities and social sciences. We introduce the 'social embeddedness of technology' notion and consider it a significant factor upon which the success of an innovation — and often, the very configuration of a technology — hinges.

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Advanced Manufacturing Technologies in Russia: Outlines of a New Policy

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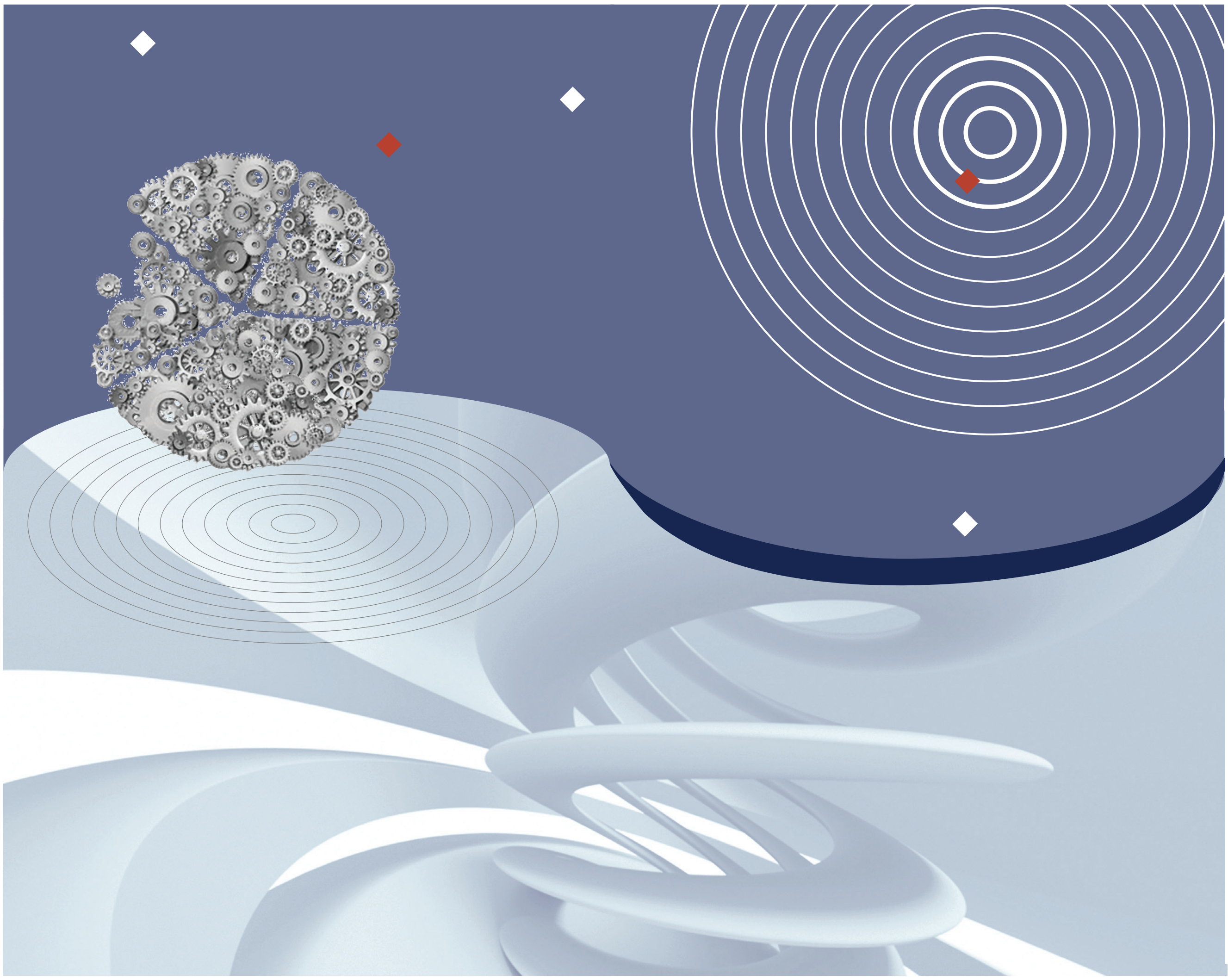

The present article, which continues the discussion of advanced manufacturing technologies initiated in Foresight-Russia issue 2 (2014) [*Dezhina, Ponomarev*, 2014], evaluates the current state of this field in Russia. The analysis here examines the state of the relevant scientific research and the readiness of industry to adopt the new technologies developed by researchers.

The study is based on bibliometric and patent analyses, as well as on expert evaluations of the markets related to different segments of advanced manufacturing.

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advanced manufacturing; state science and innovation policy; bibliometric analysis; patent analysis; demand; project consortia

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Many countries are paying considerable attention to advanced manufacturing technologies (AMTs), and in 2013 the Russian Government followed this trend in turning its gaze to such technologies. This interest is not so much a question of fashion but of real economic needs.

Advanced manufacturing technologies are a comparatively new priority of state innovation policy, even for developed countries. In Russia, where this field has been studied for some time both theoretically and statistically [HSE, 2014b, p. 398], it has taken on new meaning and has expanded considerably in the last two years. The bulk of material on the mass customization of AMTs is analytical reports by consultancy firms, not academic research. Among these are works by the 'Severo-Zapad' strategic development centre (Severo-Zapad SDC) and Strategy Partners Group (SPG). The studies of the former focus on large-scale, long-term changes in Russian industry brought about by advances in AMTs. The Foresight studies by Severo-Zapad SDC have predicted three consecutive technological revolutions that will take place in Russia in the coming decades [*Knyaginin*, 2011]:

- 2013–2020: a mass transition to modern design and life cycle management systems – the 'modular revolution';
- 2013–2020: the introduction of automated design of material functions and properties;
- 2020–2035: the development of next-generation smart environments.

In turn, SPG has concentrated on analysing the impact of AMTs on the production chain [*Idrisov*, 2011; *Idrisov, Grigoryev*, 2012]. In particular, their studies looked at the sub-optimal organizational structure of mechanical engineering as a barrier to the development of the industry. SPG remarked that AMTs contribute to decentralization and growth in the innovative potential of small and medium enterprises, meaning that they weaken the competitiveness of domestic mechanical engineering companies, where high levels of vertical integration are common.

Studies devoted to the different AMT segments in Russia, including new materials [*Labykin*, 2014a], 3D printers [*Labykin*, 2014b], robotics [*Efimov*, 2014], and laser equipment [*Saprykin*, 2014], are examples of the different directions being taken. They outline specific market parameters (value, share of Russian producers) and the positions of key players in the industry.

Recent publications by Yuriy Simachev, Kseniya Gonchar and Andrei Yakovlev examine the innovative behaviour of companies and the impact of various innovation incentive mechanisms (with no special focus on AMTs). They have assessed the dynamics and specific nature of the innovation process in manufacturing companies using constantly updated empirical material [*Gonchar*, 2009; *Golikova et al.*, 2012; *Yakovlev*, 2014]. These researchers have also analysed the effectiveness of various state innovation policy instruments [*Ivanov et al.*, 2012; *Dezhina, Simachev*, 2013]. They also touch on more general issues relating to the implementation of industrial policy, taking into account the impact of different interest groups [*Simachev et al.*, 2014]. The authors of the aforementioned studies noted the lack of favourable conditions for industrial policy in Russia and the relevance of specific initiatives to search for more effective regulatory instruments.

Studies by the Institute for Statistical Studies and the Economics of Knowledge (ISSEK) at HSE [*Gokhberg et al.*, 2011; HSE, 2014a] occupy a special position in research on state innovation policy, the state of supply and demand for technologies and the key technology trends in Russia and worldwide. Researchers at ISSEK have focused predominantly on identifying and developing policy measures to support Russia's science and technology priorities. Given that AMTs were only recently included among the state's technology priorities, ISSEK

Table 1. **Key advanced manufacturing technology segments and examples**

AMT segments		Traditional techniques and technologies (examples)	New techniques and technologies (examples)
ICT systems to support the product life cycle	Multi-dimensional modelling of complex articles	CAD/CAE/CAM, PDM	CAx for additive technologies, cloud technologies, M2M
	Intelligent production management systems		
Equipment and technologies to form articles		Machine tool industry, plastics processing equipment, etc.	Additive production, laser processing
Equipment and technologies to automate production processes		Relays, switches, sensors, power electronics	Industrial robotics, sensor systems
Advanced materials used for new production processes		Metals, plastics	Composite materials, metals, ceramics, etc.

Source: compiled by the authors.

studies have only indirectly touched on them. At the same time, ISSEK publishes a large amount of empirical data, including data on the manufacturing industry and the impact of various state regulatory instruments on the industry [*Gokhberg et al.*, 2014]. As such, despite the relative novelty of AMTs for Russia, closely related fields that are linked to the development of the manufacturing industry as well as state innovation policy, have been studied in some depth.

Our study continues a theme previously analysed by the authors [*Dezhina, Ponomarev*, 2014]. While we proposed a definition of AMTs in this first article together with a summary of foreign experience in supporting this sector, in the present study we have tried to apply the concept and hone down the segmentation of AMTs (Table 1). The article focuses on the level of supply and demand for AMTs, alongside policies to support advanced manufacturing in Russia. We use the following definition of AMTs:

> Advanced manufacturing technologies are a set of processes to design and produce, at a sophisticated technological level, customized (individualized) material objects (goods) of varying complexity, the cost of which is comparable with the cost of mass production goods [*Dezhina, Ponomarev*, 2014].

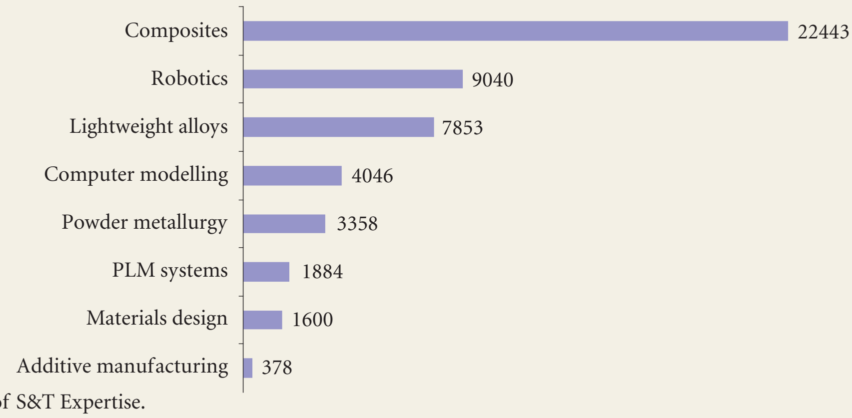
Science as a driving force for the development of advanced manufacturing technologies

To assess the scale of research and development (R&D) in the field of AMTs in Russia, we analysed publication activity using the international Web of Science (WoS) database and the Russian Scientific Citation Index (RSCI). The bibliometric data extracted from these databases were used to summarize data on two different types of research and development (R&D) — data accessible to the international scientific community and data geared predominantly towards a Russian-speaking professional audience. The data obtained chronologically from WoS are limited to a timeframe between January 2000 and September 2014, when it is widely recognized that there was a surge in interest in AMTs abroad. The timeframe for the RSCI covers its entire existence from 1991 to September 2014. The readiness of R&D results to be commercialized was assessed on the basis of data from the company Questel – Orbit for 20 years from September 1991 to September 2014.[1]

Analysis shows high developmental dynamics in all areas of AMTs in leading industrial countries and continuing high levels of research and engineering activity over the last decade. Many technological areas have advanced beyond the realm of university laboratories, having gained a fresh impetus in the research divisions of major industrial companies. The fact that it is predominantly

[1] The database work was carried out by a team in the Centre of Scientific and Technological Expertise at the Russian Presidential Academy of National Economy and Public Administration (RANEPA) at the request of the Skolkovo Institute of Science and Technology.

Figure 1. **Number of publications on RSCI according to advanced manufacturing technology type over the period 1991–2014**

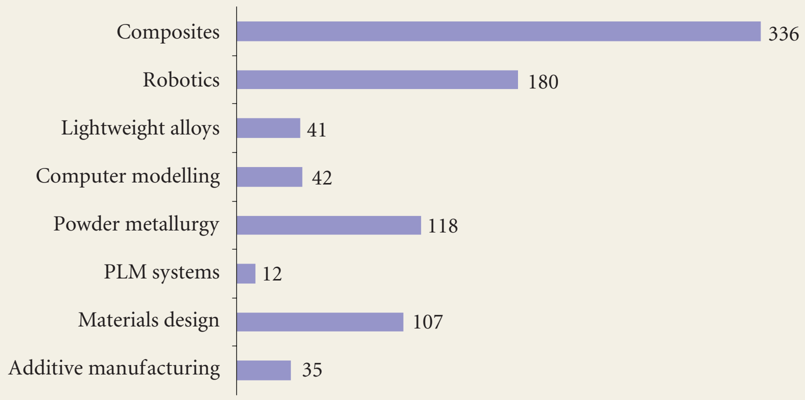


Source: RANEPA Centre of S&T Expertise.

large-scale industrial companies accounting for up to 50% of all patents issued worldwide that are in the top 30 patent holders in each AMT segment serves as confirmation of this. Against this backdrop, publication and patent activity by Russian research centres and companies looks far more modest. This indicates the lack of competitive undertakings that are capable, in the short-term (5-7 years), of securing the country's leadership in certain areas of industrial manufacturing. The highest publication activity figures for Russian specialists on WoS are recorded for 'Powder metallurgy and new alloys' (under 'New materials for AMTs'), with a little more than 2% of all publications worldwide. For such an important, defining aspect of new manufacturing directions as the use of information technologies (IT) for product life cycle management (PLM systems), the percentage is only 0.07%.

However, RSCI data paint a different picture. While the largest number of publications in both research publication databases is seen in fields such as 'Composites' and 'Robotics', is fundamentally different in other areas the situation (Figures 1 and 2). Placed third in terms of publication numbers on RSCI is 'Lightweight alloys', which could be explained by the dual purpose of a significant number of technologies falling in this group. In computer-aided material design and additive manufacturing, conversely, the proportion of publications in international journals is lower than in Russian journals, which is linked to the relative novelty of such technologies and the prevalence of fundamental R&D, the results of which are published intensively in Russian-language scientific articles. However while the institutes of the Russian Academy of Sciences (RAS)

Figure 2. **Number of publications on Web of Science according to advanced manufacturing technology type over the period 2000–2014**



Source: RANEPA Centre of S&T Expertise.

Table 2. **Indicators of advanced manufacturing technology development in Russia (based on scientometric and patent analysis of data from Web of Science for the period 2000–2014 and Orbit for the period 1994–2014)**

Name of technology	Proportion of patents issued in the Russian Federation with a Russian focus in the Orbit global database (%)	Proportion of patents issued to foreign applicants as a percentage of all patents in the Russian Federation (%)	Number of triad patents with a Russian focus	Leading technology countries
Industrial and service robotics	2.83	28.23	1	Japan, USA, China
Powder metallurgy and new alloys	2.28	51.47	1	Japan, China, USA, South Korea, Germany
Lightweight alloys for the aviation and automotive industry	2.00	73.90	1	Japan, USA, Germany, China
Composites, 'hierarchical' materials	1.87	80.61	9	France, Germany, USA, Japan, China
Computer technologies to model and manufacture articles	0.81	47.88	0	USA, Japan, China, South Korea
Information technologies for production cycle management	0.58	80.00	0	USA, Japan, China, South Korea
Computer-aided design to develop new materials with specific properties	0.30	94.00	0	China, USA, Japan, South Korea
Additive manufacturing	0.14	89.31	0	South Korea, Japan, USA, China

Source: compiled by the authors based on data from the report 'Scientometric characteristics of the development of technological directions in advanced manufacturing technologies (AMTs) in Russia amid global trends' (lead: Natalia Kurakova) prepared at the request of the Skolkovo Institute of Science and Technology.

lead the way according to bibliometric data on WoS, universities have complete superiority according to RSCI data.

Six countries act as technological drivers, leading the way in terms of the number of patents and triad patent families: USA, Japan, and China, followed by South Korea, Germany, and France. In Russia, the proportion of patents obtained by residents for technological solutions relating to advanced manufacturing technologies was critically low, especially in the field of additive manufacturing (0.14%) and computer-aided design for intensive development of new materials with specific properties (0.30%). The disproportionately high share of foreign patent applicants in the total number of patents registered in the country is clear over most of the broad spectrum of AMTs (Table 2). As such, non-residents (chiefly companies) own 89% of patents for additive manufacturing solutions. Most threatening to the country's technological interests is the situation in computer-aided design using theoretical models and databases, where 94% of Russian patents have been issued to foreigners. It is not so much the low proportion of Russian publications and patents that is alarming (this can be explained by the low level of internationalization) as much as the lack of national technology drivers in publicly owned industrial companies. Engineering companies, small and medium (but not large) enterprises, academic research institutes, and leading universities are occupying the upper echelons in Russian patent holder ratings.

The results of a scientometric and patent analysis in the AMT sector do not always coincide with expert assessments. This divergence is explained by the fact that publication activity by workers at research institutes and higher education institutions has only recently started to become visible. As a result, the correlation between R&D quality and their representativeness in international publications databases is far from perfect. The RSCI is actually continuing to accumulate a critical amount of information and, despite the length of its existence, has not reached a level of stable operation. The shortcomings of this database continue to be the subject of ongoing discussions in the scientific community. The RSCI is being improved but still cannot be seen as a source of reliable bibliometric information. The limitations of RSCI are also linked to the data analysis methods it uses. Descriptions of the subject areas were drawn up on the basis of primary and secondary key words and word combinations formulated by experts. Ultimately, bibliometric data and patent statistics are dependent on how accurately the relevant field has been delineated. For instance, a significant number of publications on composites can in part be accounted for by including terms with the root 'nano' in their list of key words ('nanotubes', 'nanomaterials' etc.), which has caused a significant increase in figures in view of the fashionable nature of nanotechnology over the last eight years i.e. since the state created the Russian Nanotechnology Corporation (Rosnano) in 2007.

Overall, despite some limitations with the scientometric analysis, it can be argued that Russia has only fragmentary world-class scientific capacity in the field of AMTs.

Readiness of Russian industry to develop and implement advanced manufacturing technologies

The lack of widely accessible statistics for the AMT sector prevents an in-depth analysis of Russian supply and demand for AMT products and solutions. Expert assessments almost entirely replace such statistics, which fragments the overall picture. In the majority of AMT areas on the domestic market, foreign companies tend to dominate. At the same time, in some fields, Russian players have managed to consolidate on the domestic market and even on foreign markets in several areas.

Statistical picture: troubled contours

Official statistical data on AMTs come from the Russian Federal State Statistics Service (Rosstat), foreign economic activity databases (TN VED), and various company databases (such as SPARK). Rosstat data are only available for the machine tools industry; the remaining industries are too specialized to have their own nomenclature with the federal statistics service. More detailed information is available from customs statistics (Table 3).

Unfortunately, even TN VED does not make it possible to specify data for certain types of AMT (3D printers, carbon fibres and articles made from carbon fibre, etc.) as it uses 10-digit industry codes. Business databases (such as SPARK) are not of much use for our purposes either as when selecting companies, it operates using key activity types which do not coincide with AMT areas. Even simple statistics based on the revenue of key players in certain industries are not

Table 3. **Export and import volumes for each market linked to advanced manufacturing technologies, in 2013** (*millions of US dollars*)

Product groups	TN VED Codes	Import	Export	Import-export ratio (times)
Machines (total)	8456–8466	2839	100	28
Of which:				
Laser	845610	83	3	25
For non-metallic articles processing	8464–8465	650	5	119
Parts and accessories	8466	309	28	11
Equipment to process resins and plastics, furnaces and chambers, welding machines, moulding flasks, casting machines, metal rolling cylinders and mills	8454, 8455, 8477, 8480, 8514, 8515	2767	142	20
Control and operation devices	9024–9032	3383	865	4
Carbonaceous materials, fibre glass and fibre glass articles, epoxy resin	390730, 681510, 7019	342	147	2
Industrial robots	847950	41	1	70
Total		10414	1292	8

Source: TN VED database.

reliable as a significant proportion of corporate income cannot be attributed to a certain market, and the revenue structure in databases is not fixed.

Industry associations or consultancy firms (Gardner, CIMdata, Wohlers Associates, IFR, etc.) carry out assessments of AMT markets abroad. In Russia, the role of such institutions in the systematic collection and analysis of statistics is still minimal. Therefore, government departments commission specialist studies to analyse specific technological fields and markets;[2] the clients then have to rely on these results, which are often judgement-based (Table 4).

The data set out in table 4 show that in the majority of industries linked to AMT developments, the situation is difficult, characterised by the dominance of foreign companies. This applies to both traditional (machine tools) and new manufacturing (3D printers). Russian players only occupy strong positions (approximately 30% market share) in the laser manufacturing and software engineering industries.

Niche competitiveness and low demand as barriers: expert assessments

Expert assessments of the level of AMT development in Russian industry correspond on the whole with the statistical assessments provided above. Thus, the best positions are held by Russian players on the software engineering and new materials markets: these players are not only successfully developing domestically but are also actively participating in international projects, supporting a technological level of manufacturing close to global standards. Among the leading group of companies in the software engineering field are ASKON, DATADVANCE, Ledas, CompMechlab, the Russian Federal Nuclear Centre All-Russian Research Institute of Experimental Physics, and Fidesis. The main players on the new materials market are Unikhimtek, ApATeK, and the Federal State Unitary Enterprise Central Research Institute of Structural Materials 'Prometey', among others.[3]

Russian companies are virtually absent from the manufacture of end products in the robotics industry. Despite the general lag in this area, certain companies are offering competitive technical solutions (Vist Mining Technologies, Eidos Robotics, and others). Production of 3D printers is at an initial stage. New companies in this field have recently started to appear for the first time in Russia

Table 4. **Value of markets linked to manufacturing products in the field of advanced manufacturing technologies, in Russia and the share of Russian companies in such markets in 2012***

Market	Market value (*millions of US dollars*)	Share of Russian companies (%)*
Machine tool industry (metal working)	1712**	5
of which lasers	332**	26
Software engineering (mCAD, mCAM, mCAE, cPDM, etc.)	205	30
3D printers	<3	<5
Industrial robotics	40	<5
Composite materials	<350	20

* Estimates.

** 2013

Sources: compiled by the authors on the basis of [*Voronina*, 2012; Creon Energy, 2014; *Kotsar*, 2013; *Laskina*, 2014; Russian Technology Agency, 2014; *Saprykin*, 2014; Gardner Research, 2014; IDC, 2013; Wohlers Associates, 2013].

[2] See, for example, the project to appraise the software engineering market in Russia carried out by the Severo-Zapad strategic development centre at the request of the Russian Ministry of Industry and Trade (available at: http://prom.csr-nw.ru/about, accessed 26.01.2015).

[3] Expert assessments were obtained during the preparation of a public analytical report by the Skolkovo Institute of Science and Technology on the science and technology development priority 'New manufacturing technologies' at the request of the Russian Ministry of Education and Sciences (November 2014). The survey only covered 69 experts, representing different AMT areas (ICT, advanced materials, robotics, additive manufacturing), potential client companies for these technologies, development institutions and government departments.

(Picaso-3d, OAO Centre for Additive Technology Skills, the Central Research Institute of Machine Building Technology, etc.)

Regarding the use of advanced technologies by organizations and manufacturing departments, experts have noted the high level of uptake by Russian enterprises of software engineering and other PLM (Product Lifecycle Management) system elements. At the same time, a key factor continues to be the fragmentation of different business processes, which makes it harder to not only collaborate with different businesses in the manufacturing chain but also work with branches of major integrated structures.

Alongside more general problems such as expensive credit resources and the shortage of highly qualified personnel, the development of Russian companies in the field of AMTs is being held back by an imbalance typical of the market, linked — on the one hand — to a shortage in demand and — on the other hand — to the lack of several important technology skills. The challenge of stimulating demand is not a simple matter of solvency, but rather involves overcoming a low motivation to modernize and high levels of monopolism, encouraging technological competition (which currently takes place mostly outside the technological plane), reducing the conservative regulation of public contracts, and extending the planning horizon. The development of innovative development programmes by publicly owned companies goes some way to mitigating the impact of the above-listed negative factors.

From the viewpoint of increasing supply, companies' capabilities are limited by the lack of a 'platform' or other key technologies. These technologies determine the competitiveness of an entire class of complex products using AMTs yet cannot be developed by a single small innovation company alone (for example, a 3D kernel for computer engineering).

Thus, the development of AMTs in Russia is hindered by stagnating demand amid a general decline in economic growth, a worsening investment climate, and the particular way in which the activities of monopolies and publicly owned companies are regulated. The sector is also affected by the lack (or underdevelopment) of the necessary technological groundwork which is caused by the low priority given to AMTs by R&D funding from various state and non-state sources. At the same time, despite Russia's high overall dependency on imports, there are still scatterings of skills in several AMT segments and potential opportunities for expansion. Stimulating the development of this sector requires coordinated efforts from the state and business to spur on and establish competitive supply.

Evolution of state instruments to support links between science and business

Russia has accumulated a wealth of experience and various instruments to stimulate links between scientific organizations and industrial enterprises; previous experience in this area is very important for the development of AMT sector. The first state innovation projects were initiated by the Russian Ministry of Industry, Science and Technology back in 2002.[4] These large-scale projects brought together representatives of the scientific and industrial spheres to solve key problems concerning the competitiveness of Russian technological products, including trying to lower the cost of manufacturing through cost-effective use of resources. Due to the significant budgetary funding (from 0.7 to 2 billion roubles for each project) and the involvement of some of the largest Russian companies, the initiatives have been referred to as 'megaprojects'.

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[4] Order of the Russian Ministry of Industry and Science 'On the organization of work at the Russian Ministry of Industry and Science to prepare proposals on projects (programmes) of special state importance' no 22 dated 11.02.2002.

The results of these megaprojects are varied. Official figures show that they are effective from a financial perspective. Moreover, some have resulted in positive effects that are significant in light of the development of AMTs. In particular, new forms of project management have been introduced by outsourcing a number of administrative duties to foreign companies [*Dezhina*, 2008, p.119]. A serious shortcoming of this tool, however, lies in the fact that R&D was financed by federal budget funds paid directly to research institutes and higher education institutions. The companies, in whose interests the work was carried out, only wanted to commercialize the results. As such, the links between the scientific structures and the companies (the customers of the R&D) who were accountable to the government (the R&D funder) were mediated and more complex. Later, in 2010, this process was optimized by using subsidies to businesses to finance complex high-tech manufacturing projects carried out jointly with higher education institutions.[5] The errors of the initial megaprojects programme in 2002 were taken into account: enterprises became the recipients of the state support, and then passed on the funds to higher education institutes which carried out the R&D.

The first results of these joint projects were revealed in 2011–2012 [*Dezhina, Simachev*, 2013]. This analysis showed that the largest payments from this system went to medium-sized companies interested in expanding their R&D through the use of research and engineering collectives and through gaining access to the scientific equipment of higher education institutes. The motive of obtaining additional funding for innovation activity was important for small firms, but less so for large companies. Moreover, economies of scale played an important role in networking: cooperation lasting for more than one year and expanding the composition of participants (scientific and industrial organizations) proved to be the most effective.

Alongside direct (including financial) state support for collaboration between R&D actors and manufacturing in the field of AMTs, infrastructure projects aimed at developing small, science-intensive business have been particularly important. One of the biggest in scale and one of the longest running such projects has been support for science and technology parks (STPs). In one form or another, STPs have received funding over the entire post-Soviet period. The results of a survey distributed to 17 science and technology parks (out of 35 initially selected), carried out by Ernst & Young and the Russian Venture Company in 2014, confirmed that only half of all science and technology parks granted access to their laboratories and specialist equipment to innovative small and medium enterprises [Ernst & Young, RVC, 2014, p.6].[6] The majority of parks only leased out premises, including for negotiations and conferences. The end result is that resident companies have been buying expensive equipment which, as a general rule, is not used to its full capacity [Ernst & Young, RVC, 2014, p. 14]. An analysis of programmes to create innovation infrastructure at higher education institutions[7] has shown that an overwhelming number of STPs are still structural sub-divisions of universities with a maximum of three employees [*Bakardzhieva*, 2014].

An attempt to consolidate successful STPs in the form of an 'Association of High-tech Science and Technology Parks' [Association of Technology Parks, 2014] has so far only been partially successful. Just three STPs in Russia meet the requirements to join this association: the Kazan IT Park, the Novosibirsk

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[5] Resolution of the Government of the Russian Federation 'On state measures to support the development of cooperation between Russian higher education institutions and organisations carrying out integrated projects to develop a high-tech industry' no 218 dated 09.04.2010.

[6] The survey was conducted among previously surveyed (i.e. not the top performing) science and technology parks (17 out of the 80–90 in existence); therefore, overall, the actual figures are likely lower then presented in the survey.

[7] Resolution of the Government of the Russian Federation 'On state support for the development of innovation infrastructure in federal higher professional education institutions' no 219 dated 09.04.2010.

Academpark, and the High-tech Technopark in the Khanty–Mansi Autonomous Okrug (or Yugra) [*Bakardzhieva*, 2014]. One possible model to optimize the work of STPs has been implemented in a project to create a prototype centre based in the Novosibirsk Academpark, which has been named the Technology Support Centre. Its purpose is to allow residents to quickly and cheaply develop prototypes of a new product and launch small-scale production. The centre's business model is based on the state purchasing the necessary equipment in consultation with the residents of the park and leasing it out at preferential rates. In parallel to this, small companies are being set up to provide small-scale manufacturing services, initially to larger clients, and later to a wider range of partners, thereby ensuring that the equipment is used to maximum capacity. The network of small enterprises immediately 'catering for' some of the innovative firms in the park allow for deeper collaboration and stronger ties between links of the manufacturing chain.

This approach has also been adopted in the form of engineering centres, which started to be set up from 2013 [Government of the Russian Federation, 2013] and are fitted out with the latest equipment. Roughly 50% of spending at these centres based in higher education institutions and research organizations goes on buying experimental industrial equipment; more than 20% goes on specialist software [*Povalko*, 2014]. The developmental history of technology infrastructure in Russia offers several examples of the successful formation of both the technological ecosystem itself and the resident companies situated within that system. Such examples can be used to broaden ties between stakeholders involved in the development of AMTs.

To date, Russia does not yet have any innovation policy instruments which meet the developmental needs of the AMT sector. At the same time, mechanisms to support collaboration between industry and research organizations and stimulate the development of the production chain through STPs can be viewed as a foundation upon which further improvements of the policy toolkit and adaptations of these tools to the specificities of developing and manufacturing products can be made.

Prospective directions for support

Our analysis of the tools used to support collaboration between research organizations and enterprises (both small and medium-sized), and our assessment of the level of preparedness of the relevant scientific research and industry for the development of AMTs allow us to recommend several trajectories for improving Russia's state policy in this field.

First. The formation of project consortia to provide targeted support to segments shaping the development of AMTs. A key element here is ensuring that there is guaranteed demand (a 'starting order') from major Russian companies or individual industries, i.e. clients taking on an obligation to purchase the technologies and/or products created by consortia when the latter achieve previously agreed technical, price or other parameters. In this respect, it is important that the demands on those performing the research are coordinated as far as possible, allowing them to concentrate their resources on achieving certain characteristics. Such cooperation could take place through the state, which would establish a set of applicable measures based on its own priorities, or without state involvement. The formation of market demand through a 'starting order' is an important factor affecting the choice of these priorities.

A central element in state support for the AMT sector is stimulating clients from all public sector companies in the economy by controlling development programmes, including forms such as 'innovative development programmes'. Another important tool continues to be the system of technical requirements in public contracts. Alternative approaches to generating 'starting orders' are possible, for instance, indirect regulation to stimulate general innovation activity in the economy. Project consortia could be set up based on the experience and links of existing technology platforms, especially those where both manufacturers and consumers of AMTs participate. The budgets of consortia could take on different configurations of company funds and state support, depending on the specific nature of the technologies, products, markets and the participants themselves.

Second. The formation of a coordinated R&D programme at the pre-competitive stage, taking into account the interests of consortia and major players involved in deciding to start AMT development. Within the scope of their respective mandates, federal departments and funds could be granted access to key R&D results obtained by consortia members during the pre-competitive stages.

Third. The creation of prospective research centres at research institutes or higher education institutions to carry out R&D on AMTs at the pre-competitive stage, as well as to train specialists on new areas of technological development. Centres must provide research, scientific, expert, and educational support for the science and technology activities of public and private sector companies, with a focus on small and medium businesses. Depending on economic viability, they could set up small innovative companies in line with their own profile. The assumption is that such centres would be open structures working on orders from both consortia (anchor investors) and the external market.

Fourth. Infrastructure support. Since the AMT areas described in this article lower the barriers to entry for small and medium companies (due to a focus on individualization and outsourcing), these companies are starting to become one of the supporting elements of the system to underpin the development of such technologies. The activities of small companies can be optimized by stimulating their links with local administrations, STPs, special economic zones, etc. In this respect, small companies are recognized as able to service the needs of medium enterprises, including the manufacture (even on a small scale) of required parts and components.

Regional and local administrations could work harder to develop infrastructure and support STPs by ensuring that preferential equipment lease rates are offered to small firms that provide services to medium and large companies. In addition, the small Science and Technology Business Development Support Fund and other support institutions for small businesses could develop various forms of collaboration between small, medium and large enterprises, making more active use of innovation vouchers, grants for staff retraining, etc. All of these measures would make it possible to establish a toolkit in Russia adapted to the specific needs of developing AMTs and contributing to the formation of an environment for effective collaboration between the clients and developers of AMTs in consortia and long-term research projects. R&D in key or 'platform' technologies could serve as a scientific basis for the development of AMTs. Finally, targeted support for small and medium innovative businesses would help create and consolidate network production chains. F

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Pilot Innovative Territorial Clusters in Russia: A Sustainable Development Model

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Many countries consider regional clusters as drivers for economic growth and an efficient tool for interaction between actors of a regional innovation system. Numerous financial and non-financial mechanisms of government support are aimed at making these clusters self-sustainable. However the emergence and outlook of a cluster largely depend on a range of basic conditions, so there is always a risk that without government support, the cluster will not be able to shift to the desired trajectory.

The paper analyses Russian experience in supporting pilot innovative regional clusters and suggests indicators of their sustainability.

Innovation policy globally over recent decades has seen the concept of clusters spread widely, accounting for growth in business competitiveness via the effective collaboration between nearby actors, enhanced access to technologies, innovations, specialist services, highly qualified executives, etc. Developed clusters have become an effective tool for attracting foreign investment and integrating domestic manufacturers into the global high-tech products market.

From 2012, Russia has implemented a support programme for innovation regional clusters in accordance with the Innovative Development Strategy for the period up to 2020 [Ministry of Economic Development, 2012]. With this in mind, 25 pilot groups were selected and split into two groups which were due to receive support over the next five years [HSE, 2013]. The first group was made up of 14 clusters with the best development programmes, according to experts. In 2013, they received federal budget subsidies worth a total of 1.3 billion roubles and could count on priority support over the next few years. The second group included 11 clusters which did not initially receive any subsidies, but started to benefit from them from 2014.

The cluster selection criteria and procedures and support structures adopted under this programme are on the whole in line with similar European programmes [*Kutsenko, Meissner*, 2013, pp. 20–24]. It is clear, however, that state funding does not guarantee success. There is the possibility that if the funding is curtailed, the clusters will cease to exist or convert into other forms. Such quasi-clusters could hamper the innovation activity of their members, confining technologies and business models to losing competitiveness [*Menzel, Fornahl,* 2007, p. 5].

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The prospects of accelerating inter-firm collaboration in local innovation systems and creating clusters with different specialties in different regions across Russia will in many ways depend on whether certain clusters are able to transition to a sustainable development model in the next five years. Consequently, it is important to highlight the weaknesses in the operations of pilot clusters and draw up recommendations to accelerate their development.

In this article, we analyse leading state cluster policy practices in certain countries, consider the most important characteristics of a successful cluster, and assess how well Russian cases match these. We also present an overall sustainable development model and summarize results based on applying this model.

Cluster policy study: International and Russian experience

The scientific and analytical literature has reviewed and analysed almost two decades of targeted cluster development around the world. Summary papers on national policies occupy an important position in this literature. Of particular note is research by the OECD, one of several studies offering intercontinental coverage, as the sample included clusters from France, Germany, Canada, USA, South Korea, and Japan [OECD, 2007]. It presents structured case studies of 26 national cluster development programmes in 14 countries. It should be noted that in view of the fundamental discrepancies in the treatment of cluster policy specific to certain countries, the research tools were not clearly defined. The characteristics of the varying approaches in different parts of the world are provided in Table 1.

The majority of other studies are focused exclusively on European countries and are based on their understanding of the concept of clusters, which explains Europe's leadership in terms of how long the cluster approach has been used and the number of clusters formed.[1]

In 2008, the consultancy firm Oxford Research presented a summary report on national and regional cluster strategies in 31 European countries [Oxford Research, 2008]. It paid particular attention to analysing state initiatives and programmes and the organizations responsible for implementing them.

Another project, the Transnational Alliance of Clusters Towards Improved Cooperation Support (TACTICS) [Pro Inno Europe, 2012], focused on core national programmes in Austria, Belgium, Great Britain, Hungary, Germany,

Table 1. **Specific features of approaches to state cluster policy**

Cluster policy elements	EU countries	East Asia and other world regions
1. 'Cluster' as a concept	An organizational mechanism created by regional entities (business, universities, research organizations, financial institutions, etc.) with the aim of solving common problems and carrying out joint projects.	All interrelated export-oriented forms of activity that are core specialization sectors in a region.
2. Definition of participants as a criterion of a cluster's existence.	Present. Clusters are a corporate management tool allowing participants to collaborate effectively with their immediate environment (competitors, contracting parties, higher education institutions, research organizations, regional authorities, etc.) Companies have to share this concept and associate themselves with a specific cluster.	Absent. Clusters are a state policy tool in industry, innovation, support for SMEs, etc. Companies may not know what a cluster is, but still consider themselves a part of it.
3. A dominant selection procedure for clusters seeking state support	Announcement of an open competitive tender which any groups of organizations viewing themselves as clusters may participate in. There may be a condition that an application is approved in advance by regional authorities.	The definition of clusters by analytical means (*cluster mapping*) or political decisions.
4. Definition of support measures	Development of joint projects by cluster participants and their correlation with possible state support measures. The state assists in cluster participant self-organization and collaboration measures, coordinated through a cluster development centre, specialist cluster development organization, etc.	Based on a 'top-down' analysis of the strengths and weaknesses of a cluster (for instance, using the 'Porter rhombus') [*Porter*, 1990].

Source: compiled by the author.

[1] 356 clusters took part in the 'Cluster Initiative Greenbook 2.0' study, of which 254 were European [*Lindqvist et al.*, 2013, pp. 11, 13].

Denmark, Spain, Italy, the Netherlands, Norway, Poland, Portugal, Slovenia, Finland, France, the Czech Republic, and Sweden. It resulted in a collection of best practices for stimulating user-driven innovations in clusters, the use of the cluster approach to develop emerging industries, cluster marketing and branding, assessing the effects of cluster policy, and international collaboration, among other things.

Over the last decade, the core literature on cluster policy has been enriched with qualitative studies. As such, the European Cluster Observatory, guided by Michael Porter's methodology [*Porter*, 2003], carried out a statistical analysis covering all European countries with a view to uncovering clusters. The resultant database then served as a basis for subsequent studies, including those at the request of the European Commission [European Commission, 2007]. The Observatory also keeps a pan-European register of specialist cluster organizations. In its 'Innobarometer' report for 2006, it assessed the impact of such structures on innovation processes [European Commission, 2006].

Another influential international project was the Global Cluster Initiative Survey. It resulted in two 'golden books' [*Sölvell et al.*, 2003; *Lindqvist et al.*, 2013] presenting analytical material on 238 and 356 clusters respectively, although this only accounted for 10–15% of the total number of clusters identified on a global scale.

The comparative study 'Clusters are individuals' is noteworthy, covering 230 specialist cluster organizations and state support programmes in 23 European countries. It set out best practices, support programmes and key success factors [*Müller et al.*, 2012] and made recommendations for the future [*Christensen et al*., 2012].

The format of recommendations for European politicians and managers is not new. One of the first guides of this type presented successful, leading experience from cluster development in the region of Upper Austria [CLOE, 2004]. The report 'Clusters and clustering policy: a guide for regional and local policy makers' [INNO Germany AG, 2010] summarized the views of a number of EU, UNIDO and OECD experts, as well as representatives of national and regional governments and cluster managers. The conclusions of the latest empirical studies are summarized in the work [*Ketels*, 2013].

The European Cluster Excellence Initiative's system of assessing the quality of cluster management[2] is a perfect example of accumulated experience, serving as a basis for the certification of almost one third of managing organizations [*Müller et al.*, 2012]. In view of the current European interpretation of clusters as an organizational mechanism (Table 1), the studies mentioned here do not touch on the economic parameters of their operations, such as their combined revenue, investment, and research and development (R&D) expenditure. The focus is instead placed on the various aspects of collaborations between participants. The more significant facts and figures include the number and make-up of participants; the life span, field of activity, sources of funding, organizational structure and staff numbers of specialist cluster organizations; and the mechanisms to take into account the different interests (primarily of business and state authorities) in their activities. In essence, it is not the cluster as a group of actors that is assessed, but rather the quality of the cluster initiative, i.e., the organizational efforts to support the cluster.

In Russia, a vast collection of scientific literature has been amassed on this topic but the standard lags far behind that of foreign studies. This is primarily due to the lack of detailed information, which started to become available only relatively recently for cluster support programmes.[3] In the majority of cases, publications relate to specific examples, while comparative works are extremely few

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[2] Available at: http://www.cluster-excellence.eu/, accessed 18.12.2014.

[3] In addition to the aforementioned pilot innovation clusters, in some Russian regions, support is being offered to cluster development centres. From 2010, as part of a small and medium enterprise development programme, the Russian Ministry of Economic Development allocated subsidies for this purpose amounting to a total of almost 650 million roubles. Funding was received in: Saint Petersburg, Astrakhan, Belgorod, Voronezh, Irkutsk, Kaluga, Kemerovo, Kirov, Kurgan, Lipetsk, Murmansk, Novgorod, Penza, Rostov, Samara, Tomsk, Tambov and Ulyanovsk regions (oblasts); Kalmykia, Sakha (Yakutia), Tatarstan and Altai regions (republics); Stavropol and Khabarovsk regions (krais), and the region of Khanty-Mansi Autonomous Okrug (Yugra).

in number.[4] Recommendations are often not adapted to Russian conditions and directly copy foreign practices; however, it remains frequently unclear what exactly are the main shortcomings of national clusters and which of the proposed measures are of greatest interest.

Statistics on Russian clusters started to expand significantly from the launch of a pilot innovation clusters competition in 2012, as part of which applicants prepared fairly comprehensive applications (a total of 94), including a development programme.[5] In 2013, participants in the first group (excluding the Medical and Pharmaceutical Industry and Radiation Technologies Cluster of Saint Petersburg) submitted further applications to the Russian Ministry of Economic Development to receive a federal subsidy to fund specific measures.

All of these materials lay the foundation for a more in-depth study of Russian clusters. It is worth mentioning the 2014 joint study by HSE and the statistical development centre 'Severo-Zapad' at the request of the state corporation Russian Venture Capital, or OAO RVK [RVK et al., 2014]. This study circulated questionnaires to all pilot clusters in Russia (and received 17 completed questionnaires) and held workshops with them.

The publication of new information opens up opportunities for proper cross-country comparison of cluster development trends and drafting of expert recommendations. Of course, many aspects analysed in foreign studies lack equivalents in Russia, where cluster initiatives are still in their early stages. At the same time, a number of problems have already emerged, knowledge of which makes it possible to outline areas of improvement in cluster policy.

In our study, we are proceeding from the premise that stable cluster development is shaped by three groups of factors:

- the external environment and composition of participants;
- the closeness of communications and the level of self-organization;
- companies and universities that make up a cluster are strategically geared towards innovation.

We will now look in more detail at each of these conditions in view of the current realities characteristic of Russian pilot clusters today.

Environment and participants

A developed urban environment, a critical mass of core companies, the dominance of private initiatives, domestic competition, and an openness to the outside world are among the basic conditions exerting a significant influence on the formation of clusters and their future prospects.

Developed urban environment

Clusters are highly sensitive to the dynamics of an urban environment which is attractive to qualified workers (including members of the creative class[6]) and offers favourable conditions for innovative business undertakings. It presupposes a high level of diversity in professions and skills, a developed infrastructure, and a strong academic component.

Some Russian pilot clusters are situated in single-specialism cities[7], and a number of these are classified as closed cities ('closed administrative territorial formations' or ZATO). During Soviet times, these places were renowned for their high

[4] Some exceptions include the 'Pilot innovation regional clusters in the Russian Federation' [HSE, 2013], a study by [*Golovanova et al.*, 2010], the empirical basis of which was an interview based on a questionnaire with content similar to the 'Innobarometer' methodology [European Commission, 2006] and the article by [*Abashkin et al.*, 2012] which contained recommendations to improve the Russian federal support programme for pilot clusters when it started in 2012.

[5] A list of applications is provided in Appendix 4 of the report [HSE, 2013]. Pilot cluster development programmes are listed on the Russian Cluster Observatory website (available at: http://cluster.hse.ru/clusters/, accessed 24.01.2015).

[6] One of the authors behind the creative class concept, Richard Florida, values its development in terms of its ability to calculate the so-called creative industries' contribution to overall employment. Creative industries are taken to mean programming, mathematics, architecture, engineering, natural and social sciences, education, training, library services, art, design, entertainment, sport, media, management, business and finance, law, health care, and trade [*Florida*, 2002].

[7] This refers largely to the Innovative Technologies Cluster in the Zheleznogorsk closed city (ZATO), the Sarov Innovation Cluster, the Shipbuilding Innovative Regional Cluster in Arkhangelsk Oblast, and the Nuclear Innovation Cluster in Dimitrovgrad, Ulyanovsk Oblast.

quality of life, but today they often lag behind regional centres in this regard, which leads to an outflow of qualified workers. In this context, the development of clusters is held back by factors such as the dominance of large enterprises (often those that created the entire city), the fixation of a particular specialism in a city, and an orientation towards public contractors.

Consequently, in such cases the problem of attracting and retaining highly qualified professionals from scientific and business circles, managers, and venture capitalists arises. For this, experience shows that it is important to implement several measures to serve as a basis for cluster policy:

- create jobs characterized by high productivity and wages compared with regional centres;
- expand economic specialization, career opportunities and growth in inter-firm mobility within the city;
- establish mortgages, preferential lease mechanisms and residential buying schemes for cluster business workers and expand modern low-rise and villa developments;
- develop food, leisure and cultural infrastructure;
- implement green technologies, improve ecology, make good use of advantages such as closeness to nature, healthy lifestyles, lack of traffic, etc.

We note that it is rare for these aspects to be given serious attention in cluster development programmes. One of the striking exceptions to this is the Dimitrovgrad Nuclear Innovation Cluster, which has initiated projects to establish a library-based modern intellectual centre, form a network of general educational organizations offering international baccalaureate programmes, and modernize the local stadium.

Critical mass of core companies

The more companies in a cluster that engage in core, associated or supporting forms of activity and involve corresponding specialists, the more likely it is that innovations will result and spread. This can be explained by the fact that geographical concentration helps to speed up how information is distributed between enterprises, exchange ideas, and brings to light new knowledge and products, including through new combinations of existing knowledge and products.[8]

Based on European experience, to achieve the required potential a cluster has to include at least 30-50 organizations [CLOE, 2004] or, according to some estimates, as many as 100 [*Pamminger*, 2014]. A global survey of 356 clusters carried out in 2012 showed that, on average, a single cluster brought together 80 participants [*Lindqvist et al.*, 2013, p. 17]. In Russia the average number of organizations in pilot clusters is 44[9], which is almost half the global average. Out of 25 clusters, only two have more than 100 members,[10] and a number of others have fewer than 20.

Out of the six industrial fields under which Russian pilot clusters can be classified [HSE, 2013], the largest number of official participants on average was seen in the information and communication technology (ICT) and electronics industry, as well as the pharmaceuticals, biotechnology and medical industry (Figure 1). Such inequality, it would seem, is linked to the fact that innovative small and medium enterprises (SMEs) undergo active development in these fields and as a result, the overall number of firms increases. In addition, these

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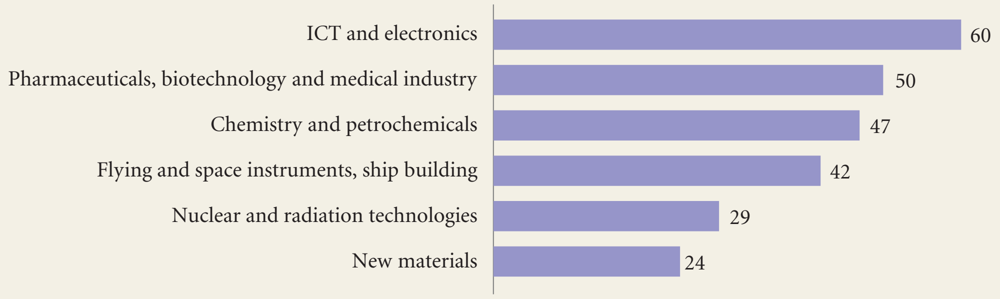
[8] According to Jared Diamond, the history of technology is a self-catalysed process, stimulating itself and accelerating over time [*Diamond,* 1997]. It is not passed on in a uniform way, and to a large degree gravitates towards clusters where there is the necessary critical mass of participants.

[9] Including regional authorities and local government bodies, educational and research organizations, financial sector institutions and public development institutes. Pilot innovation cluster development programmes approved by regional administrations in 2013 and submitted to the Russian Ministry of Economic Development for federal subsidies were used for this calculation. If these programmes were not taken any further (for clusters in the second group) or there was no list of participants, information was taken from pilot cluster development programmes in 2012. Information on clusters in Saint Petersburg and Leningrad Oblast was taken from 2012 programmes without taking into account their subsequent merger.

[10] The number of information technology cluster members in Tomsk Oblast was originally 131 organizations. However, after it became a part of the 'Pharmaceuticals, medical technology and information technology' unified cluster in 2013, the number of participants fell to 61.

Figure 1. **Average number of official pilot innovation regional clusters in Russia by industry** (*units*)



Source: author's calculations based on survey data from pilot innovation regional clusters.

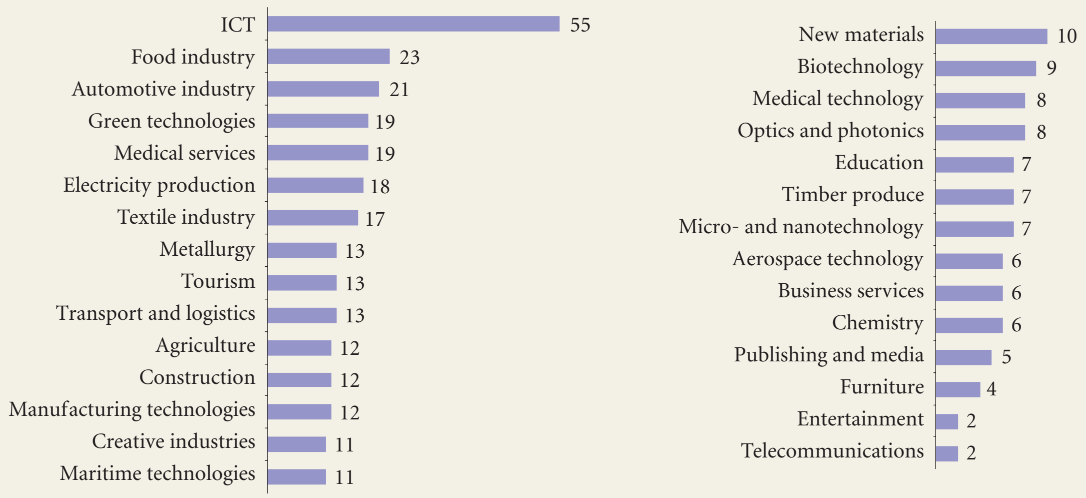
sectors are the most sensitive to cluster formation processes, in particular in the ICT sphere, which leads the way in terms of the total number of clusters globally (Figure 2).

The far from optimal pool of core enterprises in Russian clusters is having a negative impact on the number and quality of new projects. Without a focus on supporting them, clustering only intensifies the status quo in the region's economy and risks becoming an instrument for lobbying rather than innovative development.

It is worth bearing in mind that the number of similar companies in a region, in terms of their core business, should exceed the official number of members of a cluster. The reason for this is that, clearly, not all businesses are prepared to join the cluster. A cluster is primarily of interest to those receptive to the advantages of carrying out joint projects and using common services, strategically geared towards open innovations.

The relative size of clusters is also of considerable importance. In any given region, it is reasonable to support those clusters which operate in sectors that exceed the average level for the country by twice or more in terms of their economic indicators (number of employees, total revenue, export volume, R&D intensity). A gap between the current objective directions of a regional specialization and the core activity of supported clusters is also linked to risks. Such alliances can experience a shortage of resources for development (skilled workers, infrastructure, suppliers, or research provision). Moreover, support for them may not have any significant impact on the region's social and economic development. There is a lingering fear that if such clusters are picked by federal authorities, they will not become a priority for the regional administrations. This was the

Figure 2. **Global distribution of clusters by specialization field** (*units*)



Source: [*Lindqvist et al.*, 2013, p. 14].

case, for example, in the Moscow region, the city of Saint Petersburg, and the nuclear technology clusters in the Nizhny Novgorod and Ulyanovsk regions.[11]

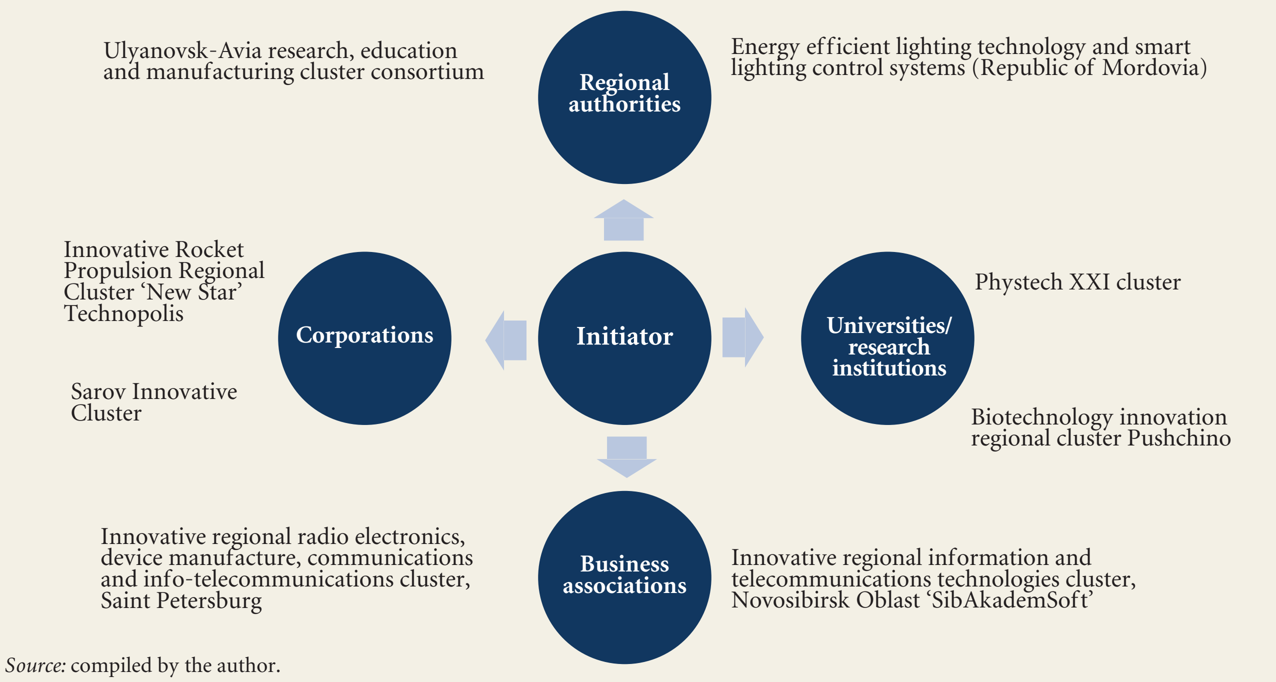
Dominance of private initiatives

A private initiative is a decisive factor in the success of a cluster. Even in cases when successful clusters established on the back of a university or a research centre encompass a large number of diverse entities (Figure 3), without enterprises playing a leading role they do not have any serious prospects. According to experts, stable cluster development comes from the prevalence of members of the business community in the upper echelons of the administration [INNO Germany AG, 2010, p. 108]. Therefore, the European system of assessing the quality of cluster management is based, among other things, on the proportion of manufacturing and service companies in the total number of participants, and this proportion must be greater than 50% [*Hagenauer et al.*, 2012, p. 2].

At least ten Russian pilot clusters do not meet this criterion.[12] In many Russian clusters, publicly owned companies tend to dominate, alongside their subsidiaries and dependent organizations, state educational and research institutions, and regional authorities. There is a clear deficit of private sector initiatives, which serves as an indicator of the essential nature and effectiveness of clusters, including investment rationality, internal relations quality and project investment appeal. The role of business only increases if a cluster initiative arose as a result of a state-organized competitive tender with corresponding support measures.

From 2013, there has been a sharp rise in the influence of regional administrations on management entities in pilot clusters. In the overwhelming majority of cases, they were the founders of specialist organizations created to coordinate

Figure 3. **Initiators of pilot innovation regional cluster creation**

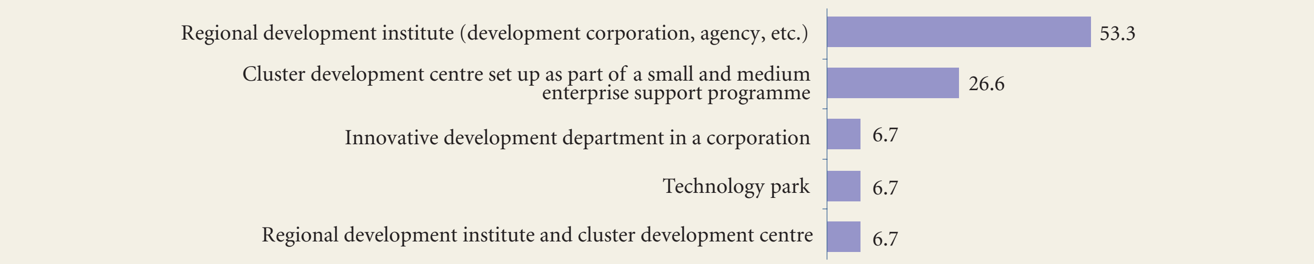


Source: compiled by the author.

[11] Federal subsidies are provided on the condition that they are jointly funded by regional authorities; extra-budgetary funds are not taken into account. This often creates tension, as receiving federal support starts to depend not on the activities of the local community and the quality of the projects prepared but more on the success of negotiations with regional administrations. Sometimes, the edge in the negotiation process starts to become part of the public domain [*Vikulova*, 2013; Sarov.Net, 2014].

[12] The Innovative Technologies Cluster in the Zheleznogorsk closed city (ZATO) (Krasnoyarsk Krai), Nuclear Innovation Cluster in Dimitrovgrad (Ulyanovsk Oblast), Radiation Technologies Cluster (Saint Petersburg and Leningrad Oblast), Shipbuilding Innovative Regional Cluster (Arkhangelsk Oblast), Innovative Rocket Propulsion Regional Cluster 'New Star' Technopolis (Perm Krai), Aerospace Cluster (Samara Oblast), Pharmaceutical, Biotechnology and Biomedicine Cluster (Kaluga Oblast), Biopharmaceutical Cluster (Novosibirsk Oblast), Petrochemical Regional Cluster (Republic of Bashkortostan), and Kamsk Innovation Regional Manufacturing Cluster (Republic of Tatarstan). The subsequent fusion of certain clusters was not taken into account, as not all merged clusters had data on the number and structure of participants. Some clusters were excluded from the calculation, as their programmes did not contain detailed information on participants.

Figure 4. Distribution of specialist organizations in pilot innovation regional clusters by Status (%)



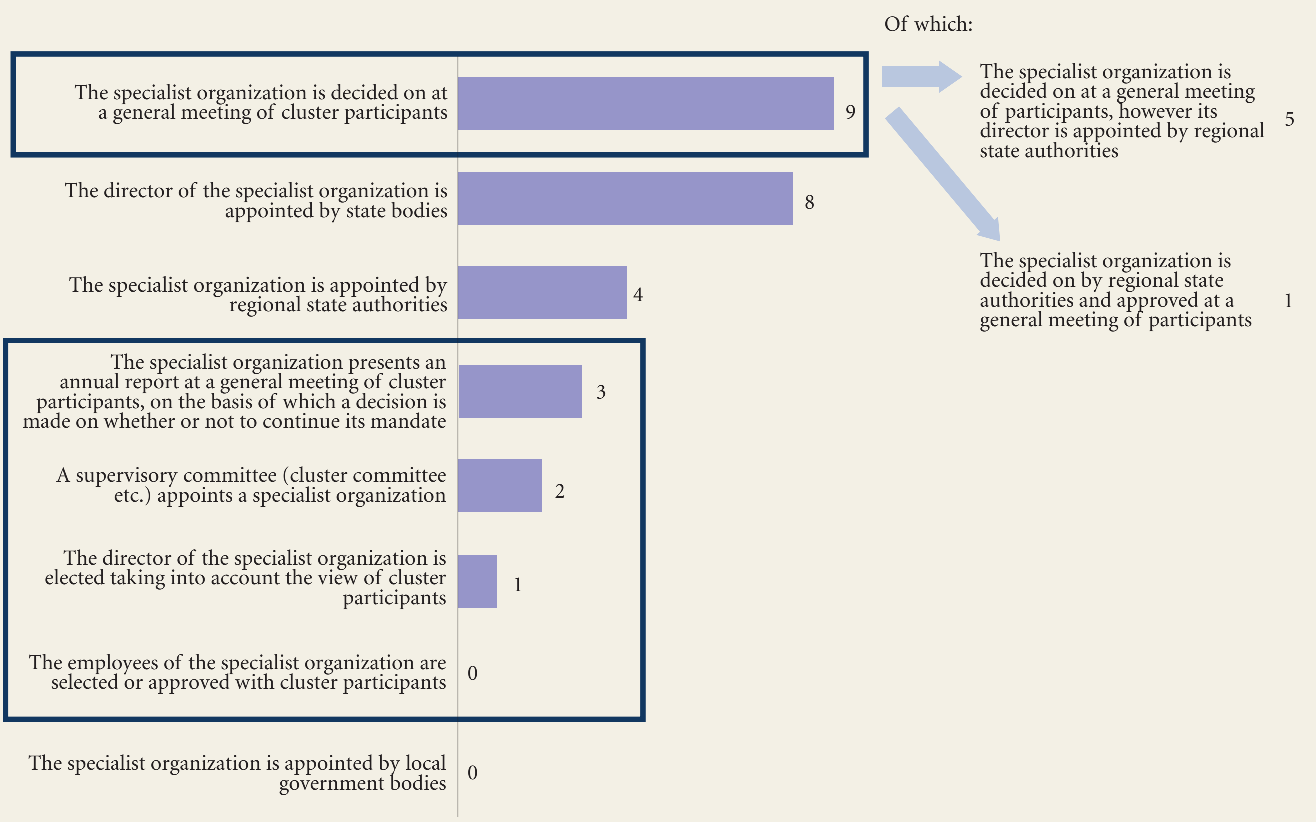
Source: author's calculations based on survey data from pilot innovation regional clusters.

collaboration between participants, carry out joint projects, etc.[13] Roughly half of these organizations were formed (or designated) as a superstructure over the top of existing administrative bodies (Figure 4).

Although regional authorities are also dependent on established rules [Government of the Russian Federation, 2013], in a number of locations the situation is one of 'dual rule.' This applies, in particular, to clusters in Moscow city and Moscow, Tomsk and Novosibirsk regions. This can weaken the legitimacy of official specialist organizations, cause disagreements and further destabilize partnerships.

The only means by which members can influence a specialist cluster organization is in a general assembly of participants (Figure 5). However, the status of this is more of a formality and is ineffective when it comes to decision making

Figure 5. Mechanisms to take into account private and state interests in the activities of specialist pilot innovation regional cluster organizations
(distribution by number of practising clusters, *units*)*

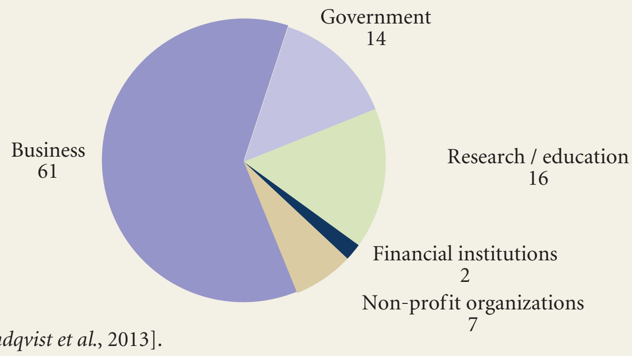


* Feedback mechanisms are identified in the frames for specialist organizations and participants of pilot innovation regional clusters; respondents could choose several answers.

Source: author's calculations based on survey data from pilot innovation regional clusters.

[13] A distinction needs to be drawn between a specialist cluster organization and a cluster committee and other forms of higher collective executive bodies functioning on a gratuitous basis. A specialist organization is an operational management entity which has employees whose main duty is to develop a cluster. These employees are personally responsible for the specific directions in which a cluster develops, how its projects are carried out, etc.

Figure 6. **Composition of supervisory boards at specialist cluster organizations globally (%)**



Source: [*Lindqvist et al.*, 2013].

on operational matters. Thus, the views of cluster participants and higher collective managerial bodies (supervisory board, etc.) are rarely taken into account when appointing managers and other employees at specialist organizations.

The international study cited above revealed the opposite situation: the share of the private sector in the higher managerial bodies of clusters to which the executive director of a specialist organization is accountable is more than half. In other words, the stance of this category of participants is decisive [*Lindqvist et al.*, 2013] (Figure 6).

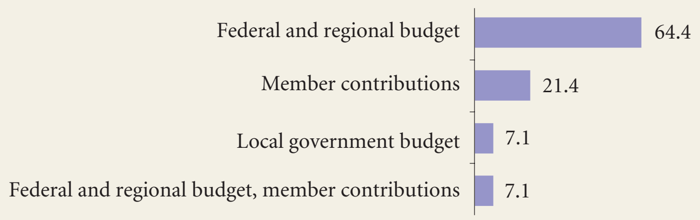
The dominance of the state in the management of Russian clusters is reinforced by its status as the main source of funding (Figure 7).

The poorly developed mechanism for payment of annual membership contributions is a sign of the weak influence of cluster members on the activities of specialist organizations.[14] In other countries besides Russia , as shown in Figure 8, the funding structure is more diversified: the largest share of private funds comes from membership contributions and the remainder from additional paid services (project management, seminars, etc.).

One of the key criteria underlying the influence of the business community is the share of SMEs in the total number of cluster participants. Under the so-called European model, they usually dominate and are the main beneficiaries of state support [*Dohse, Staehler*, 2008; *Eickelpasch*, 2008; DGCIS *et al.*, 2012; Pro Inno Europe, 2009; *Christensen et al.*, 2012, p. 10].

Figures for SMEs were included in Russia's pilot cluster selection criteria system. It transpired that the share of such companies in total participant numbers lags far behind European levels (Figure 9). The highest value seen was in ICT clusters; however, if this figure is ignored, the proportion of such entities falls from 34% to 19%. Furthermore, being a participant, technically speaking, does not imply a real contribution to state funded joint projects. An analysis of programmes submitted to the Russian Ministry of Economic Development in 2012 shows

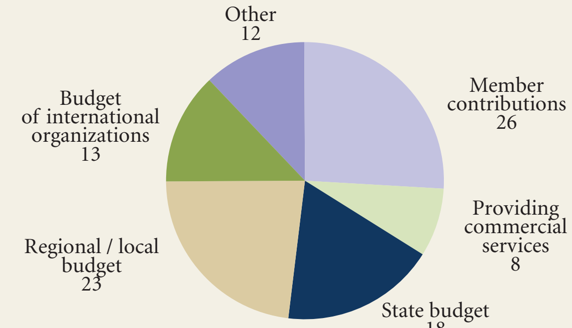
Figure 7. **Sources of funding for the activities of specialist pilot innovation regional cluster organizations (%)**



Source: author's calculations based on survey data from pilot innovation regional clusters.

[14] Out of the four respondents noting membership contributions as a source of budget replenishment, two – the non-profit organizations BFKS and Sibakademsoft – are not *de jure* specialist organizations in their clusters. In the other two cases, Dubna (the Nuclear Physics and Nanotechnology Cluster in Dubna) and Kamsk Innovation Regional Manufacturing Cluster (Republic of Tatarstan) are classified as non-profit partnerships. At the same time, there is no information on whether the stipulated membership contributions are actually collected and what share they account for in the budget structure of specialist organizations.

Figure 8. **Funding structure of specialist cluster organizations globally** (%)



Source: [*Lindqvist et al.*, 2013].

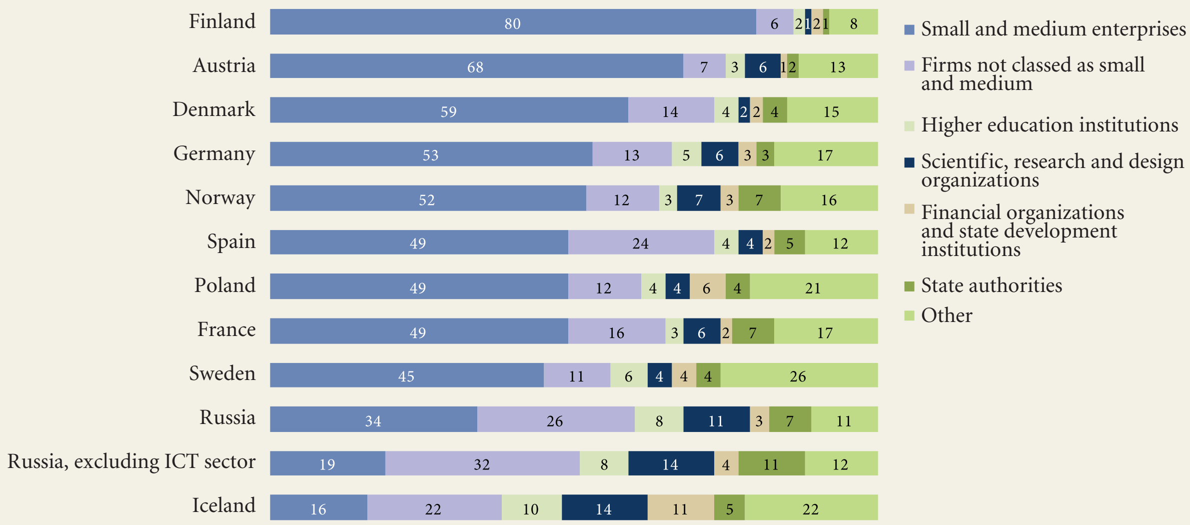
that in the majority of cases, there are few or no projects initiated by SMEs. In reality, major companies and state authorities dominate in Russian clusters.

Internal competition and openness

The existence of a sufficient number of companies from inter-related sectors in a cluster is a significant factor for the cluster's future sustainability but competition is also needed. Competition within the cluster stimulates improvement, contributes to the flow of human and financial capital, and attracts the most dynamic and pushes out the least effective entities as a result of the growing cost of immobile factors of production. It is important to ensure that there is competition between companies in a cluster. Rivalry with outside actors, including foreign companies, is not enough because this competition is not very intense. There are several objective reasons for this: differences in the cost of production factors, tax regimes, and the difficulty in benchmarking competitors. Localized competition is also stirred up by a desire not to lose to a well-known neighbour [*Porter*, 1998].

Building on Porter's thesis, we posit that internal competition between businesses is particularly important when trying to implement an innovation scenario.

Figure 9. **Proportion of various categories of cluster participants in EU countries and Russia** (%)



Source: author's calculations based on data from [*Müller et al.*, 2012, p. 18] and pilot innovation regional cluster development programmes*.

* The information base for the calculations was compiled from pilot innovation regional cluster development programmes submitted to the Russian Ministry of Economic Development in 2012. As such, the subsequent merger of a number of clusters has not been taken into account. Clusters whose programmes did not contain information on the number of participating small and medium enterprises were not included: The Ulyanovsk-Avia research, education and manufacturing cluster consortium (Ulyanovsk Oblast), the Biotechnology Innovation Regional Cluster Pushchino (Moscow Oblast), the Pharmaceutical and Medical Industry Cluster (Saint Petersburg and Leningrad Oblast), Pharmaceuticals and Medical Technology (Tomsk Oblast), New Materials, Laser and Radiation Technologies (Troitsk, Moscow), Complex Coal and Man-made Waste Processing (Kemerovo Oblast), the Nizhny Novgorod Industrial Innovation Cluster for Automobile Construction and Petrochemicals (Nizhny Novgorod Oblast), and Energy Efficient Lighting and Smart Lighting Control Systems (Republic of Mordovia). The sample covered a total of 21 clusters.

Innovations are developed more effectively if the competitive battle is fought on equal economic, social and legal grounds and unfair conduct is suppressed by the state. Fundamental differences in the environment in which competing players are situated bring to the fore such weapons as state political and military establishment involvement, attempts to financially win over or exert pressure on government officials, deals and market division, among others.

Geographical concentration, as a general rule, assures greater equality in the environmental conditions in which the competition takes place, which increases the economic viability of an innovative competition scenario. Unfortunately, in the absolute majority of cases, domestic clusters see internal competition as an undesirable factor. The exceptions are the ICT, biotechnology and pharmaceutical sectors.

A mistaken yet widespread view supposes that building a model with a single large enterprise surrounded by suppliers or localizing the value-added chain is sufficient to form a cluster. However, the localization and distribution of value-added chains, as well as the question of outsourcing, are not the only (or the main) objectives of cluster policy. Quite often, state interference leads to the opposite result: 'forced' localization, imposed contracting parties, and shaping the value-added chain 'from above' all risk turning into losses and general ineffectiveness. We note that clusters can evolve dynamically and without a single value-added chain (something characteristic, for example, of the tourism or ICT sectors). However, without developed internal competition, progress will hardly be sustainable in the long-term.

Closeness of communications and self-organization

Innovations tend to arise in open, flexible communities with low power distances and a large number of communications running between representatives of various social (including professional) groups. Therefore, a sustainable cluster presupposes intensive communications not only between organizations, but also between individual specialists irrespective of their affiliation. Together with the presence of a critical mass of core companies and human resources, this is an important prerequisite to set in motion a self-catalyzing innovation process [DTI, 2004, p. 22].

One of the basic conditions for effective communications is a high degree of trust [INNO Germany AG, 2010, p. 41]. Despite the fact that this is closely linked to culture and any changes are throwbacks to former inertia, the implementation of cluster policy requires a constructive examination of this phenomenon. To forge trust in a purposeful manner, a whole set of instruments can be put forward, including [*Hwang, Horowitt*, 2012]:

- work by 'key figures' or organizations — 'trust guides' — who are capable of establishing useful links;
- special programmes to study behaviour patterns in role models and pilot projects and their approval in real life;
- development of common collaboration standards;
- designing feedback systems.

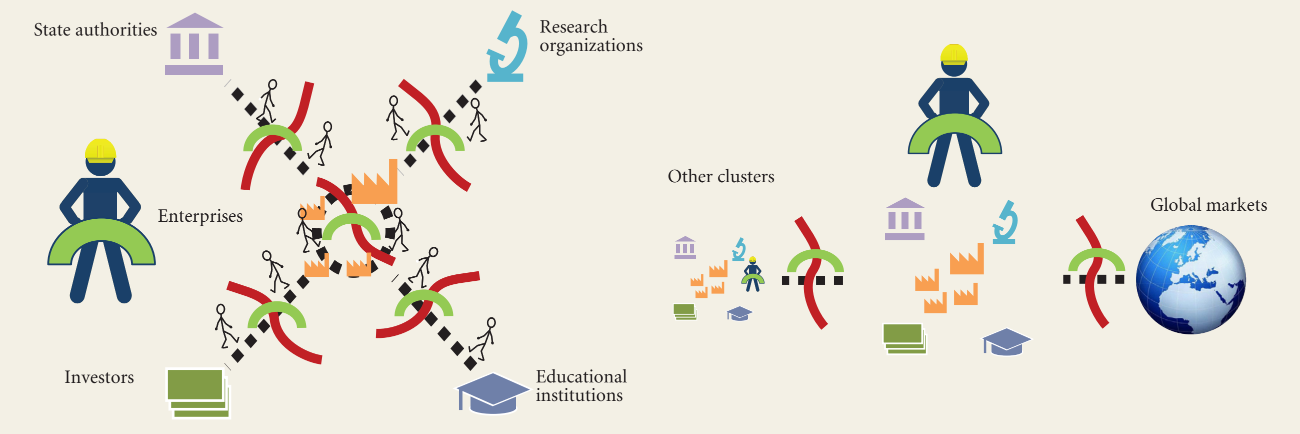
These instruments are entirely appropriate for raising trust and, consequently, developing internal communications in Russian clusters.

Specialist independent management bodies

These 'key figures' and organizations capable of establishing productive links refer to cluster managers and specialist management bodies. The first of these structures appeared in the 1990s in Austria, Germany and Finland, and later in Denmark, France, Norway, Sweden, Spain, Poland and Iceland [*Müller et al.*, 2012, p. 14]. They help to coordinate the visions, goals and strategies of participants and improve the closeness of internal communications, organize collaboration with state authorities, development institutes, publicly owned companies, other clusters, etc., and act as representatives in external measures (Figure 10).

Today, the need for institutionalization by creating specialist organizations is viewed as a significant step towards cluster development and is virtually beyond doubt [INNO Germany AG, 2010, pp. 107, 111]. The importance of state

Figure 10. **Visualization of the communicative role of cluster management bodies as 'bridge builders'**



Source: [*Sölvell, Lindqvist*, 2013].

funding for such structures, at least for the first few years, is shown by the lack of trust between participants [*Ibid*., p. 42]. It was initially assumed that specialist organizations should be supported for three to a maximum of six years, after which they should be able to self-fund or close [CLOE, 2004]. Practice however has changed this view. It transpired that even successful associations (such as the Upper Austria automotive cluster) required support from the state and the EU over a decade in order to reach a stage of sustainable self-funding. In view of the long time lag for any results to become visible, the recommendation is that they are first assessed no sooner than five years after the start of funding. Therefore, stable support for specialist organizations and cluster development centres is becoming an important condition underpinning the success of state policy. Short-term cluster initiatives are doomed to failure, and it is wrong to require them to transition to a commercial basis after only several years of budgetary funding [INNO Germany AG, 2010, pp. 116, 118, 130, 135].

A more radical position argues that support for clusters should be constant and not project-based, since such structures carry out a number of social functions [*Ibid*., p. 117]. A recent study showed that over the course of roughly the last ten years, the share of state funding for clusters stabilized at a minimum of 60% [*Lindqvist et al*., 2013, p. 5].

In this case, the practice in Russian clusters is consistent with theory. Providing for the activities of specialist organizations has come to be one of the possible measures to develop a pilot cluster applying for federal subsidies. This approach was used by virtually all entities in the first group, which formed specialist organizations with a staff and an operational plan.[15] The average number of staff at these organizations is eight people, ranging from two to 23.[16]

A survey of 17 of the 25 pilot clusters in Russia carried out at the end of 2013 revealed the most pressing activities of specialist organizations:

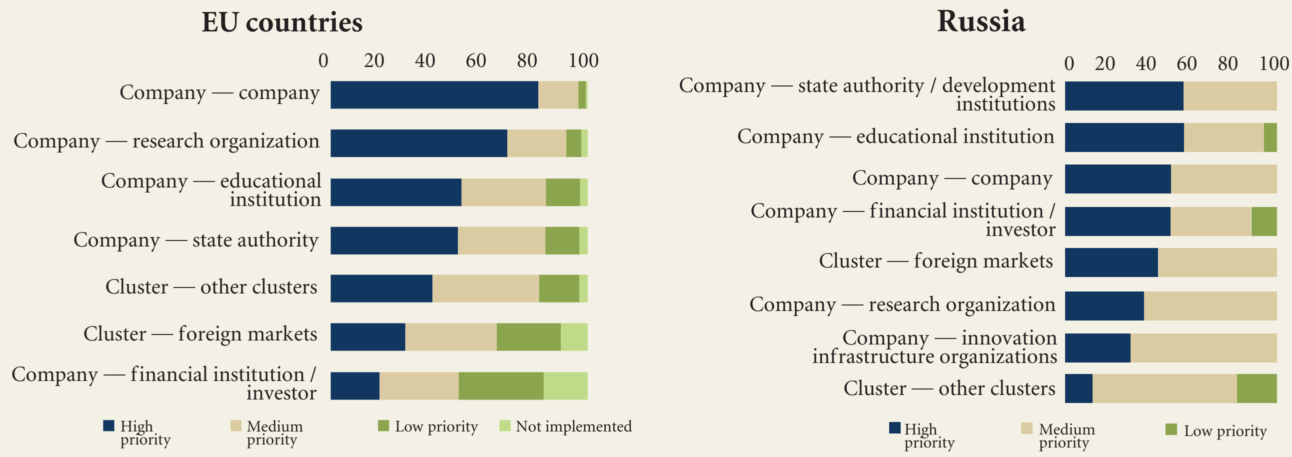
- intensifying collaboration between participants to develop and implement joint projects aimed at raising competitiveness;
- setting up joint scientific, research, design and experimental projects between participants and external partners;
- developing joint innovation projects.

One of the key roles of specialist organizations is training. In the first stages of cluster development, programmes to raise qualification levels not only perform

[15] The exception to this were clusters in Moscow Oblast (the Nuclear Physics and Nanotechnology Innovative Regional Cluster in Dubna, the Biotechnology Innovation Regional Cluster Pushchino, and the Phystech XXI cluster). The region's government did not request any federal subsidies at the first stage (and, in all likelihood, did not plan to jointly fund subsidies from the regional budget) for specialist organizations to implement measures to develop pilot clusters.

[16] The maximum staff numbers was declared by a specialist pilot cluster organization which is at the same time a regional cluster development centre. The distinguishing feature of this organization is that it has been recognized as contributing to the development of several or even all of the clusters in the region. As such, it can be assumed that the number of staff directly involved in the development of a pilot cluster is less than the total number of workers at the cluster development centre.

Figure 11. **Importance of various types of collaboration in clusters from the viewpoint of the activity priorities of their specialist organizations (%)**



Source: [*Sölvell, Lindqvist,* 2013]; author's calculations based on survey data from pilot innovation regional clusters in Russia.

an educational role, but also play the role of a joint project contributing to the establishment of contacts between employees in different organizations, the formation of interest groups, and the identification of potential areas for collaboration. Specialist measures (strategic sessions) that aim to help cluster participants agree on goals and strategies, search for shared interests, and develop joint projects are extremely beneficial.

Professional retraining, raising qualifications and arranging training were all identified as areas for potential use of federal subsidies by clusters in the first group in 2013 [Government of the Russian Federation, 2013]. Virtually all applicants for subsidies planned such measures.

At the same time, if you compare Russian and European clusters in terms of the significance of the various types of collaboration for their specialist organizations, some highly characteristic differences arise (Figure 11). One of these relates to the selection of priorities: in Europe, the priority is collaboration between companies in clusters, while in Russia the main concern is to assist in establishing and maintaining a dialogue between business and the state. In all likelihood, representatives of specialist organizations in Russian clusters see the greatest benefit in intensifying collaboration with the authorities, and not in communicating with business partners. In future, it will be important to show participants in Russian pilot clusters the benefits from B2B relations. They will then reduce their dependence on state support, and therefore the risks of revenue-oriented conduct, which constitutes a traditional barrier to the development of the innovation economy.

One other key difference is the minimum value accorded by Russian specialist organizations to working with other clusters. The reason for this lies in the fact that Russian clusters are still far fewer in number and have not existed for as long as their EU counterparts. At the same time, it is worth paying keen attention to this type of collaboration. Benchmarking of core clusters, both Russian and foreign, allows specialist organizations to hone their development strategies and programme: identifying competitive advantages, developing a unique trajectory for technological development, and expanding partnership opportunities.

A key success factor is recognized as the qualifications of cluster policy makers [*Christensen et al*., 2012, p. 11]. Cluster managers are quick to professionalize their work [INNO Germany AG, 2010, p. 109]: they have set up core associations (TCI Network) and clubs (European Cluster Managers Club) and have drawn up specialist standards [ECEI, 2012] and educational programmes [*Kutsenko*, 2013]. It is important that national clusters are not left on the sidelines in this process.

It is important to strive for independence from certain participants, especially from influential stakeholders when developing cluster management systems. A specialist organization affiliated with a particular member of a cluster will not gain the trust of other partners, making it problematic when it comes to motivating participants and pushing through joint projects.

Active working groups

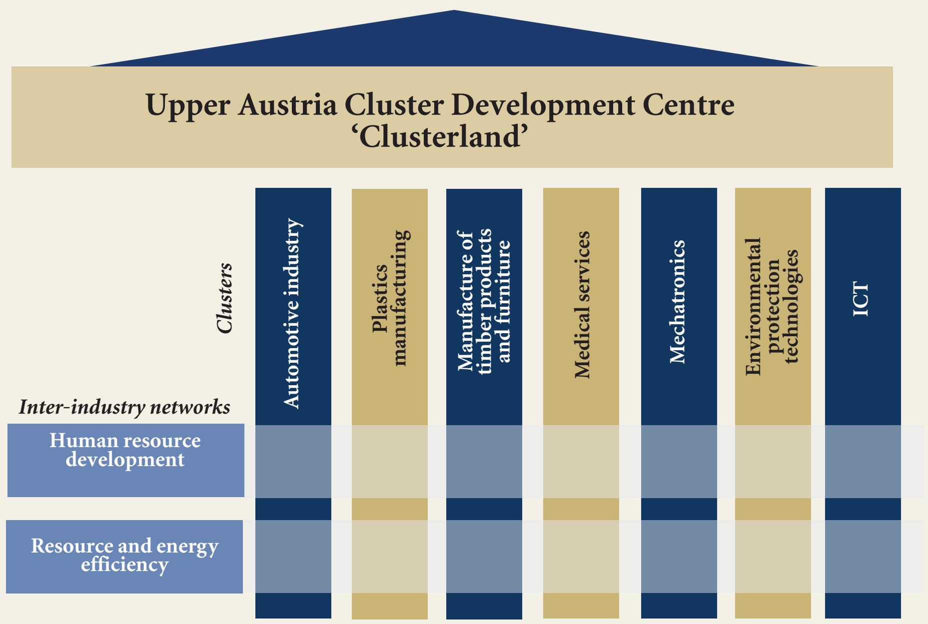
A key link in the cluster management system is specialist working groups set up for projects according to the sector and taking into account the size of the participating organizations. Such working groups are noted for their extremely intensive communications in pursuing joint initiatives. Based on the existence and level of activity of such groups, judgements can be made as to whether a cluster actually operates more dynamically whether it is only a means to attract state subsidies. Thus far, working groups have not been set up in all Russian pilot clusters, or their activity is so insignificant that it has not been recorded in the media.

One of the effective forms of working groups could be professional networked communities (associations, clubs, forums)[17] to cover communications between middle management and specialists and, thus, to contribute to the exchange of information, knowledge and experience [DTI, 2004, pp. 22–24]. In certain Russian clusters, such communities are already functioning. An indicative example is the club for IT directors in the Saint Petersburg ICT cluster.[18]

Fragmentation of intra-cluster communications through working groups becomes particularly important when the number of participants is more than 40; if it exceeds 100 it will be almost the only way to organize effective joint work.

In a number of cases, groups can bring together players from different associations. This is typical of cluster development centres which manage several clusters in one region simultaneously. Thus, in the Upper Austria region, under the patronage of a single centre seven clusters have developed over more than 15 years. It saw the creation of two inter-industry networks ('Human Resource Development' and 'Resource and Energy Efficiency'), participation in which is important for members of all clusters in the region (Figure 12).

Figure 12. **Clusters and networks under the management of the Upper Austria Cluster Development Centre**



Source: [*Pamminger*, 2014].

[17] 'Associations and collective communities (collaboration organizations) are responsible for establishing links in a cluster. As an independent area to expose and discuss common needs, current limitations and opportunities, they can serve as a focal point to concentrate efforts to eliminate or mitigate current problems... In collaboration with local institutes they create training programmes, manage purchasing consortia, develop university-based research programmes, form quality control structures, collect information relating to the cluster's activities, bring up general administrative issues for discussion, research opportunities to solve environmental problems, and control numerous different areas of general interest... For instance, in the Netherlands flower-growing cooperatives set up a specialist auction and processing and storage capacity, which is one of the largest competitive advantages of those in the cluster' [*Porter*, 1998].

[18] Available at: http://www.spbcioclub.ru, accessed 25.08.2014.

Formalization of rights, duties and decision-making mechanisms

The stepping-up of communications helps to democratize interpersonal relations (reduce the power distance).[19] In an effective cluster, partnership is fundamentally horizontal in nature and assumes equal involvement in decision making. A cluster's strategy is not identical to the interests of the largest organization, the 'finisher' or monopolist, but rather reflects an agreed upon shared vision taking into account the needs of all parties. In reality, break-through projects arise at the juncture of existing potential and skills, technologies that are relevant to a region, Foresight projects and, finally, entrepreneurial talent, through the ability to correctly combine resources and concentrate them in emerging market opportunities.

Local companies, research organizations, universities and authorities have the most complete view of their own technological and market potential. Therefore, decisions (including in relation to joint projects to receive federal subsidies) should be taken by the participants themselves, irrespective of their size and status. We note that horizontal collaboration does not replace relations in vertical value-added chains, but rather exists in parallel, with its own specific goals and rules.

However, in Russian practice, there are numerous instances where large organizations are not prepared to discuss development issues with SMEs, especially if these firms are their suppliers. SMEs, though mentioned on the list of pilot cluster participants, are generally almost unrepresented in clusters' administrative bodies. The system of management where key decisions are taken by senior officials and top managers at state companies does not fully correspond to foreign experience. As a result, rank and file participants are frequently excluded from the decision-making process, and the cluster committee is formed in such a way that only the most influential stakeholders can be members (development institutes, state corporations). At the same time, associations are being set up to bring together all the players. This set-up exists, for example, in many nuclear and radiation technology clusters. The advantage of this approach lies in consolidating figures of authority that are capable of supporting the cluster. However, there are risks of ousting or alienating local communities from the management process, which leads to disenchantment and poor motivation among participants who previously showed enthusiasm. In this case, horizontal collaboration is replaced by vertical approval and competition in the bureaucracy, and the hidden, implicit knowledge of the local community is not called for. The trend of strict subordination of cluster management bodies to regional authorities can cause just as much harm.

To guarantee equality in decision making and the involvement of all interested players in cluster activities, the following recommendations can be made:

- balance the composition of collective administrative bodies (cluster committee, supervisory board of a specialist organization, etc.) with a view to guaranteeing better representation of the various participants (large, medium and small business, higher education institutions, research, financial organizations, etc.) and the accountability of a specialist organization to higher collective administrative bodies;[20]
- develop procedures that entice interested players to draft specialist organization work plans;

[19] 'One of the greatest surprises of Silicon Valley lies in the fact that, if you want to, you can rub shoulders with virtually anybody you please. In many business spheres it is extremely difficult to get to meet an influential person. In the innovation "tropical rainforest" this can be shockingly simple, as in some places the hierarchy is not so strong; the company structure is horizontal, not vertical.' [*Hwang, Horowitt*, 2012].

[20] For example, in a number of French clusters *(les pôles de compétitivité)* they have set up managerial committees, within which they usually establish a committee division responsible for electing the cluster's president (the role of president is often carried out by the representative of a large participating company) and several boards made up of different groups of members. In this way, the board of small and medium enterprises is given four seats; the boards of large enterprises and higher education institutions are given two seats each; and others are given one seat. This system makes it possible to balance out the administrative bodies in such a way that new entrepreneurs and existing SMEs can effectively influence the strategy of the cluster and its management, put forward their own initiatives for joint projects to apply for state support, or join programmes by other participants [*Boisson*, 2014].

- introduce into the practices of specialist organizations annual reports for cluster members [ECEI, 2012, pp. 12, 23] and regular monitoring of cluster member satisfaction regarding the various aspects of their activities;
- establish open competitive procedures and formal criteria for the selection of projects applying for state funding, and ensure that the maximum possible number of participants are kept informed and involved in this process;
- introduce formalized procedures to join and leave a cluster and set member contributions over time to achieve greater independence and stability in the functioning of specialist organizations.

These measures make it possible to raise the level of institutional development in pilot clusters and to bring it closer to the corporate governance standards set by the OECD [OECD, 2004] (Figure 13). This will help to increase the trust placed in this form of collaboration by local communities, energize old and attract new participants, and balance the development of business activities in the country.

Information on the extent to which the described institutional development measures are implemented in any of Russia's pilot clusters is still absent, although some clusters (for example, the Kamsk Innovative Regional Manufacturing Cluster) are taking active steps in this direction.

There are also other practices geared towards raising trust between cluster participants. Among these are rules (a code) for collaboration, which each party undertakes to abide by upon joining the cluster in signing a corresponding document. This institution allows informal 'club' standards to be introduced, allowing reduced uncertainty in communications with contracting parties and the opportunity to progress further on the path towards forming a new cluster identity. A pioneer in this regard is the Energy Efficient Lighting Technology and Smart Lighting Control Systems cluster (Republic of Mordovia), where rules governing collaboration were established in the agreement to set up the cluster signed by its participants.

Another effective mechanism is the **feedback system**, which goes beyond specialist organization assessments and helps to accumulate and share collaboration experience (including dishonest conduct) with investors, business agents, innovation infrastructure entities, etc. Clusters' pages on social networks are examples of this. Their value lies in their democracy and openness: anybody wishing to do so can ask a question, join a discussion, and express their opinion on cluster matters. Social networks offer a more favourable environment for free contact, searching for like-minded people and making contacts in comparison to formal measures or forums on official sites. The Sarov, Dimitrovgrad and Khabarovsk clusters all already have social network pages.

Strategic orientation of companies and universities towards innovation

In recent years, the cluster policy paradigm has been gradually rethought. The focus has shifted from supporting existing leaders and the region's industry specialty to encouraging structural changes, creating new industries by establishing additional value-added chains through restructuring old chains, expanding

Figure 13. **Adaptation of OECD corporate governance principles to cluster management**

The cluster management structure must:	Participants have right to
• ensure that it relates to participants fairly, including to SMEs • ensure that there is effective monitoring of the specialist organization by higher administrative bodies of the cluster (board, cluster committee, etc.) and accountability of higher administrative bodies towards its participants • allow mechanisms to raise the efficiency with which interested entities participate in the cluster's activities • ensure that information on all significant aspects of the cluster's activity is disclosed in a timely and accurate way	• receive information on the activities of administrative bodies in a timely and regular manner • participate and vote at general meetings of cluster members • participate in electing members of higher collective cluster administrative bodies • participate in decision making to select projects applying for state support

Source: compiled by the author using materials in [OECD, 2004].

participant circles, and consolidating links between organizations, among other things.[21]

A decisive factor in competitiveness is the speed with which information spreads between industries and how long it takes to adapt to emerging technologies and replace contracting parties. In this context, the new role of specialist organizations consists of intensifying collaboration between enterprises in different spheres and regions [EFCEI, 2013, pp. 4–5].

It is to be expected that in the majority of European countries a cluster component forms an integral part of innovation policy [Oxford Research, 2008, p. 7]. A significant share of funds allocated to supporting clusters is directed at co-funding joint science, technology and innovation projects. For instance, since 2005, as part of the French cluster programme *Les pôles de compétitivité*, 738 R&D projects, involving 14,000 researchers, received funding totalling 1,470 billion euros.[22]

A focus on innovation, as mentioned above, assumes a high level of trust, all-round consideration of interests in decision making and internal competition, which serves as an optimal stimulus for innovation activity. Attempts to institutionally replace it with other mechanisms, for example, by 'forcing' large publicly owned companies to innovate, gives varied results [*Gershman*, 2013].

Every deal, in particular those linked to delayed fulfilment of obligations, holds an element of trust between contracting parties [*Arrow*, 1972]. A lack of trust leads to an increase in corresponding expenses, in some cases making the transaction economically ill-advised. The innovation activity of forms is particularly sensitive to this factor, as it is common for things to be done outside formal contracts, with heightened uncertainty. Parity in decision making requires institutional mechanisms that restrict the dominance of one organization or consortium in a cluster, clearly defining the powers, service length, accountability and renewal procedure of administrative bodies, and establishing transparent procedures for the entry of new participants and including them in the projects being supported.

The rules described form 'an inclusive institutional system' on a local level. The economic historians Daron Acemoglu and James A. Robinson suggest that it is only such institutions (in contrast to an 'exclusive institutional system') that serve as a reliable platform from which to start a long-term innovation process. This can be explained by the fact that the latter term, according to Schumpeter, consists in constant 'creative destruction', which draws in bearers of creative ideas who propose new solutions to old problems, and leads to a change in the make-up of the economic and (with time) political elite. It is precisely as a result of these circumstances that an innovative developmental path is often not called for; the ruling circles try with all their might to keep the status quo and to restrict vertical social mobility and, as a result, competition [*Acemoglu, Robinson*, 2012].

A corporation or a cluster is a micro-model of society; their innovation activity is in many ways dependent on which local institutions operate in them. Since successful innovative companies exist even in institutionally deficient conditions, it is also possible to establish productive innovative clusters geared towards 'creative destruction'.

However, for a cluster to be a source of new ideas, projects and teams, the aforementioned infrastructural and institutional conditions are not enough. Innovative advantages, like a decline in transport costs, cannot only be guaranteed through collaborative localization of manufacturers and buyers. Well-targeted, regular efforts to build communications with one another on the part of different participants are needed to develop new products.

The most fitting corporate strategy, giving rise to innovative advantages and the associated gains, is based on an 'open innovations' model [*Chesbrough,* 2003;

[21] In 2012–2013, the European Cluster Observatory, together with PwC, developed a methodology to identify so-called emerging industries in the EU, which are the result of establishing new or radically transforming existing value-added chains [European Cluster Observatory, 2012], in addition to a tool kit to appraise their development in certain regions with regard to the viability of establishing world-class clusters [European Cluster Observatory, 2013].

[22] Available at: http://www.industrie.gouv.fr/poles-competitivite/brochure-en.html, accessed 01.11.2012.

Chesbrough et al., 2006; *Vrande et al.*, 2009].[23] However, implementing this model in practice is difficult for several reasons, in particular due to the rejection of corporate culture. An example is the 'not invented here' syndrome, which reflects a distrust of results obtained outside the research division of a particular company. The spread of an open innovation strategy is also dependent on the overall level of development of the business environment and trust in the company. Sometimes, rejection of such a strategy can be explained by a rational desire to minimize risks and administrative expenses. Therefore, favourable conditions for the associated transactions presuppose the market prevalence of innovations by intermediaries — technology alliances, platforms, networks, clusters, etc. — which offer the necessary information, contacts, channels of influence, and funding. A dependence on the external environment forces players implementing an open innovation strategy to focus their attention, primarily, on partnerships with nearby organizations.

A study of R&D globalization processes carried out by INSEAD in collaboration with Booz Allen Hamilton looked at 189 companies from 17 sectors and 19 countries. The study found that collaboration by transnational companies with external entities (universities, customers, suppliers, alliance partners) tends to gravitate towards significant spatial concentration, and the location of their headquarters are collaboration localization zones [INSEAD, Booz Allen Hamilton, 2006, pp. 8–9]. Another study reached a similar conclusion [OECD, 2008, pp. 17–18]. In a number of cases, large companies situate their research divisions in locations where there are strong research organizations, universities and innovative enterprises. In this way, the pharmaceutical company Novartis concentrates its scientific and technological activity in dynamic biotechnology clusters in Basel, San Diego and Boston, each of which has its own specialism and competitive advantages [*Cooke*, 2005].

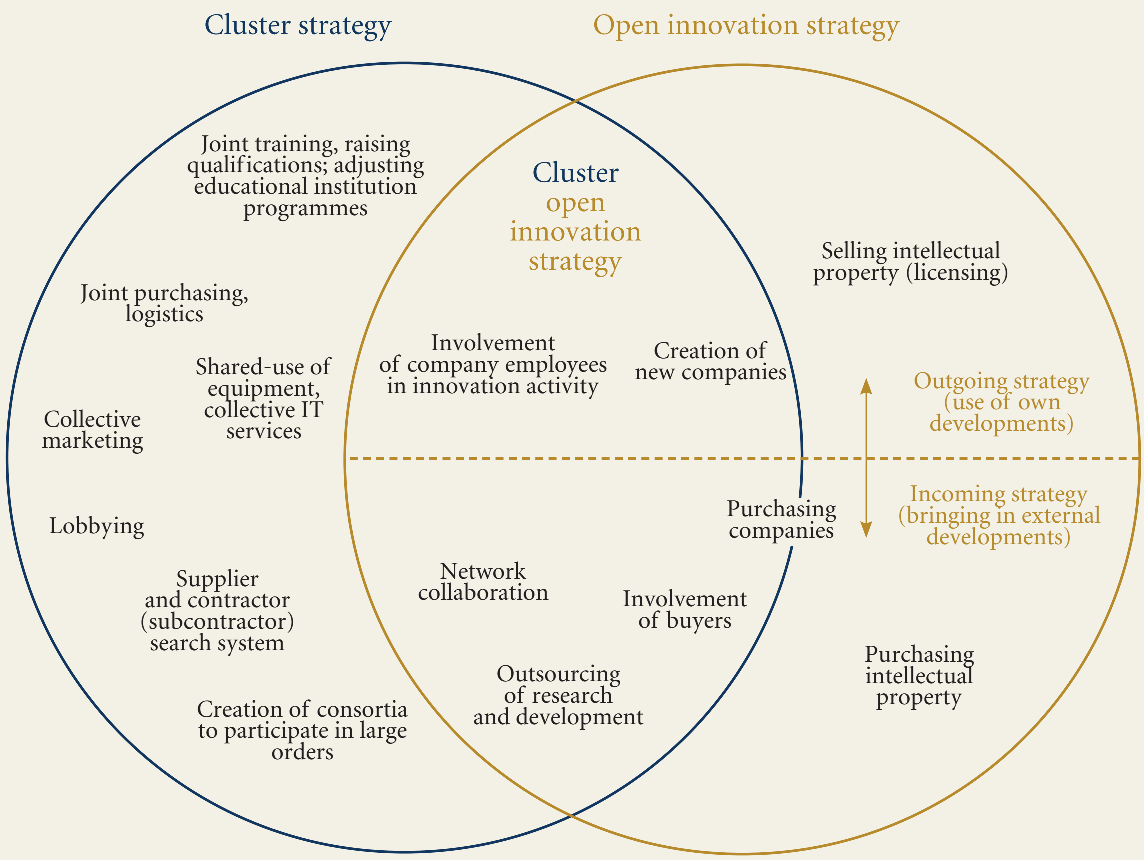
As such, the formation of clusters is closely linked to the implementation of an open innovation strategy in corporations. This model is called for in network research activity involving many organizations, when the business environment and intermediaries reduce the level of transaction costs, stimulating growth in innovation deals. At the same time, the more open a company's innovation activity becomes, the more important its involvement in a cluster. Pursuing open innovations contributes to intensifying inter-firm partnerships, the involvement of new players in a region, and the creation of a belt of small innovative enterprises around industrial giants.

At the same time, the corporate strategies of 'cluster involvement' and 'open innovations' are not identical. Aside from some overlaps, each strategy has its own sphere of implementation (Figure 14). As we can see, involvement in a cluster is not restricted to innovative activity and, likewise, not all open innovation mechanisms are sensitive to the geographical proximity factor. At the juncture of the two concepts mentioned above, an open innovation clustering strategy emerges: the targeted and systematic application of an open scheme in collaboration with other participants.

We note that implementing such an approach requires a significant resource commitment to making contacts, forming networks, organizational restructuring, changing the assessment criteria of innovation activity, and forming knowledge management systems [*Chiaroni et al.*, 2011; *Guinet*, *Meissner*, 2012]. Therefore, success in following an open innovation cluster strategy will be determined primarily by the presence of large companies. An investigation into innovation activity in European countries showed results that were anticipated: large companies collaborate four times more frequently with other organizations than SMEs [OECD, 2008, p. 14]. According to another study, SMEs only

[23] For the first time, the open innovations concept proposed by Henry Chesbrough in 2003 [*Chesbrough*, 2003] gained widespread popularity among both practitioners and researchers (a search on Google Scholar with the query 'open innovations' in 2010 showed more than 2 million mentions [*Huizingh*, 2011]). Open innovations are understood to mean well-targeted use of incoming and outgoing knowledge flows to stimulate innovation activity within a firm and expand markets to make use of the results [*Chesbrough et al.*, 2006]. Generally speaking, in the 'open innovations' model, two strategies are singled out: incoming (attracting outside solutions) and outgoing (use of internal developments) [*Chesbrough et al.*, 2006; *Huizingh,* 2011]. The first uses tools such as R&D outsourcing, the acquisition of companies and intellectual property, network collaboration, and the involvement of buyers. The second implies the creation of new companies, the sale of intellectual property (licensing) and the involvement of staff in innovation activity [*Vrande et al.*, 2009].

Figure 14. **General and special cluster strategy instruments and open innovation strategies**



Source: compiled by the author.

use certain open innovation instruments, and only extremely rarely resort to buying and selling licences, venture capital and R&D outsourcing [*Vrande et al.*, 2009].

Besides, the role of change generator can be played by universities.[24] The implementation by universities of an 'entrepreneurial higher educational institution' model, which has much in common with open innovation strategies, has led to the emergence of clusters in a number of cases. A proportion of these associations are on the list of pilot clusters (the Information Technology and Electronics cluster in Tomsk region and Phystech XXI), while others either did not make it through the competitive selection process (Tambov Bioeconomic Cluster) or were established later (Moscow composite and medical clusters).

We will now dwell in more detail on two key tools of a cluster-type open innovation strategy: the implementation of joint projects with other participants (incoming strategy) and the establishment of a belt of innovative start-ups around large companies or universities (outgoing strategy).

Joint innovation projects

Clusters should not be viewed solely as a tool to achieve certain set goals and carry out existing projects. Above all, they constitute an environment which is recognized to generate innovative initiatives, for which the ability (and desire) to accept new ideas and forms of partnership, identify weak signals in good

[24] It is not by chance that the European system of assessing the quality of management in clusters includes criteria such as it being mandatory for the university and/or research organization to be listed as official participants [*Hagenauer et al.*, 2012, p. 2]. All Russian pilot clusters comply in full with this criterion. Moreover, the proportion of universities and research organizations in the total number of participants is even higher than in European clusters (excluding Iceland) (see Figure 8 above). What is more, in EU countries the main goal of state cluster policy is often to stimulate innovation and links between business and research [INNO Germany AG, 2010, p. 36]. This is typical, above all, in the United Kingdom, Germany, Denmark, Iceland, Latvia, Norway, Romania, and Slovakia. Cluster initiatives are more often coordinated with R&D support programmes as opposed to business or infrastructure development [*Müller et al.*, 2012, pp. 43–46, 60].

time, show flexibility, and encourage collaboration are all necessary. It is advisable to focus on supporting joint innovation projects and blocking autonomous projects, even if the aim of such projects is said to be the development of the cluster as a whole [DTI, 2004, p. 38].

Belt of innovation start-ups around large companies or universities

The success of a cluster strongly depends on whether it can manage to guarantee an influx of new enterprises [*Christensen et al.*, 2012, p. 26]. An indicative example of this is 11 projects by the company Xerox, which 'broke off' into separate firms (spin-offs), and their combined income over time surpassed the revenue of the parent structure by twofold [*Chesbrough*, 2003].

In a number of cases, clusters themselves arise as a result of a long and productive process of division of new firms from universities or anchor companies [DTI, 2004, p. 35]. The comparison given in Figure 2 above with industries where foreign clusters are developing shows that in Russia there are significant reserves in sectors such as the food industry, green technology, medical services, metallurgy, the textile industry, transport and logistics, agriculture, construction, manufacturing technologies, and creative industries.

However, in the majority of countries, cluster policy is, as before, focused on supporting existing enterprises by stimulating their innovative development through the creation of cooperative links. Only a small number of state cluster programmes in European countries are geared towards the development of start-ups. Among the pioneers in this regard is the Finnish programme OSKE [*Müller et al.*, 2012, p. 44].

In relation to this, an important aspect of innovation policy is shifting the focus to start-ups, spin-offs, dynamic SMEs ('gazelles'), as well as to an ecosystem that is conducive to exchanging ideas, developing corresponding projects and business plans, searching for partners and investors, and setting up teams. In such a paradigm, the specialist organizations of clusters are becoming the connecting link between different elements of a regional innovation ecosystem — universities, research organizations, and innovation infrastructure — by directing and coordinating their activities [*Christensen et al.*, 2012, p. 10].

The significance of cluster policy should grow as an industry comes of age, when former start-ups encounter problems in expanding their activities. These problems include underdeveloped manufacturing infrastructure, lack of equipment and qualified work force, poor positioning on the global market, and inadequate communication with state authorities and research institutes. Associating in clusters helps to effectively overcome these barriers.

Recently, the development of innovation start-ups in pilot clusters has grown in importance in Russia. An analysis of federal subsidy programmes at the end of 2013 showed that the majority planned to establish an innovation infrastructure, to a greater or lesser extent geared towards these challenges. These were at engineering centres in the Kaluga, Novosibirsk, and Krasnoyarsk regions. A BioBusiness Incubator already exists in the Phystech XXI cluster, with a Biopharmaceutical building and ICT technology park under construction. In the context of the collaboration between the Innovative Nuclear Physics and Nanotechnology Regional Cluster in Dubna and the state corporation Russian Venture Capital (OAO RVK), there are plans to set up a technology enterprise centre and participate in the 'Regional Business Catalyst' project. The formation of an intra-cluster venture capital fund has been mentioned in programmes in the Republic of Tatarstan and Ulyanovsk region (in the city of Dimitrovgrad).

A unique case is the creation of a pre-incubator in the Zelenograd cluster, where thanks to a federal subsidy they built specialist infrastructure to encourage technology start-ups.[25]

The role of clusters as generators of innovative joint projects and start-ups is of great importance to the national innovation system in Russia. The lack of

[25] Unlike a common business incubator, a pre-incubator supports new enterprises not only at the 'start-up' stage, but at the 'ideas' stage. Its services consist of providing work space, computers and office equipment, consultancy, assistance in drawing up business plans and project presentations, development recommendations, and support in company registration.

attractive projects is becoming a clear pinch point for the country's economy. Only with time will we know the extent to which pilot cluster development programmes help to solve this problem.

The 'Anna Karenina Principle': Signs of sustainable cluster development

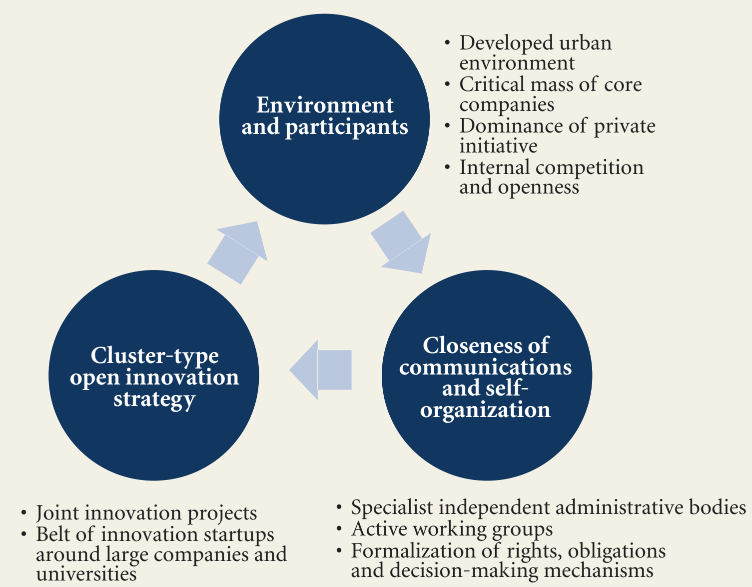
The 'Anna Karenina Principle' can be illustrated with a phrase from Tolstoy's novel: 'All happy families are alike; each unhappy family is unhappy in its own way.' [*Tolstoy*, 1999]. Jared Diamond used it to describe the process of animal domestication which ended in success when several groups of factors coincided. Out of the 148 large, land-based herbivorous mammals that existed in the world and might have been domesticated, only 14 passed the suitability test ('happy families'). The remaining 134 types were among the 'unhappy families', each with their own unique formula [*Diamond*, 1997]. Such an observation is also fair in terms of explaining the success of state efforts to establish sustainable clusters which are characterized by the presence of all the — often interrelated — signs described above (Figure 15 below).

A developed urban environment and a significant number of core companies and associated entities create the necessary prerequisites for greater communication and establish a foundation for potential self-organization (both in the form of horizontal professional or industry associations, and in the form of specialist cluster organizations). In turn, a high degree of trust and intensive internal collaboration contribute to pushing through new ideas and projects, including by creating start-up companies. Ultimately, an innovative ecosystem with an inherent culture of change is a significant element of an urban environment which stimulates the dynamics of existing clusters and the emergence of new ones. Synergy between the aforementioned groups of factors gives successful clusters stability, but the lack of one or more 'ingredients' can sharply diminish the chances of embarking on a trajectory of self-sustaining growth.

We have shown in this article that there are pilot clusters in Russia that do not fully correspond with almost all the signs listed above.

Thus, the development of many clusters situated outside the administrative centres of the corresponding regions is held back by the real quality of the urban environment. The risks caused by being part of a single-specialty and closed city is particularly high, which is clear in the Innovative Technologies Cluster in the Zheleznogorsk closed city (ZATO), the Sarov Innovation Cluster, the Shipbuilding Innovative Regional Cluster in Arkhangelsk region, and the Nuclear Innovation Cluster in Dimitrovgrad (Ulyanovsk region).

Figure 15. **A sustainable cluster development model**



Source: compiled by the author.

As yet, Russian clusters have not yet reached a critical mass of core participating companies. Above all, this is seen in areas such as new materials, nuclear and radiation technologies, aerial and space instrument manufacturing, and ship building. Innovative technology clusters in the Zheleznogorsk closed city and radiation technology clusters (Saint Petersburg and Leningrad region), the Shipbuilding Innovative Regional Cluster (Arkhangelsk region), the Titanium Cluster (Sverdlovsk region), and the Energy Efficient Lighting Technology and Smart Lighting Control Systems cluster (Republic of Mordovia) all have less than 20 participants.

A significant shortcoming of virtually all the pilot clusters is the insignificant contribution of business and the lack of internal competition. This is less the case for clusters in the ICT, electronics, pharmaceuticals, biotechnology and medical industries. At the bottom end of the scale, in ten pilot clusters the proportion of companies is extremely low at less than 50%.

In clusters in the city of Moscow and the Moscow, Tomsk and Novosibirsk regions, there was a drastic increase in the role of regional authorities in 2013, which raises the question of coordinating the interests of businesses and the state in specialist organizations.

We hypothesised that the level of trust among participants should significantly increase in connection with implementing a whole range of measures in the short-term, including educational programmes, raising the qualifications of cluster managers, active work by permanent cluster administrative bodies, and the gradual formation of collaboration frameworks and 'cluster participant — specialist organization' feedback systems. It can be expected that the level of trust in the first group of pilot clusters will grow rapidly, since these measures were in many cases supported by the state as far back as 2013.

As for institutional development to guarantee equality in decision making and the impartiality of administrative bodies, reliable information on the successes of pilot clusters is still clearly unavailable. Horizontal professional communities only operate in some of them, which are generally situated in large cities with many core companies.

As for the signs characterizing a strategic orientation on the part of cluster entities towards an open innovation model, policies to increase the number of standards and rapidly develop SMEs have had a mixed record to date. A policy of setting up new companies and nurturing 'gazelles' has only fully been reflected in the development programme of one cluster, the one in Zelenograd. Nonetheless, virtually all clusters are creating specific innovation infrastructure (primarily, engineering centres), which is to a greater (Novosibirsk region) or lesser (Republic of Mordovia or Krasnoyarsk region) extent honed to the needs of SMEs.

The question of joint innovation projects emerging in Russian clusters currently defies objective assessment. This is due to the fact that, unlike in the majority of European programmes, in Russia there is no distinction between the notion of infrastructural support for pilot clusters through funding the activities of specialist organizations and stimulating joint innovative projects. Despite the fact that a recent government resolution [Government of the Russian Federation, 2013] made provisions for joint projects to be carried out on the back of federal subsidies, the selection criteria do not include any requirements on participant numbers, innovative components, or the level of extra-budgetary funding. Policies need to be adjusted accordingly to encourage participants to develop joint innovation projects for future expert assessment.

Taking into account the numerous shortcomings in all pilot clusters of Russia, it is particularly important to identify their strengths and weaknesses. Such an analysis will make it possible to come close to selecting an individual set of support measures for each specific case or to refuse support, if the defects are too great. Sometimes, problem solving requires the use of other instruments, including those not connected with cluster policy.

Regular monitoring of supported structures is no less important a task, as it allows the state funding programme to be adjusted over time [*Christensen et al.*, 2012, p. 11].

Conclusion

In global practice, there is considerable experience in implementing cluster support programmes and studies have identified the factors underpinning their success. In Russia, state support for clusters is at an early stage, currently covering 25 pilot groups selected based on the results of a competitive tender in 2012. In order to assess the results of these pilots, the necessary methodological and organizational work needs to be done in the near future.

This article aims to fill a vacuum by analysing development programmes and focusing on pilot clusters. A comparison with equivalent foreign parameters and state programmes made it possible to formulate certain key conditions for sustainable cluster development, including the quality of the urban environment, a critical mass of core companies, the dominance of private initiatives, internal competition and openness, and the existence of specialist independent administrative bodies and active working groups. These bodies and groups clarify rights, duties and decision-making mechanisms, carry out joint innovation projects, and establish a belt of innovative start-ups around large companies or universities.

The ability of a cluster to demonstrate all of the aforementioned key conditions would imply a substantial transformation, which would enable the cluster to set off on a path of self-sustaining development. Such establishments will continue to develop and, after state support has ended, will become drivers for economic growth in their corresponding regions. The assessment of pilot clusters with the noted conditions showed that they all, to a greater or lesser extent, exhibit clear shortcomings. Therefore, their development strategy and the state support measures require some adjustment. F

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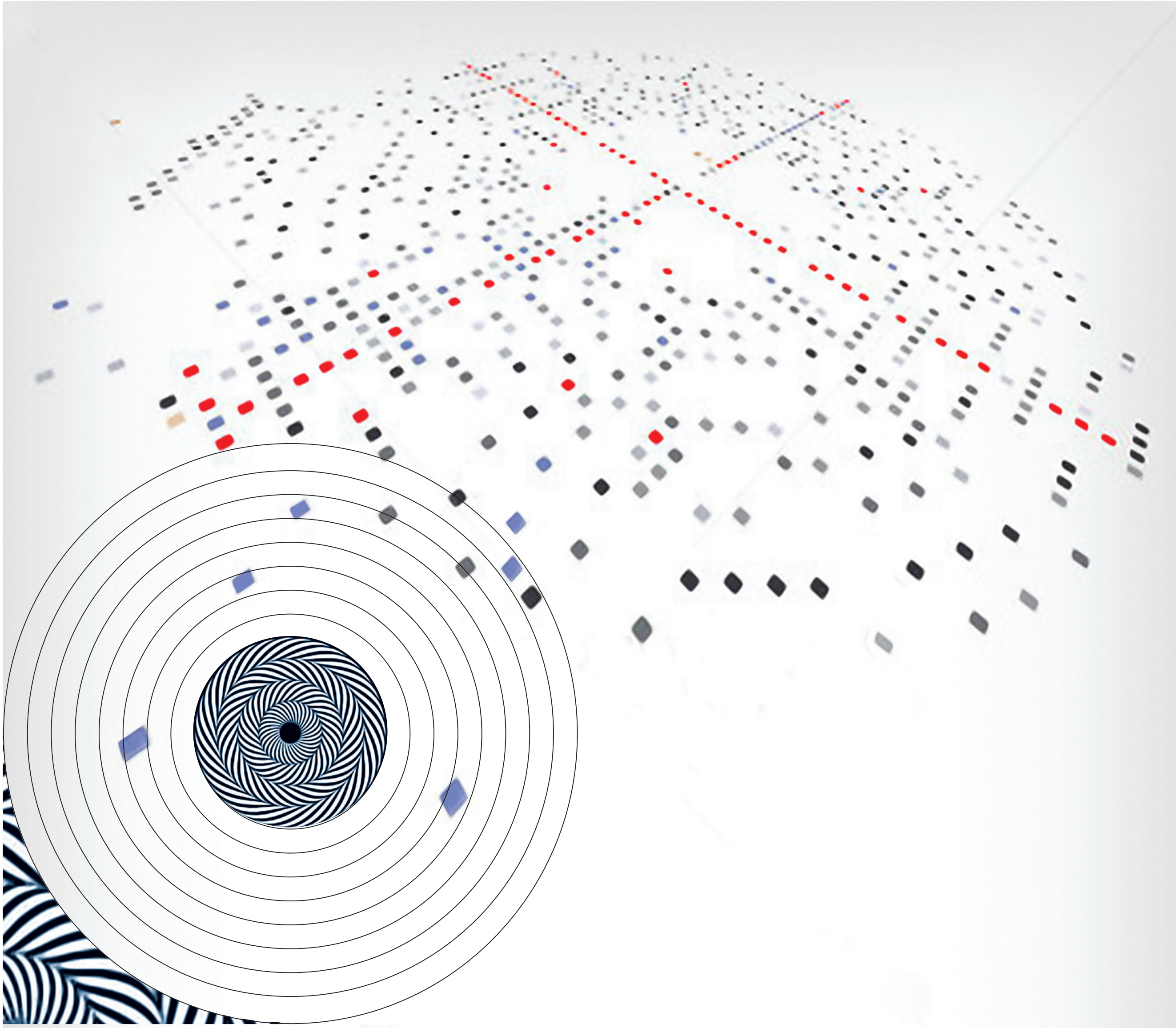
Business-catalysts as Drivers of Regional Innovation Systems

Sergey Makarov, Ekaterina Ugnich



The task of building of an innovative economy requires mechanisms and institutions that will ensure the continuity of innovative process and contribute to the successful commercialization of innovations. Foreign experience of recent years has shown the importance of the accelerating mechanism of innovative project support on the principles of which the activity of the regional business-catalyst is built. The prospects for regional business-catalysts are seen in the development of their network interaction as an important element of an open business entrepreneurial culture and the expansion of partnership relations in the region with the industrial and scientific community.

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Keywords

accelerator; regional business-catalyst; innovative process; 'the valley of death'; innovation infrastructure

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The position of a national economy in the modern global economy is determined by the quality and depth of its links between science, innovation and economic growth. In Russia, this growth is predominantly based on resource and raw material potential and does not show any signs of reorientation towards innovation, a fact corroborated by empirical observations. In 2011, less than 1% of spending by domestic companies went on the acquisition of new technologies; meanwhile, the procurement of patents, licences and other innovation activity work accounted for only 0.2%. Statistics demonstrate the low percentage of organizations involved in technological, organizational and marketing innovations: 10.1% in 2013.[1] Based on this figure, which is characteristic of the level of innovation activity in the country, the Russian economy is falling behind not only leading industrial nations (Germany — 70%, Canada — 65%, Belgium — 60%, Ireland, Denmark and Finland — 55–57%), but also the majority of countries in Central and Eastern Europe, where this figure lies between 20% and 40% [*Gokhberg, Kuznetsova,* 2011; HSE, 2011, p. 10].

One way to overcome this weakness could be to create conditions that are conducive for enterprises to independently use their resources more efficiently by capitalizing on the results of scientific research and development (R&D). This task is largely dependent on the existence of an advanced innovation infrastructure, which allows for a variety of forms of resource and information exchange between economic actors and contributes to the success of innovative enterprises, especially in the early stages of development. At present, Russia has not elaborated any clear mechanisms for infrastructure institutions to collaborate with innovative companies, and the role of key elements of this infrastructure has not yet been agreed upon. Existing contradictions between certain segments of the innovative ecosystem reduce the efficiency of support mechanisms for innovative enterprises, especially new businesses.

The task of building an innovation-oriented economy that is capable of responding to a country's challenges and threats comes up against many problems. Solving these problems very much depends on the theoretical understanding of the conditions and support mechanisms for innovative companies. The problem of developing and operating an innovation infrastructure and its component elements is addressed in numerous works by foreign and Russian academics [for example, *Etzkowitz*, 2003; *Etzkowitz, Pique,* 2005; *Malek et al.*, 2012, 2014; *Ammosov*, 2005; *Golichenko*, 2006; *Gokhberg*, 2003; *Gokhberg, Kuznetsova,* 2009; *Gokhberg et al.*, 2013]. Despite the clear interest in this problem, many issues have still not been addressed in sufficient depth, in particular the mechanisms used to establish infrastructural support for start-up innovation companies. Foreign experience in recent years has shown the effectiveness of an accelerated support mechanism in the form of business catalysts.

This article focuses on substantiating the role and place of a regional business catalyst in the system of innovation infrastructure instruments and institutions. The article assumes that regional business catalysts are the most optimal mechanism to search for and support promising innovative companies and projects.

To describe real economic processes, the study used a situational analysis method making it possible to describe the current state of affairs, to understand existing problems and propose possible means to overcome these problems. In short, this method enabled us to study current phenomena in real conditions [*Yin*, 2003]. System analysis methods offered the opportu-

[1] Based on data from the Russian Federal State Statistics Service (Rosstat). Available at: http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/science_and_innovations/, accessed 15.11.2014.

nity to identify the core characteristics of the innovation infrastructure instruments and institutions in a changing economic environment. The study was also based on evolutionary economics principles [*Nelson, Winter*, 1982] which stress that further development is only maintained and achieved by institutions that have the largest set of favourable properties and aid the successful development of the economy and society.

Innovation infrastructure includes innovative technology centres, technology parks, special economic zones, common use centres, development funds and other specialist institutions. The authors of this article have focused on non-financial means of support for innovative companies in their early stages of development, when they are experiencing the greatest difficulties in searching for resources and establishing the necessary conditions to carry out their projects.

The development of regional innovation infrastructure: Negotiating the 'valley of death'

Building an innovation-oriented economy is not only linked to adapting to pressing global economic trends, but also to searching for and capitalizing on a country's strategic advantages worldwide. The regional diversity of the Russian economy presents unique opportunities to achieve this goal. However, the imbalances between some regions in their levels of social and economic development and the large differences in resource potential between regions mean that innovative development mechanisms and institutions need to be created. These mechanisms and institutions would help to create a synergetic effect in the context of an overarching, country-wide strategy to build an innovative economy. Overcoming such contradictions is only possible through creating the institutional conditions to stimulate and energize the innovative process. The lack of effective mechanisms to set this in motion and support it on a regional level prevents the modernization of the country's economy as a whole.

Not all Russian federal regions with significant science and technology potential have achieved a high level of innovative development. The share of innovative output in their gross regional product is often small and the prospects of raising this share are unclear. Low innovation activity in such cases, as a general rule, is caused not by a lack of interesting projects, but rather cautiousness on the part of investors and the strict criteria they impose on the quality of the administrative teams, mechanisms and instruments and the weaknesses of the existing industrial base.

The stages of the innovation cycle from the conception of an idea to the launch of a product on a market are characterized by a gradual fall in investment risks and growth in potential investor income [*Ammosov*, 2005]. Each of these stages calls for the development of an individual mechanism to dampen risks and to raise funds. The early stages of the innovation cycle — the seed stage — pose the greatest threat to a new enterprise. The seed stage involves the emergence of ideas and initial results from R&D, but without any income or the legal registration of the enterprise. The investment appeal of such projects is based on how well developed the business plan is. Start-ups, which, as a rule, already have developmental prototypes and legal registration, are trying to push their product onto the market and are carrying out market research. It is at these stages, when passing the so-called 'valley of death', that innovative companies are in particular need not only of access to funding sources, but also of support for the future innovative product in the form of experience and knowledge in market and patent analysis, management and business model building skills. The difficulties experienced by companies negotiating the 'valley of death' are aggravated in Russia by the operational characteristics of the innovation environment, namely the lack of a clear understanding of the make-up and boundaries of innovation activity, poor links between those engaging in such activity and the lack of information transparency [*Gokhberg et al.*, 2013]. Russian enterprises are guilty of inertia in the development of collaborative links and searching for and making use of information linked to their activities and markets; many of them are locked in on their own potential and do not show any interest in intensive technology exchanges [*Gokhberg, Kuznetsova*, 2009]. Eliminating this problem is largely dependent on the effectiveness of the innovation infrastructure, including certain financial organizations and production, technological, consulting and other component elements [*Etzkowitz*, 2003; *Etzkowitz, Pique*, 2005; *Hoffman, Radojevich-Kelley*, 2012; *Malek et al.*, 2012, 2014; and others].

Access to investment resources is directly shaped by the quality of the innovation project: its degree of originality, potential market demand, the clarity and detail of the business plan, and the existence of a team capable of realizing the project. A poor understanding of business development mechanisms does not often allow for the required quality of the new project to be guaranteed on the part of the initiator. Innovation infrastructure instruments such as business incubators and business accelerators are widely recognized to make a project more attractive in an investor's eyes by improving all these components. In the early stages of a company's development, the so-called 'growth principle' is key, meaning the creation of the most favourable conditions to support its growth.

Effective, flexible innovation support forms and instruments could and should be used not only centrally across the whole country but also regionally [*Etzkowitz, Pique*, 2005]. This means instruments that allow innovative companies to access the organizational, scientific, research, technical and technological skills that, being concentrated in a single level of control, facilitate the effective transition through the most risky stages of the innovative cycle. The involvement of those with such skills raises the quality of the innovation projects and makes it possible to reduce expenditure on pre-seed investment.

An innovation project acceleration mechanism: origins and development

The evolution of methods and means to control economic processes gave rise to special instruments that help newly starting companies negotiate the 'valley of death' by providing them with the necessary resources, creating specific conditions and offering services. These instruments transform and improve under the influence of the ever-changing needs of those involved in innovation activity and the new challenges facing them. As the number of players on the innovation market expands, so too do the demands about the level of access to innovation infrastructure. One of the most effective elements of this could be business incubators.

The first business incubator, Batavia Industrial Centre, was formed in 1959 in the industrial centre of the state of New York, USA, as a source of new workplaces [*Lewis et al.*, 2011]. Its purpose was to provide newly created innovative enterprises with consultancy, accounting, legal and other services, and to provide them with premises upon which to operate. This allowed new players in the innovation sphere to reduce the costs of breaking onto the market by making it easier to access resources and to increase their business motivation [*Abetti*, 2004].

Another instrument is a business accelerator, which is in many ways based on similar principles to the business incubator model, yet is geared towards more intensive development of 'start-up' innovation projects over a shorter time frame. In the 1980s and 1990s, business incubators and business accelerators were viewed more as scientific laboratories than as institutions providing seed funding [*O'Connell*, 2011]. However, in the early 2000s, following the internet revolution and the so-called dot-com boom, many start-up enterprises lacked access to the capital market. This served as an incentive for the appearance of a new type of accelerators under the guidance of experienced, successful entrepreneurs offering support to companies in various forms and showing a willingness to offer them seed funding.

Business accelerators are different from other innovation infrastructure instruments in five main ways [*Malek et al.*, 2014]. First, there is competitive selection of enterprise projects and teams. Many of those submitting applications to join an accelerator are students in their final years at university. These applications are competitive and attractive to investors in terms of labour costs. Second, business accelerators support a wider range of innovation projects compared to business incubators. Third, an 'exchange' of resources and services to start-up enterprises occurs for access to a holding interest in their capital. Fourth, the projects in business accelerators grow at a relatively high speed and intensity: the duration of accelerated programmes ranges from three (for media and internet companies) to six months. Finally, a spirit of free cooperation and mutual support exist among teams of accelerator participants. Accelerators are often set up on the back of venture capital funds, business incubators or technology parks. Aside from start-up capital, innovation projects form added value through intensive mentoring and social network engagement [*Hoffman, Radojevich-Kelley*, 2012].

Accelerators are a union of experienced businessmen who provide guidance, mentoring, networking, project management, offer office services, and share their knowledge and experience with start-up company employees, helping them to overcome the difficulties surrounding the early stages of the life cycle. Accelerators see the uncertainty of the economic environment as favourable conditions for investment in innovation, especially in technology, as during this time costs reduce and opportunities for new developments tend to open up. As such, accelerators are an innovation infrastructure institution, which provides support to companies in their early stages of development. They can be seen as one of the mechanisms to increase company growth rates in a turbulent economic environment. The unique feature of this instrument lies in the depth of the technological and business expertise provided to participants. In essence, it is a commercial model for receiving quick investment with the assistance of an effective development institution supported both by the state and universities.

The first accelerator that aimed to launch innovative projects is considered to be the Y-Combinator, which was set up in California in 2005 [*Miller, Bound*, 2011]. In recent years, the number of business accelerators in the USA has risen considerably, which confirms the popularity and effectiveness of this instrument. A similar situation was seen in Europe: the first accelerator, Seedcamp was set up in London in 2007 and has now gained pan-European status, receiving more than 2,000 applications per year [*Butcher*, 2011]. Since its creation, Seedcamp has 'released' 110 innovation companies, which have attracted investment totalling 65 million US dollars.

Globally, there are more than 700 accelerators. The most successful of them are considered the American Y-Combinator and TechStars, which have already helped 566 and 248 innovative companies, respectively, to reach the market. The survival rate of projects after growing in these accelerators is more than 85%. In Russia, business accelerators started to appear in 2009. Today, 326 innovation projects are developing in 27 Russian accelerators.

However, over the period 2011-2013, only eight of these projects managed to attract investment. In the majority of cases, Russian investment management organizations (Glavstart, Plug and Play, Pulsar Venture, Techno Cup and others) are geared towards supporting information and communication technologies (ICT) and developments in various scientific fields and industrial sectors [RVC, 2014].

The popularity of this support instrument for innovation projects in their early stages is down to the specific nature of the business strategy, which guarantees links between scientific developments, industrial production, and services to push through and commercialize projects [*Miller, Bound*, 2011]. The main advantage is the shorter time frame for innovative products to reach the market through the opportunities to carry out the necessary R&D, reduce administrative costs, and search for investors more quickly. At the same time, the technological and operational risks of projects are reduced [*Malek et al.*, 2012], and their chances of being successfully commercialized are increased.

However, experts have pointed out certain problems which could reduce the effectiveness of this instrument. The length of the acceleration cycle ranges from only 3 to 6 months, meaning that a relatively young enterprise is launched onto the market when it cannot always fend for itself in a competitive environment. In addition, participating companies provide accelerators with relatively little information at the selection stage, which often does not allow them to adequately assess their potential. Moreover, support in the early stages to some extent strips a business of its 'entrepreneurial spirit' and competitive skills. As a result, such players are less attractive to investors, which are geared towards the strict market mechanisms that more reliably shape the prospects of new companies. Ultimately, it is the approach itself that is disputed, as it is based on many relatively fortuitous investments in the hope of making it in a particular industry. Experts consider a small number of targeted investments to be more effective [*Miller, Bound*, 2011].

The emergence of accelerators was, to a certain degree, a reaction to the shortcomings of the university education system in terms of instilling and spreading the required practical entrepreneurial (innovation) skills. A shorter and more intensive training cycle coupled with real business experience increases the appeal of accelerators in the eyes of students and young entrepreneurs. Overcoming these pitfalls is hardly possible without state involvement.

The activities of business accelerators are associated with certain operational costs — leasing premises, bringing in experts, promoting projects, etc. According to data from the World Bank, these costs can vary from 2,000 to 115,000 US dollars [World Bank, infoDev Finance, 2012]. Coupled with the problems of searching for successful business models amid an uncertain market climate and an unstable institutional environment in Russia, this makes the activities of business accelerators more difficult with private capital. At the same time, business catalysts have started to spring up with the involvement of state and development institutions, also based on the accelerator principle.

A regional business catalyst model: opportunities and limitations

A regional business catalyst is an instrument to generate and select the most promising completed R&D projects and quickly roll them out on the market by developing the acceleration principle outlined above. One of its main aims is to increase the number of innovation projects and ensure that they are 'investment quality'.

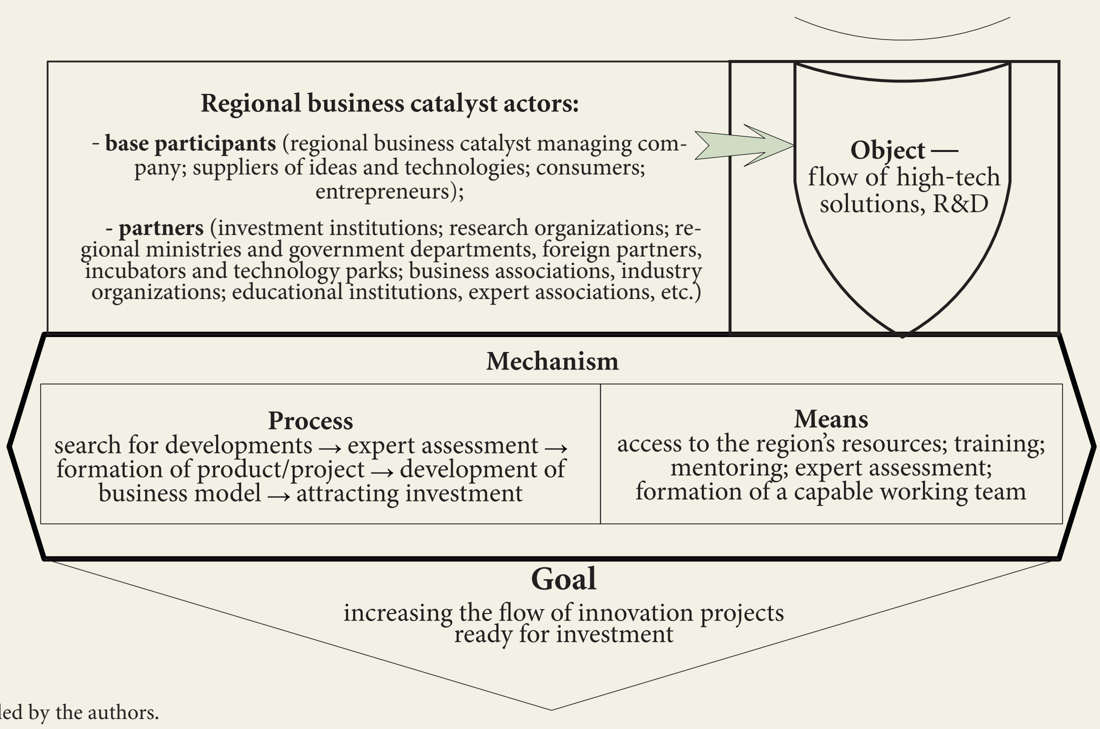
A business catalyst brings together innovation process participants in a region to establish and support innovation projects in their early stages, when even the very idea of a new business is still in need of endorsement. It is based on amalgamating the skills of key innovation system players in a region – universities, research organizations, industrial enterprises, financial institutions, private investors, regional authorities — with the entrepreneurial resources of the project initiator. The involvement of all of these parties makes it possible to reduce initial investment costs i.e. to solve the most pressing problem of any new project which is accessing resources. A local business catalyst provides developers and entrepreneurs — both residents and non-residents in a region – with a range of services to bring an innovation project to the stage of investment readiness in exchange for a share, for example, in the emerging company or a company participating in a regional business catalyst. Common standards and a transparent project selection procedure make this mechanism effective.

Therefore, a regional business catalyst makes it possible to negotiate the 'valley of death' and energize innovation activity in a region with the help of a mechanism to prepare innovative companies for investment by synchronizing and coordinating the skills of its participants. The main elements of a regional business catalyst model are set out below (Figure 1).

An innovation project 'growth' programme at a regional business catalyst tends to last on average three months and is made up of six stages:

1. *Entry into a project: searching for ideas and developments.* Ideas to be considered in a business catalyst can be presented by participants and external partner structures — business incubators, enterprises and individual entrepreneurs in a region;
2. *Expert assessment and project screening* is based on criteria such as the level of novelty, competitiveness, practical feasibility, commodification opportunities (transformation into a commodity), and prospects of protecting intellectual property rights;

Figure 1. **A regional business catalyst model**



Source: compiled by the authors.

3. *Launch of design work, product creation.* Upon completion of this phase, a clear concept of the product is formed, receiving its first reactions from the market and potential customers;
4. *Business modelling* involves an assessment of the team's ability to complete the project, carry out market research, analyse consumer values, product distribution channels, and incomes and expenditure, analyse the rate of return, identify key partners and the necessary resources, and hone down the company's development plan;
5. *Company creation and search for an investor.* The role of a business catalyst at this stage involves assisting in registering intellectual property rights to a development, creating a legal entity, organizing staff and accounts, and selecting investors that match the required profile;
6. *Leaving the project.* Attracting seed funds (an investor) and selling a share in the company.

Upon the completion of each stage, projects are screened to remove any that do not meet the stipulated criteria and conditions. According to our assessments, out of the 200 ideas and developments at the entry stage prior to assessment by an expert committee in a regional business catalyst, only roughly 40 projects will make it through. Of these, 8–12 will likely reach the stage of direct developmental work in the business catalyst, and only 4–8 of these prepared investment applications will reach the end point. The more general outcome of regional business catalysts' activity is stimulating entrepreneurial initiatives, creating business prospects that are attractive to investment and, as a result, increasing the innovation activity and potential of a region.

A regional business catalyst differs from a business accelerator in three main ways. First, it is aimed at bringing together the skills of those involved in innovation activity in a particular region with the skills of mentors from the business community who have experience in speeding up (accelerating) the early stages of the innovation cycle. Second, in a business catalyst innovative ideas are transformed into projects ready for investment. Third, a bootstrapping mechanism lies at its foundation, meaning that existing resources are used as efficiently as possible, including non-fiscal incentives at the pre-seed project development stage.

The innovation infrastructure instruments examined in Table 1 may be interlinked, complementary, and constitute a single innovation project sup-

Table 1. **Characteristics of certain innovation infrastructure instruments**

	Business incubator	Business accelerator	Business catalyst
Aim	To stimulate accelerated development of newly started innovation companies	To create quality innovation projects for investment	To generate and increase the number of innovation projects in a region for investment
Basic principles of support	To create favourable conditions, to provide the necessary resources and services	To intensively develop innovation projects by guaranteeing access to the necessary resources and skills	To expedite the creation and development of innovative projects by granting access to the necessary resources and training in the necessary skills for residents
Main initiators	Higher education institutions, research institutions, large companies, the state	Investment funds, business incubators, entrepreneurs, the state	Universities, research institutions, business incubators, development institutes
Developmental level of projects (companies) drawn in	As a rule, start-ups	Seed stage	Pre-seed and seed stages
'Growth' term	Up to 3 years	3–6 months	3–4 months

Source: compiled by the authors.

port system. Thus, for example, in the region of Astrakhan, the business catalyst was set up on the basis of the LIFT business incubator [*Timokhina*, 2014], while Moscow State University set up its own accelerator in its business incubator [*Akkerman*, 2014].

A business catalyst helps to increase the number of transactions taking place in a region to provide seed and pre-seed funding, with all interested actors of a regional innovation system involved. The regional business catalyst organizational mechanism assumes that an interested innovation infrastructure participant is registered as a legal entity. Several business catalysts in Krasnoyarsk, Rostov, Astrakhan, Kaluga, and Samara regions already operate on this basis. These regions are characterized by relatively high scientific, educational and innovation potential, a developed innovation infrastructure and an innovation support system from regional authorities. The Russian Venture Company was behind their creation with the involvement of the Moscow School of Management SKOLKOVO (Table 2).

Case study: The Rostov Oblast regional business catalyst

The business catalyst model described in the article was first launched in test form at the end of 2012 in Rostov region, based at the Don State Technical University. Of the 130 applications submitted to the regional business catalyst in 2013, six projects passed the expert selection process, received mentoring support and were later presented to investors from the Moscow School of Management SKOLKOVO business community (Figure 2). Four projects reached the stage of signing contracts with investors: one each in the energy and ICT sectors and two in the mechanical engineering sector.

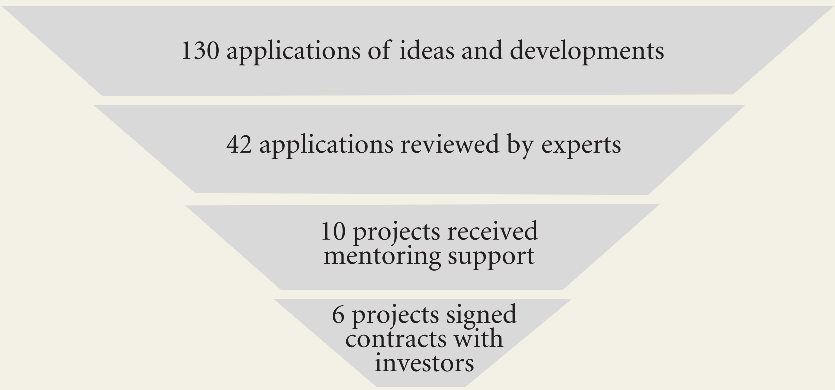
The Rostov regional business catalyst has a diversified portfolio of projects in different industries: 33% fall under mechanical engineering and 26% re-

Table 2. **Characteristics of regional business catalysts in the Russian Federation**

Launch location of regional business catalysts	**Kaluga Oblast**	**Astrakhan Oblast**	**Krasnoyarsk Krai**	**Samara Oblast**	**Rostov Oblast**
Year of launch (in test form)	2013	2013	2013	2014	2012 Since 2013 it has been operating in full in the form of a ZAO Regional Business Catalyst
Support from regional authorities	Ministry of Economic Development of Kaluga Oblast	Ministry of Economic Development of Astrakhan Oblast	Ministry of Investment and Innovation of Krasnoyarsk Krai	Ministry of Economic Development, Investment and Trade of Samara Oblast	Ministry of Economic Development of Rostov Oblast and Department of Investment and Enterprise of Rostov Oblast
Base organization	OAO Innovative Development Agency – Kaluga Oblast Cluster Development Centre	The private technology park Fabrika (LIFT business incubator)	The Krai state autonomous institution Krasnoyarsk Regional Innovation Technology Business Incubator	The non-profit partnership Regional Innovation Centre	The federal state budgetary educational institution Don State Technical University
Number of projects presented to investors	1	5	5	3	6
Priority 'growth' project areas	ICT; automation and control; energy and energy saving	ICT; agriculture and agribusiness; energy and energy saving	Metallurgy; ICT; energy and resource saving; mechanical engineering	ICT; automation and control; mechanical engineering	Mechanical engineering; mechatronics and robotics; energy and energy saving; ICT; automation and control; food industry; medical equipment

Source: compiled by the authors.

Figure 2. **Initial results of the work by the Rostov Oblast regional business catalyst**

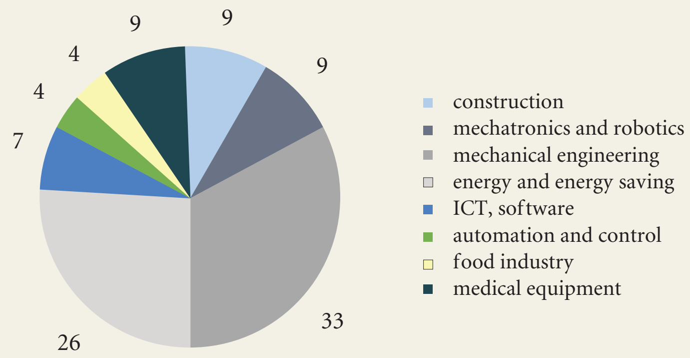


Source: compiled by the authors.

late to energy and energy saving (Figure 3). The dominance of projects of this profile can be explained by their attractiveness to the region's economy and the key role played by these industries in the region. 80% of all regional output comes from fuel, energy, mechanical engineering, and food industries. The main source of innovation projects for the business catalyst is scientific ideas and solutions developed by the region's universities and research organizations.

A business catalyst's activities are accompanied by difficulties caused by the specific nature of the projects' technical and scientific expert assessments and the inadequate coherence of key elements of a region's innovation ecosystem. In part, reinforcing the industry specialization of a business catalyst would make it possible to overcome these problems, thereby helping the optimization of the development of the end product and the strengthening of the innovation potential of the projects. At the same time, it is important to remember that acceleration is far from desirable for all projects. While an ICT project can be pushed through a business catalyst in three months, for biomedicine — where the development period for a new product and technology ranges from three to five years or more — the accelerated 'growth' mechanism is counter-productive. As stressed above, in an unstable institutional environment and in the absence of adequate skills, resources, information sources, and links between innovation project developers and the

Figure 3. **Breakdown of projects in the Rostov regional business catalyst by economic sector (%)**



Source: authors' calculations.

business community, involvement in a regional business catalyst becomes essentially the only way to prepare a quality project in a short time frame which is capable of attracting investors' attention.

The prospects of further developing regional business catalysts are connected with integrating them into a network, which would facilitate collaboration, an exchange of skills and information, and the spread of best practices nationally. The question of the rationality and limits of state involvement in funding new elements of a regional innovation infrastructure is still disputed. Such involvement can be examined in a number of other innovation support instruments (innovation projects and teams) in the early stages of work. However, full budgetary funding for business catalysts risks isolating them from the investor community and risks problems arising in attracting private capital in later stages.[2] The likelihood of expanding the network of regional business catalysts is also linked to the open nature of business catalysts, a transparent mechanism for providing resources, accessible information on the current status of projects, etc. Openness also presupposes a willingness among mentors to offer free consultations, and a will among innovative companies to share their business secrets with other participants. An open network of skills to establish a flow of 'investment quality' projects operating on principles such as enterprise, partnership and state support ensures – if participants keep to their responsibilities — that the business catalyst mechanism can quickly adapt to changing external environmental conditions.

Conclusion

This study confirms the potential of using regional business catalysts as an effective instrument to support start-up innovative enterprises. With the help of these business catalysts, developers and project initiators can find the best possible means to implement their projects, and investors and innovation managers can select the most effective forms of investment in innovation.

This support for the innovation process is provided in the early stages through accelerated programmes. It is based on generating, synchronizing and coordinating the skills of those involved in the innovation process, and aims to ensure a flow of commercial transactions from an uncoordinated mass of completed R&D projects.

An analysis of the distinguishing features of the business catalyst model compared with business incubators and business accelerators shows that a business catalyst not only brings together the skills of its participants, initiators and mentors, but also establishes common standards and a transparent selection procedure to generate innovative ideas and transform them into a project that is ready for investment. At the foundation of a regional business catalyst's work is a mechanism to make the most use of existing resources, as well as non-fiscal incentives for investment in the pre-seed project development stage.

This article discussed the history of one of the five business catalysts that currently exist in Russia, which since 2013 has prepared and presented six innovation projects spanning various economic sectors to investors in the Rostov region. This case study demonstrates not only the undisputed advantages of the business catalyst in the Rostov region for the development of innovation processes regionally (which is especially important in Russia

[2] It is widely recognized that the presence of the private investment component is extremely important when implementing many state policy instruments. As such, when setting up new high-tech companies, proactive efforts aimed at establishing an institutional environment are effective. Private measures (reactions to market collapse in the form of subsidies and investment in 'strategic' industries) are often counter-productive and have the opposite effect [*Abetti*, 2004].

in view of the country's varied 'economic geography') but it also highlights the clear problems caused primarily by the inadequate links between key elements of the local innovation ecosystem.

The prospects of successful regional business catalysts rely on the formation of networked collaboration between them, as well as ensuring that such structures are open, and expanding partnerships between industry, research, and state development institutions in supporting innovative enterprises. F

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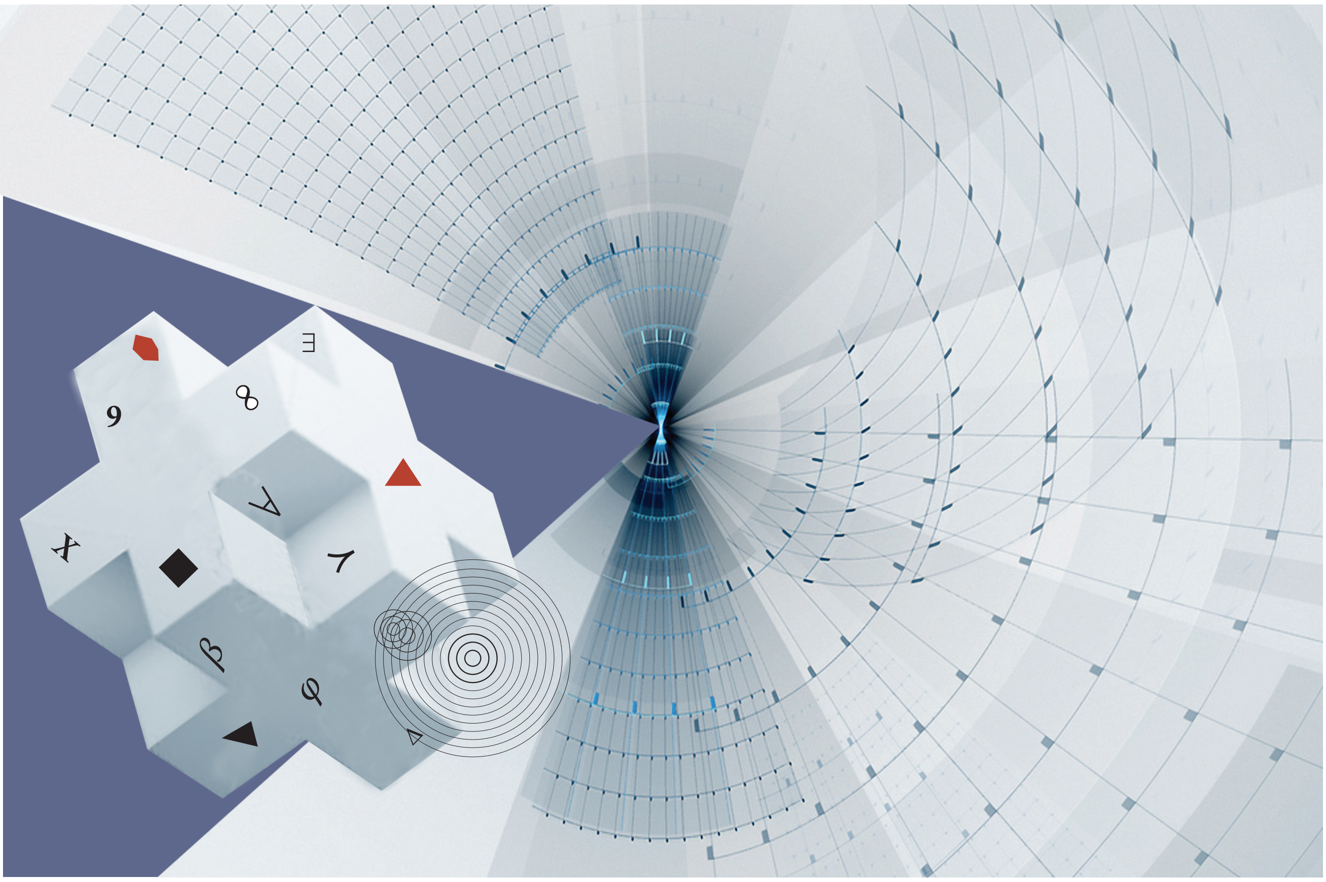
Foresight, Competitive Intelligence and Business Analytics — Tools for Making Industrial Programmes More Efficient

Jonathan Calof, Gregory Richards, Jack Smith



Creating industrial policy and programmes, especially in technology, is fraught with high levels of uncertainty. These programmes target the development of products that will not be sold for several years; therefore, one of the risks is that the products will no longer be in demand or will have been overtaken by more advanced technologies. In several cases, the authors have seen these programmes fail because the intended targets of the programme did not apply to use the programme funds (poorly targeted program) or did not use the programme properly. An integrated programme involving foresight, competitive intelligence and business analytics assists in decreasing the probability of the risks and problems described above, resulting in better designed and more successful industrial policy. These techniques can also be used to create a dashboard for monitoring programme use so that any problems can be corrected early on. The dashboard uses advanced analytics to assess programme applications and programme inquiries to assess whether the programme is being used properly. Via an integrated intelligence process, it monitors the external environment to ensure that programme assumptions in terms of what technologies are most appropriate remain valid. The dashboard relies on information available in open sources and available to the government.

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Establishing industrial policy, and its ensuing programmes and industry assistance measures, is a task fraught with high levels of uncertainty. As will be shown in this article, an integrated programme involving foresight, competitive intelligence and business analytics should not only decrease levels of uncertainty and risk but also lead to greater probabilities of policy uptake by its intended audience and also early identification of industry opportunities.

This article is based on both academic scholarship and practitioner experience. The authors have been involved collectively in hundreds of industrial policy and programme projects globally and in many academic studies. Programmes and policies were approached through the field of competitive intelligence, business analytics and foresight. In this article, we define each of these disciplines and illustrate with an example of how and why the three approaches can be combined. Finally, we also discuss a dashboard that applies these concepts. To provide a common base for discussing the three domains in the context of programme development and monitoring, the following fictitious example is used. The Canadian government has noted that demand for and discourse about nutraceutical products is growing: this could represent an enormous opportunity for Canada. Accordingly, the government wishes to design a programme that will encourage Canadian companies to produce innovative nutraceutical products and technologies. It is hoped that this will stimulate products, which will then be commercialized, leading to jobs in the sector and wealth creation. Similar to other programmes, it is envisioned as a tax credit for eligible nutraceutical R&D and commercialization investments.

Foresight

Foresight involves constructively bringing awareness of long-term challenges and opportunities into more immediate decision-making. 'Foresight is a systematic, participatory, future-intelligence-gathering and medium- to long-term vision-building process aimed at present-day decisions and mobilising joint anticipatory-preparatory actions' [For-Learn, 2014].

Foresight is neither prediction, nor does it estimate probabilities of particular pathways. Rather, it is about broadening our understanding about the drivers of societal change and becoming better prepared for the inevitable surprises ahead. Foresight normally starts with scanning to determine what is changing and why by anticipating plausible sources and origins of change, and seeking to understand the multiple complex interdependencies that motivate personal adaptation, organizational positioning — the capacity for adjustment, and societal evolution at a more macro level. Foresight then uses the various prospects of change to construct a range of plausible narratives or scenarios, and roadmaps to indicate basic directions.

Foresight asks '*what range of plausible futures might our organization have to be prepared for, and which strategies can help us build resilience and create adaptive capacity to anticipate and thrive in the turbulence of change?*'

Foresight increases organizational agility through added resilience — alertness to trends, awareness of change drivers and readiness for potential shocks, issues, and challenges. Essentially, foresight employs a rehearsal approach to preparedness by addressing the '*what if*' scenarios.

Foresight establishes a context (i.e. the boundaries and possibilities of what are deemed plausible narratives) for both the extent and speed of potential change and the adaptive risks of a designated sector, emerging market or technology domain.

Applying Foresight to Nutraceuticals

So how might the government apply foresight to nutraceuticals? How could foresight be used to address concerns about the long-term competitive viability of the nutraceuticals sector and approach the challenges of a rapidly changing technology landscape? More specifically, how should a government industry department, with an already successful track record of nurturing the development of new nutraceutical companies, approach the complexity of deciding whether, when and how to invest in a new area of technological progress with potentially transformative applications?

A first step would be to consult technology and environmental scanning reports similar to those categories highlighted in Table 1 (see below). Table 1 was developed by Ozcan Saritas and Jack Smith as a contribution to the European Commission's Future Technologies Assessment Conference overview report on the Big Picture Survey. The survey used five standard STEEP-type categories (four presented in the table) and then three sub-categories for each. The technology areas are embedded in each sub-area, and/or featured in the two highlighted areas under Science and Technology.

This foresight technique indicates that there are real uncertainties about what applications might soon become both technically feasible and economically viable and whether there may be toxicological risks. Applying this within the nutraceuticals sector found that a growing global market in nutraceuticals already exists and that the application of molecular scale nano-engineering was progressing fast and could create enormous growth if and when successfully commercialized. Significant uncertainty remains, however, around which countries and producers could do this when and how.

To better understand the broader context of these uncertainties, two additional foresight techniques are frequently employed: scenarios and technology roadmaps. Jack Smith and Ozcan Saritas [*Saritas, Smith,* 2011] and Rafael Popper [*Popper,* 2008] discuss the foresight analytical techniques and methods for selection in more depth.

Scenarios explicitly build upon identified key uncertainties. The aim of scenarios is to develop future oriented situational narrative visions and glimpses of plausible future operating environments that can reveal business challenges as well as opportunities stemming from the resolution of the identified uncertainties. Therefore, by using this technique it is possible to anticipate actions in advance of your competitors.

In the area of future nutraceutical applications, four representative scenarios could be derived from, for example, the dual uncertainties of the rate of science and technology (S&T) progress and the pace and performance results of regulatory oversight. These drivers are based on past scenario projects in similar areas in which the authors have been involved. In this example, four different scenarios emerged: called 'nutri-slow', 'nano-go', 'nutri sue', and 'nano promo'. Note that two of the scenarios involve nano-technology. The most significant issue was that regardless of whether oversight was uncertain or high, as soon as the dynamics for S&T progress become rapid, the result moves into the nano-driven zone. To apply this to the developed programme, we first need to determine where we are now (in 2014–2015); where we seem to be heading; and whether this can or should be changed in some manner through policy actions. So what messages are the foresight scenarios conveying?

- The current market in 2014 for conventional nutraceuticals is projected to remain sluggish. Yet it could soon become highly vulnerable if (as expected by leading scientists) nano-scale design and production advances enable producers in other countries or markets to shift into what is described as fast and transformative. This situation would create more competition;
- There are understandable uncertainties associated with R&D and regulatory approval, issues which will have to be closely monitored. If the new nano techniques are able to obtain approval, then current production platforms will become as obsolete as floppy disks competing against flash drives;
- While timelines are imprecise in foresight, it is clear that the key change factors — represented by the scenario drivers and uncertainties — are going to be influencing the next business cycles of nutraceuticals.

Technology roadmaps are more specific to the needs of most business enterprises than scenarios (which are typically initiated by governments). They are typically employed to further reduce uncertainty. First, roadmaps are managed by industry. Second, they have more immediate and specific decision timelines

Table 1. **Results of a foresight STEEP exercise**

Society and culture	Social norms, education, information and knowledge society	Demographics, urbanization, population health and migration	Equity, ethical, moral and legal issues
Science and technology	Science, culture and discoveries	Technology progress	Innovative, transformative, applications & products
Energy	Current energy use, peak oil, Efficiency and security	New and renewable resources	Non -renewable energy alternatives
Ecology-Economy	Stage of global finance, trade, debt and related globalization issues	BRIC rapid development economies	Climate change, global warming = sustainable ecology, new economy

Source: [*Saritas, Smith,* 2008].

for investment. In other words, they outline what specific investments will be required and when (e.g. new R&D; equipment, training and skills development, emerging market research) to acquire the needed agile capacity to realize the opportunities and reach the business destination before others.

Further analysis into nano composite new materials leads us to the possibility of nano-based nutraceuticals or nano-nutraceuticals, which would likely score highly with moderate risk in terms of policy barriers.

Although technology foresight shows that several nano-nutraceuticals have already been commercialized, risk remains nevertheless. This is mainly because the regulatory environment has not yet fully rendered its judgements and concerns about the health implications surrounding the ingestion of nano-based products.

A typical foresight insight or conclusion from technology roadmaps is as follows:

- The matrix analytical framework suggests positive potential from the new technological opportunities;
- Further R&D will be required, especially in terms of the regulatory hurdles;
- To succeed — or at least be early entrants in the emerging nano-based nutraceutical design and production platforms — excellent scientific capabilities and equipment are needed. Aspiring firms must plan and recruit for these in advance if they want to be competitive.

In conclusion, the use of foresight enables a programme recommendation for nano-nutraceuticals to be drawn up. This comes about through STEEP and scenarios. A nano-nutraceutical roadmap provides the information needed to focus the programme on the specific kinds of research and issues such as regulations that should be addressed.

Competitive intelligence

Definitions of competitive intelligence (CI) focus either on the objective of CI or how CI is done (process definition). For example, the Strategic and Competitive Intelligence Professionals (SCIP), a global association of competitive intelligence practitioners defines CI as ‘a necessary ethical discipline for decision making based on understanding the competitive environment’ [SCIP, 2014]. While this does not define CI, it does describe its objective. Similarly, Professor Du Toit defined it in terms of its objective: ‘Competitive intelligence (CI) is a strategic tool to facilitate the identification of potential opportunities and threats.’ [*Du Toit*, 2013]. Salvador and his colleagues wrote that the objective of competitive intelligence was to support innovation [*Salvador et al.*, 2013].

Others have defined competitive intelligence in terms of its process i.e. how it is created. For example, Kahaner wrote that CI is ‘a systematic program to collect and analyze information about competitors’ activities and general business trends to achieve the goals of the company. Moreover, CI consists of identifying intelligence needs within an organization, collecting data from primary and secondary sources, evaluation, and analysis’ [*Kahaner,* 1997, p. 16]. Kahaner’s definition fits with the ‘wheel of competitive intelligence’ concept, which posits that CI is developed in a systematic and ethical manner involving planning, collection, analysis, communication and management.

The field of CI has a very long and rich academic and practitioner history, with academic literature citations first appearing in the 1950s and company practices noted in the 15th and 16th century [*Juhari, Stephens,* 2006]. Thus, it can hardly be called a new discipline. However, with the increasingly competitive environment, government and business have been turning to a greater extent to competitive intelligence to better understand their environment and develop better programmes and strategies. In a survey carried out by the Global Intelligence Alliance (GIA), the percentage of respondents with CI functions grew from 63% to 76% in two years; moreover, the third of surveyed companies which did not have any CI operations stated that they intended to launch such an operation within 12 months [GIA, 2011]. A study done by the American Futures Group consulting firm found that 82% of large enterprises and over 90% of the Forbes top 500 global firms adopt CI for risk management and decisions [*Xu et al.*, 2011]. The Xu study also pointed to a high value of the CI industry: by the end of the 20th century, the study estimated that the overall production value of CI industry had reached 70 billion USD [*Ibid.*]. SCIP estimates its value at a more conservative 2 billion USD a year [SCIP, 2014]. Regardless of the figure used, studies do report that the amount spent on CI is growing and that the activity was paying off. A GIA study in 2013 reported that decision making was 15% more efficient in companies with a CI function in place, and 80% of surveyed companies said the investment was paying off in terms of the return on investment [GIA, 2013].

In trying to understand competitive intelligence practice, various organizations have surveyed CI practitioners. The GIA (www.globalintelligence.com) carries out these studies on a regular basis, two of which we described above. Academics throughout the world have looked at their country's CI practices, sometimes comparatively (see for example, [*Wright, Calof*, 2006; *Du Toit*, 2013; *Bergeron*, 2000]. In 2005, the Competitive Intelligence Foundation supported a global study on competitive intelligence practice [*Fehringer et al.*, 2006]. One of the findings of this study was that CI was being used to help make many different kinds of decisions including market entry, product development, R&D, corporate development etc. (Table 2). The study also pointed to a broad range of analytical methods used for developing CI (Table 3). Consistent with competitive intelligence theory, the information for developing CI primarily came from the organization's own employees, followed by industry experts and customers. Conferences and trade shows were also common places to gather primary sources of information. In terms of secondary sources, 97% of respondents mentioned online and print publications; the Internet and fee-based online subscriptions were also highly used (85% and 84%, respectively, said this was a very important source or these were very important sources).

Competitive intelligence has several sub-domains or speciality fields. These include competitor intelligence (intelligence focused on competition); sourcing intelligence (intelligence used in the human resource function); and competitive technical intelligence (CTI), which is of the most relevance for this article. CTI is competitive intelligence within the R&D arena [*Herring*, 1993; *Ashton, Klavans*, 1997]. Ashton and Klavans defined it as 'business sensitive information on external scientific or technological threats, opportunities, or developments that have the potential to affect a company's competitive situation' [*Ashton, Klavans*, 1997, p. 11]. Literature from as long ago as the 1960s discusses CTI. For a more detailed look at CTI, see [*Calof, Smith*, 2010].

Government use of competitive intelligence

While much of the competitive intelligence literature focuses on the use of this activity by companies to support economic and technical decisions, there is a stream of literature that looks at its importance for governments. Growth in government use of CI led to SCIP allocating a conference track to government and CI in 2004. Driving the increased use of CI by the public sector are the difficult financial, economic and political decisions facing public managers and the need for and availability of CI techniques to help with these decisions [*Dedijer*, 1994; *Watson*, 1997; *Parker*, 2000; *Hamilton-Pennel*, 2004; *Calof*, 2007]. Calof and Skinner looked at CI within the Canadian government, noting that it was used extensively in various departments for policy development [*Calof, Skinner*, 1999)]. At a technical intelligence level, Fruchet wrote that the CTI group at the National Research Council (Canadian government organization) 'provided technology intelligence products and services to business and market development customers in both the NRC research institutes and the Industrial Research Assistance Program' [*Fruchet*, 2009, p. 37]. Competitive intelligence programs

Table 2. **CI-based types of decisions** (as a percentage of total number of surveyed)

Question: What business decisions do your department's CI decisions support?

Decision supported	Types of answers				
	Frequently	Sometimes	Rarely	Never	Don't know
Corporate/business decisions	54.1	32.6	8.5	3.2	1.6
Market entry decisions	38.9	38.3	13.6	5.7	3.5
M&A, due diligence, Joint Venture	25.9	31.3	22.2	14.6	6.0
Product development	36.8	37.3	16.6	5.7	3.6
Regulatory or legal	12.9	30.6	30.5	17.4	8.6
Research or technology development	24.4	39.2	21.0	10.3	5.1
Sales or business development	48.7	35.8	10.3	2.4	2.8

Source: [*Fehringer et al.*, 2006].

Table 3. **Intensity of using different analysis techniques (as a percentage of total number of surveyed)***

Question: How often do you or others in your department use the following analysis techniques?

Technique	% used
Strategic Analysis techniques	
BCG Matrix	46.2
Industry analysis (5 forces)	78.1
Strategic groups	64.3
SWOT	90.3
Value chain	65.6
Environmental analysis	
Issue analysis	69.1
Scenarios	68.6
Stakeholder	61.8
STEEP	59.9
Financial analysis	
Financial ratio	76.1
Sustainable growth rate	66.5
Competitive & customer	
Blind spot	54.3
Competitor	90.1
Customer value	74.2
Customer segmentation	79.6
Management profiling	70.5
Evolutionary analysis	
Experience curve	48.8
Growth vector	47.0
Product life cycle	68.2
Technology life cycle	65.0

* Total percentage of answers exceeds 100%, as respondents could choose several answers.

Source: [*Fehringer et al.*, 2006].

have been used for stakeholder analysis, treaty negotiations, identification of international priorities, developing technology programmes and policy, and more.

Canada is not unique in government use of CI processes to develop programmes and policies. Bonthous examined the French government's use of CI for policy and programme development [*Bonthous*, 1995], while Gilad looked at the Japanese model, these are but a few of government use CI studies [*Gilad*, 1998].

Foresight as a complement to CI and CTI

Calof and Smith developed a framework for R&D project selection that combined foresight and competitive technical intelligence. In the article, they describe the two as complementary: 'Today's decisions will shape the environments of tomorrow whether in business or government, and however one acquires the best intelligence, new market characteristics and estimates and a disciplined imagination of plausible situations, the agility of positioning and response can be substantially increased through a complementary approach that, if successful in capturing the many dimensions of future risk, will represent an integrated capability' [*Calof, Smith*, 2010].

The perspective of foresight is 'outside in'. In other words, it looks outside the frame of any organization or country strategy and asks what the future environment looks like. Competitive intelligence, on the other hand, starts with an existing strategy and asks how the environment will affect the success of this strategy. Foresight tends to be long-term in outlook (in some cases, 50 years into the future), while the time frame for competitive intelligence is considerably shorter. The timeline for CTI is generally longer than that of other forms of competitive intelligence but far shorter than foresight. Calof and Smith reviewed several CTI studies and found that they generally had a time frame of between 3 and 10 years [*Ibid.*]. Foresight broadens understanding and identifies pathways. In contrast, competitive intelligence takes those pathways and understanding and seeks estimates, probabilities and forecasts within the short to medium-term to help companies adapt their strategies to the most likely environmental context. Competitive intelligence adopts a predictive approach to scoping future risks that seeks to provide direction to decision makers on the implications of new and emerging technologies and their prospective markets. The expected outcome is more effective organizational development and competitive strategies. Together, foresight and CI offer a package of methodologies, including primary and secondary collection approaches, facilitation methods, a variety of robust analytical methods, an ability to work with qualitative information, and a clear focus on understanding the external environment. Hence, foresight and CI are highly complementary.

Applying competitive intelligence for the design of the nano-nutraceutical programme

First, foresight provides the decision maker with two very valuable inputs: rather than the generic concept of nutraceutical, the scenario exercise focused on nano-nutriceutical. Second, roadmapping identified some of the issues that should be addressed on the path to commercialization (e.g. regulatory and company requirements in, for example, R&D capabilities.

How would a CI professional seek to develop the programme? What would their unique contribution be that is distinguishable from foresight's contribution? As noted in the previous section, CI would undoubtedly adopt a shorter term orientation, focused more on the strategy.

Foresight recommended that the Canadian government develop a programme that will encourage Canadian companies to engage in appropriate nano-nutraceutical research and commercialization. If the objective is to encourage companies to do this kind of research, CI would may ask two questions:

1. Are Canadian companies willing to engage in this kind of research? (interest and capacity);
2. What incentive will they require to engage in this kind of activity? For example, a loan guarantee? If so, at what percentage? A tax credit? If so, at what level? Grant programme?

In general, the aim of this type of government research assistance programme is to encourage companies to change their R&D behaviour to match the government's desires. How do you get a company to change its behaviour? There are many analytical techniques in CI (see [*Fleisher, Bensoussan*, 2002] for a description of some of the more popular ones). For a question like this, CI turns to a technique called profiling which involves putting together a detailed psychological based assessment of the target. Profiling seeks to determine how the target will most likely react. In understanding the target, profiling is also able to find out what someone has to do to get the designated reaction from the target. A competitive intelligence profiler would seek to develop detailed profiles on the companies that would be likely to adopt the government's research programme. The profiler would be looking for information about the company's research decisions, including what drives these decisions and the target's risk orientation. The profile needs to be designed to determine both potential companies' interest in doing nano-nutraceutical research and the kinds of incentives that would encourage a company to make this decision. Most of the information required for this kind of profiling should be readily available to the government. For example, the companies being profiled may have already applied for programmes, and associations may have presented reports and recommendations to the government. Other ways of getting information include examining past programmes, checking programme files, and having discussions with programme officers who oversaw the programme.

Table 3 (intelligence analytical techniques) lays out many of the more popular competitive CI analytical techniques. Most of these come under the category of strategic analysis and environmental analysis. The reason that environmental and strategic analysis techniques are so popular is they get at the heart of what decision makers need to know: is the market profitable and what does the company need to do to capture those profits. Therefore, a CI practitioner will want to do a market profile. Table 3 also lists some evolutionary techniques that look at technology direction within an industry. These are important because the CI officer of a company wants to ensure that the kind of research encouraged in that company is appropriate for the future environment. If it takes five years for companies to conduct the research and get something ready for commercialization, then the CI practitioner will seek to understand where the company is likely to be in the next five years and in which direction the industry is heading. Another question the CI practitioner looks at is what their company's competitors are likely to do over the next five or more years (it is unlikely, for example, that they will still be developing and using today's technology for five or more years).

One of the more popular techniques used for this purpose is called timelining. Competitive intelligence realized long ago that there were logical sequences to any major shift in a marketplace. For example, long before a new technology hits the market there had to have been manufacturing activity — and before that, testing, research, and so forth. Each of these sequenced steps leaves information that those interested can view. For example, research activities are accompanied by patents and sometimes poster sessions at conferences. It is no wonder that several companies have told employees that when they see someone new at a trade show, they should inform the management. The new player could be a potential customer, competitor, or supplier who wants to learn about the industry.

Similarly, techniques such as science mapping have been developed to look at what research communities are coming together to better predict the direction of research. While projecting 10 years out is very difficult, timelining makes things a little more certain by looking at what activities have already been done. The idea here is to identify what is currently happening in the industry at a global level and place it on the timeline. The information is taken from secondary sources such as magazines and various online databases, yet is also more commonly found by attending industry events. Event intelligence is a growing discipline within CI and involves collecting data at conferences, tradeshows, workshops, and other events to gather this kind of information. Using event intelligence, it should be relatively straightforward to identify how fast and transformative science currently is, and where various companies are positioned on the timeline. Take, for example, the following quote from *Forbes* magazine:

'*Nestle may also be exploring nutraceuticals in the form of nano-capsules that deliver nutrients and antioxidants to specific parts of the body at specific times. The technology turns previously insoluble nutrients into nano-sized particles that can be released into the body and properly absorbed, with big potential benefits for a whole new kind of health food.*' [*Wolfe*, 2005].

Clearly the company Nestle is well along the development curve. If this is where they potentially were in 2005, the CI officer will use timelining to project where Nestle is likely to be in 2014. Based on this prediction, the CI officer can assess the likely state of Nestle's research and commercial offerings in 2020 (the targeted commercialization period envisioned by the programme). Whatever focus within nano-nutraceuticals that the programme will have, the programme should lead to a better result in products that are technologically as advanced or even more so than the products of Nestle and others that will be on the market.

Having completed the analytical techniques mentioned in this section, the CI professional is now ready to make specific programme recommendations. Knowing the profile of targeted companies including these companies' risk orientation, the analysts can make incentive recommendations. With the market analysis, they can further refine the incentive. For example, if the market is growing and profitable, a lower incentive rate should be made. If the target companies are highly risk averse and the opportunity is more distant, a larger incentive would be recommended. In the hypothetical case with nano-nutraceutical research that we study in this article, nano-nutraceutical research takes a long time and has much regulatory uncertainty around it. This same field of research has widespread concerns about consumer acceptance of nano-nutraceuticals. Hence, in these sorts of situations, a higher incentive will be required. Consistent with the market and profiles, a recommendation of a grant or cash based incentive would be made. To some, a tax credit is more appealing than getting a grant or cash when levels of risk are higher. Finally, the science mapping and timelining should provide the government with the CI needed to further target incentives to those areas of nano-nutraceuticals that provide better opportunities for Canadian companies.

Business Analytics

Business analytics is in vogue as a buzz word for the use of data to inform decision making in organizations [*Davenport et al.*, 2010]. In its Big Data incarnation, it is tied closely to the use of data mining techniques to analyse large complex data sets that might provide insights if mined properly. In reality, business analytics has been used in organizations for many years and hundreds of different techniques are available — all focused on optimizing one or more organizational outcomes. Ford Motor Corporation, for example, applied the basic notion of business analytics in 1914 when Henry Ford decided to more than double employee wages. Conventional wisdom assumes that increasing the cost of production will lead to higher prices and reduced demand. Ford, however, noted an increase in demand by approximately 60% between 1914 and 1916, while prices dropped by 33% during the same time period. The sound application of business analytics enables managers to glean insights that might not be immediately obvious.

Analytic techniques might be categorized into three main types: 'describe, prescribe and predict.' Many organizations, in both the private and public sectors, are very good at descriptive analytics: charts and graphs about organizational phenomena such as how many companies took advantage of a government sponsored research credit programme, the location of companies, the amount of funds leveraged etc. Most organizations, however, are less capable of prescriptive analytics which could, for example, identify how best to allocate funds in order to optimize a certain organizational objective.

Predictive analytics has become the 'holy grail' of analytics. It is being used in some organizations. One of the most mature areas is credit risk where, by analyzing characteristics such as a borrower's past behaviour or income flows, it is possible to get accurate predictions about the likelihood of default. In policy development, the notion of 'evidence-based policy' is founded on the idea of predicting the likely impact of policy interventions. At the moment, these predictions are subjective estimations. As we will discuss below, however, much is being done to better use data to make policy decisions.

Business analytics in government

Government organizations worldwide have embraced the notion of analytics. Well-established applications of analytics in government organizations include passenger screening and tracking of aircraft in the security field, and the use of crime analytics to detect and ultimately prevent crime [IBM, 2013]. While the US appears to be ahead of many countries in applying analytics to the business of government, other countries such as Korea, Japan and Singapore have adopted risk assessment analytic approaches, intelligent traffic systems, and analytics driven monitoring systems to help anticipate and prevent occurrences such as epidemics and famine.

How does business analytics play into the scenario discussed above? If a policy initiative is to encourage businesses to invest in nano-nutraceuticals, a variety of analytic techniques can be used to anticipate the actual take-up of the provisions of the policy. Now, we will discuss two relatively simple techniques to illustrate how foresight, competitive intelligence, and business analytics can be integrated within the context of national policies.

Two aspects deserve consideration: the estimation of the expected value of the policy and the evaluation of the likelihood that participants who are expected to avail themselves of the policy will behave in ways that will provide the expected value.

Econometric models are typically used to estimate the social and economic benefits to be derived from a policy. These models, however, rely on data gathered from stakeholders related to the policy environment. One relatively new approach to gathering data is 'sentiment analysis.' This approach, based on the analysis of qualitative information appearing on millions of websites and blogs from the intended audience, helps to identify opinions related to the outcomes promoted by the policy. In addition to forecasting techniques such as scenario planning and roadmaps, sentiment analysis can provide guidance as to the attitudes prevalent in a particular population. It can be used for example, to predict the expected take-up of the policy's provisions. Assuming that expected policy outcomes include the launch of businesses developing nano-nutraceutical products, the analysis of consumer sentiment can provide clues about potential customer acceptance.

Two categories of analytics can be applied. Descriptive analytics would outline the percentage of posts that are positive or negative related to the policy in question. Based on this data, predictive analytics — using 'Big-Data' techniques such as clustering for example — can separate the population that is posting about the policy into different groups based on characteristics such as age or geographic location. Based on this grouping, different simulations can be developed to anticipate the likely reaction based on changes to certain aspects of the policy. Figure 1 illustrates these ideas.

Dark blue icons represent those opposed to the policy, while green icons represent people who support it (Figure 1). The graph shows a clustering by age and geographic categories. In this case, it indicates that aspects of the policy needs to be tweaked to better appeal to younger people in location A. Depending on the information available about people in the various cells (younger, older, location A, location B), data mining tools can be used to predict whether such policy changes are likely to appeal to each of the cells in the graph.

Using such predictive concepts, government policy makers can anticipate how the businesses they expect to participate in the initiative will respond. For example, intelligence through profiling may identify 40% as the likely rate for the grant programme based on looking at past programmes and company profiles. In contrast, analytics will refine this prediction by developing algorithms to look at the risks associated with the research and the companies' risk attitudes.

With this information in hand, we can go one step further and simulate the decision process used by *businesses* who might take advantage of the programme. Businesses typically invest in new products in order to make a profit. Investment decisions can be quantified through the use of a variety of analytic models, one being the 'net present value' (NPV) calculation. This approach discounts future expected cash flows of an initial investment to estimate potential returns. The calculation is as follows:

$$[\Sigma_t \mathit{Cashflow}_t / (1+i)^t] - \mathit{Investment}, \quad (1)$$

Where i = expected discount rate during the time period and t = number of compounding periods.

As a greatly simplified example, suppose the business would need to borrow 500,000 USD for the investment at 7% interest rate to be paid in full after three years. Using the left side of equation 1, the company estimates cash flows for the first three years after full production of approximately 600,000 USD. The future value of the loan (adding the 7% interest compounded over three years) is approximately 612,000 USD. Therefore, the company would likely not make the investment.

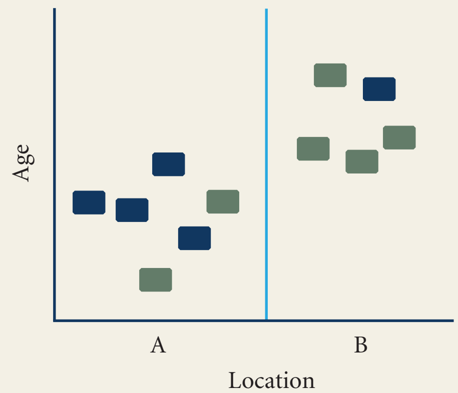
With a government programme providing a guarantee for the funds borrowed, assume the interest rate is reduced to 3%. The future value of the loan is now approximately $546,000. The decision rule for NPV calculations is to invest in projects with a positive cash flow; therefore at 3% the investment will likely be made.

Ultimately, using approaches such as that described above to simulate a business' decision model can help policy makers better predict uptake and more accurately define the parameters of a policy.

Analytics conclusion

A wealth of tools and techniques are available to policy analysts who would like to predict the likely outcomes of a policy. Data scientists, given the right type of data and data that is well-organized, can analyse and predict likely outcomes [*Provost, Fawcett*, 2013]. This capability will enable policy analysts to uniquely fine tune policies to improve the chances of realizing the results expected. As the technology available for Business Analytics improves and the techniques available to data scientists evolve, more government organizations will make use of such tools to monitor and manage operational activities. Applying such

Figure 1. **Clustering of responses by age and geography**



Source: compiled by the authors.

empirically-based predictive approaches to policy initiatives is still in its infancy but the opportunities are quite compelling.

The Combined Approach

Foresight and Competitive Intelligence offer a collection of methodologies including primary and secondary data collection approaches, facilitation methods, a variety of robust analytical methods, an ability to work with qualitative information, and a clear focus on understanding the external environment.

Business Analytics contributes modeling capabilities, methods for dealing with massive amounts of quantitative data, emerging text analysis software for qualitative data, a variety of proven internal indicators that have been used for dashboards, and a rich history of primarily internal organizational analysis with a growing literature on customer analysis.

All three domains (foresight, competitive intelligence and business analytics) are used to provide decision making support and have complementary analytical techniques that allow the decision maker to better understand the external environment including key stakeholders. The combination of the three approaches is also useful for reducing the risk of designing a flawed programme. Omitting any one of these approaches increases the risk of programme failure as the programme developer would be missing out on what could be a critical analytical component needed for the design of the programme.

Combining the three approaches is starting to appear in some government programmes. For example, in 2011 the United States government started a defence programme called FUSE (Foresight and Understanding from Scientific Exposition). The programme funds the development of 'automated methods that aid in the systematic, continuous, and comprehensive assessment of technical emergence using information found in published scientific, technical, and patent literature' [Office of the Director of National Intelligence, 2014]. Specific research areas include text analytics, knowledge discovery, big data, social network analysis, natural language processing, forecasting, and machine learning. According to [*Smalla et al.*, 2014] the programme has a clear link with competitive technical intelligence. The techniques referenced and the automated analysis intent fall within the domain of business analytics but the intent is to create foresight-based conclusions. This is a good example of the techniques from business analytics and competitive intelligence being needed for foresight purposes. In this example, combining the domains is crucial as each has unique analytical approaches that are necessary for getting the bigger picture.

Developing the dashboard and monitoring mechanisms

The purpose of a programme/policy dashboard is to give early warning of necessary changes based on external environment signals. Table 4 is a fictitious example of a dashboard for the hypothetical nutraceuticals programme we have outlined earlier in this article. The initial design was based on long-term analysis through foresight, short and medium-term analysis through competitive intelligence, and further refinement through analytics. Ultimately, however, these techniques were used to reduce programme risks and not eliminate them. Accordingly, the idea of a programme dashboard is to monitor the environment on an ongoing basis for three reasons:

1. To check if we were correct in our analysis of the potential programme users and that the programme is being used as envisioned in the programme designed by the appropriate users and for the appropriate technology development;
2. To verify that we were correct in our analysis of the nano-nutraceuticals market and that the underlying profitability, technology developments and so forth are consistent with what was assessed in the initial analysis. In addition, we want to check that the timeline projected for the industry also hold.
3. To ensure that the longer term scenario and roadmap projected for the programme design also holds.

A change in any of these could result in the programme not attaining its desired outcomes. Finding out about changes in any of these early enough can lead to programme changes that will improve its effectiveness or stop the programme if it is not meeting its objectives.

Table 4. **Dashboard for the nano-nutraceutical programme**

	Stages of implementation		
	1	2	3
Early Outcomes			
Advice and counselling			
Inquiries			
Applications			
Intermediate Outcomes			
R&D activity			
University and college training programmes			
Business clusters formation			
Patenting			
Requests for commercialization funding			
Long-Term and Environmental Factors			
Sentiment Indicators-Business			
Sentiment Indicators-Consumers			
Technology watch			
Grey literature development			
Timeline and roadmap milestones			
Roadmap and scenario monitoring			

Source: compiled by the authors.

Developing the programme dashboard and its ensuing key performance indicators (what needs to be monitored) starts with competitive intelligence and timelining. In this case, the programme developer needs to look at all the activities (and activity measurements) between announcing the programme and the final outcome, successful commercialized products and jobs. Based on our experiences with government programmes, these are the activities that are embedded in the timeline:

1. *Programme inquiries.* Once a programme is announced and before the application process opens, it is normal for companies to ask local government officers for more information about the programme, advice and counselling on applying for the programme.
2. *Applications / proposals.* Normally, several months after the programme is announced and after enquiries, companies submit applications.

At this early stage, the first two steps as identified in a competitive intelligence timeline exercise can be put on a dashboard and monitored. For example, for a technical programme in Canada it would be expected that inquiries would be made to the National Research Council officer, to Canadian Business Service centres, and in the case of some regions of Canada, to regional development officers. As part of the dashboard exercise, these individuals could be asked to enter the emails received about the programme and summaries of conversations into a database. These could be analysed using content analytics software. Applications/proposals when received can be subject to content assessment. Software could be used to look at the kind of development proposed (is it what the programme envisioned?) Analysis could also be done on whether the number of applications meets the desired level, and where the applications are coming from (regional distribution, type of companies, etc). At this stage of the programme, problems identified through the analysis of dashboard data could be investigated and the programme could be modified accordingly. Perhaps the programme is not being advertised properly (a problem we have seen before) or perhaps the incentives provided are not significant enough to encourage the desired kinds of research. We have also seen situations where the incentive was appropriate but there was no interest in doing research in the area targeted by the programme. This part of the dashboard focuses on validating and monitoring the company profiles.

In the dashboard (Table 4), the colour represents the extent to which the environmental element being measured meets the initial projections and needs of the programmes. Green would mean it is consistent with initial estimates and expectations, yellow slightly off (caution), and red would be significantly off or cannot be measured yet. In this example, early stakeholder questions and interest were initially as required by the programme (signified by green) in period 1 and period 2. Yet, in the third period it had turned yellow (caution) meaning that it is going off requirements either on a regional basis or type of questions (this would need to be investigated and if needed would signify the need for programme corrections). Advice and counselling initially started in the yellow (caution zone) but moved to green in the second and third measurement periods, Assuming the right companies are asking the correct questions and applying for funds to develop the targeted technologies for commercialization, what comes next in the timeline? What gets measured and put on the dashboard next? In this simplified example, alongside with the abovementioned ones, further intermediary steps include:

3. *R&D activity*. Next should be hiring activities and R&D;
4. *University/college training programmes.* If this is a new area of research, appropriate labour availability should be an issue thus there should be development of training programmes to support the companies' demands. Without the appropriate labour, the development and commercialization activities cannot occur;
5. *Business clusters formation;*
6. *Patenting;*
7. *Requests for funding for commercialization.*

All the activities in the intermediate outcomes are needed for the final outcomes of the programme to be realized.

The final item to place on the dashboard is monitoring of the external environment in terms of the underlying profitability, demand, interest, and all the factors examined in our earlier analysis. This concerns monitoring the factors that underlie the strategic, environmental, and evolutionary analyses. Environments do change and with it the rationale for the initial programme. A few of the items that could be on the dashboard include:

- *Sentiment indicators — Business.* This is an analytics approach assessing social media data for signs that interest from companies in the targeted areas is growing during the programme's duration;
- *Sentiment indicators — Consumers.* This is an analytics assignment assessing social media for signs that consumers' interest in the targeted areas (level 1 and 2 nano-pharmaceuticals) is growing during the programme's duration. Biofoods encountered a serious blow when consumer concerns dominated discussions;
- *Technology watch, grey literature analysis, timeline and roadmap milestones.* Governments need an ongoing technology watch programme, including grey literature analysis to examine if there are unexpected developments. For example, another country might have developed disruptive technology in the area or might have invested a lot of resources to move the technology forward at an accelerated rate. These kinds of developments need to be watched;
- *Roadmap and scenario monitoring.* Similar to timeline and roadmap milestones, these would need to be an ongoing effort to watch for signs of which scenario was emerging and whether the milestones are being met (or not) on the roadmaps.

Information for the dashboard is generally readily available. The information required for the sentiment analysis could come from social media as well as assessments of emails sent to the government agencies about their programmes. Grey literature analysis is well developed as an analytical discipline and appropriate databases would need to be accessed (all open source, public databases). Technology watch, timeline, roadmap, scenario etc. information would be gathered from several sources including:

- *Ongoing foresight and competitive intelligence projects.* The government could run Delphi's on an ongoing basis to test the longer term assumptions and commission additional competitive intelligence projects;
- *Organized data collection at conferences and trade shows.* For example, the Bio trade show would have workshops, booths, presentations and participants with the appropriate knowledge of developments in nano-nutraceuticals.

Conclusions

As mentioned at the start of this article, industrial policy is fraught with uncertainty due to its reliance on external environmental elements for its success. Foresight, competitive intelligence and business analytics taken together provide a toolkit to better understand this uncertainty and can help lead to more successful industrial policy. Foresight and Competitive Intelligence — focused on their external environment — provide the tools to understand the direction in which markets are heading, profile local industry to determine what policy instruments can be most effective, and better understand how technology might evolve. Signals picked up today through an externally focused competitive intelligence effort can be used to confirm conclusions reached in longer term foresight initiatives such as scenarios, roadmaps and scans, thereby providing the information needed to establish the long-term industrial policy required by science and technology related industries. F

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