



Article

FinTech Entrepreneurial Ecosystems: Exploring the Interplay between Input and Output

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Abstract: This paper aims to examine the interplay between the attributes of the FinTech ecosystem (input) and productive entrepreneurship (output) in Russian regions. A survey was used to gather data from FinTech representatives in ten selected regions located in Russia. The acquired responses allowed measuring the FinTech ecosystem attributes by calculating the FinTech ecosystem index. Correlation analysis was used to analyse the association between the FinTech ecosystem index and productive entrepreneurship, as measured by the number of FinTechs. Data envelopment analysis was used to determine regions with more productive entrepreneurship given the ecosystem attributes. The FinTech ecosystem index defines a similar environment in the analysed regions for financial sector entrepreneurship. The regions have high values of physical infrastructure, demand, and talent, while new knowledge and networks appear as weaknesses. Still, Moscow has the highest and Chelyabinsk the lowest FinTech ecosystem index. There appears a positive link between FinTech ecosystem attributes and productive entrepreneurship. The Moscow and Chelyabinsk regions are also revealed as the regions that effectively create an environment for productive entrepreneurship from the position of the Fintech ecosystem index. This study contributed to the existing literature by measuring FinTech ecosystem attributes and productive entrepreneurship, investigating the relationship between them and determining the territories with productive entrepreneurship. It also contributed to Russian FinTech literature by being the first to measure the environment for financial sector entrepreneurship.

Keywords: FinTech; entrepreneurial ecosystem; input and output layers; attributes; productive entrepreneurship



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1. Introduction

An entrepreneurial ecosystem is a dynamically balanced system consisting of interdependent subjects and an entrepreneurial environment (Lu et al. 2021). Its input layer is based on attributes—conditions that allow or restrict entrepreneurship (Stam 2018). Productive entrepreneurship forms the output of an entrepreneurial ecosystem (Stam 2015). It refers to the innovation activity of entrepreneurs that contributes to the commercialisation of new ideas and knowledge and leads to economic growth in a certain territory (Aidis 2005; Acs and Szerb 2007).

The entrepreneurial ecosystem approach has gained prominence among scholars and practitioners in understanding an environment for productive entrepreneurship (Feld 2020; Szerb et al. 2019). However, the link between ecosystem attributes and productive entrepreneurship remains relatively unclear (Nicotra et al. 2018). Understanding this link is important to ensure the most favourable conditions for developing productive entrepreneurship, which can lead to economic growth in a particular territory.

This paper focuses on FinTech ecosystems (FEs); they are considered a type of entrepreneurial ecosystem that supports the development of FinTech companies (FinTechs), which are high-growth companies that disrupt or contribute to the provision of traditional financial services (Laidroo et al. 2021). FEs are characterised by the proliferation of FinTechs

(Alaassar et al. 2021), which are often presented by start-ups and apply innovation in the financial sector. In the first half of 2019, 48 FinTech unicorns, start-ups valued at over USD 1 billion, accounted for 1% of the global financial industry (CBInsights 2019). This emphasises the high entrepreneurial activity in a FinTech ecosystem (FE) and allows one to perceive it as an entrepreneurial ecosystem.

Previous studies on FEs have either analysed the interplay between its actors (Hendrikse et al. 2020; Lee and Shin 2018; Yazici 2019) or focused on measuring their attributes (Ernst and Young 2014; Findexable 2021; Gagliardi 2018; Laidroo et al. 2021; Sinai Lab 2020). The disadvantage of most suggested measurement tools is that they focus on official statistics or the views of experts. The early stages of an FE's development and a lack of accumulated statistics (Diemers et al. 2015) have led to not including significant attributes or relying on a mix of information covering different territory levels. In addition, the number of studies is focused on the risks related to FinTechs (Vasenska et al. 2021; Morales et al. 2022) or the efficient use of digital technologies (Popova 2021; Lewandowska et al. 2021).

Nevertheless, to our knowledge, there is no measurement tool for FE attributes based on a survey that would allow us to aggregate the opinions of the FinTech community about the entrepreneurship environment in the financial sector. This study attempts to fill these gaps in the context of Russian regions.

Therefore, the goal of the study is measuring FE attributes and productive entrepreneurship, investigating the relationship between them and determining territories with more productive entrepreneurship.

The context of Russia is an interesting case for investigation for the following reasons. In 2021, Russia emerged as a TOP-20 country in the Global FinTech Index, rising 13 positions from the previous year (Findexable 2021). Russia has also been ranked in the TOP-3 countries for applying innovative solutions in the financial sector (Kuhn 2021). According to Ernst and Young (2019), the FinTech Adoption Index in Russia amounted to 82% in 2019, exceeding the global average rate. The above-mentioned achievements indicate that Russia has cultivated a favourable climate for FinTech development.

In this study, we developed a survey tool for measuring FE attributes: the FE index. This index extends previous conceptual and empirical work on entrepreneurial and FE ecosystems (Feld 2020; Isenberg 2011; Neck et al. 2004; Spigel 2017; Stam and van de Ven 2019; Szerb et al. 2019; Findexable 2021; Sinai Lab 2020; Laidroo et al. 2021). Two approaches—additive and multiplicative—were used to calculate the FE index.

There is no consensus in the ecosystem literature on the level of analysis—city, region, country, or other levels. This study is based on the regional level, like other empirical research on ecosystems (DeFries and Nagendra 2017; Leendertse et al. 2021; Stam 2018). The suggested tool for measuring FE attributes was tested for 10 Russian regions where most FinTechs are located.

The FE index recognises a similar environment in the analysed regions for financial sector entrepreneurship. These regions have high estimates of physical infrastructure, demand, and talent. New knowledge and networks appear to be this environment's weak sides in terms of financial sector entrepreneurship. Among these regions, Moscow has the most favourable environment for entrepreneurship in the financial sector. Such attributes as finance and leadership mostly determine Moscow's superiority over other regions. At the same time, the Chelyabinsk region has the lowest FE index value.

The correlation analysis showed a positive link between FE attributes and productive entrepreneurship, as measured by the number of FinTechs. Data envelopment analysis (DEA) indicated territories with productive entrepreneurship. With the additive FE index, Moscow was recognised as a region that has effectively created an environment for productive entrepreneurship. Regarding the multiplicative FE index, the Chelyabinsk region achieved the best results. The contrary results can be explained by the features of the FE index calculation and highlight the importance of choosing an adequate measure of FE attributes. The results of the DEA analysis also indicate that the physical infrastructure and demand in Russian regions are underutilised by entrepreneurs. In addition, the results high-

light finance, intermediate services, and formal institutions as attributes maximally used by entrepreneurs and require additional attention from policymakers for entrepreneurship development. Improving the understanding of FE attributes and their links to productive entrepreneurship would benefit both policymakers and entrepreneurs.

This paper contributes to the literature on entrepreneurial ecosystems (Stam 2018; Stam and van de Ven 2019; Mateos and Amorós 2019; Villegas-Mateos 2020; Leendertse et al. 2021) by supporting a positive link between an ecosystem’s attributes and productive entrepreneurship. Based on this link, this current research provides a tool for identifying territories with productive entrepreneurship.

This paper contributes to the FinTech literature in several respects. It extends the literature on measuring FE attributes (Ernst and Young 2014; Gagliardi 2018; Findexable 2021; Sinai Lab 2020; Alaassar et al. 2021; Laidroo et al. 2021) by developing a survey-based approach. It also contributes to the FinTech literature in Russia (Kleiner et al. 2020; Koroleva et al. 2021; Vaganova et al. 2020) by being the first to measure FE attributes.

This article is structured as follows. The theoretical and empirical backgrounds are summarised in Section 2. The methodology and data are presented in Section 3. Section 4 concentrates on the results of this study. Finally, Section 5 provides a discussion and conclusion.

2. Literature Review

2.1. Entrepreneurial and FinTech Ecosystems

Several studies (Spigel 2017; Stam 2015) indicate that an entrepreneurial ecosystem approach can be used for synthesising academic research on entrepreneurship and its regional developments. This approach supposes the analysis of two main layers: the attributes of an ecosystem (input) and productive entrepreneurship (output). The connection between attributes and productive entrepreneurship is difficult to explain due to their interdependence. Attributes influence productive entrepreneurship, but over time, output also feeds back into input (Stam 2015).

The main challenge in identifying attributes arises from entrepreneurial ecosystems’ diverse origins and complexity (Spigel 2017). Although there is no universal approach to classifying the attributes of entrepreneurial ecosystems, different scholars and practitioners have attempted to create classifications and tools for measuring them. Table 1 summarises the classifications of entrepreneurial ecosystem attributes found in the literature. The relevant articles were collected from the 2004–2020 Scopus database using the keywords ‘attributes of entrepreneurial ecosystem’ and ‘elements of entrepreneurial ecosystem’.

Table 1. Overview of entrepreneurial ecosystem attributes.

Research	Formal Institutions	Entrepreneurship Culture	Physical Infrastructure	Demand	Networks	Finance	Leadership	Talent	New Knowledge	Intermediate Services
Stam (2015); Stam and van de Ven (2019); Leendertse et al. (2021)	+	+	+	+	+	+	+	+	+	+
Szerb et al. (2019)	+	+	-	-	+	+	+	+	+	-
Nicotra et al. (2018)	+	+	-	-	+	+	-	+	+	+
Spigel (2017)	+	+	+	-	+	+	+	+	+	+
Liguori et al. (2018); Isenberg (2011)	+	+	+	-	+	+	+	+	-	+
Cohen (2006); Neck et al. (2004)	+	-	-	-	+	+	-	+	-	+

Note: + means the research includes the attribute and - means that it does not include it.

The comparison of entrepreneurial ecosystem attributes was based on [Stam's \(2015\)](#) model because it provides the most comprehensive view of an entrepreneurial ecosystem, including institutional arrangements and resource endowment elements. This model consists of 10 attributes: formal institutions, entrepreneurship culture, networks, physical infrastructure, finance, leadership, talent, new knowledge, demand, and intermediate services.

Formal institutions reflect the regulation and role of the government in ecosystem formation. Entrepreneurship culture characterises the value of entrepreneurship. It consists of an entrepreneur's innovativeness, willingness to take risks, self-organisation, and motivation. Physical infrastructure includes transport and digital infrastructure, which support the development of entrepreneurship. Demand reflects the readiness of customers to buy products or use services. Networks reflect collaboration between actors and their readiness for equal dialogue. Finance reflects access to different financial resources. Leadership characterises actors taking a leadership role in an entrepreneurial ecosystem. Talent covers the labour market and higher education. This represents the availability of highly qualified training of entrepreneurs or specialists in the market who support entrepreneurs in the process of starting a business. R&D investments are included in the attributes of the entrepreneurial ecosystem as new knowledge. Intermediate services characterise support by informal institutions, such as incubators or accelerators. In this paper, we also relied on [Liguori et al. \(2018\)](#) while developing a survey covering FE attributes.

Most attempts to measure FE attributes have been made by analytical companies. [Sinai Lab \(2020\)](#) created the Global FinTech Hub Index as an expansion of applying another index—the China FinTech Hub Index. This index is based on three perspectives, enterprise, consumer, and government, and ensures the cross-comparability of data from different countries. The Global FinTech Index ([Findexable 2021](#)) consists of three metrics, the number of FinTechs, the number of unicorns, and the environment, and ignores quality information about FE attributes. The developers of this index explained the choice of metrics using their own and their partners' experiences. According to [Ernst and Young \(2014\)](#), it is adequate to highlight four main FE attributes—talent, capital, policy, and demand—and estimate them from the opinions of experts. The report by [Gagliardi \(2018\)](#), based on 15 interviews with renowned experts, followed FE attributes: demand drive, systemic linkages, and regulatory oversight.

Practitioners' indices determine an FE's key attributes. First, it is an activity of formal institutions. Developing FinTech-friendly regulations and special state programmes contributes to developing entrepreneurship in the financial sector. Then, demand reflects the popularity of FinTech services among customers. Finance, talent, and networks are used at least once in calculating corresponding indices. Nevertheless, the indices suffer from a lack of theoretical background and are based on developers' experience. This means that indices may ignore the significant attributes and complexity of a FinTech ecosystem. A lack of accumulated statistical resources leads to basing these indices on a mixture of information covering different territories (country versus region).

Academics have suggested alternative approaches to measuring FE attributes. Based on the ecosystem index by [Stam and van de Ven \(2019\)](#), [Laidroo et al. \(2021\)](#) developed the additive FE index at the country level. We highlight the importance of IT infrastructure and FinTech regulation and reveal these elements as separate attributes of an FE. The disadvantage of this index is the unequal weight of the attributes. To our knowledge, no further attempts have been made to measure FE attributes.

A healthy entrepreneurial ecosystem generates productive entrepreneurship as an output. The term productive entrepreneurship lacks a single agreed-upon definition. Productive entrepreneurship reflects any activity that contributes to the net output of an economy. For [Aidis \(2005\)](#), this refers to innovative actions that result in an economically productive business. [Acs and Szerb \(2007\)](#) emphasise that productive entrepreneurship enables the creation and commercialisation of valuable knowledge.

Considering these definitions, it is possible to determine the main characteristics of productive entrepreneurship. First, productive entrepreneurship contributes to economic

growth, including job creation. Then, it generates innovation. Finally, it is a way of commercialising new ideas and knowledge. In the framework of this current research, productive entrepreneurship is understood as an innovation activity that contributes to the commercialisation of new ideas and knowledge and leads to economic growth in a certain territory. In Section 3.2 of this paper, a measure of productive entrepreneurship is suggested based on the proposed definition.

2.2. Developing the Conceptual Framework

In line with previous research, applying the ten attributes of an entrepreneurial ecosystem may require adjustments when considering an FE (see Table 2).

Table 2. Attributes of an FE.

Attribute	Description
Formal institutions	The extent to which a government supports the FinTech activity
Entrepreneurship culture	The extent to which entrepreneurship is valued
Physical infrastructure	The extent to which potential customers of FinTech services have access to the internet
Demand	The extent to which potential customers adopt FinTech services
Networks	The extent of communication between actors within the FE framework
Leadership	Leadership that guides and directs collective action
Talent	The extent of individuals with skills adequate for FinTech development
Finance	The amount of capital invested in FinTechs
New knowledge	Investments in new knowledge
Intermediate services	The supply and accessibility of intermediate business services

The classification of FE attributes includes the attributes mentioned in previous research and ensures a comprehensive FE view.

Formal institutions identify the rules of organising a business and of government supporting FinTech entrepreneurship. The FinTech sector is connected to applying innovations, which are often restricted by compliance with certain regulations (Bromberg et al. 2017). Entrepreneurship culture covers the propensity for entrepreneurship, including its popularity and the attitudes of the society. It is also based on the history of successful FinTechs, among other aspects. It can provide benefits and resources for potential entrepreneurs regarding how to best organise a business in the FinTech sector. Physical infrastructure reflects the possibility of customers receiving FinTech services, which require the use of web resources. This would be impossible without the creation of certain physical infrastructure. Demand is critical to the health of any sector, especially the nascent FinTech sector (Ernst and Young 2014), and is identified by customers' readiness to use FinTech services.

Spigel (2017) insisted on the different emphases of actors and their roles in an ecosystem framework. However, it is necessary to ensure equal access to actors and terms for a network to develop entrepreneurship in the financial sector (Brush et al. 2019). Leadership guides collective action (Stam and van de Ven 2019) and identifies trends in the financial sector. This leadership is critical in building and maintaining a healthy ecosystem (Feldman 2014). The ease of creating a team to start a FinTech project or to find a suitable candidate for an employment vacancy also contributes to developing entrepreneurship in the financial sector. Talent emphasises the relevance of the availability of potential employees with suitable IT and business skills and adequate experience in the financial sector.

Within an FE, access to financing is a critical attribute that ensures the growth of individual companies and the entire industry. That is why it is relevant to develop bank credits and alternative financing (e.g., venture capital, business angels, etc.). To apply innovative solutions, it is necessary to invest in and develop them. Therefore, new technological knowledge is highlighted as one FE attribute. Intermediate services include support from informal institutions, such as incubators and accelerators. Organisations create accelerator

programmes and coworking spaces (Block et al. 2018). They also connect investors to promising FinTechs, which broadens their financing possibilities (Alaassar et al. 2021).

2.3. Level of Analysis

There is no consensus in the entrepreneurial ecosystem literature regarding the level of analysis of entrepreneurial ecosystems—city, region, country, or other levels. Relevant boundaries of an entrepreneurial ecosystem are difficult to identify due to their openness. Each attribute of an ecosystem can have its own boundaries (Leendertse et al. 2021). Government support is limited by the governmental level (i.e., municipal, regional, or national). The development of physical infrastructure is identified by localities. The training of qualified personnel for entrepreneurship depends on an educational institution's location. New knowledge can be identified by the location of the innovation centres.

Kuckertz (2019) distinguished between the administrative, spatial, and conceptual boundaries of an entrepreneurial ecosystem. DeFries and Nagendra (2017) insisted on the necessity of going beyond administrative boundaries to involve stakeholders in an entrepreneurial ecosystem. Leendertse et al. (2021) focused on the analysis of entrepreneurial ecosystems at the regional level (i.e., between the municipal and national levels). However, entrepreneurs' activities are not restricted by cities or regions and can go beyond a specific country. Entrepreneurs can also be actors in several entrepreneurial ecosystems or connectors of ecosystems on a global scale (Malecki 2011). Nevertheless, ecosystem management is place-based (Roundy et al. 2018), which is why, in the framework of this current research, the defining of entrepreneurial ecosystem boundaries is possible.

Experience in measuring FE attributes also shows different levels of analysis. Laidroo et al. (2021) concentrated on the country level. Ernst and Young (2014) and Sinai Lab (2020) focused on the city level. Findexable (2021) published the Global FinTech Index on two levels simultaneously: country and cities.

In this current study, the theoretical background is the entrepreneurial ecosystem approach. Based on the results of highly cited research on entrepreneurial ecosystems (DeFries and Nagendra 2017; Leendertse et al. 2021; Stam 2018), we focused on a regional-level analysis of FEs.

3. Data and Methodology

3.1. Initial Data

In the framework of this research, a FinTech is defined as a company that contributes to the provision of financial services and has generally innovative information technology elements in its activities. It can be an independent or bank-owned company. To measure FE attributes and productive entrepreneurship and investigate the relationship between them, it was necessary to collect data on FinTechs in Russian regions. To collect data on companies, different official data sources were analysed (e.g., banks' and accelerators' websites, media)¹. As a result, a list of 332 companies was compiled and registered in 2020 in a certain region of Russia. The distribution of FinTechs across the Russian regions is presented in Table 3.

FinTechs' uneven regional distributions may indicate different stages of development and distribution of FinTech services. To achieve the goal of this research, 10 identified regions were selected for further analysis. Based on Stam's (2015) model, the data on FE attributes were collected mostly via an online survey and covered the conceptual framework developed earlier. The focus group for the survey comprised FinTech owners, board members, or executives. Table 4 presents empirical indicators of each attribute, source, and scale.

Table 3. The distribution of FinTechs across Russian regions.

Region	FinTechs	
	Number	Share (%)
Moscow	272	81.93
St. Petersburg	16	4.82
Republic of Tatarstan	6	1.81
Sverdlovsk region	5	1.51
Novosibirsk region	4	1.20
Nizhny Novgorod region	3	0.90
Perm region	3	0.90
Voronezh region	3	0.90
Chelyabinsk region	3	0.90
Rostov region	3	0.90
Other regions	14	4.22
Total:	332	100.00

Table 4. Indicators for measuring the FE Index.

Attribute	Empirical Indicator	Source	Scale
Formal Institutions	Presence of special FinTech programs	Survey	1 to 5 (best)
	FinTech-friendly regulatory legislation	Survey	1 to 5 (best)
Entrepreneurship culture	Risk-taking	Survey	1 to 5 (best)
	Doing business	Survey	1 to 5 (best)
Physical infrastructure	Companies using the internet (as % companies)	Official statistics of regions	0 to 100 (best)
	Internet users (as % population)	Official statistics of regions	0 to 100 (best)
Demand	Using the Internet for financial transactions (companies)	Official statistics of regions	0 to 100 (best)
	Using the Internet for financial transactions (population)	Official statistics of regions	0 to 100 (best)
Networks	Dialogue between actors	Survey	1 to 5 (best)
	Equal terms of competition	Survey	1 to 5 (best)
Leadership	Initiative of entrepreneurs	Survey	1 to 5 (best)
	Presence of leadership	Survey	1 to 5 (best)
Talent	Ease of creating a team	Survey	1 to 5 (best)
	Ease of finding an employee	Survey	1 to 5 (best)
Finance	Access to information about financing possibilities	Survey	1 to 5 (best)
	Ease of access to financing	Survey	1 to 5 (best)
New knowledge	R&D cooperation	Survey	1 to 5 (best)
		Survey	1 to 5 (best)
Intermediate services	Availability of incubators and accelerators	Survey	1 to 5 (best)
	Availability of advisers	Survey	1 to 5 (best)

The initial idea was to develop the FE index based only on the survey results. After designing the draft survey, a pre-test was performed on five respondents to define any inadequate and potentially ambiguous expressions. Most respondents reflected that they were not competent in assessing demand and physical infrastructure. Therefore, information on these attributes was added from official statistics. Data collected from official statistics reflected the situation in specific regions at the end of 2021. The final survey questionnaire and its correspondence to empirical indicators and sources are presented in Appendix A.

Google Forms was used as the main survey platform. The survey was carried out from May to August 2021 by representatives of Russian FinTechs. Links to the online questionnaire were sent to FinTechs via email or by mobile application in the framework of the conference TechWeek (31 May–2 June 2021). Suitable emails were determined based on

the data presented on the companies’ web pages or were found via personal contacts. The first email was followed by two to three reminders.

As a result, the dataset includes 137 responses: 100 from Moscow, 10 from Saint Petersburg, 5 from the Sverdlovsk region, 4 from the Novosibirsk region, 3 from each the Republic of Tatarstan, Nizhny Novgorod, Perm, Voronezh, Chelyabinsk, and Rostov regions. For Moscow, St. Petersburg, and the Republic of Tatarstan, the survey covered part of FinTechs’ population. This is explained by the large number of FinTechs in the regions, which led to the necessity of assessing the severity of the sampling bias. For other regions, the survey covered all representatives of FinTechs.

To assess the severity of sampling bias, the representativeness of the sample was tested using a chi-square test statistic and two indicators: the type of FinTech owner and Skolkovo membership. Skolkovo is an innovation centre that aims to develop technology entrepreneurship and research in Russia. To benefit from Skolkovo, FinTechs aim to be a member of the innovation centre. The choice of indicators is explained by the availability of relevant information. In the case of the presence of several types of owners in one company, all were included in a further analysis. Therefore, the number of owners can be greater than the number of FinTechs.

It was necessary to test whether the distribution of FinTechs in the sample was the same as in the original sample. These and further calculations were carried out in the STATA. The results of the chi-square test are presented in Table 5.

Table 5. Comparison of sample and original distributions.

Moscow			
The owner of FinTechs	Observed	Expected	Pearson
Bank	38	29	1.671
Individual	53	46	1.032
Company (not bank)	17	20	−0.671
VC fund	7	6	0.408
Pearson chi2 test (3) = 4.4750 Pr = 0.215			
FinTech is a member of Skolkovo	Observed	Expected	Pearson
Yes	15	17	−0.485
No	85	83	0.220
Pearson chi2 test (1) = 0.2835 Pr = 0.594			
St. Petersburg			
The owner of a FinTech	Observed	Expected	Pearson
Bank	0	0	-
Individual	7	10	−0.949
Company (not a bank)	4	2	1.414
VC fund	2	3	−0.577
Pearson chi2 test (3) = 3.233 Pr = 0.199			
FinTech is a member of Skolkovo	Observed	Expected	Pearson
Yes	4	3	0.577
No	6	7	−0.378
Pearson chi2 test (1) = 0.4762 Pr = 0.490			
Republic of Tatarstan			
The owner of FinTech	Observed	Expected	Pearson
Bank	0	0	-
Individual	3	3	-
Company (not bank)	1	1	-
VC fund	1	1	-
Pearson chi2 test (3) = 0.0000 Pr = 1.000			
FinTech is a member of Skolkovo	Observed	Expected	Pearson
Yes	1	1	-
No	2	2	-
Pearson chi2 test (1) = 0.0000 Pr = 1.000			

Insignificant *p*-values (Pr) in all cases imply that the distribution of the sample accords with the analysed regions’ population statistics.

3.2. Methodology

This section is structured according to the goal of the study. First, the author suggests the approaches of measuring the FE attributes and productive entrepreneurship. Then, the tool of evaluating the association between the identified indicators is discussed.

3.2.1. Calculating the FE Index

To map FE attributes, the FE index was constructed. This index compares different regions and ranks them in terms of a set of indicators. The algorithm for constructing the FE index was developed based on existing studies (Stam 2018; Stam and van de Ven 2019; Leendertse et al. 2021; Laidroo et al. 2021) and by considering the limitations of the developed measures of ecosystem attributes.

Constructing the FE index included five main stages. The first step was to calculate the average value of the empirical indicators measured by the survey. According to the information presented in Table 4, the scales of the indicators differed. The second step was to normalise the scales of the indicators. To index formalisation, it was necessary to ensure equal weight (Leendertse et al. 2021). Therefore, indicators from official statistics were adapted to a Likert scale (from 1 to 5 (best)).

The third step was the reduction of FE indicators to a comparable value. This was achieved by normalising the average value of each indicator to 1 (Stam 2018). This means that indicators in the regions performing below average have a value below 1, while indicators performing better than average have a value above 1. The fourth step consisted of ensuring the same weight of attributes in the FE index. Each ecosystem attribute was represented by two indicators. The same number of indicators for each attribute ensures the same weight in the FE index. In future research, the weighing methodology may change based on the opinions of experts or the professional community.

Finally, the value of the attributes was summed into one index. The index value remained close to 10. This means that the regions performing on average for all scoring attributes had an index value of 10. Regions performing higher than average for all scoring attributes had an index value greater than 10, while regions performing lower than average for all scoring attributes had an index value lower than 10.

Stam (2018) also analysed complex interactions among entrepreneurial ecosystem attributes and suggested calculating a multiplicative ecosystem index. This leads to index values with a much larger variation. In this research, two approaches to calculating the FE index were also used. The suggested approach overcame the limitations of previous measures of ecosystem attributes via these aspects.

First, the survey-based approach provided the opportunity to represent the opinions of many representatives of FinTechs. As a result, the data gathered better describe an ecosystem's attributes (Mathers et al. 1998). To assess the severity of sampling bias, the representativeness of the sample was tested using the chi-square test statistic with different criteria. The survey-based approach ensured the comparability of the collected data using the same questions in the same way. Second, the survey-based approach allowed for the collection of data within a particular territory and avoided the use of information from different territory levels to assess the attributes of ecosystems at a certain level. The normalisation of the scales of the indicators ensures their equal weight-to-index formalisation.

3.2.2. Indicating the Productive Entrepreneurship

There is no universal measure of productive entrepreneurship. The literature review by Nicotra et al. (2018) revealed three approaches to measuring entrepreneurship: gross-based, assumption-based, and performance-based. Gross entrepreneurship focuses on the net entry of regional indicators. For example, Piergiovanni et al. (2012) analysed the growth of companies in specialised industries. Carree and Thurik (2008) focused on changes in labour productivity at the regional level. The assumption-based approach to productive entrepreneurship focuses on the survival of start-ups. Coad and Rao (2008) indicated that

innovation-based start-ups are more survival-oriented than not. Thus, innovation-based start-ups can be a possible indicator of productive entrepreneurship.

Performance-based productive entrepreneurship focuses on the number of high-growth start-ups as an indicator. According to [Acs and Szerb \(2007\)](#), high-growth start-ups play a special role in contributing to the economic growth of territories. [Leendertse et al. \(2021\)](#) suggested focusing on the number of gazelles—companies that increase their revenue by at least 20%, starting from a revenue base of USD 1 million. [Acs et al. \(2017\)](#) insisted on using a stronger term: the number of unicorns.

Measuring productive entrepreneurship in Russian regions is not an easy task. The official statistics of Russian regions do not allow diversification of indicators—labour productivity or gross regional product—depending on a specific industry (including FinTech). There are also no unicorns in Russia ([Stas 2021](#)). We also found no gazelles in the Russian regions. Based on an assumption-based approach to productive entrepreneurship, the number of FinTechs is identified as a possible measure. Thus, FE attributes were measured by the FE index, and productive entrepreneurship by the number of FinTechs.

3.2.3. Testing the Association between the FE Index and Productive Entrepreneurship

To analyse the links between the indicators, a correlation analysis was conducted on a dataset of 10 Russian regions. This was selected partly because correlation analysis was the most common tool used in previous studies ([Stam 2018](#); [Stam and van de Ven 2019](#)). However, the small sample size reduced the relevance of the regression analysis.

DEA was used to estimate the efficiency of Russian regions using FE attributes in productive entrepreneurship. This method was originally developed for the efficiency measurement of different units and is widely used in the context of entrepreneurship ([Lafuente et al. 2018](#); [Pandey 2018](#)). DEA is a nonparametric approach based on linear programming that determines the efficiency level for each unit in a sample. The efficiency level of the decision-making units (DMUs) was identified in comparison with the best unit in the sample by deriving the compared efficiency. DEA calculates a single relative ratio for each DMU in a sample by comparing input and output information.

In the context of this current research, the DMU was a particular region in Russia, the input was the value of the FE index, and the output was the number of FinTechs. The main advantage of DEA is its ability to compare diverse and heterogeneous inputs–outputs simultaneously, with no assumption about the data distribution ([Lee and Ji 2009](#)). The number of DMUs should be not less than the multiplication of the numbers of outputs and inputs and not less than three times the sum of the numbers of outputs and inputs ([Cooper et al. 2007](#)). Therefore, the DEA analysis based on 10 regions in Russia was considered fair. The DEA efficiency value ranged from 0.0 to 1.0. Regions with a DEA efficiency value equal to 1.0 were considered effective. Regions with an efficiency value lower than 1.0 were considered ineffective.

Two types of DEA are widely used by researchers. They are input-oriented (focused on the minimisation of input information) and output-oriented (focused on the maximisation of output information) analyses. In the framework of this research, the DEA model was oriented towards the output. Policymakers and entrepreneurs aim to engage in a created environment by maximally developing entrepreneurship in a region.

DEA allows for determining slacks ([Sharma et al. 2009](#)), represented by the magnitude of inefficiency in particular inputs. Due to slacks, we additionally analysed the separate attributes of FEs and indicated ones that used inefficiency in a certain Russian region.

4. Results

4.1. The FE Index

Based on the algorithm discussed in Section 3.2, the distribution of the average values of FE attributes (normalised to one scale) in Russian regions is presented in Appendix B.

In the analysed regions, the attributes' values are distributed similarly. This indicates a similar approach to creating an environment to develop entrepreneurship in the financial

sector. The regions have high-quality physical infrastructures. Ninety percent of the population (or companies) in the Russian regions has access to the internet. This means that around 90% of the population or companies are potential customers of FinTech services. This number is comparable to the value of the 2019 FinTech Adoption Index in Russia. According to [Ernst and Young \(2019\)](#), 82% of people have used FinTech services.

Physical infrastructure influences customers' adoption of FinTech services and customers' related demands. In the case of Russian regions, demand achieves sufficiently high evaluations. It reflects a significant portion of customers, including companies, who use the internet for financial transactions. The attribute talent evaluated highly. If the founders of FinTechs do not have adequate knowledge, they will need a team of experts with such knowledge to support the launch of a FinTech ([Koroleva et al. 2021](#)). A high score for this attribute means that the representatives of FinTechs do not encounter the problem of finding experts with knowledge supporting a FinTech's launch in Russian regions.

New knowledge and networks are recognised as the weak sides of the environment for entrepreneurship in the financial sector. According to the opinions of FinTech representatives, organisations are not investing enough in R&D. The application of innovative solutions is associated with difficulties in legislation and the risk of customers' negative attitudes towards a service ([Arner et al. 2017](#); [Chuang et al. 2016](#)). Therefore, companies are not very interested in scientific developments and prefer to suggest services based on proven solutions.

In addition, an ecosystem's actors have unequal access to the financial sector. The feature of FinTech development in Russia is the superiority of banks and the state ([Stas 2021](#)). Currently, the focus of the Central Bank of Russia is to create an infrastructure environment (e.g., remote identification, a fast payment system, etc.) that would provide equal access and ensure competition for each FE actor. However, despite the Central Bank's efforts, evaluations of networks remain low.

Intermediate services (support of incubators, accelerators, or other advisers) receive high evaluations in Moscow, St. Petersburg, and the Republic of Tatarstan. Most intermediate services in Russia are in innovation centres. A significant share of FinTechs that participated in the survey were Skolkovo members. Perhaps such high values are due to this aspect.

In comparison with other regions, Moscow has high values in leadership. This can be explained by the location of the Central Bank of Russia and most cluster organisations in the financial sector. Moscow also has a sufficiently high evaluation of access to finance. Generally, alternative financing has not developed in Russia compared to other countries ([Lyasnikov et al. 2017](#)). Nonetheless, Moscow is more attractive for FinTech entrepreneurship than other regions. Most exhibitions and competitions for obtaining additional financial resources are held in Moscow. Therefore, for FinTechs, it is easier to acquire information about possible financing and to participate in competitions there. Finance and leadership mostly determine Moscow's superiority over other regions.

With the implementation of the proposed algorithm, the following results were obtained with the additive FE index (see [Figure 1](#)).

Moscow, St. Petersburg, and the Republic of Tatarstan perform better than the average for most attributes and had an index value higher than 10. The Novosibirsk and Nizhny Novgorod regions have FE index values of around 10 (9.73 and 9.6, respectively). Other regions performed lower than average for most attributes and had an index value below 10.

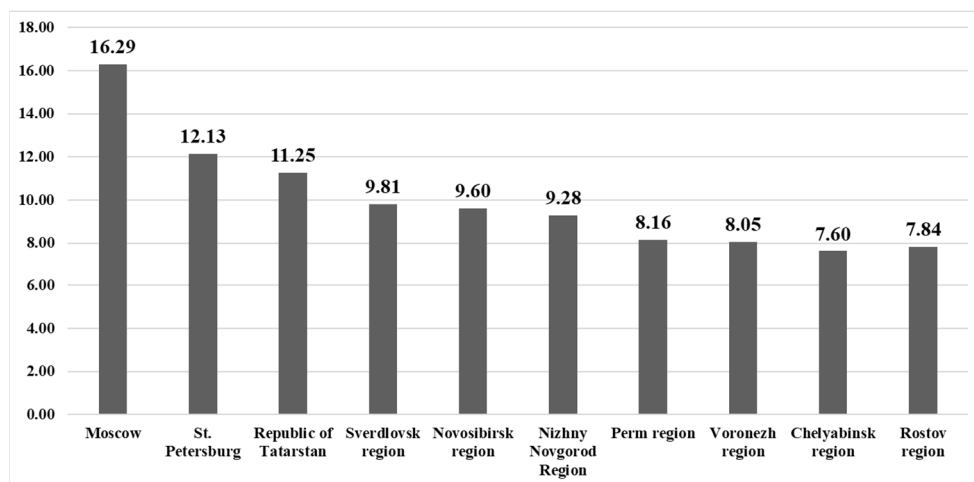


Figure 1. Additive FE index for Russian regions.

The maximum ranges of attribute evaluations are in intermediate services, finance, and formal institutions. This highlights the differences in access to finance, local and state programmes, and support from intermediate business services in the regions. Demand and physical infrastructures varied the least and achieved high evaluations. This shows the relevance of internet access and customers’ readiness to use FinTech services in all Russian regions.

The disadvantage of the additive FE index is that attributes with above-average evaluations have a stronger effect on the index than do attributes with below-average values. Supporting Stam (2018), the results of the calculation of the multiplicative FE index are presented in Figure 2. The multiplicative FE index has a variation much larger than the additive index.

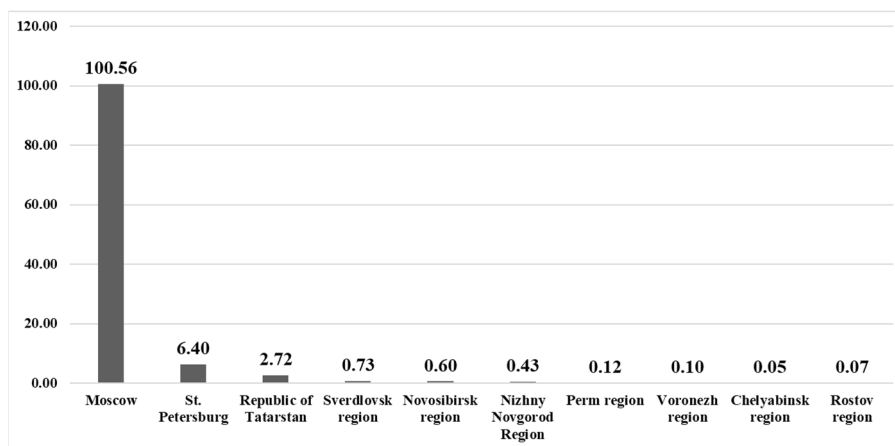


Figure 2. Multiplicative FE index for Russian regions.

As expected, the multiplicative FE index highlights a significant gap in all attributes of Moscow from other regions but does not contradict the conclusions drawn from the additive FE index. Considering the complex and nonlinear relationship between an entrepreneurial ecosystem’s attributes (Stam 2018), we support that the multiplicative index is superior to the additive index.

4.2. Relationship between FE Attributes and Productive Entrepreneurship

To test the link between FE attributes and productive entrepreneurship, a correlation analysis was conducted (see Table 6).

Table 6. Relation between FE attributes and productive entrepreneurship.

Correlation Coefficient	Additive FE Index	Multiplicative FE Index
Number of FinTechs	0.85 ***	0.99 ***

Note: *** $p < 0.001$.

Both FE indices were positively and statistically correlated significantly with the number of FinTechs. This result supports the positive association between FE attributes (input) and productive entrepreneurship (output).

Applying DEA allows for defining Russian regions with productive entrepreneurship, considering the value of the FE index. The results are presented in Table 7.

Table 7. Identification of efficient Russian regions, comparing values of the FE index with productive entrepreneurship.

Region	Additive FE Index		Multiplicative FE Index	
	Rank	Efficiency Value	Rank	Efficiency Value
Moscow	1	1.000	8	0.049
St. Petersburg	2	0.079	9	0.046
Republic of Tatarstan	3	0.032	10	0.040
Sverdlovsk region	4	0.031	6	0.125
Novosibirsk region	5	0.025	7	0.121
Nizhny Novgorod region	10	0.019	5	0.126
Perm region	9	0.022	4	0.445
Voronezh region	8	0.022	3	0.543
Chelyabinsk region	6	0.024	1	1.000
Rostov region	7	0.023	2	0.785

Using different approaches to calculate the FE index led to opposite results. This can be explained by differences in the initial data. Moscow has a 1633.16 times higher multiplicative FE index value than the Chelyabinsk region and a 2.12 times higher value with the additive FE index. Such a huge difference in measuring the environment for entrepreneurship in the financial sector led to contrary results and highlights the importance of choosing adequate measures for FE attributes.

The results based on the additive index indicate that Moscow is the region that effectively creates an environment for productive entrepreneurship. The results of the multiplicative index rank the Chelyabinsk region as the most efficient. Recall that this region received the lowest FE index value. The recognition of a region as effective means that it makes the most of the environment created in the region for productive entrepreneurship in the financial sector.

The DEA analysis, by additionally calculating slacks, revealed attributes with enough high value and that are underutilised by entrepreneurs in their activities within the framework of the financial sector. The results are presented in Table 8.

Table 8. The slack of inefficient Russian regions.

	Formal Institutions	Entrepreneurship Culture	Physical Infrastructure	Demand	Networks	Leadership	Talent	Finance	New Knowledge	Intermediate Services
Moscow	-	-	-	-	-	-	-	-	-	-
St. Petersburg	0.03	0.03	0.04	0.04	0.05	0.01	0.04	-	0.03	0.03
Republic of Tatarstan	0.01	0.02	0.03	0.03	0.03	-	0.02	0.01	0.03	0.03
Sverdlovsk region	0.02	0.02	0.05	0.05	0.03	0.02	0.03	0.02	0.04	-
Novosibirsk region	0.01	0.04	0.03	0.03	0.02	0.02	0.03	0.01	0.02	-
Nizhny Novgorod region	0.01	0.02	0.02	0.02	0.01	0.01	0.02	0.01	0.01	-
Perm region	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01	-
Voronezh region	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.01	-
Chelyabinsk region	0.01	0.01	0.03	0.03	0.02	0.01	0.01	0.01	0.01	-
Rostov region	0.02	0.02	0.04	0.04	0.02	0.02	0.02	0.01	0.03	-

In the context of Russian regions, physical infrastructure and demand are attributes underutilised by entrepreneurs in their financial sector activities. The insufficient use of attributes is explained by the insufficient development of other attributes. This was also visible in [Spigel \(2017\)](#), who showed a significant dependence between attributes in an ecosystem.

Finance, intermediate services, and formal institutions are identified as attributes maximally used by entrepreneurs and require additional attention from policymakers for developing entrepreneurship. This partly supports the conclusions made earlier in the results of analysing the FE index. In Russian regions, alternative finance (e.g., venture capital, business angels, etc.) is poorly developed. Most FinTechs are financed by their owners ([Koroleva et al. 2021](#)). Intermediate services are located mostly near innovation centres. Therefore, support from incubators or accelerators is accessible only to members of these centres. Formal institutions highlight the necessity of developing FinTech-friendly legislation and special state programmes. Thus, improving the understanding of FE attributes and their links to productive entrepreneurship could benefit policymakers and entrepreneurs.

5. Conclusions and Discussion

This paper provides evidence of the relationship between FE attributes and productive entrepreneurship in regions of Russia. We propose a survey-based tool for measuring the attributes of FEs that seems to properly capture underlying phenomena. This approach expands the application of [Stam's \(2015\)](#) model and [Liguori et al.'s \(2018\)](#) perceptual measure to FEs in terms of measuring attributes. The suggested approach provides the opportunity to represent the opinions of many FinTech representatives. A survey-based approach allows for the consideration of FEs' uniqueness and remains flexible in terms of covered territory.

The creation of a favourable environment for entrepreneurship had a positive association with productive entrepreneurship in the financial sector of Russian regions. In addition, the DEA analysed the regions with productive entrepreneurship, based on the results of measuring FE attributes. These results can help policymakers and entrepreneurs understand the strengths and weaknesses of a certain region's environment and use them to

accelerate business activity in the financial sector. The results of the DEA analysis support [Spigel \(2017\)](#) in matters of the interdependence of an FE's attributes and highlight the need for more balanced development of an entrepreneurial environment in the financial sector.

This paper extends the literature on measuring FE attributes ([Ernst and Young 2014](#); [Gagliardi 2018](#); [Findexable 2021](#); [Sinai Lab 2020](#); [Alaassar et al. 2021](#); [Laidroo et al. 2021](#)) by developing a survey-based approach. It also contributes to FinTech research in Russia ([Kleiner et al. 2020](#); [Koroleva et al. 2021](#); [Vaganova et al. 2020](#)) by being the first to measure FE attributes in regions of Russia. The approbation of the algorithm determines a similar approach for creating an environment to develop entrepreneurship in the financial sectors of different regions. The regions have sufficiently developed physical infrastructures and high demand for FinTech services. New knowledge and networks were defined as weak aspects of the entrepreneurial environment in Russia's financial sector. It is also possible to highlight the unbalanced development of FE attributes throughout the regions.

This paper contributes to the literature on entrepreneurial ecosystems ([Stam and van de Ven 2019](#); [Mateos and Amorós 2019](#); [Villegas-Mateos 2020](#); [Leendertse et al. 2021](#)) by analysing the link between ecosystem attributes and productive entrepreneurship and by suggesting a tool for revealing effective regions in the context of FE attributes and productive entrepreneurship. This allows us to determine the attributes that are underutilised or not sufficiently developed to contribute to entrepreneurs' activities.

Our results have limitations. The analysis was based on a relatively small number of regions in one period. To arrive at more robust findings, this analysis should be repeated in multiple periods. This would deliver more data points of FE index values and productive entrepreneurship and allow for feedback effects of productive entrepreneurship on FE attributes. The analyses should also be repeated in other contexts, potentially estimating different relationships between FE attributes and productive entrepreneurship. The approbation of a developed survey-based approach was realised at the regional level. However, it can be debated whether regional borders provide the most adequate boundaries for FEs. Boundaries are almost always arbitrary, likely somewhere between the municipal and national levels ([Stam 2018](#); [Stam and van de Ven 2019](#); [Leendertse et al. 2021](#)).

Despite these limitations, and due to the increasing role of FinTechs, this paper provided a unique example of measuring FE attributes based on the survey approach, understanding the link between attributes and productive entrepreneurship, and indicating territories that effectively use a created environment to develop entrepreneurship in the financial sector.

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Appendix A. Indicators and Questions in the Questionnaire

Empirical Indicator	Claim	Scale	Source
Presence of special FinTech programs	The local government has programmes in place to help new FinTechs, such as with training programmes or special grants.	1—completely wrong; 2—wrong; 3—rather yes than no; 4—true; 5—absolutely true	Liguori et al. (2018)
FinTech-friendly regulatory legislation	There is clear progressive regulatory legislation that supports FinTech activity in the region.	1—completely wrong; 2—wrong; 3—rather yes than no; 4—true; 5—absolutely true	Pollari (2017)
Risk-taking	The social values and culture of the region encourage entrepreneurial risk-taking.	1—completely wrong; 2—wrong; 3—rather yes than no; 4—true; 5—absolutely true	Doğan (2016)
Doing business	It is relatively easy to start a business, including in the region's financial sector.	1—completely wrong; 2—wrong; 3—rather yes than no; 4—true; 5—absolutely true	Feld (2020)
Dialogue between actors	The actors of an FE aim to communicate with each other on controversial issues in the region.	1—completely wrong; 2—wrong; 3—rather yes than no; 4—true; 5—absolutely true	Hendrikse et al. (2018)
Equal terms of competition	The actors of an FE compete on equal terms in the region.	1—completely wrong; 2—wrong; 3—rather yes than no; 4—true; 5—absolutely true	Brush et al. (2019)
Initiative of entrepreneurs	The social values in the region encourage FinTech founders' self-sufficiency and personal initiatives.	1—completely wrong; 2—wrong; 3—rather yes than no; 4—true; 5—absolutely true	Liguori et al. (2018)
Presence of leadership	There is a certain leader who guides and directs collective action in the region.	1—completely wrong; 2—wrong; 3—rather yes than no; 4—true; 5—absolutely true	Lobo et al. (2016)
Ease of creating a team	It is easy for FinTechs to create a team of individuals with knowledge supporting its launch in the region.	1—completely wrong; 2—wrong; 3—rather yes than no; 4—true; 5—absolutely true	Koroleva et al. (2021)
Ease of finding an employee	It is easy for FinTechs in the region to find an employee to fill an open position.	1—completely wrong; 2—wrong; 3—rather yes than no; 4—true; 5—absolutely true	Kuzmina-Merlino and Saksonova (2018)
Access to information about financing possibilities	Information on what funding programmes are available for FinTechs is easily accessible.	1—completely wrong; 2—wrong; 3—rather yes than no; 4—true; 5—absolutely true	Liguori et al. (2018)
Ease of access to financing	Local individual investors in the region are willing to financially support FinTechs.	1—completely wrong; 2—wrong; 3—rather yes than no; 4—true; 5—absolutely true	Liguori et al. (2018)
R&D cooperation	Financial organisations have cooperative agreements in R&D with other actors in the region.	1—completely wrong; 2—wrong; 3—rather yes than no; 4—true; 5—absolutely true	Cassiman and Veugelers (2002)
	Financial organisations invest in R&D in the region.	1—completely wrong; 2—wrong; 3—rather yes than no; 4—true; 5—absolutely true	Cassiman and Veugelers (2002)
Availability of incubators and accelerators	Local organisations (e.g., incubators and accelerators) are active in supporting FinTechs.	1—completely wrong; 2—wrong; 3—rather yes than no; 4—true; 5—absolutely true	Liguori et al. (2018)
Availability of advisers	Professional services (e.g., lawyers and accountants) for FinTechs are readily available in the region.	1—completely wrong; 2—wrong; 3—rather yes than no; 4—true; 5—absolutely true	Liguori et al. (2018)

Appendix B. The Distribution of the Value of FE Attributes in Russian Regions

Attribute	Empirical Indicator	Moscow	St. Petersburg	Republic of Tatarstan	Sverdlovsk Region	Novosibirsk Region	Nizhny Novgorod Region	Perm Region	Voronezh Region	Chelyabinsk Region	Rostov Region	Mean
Formal institutions	Presence of special FinTech programs	3.78	2.30	2.00	1.40	1.33	1.66	1.33	1.33	1.00	1.00	1.71
	FinTech-friendly regulatory legislation	2.36	1.90	1.00	1.33	1.25	1.00	1.00	1.00	1.00	1.33	1.32
Entrepreneurship culture	Risk-taking	3.72	2.60	2.67	2.20	2.75	2.66	2.33	1.66	1.33	2.00	2.39
	Doing business	3.11	2.50	2.00	2.20	2.50	2.00	1.33	1.00	1.00	1.33	1.90
Physical infrastructure	Internet users (companies)	4.92	4.66	4.91	4.74	4.50	4.73	4.52	4.74	4.62	4.68	4.70
	Internet users (population)	4.60	4.48	4.38	4.30	4.20	3.89	4.07	3.77	4.24	4.35	4.23
Demand	Using the Internet for financial transactions (companies)	4.36	3.96	3.35	3.52	3.40	3.58	3.48	3.55	3.55	3.74	3.65
	Using the Internet for financial transactions (population)	4.51	4.46	4.28	4.12	4.21	3.99	3.87	3.97	4.09	4.17	4.16
Networks	Dialogue between actors	3.01	2.70	3.00	1.60	1.75	1.00	1.33	1.66	1.66	1.33	1.90
	Equal terms of competition	2.06	1.90	1.67	1.80	1.50	1.66	1.00	1.66	1.33	1.00	1.56
Leadership	Initiative of entrepreneurs	3.88	2.80	2.67	2.40	2.25	2.66	1.66	1.33	2.00	2.33	2.40
	Presence of leader	4.78	2.40	1.33	3.00	2.50	2.33	2.00	1.66	1.66	1.66	2.33
Talent	Ease of creating the team	4.73	3.10	3.00	3.20	3.25	3.00	2.33	2.00	2.33	2.00	2.89
	Ease of finding employee	3.13	3.20	2.33	2.60	2.25	2.66	1.66	2.00	1.33	1.66	2.28
Finance	Access of information about financing possibilities	3.12	1.70	1.67	1.60	1.25	1.33	1.00	1.33	1.00	1.00	1.50
	Ease of access to financing	2.92	1.70	1.33	1.40	1.50	1.50	1.60	1.33	1.33	1.00	1.56
New knowledge	R&D cooperation	3.10	1.80	2.33	1.40	1.50	1.50	1.66	1.33	1.33	1.33	1.73
		2.03	1.90	2.00	1.80	1.50	1.00	1.33	1.33	1.00	1.66	1.56
Intermediate services	Availability of incubators and accelerators	4.81	2.80	3.67	1.25	1.75	1.66	1.66	1.66	1.33	1.00	2.16
	Availability of advisers	4.70	3.80	3.33	1.40	1.25	1.66	1.33	1.33	1.33	1.00	2.11

Note

¹ Main data sources are Rusbase (<https://rb.ru/fintech/> (accessed on 31 July 2021)), FintechLab (<http://list.FinTech-lab.ru/> (accessed on 1 August 2021)), and FinTech Association (<https://www.fintechru.org/> (accessed on 1 August 2021)).

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