Chapter 19
(Research): Innovations in the Arctic: Special Nature, Factors, and Mechanisms

Nadezhda Zamyatina and Alexander Pilyasov

Abstract Arctic innovations are considered in a broad context – as a way of life in northern communities with omnipresent technological, economic and social implications. Consideration of innovations reveals a gap in modern research in the social sciences between the numerous works on innovation in large urban agglomerations and the almost complete absence of efforts to study innovation in the world periphery, including the Arctic. Major features of the human dimension of the innovation process in the Arctic are: (a) prominent position of the individual Schumpeterian-type entrepreneur-innovator, the creative destroyer, whose role and meaning is visible, tangible and concrete; (b) unprecedented role of local knowledge and competencies, which are based on the extremely specific natural and economic conditions of the Arctic; and (c) extreme unevenness in the concentration of talents in space and time that are explained by resource development cycles. As an outcome, six types of innovation systems (IS) are revealed in the global Arctic: (1) IS of multifunctional urban centers; (2) Network IS in the old-developed resource and coastal regions; (3) IS of base city-islands in old-developed resource regions; (4) IS of areas of modern pioneer development (frontier IS); (5) "Privileged" IS of island capitals; (6) West Siberian ISs as a network of resource urban centers. The fundamental specificity of the Arctic innovations stems from differences across developed regions in actors, networks and institutions.

19.1 Introduction

Traditionally, innovations in the Arctic were considered very narrowly as a technological phenomenon that provides the saving of expensive labor costs in the interests of production efficiency (Matveev, 2011). The scientific literature discussed innovative solutions in life support systems (heat and energy supply, food security, etc.) in the Arctic (Pilyasov & Yadryshnikov, 1997). However, innovation has never been

N. Zamyatina (✉) · A. Pilyasov
Lomonosov Moscow state University, Moscow, Russia

P. A. Berkman et al. (eds.), *Building Common Interests in the Arctic Ocean with Global Inclusion, Volume 2*, Informed Decisionmaking for Sustainability,
https://doi.org/10.1007/978-3-030-89312-5_19

considered in a broad context – as a way of life in northern communities, as an «omnipresent» technological, economic and social phenomenon. It seems that the time has come to take a look at Arctic innovations in such a broad, and not technological, but social way of changing the internal foundations of human life.

Unlike many other polar territories, which are closer in terms of socio-economic development to the "mainland" parts of their countries, the Russian Arctic is more specific and more different in terms of the course of the innovation process from the zone of main settlement. In addition, in the Russian Arctic there are many regions, the natural and economic conditions of which are also internally very different from each other, producing a continuum of situations in the deployment of the innovation process in the Arctic periphery. All this makes the study of Arctic innovations and the innovation system here interesting not only for Russia, but for the entire Arctic world.

Arctic innovations are not just an extention to the Arctic of those innovations that were previously spread in densely developed regions of the country, adjusted for the natural extremity and transport remoteness of these polar territories. No, this is an absolutely special holistic phenomenon that needs to be separated from the rest, and not understood as just an extreme, ultimate form of well-studied and well-known phenomena of the more southern regions of the country's main settlement zone.

Currently, innovation processes in the Russian Arctic are multidirectional in nature. On the one hand, the accelerated development of the Arctic means the intensification of contradictions between new technologies and established social institutions and spatial structures of socio-economic systems, such as systems of resettlement and distribution of productive forces, territorial structures of the economy. On the other hand, it is the Russian Arctic that is often ahead of other regions of the country in the development of innovations that facilitate the solution of the most acute problems of socio-economic development of the Arctic (such as remoteness and a rare transport network and a sparse network of settlements). Here, the population and entrepreneurs are more active users of e-commerce, Internet search of business partners, communication capabilities of social media (Pilyasov, 2018).

The task of studying Arctic innovations as an absolutely separate, specific phenomenon has determined the organization of this chapter. In the first section, the authors state a gap in modern research in the social sciences between the numerous works on innovation in large urban agglomerations and the almost complete absence of efforts to study innovation in the world periphery, including the Arctic. The next section attempts to answer the question: what is the phenomenon of Arctic innovation itself? In the third section, specific examples are used to describe the most common mechanisms of innovative development in the Russian Arctic. In the fourth section, an attempt is made to take a holistic view of the phenomenon of Arctic innovations from the perspective of the concept of a peripheral innovation system and its major types. In contemporary conditions of a dynamic and turbulent Arctic, this system is an important mechanism to guarantee resilience for these peculiar and specific territories of the world through informed decisionmaking processes, science diplomacy, and harmonization of multi-actor

interests. Finally, the last section provides an answer to the question: how can Arctic innovations be of interest to the rest of the world?

19.2 The Concept of the Geography of Innovations and the Russian Arctic: The Current Gap and Problem Statement

Research on the geography of innovation started in the early 1990s, and it is necessary to note the breakthrough of Maryann Feldman, who introduced the term. In 1994, her pioneer monograph on this subject appeared (Feldman, 1994). Gradually, through the efforts of a large army of researchers, innovations themselves began to be understood much more broadly than traditional technological, production innovations, which were recognized in the industrial era. The interpretation of innovations as a social phenomenon, which depends on the personality of their creator (even, one might say, his biography), on the type of his communication (how wide?), on the institutional environment, and on the historical and cultural context in which it develops, has gradually begun to take hold. And this social phenomenon depends upon all kinds of proximity (spatial, social, organizational, institutional, and cognitive) identified by Boschma (2005).

The talented works of M. Feldman, R. Boschma, R. Florida (Florida, 2008), B. Asheim (Asheim & Gertler, 2005), D. Audretsch (Feldman & Audretsch, 1999) and others were concentrated mainly on large-scale urban areas of high density communications, with excellent infrastructural equipment, with the strong development of knowledge-intensive business services and creative class. In Russia, interesting work in this direction in recent years has been carried out by our colleagues, economic geographers and regional economists V. Baburin (Baburin & Zemtsov, 2017), S. Zemtsov (Zemtsov et al., 2016), E. Kutsenko, and others.

The breakthrough in the development of the topic of the geography of innovations did not affect the sparsely populated and low-density spaces of the world, including the Arctic zone. Powerful and broad research studies of the anatomy of the innovation process, dominating in the developed regions, have stopped at the Arctic's borders.

At the same time, within the Arctic itself there were very interesting studies, but modest and narrow in their design: for example, on the influence of a snowmobile technological revolution on the traditional way of life of small Indigenous peoples of the North (Pelto, 1987; Stammler, 2009), on the topic of "smart specialization" in the Arctic (Healy, 2017), on the patent activity in the State of Alaska (Zbeed & Petrov, 2017), and on the metrics of creative capital in the cities and towns of the Canadian North and Alaska's regions (Petrov, 2008, 2011).

A gap is evident between, on the one hand, the accumulated potential for studying the geography of innovations as a collective social process in densely developed and large urban areas of the European Union, the USA, and Russia and, on the other

hand, limited studies in the Arctic, either too narrow or, on the contrary, too general, not reflecting the fundamental features of the Arctic zone. There is a need to link the local, micro-analytical and the national levels in understanding the innovation process in the Arctic: to use the achievements of the school of geography of innovations and apply them creatively to the realities of the Arctic.

19.3 The Special Nature of Arctic Innovation

Summarizing the numerous works of our foreign colleagues in the geography of innovations and our own 35 years of experience in researching economic and social processes in the circumpolar North and in the Arctic of Russia, let us formulate ideas about the phenomenon of Arctic innovations by comparing the Arctic and the "mainland". Significant differences of the Arctic in the innovation process from the territories of the temperate zone are clearly grasped through three slices: key actors; features of the urban settlement system; the nature of knowledge, information exchanges and learning (Table 19.1).

The Arctic as a whole is more "corporate" territory in Russia in the sense of a stronger presence in its economy of large resource corporations of global or national scale. Arctic corporations are the most important generator of production innovations, which include new technologies for the development of mining projects, new growth "poles"/greenfield projects (resource extraction facilities, new elements of the settlement system like shift camps), as well as brownfield projects of technological modernization of old mining enterprises. Given the production nature of a typical Arctic economy, these production innovations often set the context and lead the other (ICT, life-supporting) innovations. For example, corporate winter roads can serve as communication and life-supporting innovations which can be used for transportation and life support for the population of the entire village closest to the mining field.

Do actors change at different stages of the innovation process? Initially, at the search stage, its key actors are individual innovative entrepreneurs, completely independent loners, or part of a small venture firm, or integrated into large state or corporate super-organizations (Pilyasov, 1993). Very quickly, at the stage of pioneering development, they are replaced by subdivisions of global or national resource corporations, public or private. There is no other way to solve the costly tasks of developing a new production project or a new resource territory in the Arctic.

Big corporations also dominate at the next stage of rapid production growth, which provides companies with economies of scale without which they simply cannot exist. But the same economies of scale will kill incentives for innovation in prospecting and production further.

The subsequent inevitable decline in production again strengthens the interest of companies in innovation, but at the same time the innovation process itself is significantly diversifying, and small and medium-sized businesses in exploration,

Table 19.1 Differences between Arctic innovations and «mainland» innovation

Features	Arctic	«Mainland»
Key actors of innovation process	Resource corporations, entrepreneurs, including Indigenous	SME, corporations, state, NGOs etc.
Agglomeration effect	Weak or absent	Strong
Externalities	Narrow specialization	Urban diversity
Type of knowledge	DUI synthetic	STI, DUI[a] analytical, synthetic, symbol
Circulation of knowledge+	Temporary geographical proximity	Constant geographic proximity
Circulation of knowledge -	Closed corporate loop	Fragmentation, distrust of actors
Barriers for absorptive capacity	Overspecialization lock-in	Cognitive lock-in from path-dependency
The main way to "acquire" knowledge	Exploration and search	R&D
The main sources of new knowledge	External networks, tacit knowledge	Internal networks, formal knowledge
The flow of knowledge: Forms	Employee mobility, Internet publications, electronic forums	Spin-offs, cooperation with other actors (suppliers, consumers, competitors)
Learning process	Learning by doing, by experiencing	Retraining courses, formal training
Research subsystem	Interdisciplinary expeditions, experimentation	Universities, research institutes, academic laboratories, etc.
Operational subsystem (dominant local production system)	Mining industry	Manufacturing industry
Key industrial contracts	Vertical (mining, processing, marketing)	Horizontal (subcontracting, etc.)
Source of innovation	Combination of activities, interdisciplinarity, interchange and integration of competences	Division of labor and competencies, micro-specialization

[a]*STI* Science, Technology and Innovation, *DUI* Doing, Using and Interacting mode (Asheim et al., 2019)

production and production services become its participants (along with the R&D divisions of companies). Later on, under the pressure of depletion, the innovation process becomes even more radical - gradual production innovations are replaced by revolutionary ones and the local innovation system itself is reborn from a purely sectoral, corporate one into a territorial one, with simultaneous diversification through the active development of social, life-supporting, service innovations which existed before, but were strictly subordinated to the interests of the main resource-extracting industry.

An intense innovation search at the stage of depletion, in which the structures of small and medium-sized businesses are actively involved, can give rise to a new

cycle of economic development of new natural resources or new regions, with the repetition of the indicated patterns of the innovation process.

The type of natural resource significantly concretizes the described scheme (Kryukov, 1998), determines the dynamics of the innovation process and the involvement of various actors, such as large companies and small and medium-sized businesses, both in the mining industry itself and in the structure of knowledge-intensive business services. The rule applies: the more specific is the natural asset and material assets that are geared towards its extraction and transportation, the greater the load on the innovation system in ensuring the effective deployment of the entire resource chain from extraction to the sale of the final product.

Several features of the human dimension of the innovation process in the Arctic can be noted. First is the prominent position of the individual personality of the Schumpeterian entrepreneur-innovator, the creative destroyer, whose role and meaning is visible, tangible and concrete, as rarely happens in densely populated regions of the world.

It is much easier for such original people who are absolute crushers of indisputable truths to find support for their ideas and reach their implementation in the Arctic than anywhere else. The fact is that the conditions for competitive selection of ideas do not work here, so the chance that an adventurous idea will survive and become legitimate is much higher than anywhere else. Tolerance for innovative adventurism in the Arctic is greater than in densely developed areas. All this creates an excellent environment for the most daring and even adventurous experiments. One can call it «the open horizons for crazy ideas» effect.

Second is an unprecedented role of local knowledge and competencies, which are based on the extremely specific natural and economic conditions of the Arctic. Meanwhile, the ability to understand them sharply differs even among highly qualified personnel. Those of them who have the talent for quickly absorbing local tacit knowledge, are capable of making breakthroughs in the economic development of areas for new resource development in the Arctic.

Third is the extreme unevenness in the concentration of talents in space and time, which is explained by resource development cycles: at the exploration and pioneer stage, a unique concentration of talents arises in a new resource project, which then dissipates at the subsequent and more routine stages of rapid growth and stabilization of production and is rarely repeated at the stage of exhaustion and decline.

A researcher who compares the internal anatomy of the innovation process in the "mainland" and in the Arctic, associated with the nature of knowledge, its flows, is faced with a paradox. In the Arctic, new knowledge is generated not in laboratories, not owing to classical achievements of fundamental academic science, but during field expeditions, observations of the production process, and training in the process of field or stationary work. The role of concrete experience in Arctic knowledge generation and innovation is unprecedented.

And this Arctic knowledge often is not analytical, narrowly sharpened, professional knowledge of egg-headed cabinet scientists, but synthetic, engineering knowledge of Arctic practitioners and experts. In this knowledge, the tacit component that

is not fully formalized in books and textbooks is very strong, tied to an expert, a carrier of unique competencies and local "field" knowledge.

In full accordance with modern ideas about the innovation process (Asheim et al., 2019), the fundamental specificity of the Arctic stems from its differences from the developed regions in *actors, networks and institutions*: dominant corporate actors, the increased role of external networks, gatekeepers and institutions of temporal proximity in the circulation of knowledge, the dominant institutions of the mining and not manufacturing industries, which all have a multifaceted effect on the nature of knowledge and knowledge spillovers.

If for the "mainland" the research laboratory is the classical birthplace of innovation, the field geological expedition can serve as such a standard image for the Arctic. In such expeditions, all the Arctic specific features of actors, networks and institutions of the innovation process are fully reflected. And the "customer", which drives the demand for geological discovery, is a resource corporation.

19.4 Specific Arctic Mechanisms of Innovative Development

In order to come to terms with the special Arctic mechanisms of innovative development that are not like the mainland, the researcher is reminded of "Alice through the Looking Glass": "You don't know how to manage Looking-glass cakes," the Unicorn remarked. "Hand it round first, and cut it afterwards" (Carroll, 1973).

A powerful mechanism for innovative development in the Arctic is the process of developing a new frontier itself. The frontier is a well-known phenomenon from the history of the United States. Among other features, the frontier went down in history as a generator of political and social, technological and technical innovation. It is believed that it was on the frontier that many innovations were born that eventually determined the national character of Americans (Burstin, 1958).

The innovative potential of the frontier was determined by a rare combination of two factors. On the one hand, the development of new territories required solving many problems arising from the specifics of the new territory: new soils, new social composition, etc. On the other hand, the rapid involvement of large amounts of resources in the economic turnover made it possible to achieve the effect of increasing returns and high profits. Profits delivered sufficient financial resources for the pilot implementation of innovations. The frontier was a true innovation laboratory, where new solutions were not only invented, but immediately tested, and if successful, achieved mass distribution.

In modern conditions, the front-line mechanism of innovative development, tied to the pioneering development of Arctic resources, became manifest when a new Yamal-LNG project was deployed in the shift camp of Sabetta in the north of the Yamal-Nenets autonomous okrug. The pilot project receives the special status of an experimental initiative (as earlier in Soviet times, the status of the all-national –

"vsesoyusnaya" or "vserossiyskaya"- construction) and special tax regimes for its deployment, which subsequent projects of a similar nature do not have.

The economy of developed territories is the economy of large numbers, large quantities, sometimes even overpopulation with ultrahigh density. Therefore, the innovative mechanism here is more reminiscent of the laws of evolution according to Darwin: competition, selection of the most viable option and its consolidation in the course of subsequent development.

On the other hand, the economy of the Arctic is an economy of small numbers, insufficient density and frequent interruptions, developmental delays and even "extinctions" and then "re-development". In conditions of small quantities, an innovative mechanism is formed from a creative reassembly of a few familiar elements in a new unexpected way. And the realities of the catastrophe economy in the form of frequent abandonment of former economic sites lead to the increased importance of pioneer development from scratch, the high role of radical, rather than gradual, innovations. This is not continuous evolution, but discrete catastrophism, which is the "fuel" for Arctic innovation.

Often, innovations in the Arctic are launched in the course of force majeure temporary abandonment of the principle of division of labor and, conversely, the combination of functions caused by a shortage of workers and crisis. This frequently happens suddenly, but it is during these periods of forced combination of occupations, which were previously considered absolutely impossible and unacceptable, that many Arctic innovations arise (rather than simple local adoption of new innovations from outside).

19.5 Peripheral Innovation System

The deepening theoretical ideas on the specifics of the innovation process in remote and peripheral territories is critical to ensure that industrial and innovation policy is based on real knowledge of these territories, and does not routinely repeat theories that reflect the experience of the metropolitan regions but do not work on the periphery.

Summarizing the few works that have appeared in the last 10 years on innovations in the periphery (Ferrucci & Porcheddu, 2006; Virkkala, 2007; Petrov, 2011; Karlsen et al., 2011; Dawley, 2014; Isaksen & Karlsson, 2016; Asheim et al., 2019), allows us to identify their key features.

In these peripheral regions, as a rule, there are no opportunity for the full-blooded manifestation of economy on urbanization, the agglomeration effect, although these factors are the core of modern economic-geographical and regional-economic studies after the work of P. Krugman (Krugman, 1991), R. Florida (Florida, 2008) M. Fujita (Fujita & Krugman, 1999). But what arises here in place of this powerful effect?

Instead of permanent, stationary urban and economic agglomerations, in the remote territories of the Arctic and the North, there are temporary agglomerations

and mobile economic associations. We can call them temporary "poles of growth/development" in the terms of F. Perroux (Perroux, 1950). And these temporary concentrations of business entities are based on effects of temporal proximity, a concept that has been developed in recent years by the French school of proximity theory, headed by A. Torre (2008).

Another striking feature of peripheral innovation system is the small number of knowledge organizations, for example, structures of higher and secondary professional education, academic institutions. This defines a "thin" layer of local knowledge. Under these conditions, the knowledge potential of the global resource corporation, the local branches of TNCs with which local small businesses contract (Iammarino & McCann 2013), is of great importance. Resource corporations become agents of new technologies in remote areas, industrial innovations determine the technological path of the territories where they are located (Dosi, 1982).

The projects they implement for new resource development through subcontracting procedures and tight interaction with local small businesses, can have a profound effect on the formation of a local innovation system. One can compare this role with the role of universities and other higher and vocational education institutions in the central regions. Therefore, the creation of a modern theory of the peripheral innovation system without strong integration with the modern theory of TNCs is impossible.

The small number of organizations carrying new knowledge is combined in remote areas with the enormous importance of state support for institutions in the innovation process. The role of such support is significantly higher than it is in the central regions. The state acts here as the main force capable of reducing the information costs of uncertainty for all actors. The dependence of the innovation system on state support measures, on political initiatives, on budget investments (in conditions of weak market forces) is unprecedentedly great here.

But this support itself should be specific. The fact is that modern researchers distinguish between industries and firms with different innovative "modes." Some give rise to innovations according to the "science-technology-innovation" algorithm, others according to the "doing-utilizing-interacting" algorithm. The first relies on the institutions of fundamental science and the implementation of their advanced achievements. It is clear that this is the reality of central, but not peripheral regions.

On the other hand, the second mode is more typical for the remote mining regions of the Arctic and the North. Here many competencies are acquired right in the process. Researchers note that in remote areas a compromise is also possible when the company integrates knowledge from various sources in its innovative projects, on the one hand, based on the achievements of fundamental science, and on the other hand, on its practical experience. Sectors and firms that are subject to different innovation regimes need different types of support in the form of institutions, knowledge and other infrastructure of the regional innovation system.

Inside peripheral innovation systems, interfirm and spatial flows of knowledge are usually weak for the simple reason of the lack of diverse knowledge here. Those types of knowledge that are usually readily accessible "on the side" to firms in large

urban centers are not available to neighbors here. There are no knowledge spill-overs nearby.

That is why firms on the periphery are often forced to "internalize" various types of knowledge (e.g. Surgutneftegas does this). The desire to reach a high level of self-sufficiency in technical and engineering, geological and other knowledge among TNCs in the peripheral regions is connected precisely with the fact that it is not possible to find these competencies in local labor markets nearby. This causes the desire of the company to ensure the stability of its qualified and competent personnel.

Another strategy for acquiring knowledge is the entry of firms from peripheral regions into geographically wide networks with external partners. Weak links of peripheral innovation systems with their own sources of new knowledge makes it natural to turn to external sources. Using the expression from a popular scientific article, we can say that in the peripheral regions there is little *buzz*, but a lot of knowledge from *global pipelines* (Bathelt et al., 2004).

Even for those firms that habitually rely on their internal knowledge, it is critical to have networks of external partners, suppliers of new knowledge.

Studies show that ceteris paribus, large and small peripheral firms are indeed more likely to enter into contractual relations with distant (global) partners and are generally more inclined to cooperate than firms in central regions. It is as if they themselves are aware of their information, knowledge vulnerability.

You could even say that each peripheral company should have its own strategy of "sucking in" external knowledge and forming for these purposes temporary and permanent partner networks for familiarization with global knowledge flows. The effectiveness of familiarization with external channels of knowledge depends on the "absorptive capacity" of the company on the periphery, which, in turn, depends on the hiring of educated and competent people. Their presence strengthens the firm's ability to extract external knowledge, mix it with its own and commercialize it.

The features of a particular periphery form specific conditions for attracting new knowledge in some case through labor migration, in others through internships and business trips of its full-time employees, and in others through master classes by world-class professionals. The work of our foreign colleagues describes how on the periphery local "islands" of innovation can arise due to the migration of prominent ("star") scientists (Trippl, 2013).

But how can we identify the model of a peripheral innovation system in practice? The realities of the mono-resource Arctic regions of Russia give us such an opportunity. According to the canonical representations of this concept, this system consists of two subsystems: research and operational production. New knowledge is generated in the first, and it is commercialized in the second in the interests of the local economy and economic development. For the regions of the Arctic, this means that the first subsystem generates new geological knowledge about the mineral resources, fuel and energy resources of the territory (and this can happen in a variety of structures, for example, in the contour of a resource corporation, but, of course, not in the classic system of developed areas in universities or research laboratories).

The second subsystem uses this knowledge in the process of developing new deposits of natural resources discovered by the first subsystem.

So that the process is not interrupted, both systems must be in balance: the decrease in reserves of the first subsystem must not lag behind the repayment of reserves in the process of production by the second subsystem. The practice of the Soviet era shows that it was incredibly difficult to maintain this balance for a long time due to the natural laws of decreasing returns on natural assets from previously and long-discovered mineral deposits. The difficult and dynamic dialectics of the development of these two subsystems determine the overall effectiveness of the entire regional innovation system of a specific resource region of the Arctic.

Is it possible to identify different types of innovation systems in the global Arctic? Features of innovative development are always largely determined by the specifics of the space in which communication and knowledge flows between the actors of the innovation system take place. The properties of a particular space are determined by the characteristics of the settlement system, transport and communication connectivity of the territory.

The global Arctic with its exceptional variety of local options for transport and information accessibility, the presence and absence of the agglomeration effect and sharp changes in population density is a real encyclopedia of options for the development of the innovation process and the corresponding local innovation systems. An idea of this diversity can be obtained from Fig. 19.1 and Table 19.2.

This classification of innovation systems is based on the idea of the leading role of spatial factors in the development of Arctic innovations. As in the rest of the world, an important condition for the innovation process is the concentration of the population in urban agglomerations, but there are some peculiarities here: the largest urban agglomerations of the Arctic concentrate private and/or state structures that control economic processes over many thousand kilometers of the Arctic zone and therefore have similar functions as the global cities.

The presence of a city network simplifies the flow of knowledge between individual actors in the innovation process. But in some areas of the Arctic, cities are isolated from large national and interregional centers by thousands of kilometers. Under these conditions, remote small cities often assume functions that in the larger zones of settlement would be characteristic for much larger urban centers.

Given the remoteness and daily challenges of the harsh Arctic environment, many urban centers are forced to innovate. At the same time, in areas where there are no cities at all, the innovation process is concentrated in the activities of large resource corporations, and here it acquires a complex character, integrating logistics, technological and organizational innovations.

There are also unique cases that have no analogues in other parts of the world. These are relatively isolated administrative capitals in terms of transport (with a small adjacent territory), concentrating - due to their capital position - financial and information resources as well as a significant pool of creative and ambitious people who arrived from different regions. The insular position usually promotes peripheralization. But here, on the contrary, innovation processes are intensified, and isolation acts as a challenge that enhances the innovative search. The opposite

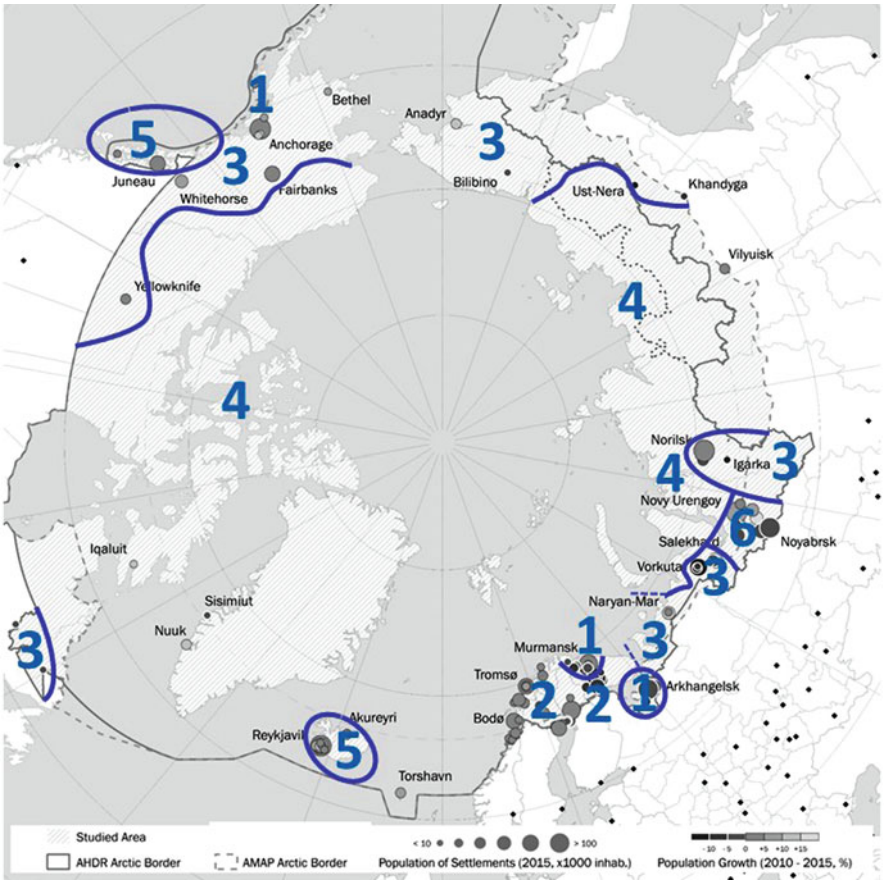

Fig. 19.1 Types of innovation systems in the global Arctic (numbers see in text and Table 19.2) Source of the base map: Zamyatina and Goncharov (2018). Arctic zone of Russia borders as of 2018.

example is the Russian network of cities in the north of Western Siberia, created in the 1970s and 1980s. These cities are characterized by reduced innovation activity.

Let us consider these types of local innovation systems (IS) in the global Arctic in more detail.

1. **IS of multifunctional urban centers.** This type includes the agglomerations of the cities of Anchorage, Arkhangelsk and Murmansk. Here, the innovation processes are the closest to those in densely populated areas of the world, in large urban agglomerations, but there are many specific features. These cities are relatively small by world standards (about 300 thousand residents, with agglomerations up to 500 thousand). The headquarters and administrations of large Arctic corporations and megaprojects are located here (for example, Arkhangelsk

Table 19.2 The relationship between space properties and the type of local innovation system

Type of innovative system (IS)	Spatial features			Features of innovative systems			
	Territory	Features of the settlement system	Transport accessibility (connectivity)	Major actors	Type and characteristics of key innovations	The scope of innovation	Type of IS
Regular types, differentiated by the level of development of the territory							
1. IS of multifunctional urban centers	Cities of Anchorage, Archangelsk, Murmansk	Urban agglomerations	Best in the Arctic: International multimodal transport hubs	Divisions of large corporations, universities, local governments, international organizations	Logistic, managerial, technological and organizational innovations (own and borrowed)	Interregional	Central: Interregional level
2.Networks IS in the old-developed resource and coastal regions	Arctic regions of Norway, Sweden, Finland; Murmansk region (outside the Murmansk agglomeration), the republic of Karelia in Russia	A network of cities connected by year-round transport routes, combined with old and young mines.	High: Year-round land transport network	Universities, mining and manufacturing corporations, small businesses, civil society structures	Non-specific (borrowed) technological, social	Local	Peripheral IS
3.IS of base city-islands in old-developed resource regions	Central Alaska, southern Yukon and Northwest Territories, Labrador City in Canada, Chukotka, lower Yenisei, Nenets autonomous okrug and Vorkuta	"Island" base cities in combination with old and young (including rotational) settlements at the deposits (no further than 250 km from cities) and traditional settlements of	Medium: Single highways, partially off-road	Specialized Arctic R&D centers (their presence is a distinctive feature of the type), resource corporations, small businesses, local governments	Highly specific Arctic innovations in life support, manufacturing, Creative crafts; high level of integration of traditional knowledge and borrowed advanced technologies	Interregional	Central (regional level, for regions of the new and old frontier)

(continued)

Table 19.2 (continued)

Type of innovative system (IS)	Spatial features			Features of innovative systems			
	Territory	Features of the settlement system	Transport accessibility (connectivity)	Major actors	Type and characteristics of key innovations	The scope of innovation	Type of IS
		Indigenous peoples					
4.IS of areas of modern pioneer development (frontier IS)	Tundra regions of North America (including Greenland) and eastern Eurasia (from Yamal to Yakutia)	A mix of resource corporations' camps and Indigenous villages; small number of sparsely populated isolated logistics and/or administrative centers	Low: Off -road	Corporations	Integrated development (interdisciplinary) innovations (transport, environmental, social, technological, etc.)	Interregional (limited to the territories of the resource corporation)	Frontier IS
Specific types associated with natural and / or historical unique features of territories							
5. "Privileged" IS of island capitals	Iceland and southern Alaska (with Juneau and adjacent islands), Faroe Islands	Network of cities on the islands	Medium: The island position is offset by the presence of international airports and a good level of development of maritime transport in the absence of restrictions on ice conditions	Universities, governments, international organizations (Iceland), civil society structures, small businesses	Innovations in the field of green economy and environmental management, tourism; social	From local to international	Central (regional level, outside the resource frontier)

6. West Siberian IS- a network of resource urban centers	Southern Yamal-Nenets autonomous okrug	A network of young single-industry cities with hydrocarbon deposits	High: All-season road network	Corporations and city governments, small businesses	Corporate industrial innovations (more often brought from cities - centers of corporate R&D), urban space innovations (borrowed)	Local, in some cases - interregional (limited to the territories of presence of the corresponding corporation)	Peripheral IS

is the center of the entire hydrometeorological service of the western sector of the Russian Arctic). A significant part of personnel training for work in the Arctic is also concentrated here, and large-scale scientific research is being conducted.

The main driving force of the innovation process here is the search for management solutions focused on global and national problems of the development of the Arctic, the synthesis of knowledge about Arctic regional diversity. Relatively small in terms of population, these cities concentrate information from across the Arctic.

2. **Network IS in the old-developed resource and coastal regions.** This type includes Arctic Scandinavia, Finland, enclosing the territories of the Murmansk region, Karelia, Arkhangelsk region (except for large urban agglomerations). In terms of the nature of the space, these territories resemble the peripheral regions of the more developed territories of Europe and North America with the difference that the network of cities is more sparse, and the role of the extractive industries in the economy is relatively increased. The presence of a relatively dense network of small towns determines the main features of this region. Even in the case of new mining operations (for example, powerful gold deposits like Kittilä in Finland), companies can use nearby settlements and a largely ready-made transport infrastructure as a base.

The natural environment is not so harsh as to require special technological solutions. Numerous local universities are focused mainly on solving local problems (including in the resource industries). Due to the relatively good (for the Arctic) accessibility, these regions are ready for the development of mass tourism through the efforts of local entrepreneurs.

The presence of the characteristic problems of the development of single-industry cities (combined with an orientation towards high standards of quality of life) stimulates the development of social and organizational innovations - for example, the complex process of transferring a part of the city of Kiruna to a new location. In Russia, Kostomuksha stands out in this type as one of the first cities in the country to develop its own brand in the interests of local small businesses.

The most important factor and a favorable prerequisite for the deployment of an innovation system here is the best infrastructural arrangement of space in the global Arctic. At the same time, the innovation process is focused on solving local problems and differs little from the innovation process in other old industrial regions of Europe. It is not surprising that the very concept of a peripheral innovation system was born here (Asheim, Isaksen, Trippl, 2019). It is the least "Arctic" of the Arctic innovation systems. An exception is Tromsø, which is close to the next type in its developmental characteristics.

3. **IS of base city-islands in old-developed resource regions.** This type is distinguished by the presence of remote cities and is perhaps the most specific innovation system in the Arctic. An important factor in its development is the functional diversity of the local environment. This category includes both cities and villages of Indigenous peoples, old (often abandoned) and new (developed on

a rotational basis) resource projects located in relative proximity to each other (the distance from cities to deposits usually does not exceed 250 km, which makes it possible to use local cities as reference points for development).

However, a key feature of the development of local innovation systems is their high orientation toward innovative search in the field of life support in the Arctic, and the general high level and rich traditions of this search. The main settlement network was formed in such areas, as a rule, 75–100 years ago, at a time when it was technically impossible to develop on a rotational basis and, accordingly, the development of natural resources was accompanied by the creation of *forced multifunctional* support cities and settlements usually with attempts to develop local agriculture, production of building materials, etc., as well as scientific research.

This type is similar to the previous one, but differs in terms of a sparser network of settlements (especially urban ones), a poorer level of transport accessibility, more severe natural conditions, and, as a consequence, a higher innovative activity aimed at life support. Local cities serve as bases for the development of the surrounding area and often have specialized R&D institutions aimed at developing solutions in the field of Arctic life support in general as well as adapting the experience of Indigenous peoples in the modern economy. Typical examples of such R&D organizations are "markers" such as the Cold Climate Housing Research Center[1] and the Alaska Center for Energy and Power[2] in Fairbanks, scientific research in the field of construction on permafrost and the Research Institute of Agriculture and Arctic Ecology[3] in Norilsk, and the Uelen bone carving workshop (serving as an example of the integration of traditional crafts into the world commodity market) in Chukotka.

4. **IS of areas of modern pioneer development (frontier IS).** Such ISs are developing in areas with an extremely low population density, an almost complete absence of cities (with the exception of small logistics and administrative centers such as Nuuk and Tiksi), extremely difficult climate conditions, low transport accessibility, and often lack of Internet connection. This zone is characterized by the strongest contrast between the traditional subsistence and the powerful processes of Arctic industrialization associated with the activities of large resource corporations. In the absence of large research centers in this zone, the bulk of innovation is brought in from outside, from the locations of R&D units of large TNCs. At the same time, however, successful solutions found in a specific place are often replicated on a global scale. For example, with the arrival of American investors in oil production in the Nenets autonomous Okrug in the 1990s, for the first time in Russia, the method of drilling from frozen ice pads[4] (Ardalinskoye field) was used.

[1] http://www.cchrc.org/

[2] http://acep.uaf.edu/

[3] http://norilsk-niisharctic.ru/

[4] http://www.oilru.com/nr/79/774/

5. **"Privileged" IS of the island capital regions** (e.g. Iceland and Juneau, Alaska and adjacent islands). ***The development of these IS is determined, on the one hand, by the capital status of the largest cities in these territories and on the other, by their relatively high transport isolation. The first challenge is to attract creative, ambitious people to them, including potential innovators, by the concentration of information and administrative resources. The second factor involves an increased need for developing solutions in the field of reducing the cost of life support.*** It is not surprising that the combination of both factors makes the Alaska metropolitan area around Juneau and Iceland attractive to a high level of green energy development. In addition, both districts are characterized by a high level of tourism development and traditional specialization in fishing, both areas of application of local innovation.
6. **West Siberian type: networks of single-industry urban centers.** Despite the concentration of relatively large (from 25 to 100 thousand people) cities, which is unique for the Arctic, the IS developing here is characterized by "stagnation" due to the single-industry resource nature of these cities. The most important factor in the development of innovations here is external relations with the more southern regions of Russia (the zone of main settlement with the main centers of production of innovations) as well as the search for innovative technological solutions (in the fields, relying on the infrastructure of basic cities).

The most important factor and a favorable prerequisite for the deployment of the innovation system here is the highest level of per capita wealth and the highest "density" of resource wealth per unit area. The key actors are large resource corporations as well as local administrations seeking to increase the attractiveness of the urban environment for the population.

19.6 The Global Importance of Arctic Innovation

The Arctic today is a gigantic laboratory, developing solutions for rather specific conditions, including, for example, a very cold climate, strong winds, high migration mobility of the population and the associated socio-cultural challenges, and a sparse network of settlements. Among others, the last point deserves special attention in the context of its potential significance for the global system.

The modern global system is characterized by high mobility of the population and goods. Sociologist John Urry speaks of the mobility paradigm as the basis of modern civilization (Urry, 2007). Mobility is the very paradigm that Urry has put forward as determining for a modern society, which is urban, dependent on oil and on intelligent systems that provide mobility. Incidentally, he considered the rapid spread of infections diseases (through animals) as a consequence of this mobility.

In the event of any cataclysms that would entail a sharp rise in the price of hydrocarbons (or, on the contrary, a voluntary rejection of the excessive mobility that environmental alarmists are calling for today), mobility can plummet. This will

inevitably require a complete restructuring of economic, technological, and economic processes.

Urry also gave a gloomy forecast for the end of the era of mobility: "We definitely should not expect that the mobile world of the 20th century will remain an organizational principle in this century. Some even argue that climate change, environmental pollution and energy shortages in the 20th century will extremely limit the possibilities for rebuilding future mobility and using the energy necessary to avoid the "societal collapse" of the kind that the Roman Empire or civilization Maya due to the development of their internal contradictions. Mobile life for millions can be a short-lived phenomenon. Over the course of a century, until the contradictions have fully manifested themselves, the rich world has gone wild, and as a result, in the 21st century, when societies will have a hard time, people and machines will have a much slower inheritance in their hands" (Urri, 2012, p. 62).

Due to the low density of settlements (increased average distances between settlements), the increased cost of transporting fuel in the Arctic today is such a model of the "society of expensive oil" (despite the fact that now the price of oil is low). In other words, the *Arctic today is already a laboratory of a possible future for all of humanity in the "after mobility" era*, and its "recipes" can be potentially recipes for the adaptation of mankind to low mobility conditions.

What are these recipes? There is, for example, the practice of complex, multifunctional trips, when a trip is used to the maximum to perform many tasks at the same time (treatment, rest, shopping, collecting information, etc.). Another example is the expanded role of stocks and the corresponding warehouse infrastructure, a strategy that is characteristic of the Arctic and completely opposite to the just-in-time strategy prevailing under milder conditions. It is possible that these exotic strategies will turn out to be the mainstream of the future development of mankind making it worth looking at the Arctic as an experimental training ground for survival strategies.

The Arctic strategy is a strategy of large stocks of equipment and spare parts. The unreliability of transport routes, the untimely delivery, the instability of aircraft schedules and blocking of the road due to weather conditions are absolute realities of modern, and not a hundred years ago, Arctic life. Today we can study this "reserve" not as the past but as, quite possibly, the future of mankind.

These examples disprove the traditional notion that innovations in the Arctic can be of interest to the rest of the world only in its basic extractive industries. The Arctic cities of Russia, (e.g. Norilsk) have been developing for many decades unique competencies for the collective survival of hundreds of thousands of people in conditions of extreme cold discomfort and extreme instability of permafrost. We are talking about new technologies for Arctic multi-story construction on permafrost, about geological research, and in general about the formation of a whole range of specific Arctic science-intensive business services that are demanded by resource corporations which in their essence are no longer industrial, but from a post-industrial era.

19.7 Conclusion

Our multi-faceted study of Arctic innovations is aimed at straightening out the bias that has developed in the social sciences in recent decades between numerous studies of innovations in large urban agglomerations of the world and an almost complete absence of such research in the Arctic territories. Since the 1970s, the Arctic was presented to researchers as a natural "research laboratory" for the analysis of socio-economic processes due to the sparseness of the infrastructure and the relative simplicity of the links within socio-economic systems.

Continuing this tradition, our work can be understood as a logical step for developing a methodological base for a better understanding of the nature of innovative development in the remote regions of Russia and the world. The scientific algorithms, methods, and research methodology worked out using the relatively simple economic structure of the Arctic zone as an example can subsequently be used constructively and make a contribution to the study of peripheral innovation systems in other parts of the world.

The emphasis on innovation provides a new interpretation of the usual phenomena of Arctic life (e.g. remoteness, cold discomfort, energy and food security) from the standpoint of the "dramaturgy" of the struggle between the new and the old in the Arctic.

The innovation process always transforms the status quo that existed before. The peculiarity of the Arctic is that here it is usually forced to have a more radical, more revolutionary character. In a poorly developed and settled social environment, any innovations cause a very noticeable and visible transformation.

The paradox is that the Arctic, which gave birth to the concept of sustainable development for the whole world due to the imperative of finding ways to balance conflicting environmental, social and economic goals, is itself often an example of non-equilibrium development. The regional innovation system and the innovation process further reinforce this disequilibrium, but give it a constructive and creative rather than a catastrophic character.

This exploratory behavior is aimed at overcoming the effects of exhaustion and stagnation, which in the Arctic are not only destructive, but threaten the very continued existence of man-made urban, economic and social systems. This resultant innovative search, which is a forced feature of both the natural and social systems of the Arctic, provides an opportunity for a new dynamic beginning of the process of economic development, which always at the first stage provides an attractive tone to development. The difference between the Arctic and other parts of the world is that it is constantly ready for such an innovative reformatting.

It is the Arctic innovation system that materializes the completely new role of science in the development of the Arctic. Science is a key factor in informed decisionmaking, as a guarantor of the formation of the common interests of influential actors and as an effective institution that ensures the resilience of the Arctic territories under conditions of rapid social and natural changes.

References

Asheim, B. T., & Gertler, M. S. (2005). The geography of innovation: Regional innovation systems. In J. Fagerberg, D. C. Mowery, & R. Nelson (Eds.), *The Oxford handbook of innovation* (pp. 291–317). Oxford University Press.

Asheim, B. T., Isaksen, A., & Trippl, M. (2019). *Advanced introduction to regional innovation systems* (146p). Edward Elgar.

Baburin, V. L., & Zemtsov, S. P. (2017). Innovatsionnyy potentsial regionov Rossii. KDU. In Russ [Baburin, V. L., & Zemtsov, S. P. *The innovative potential of the regions of Russia*. KDU].

Bathelt, H., Malmberg, A., & Maskell, P. (2004). Clusters and knowledge: Local buzz, global pipelines and the process of knowledge creation. *Progress in Human Geography, 28*, 31–56.

Boorstin, D. J. (1958). *The Americans: Colonial experience* (434 pp). Random House.

Boschma, R. (2005). Proximity and innovation: A critical assessment. *Regional Studies, 39*(1), 61–74.

Carrol, L. (1973). Alice through the looking glass.

Dawley, S. (2014). Creating new paths? Offshore wind, policy activism, and peripheral region development. *Economic Geography, 90*(1), 91–112.

Dosi, G. (1982). Technological paradigms and technological trajectories. *Research Policy, 11*, 147–162.

Feldman, M. (1994). *The geography of innovation*. Springer.

Feldman, M. P., & Audretsch, D. B. (1999). Innovation in cities: Science-based diversity, specialization and localized competition. *European Economic Review, 43*(2), 409–429.

Ferrucci, L., & Porcheddu, D. (2006). An emerging ICT cluster in a marginal region. The Sardinian experience. In *Regional development in knowledge economy* (pp. 203–226). Routledge.

Florida, R. (2008). *Who's your city?* (374p). Random House Canada.

Fujita, M., Krugman, P., & Venables, A. (1999). *The spatial economy: Cities, regions, and international trade*. MIT Press.

Healy, A. (2017). Innovation in circumpolar regions: New challenges for smart specialization. *Northern Review, 45*, 11–32.

Iammarino, S., & McCann, P. (2013). *Multinationals and economic geography: Location, technology and innovation*. Edward Elgar.

Isaksen, A., & Karlsson, J. (2016). Innovation in peripheral regions. In R. Shearmur, C. Carrincazeaux, & D. Doloreux (Eds.), *Handbook of the geographies of innovation* (482pp). Edward Elgar.

Karlsen, J., Isaksen, A., & Spilling, O. (2011). The challenge of constructing regional advantage in peripheral areas: The case of marine biotechnology in Thomson's, Norway. *Entrepreneurship and Regional Development, 23*(3), 235–257.

Krugman, P. (1991). *Geography and trade*. MIT.

Kryukov, V. A. (1998). Institutsional'naya struktura neftegazovogo sektora. Problemy i napravleniya transformatsii (280s). IEiOPP. In Russ [Kryukov, V. A. *Institutional structure of the oil and gas sector. Problems and directions of transformation* (280p.). IEiOPP].

Matveyev, O. A. (2011). Innovatsionnoye razvitiye regionov Severa: sostoyaniye i perspektivy (320s). Sovremennaya ekonomika i pravo . In Russ [Matveev, O. A. *Innovative development of the regions of the North: State and prospects* (320p). Modern Economics and Law].

Pelto, P. (1987). *The snowmobile revolution. Technology and social change in the Arctic*. Prospect Heights/Waveland Press.

Perroux, F. (1950). Economic space. Theory and applications. *The Quarterly Journal of Economics, 4*(1), 89–104.

Petrov, A. N. (2008, June). Talent in the cold? Creative capital and the economic future of the Canadian North. *Arctic, 61*(2), 162–176.

Petrov, A. N. (2011). Beyond spillovers. Interrogating innovation and creativity in the peripheries. In H. Bathelt, M. Feldman, & D. Kogler (Eds.), *Beyond territory. Dynamic geographies of knowledge creation, diffusion, and innovation* (pp. 168–190). Routledge.

Pilyasov, A. N. (1993). Trest Dal'stroy kak superorganizatsiya. Kolyma 8–11 (8, s. 34–37, 9–10, s. 37–41, 11, s. 28–33). In Russ [Pilyasov, A. N. *Dalstroy trust as a super-organization*. Kolyma, 8–11. (No. 8, p. 34–37, No. 9–10, pp. 37–41, No. 11, pp. 28–33)].

Pilyasov, A. N. (2018). Arkticheskaya diagnostika: plokh ne metr – yavleniye drugoye. Sever i rynok: formirovaniye ekonomicheskogo poryadka. Tom *61*(5), 35–56. In Russ [Pilyasov, A. N. Arctic diagnostics: Not a bad meter – Another phenomenon. *North and Market: The Formation of an Economic Order*. *61*(5), 35–56].

Pilyasov, A. N., & Yadryshnikov, G. N. (1997). Nauka kak faktor sotsial'no-ekonomicheskogo razvitiya rossiyskogo Severa (37s). SVKNII. In Russ [Pilyasov, A. N., & Yadryshnikov, G. N. *Science as a factor in the socio-economic development of the Russian North* (37p). SVKNII. 1997. 37p.].

Stammler, F. (2009). Mobile phone revolution in the tundra? Evolution in the tundra? Technological change among Russian reindeer nomads. *Folklore, 41*. http://www.folklore.ee/folklore/vol41/stammler.pdf

Torre, A. (2008). On the role played by temporary geographical proximity in knowledge transmission. *Regional Studies, 42*(6), 869–889.

Trippl, M. (2013). Islands of innovation as magnetic centres of star scientists? Empirical evidence on spatial concentration and mobility patterns. *Regional Studies, 47*(2), 229–244.

Urri, D. (2012). Mobil'nosti. Predisloviye k russkomu izdaniyu. Praktis (In Russ.). [Urry, J. *Mobility. Preface to the Russian edition*. Praktis].

Urry, J. (2007). *Mobilities* (336 p). Polity Press.

Virkkala, S. (2007). Innovation and networking in peripheral areas -a case study of emergence and change in rural manufacturing. *European Planning Studies, 15*(4), 511–529.

Zamyatina, N., & Goncharov, R. (2018). Arctic urbanization: Resilience in a condition of permanent instability. The case of Russian Arctic cities. In K. Borsekova & P. Nijkamp (Eds.), *Resilience and urban disasters surviving cities* (New horizons in regional science series) (pp. 136–154). Edward Elgar Publishing. https://doi.org/10.4337/9781788970105

Zbeed, S. O., & Petrov, A. N. (2017). Inventing the New North: Patents & knowledge economy in Alaska. In Arctic yearbook (pp. 1–18).

Zemtsov, S., Muradov, A., Wade, I., & Barinova, V. (2016). Determinants of regional innovation in Russia: Are people or capital more important? *Foresight-Russia, 2*, 29–42.