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RESEARCH ARTICLE

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Examining the interaction of sustainable innovation activity and the life cycle of small high-tech enterprises

Elena D. Vaisman[1] | Maria V. Podshivalova[1] | Andrew Adewale Alola[1,2]

[1]South Ural State University (National Research University), Chelyabinsk, Russia

[2]Department of Economics, Faculty of Economics, Administrative and Social Sciences, Istanbul Gelisim University, Istanbul, Turkey

Correspondence
Andrew Adewale Alola, Department of Economics, Faculty of Economics, Administrative and Social Sciences, Istanbul Gelisim University, Istanbul, Turkey.
Email: aadewale@gelisim.edu.tr

Abstract

The direction of this study was engineered by the need to increase the innovation activity of high-tech enterprises (primarily small enterprise) and to test the hypothesis that the innovation activity of such enterprises depends on the stage of their life cycle. At the first stage, we formulated the assumptions and prerequisites for the formation of a sample for the study: 106 small enterprises of the electric power industry of the Chelyabinsk region of Russia Federation. At the second stage, we developed a method to determine an enterprise's life cycle stage, taking into account the specifics of small industrial enterprises. Our method involves the sequential implementation of two steps. In the first, we use the traditional indicator of age of the enterprise, and in the second, we assess the degree of stability of key financial indicators of enterprise activities. At the third stage, based on the proposed method, the sample was divided into three groups: growing, mature, and long-lived enterprises, for each of which an assessment of innovation activity was carried out. As a result, we determined that small Russian enterprises in the high-tech industry demonstrate an increase in innovation activity at the stage of maturity, as a rule. However, even at this stage, only one in three enterprises shows such activity. This can be explained by the low demand for small businesses in the Russian national innovation system, as well as the lack of highly qualified personnel and the prevailing stereotypes of attitudes toward small businesses. As captured in the Sustainable Development Goals (SDGs) 9 (industry, innovation, and infrastructure), the proposed approach can be applied in the development of regional support programs and strategies for the development of small high-tech enterprises.

KEYWORDS

company life cycle, high-tech production, innovation, Russia, small industrial enterprises, sustainable development

1 | INTRODUCTION

The importance of innovation in maintaining the competitiveness of industries and businesses is beyond doubt. There are a number of studies confirming the positive impact of innovation on the export potential of companies[1] (Love et al., 2016; Volkova & Karachev, 2016), resistance to crisis (Shipovich, 2011) and on maintaining competitiveness (Blüher et al., 2000; Krivorotov et al., 2020). The importance of innovation, primarily in the manufacturing sector, is increasing due to the digitalization of the economy (Adams et al., 2006; Forsman, 2011; Philip et al., 2021) and the development of hypercompetition.[2] These changes primarily affect high-tech industries, which increases the urgency of identifying the key factors that stimulate innovation activity and developing

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a methodological justification for an innovative strategy for the development of enterprises in such industries. The scientific community and policy-making institutions at large understand that the success of the socio-economic development of national economies is largely determined by an increase in the innovation activity of the high-tech enterprises, as evidenced by a number of studies on the search for drivers of innovation activity of high-tech enterprises (Ryzhkova & Spitsyn, 2020; Zahoor & Al-Tabbaa, 2020; Zawislak et al., 2018).

There are few high-tech industries in the structure of industrial production in Russia whose enterprises actively implement strategies of innovative development. One such industry is the production of electrical equipment, the positive development trends of which include their significant export potential, the introduction of energy conservation principles, the active use of new technologies, including digital technologies, and their leading role in import substitution programs. Enterprises of the electrical industry supply equipment to almost all spheres of the economy (among which 20% of consumption falls on the fuel and energy complex, 19%—on the agro-industrial complex, and 15%—on utilities). The index of production of electrical equipment decreased by 27% from 2010 to 2015, which is understandable considering the financial crisis and the imposition of sanctions in 2014. Over the following 3 years (2016–2019), this indicator increased by 11%, thanks to the introduction of import substitution programs and the entry of domestic manufacturers into the international market.[3]

The dynamics of the number of enterprises in the industry is somewhat different. From 2010 to 2019, this figure decreased by 41% or by 5798 units. At the same time, the number of small businesses saw the most significant reduction—almost 2 times (4512 units). The decline in the number of medium and large industries is slightly less, amounting to 23% or 1286 enterprises.[3] This indicates that there are issues in maintaining the competitiveness of domestic small producers. We believe this is associated with a lack of innovation, since innovation is a critical survival factor for high-tech industries in hypercompetitive conditions, as has been proven in a number of empirical works (Huergo & Jaumandreu, 2004; Kiriri, 2004; Lopes et al., 2016).

We could assume that small industrial enterprises simply do not have time to show innovation activity due to their short life cycle. But this leads to questions regarding the stage of the life cycle of small enterprises at which innovation activity is formed and manifested. Thus, the research paradigm of the relationship between the scale of a business, its life cycle, and its innovation activity is becoming relevant.

Based on the indicated research paradigm, the following hypotheses are presented: the innovation activity of small industrial enterprises significantly depends on the stage of their life cycle: The more mature a business is, the greater the possibilities for the development and implementation of innovations. To test this hypothesis, we set a number of tasks that guides the objective of the study. The novelty of the study is highlighted through the presentation of the structure of the study. First, we conducted a literature review, examining modern advances in research on high-tech small and medium-sized enterprises (SMEs), assessing the stage of the life cycle of enterprises, and innovation activity. Second, we formulated our initial assumptions and prerequisites, substantiating the choice of the research object. Then, on the basis of a critical literature review, we formulated a method for determining the stage of the life cycle of small industrial enterprises. The results section summarizes the results of practical testing of the proposed methodological approach in relation to the selected research object. In the discussion, we present our view on the reasons for the current situation. Finally, the conclusion and policy section describes our contribution to the modern body of knowledge on innovation activity at various stages of the life cycle of high-tech SMEs. Recommendations on the application of the results obtained are offered.

2 | RESEARCH THEORY AND LITERATURE

This part of the study is dedicated to the presentation of the related literature as guided by the research theory.

2.1 | Literature review

Small business innovation has been actively studied around the world for the past decades. Researchers have examined the impact of innovation on the growth of small firms (Di Cintio et al., 2017), on the survival of small firms (Jung et al., 2018; Kim & Hwang, 2019), and on export potential (Davcik et al., 2021; Falk & De Lemos, 2019; Love et al., 2016). Empirical studies from China and Korea dominate among the papers devoted to the innovation activity of small high-tech firms in particular. These authors investigate the impact of inter-firm cooperation on innovation (Mei et al., 2019), the impact of innovation on the growth of small high-tech firms (Nunes et al., 2012), and the effectiveness of innovation (Gu et al., 2016; Guo et al., 2020), even as it relates to the environment sustainability (Alola et al., 2021; Magazzino et al., 2021). The vast majority of these papers use R&D as an indicator of innovation activity, but it is not an unequivocal choice for the study of small innovative enterprises (SIE). There is evidence of the importance of R&D for product innovation in small industrial firms (Raymond & St-Pierre, 2010), but there is also research proving the neutral (Török et al., 2018) and even negative impact of R&D on the development of small high-tech enterprises (Nunes et al., 2012). Some studies (Roper & Hewitt-Dundas, 2008) point out that R&D is generally not characteristic of small industrial enterprises. This is partly due to their high cost (Wilthagen, 2012). In addition, Nunes et al. (2012) proved that intangible assets are especially important for high-tech small enterprises. This means that intangible assets can be considered a more accurate indicator of the innovation activity of such industries, especially in high-tech industries. Thus, we can conclude that the number of empirical works studying the innovation activity of small high-tech companies through the trends of investments in intangible assets is insignificant.

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Within our study, modern achievements in determining the relationship between innovation activity and the stage of an enterprise's life cycle also came into question. We found that in the middle of the last century, many researchers studied the life cycles of enterprises in relation to the life cycles of innovation processes. This was a consequence of the linear approach to innovation, when the early stages of the development of a company created on the basis of a new idea corresponded to the early stages of innovation (e.g., Bush, 1945). Subsequently, scientists have thoroughly criticized the linear model of innovation and proposed more complex configurations. In particular, Kline and Rosenberg (1986) developed the chain-linked model. Santo (1990) considered the innovation process as a continuous cyclical process, creating the cybernetic model. Cooper (2001) treated the innovation process as discrete. These and other models more closely correspond to modern trends in the growing importance of networking among participants in the creation of innovations. At the same time the authors of the new models pay almost no attention to the relationship between the development of the innovation process and the movement of enterprises through the life cycle.

Another line of studies outlined the relationship between the innovation activity of companies and the location and concentration of innovative firms. It is interesting to note studies provides information on the existence of knowledge externalities associated with clustering and localization—the Marshall–Arrow–Romer externalities (Romer, 1986). In a recent study for the case of Russia by Vaisman and Podshivalova (2018), the level of institutional development of the territories where these enterprises are located plays a significant role in the development of small industrial enterprises and their accessibility to open innovations. However, there are no existing studies on the relationship between the degree of innovation activity and the stage of the life cycle of enterprises. There are but a few similar works in the field of research such as Laforet (2013) that illustrates the effect of age on organizational innovation in small firms, and Santoro et al. (2021) that examined its effect on the internationalization of small firms. Aziz and Samad. (2016) examined the food industry in Malaysia to study the relationship between innovation, competitiveness, and the age of small firms. However, in all the works listed above, age was not considered as an indicator of the stage of the life cycle.

Lastly, in relating the aspect of innovative activity of business and its relationship with sustainable development, the recent study of Imbrogiano and Nichols (2021) is a familiar literature in this regard. Indeed, the impact of innovation on the sustainability of companies' development remains underexplored, including in relation to SMEs. Empirical studies in this area are sparse, but example is a recent paper by Saether et al. (2021) on the relationship between green innovation and sustainability in the case of Norwegian maritime firms. One of the trends in modern research is the understanding that sustainable innovative development of companies which is also important for the company/organization's drive to achieving environmental sustainability (Çop et al., 2020, Çop et al., 2021). However, there seems to be lack of literature on small high-tech companies and innovation aspect for the case of Russia Federation.

Thus, it becomes obvious that there are at least two methodological gaps in relation to high-tech small companies: issues of studying the relationship between life cycle and innovation and the use of intangible assets as an indicator of the innovation activity of such firms. Our study will serve as a new contribution to eliminating the identified knowledge gaps.

3 | METHODOLOGY

To test our hypothesis, we formulated a number of initial assumptions and prerequisites. We selected enterprises of the Chelyabinsk region as the object of our study, due to the following circumstances. First, the Chelyabinsk Region leads the most numerous group of regions in the rating of innovative development of Russian regions published by the Institute for Statistical Studies and Economics of Knowledge of the Higher School of Economics.[4] Secondly, industry leaders in the region are developing (for example, the Ozersk Plant of Energy Devices Energoprom entered the top 30 leaders in labor productivity in the electrical industry in Russia).[5] Thirdly, the production of electrical equipment occupies roughly 1.31% of the region's GRP, and the number of machine-building enterprises is higher than the Russian level with a stable predominance among them (about 82.4%) maintaining profitability.[6]

For the initial sample, we chose small enterprises operating in the Chelyabinsk region (as of 01.01.2020), the main activity of which is the production of electrical equipment (OKVED 27). We obtained data from the SPARK financial reporting database. The initial sample was preliminarily adjusted to exclude companies with signs of shadow activity (so-called fly-by-night firms). In our case, these are small businesses with an average headcount of three or less people. The final sample included 106 small businesses.

Then, to ensure comparability of business conditions, we chose the post-crisis years of 2008 to 2019 as our period of analysis, also excluding 2020 as the period of the onset of the COVID pandemic (due to the strong force majeure impact on business).

Moreover, Laforet (2013) showed that in the sector of small and medium-sized enterprises, organizational innovations do not lead to an increase in operational efficiency. This is why we assumed that technological innovations (of process and product) have such an impact. These innovations can be measured through enterprises' investments in intangible assets (IA). According to the results of recent studies, the size of R&D is recognized as an inappropriate indicator of the innovation activity of small manufacturing enterprises (Wellalage & Fernandez, 2019). As a result, we chose the level of investments in intangible assets as the indicator of the innovation activity of the sampled enterprises. This choice corresponds with the recommendations of the latest version of the OECD Guidelines.[7]

To further substantiate our research method, we turned to the theory of the organization's life cycle (OLC) to determine the number of life cycle phases, the method for identifying a specific phase, and signs of the transition from one phase to another. The dispersion of

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opinions we found regarding the number of OLC phases is quite wide: from three (Downs, 1967; Katz & Kahn, 1978; Scott, 1976) to nine (Torbert, 1974) and even 10 (Adizes, 2008). With a certain degree of conditionality, this fact can be explained by two factors. First, different approaches to explaining the specifics of the life cycle itself: some authors believe that the nature of the life cycle mainly depends on the part of the organization, others associate it with strategic changes within the organization, and a third group explain the nature of OLC by changes in the internal or external environment. Second, researchers set different goals: They may study the nature of the life cycle itself or its use in company management.

No less diverse are the approaches to identifying the phase of an organization's life cycle and signs of transition from one phase to another. We attempted to classify these approaches by introducing a number of analytical features (Table 1). The most indicators of the OLC phase include the age and financial indicators of business, both absolute and relative. At the same time, in other international studies, authors commonly assess businesses through survey, or occasionally by expert evaluation.

Thus, we believe that it is expedient to supplement modern methodological tools with a new approach that takes into account the specifics of small industries. Considering that in the case of small

TABLE 1 Classification of approaches to determining the phase of OLC

Classification attribute	Varieties		Authors
Method	Poll		S.S. Nazarenko (2014), V. Dickinson (2011), D.L. Lesters et al. (2003), G.V. Shirokova (2007)
	Cash flows		Bruwer and Hamman (2008), Yu.S. Ovanesov (2013)
	Evaluation		L. Greiner (1972), S.H. Hanks et al. (1993), I. Adizes (1989, 2008), Tsvetkov and Pleshakova (2015)
Nature of indicators	Common to all methods	Organization age, size, growth rate	Most of the authors
	Specific	Financial	Yu.S. Ovanesov (2013), Skorokhod and Pakhtusova (2017)
		Non-financial	V. Dickinson (2011)
		Financial and non-financial	Anthony and Ramesh (1992); Ivashkovskaya and Yagel (2007); V. Dickinson (2011); Yu.S. Ovanesov (2013); Skorokhod and Pakhtusov (2015)
Structure of indicators	Single and integrated		Y. Cao (2010), Hasan and Habib (2017)
	Cluster variables		S.H. Hanks et al. (1993); D. L. Lesters et al (2003); G.V. Shirokova (2007)
Source of information for assessment	Accounting and statistical reporting		Skorokhod and Pakhtusova (2015)
	Survey		D.L. Lester et al. (2003), Shirokova (2007), I. Adizes (2008) et al.
Influence of the OLC phase	Influence on certain operational indicators, investment decisions, financing decisions		H. De Angelo et al. (2006); Owen and Yawson (2010); Yu. Cao (2010); Yu.S. Ovanesov (2013); N.N. Nikolashina (2014); Hasan and Habib (2017); R. Faff et al. (2016); K. Elsaed and Wahba (2016)
	Corporate social responsibility, idiosyncratic volatility		Hasan and Habib (2017)
	Innovation activity		Sorensen and Stuart (2000)
Explanatory models	Explanatory variable, linear regression model		E.V. Krasilnikova (2016)
	Sample of enterprises		P. Castro et al. (2016)
Justification	Based on empirical evidence		R.K. Kazanjyan (2017); S.H. Hanks et al. (1993)
	No empirical evidence		L. Greiner (1972)
Variable characteristics	Crisis in organization		L. Greiner (1972), I.V. Ivashkovskaya and Yagel (2007)
	Set of organizational variables associated with organization and its structure		L. Greiner (1972), Flamholtz and Randle (1986)
	Common routine problems of organization		I. Adizes (2008).

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businesses, age is an indicator of survival rather than a qualitative characteristic of the stage of life itself, we should additionally consider indicators of the stability of the financial indicators of small enterprises.

A critical review of the identified approaches to determining the OLC phase allowed us to form an original method that implements a two-step approach: (1) applying the basic criterion—the now traditional indicator of enterprise age; (2) applying clarifying criteria—key financial indicators of companies' activities. Existing literature proposes the use of their absolute and relative values. Instead, we propose to use the degree of stability of such indicators as a criterion for identifying the phase of the life cycle of a small enterprise. This approach is based on the idea that the more mature a business is, the more stable its key financial indicators; and on the contrary, the stochastic nature of the latter indicates the stage of formation and growth.

We deliberately abandoned the survey method (questionnaire) widely accepted in many other research practices in favor of objective statistics data, since small businesses are characterized, on the one hand, by a rather low level of corporate governance quality and corresponding management competencies (Gutorov et al., 2015; Muda & Rahman, 2016), and on the other hand, exaggeration of their capabilities, as noted in the course of surveys among the majority of managers (Bertrand & Schoar, 2003; Cooper et al., 1988). A critical literature review allowed us to adjust the research method as follows.

First, taking into account the specifics and relatively short life cycle of small industrial enterprises, it was assumed that it would be sufficient to single out three phases of OLC. In our study, we labeled these stages as Growth, Maturity, and Longevity. The highlighted non-standard phase Longevity is an indicator not so much the approach of a small firm to the last final stage of its existence (usually called dying), but rather an indication of deep maturity. In other words, not the beginning of the maturity stage, but its completion.

Second, at the first stage, using the age of the company as a basic criterion, we divided the sample companies into three analytical groups by their age, and accordingly, their OLC phase: Growing (61 companies)—up to 10 years; Mature (31 companies)—10–20 years; Long-Lived (14 companies)—more than 20 years. The logic of this stage is simple—companies do not remain in the growth stage in perpetuity; maturity cannot occur in the first years of a company's existence. Accordingly, the age of the company serves as the initial indicator of the OLC stage.

Third, the clarifying indicators used at the second stage included a fairly wide list of key items from the financial statements of the sampled enterprises. Their absolute and relative values were taken into account. For each key line item of the statement of financial results, a time series of its share in revenue was determined. Further, for each small enterprise in the sample, the variation in the indicators of the time series was determined for the entire life cycle if it was shorter than the analyzed period or for a 10-year period (the length of the analyzed period) if the life cycle was longer than the analyzed period.

Fourth, the stability of financial indicators was assessed by the classical coefficient of variation. However, small manufacturing companies are more sensitive to changes in the external environment (Bokareva, 2013) and, accordingly, have a higher volatility of indicators, so we have adjusted the gradation of the coefficient values. As a result, variation up to 40% of the financial indicator was recognized as stable, predictable—41%–80%, and over 80%—stochastic.

4 | RESULTS

Our results were obtained in the context of analytical groups formed on the basis of the basic criterion of the OLC phase.

4.1 | The growing sample group

The Growing sample group included 61 small enterprises. These enterprises were divided into groups depending on the calculated coefficients of variation. The results are shown in Figure 1. The share of enterprises with stable financial indicators—such as revenue, profit on sales, and net profit—is small.

Only 28% of enterprises in this group have a stable revenue, while 44% show stochastic change. In addition, the share of unprofitable enterprises is large—46%. This allows us to conclude that enterprises of the Growing group are mainly at the stage of emergence and growth. An analysis of the structure of the balances of innovation activity showed that small enterprises in the industry under 10 years old are not characterized by investments in IA (only 5 out of 61 companies were found to have investments in this asset, or 8%). It is important to note that long-term financial investments (only found in 6 companies, 10%) and stability of net assets (in 11 companies out of 61, 18%) are not typical for the enterprises of this group, which may serve as evidence of the resource constraints of the first years of the life of small enterprises.

At the Growth stage, small enterprises in the high-tech industry, as a rule, do not differ in innovation activity, including due to instability of demand and resource constraints, which suggests that the problem of low innovation activity of small producers in Russia derives from problems associated with the low availability of financial resources.

4.2 | The mature sample group

The Mature sample group included 31 small enterprises. Calculating the coefficients of variation of the financial indicators of these enterprises (Figure 2) made it possible to determine that profits on sales are stable in 45% of the enterprises, stochastic—only 19%. The share of firms with unstable share of commercial and administrative costs in this group is slightly lower than in the Growing group. The discovered 100% stability of the share of the prime cost in the proceeds is evidence that production costs (wages and costs of basic materials) are substantially normalized.

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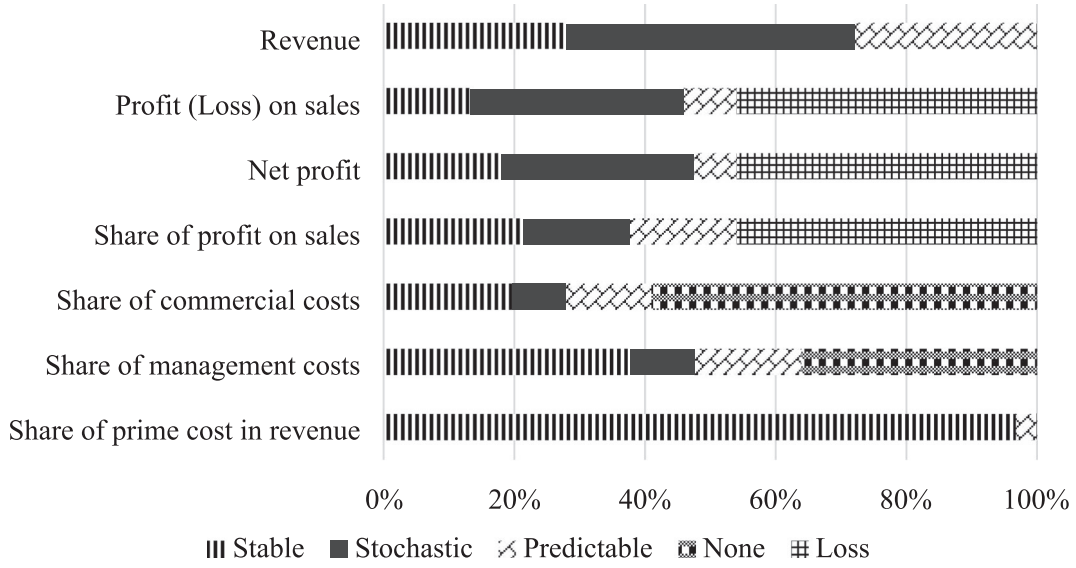

FIGURE 1 Assessing the indicator stability of the growing sample group

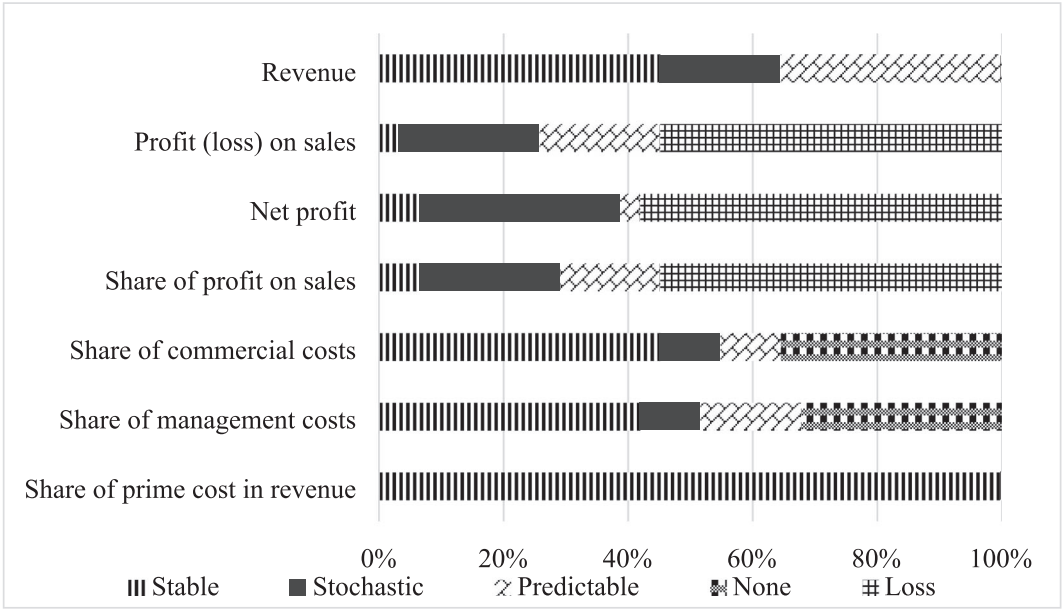

FIGURE 2 Assessing the indicators stability of the mature sample group

Mature enterprises more frequently invest in IA (10 out of 31 enterprises, or 32%), long-term financial investments are more common in enterprises of this group (9 out of 31, or 29% companies). Moreover, at this stage, small enterprises in the electrical industry also demonstrate higher business activity: In the Growing group, 18% of enterprises were found to have steadily increasing net assets, while in the Mature group, this was true of 48%.

Russian small enterprises in the high-tech industry, as a rule, demonstrate an increase in business and innovation activities at the stage of maturity and have a higher resource endowment than growing enterprises.

4.3 | The long-lived sample group

This group includes 14 enterprises that have been on the market for more than 20 years. The calculated coefficients of variation are presented in Figure 3.

The results of the analysis of these enterprises look interesting, since both the stability of their net assets (50% of the group) and the prevalence of long-term financial investments (36%) are close to the indicators of the group of mature enterprises. However, the stability of sales proceeds and the prevalence of investments in IA are significantly higher—78% and 57%, respectively.

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Indirectly, this indicates that the innovation activity of a small enterprise in a high-tech industry depends significantly on its age and the level of business maturity. So, the longer the period of operation and the more stable the income and, accordingly, the more stable the market position (that is, the company successfully retains the conquered market niche), the more stable the position, income, sources of financing of the company. This, ultimately, gives such enterprises the opportunity to reveal their innovative potential at the stage of deep maturity. This conclusion correlates with the results of the empirical studies (Morck and Yeung, 2001; Podshivalova et al., 2021), the authors of which concluded that small firms realize their innovative potential only at the stage of maturity, when they have accumulated the appropriate capital. In addition, the obtained results helped us identify a new reason for the low innovation activity of small industrial enterprises—the insufficient number of mature manufacturing companies.

At the end of our analysis, we compared the share of small businesses with stable financial performance among the three analytical groups (Table 2). There is a direct relationship between the life-span of a business and the stability of its performance. The only financial indicator with an inverse relationship was the amount of short-term borrowed funds. Among long-lived companies we did not find enterprises with stable dynamics of this source of financing, which may indicate that they are less likely to seek external financing due to the presence of their own working capital (including due to more stable cash flows).

The data also indicate that profit on sales, net profit, and their derived coefficients are not informative in determining the phase of

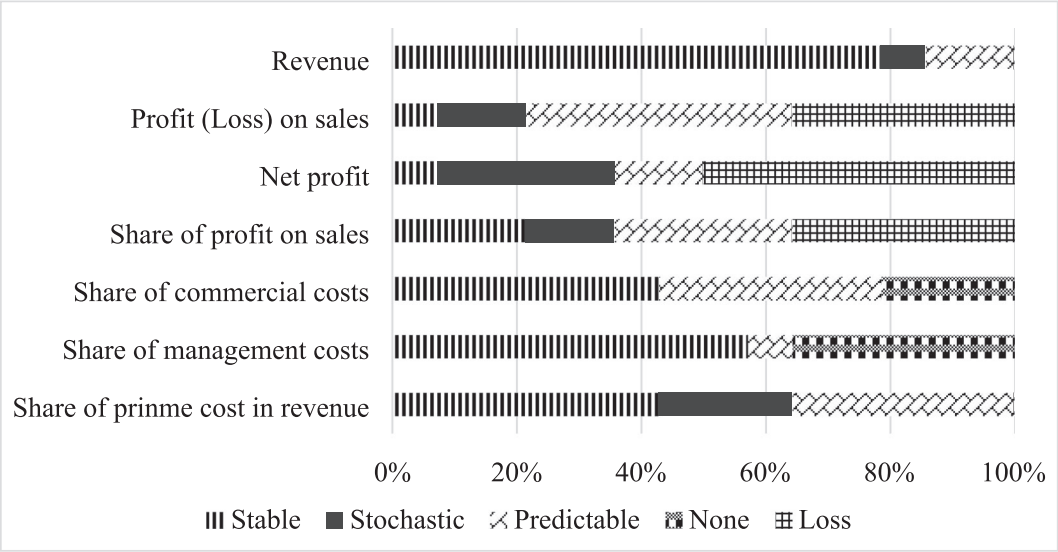

FIGURE 3 Assessing the indicators stability of long-lived companies

TABLE 2 Share of companies with stable performance, %

Financial indicator	Growing	Mature	Long-lived
Fixed assets	21	32	50
Net assets	18	48	50
Stocks	29	26	64
Receivables	16	32	50
Short-term financial investments	10	19	21
Undestributed profits	13	35	64
Short-term borrowed funds	36	22	0
Accounts payable	23	39	57
Long-term obligations	27	48	71
Revenue	28	45	78
Profit on sales	13	3	7
Net profit	18	6	7

Source: Authors' calculations.

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the life cycle of small businesses. This is primarily because representatives of small businesses in Russia, for the most part, actively use the methods of so-called tax optimization, as a result of which the high volatility of profit indicators for these enterprises does not reflect the true state of affairs. This is the primary reason we used sales proceeds as a complementary indicator of the life cycle stage.

5 | DISCUSSION OF RESULTS

Our results indicate that in the Chelyabinsk region, small enterprises of the electrical industry mainly show innovation activity at the Maturity stage, when they accumulate the necessary resources to do so. The fact that the region is in the middle of the Russian ratings for many parameters of development, and, first of all, in the level of innovation activity.[8] In other words, the Chelyabinsk region is in this case a statistically-average region. This gives us reason to assume that this situation is generally typical for high-tech small industry in Russia.

This conclusion confirms our research hypothesis. We believe that our research serves as a new argument on the importance of the life cycle stage on the innovative development strategy of enterprises, which has been noted in the publications of the followers of this theory for the last 40 years (Anthony & Ramesh, 1992; Dickinson, 2011; Greiner, 1972; Miller & Friesen, 1984). In a number of cases, a body of evidence was even obtained showing that the innovative potential of any enterprise manifests only after the business has been in operation for several years (Lewis & Churchill, 1983; Kiriri, 2004; Lopes et al., 2016). At the same time, foreign experts note that the desire for innovation activity directly depends on the size of the enterprise (Gorodnichenko & Schnitzer, 2013). This means that in the case of the traditional development of a small business (when an enterprise is not a dependent or subsidiary of a large company and/or is not affiliated with government agencies), the trajectory of its innovative development has its own specific characteristics. In addition, our study revealed a new factor in the unstable innovation activity of small producers of high-tech industries in Russia—an insufficient number of mature enterprises capable of independently realizing their innovative potential.

Studies on the innovation activity of small enterprises in other countries revealed that such enterprises introduce innovations at the first stages of their life cycle (for example, see (Wellalage & Fernandez, 2019), based on a sample of 13,430 small and medium-sized firms in Eastern Europe and Central Asia). According to Ruhnka and Young (1987) and, later, Hall and Lerner (2010), the early development of innovations in companies begins as soon as the first two stages of the life cycle, and partially in the third (out of five). Our results allow us to agree with this conclusion only in terms of large businesses which are capable of attracting investments, including from the stock market—it cannot be considered fair for small industrial businesses, especially Russian small businesses.

We believe that the discrepancy between Russian and foreign practices in this matter can be explained by the following factors.

1. Specificity of systems of innovative development in different countries. In Russia, it is large enterprises that have historically played a key role in this system. The role of the small sector of Russian industry, including the high-tech industry, is therefore incomparable with similar indicators of developed countries. The share of SIEs is no more than 2%.[9] Accordingly, the contribution of such enterprises to GDP is small—0.8 …, 1%.[10] Small and medium-sized businesses account for less than 0.3%[11] of the export of innovative products, while this same indicator is 15 to 40%[12] in developed countries. This is primarily associated with the low demand for SIEs in the Russian national innovation system.
2. The significant number of young innovation-active firms abroad might be explained by the popularity of the strategy of innovative development of large business based on the SPV (special purpose vehicle). For example, in Germany, interaction between organizations is considered a significant factor in the innovation activity of small businesses (Bluher et al., 2020). According to empirical data obtained by Hilmersson and Hilmersson (2021), various forms of inter-firm cooperation for innovative small enterprises are gaining particular significance. They concluded that when small enterprises develop innovative potential at the early stages of their life cycle, they more often increase their competitive advantages, and if they do not, they can compensate through active cooperation.
3. A recent study of small foreign firms (Muda & Rahman, 2016) proved that human capital has the greatest influence on firms' efficiency and is most significant for the early stages of their life cycle. According to surveys by Rosstat and Support of Russia,[13] one of the reasons for the low innovation activity of small industrial enterprises in Russia is the lack of highly qualified personnel (apparently due to lower salaries and restrictions on career growth).
4. The lack of financial support from the state is also considered a factor in the lack of sustainable innovative development of domestic small industrial enterprises, with very convincing figures cited in defense of this postulate. Without diminishing the importance of state support, we believe that it does not play a key role in the current situation. There are widely known cases when Russian enterprises received funding but did not increase the innovation component of their activities. It seems that the difference in attitudes toward small business plays a big role here—not so much from the government as from society, which explains the different role of small industrial enterprises in the economies of developed countries and Russia. The goals of opening small industries differ. In developed countries small industrial enterprises open with the aim of immediately creating innovative products, whereas in Russia such enterprises are mostly focused on research, protection of intellectual property, and commercialization of innovations (Korolev, 2017).

In general, our study helps fill the gap of empirical articles on the innovation activity of small high-tech enterprises at various stages of the life cycle. Researchers have only become interested in the study of

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the innovation activity of small high-tech companies relatively recently (see, e.g., Gu et al., 2016; Guo et al., 2020; Nunes et al., 2012).

Our results contribute to the development of two theories related to high-tech small industrial enterprises. The first is the life cycle theory. Although we used the traditional indicators of life cycle stages (also applied in the works of Ovanesov, 2013; Skorokhod & Pakhtusova, 2017; Anthony & Ramesh, 1992; Dickinson, 2011), we managed to expand the possibility of identifying the life cycle stage of enterprises by introducing a new criterion: the stability of relative financial indicators, not previously used in this kind of research. The second is the theory of innovative development, improved by the study of the relationship between stable innovation activity and the stage of the life cycle in high-tech small industries. While earlier papers (Hall & Lerner, 2010; Raymond & St-Pierre, 2010) used R&D as an indicator of innovation activity, we examined investments in intangible assets as a more adequate indicator (proved in the work of Nunes et al., 2012) of the peculiarities of innovative development of small enterprises of high-tech industries.

6 | CONCLUSION AND POLICY

The conducted research led us to the following conclusions. First, the innovation activity of small high-tech enterprises greatly depends on their age and life cycle. Secondly, for the Russian economy, which is characterized by institutional restrictions on the development of small businesses, small high-tech enterprises reveal their innovative potential at the stage of deep maturity, when their business activity is at its peak. We believe that this conclusion is also valid for economies with similar institutional constraints. In a recent study (Das et al., 2020), it was proved that institutional factors became dominant for the sustainability of small industrial enterprises, which means that with a high degree of probability, our conclusions can also be attributed to such countries as Brazil and India.

6.1 | Policy and recommendation

Our findings allow us to formulate a number of recommendations. Stable innovative development throughout the entire life cycle of small high-tech industries can be achieved: (a) by organizing government support for such companies, including the temporary easing of the tax burden during the formation period (the first stages of the life cycle). However, this recommendation poses a new task for future research in this direction, namely: a method must be developed to select small enterprises in high-tech industries to receive limited budget funds. One of the serious challenges of this task is identifying methods to predict the development of high-tech industries and indicators to assess the level of technological development of companies; (b) by using institutional mechanisms to stimulate the development of cooperation between small high-tech industries and large industrial companies and universities; (c) if owners and managers of small high-tech enterprises take into account the specifics of the institutional environment of the national economy when developing strategies for innovative development and plan cooperation measures or measures to obtain state support to achieve sustainable innovative development.

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ORCID

Elena D. Vaisman https://orcid.org/0000-0003-1763-2306
Maria V. Podshivalova https://orcid.org/0000-0003-3589-8386
Andrew Adewale Alola https://orcid.org/0000-0001-5355-3707

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