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Mikhail Nazarov, Nadezhda Butryumova, Sergey Aleksandrovskiy, Dmitry Sidorov

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Mikhail Nazarov* and Nadezhda Butryumova

Faculty of Management,
Venture Management Department,
HSE University,
Bolshaya Pecherskaya 25, 603000, Nizhny Novgorod, Russia
Email: mgnazarov@hse.ru
Email: nbutrymova@hse.ru
*Corresponding author

Sergey Aleksandrovskiy

Faculty of Management,
Marketing Department,
HSE University,
Bolshaya Pecherskaya 25, 603000, Nizhny Novgorod, Russia
Email: saleksandrovskiy@hse.ru

Dmitry Sidorov

Faculty of Management,
Venture Management Department,
HSE University,
Bolshaya Pecherskaya 25, 603000, Nizhny Novgorod, Russia
Email: dsidorov@hse.ru

Abstract: The paper addresses the question of how technologically entrepreneurial companies co-evolve with the entrepreneurial ecosystem in the context of transforming economy and emerging of new institutions. Employing a co-evolutionary approach and a case study design, we have studied 15 technology enterprises established in the Russian region in the 1990s, 2000s, and 2010s. As a result, we have found out about two types of entrepreneurs: 1) "Wild entrepreneurs," more typical for the early stages of transition, are independent and rely on informal institutions; and 2) "Tamed entrepreneurs" become more common during the transition progresses, prefer a clear and developed formal institutional environment. Also, we have discovered that the entrepreneurial ecosystem dynamics are a joint outcome of entrepreneurs' intentionality, environment, and institutional effects. Premature formalisation of institutes in conditions of weak informal institutions may lead to a growing dependence of entrepreneurs and their businesses on an increasingly rigid environment, and thus to the generation of weaker entrepreneurs.

Keywords: entrepreneurial ecosystem; technology entrepreneurship; transforming economy; co-evolution; Russia.

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Biographical notes: Mikhail Nazarov is an Associate Professor at the National Research University Higher School of Economics, Russia. His primary research interests are in the areas of innovations, entrepreneurship and entrepreneurship ecosystems, and family business. He has more than 10 years of teaching experience in innovation and entrepreneurship. He took part in several research projects as Legal Obstacles to Innovation Entrepreneurship in Russia, Evolution of technology entrepreneurship in the Nizhny Novgorod region, STEP 2019.

Nadezhda Butryumova is an Associate Professor at the National Research University Higher School of Economics, Russia. She has more than 10 years of teaching experience in innovation and entrepreneurship. Her primary research interests are in the areas of commercialisation of innovations, entrepreneurial ecosystems and innovation infrastructure, technological entrepreneurship and startups, entrepreneurship education. She has conference proceedings in the sphere of technological entrepreneurship, publications in leading Russian journals (such as The Moscow University Economics Bulletin, the journal Vestnik of Saint Petersburg University. Management, Innovations, Regional Economics: Theory and Practice and etc.) and in the *Journal of Technology Management and Innovation*. She took part in such research projects as Legal Obstacles to Innovation Entrepreneurship in Russia, Evolution of technology entrepreneurship in the Nizhny Novgorod region, Obstacles to innovation entrepreneurship development in Nizhny Novgorod Region, Study of Schoolchildren Entrepreneurial Intentions and Activities in Nizhny Novgorod.

Sergey Aleksandrovskiy is an Associate Professor at the National Research University Higher School of Economics, Russia. His primary research interests are in the areas of innovations research, entrepreneurship and marketing. His research publications have appeared in *Int'l Journal of Internet Marketing and Advertising, Int'l Journal of Business Innovation and Research*.

Dmitry Sidorov is a Senior Lecturer at Venture management Department of National Research University Higher School of Economics, Russia. He has more than 10 years of teaching experience in innovation and entrepreneurship. His primary research interests are in the areas of commercialisation of innovations, entrepreneurial ecosystems and innovation infrastructure, technological entrepreneurship and startups, startups' teams formation. He has years of practical experience in the hi-tech startup management as well as entrepreneurial ecosystem development.

1 Introduction

The importance of technological entrepreneurship cannot be underestimated for the economic growth, differentiation and acquisition of the competitive advantage both at the company level and at the level of the region and country (Bailetti, 2012; Bruton and Rubanik, 1997; Li et al., 2006; Venkataraman, 2004). Despite the fact that there are a lot of papers, devoted to different aspects of technological entrepreneurship development,

most of which consider this phenomenon in the context of stable developed economies, the specifics of technology entrepreneurship in transforming economies is still under-represented (Bruton and Rubanik, 1997, 2002; Etzkowitz, 2000; Lau and Bruton, 2011; Tchalakov et al., 2010).

Nowadays the entrepreneurship development is considered through the ecosystem approach. However, despite the growing popularity of the concept of an entrepreneurial ecosystem, this approach has, at the moment, a number of shortcomings (Alvedalen and Boschma, 2017; Audretsch et al., 2018; Spigel, 2017). Alvedalen and Boschma (2017) conducts a critical analysis of studies in entrepreneurial ecosystems and highlights a number of areas for further research. Among other things the authors point to the lack of research aimed at studying the role of institutions in the development of entrepreneurial ecosystems, as well as the lack of understanding of how ecosystems originate and develop. Spigel and Harrison (2018) urge other researchers to investigate how entrepreneurs collect resources and support from an ecosystem, depending on the industry and stages of development. Thus, it can be concluded that there is a theoretical gap in the understanding of how entrepreneurial companies co-evolve with the entrepreneurial ecosystem, especially in the context of transforming economy and emerging of new institutions.

Transforming economies differ from developed ones by a set of institutions and very volatile conditions (He, 2009). Transition is usually characterised by the situation when former institutions are weak or do not work, and new institutions have not been established yet. In such conditions society relies on informal institutions which, to some extent, substitute the lack of governmental support and functions (formal institutions). Estrin and Mickiewicz (2011) argue that informal institutions, including attitudes and social norms, play a significant role in nascent entrepreneurship in transforming economies of the former Soviet Union.

But with time in attempts to catch up with developed economies government may be tempted to force the creation of formal institutions or to substitute the lack of informal institutions with governmental functions and services. This can undermine the development of entrepreneurship in the long term. For example, Chepurenko et al. (2017) found out that increased access to cheap credits for the established SME might lead to the decrease of entrepreneurial activity in the respective region.

That is why it is important to learn how technological entrepreneurs and entrepreneurship ecosystem co-evolve in the context of transforming economies, and how informal and formal institutions affect their development, what strategies technological entrepreneurs exploit and how these strategies change as the environment develops.

Summing up, entrepreneurship is usually viewed through the prism of ecosystems, predominantly in developed economies (Acs et al., 2017; Moore, 1993; Spigel and Harrison, 2018; Tsujimoto et al., 2018). That is to develop entrepreneurship an economy needs to support an entrepreneurship ecosystem. The needed institutions shall be born in the process of the dialogue between entrepreneurs and the government. However, in a transforming economy the formation of entrepreneurship ecosystems happens spontaneously, the government is weak, so the main role is played by informal institutions. Later on the state gains strength and begins to intensively establish formal institutions, unrelated to the established informal institutions. That is why, it is not clear, how this statement and formalisation of institutions can affect the development of the entrepreneurial ecosystem and technological entrepreneurship. We suggest that this study

can provide new insights and understanding of entrepreneurial processes associated with Russian and transforming economies in general.

In this paper we address the theoretical gap in the understanding of how technological entrepreneurial companies co-evolve with the entrepreneurial ecosystem in the context of transforming economy and emerging of new institutions. The main question of the research is "How do technological entrepreneurs co-evolve with the entrepreneurial ecosystem in transforming economy?"

The paper makes the following contributions to the existing literature. The first one is that it attempts to analyse entrepreneurial ecosystem dynamics through the prism of the co-evolutionary approach. By doing so it links the entrepreneurship ecosystem literature with the research on new organisational forms of co-evolution, and with our knowledge, this is one of the first papers attempting to do this conceptually and empirically. Our results develop the theory of entrepreneurial ecosystems in the part of the role of institutions in the development of entrepreneurial ecosystems. In response to the call by Alvedalen and Boschma (2017) we show that entrepreneurial ecosystem dynamics is a joint outcome of entrepreneurs' intentionality, environment, and institutional effects. We also show that premature formalisation of institutes in conditions of weak informal institutions may lead to a growing dependence of entrepreneurs and their business on an increasingly rigid environment, and thus to the generation of weaker entrepreneurs. Such entrepreneurs are less inclined to develop informal institutions, what triggers further strengthening of formal institutions, and drives the process of entrepreneurial ecosystem co-evolution of the transition economy further away from its counterparts in developed economies.

The paper has the following structure. Firstly, we review the existing literature (see brief characteristics in Table 1) that links entrepreneurial ecosystems with institutions and co-evolution and develops a conceptual model. In this section, we also derive some assumption about the interaction between entrepreneurial ecosystems and technological entrepreneurs and the dynamics of it. Then the methodology of the research is presented and justified. Section 3 provides the results of cases' analysis, which are discussed afterwards. The last section provides conclusions and links some of the results with what others have found in literature and how it could fit into the future agenda of the entrepreneurial ecosystems research.

2 Theoretical background

All the studied literature was systemised into two main topics: Transforming economy and institutions, and co-evolution of entrepreneurial ecosystems and technology entrepreneurship in the context of transforming economy. Main characteristics of each paper are presented in Table 1.

2.1 Transforming economy and institutions

Transforming economies have a different set of institutions and very volatile conditions compared to developed economies (He, 2009). It affects the process of entrepreneurship ecosystem formation and evolution and makes the difference between transforming and developed economies. One of the main peculiarities of economy in transition is weak governance. It affects the policy, legal environment for entrepreneurship, tax system, financial system, IP protection, support infrastructure and etc.

Table 1 Literature on entrepreneurship ecosystem and technological entrepreneurship development

Topic	*Research theme*	*Author*	*Type*	*Countries involved*	*Major results/explanatory power*
Transforming economy and institutions	Development of entrepreneurship in transforming economy	He (2009)	Qualitative/ quantitative	China	The analysis is based on a novel set of data stemming from seven nation-wide random sampling surveys (1993–2006) spanning the provincial, city, county, town, and village levels across several industry sectors. Number of valid questionnaires returned is varied from 1171 to 3258 from year to year. Analysis reveals unique features of the business environment as well as novel entrepreneurial behaviours under a transitional economy where political uncertainty, nonexistent private property rights, and underdeveloped financial markets are commonplace rather than an exception. Author found out unique strategic behaviours and business models of entrepreneurs in emerging markets and/or transitional economies
	Institutions and entrepreneurship development	Sine and David (2003)	Qualitative	The US	Based on historical analysis and case study, authors conclude that environmental jolts mobilise actors to reformulate institutions, resulting in increased entrepreneurial opportunity. Environmental jolts catalyse search processes and motivate the evaluation of current institutional logics
	Property Rights, Deregulation, and Entrepreneurial Development in a Transforming Economy	Zhou (2017)	Quantitative	China	This paper investigates the relative roles of formal property rights institutions vs. deregulated markets in entrepreneurial development, based on China's market transition. Using provincial-level panel data from China's transition economy (nine-year period, from 1998 to 2006.). This study has the following findings: On average, both formal protection of property rights and deregulated markets have positive effects on entrepreneurial development; yet, as market transition progresses, the effect of formal protection of property rights increases, while that of deregulated markets decreases. Effect size is calculated and discussed. These results are robust to both multiple model specifications and an endogeneity test using an instrumental variable approach

Table 1 Literature on entrepreneurship ecosystem and technological entrepreneurship development (continued)

Topic	*Research theme*	*Author*	*Type*	*Countries involved*	*Major results/explanatory power*
Transforming economy and institutions	Institutions and entrepreneurship development	Djankovet al. (2006)	Quantitative	135 countries	Using objective measures of business regulations in 135 countries (the Doing Business database of World Bank), authors establish that countries with better regulations grow faster. Improving from the worst quartile of business regulations to the best implies a 2.3% point increase in annual growth. Effect size is calculated and discussed
	Institutions and entrepreneurship development	Aidis et al. (2008)	Quantitative	GEM countries, in particular Russia, Poland, Brazil	Research is based on the Global Entrepreneurship Monitor's (GEM) dataset collected in 2001–2005, which rely on stratified samples of at least 2000 individuals per country. Authors concluded that Russia 's institutional environment is important in explaining its relatively low levels of entrepreneurship development, where the latter is measured in terms of both number of start-ups and of existing business owners. In addition, Russia's business environment and its consequences for the role of business networks contribute to the relative advantage of entrepreneurial insiders (those already in business) to entrepreneurial outsiders (newcomers) in terms of new business start-ups. Probit model is used, parameters calculated and discussed
	Institutions and entrepreneurship development	Puffer et al. (2010)	Qualitative	Russia, China	Authors develop a rationale of how three institutions affect entrepreneurs in Russia and China—the frailty of private property as a formal institution, and the heavy reliance upon two informal institutions, trust within networks, and the use of blat and guanxi in Russia and China, respectively. Full convergence toward entrepreneurs' reliance on formal institutions may not readily occur in countries like Russia and China due to the embeddedness of informal institutions

Table 1 Literature on entrepreneurship ecosystem and technological entrepreneurship development (continued)

Topic	*Research theme*	*Author*	*Type*	*Countries involved*	*Major results/explanatory power*
Entrepreneurship ecosystem development	Coherent ecosystem design	Tsujimoto et al. (2018)	Conceptual	n/a	This paper provides an overview of 90 previous studies using the ecosystem concept in this field, all published in leading academic journals, and clarifies their four major research streams. As a result of the review, this study presents an integrated model of the existing literature. Furthermore, this paper proposes original definitions of the ecosystem and the concept of a coherent ecosystem. This coherency is the core concept underlying the explanation of the dynamic evolution or extinction of the ecosystem
	Institutions, entrepreneurship and growth: the role of nationalentrepreneurial ecosystems	Acs et al. (2017)	Quantitative	46 countries	Based on data from a representative global survey and institutional sources for 46 counties over the period 2002–2011, authors found support for the independent impact of institutions as well as for the role of the ecosystem in less developed economies. Authors explore empirically the relationship between economic growth, factor inputs, institutions, and entrepreneurship: whether entrepreneurship and institutions, either independently or in combination in an ecosystem, represent the 'missing link' in explaining cross country differences in productivity. Authors introduce a new concept: namely National Entrepreneurial Ecosystem that is based on a methodology that combines institutions and human agency into an interdependent system of complementarities. They argue that entrepreneurship operating in particular institutional contexts, perhaps via the National Entrepreneurial Ecosystem, impacts efficiency which measures how effectively given technology and factors of production are actually used

Table 1 Literature on entrepreneurship ecosystem and technological entrepreneurship development (continued)

Topic	*Research theme*	*Author*	*Type*	*Countries involved*	*Major results/explanatory power*
Entrepreneurship ecosystem development	Co-evolution of entrepreneurial ecosystem	Spigel and Harrison(2018)	Conceptual	n/a	Authors develops a process perspective on EE, in which ecosystems are viewed as ongoing processes of the development and flow of entrepreneurial resources such as human and financial capital, entrepreneurial know-how, market knowledge, and cultural attitudes. The presence and circulation of these resources helps explain how ecosystems evolve and transform over time and allows to distinguish between strong, well-functioning ecosystems and weaker, poorly functioning ones. Also authors show that a process perspective on ecosystems provides a more nuanced approach to how ecosystems operate and influence the entrepreneurship process, which can lead to more effective policy interventions
	Entrepreneurial ecosystems	Mason and Brown (2014)	Conceptual	n/a	Authors introduce the entrepreneurial ecosystem definition, and discuss different concepts of entrepreneurial ecosystems. The dynamic nature model of entrepreneurial ecosystems was considered. Authors discuss metrics for the entrepreneurial ecosystems measurement
	Entrepreneurial ecosystems research	Alvedalen and Boschma (2017)	Conceptual/ qualitative	n/a	The entrepreneurial ecosystem literature is discussed. A number of concept shortcomings reviled. Authors make a number of suggestions to take up in future research on EE for each of these shortcomings: 1, The network literature has the potential to enrich the EE-concept both in theoretical and analytical terms. 2, To integrate institutions more deeply in the EE literature. It means to include a dynamic perspective on institutions in EE (focus on institutional change; focus on institutional entrepreneurship at the micro-level; emphasis on institutions that question and block institutional change, and prevent regions to turn into dynamic EE). 3, To use an evolutionary perspective that accounts for the evolution of EE in order to compare different EE in their evolution and performance over time: which mechanisms makes EE move from one stage to another, and which different types of connections

Table 1 Literature on entrepreneurship ecosystem and technological entrepreneurship development (continued)

Topic	*Research theme*	*Author*	*Type*	*Countries involved*	*Major results/explanatory power*
Entrepreneurship ecosystem development	Entrepreneurial ecosystems	Audretsch et al. (2018)	Conceptual	n/a	Authors critically reflect on the usage of the term 'ecosystem', briefly summarise the extant literature and grasp the main features of entrepreneurial ecosystems, namely the economic, technological, and societal dimensions of entrepreneurial ecosystems. They focus on the key elements that characterise an ecosystem, and hence, untangle under what conditions entrepreneurial firms shape and influence economic, technological, and societal thinking within their ecosystem
	Entrepreneurial ecosystems	Spigel (2017)	Qualitative	Waterloo, Ontario, and Calgary, Alberta, Canada	The paper argues that ecosystems are composed of 10 cultural, social, and material attributes that provide benefits and resources to entrepreneurs and that the relationships between these attributes reproduce the ecosystem. This model is illustrated with case studies of Waterloo, Ontario, and Calgary, Alberta, Canada. The cases demonstrate the variety of different configurations that ecosystems can take
	Evolutionary framework of entrepreneurial ecosystems	Mack and Meyer	Conceptual/ qualitative	The US	An evolutionary framework of entrepreneurial ecosystems development is offered that integrates important components from prior work and describes how critical elements of an entrepreneurial system interact and evolve over time. The framework is demonstrated by profiling the entrepreneurial ecosystems of Phoenix, Arizona
	Entrepreneurship in transforming economies	Manevand Manolova (2010)	Qualitative	n/a	The paper maps research on entrepreneurship in transitional economies since the start of institutional reforms. Data came from 129 academic journal papers published between 1990 and 2009

Sine and David (2003) in their paper state that institutional environment change, crisis and other economic phenomena strongly affect and increase entrepreneurial opportunities. Authors consider that a stable institutional environment strongly discourages the entrepreneurial activity. Changes create shocks and prerequisites for the entrepreneurial opportunities, they catalyse the subsequent actions. In crisis institutional actors search causes of the crisis situation and ways of solving the problems. These circumstances give entrepreneurs the incentive to act.

Weak governance and transforming institutions have ambivalent effect on the development of entrepreneurship and its ecosystem. On the one hand it can impede development of entrepreneurship and foster growth of shadow economy, because long-term partnerships cannot be established, the level of trust is low due to weak institutions. In such circumstances entrepreneurs are forced to spend more resources to protect their assets and rely primarily on their own resources and capabilities.

On the other hand, there is some evidence (Zhou, 2017) that at early stages of transition weak governance and deregulation provide growth of private entrepreneurship. The deregulation influences market development and removal of hostile policies (Djankov et al., 2006).

The uniqueness of the context of transforming economies originates from the ambiguity of institutional reforms. The process starts with total institutional reforms, what leads to the opposite consequences. On the one hand institutional reforms have made entrepreneurial endeavours possible. On the other hand an institutional hiatus has severely constrained the entry and growth of new and small firms (Manev and Manolova, 2010). Also transformation is usually characterised by not well established private property laws and rights (He, 2009). Moreover, ownership and resources take on a different meaning, as initially the government owns every resource, and it is necessary to maximise social resources and leverage constrained ownership in order to engage in entrepreneurial activities. In contrast with material and financial resource constraints, the development of human capital in transforming (mostly post socialism) economies was relatively high (Manev and Manolova, 2010).

In the papers dedicated to Russia (Aidis et al., 2008; Chepurenko, 2014; Puffer et al., 2010), there are some findings: poor entrepreneurial development can be explained by the prematurity of their institution environments; in such circumstances entrepreneurs with well-developed personal networks are more successful overall.

2.2 Co-evolution of entrepreneurial ecosystems and technology entrepreneurship in the context of transforming economy

At the moment the development of entrepreneurship is usually viewed through the prism of the concept of an ‘entrepreneurial ecosystem’ (Acs et al., 2017; Moore, 1993; Spigel and Harrison, 2018; Tsujimoto et al., 2018). Since its introduction in 1990-s (Moore, 1993, 1996), the concept has gained huge popularity (Acs et al., 2017; Spigel and Harrison, 2018; Tsujimoto et al., 2018) and has been developed in works of different authors (Cohen, 2006; Fritsch and Franke, 2004; Neck et al., 2004; Van De Ven, 1993).

Mason and Brown (2014, p.5) proposed their definition of the entrepreneurial ecosystem as

> "a set of interconnected entrepreneurial actors (both potential and existing), entrepreneurial organizations (e.g., firms, venture capitalists, business angels, banks), institutions (universities, public sector agencies, financial bodies) and entrepreneurial processes (e.g., the business birth rate, numbers of high growth firms, levels of 'blockbuster entrepreneurship', number of serial entrepreneurs, degree of sellout mentality within firms and levels of entrepreneurial ambition) which formally and informally unite to connect, mediate and govern the performance within the local entrepreneurial environment."

There are several attempts to consider the dynamics of the formation of the entrepreneurial ecosystem (Mack and Mayer, 2016; Mason and Brown, 2014; Spigel and Harrison, 2018). Researchers consider the process of an entrepreneurial ecosystem formation as a self-reinforcing process, when an ecosystem strengthens through the entrepreneurial success, new resources creation, the up-skilling of companies and the workforce, and the formation of new organisations. These approaches to the description of the dynamics of the formation of an entrepreneurial ecosystem are of high value, but are carried out and supported predominantly by the examples of developed economies (USA, Canada, UK, etc.)

Mason and Brown (2014) pointed to the need for 'fertile soil' in the region where an entrepreneurial ecosystem could develop. According to the authors, this fertile soil is formed by large knowledge institutions that attract talents from other regions. Further necessary elements are organisations that perform the function of incubation of entrepreneurs. At the same time, the authors point out that this role is better fulfilled by companies that operate in the market, rather than state-funded structures that are not exposed to the market. Then in the presence of a trigger factor the process of forming spin-off companies begins which is self-reinforcing and which leads to the formation of an ecosystem. As the spin-off movement develops, institutions that support the development of entrepreneurship, including venture funds, begin to develop.

Spigel and Harrison (2018) consider an entrepreneurial ecosystem as dense networks between entrepreneurs, investors, advisors, and other key actors that are based on the long-term trust and a localised culture that encourages networking and connecting, which support the flow of resources within the ecosystem, making it easier for entrepreneurs to approach them. A nascent ecosystem develops through the entrepreneurial success, which leads to the establishment of new bonds among actors, new resources creation or attraction from other regions and the formation of new organisations. Over time entrepreneurial culture hardens and helps to attract more resources, entrepreneurs and workers to the ecosystem. From the authors' point of view, density of networks and the flow of resources in the ecosystem are the most important success factors. The authors point out that some economic shocks or culture shifts can weaken an ecosystem in the result of the significant outflow of entrepreneurial resources and loss of connection. The lack of trust, caused by the lack of time to invest in creating a strong community of entrepreneurs, leads to limited resources.

The question of how the offered model fits to describe the dynamics of the entrepreneurial ecosystem formation in transforming economies remains open. We see the following differences in the premises. Firstly, in transforming economies the presence of 'fertile soil' is possible, i.e., knowledge institutions exist, but they are not so attractive, also there may not be such an anchor organisation that has a great experience of interacting with the market and leads entrepreneurship development. In transforming economies, especially in the period of the radical transition from a planned to a market

economy, the main source of entrepreneurship is necessity-based entrepreneurship (Bosma et al., 2009; Manev and Manolova, 2010). At the same time necessity-based entrepreneurs as a rule choose the trade industry, where you can expect a quick return on investment rather than technology sphere. Thus the proposed models (Mack and Mayer, 2016; Mason and Brown, 2014; Spigel and Harrison, 2018) are valid for established market economies, but poorly fit in for the explanation of entrepreneurial ecosystems emergency in transforming economies where the very phenomenon of entrepreneurship and entrepreneurial culture is only emerging.

Based on the literature review the main characteristics of which are presented in Table 1, we can make an assumption concerning the entrepreneurship ecosystem co-evolution. The formation of an entrepreneurial ecosystem and the development of technological entrepreneurship in a transforming economy begin with the total change in institutions because of the transition to a market economy. The collapse of institutions leads to the release of resources (primarily material and technical) and creates a huge number of entrepreneurial opportunities. The first technology businesses begin to utilise the released resources of the collapsing research and industrial cluster in a 'wild market' environment. At this stage technology businesses use a niche strategy and rely on informal institutions such as network of personal connections to protect the business and ensure competitiveness. With the formation and strengthening of new formal institutions the role of the initial released resources of the decaying science and industry cluster weakens, as well as the role of informal institutions. The main source of technology becomes one's own development focused on market needs. In the context of globalisation and penetration of foreign competitors, technology businesses continue to use niche strategies, focus on customer needs and use less resource-intensive technologies in the conditions of inconsistent and fragmented entrepreneurship policy. However, we suppose that new generations of technological entrepreneurs rely more on formal institutions rather than informal ones, as it is easier to acquire. This shift of focus from informal institutions to formal ones might weaken an entrepreneurship ecosystem, as it requires dense network of participants. This density predominantly could be reached by informal interactions and institutions.

3 Method

3.1 Research design

We applied a qualitative research design – case study. Case study helps to understand the process of development of local companies from different angles such as founders and official statistics (Marshall and Rossman, 2016; Yin, 2009) and to explore context-sensitive explanations in Russia-like other transforming economies where contextualisation of research design is necessary and desirable (Eisenhardt and Graebner, 2007; Tsui, 2006).

The focus of this research is on conditions in which Russian technology entrepreneurs from different generations survived and developed their business. We employed a comparative case study approach that helps to conceptualise the examined entrepreneurial processes.

The main research question is "how do technological entrepreneurs co-evolve with the entrepreneurial ecosystem in transforming economy?" In order to answer it we used

questionnaires developed for similar studies in other countries (ANDE, 2013; Bosma et al., 2008).

For understanding the external environment and business climate for entrepreneurship in the studied region we combined questions of the expert interview from the GEM (global entrepreneur monitor) research (Bosma et al., 2008) and the question of Aspen approach to the entrepreneurial ecosystem assessment (ANDE, 2013).

Research on entrepreneurial ecosystems emphasises the need for a multi-dimensional approach to measurement. It means that we should take into account all the various domains that can affect entrepreneurship in a particular region. In the previous study (ANDE, 2013) the authors compared Entrepreneurial Ecosystem Assessment Frameworks. They evaluated nine approaches including OECD, World Economic Forum and etc. Two domains, each occurred in only one of these approaches. So these approaches were excluded by the authors (ANDE, 2013). The final list contained eight domains from seven approaches. We used this list of domains in our research design:

- *Finance*. Access to banks loans, development of venture capital market, activity of angel investors, government grants and special foundations, activity of microfinance institutions, existence of Public Capital Markets.
- *Support*. Existence of support infrastructure: business-incubators, techno parks, business-accelerators. Access to special services such as legal services, accounting services, technical experts, and mentors. Access to different professional associations and networks.
- *Policy*. National and regional government policy of entrepreneurship; tax rates and incentives for innovation companies and for young entrepreneurs; government support programs for small business and entrepreneurship development costs to start up a business.
- *Markets*. Activity of domestic and international corporations, demand for high technologies; level of competition and barriers to market entry, free niches and a number of market opportunities.
- *Human Capital*. Access to human capital: high qualified personnel, engineers, economists and managers. Quality of higher education: educational programs adapted to the new economy.
- *Infrastructure*. Access to main resources such as electricity, gas, water; access to the transport infrastructure; level of development of communications (mobile, internet).
- *Research and Development*. Activity of public and private research centers and laboratories; patenting system and IP protection.
- *Culture*. Motivation to become technological entrepreneurs; the attitude of the society to technological entrepreneurship; activity of social and professional associations and networks.

We combined designs of the GEM research (Bosma et al., 2008) and the Aspen approach to the entrepreneurial ecosystem assessment (ANDE, 2013). We applied research domains from these studies. These studies contained a Culture domain which explored motivation to become technological entrepreneurs, the attitude of the society to technological entrepreneurship, and activity of social and professional associations and

networks. Culture domain examines the underlying business culture (attitude and activity) in the region and how this culture shapes motivation to become an entrepreneur. We named Culture domain as it was in the previous study.

It is noted in the previous study (ANDE, 2013) that domains are not a rigid classification. It was designed to help development agencies to prioritise domains and understand the extent to which entrepreneurial growth can be attributed to the program in a specific domain. So we can choose a different name for the Culture domain in future studies.

Culture can be seen as informal institutions related to entrepreneurship (Bosma et al., 2008). Other domains can be seen as formal institutions (Kaufmann et al., 2018).

For understanding internal factors of technological entrepreneurship development in the region we examined such internal parameters as motivation to the entrepreneurial activity in the technological sphere, sources of ideas and innovations, knowledge and competences, resourcing and business development strategy (Bruton and Rubanik, 1997).

We followed the recommendations for context and research design in qualitative scholarship in transforming economies (Plakoyiannaki et al., 2019). We collected data from companies we know. Personal relationships help to unpack in-depth motives and insights of respondents. The topic of the research was attractive to respondents so we easily recruited samples. We also used multiple data sources for the better understanding of the studied entrepreneurs (Yin, 2009). We matched words from interviews with secondary data from official statistics. We conducted interviews in the Russian language. All members of the research team got experience in academic and practice research. Our in-depth knowledge of local context and history of the studied companies along with research experience helped to arrange informal conversation with respondents. We did not exclude any explanation from transcripts.

3.2 Context

We explained the research output in relation to the context of Russia. Scholars criticised transforming economies studies for ignoring context or relying on theories and methods designed in Western context or lacking context-sensitive explanations (Jia et al., 2012). Scholars use context to inform the research questions of the study, develop local theories, and explain local phenomena. Such approach helps scholars to consider whether theoretical assumptions developed in a specific context (contextualisation) are transferable to other contexts (generalisation) (Tsui, 2004).

Transforming economies have their own context that affects the entrepreneurial ecosystem formation and creates conditions for technology entrepreneurship development.

The history of Russian entrepreneurship in the market economy started in 1989 when we could see the first steps of transformation. From 1990 to 2000 a new legal and institutional framework for entrepreneurship was established in Russia (Ageev et al., 1995; Astrakhan and Chepurenko, 2003; Chepurenko, 2001). In the beginning of 1990s startups faced lack of resources and support infrastructure for small business. Interventionist approach of the government policy dominated the first (1994–1995) and the second (1996–1997) federal programs of state support for small business (Astrakhan and Chepurenko, 2003; Chepurenko, 2001). At that period the government policy in the area of small business was focused on consulting, information and financial support including local tax exemptions. Continuous changes and reshuffles provoked instability

in government policy and support of entrepreneurship. As for potential of technological entrepreneurship, during that period the main goal of the policy in science and technology was to ensure the survival of Russian science in crisis (Klochikhin, 2012). So a lot of high educated employees decided to start their own technological businesses.

The first wave of high entrepreneurial activity stopped in 1993, after that the number of businesses stabilised at a relatively low level (Radaev and World Institute for Development Economics Research, 2001). The business model of the majority of startups at that period in Russia were focused on the local needs service, but not on the real business development (Aidis et al., 2008; Radaev and World Institute for Development Economics Research., 2001). The first wave of entrepreneurs faced some difficulties in the new economy, such as lack of managerial competencies (Hisrich and Grachev, 1993), counterbalance the hostile environment and deal with the informal economy (Kihlgren, 2003; Kuznetsov et al., 2000; Zhuplev and Shtykhno, 2009). The poor effect made by support programs of entrepreneurs was caused by macroeconomic and political risks, weak monitoring of previous programs results and corruption. After financial crisis of 1998 the government declared a new program of creating favourable conditions for small enterprises including regulatory and legal support, development of new financial technologies and international cooperation, and bringing foreign investment to Russian small businesses (Chepurenko, 2001).

From the mid-2000s the government started the development of the innovation system in Russia (Ivanov, 2011). The government launched a range of supporting organisations (business incubators, technoparks, etc.) and the Russian Venture Corporation to stimulate the technological business (Klochikhin, 2012). The policy in the area of small business support at that period was focused on indirect tools such as reducing red tape and decreasing the costs of entry and administration of business. In 2009 the new federal law allowed universities and scientific institutions to set small innovative companies ('Federal Law No 217-FZ', 2009). More over government policy of small business development started supporting small innovation business and startups through access to resources, development of expertise, and support in entering new markets (Chepurenko, 2011). At the same time at that period we could see that personal connections played a vital role in bureaucratic procedures; tax inspections created a lot of problems for entrepreneurs; entrepreneurs felt a tougher competition (CEFIR, 2007). An economic crisis period in 2008–2010 also negatively affected the entrepreneurship activity in Russia. Despite this a lot of current 'gazelles' (including manufactures, IT and business services) were set up in that period. Gazelles accounted for 12–15% of the total number of active ventures in Russia in the mid-2000s (Yudanov, 2008). Several authors expressed concerns about implementing the innovation policy and its inconsistency (Butryumova et al., 2016). It provokes instability and arbitrary bureaucratic intervention (Aidis et al., 2008; Chadee and Roxas, 2013). Such factors as weak institutions and law, ad hoc enforcement of regulations, regional autonomy, property rights and corruption restrain entrepreneurship in Russia (Aidis and Adachi, 2007; Szerb and Trumbull, 2018; Timofeyev and Yan, 2013).

Ojala and Isomäki (2011) mentioned that during 17 years of Russian transformation there were no significant factors that positively or negatively affect the entrepreneurship development in Russia. According to the Szerb and Trumbull (2018) research, despite the formation of the institutional framework for entrepreneurship, the Russian Global Entrepreneurship Index (GEI) shows the decrease in years 2006 to 2016. Sub-indexes of GEI Abilities (ABT), and Aspirations (ASP) on the whole show decrease in years

2006–2016. Only sub-index Attitudes (ATT) show the increase in years 2011 to 2016. It means that such pillars as opportunity perception, start-up skills, risk acceptance, networking, and cultural support were improved in the period of 5 years. If we compare average GEI sub-indexes' pillars of Russia (2012–2016) and efficiency-driven countries, we will see that Russia still has an extremely low cultural support of entrepreneurship; a high human capital; an extremely bad performance in internationalisation and also in risk capital. Additionally Russian current entrepreneurs still lack entrepreneurial skills, do not go global, and grow thanks not to product development or new technologies (Szerb and Trumbull, 2018).

The focus of our analysis is on technology entrepreneurial companies operating in the region that was scientific and commercial center of the USSR. People living in the Nizhny Novgorod region faced challenges in accessing government support or infrastructure when starting their businesses in the 1990s. Lack of experience, knowledge and available resources were a big concern for early entrepreneurs. Cultural norms and traditions of the Soviet Union restricted innovative ideas and actions. Resistance to changes comes from a traditional mindset and social hierarchy deeply grounded in the USSR. There were other restraining factors like limited manufacturing capabilities, workforce retention, naive management and etc. However, ongoing economic transformations in the 1990s provided a fertile ground for technology entrepreneurs to break the established norms. Different stages of transitions set different opportunities and constraints. Therefore entrepreneurs had to overcome barriers with proactive action and ability to implement strategy effectively. These characteristics helped entrepreneurs to survive in the transformation period.

We choose to focus on Nizhny Novgorod due to its historical and economic significance for Russia. We can clearly observe the examined entrepreneurial processes because of the developed professional network of the university and personal connections to entrepreneurs from different generations in the surveyed geographical area. Our understanding of how entrepreneurs act and create value in Russia is possibly biased by general view of how the business acts in transforming economies.

The city of Nizhny Novgorod and its region represents main facts and milestones of Russian economic and industrial history. Before the socialist regime the city was the center of commerce with stable entrepreneurial traditions selling up to a half of the total production of export goods in Russia (Fitzpatrick, 1990). During the period of industrialization (1929–1941) a range of plants and engineering institutions were built up. Due to a high concentration of scientific and industrial companies and research facilities, the city got the status 'closed' for foreigners during the Soviet period. By 1991 Nizhny Novgorod city had presented itself and the region as a huge scientific and industrial center.

During the transition to a market economy the city was opened and that led to the redistribution of resources accumulated in research, engineering institutions and industry. It triggered the growth of technology entrepreneurship in the region.

From 2012 to 2016 this region was taking the fourth place in the Russian Regions Innovation Ranking (Abdrakhmanova et al., 2017). Nowadays there are 39 scientific institutions, 21 design bureaus, 14 Universities (including branches) and 16 industrial research and development centers (MES RF, 2016). Also the region has developed a net of business-incubators, technoparks, financial institutions such as business-angels network and venture fund. So as the result we can see a range of technological companies established over the last several decades in this region.

The Nizhny Novgorod region covers the area of 76.6 thousand sq.km with the population of 3.2 mln. people in 2017. The annual number of the employed is 1.6 mln. people. The average consumer spending per capita (per month) – 23.5 thousand Rub (385 US dollars[1]). The average consumer income per capita (per month) – 30 thousand Rub (492 US dollars). Gross regional product in 2016 – 1,182,265 mln. Rub (14,075 mln. US dollars). The retail trade turnover in 2018 – 696,909 mln. Rub. (11 424 mln. US dollars) (Federal State Statistics Service, 2018).

The region experienced dramatic changes over a period of last few decades. We explored those changes in the regional business environment by domains and highlighted key points in decades. Each domain includes quotes from the interview with entrepreneurs along with statistics of social and economic characteristics of the region. Such combination of quantitative and qualitative data helps to examine evolution of regional high-tech startups with a decline of scientific cluster and brings in the rich description of the regional context, startups and the link between them.

3.3 Data sampling

We collected insights from interviews with entrepreneurs, most of which cannot be easily observed or historically studied, because of the lack of information from other sources. Not much data are available about private companies from the 1990s in Russia.

We studied companies in three different time periods (three generations) from the 1990s to the 2010s to tell a story of technology business evolution in the region (see Table 2 for the description of interviewed companies). The case is an individual entrepreneur. We contacted 15 entrepreneurs. All of them responded to the calls. During interviews we asked companies about the year of the company foundation and confirmed it with the secondary data to assign an entrepreneur to specifics generations surveyed. Table 2 provides a profile of surveyed entrepreneurs.

We identified technology entrepreneurs by selecting a number of enterprises that started a business in the Nizhny Novgorod region from the 1990s till the 2010s. All the surveyed companies were running a business at the moment of the research. Thus we studied only operating businesses. All the surveyed companies started their businesses in the Nizhny Novgorod region. We interviewed only Russian companies and did not interview any foreign-invested firms.

We started with a preliminary research in local media and official statistics to explore companies' history and environment evolution. This step helps to better understand milestones reached by the entrepreneurs from different generations and explain the context in which they acted. We defined a list of companies that met our criteria and then we found the contact of company founder/owner and contact owner. After that we conducted in-depth interviews with founders and owners of technology companies launched in the Nizhny Novgorod region. We asked how they started a business and what they actually did when started in different time periods. (Mcmullen and Dimov, 2013). The vividness of qualitative data helps us to reveal multiple domains in characteristics of entrepreneurs and environment (Graebner et al., 2012).

We used plenty of sources to build a sample: personal relationship with companies and professional and personal networks (Xin and Pearce, 1996), contacts from technological entrepreneurship events, companies from Russian innovative rating TechUspekh, success stories published in Russian press (interviews/talks), companies that got investment from the regional venture fund, contacts of regional business angels

association, university and research organisations (like Institute of Applied Physics) spin-off companies. Scholars criticised convenience sampling (Yin, 2009), but it is unavoidable when conducting qualitative research in Russia because of the difficulties in gaining access to respondents (Eckhardt, 2004). Russian entrepreneurs were open to research and willing to provide the required data mostly because of personal relationship. Personal relationships and entrepreneurial reputation of the university supported respondents in providing their true thinking during the interviews (Boddy, 2007; Eckhardt, 2004).

Table 2 Companies' profile

Company name	*Year of foundation*	*Generation*	*Source for innovation*	*Product or technology*
Binar Co	1989	G1	Private ideas/research institute	New materials, new equipment
Prima-NN	1990	G1	Private ideas/research institute	Radio communication equipment
Meduza	1992	G1	Research Institute	Medical ultrasound equipment
Gycom	1994	G1	Research Institute	Gyrotron complexes
Neolith	1999	G1	Private ideas	Artificial stone
Mega-NN	2001	G2	Private ideas	Information and communications technology
Centre for science and technical development	2007	G2	Research Institute	Lasers
Intellectual technologies	2009	G2	Private ideas	Mobile applications
Lesnoy Dozor	2010	G2	Private ideas/university	Information technology
SMIS	2011	G3	Private ideas inspired by regulation	Information technology
Energiya	2015	G3	Private ideas	Information technology + equipment
Telcom	2016	G3	Private ideas/previous business	Cloud solutions + telecom
Infotoriya	2017	G3	Private ideas	Information technology
Fun Editor	2018	G3	Private ideas	Information technology
Nerabank	2018	G3	Private ideas	Fintech

After all the main source of data is interview with the entrepreneur. This is the point of the study: to explore a self-reported view of entrepreneurs and to gain insights from the entrepreneur, not to explore actual behaviour in the past (which is hardly possible) or only official statistics. We applied secondary data only to build a company profile before the interview (company meets our criteria) and clarify some vague points from interviews.

We set criteria for the sample that helped us not to lose the focus of the study:

- Company is a resident of the Nizhny Novgorod region (not a branch)
- Company is still operating or acquired by other company, which is still in business
- Company uses technologically new or significantly improved products or processes in its operations, or both products and processes during the period of study (OECD, 2005)
- Possible sources for innovation: Research Institute of Russian Academy of Sciences, universities, large enterprises or experimental design bureaus, private ideas
- Only for-profit entrepreneurs that gained recognition in professional communities and society in the region.

We designed a diverse sample with cases from multiple industries with different sources of ideas. This sampling diversity helps to explore many paths to technology entrepreneurship in the region.

After the preliminary study of technology companies based on these criteria, we chose fifteen cases to tell a story of technology business evolution in the region (see Table 2 for description of interviewed companies). The further research consists of desk research (secondary data analysis) and primary data collection.

3.4 The interview and data processing

Native speakers gave all interviews in the Russian language to ensure the trustworthiness (Fukuyama, 1996). We conducted interviews in the informal manner which is an efficient data collection approach (Liu et al., 2019; Win and Kofinas, 2019). We are not new to the topic and use professional language of Russian entrepreneurs (jargon) to facilitate insightful and rich conversations (Marschan-Piekkari and Reis, 2004). Members of the team (researchers) have been working in the university and outsider teams which is highly recommended for the research of emerging markets.

We focused on the details of the process that the entrepreneurs adapted in each case. We asked about failures and shortcomings, not only about positive events. This approach saved us from selective recollection of positive outcomes which is crucial in developing insights about decision drivers and how decisions led to a successful outcome (Sardana and Scott-Kemmis, 2010).

An average length of the interview was 50 min. All interviews were conducted in companies' offices to support the natural environment of the entrepreneur's workflow. We recorded each interview for transcription and analysis. We translated only the meaning of transcript into English and only the parts that referred to the topic of the study.

We analysed the collected data employing the qualitative content analysis (QCA) approach. With regard to the QCA, Mayring (2014) depict distinct approaches of qualitative analysis namely summary, explication, structuring, and inductive category formation. Structuring refers to filtering out particular aspects of the data in accordance with determined theoretically based dimensions. For understanding external environment and business model evolution we used structuring. The data from interviews were summarised and structured in accordance with domains of entrepreneurial ecosystem. We

also took into account the year of company foundation in order to follow changes in entrepreneurial ecosystem domains and entrepreneur's businesses.

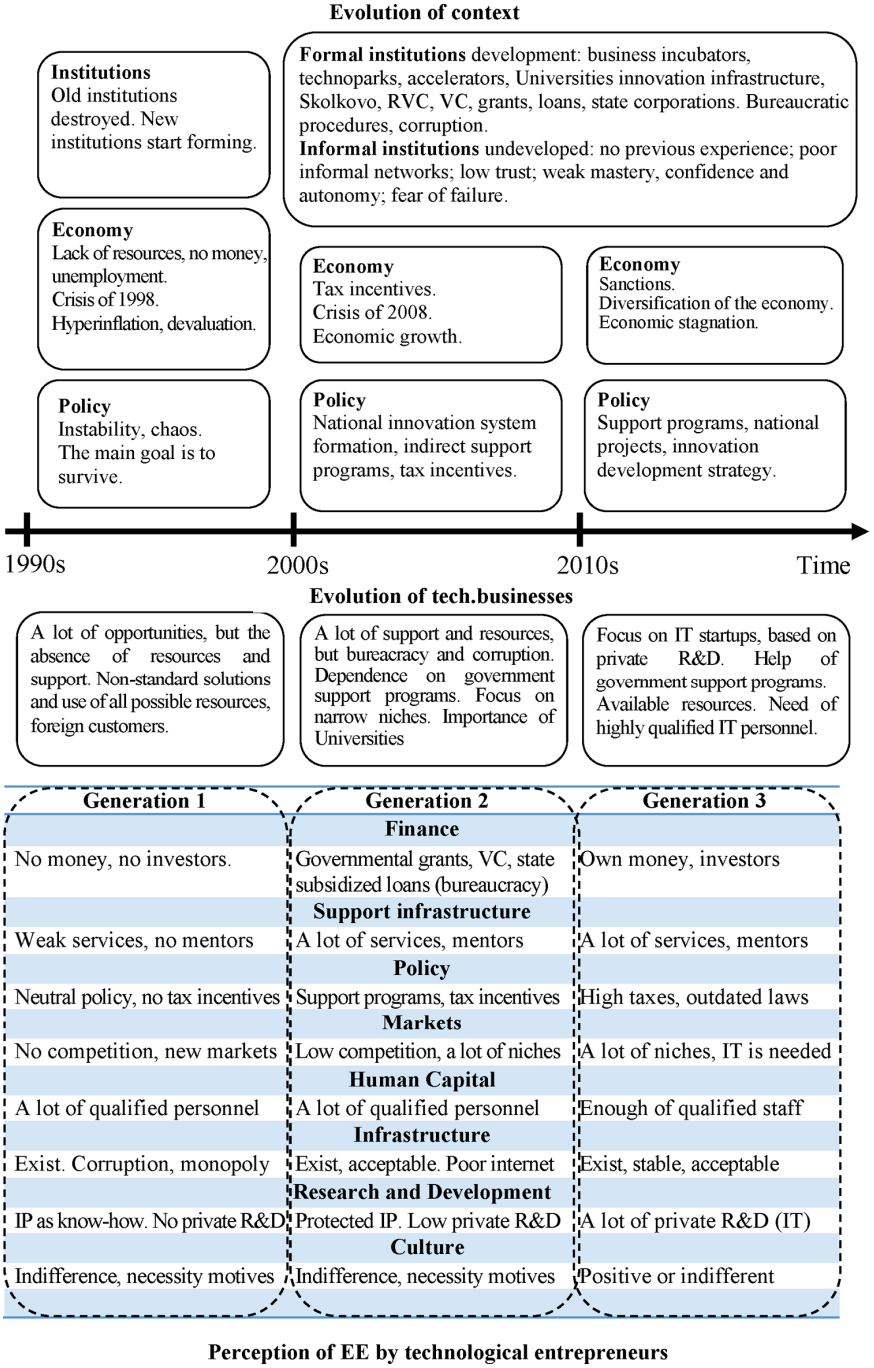
4 Results

We have designed a time-line based on the case analysis, that visualises the co-evolution of the entrepreneurial ecosystem and technological entrepreneurs in transforming economy. Figure 1 shows the key changes that have occurred in the ecosystem, the perception of these changes by technology entrepreneurs.

In the first period after the collapse of the USSR we observe a radical change of institutions. During this period the country on the whole got over the general economic crisis, accompanied by hyperinflation, devaluation and unemployment. The unstable political system and general chaos provoked the emergence of the first generation of entrepreneurs. On the one hand this situation in the country opened up a huge number of entrepreneurial opportunities in the form of free markets and lack of competition for the first wave of entrepreneurs. On the other hand lack of salaries and jobs made people started doing businesses in order to survive. Entrepreneurs created their companies in the absence of resources and any kind of support. Due to the fact that the technology business was resource-intensive and required highly qualified personnel, it was necessary to find non-standard solutions and use all possible resources. The lack of norms and institutions freed their hands and did not interfere with work. Poverty of clients in Russia pushed entrepreneurs find customers abroad. A type of technological entrepreneurs formed during this period can be called "wild entrepreneurs".

Since the 2000s the government has begun to actively form a national innovation system, to make the transition to an economy based on new technologies and innovations. It was rather a strategy of catching up innovative development. Because of the desire to speed up the events, the development of informal institutions was problematic. During that period formal institutions were created in the form of state corporations, entrepreneurs support programs, tax preferences and etc., which also replaced the role of informal institutions. During that period innovative development programs at universities were being implemented, actively worked both private and state venture investors (including the RVC State Fund, Skolkovo). However in cases of that period we could very often find comments that state support was accompanied by bureaucratic procedures and corruption. The economy during that period showed high annual rates of economic growth. But at the same time during that period Russia experienced the financial crisis of 2008. In this situation we observe the emergence of a new type of technological entrepreneurs, let us call them "tamed entrepreneurs", which are guided by the established formal institutions. Their business models more often show dependence on government support and financing programs. The availability of the necessary resources in the public domain facilitates activities, but increasingly saturated markets are forcing technology entrepreneurs to focus on narrow niches. The complexity of access to scientific infrastructure for conducting private scientific research generates a surge of spinoffs from universities that use the university's infrastructure. Still weak trust to partners, lack of previous business experience give rise to uncertainty in the presence of business competencies and fear of failure.

Figure 1 Time line of the co-evolution of entrepreneurial ecosystem and businesses of technological entrepreneurs in the transforming economy (see online version for colours)



Generation 1	Generation 2	Generation 3
	Finance	
No money, no investors.	Governmental grants, VC, state subsidized loans (bureaucracy)	Own money, investors
	Support infrastructure	
Weak services, no mentors	A lot of services, mentors	A lot of services, mentors
	Policy	
Neutral policy, no tax incentives	Support programs, tax incentives	High taxes, outdated laws
	Markets	
No competition, new markets	Low competition, a lot of niches	A lot of niches, IT is needed
	Human Capital	
A lot of qualified personnel	A lot of qualified personnel	Enough of qualified staff
	Infrastructure	
Exist. Corruption, monopoly	Exist, acceptable. Poor internet	Exist, stable, acceptable
	Research and Development	
IP as know-how. No private R&D	Protected IP. Low private R&D	A lot of private R&D (IT)
	Culture	
Indifference, necessity motives	Indifference, necessity motives	Positive or indifferent

Perception of EE by technological entrepreneurs

Source: Developed by the authors on the base of cases analysis

The third period considered in the study is characterised by new circumstances: on the one hand, more intensive diversification of the economy, continuing innovative development programs, ongoing national projects for small business development; on the other hand, the difficult foreign policy situation provoked the introduction of sanctions, which led to some stagnation of the economy. At the same time, we can see a shift of technology entrepreneurs to the information technology industry. This greatly affects their business models, which do not require complex scientific research and can be realised by the team. Therefore independent entrepreneurs, based on their developments, start their business without problems. Government support programs and innovation infrastructure help technological entrepreneurs launch new startups. Previous experience and established relationships make it possible to attract resources. The flip side of such a business model is the need for highly qualified IT personnel. The difficulty in finding such employees lies in the demand for such personnel abroad. Such entrepreneurs on the whole may be classified as "tamed entrepreneurs".

Below we show how technological entrepreneurs percept the ecosystem evolution.

4.1 Finance

In the 1990s entrepreneurs faced the lack of financial resources (Table 3). Founders and companies' team members provided the main funding. These conditions lasted until the beginning of 2000s. In the 2000s assistance funds and programs for entrepreneurship emerged and it was of big help for the local business. In the end of 2000s and in the 2010s university grants, business incubators and accelerators enforced that assistance.

Table 3 Citations about finance

Year	*Generation*	*Citations from interview*
1989	G1	N/A
1990	G1	Clients were the only source of money for the business. No credits, no venture capital, no angel investors. Start capital was our money (money of the team). We used barter transactions for deals because of high inflation
1992	G1	Start capital was personal financial resources of the team. We used loan only once for a big project. We received subsidy and loan on special conditions. Later, as a spin-off, we received a lot of financial support from the government
1994	G1	There was no debt capital due to unstable economic environment. Starting capital was founders' money. We were reinvesting the whole profit
1999	G1	We were reinvesting the profit and did not use credits
2001	G2	Free capital emerged, people were looking for investment opportunities, but there was not angel investors yet. We used reinvestment for further development
2007	G2	The Assistance Fund ("START" and 'UMNIK' programs) provided financial support. There was no need in additional external finance
2009	G2	Starting grant from university, Higher School of Economics

Table 3 Citations about finance (continued)

Year	*Generation*	*Citations from interview*
2010	G2	Getting finance was not a problem. We got a history of collaborations with the Assistance Fund and Business angels. We started operating as Skolkovo resident
2011	G3	Founders had enough money for start
2015	G3	Finance resources were attracted from old friends in exchange for profit share without share in control. Also starting grant from regional government was attracted (later it was returned because the company have not manage to meet necessary indicators of innovation development)
2017	G3	Investor was found to cover the needs in financing
2016	G3	There were enough money from previous business
2018	G3	Founders'money
2018	G3	Money from investor

The volume of bank loans for business in the region grew ten times from 2001 until 2010. The first business incubator launched in 2007 was followed by other facilities launches (eight incubators by 2014, one technopark by 2015) in the region. The association of business angels started their activity in the region in 2006 and was followed by the emergence of business accelerators in 2010s. (Federal State Statistics Service, 2018; Ministry of Industry, 2014)

4.2 Support infrastructure

In the 1990s entrepreneurs observed a shortage of supporting infrastructure and lack of information about any support for the business in the region (Table 4). Entrepreneurs had to know the necessary people to get any assistance from the government. As a reaction to such conditions, a common business practice was partnerships with service providers for supporting infrastructure. In the 2000s entrepreneurs started to borrow professional services and expertise from research institutes as well. Business incubators and supporting facilities emerged in the region. A number of business incubators were rapidly growing. In the 2010s entrepreneurs still had issues in getting access to support infrastructure, but remembered they could get all the necessary for their business anyway.

Table 4 Citations about support infrastructure

Year	*Generation*	*Citations from interview*
1989	G1	Nobody supported, but nobody hindered entrepreneurial activity. There was a freedom. Enough to develop a business. Government of Nizhny Novgorod (the centre of the region) provided us with an office space
1990	G1	There were no money, no resources, no base for starting a business, and there was no support from the government or special structures. Actually, we did not need that support, and tried to stay away from the government and its programs

Table 4 Citations about support infrastructure (continued)

Year	*Generation*	*Citations from interview*
1992	G1	There were a lot of subsidies and support, but with a shortage of information about it. It was necessary to know right people who can provide you with it
1994	G1	As founders, we preferred not to get any support from the government. Our attitude was "the best help is not hinder"
1999	G1	Started partnership with a lawyer company
2001	G2	We did not use support infrastructure
2007	G2	We used infrastructure of IPS RAS. There was no need in additional support. We overcome local obstacles by collaboration with skilled professionals
2009	G2	The location of the sole incubator in the region was very unsuitable
2010	G2	While access to infrastructure was not easy, you still could get what you need
2011	G3	Initially there was no support, but when they came to the technopark: office, info-field, administrative resource, grants
2015	G3	Support only from business incubator. Not enough funding, although a 300K grant was received
2016	G3	Technopark – moral support. From an economic point of view – not too profitable
2017	G3	Business Incubator provides office plus administrative resource
2018	G3	We participate in the IT cluster
2018	G3	We did not feel support, there is no free space in our technology park for our project, we are considering moving to TASED in order to pay less taxes

4.3 Policy

In the 1990s entrepreneurs enjoyed simple registration processes, low taxes and no legal boundaries, but got no government support at all (Table 5). There were also obstacles with export and import for new businesses. In the 2000s entrepreneurs observed rapidly changing laws on doing business and ongoing lack of government support. Those days were followed by growing government control over business environment. National incubators like Skolkovo emerged with lower taxes for their residents. Such support was not stable as well as anything else in the economic environment within Russia. In the 2010s entrepreneurs still observed no stable government support for business and regulation became excessive.

A number of companies in the region grew from nearly 6 thousand in 1990 to 60 thousand (including 13 thousand small enterprises) in 2001. By 2009 there had been 88 thousand companies operating in the region (including 31 thousand small enterprises) (Federal State Statistics Service, 2018).

Table 5 Citations about policy

Year	*Generation*	*Citation from interview*
1989	G1	It was very simple to register and start a business. There was no bureaucracy, no limitations. Tax rate were very low. It was the only tax (15% income tax). Legislative system for business did not exist, and did not hinder business activity
1990	G1	It was not a problem to register and start a business. No problems with legislative system as well
1992	G1	As a medical and social business, we received special preferences: no taxes for 3 first years, a lot of government support on federal and regional levels. Bureaucratic system was very simple. It was easy to go through certification and get all permits for medical equipment manufacturing. In general, conditions were more comfortable than now for doing business. I remember a very simple process of registration
1994	G1	There were some obstacles in import and export process
1999	G1	We got subsidised credit. Tax rates were acceptable. Unclear registration of business processes
2001	G2	There was no any governmental support, and that was advantage. Legislation and rules were changing frequently
2007	G2	There was too much control from the government. We payed smaller taxes as Skolkovo resident
2009	G2	Policy and government support were below the normal level
2010	G2	Some things become better and some become worse
2011	G3	The lack of organisation of the tender system when working with government orders, a high level of tax burden
2015	G3	Excess taxation, especially VAT
2016	G3	One of the reasons for the start of this project was the excessive pressure of the security forces on the previous business. Difficulties in registering a company: despite the ease of the procedure, problems arise if the founders of the company were previously engaged in business. The tax system is very inconvenient, the use of available privileges results in the costs of administering them. The catastrophic influence of the "Spring Law", which shifted the task of providing internet security to business
2017	G3	Does not consider as a problem
2018	G3	Patent law imperfection is equal in importance to the difficulty of raising funds
2018	G3	There is no cryptocurrency law; excessive regulation; laws do not keep pace with technology; complicated bookkeeping

4.4 Markets

In the 1990s entrepreneurs enjoyed the time for business opportunities: no competition, no entry barriers, and no requirements for certification or licenses for the products (Table 6). Those wild market conditions existed alongside with low trust from clients, low demand and shortage of the high quality raw materials and suppliers in Russia. Low level of foreign language skills and soviet image of new Russian entrepreneurs slowed down launching a business with partners outside Russia by export and import. Selling to the government also was not easy. If a business wanted to make a deal with the state, it

had to know the right people in the government who might help to get a contract. Emergence of low-priced China products in the end of the 1990s only enforced competition inside Russia. Prepaid orders or barter were key forms of transactions until the end of the 1990s. Word of mouth and references were main tools of acquiring new customers. In the 2000s there still was a low demand for innovation products in Russia. Most clients came from Europe and marketing became the key tool of business development. In the 2010s entrepreneurs observed the demand for innovations from b2b market. Marketing and understanding a customer became key concepts of doing business.

Table 6 Citations about markets

Year	*Generation*	*Citation from interview*
1989	G1	There were many business opportunities, markets just emerged, and competition did not exist. There were no or low entry barriers to market. First consumers came from people we knew with prepaid orders. There was corruption. It was impossible to get an order from the state company, if you did not have any connections in there. It was very tricky to enter a foreign market, or to find the foreign supplier. Now it is hard to enter a market because of strong competition, noncompetitive ways of market combat, and high cost of entering
1990	G1	Clients did not trust the company, because of our small experience and complexity of business. First clients knew us, trusted us and ordered products. We offered special conditions for clients to attract contracts. It was hard to do business, but there were a small number of competitors. The main competitor was a scientific institute, which team abandoned it in the 1990s. Moreover, this institute used unfair ways of competition. Our marketing strategy was oriented on clients, their needs. We started partnership with different organisations for attracting necessary resources
1992	G1	There was no competition. The market was empty. Consumers needed a new product and were ready to buy it. Some customers did not have money and we used barter transactions for deals with them. By the end of 1990s, there were many competitors from China with low prices. Chinese changed the market and found empty niches. In our days, there is still a strong demand on medical equipment all over the world. The difference between the 1990s and today is competition. In the 1990s, consumers bought the equipment even without certificate and license, because consumers did not have anything. Now it is necessary to fight for each client. We were an engineering company and did not produce equipment. We had industrial partner for it. We did not tried to enter a foreign market
1994	G1	Our main consumers were from abroad (EU mostly). Main marketing tools – word of mouth (recommendations within science community). There was no domestic demand. Due to economic collapse, different plants were willing to supply any raw materials, equipment, if a buyer prepaid. Today there is a degradation of industry in Russia. It is almost not possible to buy equipment and some materials on domestic market
1999	G1	We worked on domestic market. Main competition was in marketing. Demand on innovation products was low
2001	G2	There was no demand for innovation

Table 6 Citations about markets (continued)

Year	*Generation*	*Citation from interview*
2007	G2	Main consumers were coming from foreign markets (mostly western Europe). There was no domestic demand due to the structure of Russian economy
2009	G2	We supplied for domestic b2b
2010	G2	The competition was not easy. The key competitive advantage was an understanding what a customer really needs
2011	G3	There is no demand for innovative products per se
2015	G3	Barriers to entry to the market are surmountable, innovation is of no interest to anyone, everything is decided only by price
2016	G3	Fall 4 times from 2016 to 2019 due to market dying out
2017	G3	There are ones who see technology as the future
2018	G3	I build a dialogue with customers and partners through the prism of necessity, profitability or personal relationship. Direct sales and presentations of a working product — we chose this path
2018	G3	High demand for everything related to automation/internet of things

4.5 Human capital

In the 1990s many professionals (scientists from universities and institutes, engineers) were available for hiring to create new technologies and products, but they had no education in business, entrepreneurship or marketing (Table 7). The first school for managers emerged in the 1990s. Although such education was not popular, graduates admitted it was helpful for doing business in the region. In the 2000s technical innovators still preferred to manage the company without business education although a number of business schools were growing. Qualified personnel for creating innovations were not an issue at that moment. Problems started in the mid-2000s, when companies had troubles with finding new employees for R&D and engineering. As a reply to that, challenged entrepreneurs developed relations with scientific institutions and universities like IAP RAS[2] as sources of human capital. In the 2010s that cooperation with universities and institutes still helped to hire new people for R&D.

Table 7 Citations about human capital

Year	*Generation*	*Citation from interview*
1989	G1	Those days many high-qualified people could create new technologies, but we did not have competencies in business and there were no educational programs for managers
1990	G1	Many high-qualified personnel from scientific university were available for hiring
1992	G1	Based on the scientific institute, we had a lot of engineers, scientists, and other qualified personnel at hand, but we did not have competencies in business, entrepreneurship and marketing. Today it is opposite; there is a shortage of high-qualified engineering personnel and constructors

Table 7 Citations about human capital (continued)

Year	*Generation*	*Citation from interview*
1994	G1	Our competitive advantage was highly qualified and relatively cheap local personnel. At the end of 80s, the first school of managers launched and we got competencies to manage a business. Such education was not so popular those days, but it was very useful for new connections and managerial knowledge
1999	G1	We had no problems with hiring
2001	G2	Those days most technical innovators had no special education in business, but was highly qualified in science areas. University degree (in natural sciences) was a competitive advantage. Our director graduated from university. Our team was also a key competitive advantage
2007	G2	There was no problem to find professional employee with R&D competences because our team was growing from IAP RAS since the 1990s. Today it is hard to find professionals with R&D competences
2009	G2	Hiring was not an issue
2010	G2	Hiring in R&D was not an issue due to strong connection with the state university of Nizhny Novgorod (UNN)
2011	G3	People were in the project initially, the main challenge was to organise them
2015	G3	Huge difficulties in finding qualified personnel
2016	G3	The team came from a previous project
2017	G3	The best conditions abroad complicate business management here; the team was formed before the project began
2018	G3	Not faced with the problem of recruitment due to the immaturity of the company
2018	G3	One of the problems is lack of staff (IT specialists)

The team and technologies were key factors of technological business success. Teams from the 1990s consisted of people who worked together for a long period in scientific institutions. It confirms a strong partnership between technology entrepreneurs from the 1990s and scientific institutions that they graduated from. It was a significant factor to survive and succeed. University was a source of new highly qualified specialists for business in the region. A number of universities in the region grew from 11 in 1990 to 16 in 2001, and 18 in 2008. Those universities released 9 thousand graduates in 1990, 14 – in 2000 and 39 – in 2008. (Federal State Statistics Service, 2018).

4.6 Infrastructure

In the 1990s entrepreneurs faced corruption if they wanted any access to the infrastructure owned by the government. Those, who could not bribe, had to develop infrastructure by themselves or arrange strategic partnerships with institutions or private service companies, which could help (Table 8). In the 2000s infrastructure changes emerged. Entrepreneurs from 2000s remembered no problems with infrastructure. In 2010s entrepreneurs remembered nothing negative about infrastructure.

In the nationwide survey of 2001, 55% of Russian entrepreneurs believed that corruption existed in the government. That number grew to 62% in 2005 (National Research University Higher School of Economics, 2005).

4.7 Research & Development

In the 1990s entrepreneurs did not trust legal IP protection (Table 9). There was no patent system and no technology transfer process. Weak legislation in intellectual property protection enabled technology entrepreneurs to carry knowledge and technologies away from research institutions. 'Know how' was a common practice of IP protection. In the end of 1990s entrepreneurs preferred to develop their business rather than protect IP. Technology transfer occurred when qualified people with knowledge (of "know how") left scientific institutions for starting a business and took away technologies from research institutes. That transfer evolved from simple leaving to spin-off cooperation which still used "know how" as a main form of IP protection, but also started to patent some technologies. In the 2000s many scientific institutions went out of business but the science staff and their ideas did not disappear. Those entrepreneurs who had relations in the science community and to that staff, got natural access to technologies via institutes' people looking for a new job. Such hiring was a foundation of the future growth. In 2010s many companies began to launch in-house R&D departments to grow technologies. The latter generation of technology entrepreneurs create ideas without strong relations with scientific institutions.

Table 8 Citations about infrastructure

Year	*Generation*	*Citation from interview*
1989	G1	Corruption was a real problem for access to infrastructure
1990	G1	N/A
1992	G1	We used infrastructure of the scientific institute, which was our strategic partner
1994	G1	We had no problems with access to infrastructure
1999	G1	We only had infrastructure created by ourselves. The city government did not provide anything
2001	G2	We used existing infrastructure of electric transport. Part of infrastructure was in monopolistic use (like cable canalisation)
2007	G2	We had no problems with access infrastructure
2009	G2	Infrastructure was ok
2010	G2	Infrastructure was ok
2011	G3	No problems
2015	G3	No problems
2016	G3	Inflated due to monopoly prices; extremely difficult access to the data center of Rostelecom
2017	G3	No problem, but difficulties were at the stage of finding the necessary information
2018	G3	No problems
2018	G3	No problems

There was an increase of interest to patenting with the new generation of entrepreneurs. Companies got patents for entering the foreign market, applying to some grant programs, collaborating with venture funds, or fighting violations of their rights. Entrepreneurs from different generations do not believe in rights of protection when they patent intellectual property, but they are sure that intellectual property is a key competitive advantage for business, and they protect it as «know-how».

In 2005 companies in the region got 145 patents, 615 patents in 2006. Spendings (in US dollars) on R&D had grown two times by 2000 (as compared to spending in the early 1990s), and 12 times by 2010 (Federal State Statistics Service, 2018).

Table 9 Citations about Research & Development

Year	*Generation*	*Citation from interview*
1989	G1	Background with scientific institute gave us experience and knowledge, which were a basis for business ideas. There were no patents or technology transfer process. Our team had enough knowledge and skills to solve all engineering tasks in business. The system of intellectual property (IP) rights protection did not exist. We protected all IP as 'know how' and did not trust official legal protection. The market of technologies did not exist, but entrepreneurs were searching for them and found technologies anyway
1990	G1	We used an image of reliable qualified engineers from the scientific institute in order to find clients and receive first orders. The institute became our competitor and used its connections and resources to compete in unfair. We did not officially transfer IP from the scientific institute, but took away knowledge and use our experience for business. We did not need to protect IP, because we produced specific product (engineering and construction documentation), that were protected as a "know how"
1992	G1	We had close relationships with institute, because team worked as research fellows in the institute. We used equipment, office space and materials of institute and cooperate with institute as a spin-off company. We protected IP as 'know how' and patented some technologies
1994	G1	There was poor protection of IP in Soviet science institutions. There was no formal transfer of IP. Employees of science institutions left a job in institute, and transferred technologies (as "know how") to new businesses. Today we still actively use our connection to the science-research institute in order to improve production processes
1999	G1	We did not protect our IP. It was a time when you need to develop a business faster than competitors did. Development was a priority
2001	G2	Many science institutions went out of business, and their ideas and technologies were available in public with fired employees. That situation provided us with huge opportunities for entrepreneurship
2007	G2	Our team had access to technologies, because we had connections in scientific community
2009	G2	We had easy access to technologies because of the 'software developer' status
2010	G2	We had in-house R&D. We got key competences with people from the state university of Nizhny Novgorod (UNN)
2011	G3	Internal Software Development

Table 9 Citations about Research & Development (continued)

Year	*Generation*	*Citation from interview*
2015	G3	Technology developed independently from the ground
2016	G3	The basis of cloud solutions was developed in the framework of the previous business
2017	G3	The company uses its own development; while the company intentionally relied only on those solutions, with access to which there are no problems
2018	G3	We tried to build development on existing technologies, so as not to go into the development of fundamental elements, concentrating on functionality. The sphere was close – from a previous activity
2018	G3	Own development

4.8 Culture

In the 1990s common people in the region did not understand entrepreneurship and motivation of those who leaved institutions for starting a business (Table 10). Entrepreneurs remembered that most of their colleagues at the previous work did not share their passion for entrepreneurship, but family and professional community did. Lack of money and desire for self-actualisation motivated people to leave scientific institutions and start a business for commercialisation of ideas born in scientific institutions. Commercialisation was not an option within institutions in those days. In the new world of business, entrepreneurs faced problems beyond simple attitude of society. In the 1990s criminals tried to steal businesses from entrepreneurs, but a hi-tech business seemed to be unmanageable without support of qualified personnel and criminals stayed away from such a business after all. In the 2000s entrepreneurship still had a negative image in society associated with theft, but the production business was appreciated by common people, because it created something new (jobs and products). In the 2010s entrepreneurship culture hardly existed and image of entrepreneurs still remained unclear.

Table 10 Citations about culture

Year	*Generation*	*Citation from interview*
1989	G1	Shortage of money and boredom built our motivation. Family supported us, but former colleagues treat us as fools. Community attitude was positive. We were like heroes, press and people took attention to us. We had experience in another sphere, not entrepreneurship. Directors from Soviet Union (Red Directors) misunderstand entrepreneurial activity and slow down some processes related to starting a business. Stereotypes from Soviet period also slow down our activity. The main barrier was barrier in our minds. Access to the information about market is available everywhere, it is necessary to look for it
1990	G1	Our previous jobs in scientific institute were not oriented on the self-actualisation and the system was not interested in initiative and active people. Former colleagues did not support business ideas, but some of them joined us and started a business together. Shortage of money motivated people to find a new source of money

Table 10 Citations about culture (continued)

Year	*Generation*	*Citation from interview*
1992	G1	Our motivation was motivation based on self-actualisation, and shortage of money. We wanted to implement our scientific results. In the scientific institute, there was no opportunity to commercialise these results. Community supported an idea of starting a business
1994	G1	We did not consider ourselves as entrepreneurs. We had no entrepreneurial education. In general, we applied common sense for management. We faced criminals, but our business seemed be unmanageable for them without competences in hi-tech
1999	G1	We observed a negative attitude to entrepreneurship in society where entrepreneur meant thief. Society appreciated a business in the production sphere, because such business created something new, not just commerce. There were many opportunities for technological business, but those remained unseen, because people were busy with redistribution of equity
2001	G2	Attitude to entrepreneurship was extremely negative. Our investor and cofounder were experienced entrepreneurs
2007	G2	Our team were still involved in science with IAP RAS and got benefits from this connection
2009	G2	N/A
2010	G2	There was no entrepreneurial culture
2011	G3	Overallpositive
2015	G3	Nomatter
2016	G3	In 2016 it was better than now
2017	G3	Everyone does not care, although there are few who see technology in the future
2018	G3	Everyone wonders if the final product will turn out. Everyone likes the idea
2018	G3	On the whole, it's positive, but no one believes or understands it

Entrepreneurs in all cases had a stable job, but they were dissatisfied with opportunities to realise their ideas. Entrepreneurs of the 2000s were more ambitious, self-confident, and eager to increase their income.

5 Discussion

The data collected in the previous section reflect three decades of co-evolution of the business ecosystem and its participants. We can see how the conditions for doing business have changed. These changes were smooth, but very substantial. It is well seen that all domains of business factors have undergone changes. This should be connected with the establishment and development of new institutions in the economy of Russia.

We know that informal institutions are an essential part of entrepreneurial ecosystem (Estrin and Mickiewicz, 2011). But the accent is usually put on the functions on these institutions what creates an illusion of substitution possibility for these functions.

The formation of institutions in transition economies takes place in a very short time period, and everyone can see that the participants in the study point to formal institutions, talking about their interaction with the external environment. That is, approximately in the mid-2000s, the state created formal institutions which substituted the functions of informal institutions, which had not managed to be formed during the 1990s. Evidence of the rapid formation of formal institutions can be seen in Tables 3–10. We can see that evaluations of such direct factors as *Finance* and *Support* have changed from 'none' to 'good' or 'satisfactory' during the period of 30 years. A huge raise in evaluation occurred after 2006, when support infrastructure was established and innovations and technology were well financed.

Partly direct factors change slower. From the evidence of companies under study Policy is evaluated as inconsistent or excessive. It has not managed to mitigate high risks and unfavourable business environment, which make technology business unattractive and unstable for new entrepreneurs who usually choose traditional and simple types of business. Human capital remains almost the same in its quality. However, we should mention that some cases point to the fact of degradation of human capital, especially in engineering. Infrastructure and Research and Development improved slightly in the opinion of the studied companies. It is also worth mentioning that the evidence from case studies points to deterioration of market conditions. Case companies, established in the beginning of 1990's, say that they are facing market saturation and "non-competitive ways of market combat, high cost of entering".

Indirect factor Culture remains almost unchanged in general for 30 years, though some changes in the attitude towards technological entrepreneurship have taken place. In such a difficult period for the country in the 1990s the attitude of society to the entrepreneurs in general was extremely negative. Typical association with entrepreneurship was larceny and fraud. But society gave respect to technological entrepreneurs, due to the manufacturing, real production and new complex technologies. In the new century public attitudes towards entrepreneurship began to change for the better. Now the creation of new business is associated with a new product and new jobs, but the attitude of society to the technological entrepreneurship grew cold.

In parallel with the changes in the environment we observe changes in the business architecture of the companies participating in the research. We see the dominance of companies producing high-tech material product in the first generation. Service oriented companies prevail in the second and third generations. In addition, first-generation companies actively use available resources that have depreciated (and become easily available) after the collapse of the Soviet Union. This applies to all types of resources: human, material and non-material. In the second and third generations it was more difficult for companies to attract resources because free resources were consumed over a decade, and no new resources were created. One of the answers to this challenge was to focus on computer and internet technologies. This made it possible to radically reduce the need for material resources and simplify access to technology. The fact of technological entrepreneurship focus change from high technology to IT lies in well accordance with the results obtained in a number of works (Aidis et al., 2008; Radaev, 2001). A change of focus is also a change of the business model. While the first wave was characterised by product business models aimed at creating products unique in the world, the second and third waves represent service business models whose strategy is variation on risk avoidance. This result is in good agreement with the previous data (Kihlgren, 2003; Kuznetsov et al., 2000; Zhuplev and Shtykhno, 2009).

This point is in good correspondence with the case of China (Zhou, 2017) where we can also find two types of entrepreneurs: the first one is independent and positively responding to the deregulation; the second one prefers clear and developed institutional environment. The first type is more typical for early stages of transition while the second type becomes more common during the transition progress.

Our study shows that companies of the second and third generations have a higher level of expectations from the ecosystem than the first generation. This includes participation in business support programs, grants, and anticipation of favourable changes in legislation. All of this can be seen as a growing dependence on the increasingly rigid environment. Thus a more developed artificial ecosystem represented by formal institutions generates weaker entrepreneurs who are less inclined to form strong informal institutions. This serves as a trigger for further strengthening of formal institutions, and thus serves as a driver of the process of co-evolution, taking the entrepreneurial ecosystem of the transition economy further away from its counterparts in developed economies. Everyone can see the Russian Global Entrepreneurship Index (GEI) decrease from 2006 to 2016 (Serb and Trumbull, 2018).

It is also important to note the decline in the quality of formal institutions as they are strengthened. This fact has also been reflected in a number of works: the bureaucracy increase (Aidis et al., 2008; Chadee and Roxas, 2013) and growing complication of interaction with tax service (CEFIR, 2007); mistakes inimplementation of the innovation policy and its inconsistency (Butryumova et al., 2016); ad hoc enforcement of regulations (Aidis and Adachi, 2007; Tyimofeyev and Yan, 2013)

6 Conclusions

We examined 15 case-studies of technology enterprises established in the Russian region in 1990s, 2000s, and 2010s to study the issue of co-evolution of entrepreneurial ecosystem and its participants – technology entrepreneurs.

As a result we have found out that an entrepreneurial ecosystem formation as well as technological entrepreneurship development in the transforming economy is triggered by a total change in institutions during transition to the market economy. The collapse of former institutions leads to the release of resources and creates a wide range of entrepreneurial opportunities. Nascent technology businesses utilise the releasing resources of collapsing research and industrial clusters in the ‘wild market’ environment. At this stage technology businesses predominantly produce high-tech material product, using a niche strategy and network of personal connections to protect the business and ensure competitiveness. While informal institutions such as attitudes, social norms, and networks remain underdeveloped, the government creates a range of formal institutions, aiming to compensate this drawback. At the same time availability of the initial released resources of the decaying science and industry cluster weakens. That leads to premature formalisation of institutes and slows down establishing of dense networks and entrepreneurship development. Entrepreneurial behaviour of ‘tamed’ technological entrepreneurs become more focused on formal institutions with low intentions to develop their own entrepreneurial ecosystem. Their business models focus on less material resource-intensive technologies in order to radically reduce costs and simplify business architecture.

We have linked this feature with the evolution of the ecosystem, and we see an understandable coevolutionary mechanism at the root of the observed facts. In the undeveloped ecosystem there is a temptation to accelerate its development and not to wait for the completion of a long formation of informal institutions. Instead, it is possible to quickly create formal institutions with the right set of functions. An ecosystem represented by formal institutions generates entrepreneurs who are more dependent on centralised support programs. Moreover, these entrepreneurs are less motivated to form informal institutions because they do not lack access to the necessary functions. This, in turn, leads to further strengthening of formal institutions, i.e., there is a positive feedback. As a result the co-evolutionary dynamics based on the attempt to accelerate development based on formal institutions are moving the development of the entrepreneurial ecosystem away from the goal.

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Notes

[1]All figures in US dollars are based on Central bank currency exchange rate for that period.

[2]Institution of Applied Physics of Russian Academy of Science.