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# Research and development as a determinant of growth in entrepreneurial activity in Russian regions

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**ABSTRACT**

**Relevance.** The study addresses the critical role of Research and Development (R&D) in fostering entrepreneurial growth in Russia, particularly amid challenges such as centralized financing, an aging population of skilled specialists, and external sanctions pressure in high-tech sectors.

**Research Objective.** This study examines the impact of R&D on firm creation across 80 Russian regions from 2015 to 2021, with a focus on differentiating between fundamental and applied research.

**Data and Methods.** The analysis is based on regional datasets spanning 2015–2021, employing regression methods to assess the relationship between R&D investment and entrepreneurial activity.

**Results.** The findings indicate a significant positive association between R&D and entrepreneurial growth, both in the current and subsequent years. Regional heterogeneity analysis reveals that fundamental research exerts the strongest effect, exceeding applied research and development activities, despite receiving the smallest budget allocation. The lagged effects remain statistically significant, confirming that knowledge spillover mechanisms operate across a one-year horizon. Historical and structural challenges, including centralized funding and demographic constraints, further shape these outcomes.

**Conclusions.** To sustain and enhance R&D-driven entrepreneurship, the study recommends decentralizing tax policies and improving access to federal resources for regional technological development, particularly in education and innovation ecosystems. Addressing these issues is crucial for mitigating the adverse effects of sanctions and brain drain in high-tech sectors.

**KEYWORDS**

R&D heterogeneity, innovation, growth, firm dynamics, entrepreneurship, russian regions, regional heterogeneity, regional development

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# НИОКР как фактор роста предпринимательской активности в регионах России

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**АННОТАЦИЯ**

**Актуальность.** В исследовании рассматривается критическая роль исследований и разработок (НИОКР) в стимулировании роста предпринимательства в России, особенно в условиях таких проблем, как централизованное финансирование, старение квалифицированных специалистов и внешнее санкционное давление в высокотехнологичных секторах.

**КЛЮЧЕВЫЕ СЛОВА**

неоднородность НИОКР, инновации, рост, динамика фирм, предпринимательство,

**Цель исследования.** В данном исследовании изучается влияние НИОКР на создание фирм в 80 регионах России в период с 2015 по 2021 год с акцентом на разграничение фундаментальных и прикладных исследований.
**Данные и методы.** Анализ основан на региональных наборах данных за 2015–2021 годы с использованием методов регрессионного анализа для оценки взаимосвязи между инвестициями в НИОКР и предпринимательской активностью.
**Результаты.** Полученные данные указывают на значительную положительную связь между НИОКР и ростом предпринимательской активности как в текущем, так и в последующих годах. Анализ региональной неоднородности показывает, что фундаментальные исследования оказывают наиболее сильное влияние, превосходя прикладные исследования и разработки, несмотря на наименьшее бюджетное финансирование. Отложенные эффекты остаются статистически значимыми, подтверждая, что механизмы распространения знаний действуют в течение одного года. Исторические и структурные проблемы, включая централизованное финансирование и демографические ограничения, дополнительно влияют на эти результаты.
**Выводы.** Для поддержания и повышения предпринимательства, основанного на НИОКР, исследование рекомендует децентрализовать налоговую политику и улучшить доступ к федеральным ресурсам для регионального технологического развития, особенно в образовательных и инновационных экосистемах. Решение этих проблем имеет решающее значение для смягчения негативных последствий санкций и утечки мозгов в высокотехнологичных секторах.

российские регионы, региональная неоднородность, региональное развитие

**ДЛЯ ЦИТИРОВАНИЯ**
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## 研发作为俄罗斯各地区创业活动增长的因素

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**摘要**
**现实性**：本文探讨了研发在推动俄罗斯创业增长中的关键作用，尤其是在集中化融资、高素质人才老龄化以及高技术领域面临外部制裁压力等挑战背景下。
**研究目标**：本研究考察了2015年至2021年期间研发活动对俄罗斯80个地区企业创建的影响，重点区分了基础研究与应用研究的作用。
**数据与方法**：该分析基于2015–2021年的区域数据集，采用回归分析方法评估研发投资与创业活动之间的相互关系。
**研究结果**：研发与创业活动增长之间存在显著的正相关关系，该效应在当期及后续年份均有所体现。区域异质性分析显示，基础研究的影响最为强劲，尽管其获得的预算资金最少，但其作用仍超过应用研究与开发。滞后效应在统计上依然显著，证实知识传播机制的作用周期为一年。历史和结构性问题，包括资金集中化与人口结构限制，对这些结果都产生了进一步影响。
**结论**：为维持和促进以研发为基础的创业活动，本研究建议实施税收政策分权化改革，并改善区域技术发展（尤其是在教育和创新生态系统领域）对联邦资源的获取渠道。解决这些问题对于缓解制裁带来的负面影响以及遏制高技术领域的人才流失至关重要。

**关键词**
研发异质性、创新、增长、企业动态、创业精神、俄罗斯地区、区域异质性、区域发展

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## Introduction

Research and development (R&D) is a central driver of innovation-led economic growth and an important catalyst for entrepreneurial activity. While the effects of R&D on aggregate economic growth have been extensively studied and supported by both theoretical and empirical work, the mechanisms linking R&D investment to entrepreneurship remain less well understood. In particular, although the R&D-based endogenous growth model developed by Romer (1990) has been widely applied, its implications for entrepreneurial development, especially in the Russian context, have received limited attention.

In endogenous growth models, technological progress and productivity are driven by R&D investments (Baldanzi et al., 2019; Gehringer and Prettner, 2019). However, the relationship between innovation and growth is mediated by institutional and demographic factors, including population aging, which may stimulate savings and subsequent investments in productivity-enhancing technologies (Acemoglu and Restrepo, 2022). This is particularly relevant for Russia, where aging demographics and stagnant productivity pose critical challenges (Gurvich and Ivanova, 2018).

Entrepreneurship in Russia often operates in low value-added sectors, supporting regional economies while facing constraints in transitioning toward high-productivity activities. R&D investment, largely driven by large firms, generates spillover effects that are unevenly distributed due to institutional fragmentation and regional disparities. Recent empirical evidence highlights these dynamics. Belyakov et al. (2025) find a positive relationship between demographic aging and total factor productivity (TFP), potentially driven by higher savings among older cohorts that lower interest rates and stimulate R&D investment (Belyakov et al., 2021). Spatial econometric analyses further show that population aging has a significant but heterogeneous impact on regional growth in Russia (Artamonov et al., 2021). Methodological advances in regional analysis also emphasize the role of quality-of-life indicators as mediators between R&D and entrepreneurial outcomes; for example, Kurbatskii and Mironenkov (2023) demonstrate that weighted principal component methods effectively capture regional welfare disparities that shape knowledge spillovers and firm formation.

The institutionalization of R&D and entrepreneurship is critical to achieving these results. Russia's legacy of Soviet-era science cities, which are today hotspots for high-skilled labor and innovation (Schweiger et al., 2022), shows how route dependence shapes regional differences. The role of organized clusters as institutional entrepreneurs is further explored by Lupova-Henry et al. (2021). Empirical evidence suggests that proximity to research institutions and the quality of human capital are strong predictors of patent activity (Zemtsov et al., 2016), while entrepreneurial clusters are concentrated in Moscow, St. Petersburg, and a limited number of regions such as Kaluga and Belgorod, which benefit from agglomeration effects (Zemtsov et al., 2021). Nevertheless, innovation among small and medium-sized enterprises (SMEs) remains constrained by weak ecosystem linkages (Andreeva et al., 2016). This challenge has become more pronounced in the context of post-2014 sanctions and COVID-19-related stimulus measures, highlighting the need for alternative policy approaches (Zemtsov et al., 2020; Zhemkova, 2023).

Despite the growing importance of both R&D and entrepreneurship in the modern economy, no study to date has explicitly examined their relationship in the Russian context. To address this gap, the present study tests the following hypotheses: (H1) R&D activities promote entrepreneurial growth in Russian regions, and (H2) the magnitude of this effect varies by type of R&D activity. By investigating these hypotheses, the study contributes new empirical insights to the literature and offers policy-relevant implications for governments and firms seeking to allocate R&D resources more effectively to stimulate entrepreneurial development.

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature. Section 3 describes the data, methodology, and model specifications. Section 4 presents the empirical results. Section 5 discusses the findings in relation to existing studies and outlines policy implications. Section 6 concludes.

## Theoretical Framework

Endogenous growth theories, such as those proposed by Romer (1990) and Aghion and Howitt (1992), emphasize that technological progress — fuelled by intentional R&D investments — generates spillover effects that entrepreneurs exploit to launch new ventures. Romer's model highlights how knowledge, as a non-rivalrous good, creates increasing returns to scale, while Aghion and Howitt's "creative destruction" framework illustrates how innovation displaces incumbent technologies, fostering dynamic competition and new firm entry. These models underscore that entrepreneurship is not merely a function of individual traits but a systemic outcome of knowledge accumulation and diffusion (Acs et al., 2009).

There is a critical distinction between firm expansion (e.g., incumbents scaling operations) and entrepreneurship (new firm creation). Entre-

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preneurship is particularly important for innovation-led development because startups are often able to commercialize knowledge that remains underutilized within existing organizations. This mechanism, commonly referred to as knowledge spillover entrepreneurship (Acs et al., 2013; Audretsch & Keilbach, 2007), highlights the role of new firms in translating R&D outcomes into marketable innovations. Empirical studies provide strong support for this view. Baptista and Mendonça (2010) show that proximity to universities, which serve as key R&D hubs, increases the formation of knowledge-based startups by improving access to human capital and ideas. Similarly, Astebro et al. (2012) find that high-quality startups are primarily founded by university graduates rather than faculty members, indicating that R&D institutions stimulate entrepreneurship indirectly through skill formation. Together, these findings suggest that entrepreneurship functions as a critical conduit for R&D spillovers, transforming latent knowledge into economic value.

Empirical studies consistently show a positive relationship between R&D investment and entrepreneurial activity, although the strength and nature of this relationship vary across contexts and types of R&D. At the macro level, regions with well-developed R&D infrastructure, such as industrial clusters (Delgado et al., 2010) or "science cities", tend to exhibit higher rates of startup formation due to agglomeration effects, including shared resources and dense knowledge networks. For instance, Baptista and Mendonça (2010) demonstrate that regions hosting universities and highly educated workforces attract more knowledge-intensive startups, while Link and Scott (2005) show that universities' participation in research joint ventures (RJVs) facilitates the diffusion of innovation. At the same time, the entrepreneurial impact of R&D is heterogeneous. Industrial R&D is more likely to generate spin-offs, whereas public R&D, such as that conducted in government laboratories, may fail to translate into new firm creation without effective entrepreneurial intermediation.

On the other hand, the analysis of R&D's impact on the microeconomic level focuses on firm growth. The definition of firm growth differs from study to study. Some studies define it as an expansion of the firm's size and an enhancement of its performance. The firm size and its performance can be measured in various ways, but the most representative indicators used in previous studies are growth in sales (Freel, 2000; Del Monte and Papagni, 2003; Freel and Robson, 2004; Adamou and Sasidharan, 2007; Winters and Stam, 2007; Demirel and Mazzucato, 2012; García-Manjón and Romero-Merino, 2012; Zhu et al., 2021), or employment ratio (Yang and Huang, 2005; Stam and Wennberg, 2009). Other papers linked the concept of firm growth to entrepreneurship. These papers used the number of new firm births as a dependent variable and measured its elasticity depending on the R&D variables (Kirchhoff et al., 2002; Choi and Phan, 2006; Kanellopoulos and Fotopoulos, 2019). However, the fact that most research focuses on firm growth rather than entrepreneurship highlights that the connection between R&D and new firm creation remains underexplored.

Disaggregating R&D by sector and firm size reveals additional heterogeneity in these relationships. Aghion et al. (2005) identify an inverted-U relationship between competition and innovation, indicating that moderate levels of competition, which are often observed in R&D-intensive sectors, are most conducive to entrepreneurial incentives, whereas excessive competition can suppress innovation by reducing expected returns. Similarly, Audretsch and Keilbach (2007) emphasize that knowledge spillovers are geographically bounded, leading to uneven entrepreneurial outcomes even within countries with high overall R&D intensity.

The empirical literature on R&D and firm growth is extensive but yields mixed results. A substantial body of research reports a positive relationship between R&D investment and firm growth (Kirchhoff et al., 2002; Del Monte and Papagni, 2003; Yang and Huang, 2005; Choi and Phan, 2006; Adamou and Sasidharan, 2007; Stam and Wennberg, 2009; Capasso et al., 2015; Kanellopoulos and Fotopoulos, 2019; Zhu et al., 2021), emphasizing R&D as a key driver of firm expansion and performance. These findings support policy arguments for actively promoting R&D investment.

In contrast, other studies report negative or ambiguous effects. Freel and Robson (2004), analyzing SMEs in Scotland and Northern England, find that product innovation can reduce sales and productivity growth in manufacturing firms. Similarly, Freel (2000) finds no significant difference in sales performance between innovative and


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non-innovative small manufacturing firms, while Winters and Stam (2007) report mixed effects of innovation on sales growth among high-technology SMEs in the Netherlands. One explanation for these inconsistent findings is firm-level heterogeneity in absorptive capacity, which affects the ability to translate R&D investment into growth outcomes.

Demirel and Mazzucato (2012) show that for U.S. pharmaceutical firms, R&D positively affects growth in large firms with patenting activity, while for small firms the effect is contingent on sustained patenting over at least five years. García-Manjón and Romero-Merino (2012) similarly argue that R&D is essential primarily for the growth and survival of firms in high-technology sectors. Moreover, as noted by Freel (2000) and Coad and Rao (2008), the positive impact of innovation on growth is often concentrated among a small group of high-growth firms rather than being broadly distributed.

Even when positive effects are sustained, the size of the impact can vary due to the heterogeneity of companies. Zhu et al. (2021), in their study of Chinese companies, revealed that R&D has a significant positive impact on firm growth and that R&D of private enterprises has a greater impact on firm growth than that of state-owned enterprises across all quantiles. Large firms exhibit significantly greater R&D effectiveness compared to SMEs. Yang and Huang (2005), in their study on firm growth in the Taiwanese electronics industry, demonstrated that an increase in R&D induces a higher growth rate, and this impact is particularly higher for small firms.

Entrepreneurial activity has attracted considerable attention from researchers and policymakers in Russia. Despite global evidence linking R&D to entrepreneurship, Russia remains an understudied yet compelling case due to its unique institutional and regional disparities Russian literature primarily examines R&D's impact on firm productivity, particularly in state-owned enterprises, while largely ignoring its role in fostering new firm creation. This omission is important given the country's declining startup rates and continued reliance on legacy industries. Regional inequalities further compound the problem. For example, "science cities" such as Dubna concentrate R&D resources but struggle to commercialize innovations, while peripheral regions face brain drain and underfunded universities. Centralized R&D funding also skews opportunities, leaving entrepreneurial ecosystems underdeveloped outside Moscow and St. Petersburg.

Institutional legacies, including Soviet-era centralization and weak intellectual property rights, hinder knowledge spillovers. Unlike the U.S. or EU, where universities actively partner with startups (Link & Scott, 2005), Russian academia largely remains siloed from industry, limiting entrepreneurial pathways for graduates (Astebro et al., 2012). Human capital distribution is also uneven. Elite universities produce top-tier STEM graduates, whereas regional vocational schools often lack curricula aligned with labor market needs (Medyanik et al., 2024).

Several studies have examined R&D's impact on firm growth in Russia. However, these studies focus mainly on productivity or performance improvements (Pushkarev & Mariev, 2018; Trachuk & Linder, 2018; Nagieva et al., 2020; Mariev et al., 2022) and do not explore the link between R&D and entrepreneurship, specifically new firm formation. This review highlights two gaps in the literature. First, while prior research accounts for firm heterogeneity, such as size, growth rate, patenting activity, and industrial sector, it does not examine the differential effects of distinct types of R&D. Second, firm growth has been measured either as growth in sales, productivity, or size, or as entrepreneurial growth through new firm entry, but the latter has not yet been studied in Russia.

Our study addresses these gaps by analyzing three types of R&D activity: fundamental research, applied research, and development. We also investigate their relationship with entrepreneurship, which is measured by new firm entry. Based on this framework, we propose two hypotheses:

H1: R&D activities positively influence entrepreneurial growth, measured by new firm entry, in Russian regions.

H2: The impact of R&D varies across different types of R&D activities.

## Method and Data

### *Baseline OLS model*

Our model is designed to assess the impact of R&D on entrepreneurial growth. In this study, entrepreneurial growth is measured by the number of firm entries across Russian regions. R&D activity is proxied using two indicators: R&D expenditure and the number of R&D personnel. Firm creation is also influenced by macroeconomic conditions (Dvoulet, 2017); therefore, we control for trade intensity and regional economic growth. Increased trade volumes may require firms to expand production capacity, potentially leading to the formation of new firms, while stronger economic performance generally encourages entrepreneurial activity. Moreover, because firm creation may involve time lags, we estimate the effects of R&D on entrepreneurial entry in both period *t* and *t+1* of a dependent variable is estimated. Equations (1) and (2) present the baseline OLS specifications.

$$\text{Ln (Firm)}_{it\,(\text{or } t+1)} = \beta_0 + \beta_1 \text{Ln (RnD\_cost)}_{it} + \beta_2 \text{Ln (Trade)}_{it} + \beta_3 \text{GGRP}_{it} + \epsilon_{it}; \quad (1)$$

$$\text{Ln (Firm)}_{it\,(\text{or } t+1)} = \beta_0 + \beta_1 \text{Ln (RnD\_employee)}_{it} + \beta_2 \text{Ln (Trade)}_{it} + \beta_3 \text{GRPC}_{it} + \epsilon_{it}; \quad (2)$$

***Heterogeneity model***

R&D can be categorized into multiple types. The Russian database classifies R&D into three distinct activities: fundamental research, applied research, and development. The impact on firm creation may vary depending on the type of research. Fundamental research is long-term in nature, laying the theoretical foundation for future applications, whereas applied research and development are more short-term, focusing on immediate technological implementation. Based on this distinction, we specify Equations (3)–(5) to examine the heterogeneous effects across R&D types as follows:

$$\text{Ln (Firm)}_{it\,(\text{or } t+1)} = \beta_0 + \beta_1 \text{Ln (RnD\_fundamental)}_{it} + \beta_2 \text{Ln (Trade)}_{it} + \beta_3 \text{GRPC}_{it} + \epsilon_{it}; \quad (3)$$

$$\text{Ln (Firm)}_{it\,(\text{or } t+1)} = \beta_0 + \beta_1 \text{Ln (RnD\_applied)}_{it} + \beta_2 \text{Ln (Trade)}_{it} + \beta_3 \text{GRPC}_{it} + \epsilon_{it}; \quad (4)$$

$$\text{Ln (Firm)}_{it\,(\text{or } t+1)} = \beta_0 + \beta_1 \text{Ln (RnD\_development)}_{it} + \beta_2 \text{Ln (Trade)}_{it} + \beta_3 \text{GRPC}_{it} + \epsilon_{it}; \quad (5)$$

***Dynamic panel GMM estimation***

The creation of new firms may increase R&D expenditures, as startups often incur substantial costs during early-stage product development. Our study examines the causal effect of R&D on firm formation. To address potential endogeneity concerns, we employ two-step difference GMM estimation (Arellano and Bond, 1991), which helps mitigate endogeneity problems. The GMM model specifications are presented in Equations (6)–(9) as follows:

$$\text{Ln (Firm)}_{it} = \beta_0 + \beta_1 \text{Ln (Firm}_{it-1}) + \beta_2 \text{Ln (RnD\_cost)}_{it} + \beta_3 \text{Ln (Trade)}_{it} + \beta_4 \text{GRPC}_{it} + \epsilon_{it}; \quad (6)$$

$$\text{Ln (Firm)}_{it} = \beta_0 + \beta_1 \text{Ln (Firm}_{it-1}) + \beta_2 \text{Ln (Firm}_{it-2}) + \beta_3 \text{Ln (RnD\_cost)}_{it} + \beta_4 \text{Ln (Trade)}_{it} + \beta_5 \text{GRPC}_{it} + \epsilon_{it}; \quad (7)$$

$$\text{Ln (Firm)}_{it} = \beta_0 + \beta_1 \text{Ln (Firm}_{it-1}) + \beta_2 \text{Ln (RnD\_employee)}_{it} + \beta_3 \text{Ln (Trade)}_{it} + \beta_4 \text{GRPC}_{it} + \epsilon_{it}; \quad (8)$$

$$\text{Ln (Firm)}_{it} = \beta_0 + \beta_1 \text{Ln (Firm}_{it-1}) + \beta_2 \text{Ln (Firm}_{it-2}) + \beta_3 \text{Ln (RnD\_employee)}_{it} + \beta_4 \text{Ln (Trade)}_{it} + \beta_5 \text{GRPC}_{it} + \epsilon_{it}; \quad (9)$$

***Data description***

This study examines the impact of R&D on growth in entrepreneurial activity (measured by the number of firms in Russian regions) using panel data from 80 Russian regions for the period 2015–2021. The data were obtained exclusively from the Federal State Statistics Service of Russia (Rosstat)[1]. All monetary values originally denominated in rubles were first converted to USD using the annual average exchange rates published by the Central Bank of Russia[2], then adjusted to constant 2015 USD values using Russia's GDP deflator from the World Development Indicators[3]. The use of relative shares is justifiable because it focuses on intra-national variation. Models are designed to express how much a region contributes to the national R&D context, rather than how much it spends in absolute terms allowing for comparability across regions and time, using relative shares controls for

[1] Retrieved from: https://rosstat.gov.ru/ (date of access: 01.11.2023).

[2] Retrieved from: https://www.cbr.ru/eng/ (date of access: 01.11.2023).

[3] Retrieved from: https://data.worldbank.org/ (date of access: 01.11.2023).


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Table 1

**Variable Definitions and Data Sources**

| Notation | Definition |
|---|---|
| $i$ | Regions in Russia (80 regions) |
| $t$ | Year (2015~2021) |
| $Ln(Firm)_{it}$ | Log of the number of firms per person in region *i* |
| $Ln(RnD\_cost)_{it}$ | Log of R&D costs in region *i* divided by the sum of total R&D costs in Russian regions in year *t* |
| $Ln(RnD\_employee)_{it}$ | Log of the number of R&D employees in region *i* divided by the sum of total R&D employees in Russian regions in year *t* |
| $Ln(RnD\_fundamental)_{it}$ | Log of R&D costs in fundamental sciences in region *i* divided by the sum of total R&D costs in fundamental sciences in Russian regions in year *t* |
| $Ln(RnD\_applied)_{it}$ | Log of R&D costs in applied sciences in region *i* divided by the sum of total R&D costs in applied sciences in Russian regions in year *t* |
| $Ln(RnD\_development)_{it}$ | Log of R&D costs in development activities in region *i* divided by the sum of total R&D costs in development activities in Russian regions in year *t* |
| $Ln(Trade)_{it}$ | Log of average of export and import share of region *i* compared to the total export and import in Russian regions in year *t* |
| $GRPC_{it}$ | Growth rate of GRP per capita in region *i* |
| $\epsilon_{it}$ | Error term |

Table 2

**Summary Statistics**

| Variables | Mean | Maximum | Minimum | Std. Dev. | Observations |
|---|---|---|---|---|---|
| $Ln (Firm)_{it}$ | –3.80 | –2.35 | –5.05 | 0.36 | 526 |
| $Ln (RnD\_cost)_{it}$ | –5.97 | –1.00 | –9.64 | 1.67 | 526 |
| $Ln (RnD\_employee)_{it}$ | –5.69 | –1.13 | –9.49 | 1.50 | 526 |
| $Ln (RnD\_fundamental)_{it}$ | –5.79 | –0.81 | –9.46 | 1.48 | 526 |
| $Ln (RnD\_applied)_{it}$ | –19.90 | –14.62 | –24.11 | 1.65 | 526 |
| $Ln (RnD\_development)_{it}$ | –6.77 | –1.10 | –15.13 | 2.61 | 526 |
| $Ln (Trade)_{it}$ | –5.83 | –0.83 | –13.48 | 1.76 | 526 |
| $GRPC_{it}$ | 0.04 | 0.72 | –0.20 | 0.09 | 480 |

*Source:* calculated by the authors.

national trends (e.g., inflation, systemic changes), making regional differences more interpretable. Tables 1 and 2 present the data description and summary statistics, respectively.

Figure 1 presents the total number of registered companies in Russia during 2015–2021, showing a consistent downward trend. Over this five-year period, the number of companies declined from 5.04 million to 3.34 million. Several factors may explain this decline. First, recent years have seen increasing numbers of Russian companies ceasing operations due to bankruptcy[4]. These liquidated firms are directly reflected in the official statistics. Second, government crackdowns on gray-market schemes — including illegal cash operations, offshore money transfers, and tax evasion — have reduced the number of registered legal entities. Previously common practices such as “envelope salaries” (unofficial cash payments) have become more difficult and costly, making formal wage payments more attractive, particularly for employers with large workforces.

Figure 2 presents the ratio of R&D costs to GRP in Russia in 2015–2021, showing cyclical fluctuations with an overall downward trend. The ratio experienced a sharp decline from 2015 to 2016, falling below 1.2 %. While it showed modest recovery in 2017, the ratio remained below 1.2 %. Another significant drop occurred in 2018 (be-

[4] RBC. (2022). Retrieved from: https://www.rbc.ru/economics/19/01/2022/61e6c8219a7947a716d7803d (date of access: 28.12.2023).

low 1.1 %), followed by a partial recovery to above 1.15 % in 2019–2020. However, 2021 saw a further decline to below 1.0 %.

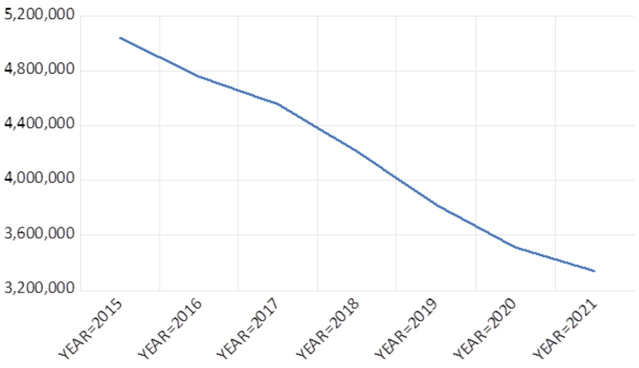


***Figure 1.*** *Annual number of companies*

Source: authors' calculations based on Rosstat data (Retrieved from: https://rosstat.gov.ru/regional_statistics (date of access: 24.12.2023)).

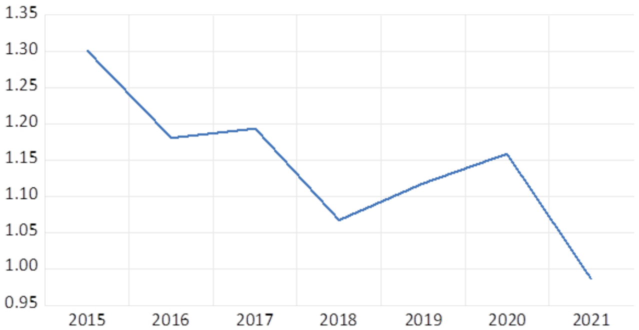


***Figure 2.*** *R&D costs to GRP (%)*

*Source:* author's calculations based on Rosstat data (Retrieved from: https://rosstat.gov.ru/regional_statistics (date of access: 24.12.2023)).

Figure 3 presents the number of employees in R&D per population ( %) in Russia. It can be seen that the ratio of employees in the R&D sector is continuously decreasing for the period 2015–2021. This declining tendency is mostly shown by breaking down the data per district from 2016 to 2021 (Figure 3). The reason for this is linked to Figure 2: As the R&D costs to GRP ratio declines, the number of personnel working in R&D sectors declines accordingly. In addition, Russia is going through insufficient replenishment of scientific personnel. In 2020, 85.5 thousand people were accepted into research organizations, while 91.1 thousand people left[5].

[5] AIF.RU. (2021). Retrieved from: https://aif.ru/society/opinion/pochemu_v_rossii_uchyonyh_stanovitsya_vsyo_menshe (date of access: 29.12.2023). RBC

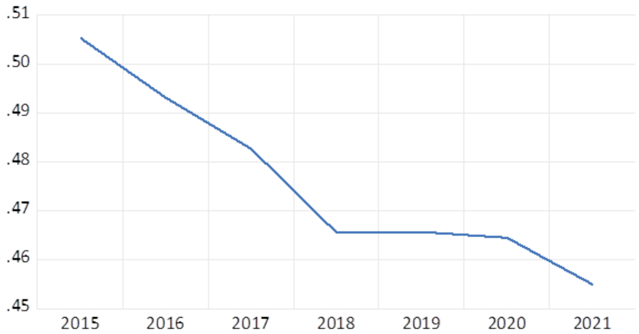


***Figure 3.*** *The number of employees in R&D to population ( %) in Russia*

*Source*: author's calculations based on Rosstat data (Retrieved from: https://rosstat.gov.ru/regional_statistics (date of access: 24.12.2023)).

Figure 4 displays how R&D costs are allocated for different types of research. The pattern of the allocation does not show any difference for 2015–2021. In Russia, approximately 60–70 % of the R&D spending is dedicated to the development of products and services to commercialize the new technology. Slightly more than 30 % of the R&D costs are directed toward applied and fundamental research, while the least R&D costs are headed toward fundamental research.

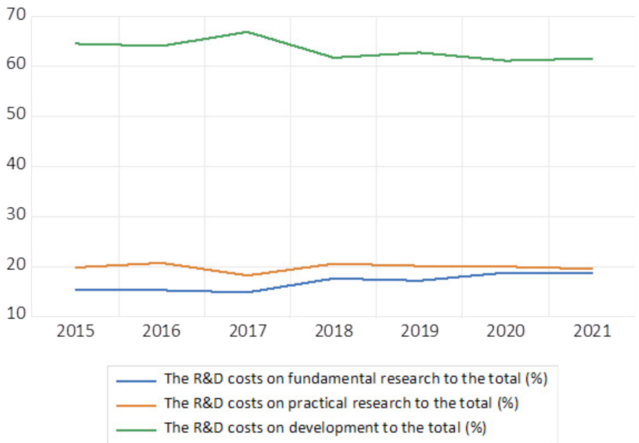


***Figure 4.*** *R&D spending by type of research*

*Source:* authors' calculations based on Rosstat data (Retrieved from: https://rosstat.gov.ru/regional_statistics (date of access: 24.12.2023)).

***Regional comparison in major indicators across Russian federal districts***

The analysis of regional dynamics reveals significant heterogeneity across Russian federal districts, underscoring the spatial unevenness of both entrepreneurial activity and R&D inputs. While the aggregate national data indicates a general contraction in these indicators, a closer examination of Figures A1–A3 in Appendix highlights unique regional trajectories that are essential for understanding the localized impact of R&D on firm creation.

As depicted in Figure A1, the decline in the number of registered companies is not merely a national aggregate trend but a pervasive phenomenon observed across all eight federal districts from 2015 to 2021. This synchronized downward trajectory suggests that systemic factors — such as stricter federal tax compliance measures, the liquidation of "grey" market firms, and economic volatility — have exerted a uniform pressure on business density, irrespective of a region's specific economic base. However, the intensity of this decline varies, with industrially developed districts facing sharper absolute reductions in active legal entities compared to less saturated peripheral regions.

In terms of financial inputs, Figure A2 illustrates the ratio of R&D costs to Gross Regional Product (GRP), revealing pronounced disparities in regional innovation intensity. Unlike the uniform decline in firm counts, R&D spending exhibits distinct regional volatility. The Central, Northwestern, and Southern federal districts demonstrate the most significant downward trends in R&D intensity. This is particularly alarming given that these districts host the majority of Russia's "science cities". The universal decline observed across all districts between 2020 and 2021 further indicates that the pandemic-induced economic shock exacerbated existing structural underfunding, leaving no region insulated from the contraction in innovation capital.

This contraction in financial resources is mirrored by a depletion of human capital, as shown in Figure A3. The number of R&D employees per capita displays a continuous decreasing tendency across most districts from 2016 to 2021. This trend is inextricably linked to the reduction in R&D funding (Figure A2), as reduced grants and contracts directly limit the capacity of regional research institutions to retain personnel. The data suggests a "hollowing out" effect where even regions with strong academic legacies are failing to replenish their scientific workforce, likely due to the combined pressures of an aging demographic of experts and the outmigration of younger specialists primarily to Moscow or abroad.

## Results

Table 3 presents the effects of R&D on growth in entrepreneurial activity. Both R&D spending and R&D personnel are positively associated with the number of firms with statistical significance. This positive and significant correlation holds both in cross-section fixed effects and cross-section random effects models. This indicates that increasing R&D spending and expanding the personnel in R&D sectors will contribute

Table 3

**Effects (t) of R&D on the Entrepreneurial Growth**

| | OLS.1 | OLS.2 | FE.1 | FE.2 | RE.1 | RE.2 |
|---|---|---|---|---|---|---|
| Constant | –3.05*** | –3.06*** | –3.52*** | –2.58*** | –3.14*** | –3.01*** |
| | (0.05) | (0.05) | (0.22) | (0.32) | (0.10) | (0.11) |
| Ln(RnD_Cost) | 0.06*** | | 0.08** | | 0.10*** | |
| | (0.01) | | (0.03) | | (0.02) | |
| Ln(RnD_employee) | | 0.05*** | | 0.23*** | | 0.13*** |
| | | (0.01) | | (0.05) | | (0.02) |
| Ln(Trade) | 0.07*** | 0.09*** | –0.02 | –0.01 | 0.02 | 0.02 |
| | (0.01) | (0.01) | (0.02) | (0.02) | (0.01) | (0.01) |
| Grw_GRP | 0.41*** | 0.40** | 0.19*** | 0.16*** | 0.18*** | 0.17*** |
| | (0.15) | (0.16) | (0.06) | (0.06) | (0.06) | (0.06) |
| Cross-section effect | No | No | Yes | Yes | Yes | Yes |
| Obs. | 480 | 480 | 480 | 480 | 480 | 480 |
| r2_a | 0.38 | 0.37 | 0.91 | 0.92 | 0.11 | 0.12 |
| Hausman-test (p-value) | | | | | 0.00 | 0.00 |

*Note:* standard errors are in parentheses (*: p < 0.1, **: p < 0.05, *** p < 0.01).

Table 4

**Effects (t+1) of R&D on the Entrepreneurial Growth**

| Dep. Var. | OLS.3 | OLS.4 | FE.3 | FE.4 | RE.3 | RE,4 |
|---|---|---|---|---|---|---|
| Constant | –3.08*** | –3.09*** | –3.58*** | –2.92*** | –3.15*** | –3.06*** |
| | (0.05) | (0.06) | (0.24) | (0.31) | (0.10) | (0.11) |
| Ln(RnD_Cost) | 0.05*** | | 0.07** | | 0.09*** | |
| | (0.01) | | (0.03) | | (0.02) | |
| Ln(RnD_employee) | | 0.04*** | | 0.18*** | | 0.11*** |
| | | (0.01) | | (0.05) | | (0.02) |
| Ln(Trade) | 0.08*** | 0.09*** | –0.02 | –0.02 | 0.03** | 0.03* |
| | (0.01) | (0.01) | (0.02) | (0.02) | (0.02) | (0.02) |
| Grw_GRP | 0.59*** | 0.59*** | 0.38*** | 0.35*** | 0.35*** | 0.34*** |
| | (0.18) | (0.18) | (0.06) | (0.06) | (0.06) | (0.06) |
| Cross-section effect | No | No | Yes | Yes | Yes | Yes |
| Obs. | 400 | 400 | 400 | 400 | 400 | 400 |
| r2_a | 0.40 | 0.39 | 0.94 | 0.94 | 0.18 | 0.18 |
| Hausman-test (p-value) | | | | | 0.00 | 0.00 |

*Note:* standard errors are in parentheses (*: p < 0.1, **: p < 0.05, *** p < 0.01).

to the formation of companies in Russia. While model fit improves with the fixed effects estimator, the adjusted R-squared exceeds 0.90.

Table 4 describes the effects of R&D on entrepreneurial growth after one year. The result of the effects of *t+1* is consistent with that of the current year. Both the effects of R&D costs and personnel size on the number of firms are positive and significant after 1 year. This confirms that R&D investments stimulate entrepreneurial activity not only immediately but also with a one-year lag. As in the current-year model, the fixed effects specification demonstrates superior model fit, with an adjusted $R^2$ of 0.94.

To examine heterogeneity in R&D effects, we constructed additional models analysing how different R&D types influence firm creation. Specifically, we tested the impacts of fundamental research, applied research, and product development separately.

Tables 5–7 present the effects of expenditures on fundamental research, applied research, and

Table 5

**Effects of Fundamental Research on Growth in Entrepreneurial Activity**

| Dep. Var. | $Ln(Firm)_{it}$ | | | $Ln(Firm)_{it+1}$ | | |
|---|---|---|---|---|---|---|
| | OLS.1 | FE.1 | RE.1 | OLS.2 | FE.2 | RE.2 |
| Constant | –2.95*** | –3.58*** | –3.11*** | –2.98*** | –3.55*** | –3.08*** |
| | (0.06) | (0.19) | (0.11) | (0.06) | (0.20) | (0.11) |
| Ln(RnD_Fundamental) | 0.07*** | 0.07*** | 0.09*** | 0.07*** | 0.09*** | 0.10*** |
| | (0.01) | (0.03) | (0.02) | (0.01) | (0.02) | (0.02) |
| Ln(Trade) | 0.08*** | –0.03 | 0.03** | 0.09*** | –0.03 | 0.04*** |
| | (0.01) | (0.02) | (0.01) | (0.01) | (0.02) | (0.01) |
| Grw_GRP | 0.34** | 0.19*** | 0.17*** | 0.53*** | 0.38*** | 0.33*** |
| | (0.15) | (0.06) | (0.06) | (0.17) | (0.06) | (0.06) |
| Cross-section effect | No | Yes | Yes | No | Yes | Yes |
| Obs. | 480 | 480 | 480 | 400 | 400 | 400 |
| r2_a | 0.40 | 0.91 | 0.1 | 0.42 | 0.94 | 0.18 |
| Hausman-test (p-value) | | | 0.00 | | | 0.00 |

*Note:* standard errors are in parentheses (*: p < 0.1, **: p < 0.05, *** p < 0.01).

Table 6

**Effects of Applied Research on Growth in Entrepreneurial Activity**

| Dep. Var. | $Ln(Firm)_{it}$ | | | $Ln(Firm)_{it+1}$ | | |
|---|---|---|---|---|---|---|
| | OLS.1 | FE.1 | RE.1 | OLS.2 | FE.2 | RE.2 |
| Constant | −2.44*** | −3.22*** | −2.43*** | −2.53*** | −3.45*** | −2.63*** |
| | (0.19) | (0.35) | (0.24) | (0.20) | (0.32) | (0.23) |
| Ln(RnD_Applied)) | 0.04*** | 0.04** | 0.06*** | 0.04*** | 0.03** | 0.05*** |
| | (0.01) | (0.02) | (0.01) | (0.01) | (0.02) | (0.01) |
| Ln(Trade) | 0.09*** | −0.04 | 0.04*** | 0.09*** | −0.03 | 0.04*** |
| | (0.01) | (0.02) | (0.02) | (0.01) | (0.02) | (0.01) |
| Grw_GRP | 0.38** | 0.20*** | 0.17*** | 0.59*** | 0.39*** | 0.35*** |
| | (0.15) | (0.06) | (0.06) | (0.18) | (0.06) | (0.06) |
| Cross-section effect | No | Yes | Yes | No | Yes | Yes |
| Obs. | 480 | 480 | 480 | 400 | 400 | 400 |
| r2_a | 0.38 | 0.91 | 0.10 | 0.39 | 0.94 | 0.15 |
| Hausman-test (p-value) | | | 0.00 | | | 0.00 |

*Note:* standard errors are in parentheses (*: p<0.1, **: p<0.05, *** p<0.01).

Table 7

**Effects of Product Development on Growth in Entrepreneurial Activity**

| Dep. Var. | $Ln(Firm)_{it}$ | | | $Ln(Firm)_{it+1}$ | | |
|---|---|---|---|---|---|---|
| | OLS.1 | FE.1 | RE.1 | OLS.2 | FE.2 | RE.2 |
| Constant | −3.12*** | −3.68*** | −3.25*** | −3.15*** | −3.80*** | −3.31*** |
| | (0.05) | (0.19) | (0.09) | (0.05) | (0.18) | (0.09) |
| Ln(RnD_development)) | 0.03*** | 0.04*** | 0.05*** | 0.03*** | 0.03*** | 0.04*** |
| | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) |
| Ln(Trade) | 0.09*** | −0.02*** | 0.04*** | 0.09*** | −0.02 | 0.04*** |
| | (0.01) | (0.03) | (0.01) | (0.01) | (0.03) | (0.01) |
| Grw_GRP | 0.33** | 0.14** | 0.11* | 0.55*** | 0.39*** | 0.34*** |
| | (0.16) | (0.07) | (0.06) | (0.18) | (0.07) | (0.06) |
| Cross-section effect | No | Yes | Yes | No | Yes | Yes |
| Obs. | 480 | 480 | 480 | 400 | 400 | 400 |
| r2_a | 0.37 | 0.90 | 0.13 | 0.39 | 0.93 | 0.19 |
| Hausman-test (p-value) | | | 0.00 | | | 0.00 |

*Note:* standard errors are in parentheses (*: p < 0.1, **: p < 0.05, *** p < 0.01).

product development on firm creation, respectively. The results consistently show positive effects for all R&D types at the 1 % significance level, with these effects persisting into the *t+1* period. Notably, the regression coefficient for Ln (RnD_Fundamental) exceeds those of Ln (RnD_Applied) and Ln (RnD_Development), indicating that fundamental research contributes most significantly to firm creation in Russian regions. This finding is particularly noteworthy given that Russia allocates the smallest portion of its R&D budget to fundamental research activities.

To enhance the reliability of our results, we further estimated models using the GMM method. As shown in Table 8, the positive and statistically significant effects of both R&D costs and personnel remain robust in the GMM specifications, consistent with the baseline model results.

## Discussion

In this study, we examine the impact of R&D on entrepreneurial growth in Russia. Regression analysis shows a positive association, consistent with prior findings (Kirchhoff et al., 2002; Kanellopoulos and Fotopoulos, 2019). These results hold for both *t* and *t+1* across OLS, FE, RE, and GMM estimators. We also find heterogeneity in R&D effects by type, with the strongest im-

Table 8

**Effects of R&D on Growth in Entrepreneurial Activity Two-step difference GMM**

| | GMM.1 | GMM.2 | GMM.3 | GMM.4 |
|---|---|---|---|---|
| Firm (t–1) | 0.85*** | 1.67*** | 0.81*** | 1.04*** |
| | (0.04) | (0.41) | (0.04) | (0.26) |
| Firm (t–2) | | –0.94** | | –0.31 |
| | | (0.45) | | (0.24) |
| Ln(RnD_Cost) | 0.15** | 0.32** | | |
| | (0.07) | (0.16) | | |
| Ln(RnD_Employee) | | | 0.57*** | 0.68** |
| | | | (0.16) | (0.27) |
| Ln(Trade) | –0.04 | 0.03 | 0.02 | 0.05 |
| | (0.03) | (0.06) | (0.03) | (0.05) |
| Grw_GRP | –0.11* | –0.28* | 0.05 | –0.06 |
| | (0.06) | (0.15) | (0.08) | (0.10) |
| AR (2) | 0.22 | 0.37 | 0.40 | 0.48 |
| Obs. | 320 | 320 | 320 | 320 |

*Note:* standard errors are in parentheses (*: $p < 0.1$, **: $p < 0.05$, *** $p < 0.01$).

pact coming from fundamental research. This aligns with previous literature: R&D's effect on employment growth is more pronounced in small firms (Yang and Huang, 2005), larger in privately owned and large companies (Zhu et al., 2021), and varies with firm size, patenting activity, and persistence (Demirel and Mazzucato, 2012). Our study adds to the literature by quantifying these differences across R&D types.

Despite R&D's role in fostering entrepreneurship, the R&D-to-GRP ratio in Russia has steadily declined from 2015 to 2021. Revitalizing national and regional economies requires policies to promote R&D. Our findings support theoretical models for Russian regions, highlighting the importance of firm-level innovation incentives to drive productivity and economic growth (Zamulin and Sonin, 2019). Given the state's central role in R&D financing, measures such as unifying Russia's scientific-technological space, establishing transparent interregional cooperation rules, and expanding federal funding for regional R&D initiatives are recommended (Mazilov and Davydova, 2020). Regional authorities often lack resources to support local entrepreneurship effectively, making ecosystem-based approaches (Zemtsov et al., 2021) difficult to implement, especially amid outmigration of young entrepreneurs.

Socio-cultural barriers also limit innovation commercialization. Auzan et al. (2019) identify these factors as key constraints. Potential solutions include promoting the image of innovators and reducing regulatory pressure through targeted legal reforms. Rapid digitalization in Russia may further simplify administrative and socio-cultural obstacles, enhancing the business environment and supporting entrepreneurship.

It should also be noted that, in Russia, the federal government owns 60% of universities, and many of them are separated from industrial sectors, which makes it difficult to establish industrial contracts for applied research[6]. In this sense, university-industry cooperation in the form of collaborative research, research contracts, or scientific consultancy should be strengthened to facilitate knowledge spillovers and technological advancement (Mascarenhas et al., 2018). This alliance can be expanded by including the government.

In addition, securing quality personnel is also a critical issue for Russia to enhance the efficiency of R&D. Russia has long experienced brain drain, with skilled workers leaving for better career opportunities and socio-economic stability (Kouznetsova, 1996; Wang et al., 2019). This outflow began after the Soviet Union's collapse and has intensified under the current geopolitical situation (Davies et al., 1994; Korobkov et al., 2022).

[6] RBC. (2021). Retrieved from: https://trends.rbc.ru/trends/education/60c9b7839a794762950e8ead (date of access: 29.12.2023).


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Addressing these structural challenges requires proactive strategies to attract and retain skilled labor. Derbeneva et al. (2024) highlight the role of "creative reindustrialization" as a mechanism for regional revitalization. Their analysis shows that managing this transition depends on factors such as targeted expansion of the creative sector and effective use of regional proximity. By combining this framework with our results, we show that regions with declining traditional R&D can maintain entrepreneurial growth by actively supporting creative and knowledge-based industries, instead of depending only on legacy industrial models.

## Conclusions and Limitations

This study examines the impact of R&D on entrepreneurial growth across 80 Russian regions from 2015 to 2021. The analysis reveals a decline in the number of firms in this period, which is likely attributable to increased bankruptcies and stricter government policies against shell companies. Concurrently, the R&D-to-GRP ratio and the size of the R&D workforce decreased — a trend consistent across regional disaggregations. Regression results, however, demonstrate a positive and significant association between R&D and entrepreneurial growth in both the current t and subsequent *t+1* years. The effect holds across all R&D types but is most pronounced for fundamental research, underscoring its role as a key driver of entrepreneurial development in Russia.

To strengthen R&D investment and promote entrepreneurial growth, policy-makers must address two interrelated challenges: establishing regional funds to support high-tech entrepreneurship and enhancing local technological universities to retain young talent and reduce brain drain. Population aging, partly driven by rising life expectancy, could further increase investment capacity, as many highly skilled specialists from older cohorts possess USSR-era education and experience. However, given strategic risks and ongoing sanctions, federal authorities should prioritize these measures, especially in critical technologies.

A limitation of this study is its reliance on firm counts as a proxy for entrepreneurial growth, which conflates firm entry and exit. Future research should use more precise measures, such as net firm creation, and examine sectoral heterogeneity, for example, the differential effects of R&D in high-tech versus agricultural sectors, depending on data availability. By combining endogenous growth frameworks with detailed analyses of R&D types and regional disparities, future studies could provide insights on leveraging Russia's R&D legacy to drive entrepreneurial renewal, a pressing need for the country's innovation-driven future.

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**Declarations**

**Competing interests.** The authors have no relevant financial or non-financial interests to disclose.

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## Appendix

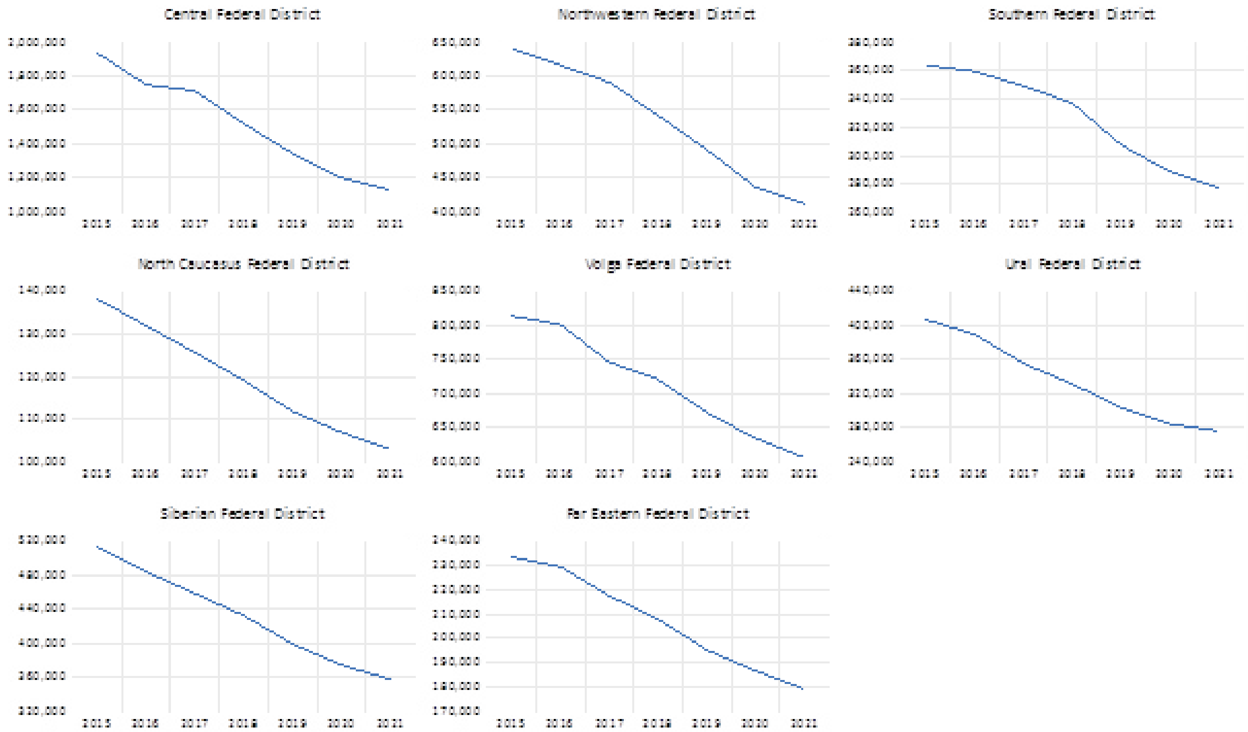


*Figure A1. Number of companies by federal district and year in Russia*

*Source:* authors' calculations based on Rosstat data (Retrieved from: https://rosstat.gov.ru/regional_statistics (date of access: 24.12.2023)).

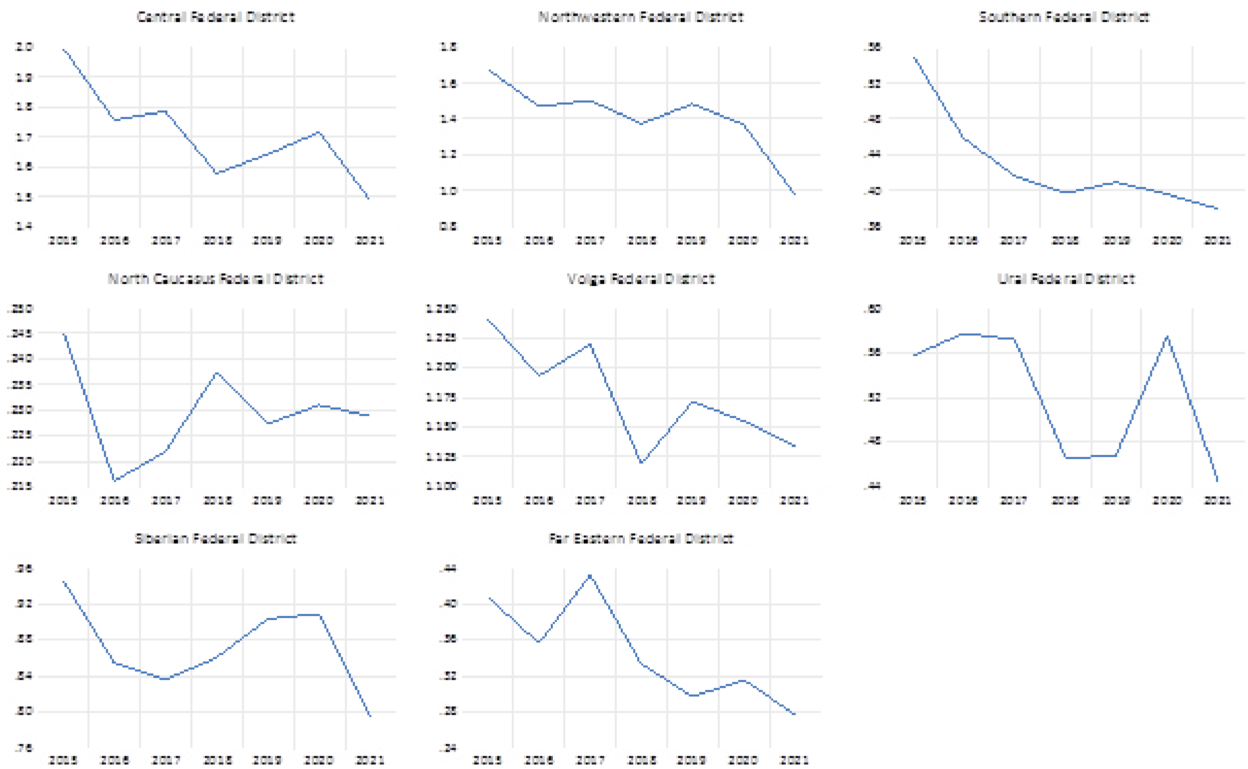


*Figure A2. R&D costs to GRP (%) in Russia per federal district*

*Source:* authors' calculations based on Rosstat data (Retrieved from: https://rosstat.gov.ru/regional_statistics (date of access: 24.12.2023)).

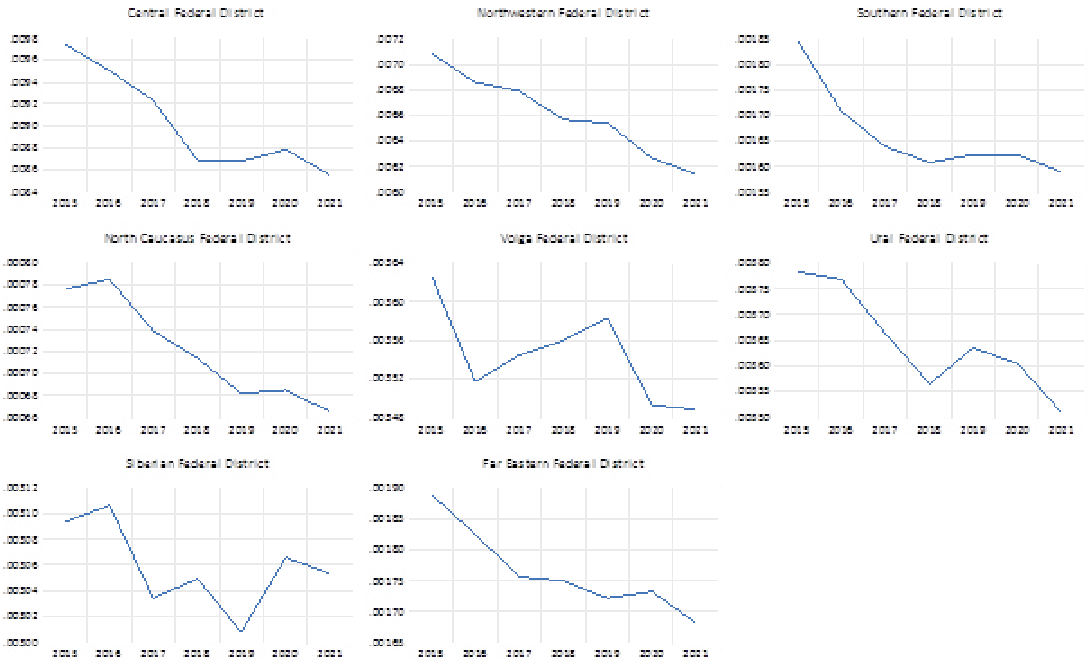


*Figure A3. Share of R&D employees in the total population by federal district in Russia (%)*

*Source:* authors' calculations based on Rosstat data (Retrieved from: https://rosstat.gov.ru/regional_statistics (date of access: 24.12.2023)).

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