Building a High-Performing Collaborative Innovation Ecosystem in the Arctic

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Global climate change, growing economic interest in the Arctic, and the inflow of investments into infrastructure in the Arctic regions have provided added impetus for the development of technology clusters and innovation ecosystems in the North and the Arctic. The goal of this study is to conceptually illustrate the roles of the actors involved in the development process of the innovation ecosystem in the Arctic regions. This research is crucial for optimizing the role of the actors responsible for the genesis of the innovation ecosystem in the Arctic regions and is based on a case study of the Yakutia innovation ecosystem. The Republic of Sakha (Yakutia) currently holds the leading position in the IT sphere of Far East Russia, accounting for 85% of the region's IT services exports in the first quarter of 2020 and 82% in 2019. Yakutia develops the northernmost innovation ecosystem, with IT Park Yakutsk as its base, in collaboration with different actors from governments, universities, startup communities, and venture capital firms. This study applies a qualitative approach, with the data collection conducted using in-depth interviews. The interviewees in this study represent various actors, including businesses, governments, universities, and financial institutions. Theories developed by Dedehayir et al. (2018) and Tsujimoto et al. (2018) are used to explain and analyze the disposition, roles, and interactions of the actors during the genesis (birth phase) of the innovation ecosystem in the North. This study argues that building high-performing innovation ecosystems will produce digital and economic transformations that improve the sustainability and resilience of the societies in the Arctic.

Introduction: Genesis of the innovation ecosystems in the Arctic

Digitalization has opened new opportunities for isolated northern areas, such as the Arctic regions. The imminent dangers of global climate change have garnered a significant rise in economic interest in infrastructure development in the Arctic. Specifically, there is a growing interest in the development of technology clusters and innovation ecosystems in the North and the Arctic.

This article aims to answer the following research question: who are the key actors in the genesis of the Arctic innovation ecosystem? This research is crucial for optimizing the roles of the actors responsible for the genesis (birth phase) of the innovation ecosystem in the North, specifically in the Arctic regions, which are peripheral and environmentally sensitive areas. The habitable areas in

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the Arctic regions have low population densities, the ecosystems are fragile, and the current economic activities revolve primarily around natural resource extraction. However, there is growing interest in a shift from an extraction economy toward a digital economy. The specificity of the Arctic regions and their environmental and economic sensibility disallow the adoption of general approaches to infrastructure development and fundamental business strategies. The specificity of the Arctic regions requires the formulation of a unique approach that involves local Indigenous communities as the key actors in the process of infrastructure development from its earliest stages, combined with the development of sustainable technologies and effective collaboration. The ecosystems approach opens new perspectives to supporting sustainable infrastructure and building innovation ecosystems in the Arctic regions.

This study adopts the qualitative method, with in-depth interviews of 16 experts, including the leaders, directors, and CEOs of the organizations involved in the genesis of the innovation ecosystem, from businesses, the government, universities, and financial institutions in the Republic of Sakha (Yakutia). These include the Yakutia technology park; Venture Company Yakutia; the Innovation Development Fund; IT Association of the Sakha Republic; Yakutia Development Corporation; the Ministry of Innovations, Digital Development and Infocommunication Technologies of the Republic of Sakha; MIT Regional Entrepreneurship Acceleration Program (REAP) Team Yakutia; Arctic Innovation Center; North-Eastern Federal University (NEFU) Research and Innovation (R&I); Acceleration B8; the NEFU student business incubator, OREH; the ride-hailing company, inDriver; AI Ayana; and several MedTech and EdTech startups.

Theoretical background on innovation ecosystems

The innovation ecosystem is defined as "the collaborative effort of a diverse set of actors toward innovation, as suppliers deliver key components and technologies, various organizations provide complementary products and services, and customers build demand and capabilities." (Moore, 1996, as cited in Dedehayir et al, 2018, p.18) The innovation ecosystems refer to heterogeneous constellations of organizations that co-evolve capabilities in the co-creation of value (Moore, 1993; Adner and Kapoor, 2010; Autio & Thomas, 2014). Categories of entities that constitute an innovation ecosystem include producers, suppliers, distributors, finance and research institutions, makers of complementary technologies, and regulatory bodies (Mäkinen & Dedehayir, 2013). Innovation ecosystems are distinct from similar constructs in organizational networks, such as clusters and value networks (Porter, 1998). Clusters refer to "critical masses—in one place—of unusual competitive success in particular fields" (Porter, 1998: 78).

Innovation ecosystems can be viewed as "being centered about a platform that brings providers of products and services into exchange with the users of these products and services" (Gawer, 2014; Thomas and Autio, 2013, as cited in Dedehayir et al, 2018, p.19). Building on innovation ecosystems literature, Adner (2012) introduces methods for designing the ecosystem's *value blueprint* (locations and links between ecosystem actors); envisaging risks to value creation; determining the value of leadership and followership roles in the ecosystem; timing the introduction of innovations; and projecting the dynamic reconfiguration of the ecosystem over time. Autio and Thomas (2014) provide a literature review on the boundaries, structure, and management of innovation ecosystems, while Gawer and Cusumano (2014) put forward a conceptualization of platforms, that distinguishes between *internal platforms* (comprised of a firm and its sub-units), *supply-chain platforms*

(comprised of assemblers and suppliers), and *industry platforms* (comprised of a platform leader and its complementors) which underpin innovation ecosystems.

Thomas and Autio (2013; 2014) examine the emergence of six digital service platform ecosystems. Their research findings highlight the cruciality of four activities to the emergence of an ecosystem: resource activities, which involve the acquisition and management of resources by a hub firm; technological activities, which include the design and provision of technologies; institutional activities, which revolve around the establishment and implementation of rules of engagement; and context activities (regulatory activities). The process of emergence has three phases: initiation, momentum, and optimization, which closely align with the birth, expansion, and leadership phases described by Moore (1993). According to Tsujimoto et al. (2018), the ecosystem concept analyzes organic networks based on their positive, negative, and competitive aspects, such as ecosystem-level competition, predation, parasitism, and destruction of the entire system. Each actor in the ecosystem has different attributes, principles, and purposes, and these differences impact outcomes at the ecosystem level. The analytical border of the ecosystem is the product/service system, which is not limited by national borders, regional clusters, or contract relations. Furthermore, Tsujimoto et al. (2018) defined a multi-actor network perspective (MNP), which includes various actors and analyzes the dynamic networks among actors with attributes that are different from those of private firms. Tsujimoto et al. (2018) described four major research streams: the industrial ecology perspective, the business ecosystem perspective, platform management within the business ecosystem perspective, and the MNP.

Engagement and roles of actors in the innovation ecosystem genesis

Dedehayir et al. (2018) define several key roles, which are categorized into four groups: leadership roles, direct value creation roles, value creation support roles, and entrepreneurial ecosystem roles. Their study focuses primarily on the genesis of innovation ecosystems, such as the birth or pioneering phase of the innovation ecosystem lifecycle according to Moore's (1993; 1996) four-phased description of an innovation ecosystem. Scholars have also broadly highlighted central roles in innovation ecosystems, such as the ecosystem leader, which is analogous to Moore's (1993) platform leader (Cusumano & Gawer, 2002). Dedehayir et al. (2018) categorized the main activities, identifying the ecosystem leader with four sets of higher-level activities: ecosystem governance, forging partnerships, platform management, and value management. The ecosystem leader and the complementor roles are two quintessential roles unique to the innovation ecosystems literature. According to Dedehayir et al. (2018), the ecosystem leader actor first engages in governance-related actions—which include designing the roles of other actors and coordinating the interactions between the actors—during the birth phase of the ecosystem. Platform management activities include designing and building the platform, with the ecosystem leader aiming to generate value from the participation of a host of actors, including a user community and the producers, which necessitates having different actors join the platform by exchanging ideas, engaging in transactions, and collaborating.

The traditional value chain roles defined by Dedehayir et al. (2018) as "direct value creating roles" are the suppliers, assemblers, users, and complementors. Value creation supporting roles are described by Dedehayir et al. (2018) as additional roles that interact with two different partners: experts and champions. According to the literature, the role of experts is associated with actors such as universities and research organizations, which generate knowledge, inventions, and

discoveries (Clarysse et al., 2014). The entrepreneurial ecosystem roles identified by Dedehayir et al. (2018) include entrepreneur, sponsor, and regulator. The entrepreneur also intermediates between actors conducting research (e.g., universities) and those aiming to commercialize technologies.

The engagement of the actors is defined by Storbacka (2019) as "an actor's (human or machine) or a group of actors' (collectives or organizations) exchange-based and non-exchange-based resource contributions, which are facilitated by dispositions and formed partly by actor specific characteristics and partly by the institutional and organizational arrangements prevalent in the context in which the resource contributions occur" (Storbacka, 2019: 4). The literature on actor engagement highlights various perspectives, and the most recent studies reveal a focus on a generic view of actor engagement. Storbacka and Cornell (2016) argue that "an actor-to-actor perspective" with the strict roles of producer vs. consumer or seller vs. buyer are useless, as actors can have different roles and comparable processes of engagement; hence, there is a need for a generic view of actor engagement. Kleinaltenkamp et al. (2019) argue for the need to understand the collective engagement of multiple (individual) actors. They define collective engagement as "multiple actors' shared cognitive, emotional, and behavioral dispositions, as manifested in their interactive efforts toward a focal object" (Kleinaltenkamp et al., 2019). Collective engagement has similarities to the discussion on multi-actor engagement (Li et al., 2017).

The most vital role in market-shaping activities is attributed to actors' engagement strategies. According to Storbacka (2019), with market-shaping strategies, actor engagement leads to market innovations, which lead to value creation in a market. Storbacka and Nenonen (2011) suggest that the performative power of any market actor depends on its network position and its business model. They highlighted that actors' networks within a service ecosystem can drive innovation, with those actors shaping the markets, as markets are not fixed in time, and are in the process of constant development (Storbacka & Nenonen, 2011). According to Storbacka (2019), this mechanism is considered the foundation for *economies of actor engagement* which is reaped when focal actors achieve increasing returns by mobilizing actor engagement. Based on this, some scholars argue that actor engagement is essential for market-shaping strategies aimed at market innovation. Furthermore, current shifts in the operating environment are elevating the role of actor engagement, making the management of actor engagement a strategic priority.

Methodology

The qualitative method brings in-depth focus to some phenomena, particularly when the boundaries between the phenomena and its context are vague or not clearly evident (Patton 1990: 13–14.) According to Robson (2011:136), the case study is "a strategy for doing research that involves an empirical investigation of a particular contemporary phenomenon within its real-life context using multiple sources of evidence." A case study can be seen as an applicable empirical method of inquiry that investigates contemporary phenomena in depth and in a real-life context (Yin, 2009: 18).

This qualitative study applies theoretical triangulation to establish the credibility of the research. By using several theories in the conceptual framework, such as the theories of Dedehayir et al. (2018) and Tsujimoto et al. (2018), this study attempts to optimize the roles of the actors in the genesis of the innovation ecosystem in the Arctic regions based on a case study of the Yakutia innovation ecosystem. For transferability, the research context and assumptions are described to

make the research consistent in terms of general understanding. The collected data consists of 16 in-depth interviews in keeping with the general objectivity and confirmability of qualitative research.

Data collection

Qualitative samples should be selected purposefully to choose information-rich cases for in-depth study (Patton, 2002). Qualitative data collection was used to define the roles of actors based on a case study of the Yakutia innovation ecosystem with in-depth interviews of 16 interviewees, including directors and CEOs. The case study is based on empirical data gathering conducted by one of the authors in Yakutsk, Russia in 2021. The data was gathered via in-depth interviews with a duration of approximately 40 minutes to two hours. The interviews were recorded using a Zoom recorder. The audio of the interviews was transcribed and translated. The information was filtered to increase the reliability of the study. The interviewees were 16 representatives of various organizations, including the directors and CEOs of the key organizations that constitute the innovation ecosystem: Yakutia technology park, Venture Company Yakutia, the Innovation Development Fund, IT Association of the Sakha Republic, Yakutia Development Corporation, MIT REAP Team Yakutia, the Ministry of Innovations, Digital Development and Infocommunication Technologies, Arctic Innovation Center, NEFU R&I, Acceleration B8, OREH, inDriver, AI Ayana, and several MedTech and EdTech startups. The companies were systematically selected based on the Yakutia MIT REAP model and were classified according to the Tsujimoto et al. (2018) model.

Data analysis

Analysis of the research data proceeded in two phases. First, the case description of the innovation ecosystem was given, and the interviews were classified into clusters according to the original MIT REAP model and the Tsujimoto et al. (2018) MNP model. The MNP model was applied to analyze dynamic networks among the actors and define their roles and dispositions. Tsujimoto et al. (2018) defined four perspectives: the industrial ecology perspective, the business ecosystem perspective, platform management within the business ecosystem perspective, and MNP. The 16 interviews were classified according to the Tsujimoto et al. (2018) MNP model, and the MIT REAP model was applied for clustering into groups: government, universities, risk capital, entrepreneurs (startups), and platform management (Tsujimoto, 2018). The interviews in each cluster were grouped and analyzed to present the view of each cluster, such as a governmental view, platform management view, risk capital view, startup view, university/ institutional view, and entrepreneurial view.

Secondly, each cluster has been discussed further based on the Dedehayir et al. (2018) model of the actors' roles in innovation ecosystem genesis. Clusters are linked to the roles that actors play in the innovation ecosystem: leadership roles, direct value creation roles, value creation support roles, and entrepreneurial ecosystem roles. Clustering based on the MNP and the innovation ecosystem genesis actor's roles defines and facilitates a deeper understanding of the actors' roles, their disposition, and their perspectives on the Yakutia innovation ecosystem. This analysis attempts to illustrate the applicability of the proposed frameworks to the development of the Arctic innovation

ecosystem.

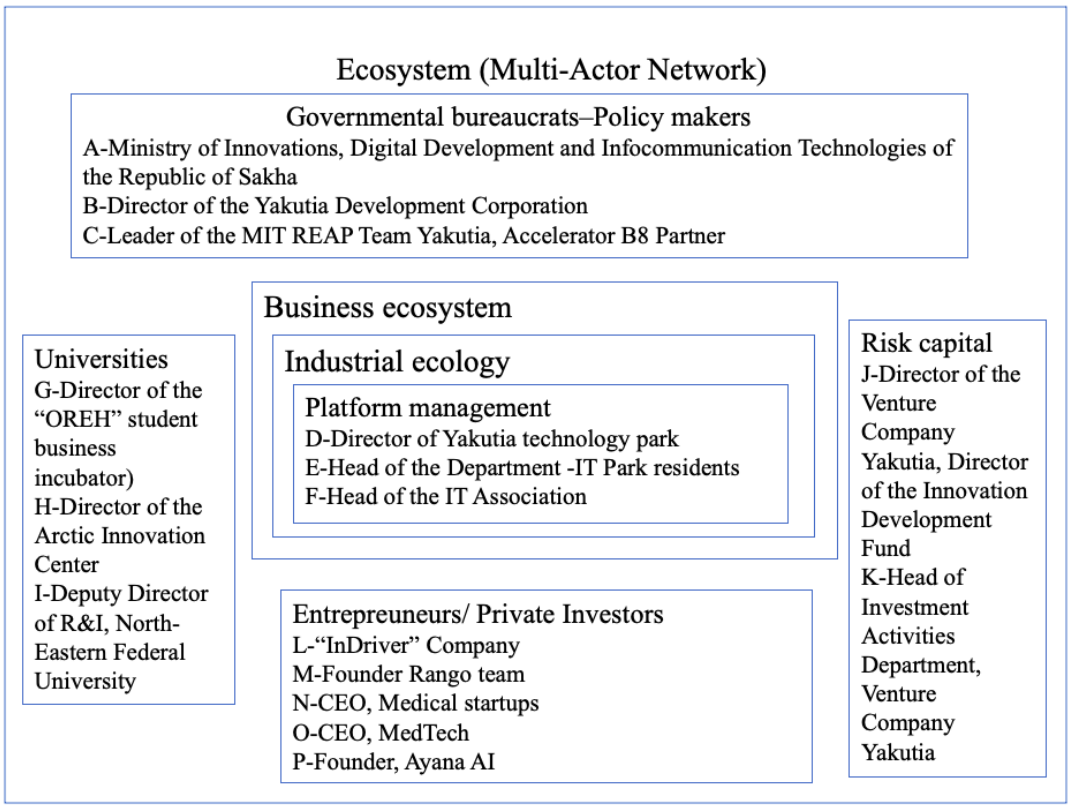

Figure 1. Clustering of the 16 interviews (based on Tsujimoto et al., 2018)

Results and discussion

Yakutia innovation ecosystem case study

The Republic of Sakha (Yakutia) is an IT services leader in Far East Russia and plans to create innovation ecosystem expertise in other northern regions. With a population of 934,330, Yakutia currently holds the leading position in the IT sphere of Far East Russia, accounting for 85% of the region's IT services exports in the first quarter of 2020 and 82% in 2019. Yakutia develops the northernmost innovation ecosystem, with the IT Park Yakutsk platform as its base, in collaboration with different actors from government, universities, the startup community, venture capital firms, and other financial institutions. The first in Far East Russia and the northernmost high-tech park, IT Park Yakutsk is a platform for accumulating IT expertise through multiple projects and provides 150 residents with services, integrating them into the national and international innovation ecosystem. The primary areas of activity of the IT Park Yakutsk residents are computational linguistics and AI, industrial integration systems, mobile applications and game development, augmented and virtual reality, bioinformatics, and the Internet of things (IoT). An important aspect of the work done by the IT park is the Acceleration B8 program, with participants receiving all the necessary resources and services for developing a minimum viable product (MVP).

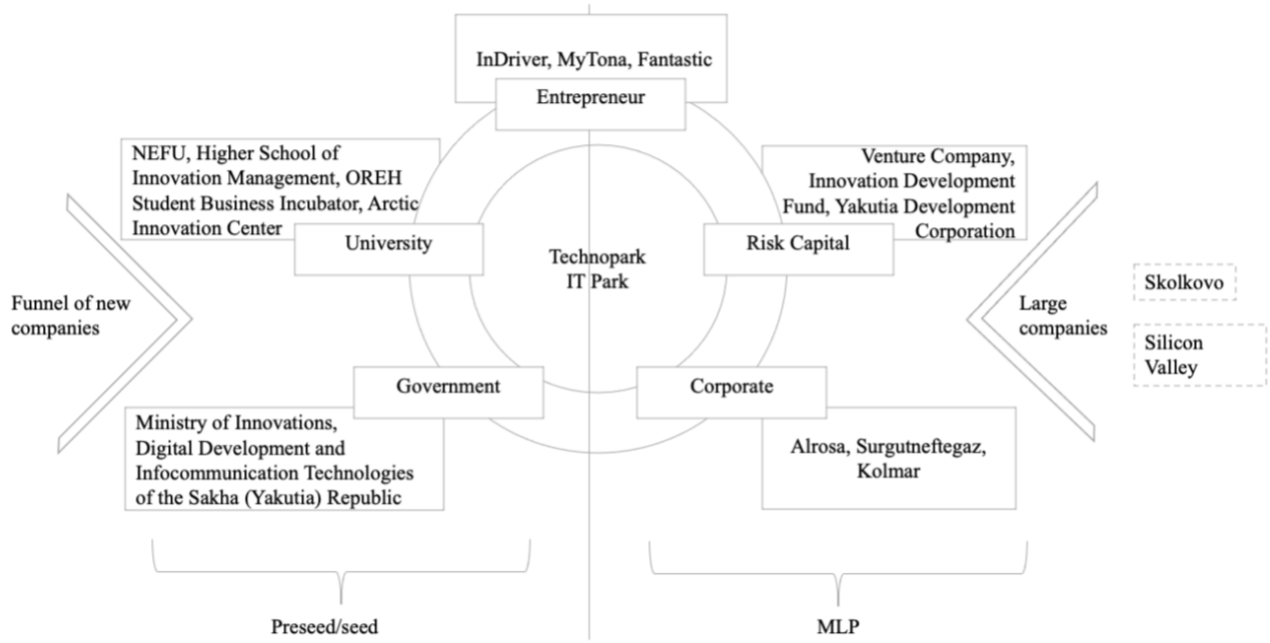

Figure 2. Yakutia Innovation Ecosystem (updated based on the original MIT REAP Yakutia model)

Yakutia innovation ecosystem: Key actors and their roles

This section presents a discussion of the analyzed interviews and a summary of the discussed issues. The Yakutia innovation ecosystem comprises different actors, including governmental organizations, financial institutions, educational institutions, and startups. The idea for the Yakutia innovation ecosystem concept was initially formed in 2018 by regional representatives on the MIT REAP Team Yakutia. After graduation from MIT REAP, they set out to establish the innovation ecosystem in Yakutia, in keeping with the Republic of Sakha (Yakutia) government's strategy of focusing on the digital transformation of the economy.

The interviews in the case study on the Yakutia innovation ecosystem reveal that most of the interviewees were familiar with the concept of ecosystems, with only a few of the startup CEOs (Person M and Person O) asking for an explanation of the concept. All 16 interviewees described the following as the key actors: the entrepreneurial community (comprising startups, as distinguished from large companies); governmental structures, including platforms and financial institutions; educational institutions (universities and university acceleration programs); and corporations, which were mentioned by 14 interviewees as the key actors.

Several perspectives were presented in the interviews: governmental, large private companies, startups, and educational institutions. The only limitation—in the form of restricted access to data—was encountered with corporations by virtue of their internal privacy policies. Therefore, the interviews were clustered according to the Dedehayir et al. (2018) model. All the interviewees highlighted the importance of collaboration, but the motivations attached were different, e.g., low population density and networking perspectives (mentioned by eight interviewees), common goal (by twelve interviewees), and new market opportunities (by 14 interviewees).

For example, a former Yakutia Deputy Minister of Investment and Enterprise and MIT REAP Team Yakutia leader said that:

> the most important thing in order to build one ecosystem is that the system of interaction, the structure of subjects must be stable, the connections between actors in the ecosystem must be very strong, when everyone has a common understanding of how it all looks, then everything happens much easier and faster (Person C, MIT REAP Yakutia Team leader).

By discussing the key network dimensions, the key actors mostly identified their personal relations and networks as the foundation for building supplier networks. However, they also mentioned the role of governmental platforms as intermediaries (mentioned by 14 interviewees), as noted by the CEO of a startup:

> The Arctic is small, Yakutia is smaller, there are not many people, even if you drive around Russia, there will be about 500 professional developers and programmers. We build networks through social media and networking events. Whereas in Silicon Valley, the startup networking takes place over coffee, in Russia it happens on semi-state platforms like Skolkovo, the Startup Village, and others (Person N, CEO, Medical startup).

Based on the interview material, the 16 interviewees discussed global market orientation and export and did not focus only on the domestic market. Most respondents (15 of the interviewees) highlighted that the domestic market for services is small and mentioned Yakutia's export-oriented strategy.

> It is much easier for us to integrate into international clusters than into clusters in Moscow. This is the main difference from other Russian ecosystems (Person N, CEO, Medical startup).

However, some respondents highlighted that there is an issue keeping socially oriented impact startups from going global, as their primary focus is the republic and its domestic market:

> In the republic, there is an emphasis on global market scaling. The companies with prospects of going beyond the region are supported the most. However, most companies work within the region, especially socially oriented companies. If only large companies or corporations could support and sponsor research in the area of socially oriented startups, that would be great (Person G, Director of the OREH Student Business Incubator).

Different perspectives on the key actors and their roles

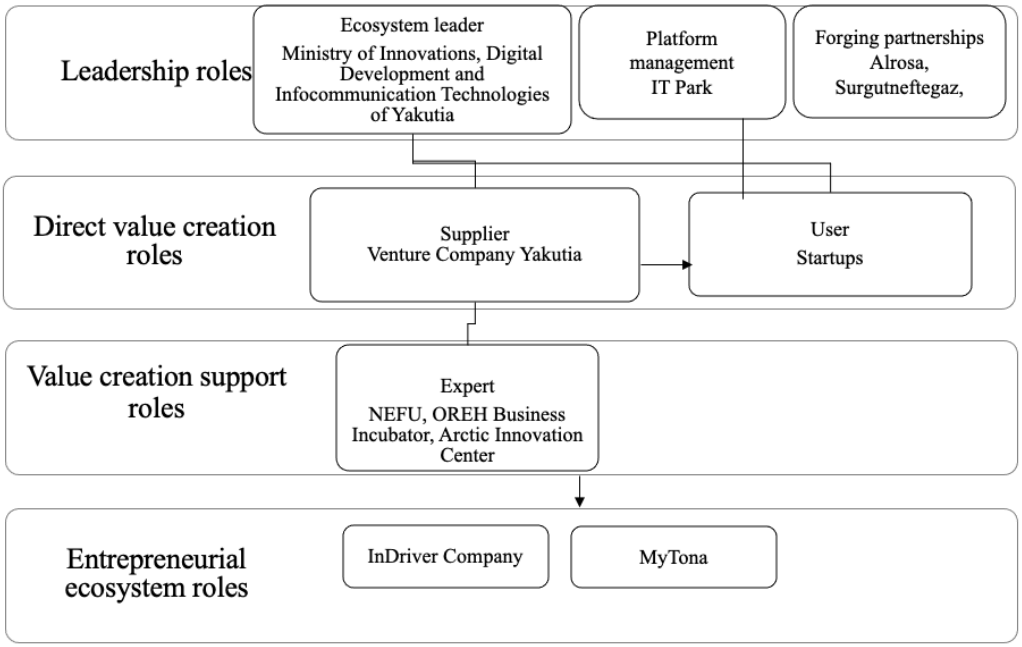

Figure 3. Roles of actors in the Yakutia innovation ecosystem (based on the 2018 Dedehayir et al. model)

Leadership roles: Governmental view

According to Dedehayir et al. (2018), the main leadership roles are the following: ecosystem governance, forging partnerships, platform management, value management, and dominator.

The leader's role in the genesis of the innovation ecosystem is usually played by the government. The role of ecosystem governance is to decipher roles, coordinate interactions, and orchestrate resource flows. Based on the interviews in the case study, a strategy launched in 2018 by the government of the Republic of Sakha (Yakutia) with a focus on the digital transformation of the economy and the initiative to build the IT park and establish the MIT REAP group was the beginning of the innovation ecosystem genesis.

The governmental cluster interviewees described the governmental structures as the key players and holders of the leadership roles in the Russian Arctic. However, the governmental cluster respondents also described the importance of the business community in the development of startups into large firms.

> The main subject of the innovation ecosystem is the entrepreneurial community. Even when everything else is built, including the infrastructure and the support system, and money is allocated, if there is no entrepreneurial community, it is all empty and everything would literally die. The active entrepreneurial community in Yakutia is at the core of the ecosystem (Person C, MIT REAP Team Yakutia leader, former Deputy Minister of Investment and Enterprise of Yakutia).

The business community, which includes SMEs and large companies, creates a supporting environment for startups, and sometimes large firms can create their own ecosystem that could even compete with governmental support programs. The interviewees also mentioned the

acceleration programs initiated by Sinet Group (inDriver) and the MyTona companies (SmartIT with MyTona Company, Yakutia2World Acceleration program, and the Aurora Tech Award for women tech entrepreneurship) to support startups in the region.

Leadership roles: Platform management view

In studies on ecosystems, there is a research stream that is focused on platform-based ecosystems, with the research spotlight on the activities of the platform leader (Cusumano & Gawer, 2002). Platform management activities include designing and building the platform, with the ecosystem leader aiming to generate value from the participation of the key actors, including a user community and the producers. The platform creates an environment for engagement in transactions and knowledge exchange and orchestrates the processes via which all actors interact and cocreate.

The platform management view is represented by the Yakutia information technology park (IT Park). The interviewees of the platform management cluster define their role as that of the key actor in the Yakutia innovation ecosystem. They provide educational and consulting support services for over 150 startup residents and build innovation-oriented platforms in collaboration with 50 IT schools and business centers in the remote regions of Yakutia, including the Arctic regions:

> We provide property support, promotion, project packaging, business plan, we are looking for investors, and we also provide equipment. Large companies and corporations outsource their problematic tasks to us, and our residents solve them (Person D, Director of Yakutia Information Technology Park).

Forging partnerships: corporations

The governmental cluster interviewees highlighted the role of corporations as one of the key players:

> a lot depends on the path that the main corporations of a region or country take, both in politics and in the economy (Person C, MIT REAP Team Yakutia leader).

The role of corporations is defined as a large platform for the implementation of technological solutions, for conducting various experimental design implementations and undertaking the technical and scientific aspects of production. Corporations are considered the primary customers and consumers of the results of innovative solutions. Governmental structures pay special attention to large corporations, and large companies play the role of the key actors and customers of the IT industry's services and products. In Yakutia, the main resource mining corporations are considered innovation ecosystem actors, based on the MIT REAP model, including corporations such as Alrosa, a partially state-owned Russian diamond mining company; Surgutneftegaz, a public joint stock oil company; and Kolmar LLC, a coal mining and processing company. For example, the Startup Expedition program was a 2020 collaborative joint project of the IT park and the Innovations Development Fund, along with Alrosa IT, executed as part of Alrosa's corporate digital transformation via innovative solutions provided by IT park residents.

Direct value creation roles: Risk capital view

The traditional value chain roles defined by Dedehayir et al. (2018) are the supplier, assembler, user, and complementor. The interviewees in the risk capital cluster are financial institutions and

venture funds. The interviewees from risk capital organizations identified their role as value creation, as they provide knowledge, acceleration programs, networking, and financial support.

Venture Company Yakutia focuses on pre-seed and seed investments, networking and education for startups, and connection to investors and business angels. Venture Company Yakutia invests in startups via auction contracts and does not immediately take up shares of the companies. This is in keeping with the rule of the *valley of death* in the startup financing cycle, as 90% of startups typically fail at inception. However, startups typically acquire skills and competencies for further development. Therefore, Venture Company Yakutia organizes educational courses, startup expeditions, and programs to facilitate this growth.

> In addition to funds from venture capital firms and the Ministry of Innovations and Technopark, there are successful entrepreneurs who help develop innovation ecosystems, who have managed to create international businesses: companies like inDriver, MyTona, and Fantastic. Thanks to these companies who have set an example, we have more and more innovation-oriented companies (Person K, Venture Company Yakutia).

Direct value creation roles: entrepreneurs/startups view

Startups as users contribute value to the ecosystem by defining a problem or need, which is the prime trigger and the starting point for the innovation ecosystem genesis. Furthermore, startups as users can be the source of innovative ideas around which ecosystems are created. Startups as users of innovation ecosystems hold a direct value creation role.

By defining the dispositions, the startups shared their position that the government needs to create a platform but should not control the ecosystem and its actors.

> The task of the state is to create the infrastructure, build the IT park, give permission to build a cluster, finance the construction, establish the fast Internet, but not to interfere with the work of startups (Person N, CEO, Medical startup).

Startups emphasize that the role of the state is needed only at the initial stage, and the task of the state is to build infrastructure, platforms, and sites. Subsequently, the state can only hinder the development of innovation through excessive control, reports, and bureaucracy.

The startup interviewees noted that the private sector and government agencies have different perspectives and interests in the development of innovation. Yakutian startups are focused primarily on the global market but are not looking to merge with the central Russian ecosystems. Rather, the goal is to enter the international markets of Europe, Asia, and America.

Value creation support roles: university/ institutional view

Dedehayir et al. (2018) highlight the roles of the "expert" and "champion" as additional roles, which create value as supporting roles by interacting with different partners. According to the literature, the role of the "expert" is associated with actors such as universities and research organizations, which generate knowledge, inventions, and discoveries (Clarysse et al., 2014).

The university cluster, represented by the NEFU, Arctic Innovation Center, and the NEFU student business incubator, OREH, defined their role as a supporting role for creating students' startups and university-based R&I products/services in the pre-seed/seed phase.

> The university accelerator is a seed/pre-seed level testing platform for students who have just started creating MVPs. When they start scaling, they move to the Technopark residence (Person G, Director of the OREH Student Business Incubator).

The role of the university is to transfer knowledge and competencies to young entrepreneurs to help them to proceed from an MVP to acceleration programs and larger ecosystems such as the IT park, Sinet Acceleration, Skolkovo, or Silicon Valley.

> The NEFU is the largest scientific center in the republic. More than 60% of the scientific articles from the republic are published by our employees, and we hold the 15th place in Russia for patenting and support of intellectual property (Person I, Deputy Director of R&I, NEFU).

Entrepreneurial ecosystem roles: Entrepreneurial view

The entrepreneurial ecosystem roles were identified by Dedehayir et al. (2018) as entrepreneur, sponsor, and regulator (the entrepreneur also intermediates between actors conducting research, such as universities, and those aiming to commercialize technologies).

Based on the view of the interviewees, one of the key roles in the innovation ecosystem is played by the Yakutia-born global company, inDriver, which was valued at $1.23 billion (2021) in Silicon Valley and has created acceleration programs to support the northern IT industry. inDriver can serve as an example of a company performing the role of the market-shaping actor, offering a new market proposition in the context of the Yakutia innovation ecosystem.

> inDriver is a ride-hailing company founded in 2012, which is now represented in 34 countries of the world. The company has recently become a "unicorn." Sinet Group launched Begin IT, Spark, and Yakutia2World to support the development of the IT community (Person L, inDriver).

BeginIT is a social and educational project designed to provide career guidance in the field of new technologies to children from orphanages, boarding schools, and rural schools around the globe. SinetSpark, a high-tech development project of Yakutia founded in 2020, is currently testing dome technologies in cold climates and supporting impact projects. Yakutia2World is a development program for technology projects, with an eye to scale these projects internationally.

Summary

Based on this qualitative study, the actors in the Yakutia innovation ecosystem pursue the common goal of shifting from an extraction economy toward a digital economy and the creation of a new jobs market.

The interviewees described specificities of the Yakutia innovation ecosystem: risk tolerance, which is shaped by extreme physical conditions; and a relatively small internal market and export-oriented IT products and services. Regarding the main barriers and challenges to the export-orientation of the IT industry, the experts highlighted bureaucracy and language barriers (interviewees G, H, M, and N).

The specific interests of Yakutian startups are socially oriented. Local startups are mostly embedded in social entrepreneurship projects and impact projects related to ecology, the health of

local peoples, wellbeing, educational technologies, and digitization of native indigenous languages. However, the startups admit that the internal market is small and they need to switch to export-oriented business strategies and pursue larger markets (interviewees M, N, O, and P, startups). The startup interviewees expressed their interest in the Arctic perspective: networking and exploring business opportunities with other Arctic regions and countries and international support for socially oriented projects (interviewees M, N, O, and P, startups). The startups also shared their vision on test sites, which are needed in the North. The extreme physical conditions of Yakutia can serve as a platform for testing cryotechnologies and technologies related to adaptation in the Arctic.

The goals of the ecosystem and the goals of its actors are aligned, but there are certain conflicting interests between the different perspectives represented by the corporations, the government, and startups. Governmental entities are forging partnerships with corporations and are interested in corporations as the key customers of IT products and services. The corporations are looking for solutions and services for the development of their business ecosystems in central hubs such as Skolkovo, or R&I of the foremost universities in Moscow and St. Petersburg. The startups are willing to wield less control over the ecosystem in exchange for governmental structures, more financial support, and less bureaucracy for small startups.

The classification of the roles of the actors by Dedehayir et al. (2018) is relevant in the context of the genesis of the emerging innovation ecosystems in the Arctic. The case study on the Yakutia innovation ecosystem shows that the leadership roles in the genesis process are played by the government and platform management and by forging partnerships with corporations in the Russian Arctic. The direct value creation roles of venture funds, the value supporting roles of universities, and the entrepreneurial ecosystem roles played by the actors building the ecosystem are currently in the pre-seed/seed and MVP phase.

In general, the experts find that startup support tools and priority development areas in the Arctic should be unique, considering the specific conditions of the Arctic and the local peoples building the Arctic innovation ecosystems.

Leadership	Ecosystem leader Ecosystem government: Ministry of Innovations Platform management IT Park Forging partnerships	decipher roles build platform attract and link partners	coordinate interactions. open platform create collaborations	orchestrate resource flows orchestrate stimulate
Direct Value creation	Supplier Venture Company User Startups	define needs	provide ideas	supply components purchase and use
Value support	Expert NEFU, OREH Business Incubator, Arctic Innovation Center	generate knowledge technologies	provide expertise	transfer
Entrep. ecosystem	Entrepreneur Sponsor InDriver Company Mytona Company	co-locate give resources	set up network co-develop offering	link to other actors

Figure 4 Roles and activities across the genesis of the Yakutia innovation ecosystems (based on the 2018 Dedehayir et al. study)

Indigenous actors' role in the Arctic innovation ecosystem

The key organizations in the Yakutia innovation ecosystem are Indigenous led, and the experts and all the interviewees are of Indigenous Sakha and Evenki origins. The specificity of the Arctic regions requires the formulation of a special approach that involves the local Indigenous communities as the key actors in the development of infrastructure from inception. The case of the Yakutia innovation ecosystem can serve as an example of such collaboration in the Arctic.

The interviewees highlighted the importance of cultural codes as Indigenous knowledge that could be introduced into the innovation ecosystem genesis in the Arctic. The main cultural code is the freedom of the Arctic peoples, which may form the essence of the *entrepreneurial spirit*, creative freedom, risk tolerance, and fast adaptation to changing environments. The interviewees discussed the extreme conditions and their unique survival experiences as drivers of their entrepreneurial motivation. However, the interviewees also mentioned "northern closeness" as a mental factor that is beneficial for the development of IT skills and competencies but is also limiting with respect to networking opportunities.

By discussing the impact of innovation ecosystems on Indigenous communities, the CEO of AI Ayana, who is of Evenki origin, mentioned that:

> the peoples will disappear, but the culture in the digital format will remain forever. IT allows culture to be preserved literally across the globe… digitalization is a part of our life, and it is also a basic demand like warmth and light (Person P, CEO, AI startup).

Most of the interviewees agreed that technologies will bring more positive impact than negative impacts, especially in the North. A negative impact that was mentioned was the youth being distracted away from the traditional way of living. However, a CEO of Sakha origin stated:

> traditional culture is not interesting for young people because technologically innovative methods are not used in transfer of knowledge (Person N, CEO, Medical startup).

The primary factors for engendering highly effective collaboration toward building a high-performing innovation ecosystem in the Arctic were defined by the experts as the mission, goals and values, team spirit, and trust between the actors. The republic plans to grow the share of the gross regional product contributed by the creative industry, developing the movie industry and AI, GameDev, healthtech, and impact startups, thus increasing the number of jobs in the creative industries. Yakutia is relying on innovation and technological development to transition from an extraction economy to a digital economy.

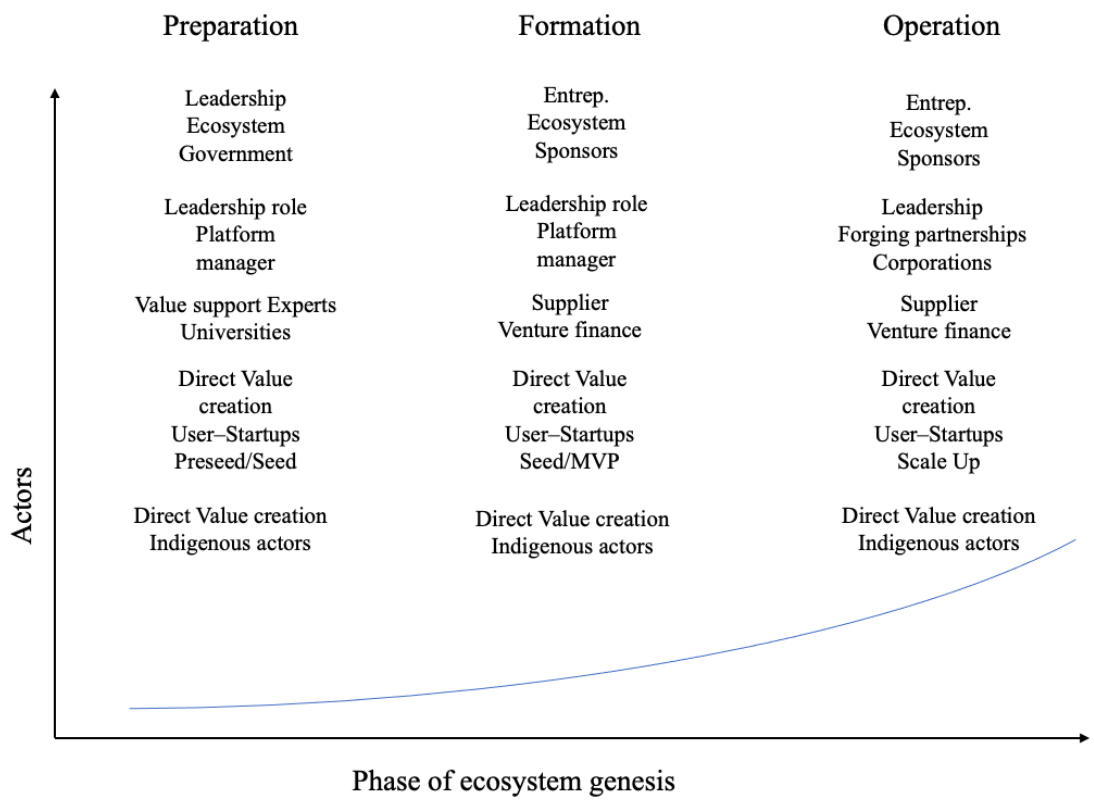

Figure 5. Arctic innovation ecosystem genesis (updated figure based on the 2018 Dedehayir et al. study)

Conclusion and future research

The Arctic innovation ecosystem

The Russian Arctic case study on the Yakutia innovation ecosystem contributes to the discussion on the Arctic innovation ecosystem concept. By engendering highly effective collaboration via platforms built by intergovernmental and international organizations—such as the Northern Forum, the Arctic Council, and research platform centers like the Snowflake International Arctic Station—Arctic countries and their regions could benefit immensely from collaboration in the fields of innovation and technology.

The Arctic innovation ecosystem could benefit from research on the roles of its actor, actor engagement, and strategies related to engendering effective collaboration using the ecosystem approach. The analytical border of an ecosystem is the product/service system, which is not limited by national borders, regional clusters, or contract relations (Tsujimoto et al., 2018). Therefore, engendering highly effective collaboration toward building a high-performing innovation ecosystem using the Arctic perspective could be beneficial not only for business, research, and policy actualization, but also for the local peoples and indigenous communities. The Arctic innovation ecosystem perspective holds great significance and potential for application toward benefiting the Arctic communities and their economies, and for the transition from an extraction economy to a digital economy. As expressed by one of the interviewees:

> It is necessary to take into account the common problems of the Arctic and exchange experiences. Technology is the best tool for collaboration. The Internet

> shortens distance. Common Arctic problems are the factor for collaboration (Person P, AI startup).

By elucidating the Arctic perspective and through the case study, this research argues that building high-performing innovation ecosystems may lead to digital and economic transformations that produce more sustainable and resilient societies in the Arctic. The goal of this study is to provide an answer to its research question and achieve the aim stated in the introduction. Regarding the research question: who are the key actors in the genesis of the Arctic innovation ecosystem? The research clarifies the roles of the actors in the genesis (birth phase) of the innovation ecosystem in the Arctic regions based on a case study on the Yakutia innovation ecosystem and a theoretical background on the ecosystems approach, multi-actor networks, and the role of the actors in innovation ecosystems. The study attempts to frame the role of the key actors and their dispositions during the genesis of the Arctic innovation ecosystem (Figure 5).

In the context of ecosystems research, the key debates are on the issues of building innovation ecosystems, value creation and co-creation for the actors in the innovation ecosystems, and building platforms for these organizational networks. Future research could examine emerging themes in ecosystems research such as actor engagement, human-machine interaction as an independent actor, multi-actor networks, digital platform development, platform ecosystems research, and the integration of the ecosystem perspective into research areas such as environmental sustainability and circular economy—specifically in the context of the Arctic.

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Appendix 1

Questions

1) What is your organization's role in the development of the innovation ecosystem in Yakutia?
2) Who are the key actors in the Yakutia innovation ecosystem?
3) Please define and draw the key actors, key actors' groups and their relationships within innovation ecosystem?
4) How do the roles of companies/organizations differ in the innovation ecosystem?
5) How do you collaborate with other actors in the innovation ecosystem?
6) What do you think helps to achieve effective collaboration?
7) How do you define your own goals regarding the ecosystem?
8) How are the ecosystem goals defined?
9) Are the ecosystem goals and actor goals aligned, conflicts?
10) Do you use informal personal networks?
11) What is your experience with the indigenous heritage projects?
12) What indigenous knowledge would you incorporate into the innovation ecosystem genesis in the Arctic?
13) How does the Yakutia innovation ecosystem differ from other ecosystems and networks? What is unique to the innovation ecosystem in Yakutia?
14) What do you find unique about building innovation ecosystems in the Arctic?
15) What factors, in your opinion, help to engender highly effective collaboration toward building a high-performing innovation ecosystem in the Arctic?
16) What are the main barriers and challenges to building the innovation ecosystem?
17) Why are companies/organizations struggling to innovate effectively?
18) What are the key benefits that innovation ecosystems can offer?
19) What positive social impact could come from the innovation ecosystems in the Arctic?
20) How will the development of robotics, AI, and IoT affect companies, societies, and local communities in the Arctic?