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# CEO Characteristics and Innovations: Evidence from Russian Public Companies

Complied by second year student
Of Management, Master in
Corporate Finance Program:
**Anastasiia Avdeeva**

Research advisor:
Candidate of Economics,
Associate Professor, **Yulia B. Ilina**

Saint Petersburg

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## ЗАЯВЛЕНИЕ О САМОСТОЯТЕЛЬНОМ ХАРАКТЕРЕ ВЫПУСКНОЙ КВАЛИФИКАЦИОННОЙ РАБОТЫ

Я, Авдеева Анастасия Андреевна, студентка второго курса магистратуры направления «Корпоративные финансы», заявляю, что в моей магистерской диссертации на тему «Характеристики CEO и инновации: анализ российских публичных компаний», представленной в ГАК для публичной защиты, не содержится элементов плагиата.

Все прямые заимствования из печатных и электронных источников, а также из защищенных ранее выпускных квалификационных работ, кандидатских и докторских диссертаций имеют соответствующие ссылки.

Я ознакомлена с действующим в Высшей школе менеджмента СПбГУ регламентом учебного процесса, согласно которому обнаружение плагиата (прямых заимствований из других источников без соответствующих ссылок) является основанием для выставления за выпускную квалификационную работу оценки «неудовлетворительно».

/Авдеева А.А./

*(подпись)* 29.05.2022

# АННОТАЦИЯ

| | |
|---|---|
| Автор | Авдеева Анастасия Андреевна |
| Название ВКР | Характеристики CEO и инновации: анализ российских публичных компаний |
| Образовательная программа | Менеджмент |
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| Год | 2022 |
| Научный руководитель | Ильина Юлия Борисовна |
| Описание цели, задач и основных результатов | Цель исследования — определить и изучить взаимосвязь между характеристиками генерального директора в российских публичных компаниях и инновационностью компании с точки зрения количества патентов и затрат на НИОКР.<br>Задачи:<br>1) Провести обзор литературы о характеристиках CEO, инновациях по отдельности и об их взаимосвязи в целом.<br>2) Сформулировать гипотезы о возможной связи характеристик генерального директора с инновационностью компании.<br>3) Получить данные о характеристиках генерального директора и показателях инновационности для списка российских публичных компаний.<br>4) Выбрать методологию исследования и провести эмпирическое исследование взаимосвязи отдельных характеристик генеральных директоров с инновационностью в российских компаниях.<br>5) Обсудить результаты эмпирического исследования и разработать теоретические и практические способы применения результатов.<br>Основные результаты<br>В рамках исследования были построены две регрессионные модели по панельным данным за 2015-2019 на примере ряда Российских публичных компаний: одна модель оценивает взаимосвязь характеристик CEO и количества патентов, другая – взаимосвязь характеристик CEO и затрат компании на НИОКР. В результате исследования сделан ряд выводов о том, какими характеристиками должен обладать CEO, чтобы развивать компанию в направлении инноваций. Так, было установлено, что наличие у CEO степени MBA и/или докторской степени негативно влияет на инновационность компании, в то время как опыт работы гендиректора в госструктурах, а также опыт работы в самой исследуемой компании на других должностях - позитивно связаны с инновационностью компании. |
| Ключевые слова | Генеральный директор, характеристики генеральных директоров, инновации, НИОКР, патенты, российские компании |

# ABSTRACT


| | |
|---|---|
| Master Student's Name | Anastasiia Avdeeva |
| Master Thesis Title | CEO Characteristics and Innovations: Evidence from Russian Public Companies |
| Educational Program Management | Management |
| Main field of study | Corporate finance |
| Year | 2022 |
| Academic Advisor's Name | Yulia B. Ilina |
| Description of the goal, tasks, and main results | The goal of the research is to determine and examine the relationship between the CEO characteristics in Russian public companies and the company's innovativeness in terms of number of patents and R&D expenditures.<br>Tasks:<br>1) To conduct a literature review about CEO characteristics, innovations separately and about their relationship in general.<br>2) To state the hypotheses about possible relationship between CEO characteristics and company's innovativeness.<br>3) To obtain the data on CEO characteristics and innovation measures for a list of Russian Public companies.<br>4) To choose a research methodology and conduct an empirical study of particular CEO characteristics that are assumed to have relationship with innovativeness in Russian companies.<br>5) To discuss the results of empirical study and develop theoretical and practical implications for results.<br>Main results<br>As part of the study, two regression models were built based on panel data for 2015-2019 using the example of a number of Russian public companies: one model evaluates the relationship between the characteristics of the CEO and the number of patents, the other - the characteristics of the CEO and the R&D expenditures. As a result of the study, a number of conclusions were drawn about what characteristics a CEO should have in order to develop a company in the direction of innovation. Thus, it was found that the presence of an MBA degree and/or a PhD in the CEO education background negatively affects the company's innovativeness, while the working experience of the CEO in governmental structures, as well as working experience in the company under study in other positions earlier, is positively associated with the company's innovativeness. |
| Keywords | CEO, CEO characteristics, innovations, R&D, patents, Russian companies |

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# INTRODUCTION

The determining impact of science, innovation on the progress of the economy and society is a well-known and generally recognized fact. But at the same time, issues related to innovation and their management do not lose their relevance and are widely covered in the literature [Vlasova, V., 2017]. The innovative activity of an enterprise has a direct impact on the level of competitiveness, ensuring that the enterprise achieves innovative development goals [A.V. Volkova, L.N. Zakharova, 2021]. Innovation makes it easier for companies to go through environmental, economic and financial challenges [Burcay and Sismanoglu, 2015].

The identification of factors that can influence the innovative activity of an organization is important for choosing directions for improving the innovative activity of an organization, as well as for developing proposals for improving management methods [Pankratova E., 2019]. In addition, identifying the mechanism of influence of factors can also be one of the directions for further research in the field of innovation management within a particular industry or organization.

The factors that can have an influence on the innovative activity of the company that are being examined in this research are the characteristics of the CEO. The way the company operates in terms of strategy and innovation strategy in particular, is determined by the decisions of the CEO of the company. Studies of the innovative activity of companies allow to conclude that, with all the unity of the functions performed by the head of the company, there are certain differences in the requirements for top management and the nature of management in general, depending on the priorities in the choice of innovative strategies [Kokurin D.I., 2007]. One of the main conditions for the effectiveness of the company and its innovativeness is the "efficiency" of the CEO themselves [Maslova V.M., 2007].

The goal of the research is to determine and examine the relationship between the CEO characteristics in Russian public companies and the company's innovativeness in terms of number of patents and R&D expenditures. This topic was chosen in order to study how some particular characteristics of CEO can have an influence on company's innovation measures.

Main research question:

- Which characteristics of CEO are important to examine and to change in order to improve the innovativeness of the Russian companies?

There is a list of research goals for completing the thesis:

1) To conduct a literature review about CEO characteristics, innovations separately and about their relationship in general.

2) To state the hypotheses about possible relationship between CEO characteristics and company's innovativeness.

3) To obtain the data on CEO characteristics and innovation measures for a list of Russian Public companies.

4) To choose a research methodology and conduct an empirical study of particular CEO characteristics that are assumed to have relationship with innovativeness in Russian companies.

5) To discuss the results of empirical study and develop theoretical and practical implications for results.

The first chapter of this study is theoretical, includes a literature review of the concepts used in the work, such as innovation and innovativeness, also includes an overview of the situation with innovations in the Russian market, as well as a review of the literature on the study of the relationship between the characteristics of the CEO and innovation.

The second chapter is practical, devoted to empirical research. As the CEO characteristics there will be taken various demographic parameters, data on education, work experience of CEOs and some other data. As the measure of firm innovativeness there will be taken two metrics - R&D expenditure and number of patents. The empirical study is going to be based on the data from 61 companies form Broad Market Index of Moscow Stock Exchange, taking into account data from year 2015 to year 2019. The research method used is regression model on panel data.

In the end of chapter 2 there is a discussion of the results of the study, as well as a direct proposal for a possible practical implication of the results. Also, at the end of the second chapter, it is clarified what limitations exist in this study, and what other connections or parameters can be studied further, based on this paper.

# Chapter 1: Innovations and CEO

## 1.1. Innovations and measurements

### The definition of innovations and innovativeness

For this study, it is important to understand what innovation is. During the literature review, it was found that there are different perceptions of innovations that exist. The concept of innovation varies somewhat from author to author, from one industry to another. The following are examples of the interpretation of innovations from various sources, similar interpretations and differences in the understanding of the term are noted.

To begin with, let's turn to the definition of innovation, which was proposed by one of the Hungarian economists. According to Santo B. (1990), innovation can be understood as updates and improvements both in terms of works, services, goods, and in the way of producing goods and providing services, and in terms of the process of selling goods and services. Also, according to the economist, innovation should improve the consumer properties of the product, service, which will contribute to gaining benefits in the future, or is directly related to providing benefits to the company.

Looking at the definition of the Austrian and American economist, Joseph Alois Schumpeter, the definition will be somewhat different from the previous one. If the previous definition focused on results, or rather, on the benefits received, then this economist Joseph Schumpeter (2008) defines innovation primarily as a process - any organizational, technological or technical change that occurs in one of the company's processes, including development, production and marketing processes for products. Despite the emphasis on the "process of change", Schumpeter does not deny that the result of innovation directly affects the characteristics of products and the economic processes of the company, and in the end, innovation can provide a positive economic dynamic for the company.

In addition to the previous opinion, the German specialist F. Haberland (1980) also believes that innovation is, first of all, a process of change that can cover all changes in a company: organizational, economic, technological, technical, scientific. Just like the previous author, Haberland writes about the result of innovation as a qualitative improvement over existing products, and this result should serve to increase economic efficiency in the company.

There is a definition of innovation, given not by one person, but by an entire organization - the Organization for Economic Cooperation and Development, the statistical office of the European Communities. This organization describes innovation [Oslo Manual, 2006] as the introduction and use of a new or improved product or process. The novelty of innovations in this

case is considered not in relation to already existing products and processes in the world as a whole, but in relation to products and processes in a particular company.

Some believe that innovations are new technical and technological solutions, as a result of which new products or new technologies appear. Others, on the contrary, include any innovations that are associated with the development of industrial production (the introduction of new equipment and technology; methods of organizing production, enterprise management). All those new solutions that increase economic efficiency and contribute to the solution of social problems and, which is especially important, in market conditions, ensure the financial stability of the enterprise. According to Kazakova R.P. and Bolkina G.I. (2015), the most correct approach to the definition of innovation is the second point of view. In this case, innovations include other types of innovations:

- product innovations (these can be fundamentally new and improved (modernized) types of products);
- innovative services (new types of services in healthcare, education, etc.);
- social, personnel innovations (new approaches to social and personnel policy at the enterprise);
- innovations in production systems (in the system of accounting, planning, labor motivation, organization of internal production flows, etc.).

Also, the following categorization of innovations is given Christensen C. M, Van Bever D. (2014):

- innovations that improve productivity ("... help to replace old products with new and better models. They usually create quite a few jobs, because they are substitutes");
- efficiency-enhancing innovations ("… help companies create and sell mature, established products or services to the same customers at lower prices." "Efficiency-enhancing innovations play two important roles. First of all, they increase productivity, which is essential to remain competitive, but has the painful side effect of job cuts. Secondly, they free up capital for more efficient use");
- market-creating innovations ("allow complex or expensive products to be changed so radically that they create a new class of consumers or a new market") enable the creation of many jobs.

Open innovation can be effective for exploration and production companies, large and small Hartmann D., Trott P. (2018). They will benefit from risk sharing and access to technology at a lower cost of resources than would be necessary if they were developing technology exclusively for themselves. In fact, many companies in the industry already benefit from access to

technology developed outside of their organization. Sharing technology through formal and informal means is the backbone of successful industry clusters, with the main players in the industry deliberately focusing on a small geographic area and benefitting from a common pool of resources, including subcontractors and employees.

Referring to the Russian-language literature on the topic, one can also find various definitions of innovation. For example, the textbook "Reengineering of Innovative Entrepreneurship" [V.G. Medynsky and S.V. Ildemenov, 1999] focuses on the material result of innovation, i.e. on a physical facility that was developed in the course of the company's research and development activities, and then implemented in production. The main criterion for such an object is its novelty in relation to the previous analogue, then the object will be considered an innovation.

On the contrary, in the book "Theory and Practice of Innovation" [Lapin, 2008], innovation is defined as the process of creating, disseminating and using a new practical tool. According to the author, this should not necessarily be a material result, but any tool that will help to better satisfy the needs of society in general and people in particular.

Referring to the Russian legislation, in the Concept of the innovation policy of the Russian Federation dated July 24, 1998 No. 832, the concept of innovation is also given. In this document, innovation is considered as the end result of an innovation activity, which is marketed as an improved product or applied in practice as an improved process.

It is also worth considering related concepts. Basically, the authors agree that innovation should be distinguished from invention [Andrianova N.A., 2015]. An invention should be understood as an idea or a prototype of a new product, and an innovation is something that has entered the market and can have practical application.

One of the related concepts is also the concept of "innovativeness". For the first time, the term was used by Joseph Alois Schumpeter, who presented it as a system of changes [Schumpeter, J., 1934]. According to the Merriam-Webster dictionary, innovativeness is “the skill and imagination to create new things”. Basically, in the general sense, this term is equated with innovation, i.e. is associated with the creation of something new, but innovation is a process or result, while innovativeness is a characteristic of an object that innovates. Those. if a company is developing new products and processes, then we can talk about its innovativeness.

Summing up this section, it must be said that despite some differences in the interpretation of innovation, all authors agree on one thing: innovation is something completely new or improved in relation to its analogue, innovation takes place in various areas, processes, products.

**The role of innovations in Russian market**

Innovation is a factor in development, whether it is a company, industry, country or the world as a whole. In the context of economic crises and tougher competition in various geographic and product markets, innovation is becoming more relevant than ever. At their expense, companies can acquire unique competitive advantages, open new markets, and expand customer networks. For the Russian market, innovations are no less relevant.

First, over the past few years, the problem of import substitution has never been more relevant in Russia. This problem is related to national security when it comes to the need to be able to replace vital goods, equipment, if these things stop coming from abroad. Also, this problem is relevant due to the expanding packages of sanctions, both on exports from the countries of the European Union and on imports from Russia. For example, the RBC Group published more than 10 articles in March-April 2022 about new export and import sanctions against Russia.

Secondly, innovation is one of the opportunities for the growth of the Russian economy. After the crisis of 2014-2015, according to Rosstat, GDP did not undergo significant growth, while lagging far behind the pace of world development and the development of the largest Western countries. Innovations act as the most important driving force of the country's sustainable economic growth, contribute to the creation of a reliable material and non-material basis for the life of present and future generations. Russia is currently experiencing an urgent need to intensify and intensify innovation.

Another reason that emphasizes the relevance of innovation in Russia is that the Russian economy has a number of predominant sectors in which technical and technological development is very important. Basically, these are industries that are characterized by a large scale of production, requiring large investments. Such industries include the oil and gas industry, energy, mining and metalworking industries. For these industries, the issue of shortening the production cycle, reducing operating costs, increasing the number of manufactured products and services is especially acute, as the demand for traditionally produced resources, in particular, some types of energy resources, decreases, the cost of equipment and parts for production increases, and mineral reserves are declining.

One of the regulatory documents that define the strategic guidelines and main vectors for the development of the national economy and Russian society for the recent period was the Decree of the Government of the Russian Federation dated November 17, 2008 No. 1662-r “On the Concept of the Long-Term Socio-Economic Development of the Russian Federation for the period up to 2020” and for the upcoming period a single plan for achieving the national development goals of the Russian Federation for the period up to 2024 and for the planning period up to 2030 dated 01.10.2021.

Further, it is necessary to consider numerical indicators characterizing innovations in Russia. In different years, KPMG and McKinsey provided reports on innovations, including those on the Russian market. Thus, the Agency for Strategic Initiatives (ASI) and the international consulting company KPMG (2020) surveyed 148 large Russian enterprises - more than 30% of large Russian companies are ready to allocate 5–10 billion rubles for these purposes. per year, and 10% - more than 10 billion rubles.

In 2017, a study by McKinsey found that 94% of executives surveyed were dissatisfied with their company's performance in innovation. The results of a survey conducted by McKinsey among leaders of large companies [Innovation in Russia - an inexhaustible source of growth, 2018] also showed that more than 80% of them believe that innovation is the most important success factor, but at the same time, less than 10% are satisfied with the level of development of innovation in their companies or in general are engaged in this issue.

Table 1 shows data on Gross domestic expenditure on R&D by type of R&D institution in thousand rubles, data shows the proportional importance of R&D investment across industries.

***Table 1.*** Gross domestic expenditure on R&D by type of R&D institution (thousand rubles)

| | **2005** | **2010** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** |
|---|---|---|---|---|---|---|---|---|---|
| **Research institutes** | 136699353 | 290022808 | 41729 5914 | 472146462 | 508671691 | 529229804 | 557552584 | 578340931 | 643561481 |
| **Design organizations** | 563850 16,8 | 120926726 | 14550 6117 | 168283263 | 175200033 | 176836173 | 177912175 | 176896333 | 210473879 |
| **Construction/Exploration organizations** | 162646 4,3 | 421516 6,6 | 40129 67,1 | 401731 3,5 | 276486 8,3 | 255801 2,5 | 230528 7,2 | 205828 1,8 | 103587 8,8 |
| **Pilot plants** | 171135 ,5 | 564476 ,6 | 18914 48,8 | 267963 4,5 | 322891 6,7 | 320402 5,6 | 113372 08,7 | 119740 06,1 | 570996 1,2 |
| **Higher education institutions** | 109630 94,5 | 387873 66,4 | 63138 131 | 779758 05,2 | 829724 15,2 | 804241 85,9 | 868426 69,4 | 917413 79,8 | 100255 581 |
| **Industrial enterprises** | 126334 35,9 | 328387 80,9 | 59346 858 | 609621 71,4 | 746938 99,2 | 757474 20,1 | 902170 91 | 797606 17,2 | 925766 31,2 |
| **Others** | 123066 50,8 | 360219 09,9 | 58606 203 | 614623 43,5 | 671372 33,9 | 758155 98,6 | 929854 22 | 874760 96,1 | 811732 52,1 |
| **Total** | 230785 150 | 523377 234 | 74979 7639 | 847526 993 | 914669 057 | 943815 220 | 101915 2437 | 102824 7645 | 113478 6665 |

Source: Science and Technology Indicators in the Russian Federation 2021

According to data for 2018, Research institutes accounted for the most expenses, and the Construction project and exploration organizations block accounted for the smallest share. As of 2019, spending per institution has increased proportionately, with Research institutes also accounting for the largest share. This is due to state support for scientific activity, which serves as a further basis for the creation of technical and technological innovations.

If the total gross domestic expenditure on R&D is taken into account (Fig.1), it is clear that the expenditure is growing every year. This means that the need for innovation has been identified, and many companies and the government are interested in investing in R&D in order to develop and bring to the market innovations and improvements that, in the future, will improve the life of Russian society in certain aspects.

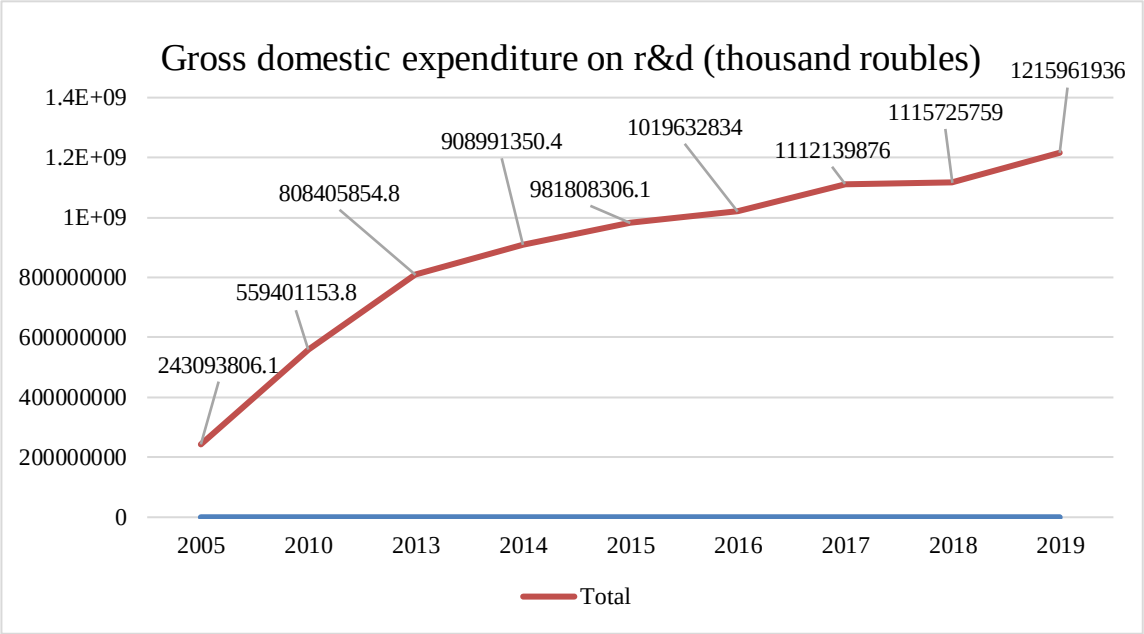


***Fig. 1.*** *Gross domestic expenditure on R&D*

*Source: Science and Technology Indicators in the Russian Federation 2021*

Next, data on patents in Russia are considered. In accordance with Russian legislation, a patent is a title of protection issued on behalf of the state to a person who has filed an application in accordance with the procedure established by law, in confirmation of his rights to an invention, utility model, industrial design.

In accordance with Art. 1354 of the Civil Code of the Russian Federation, the patent certifies:

- priority of an invention, utility model or industrial design;
- authorship;
- exclusive right to an invention, utility model or industrial design.

Figure 2 shows that in recent years the relevance of patents has remained at approximately the same level. In 2005, 2014 and 2017 there were notable jumps in the number of patent applications filed. For more than 15 years, the number of patent applications filed has not fallen below 30,000 applications per year, in some more breakthrough years, the figures exceeded 40,000 patent applications per year.

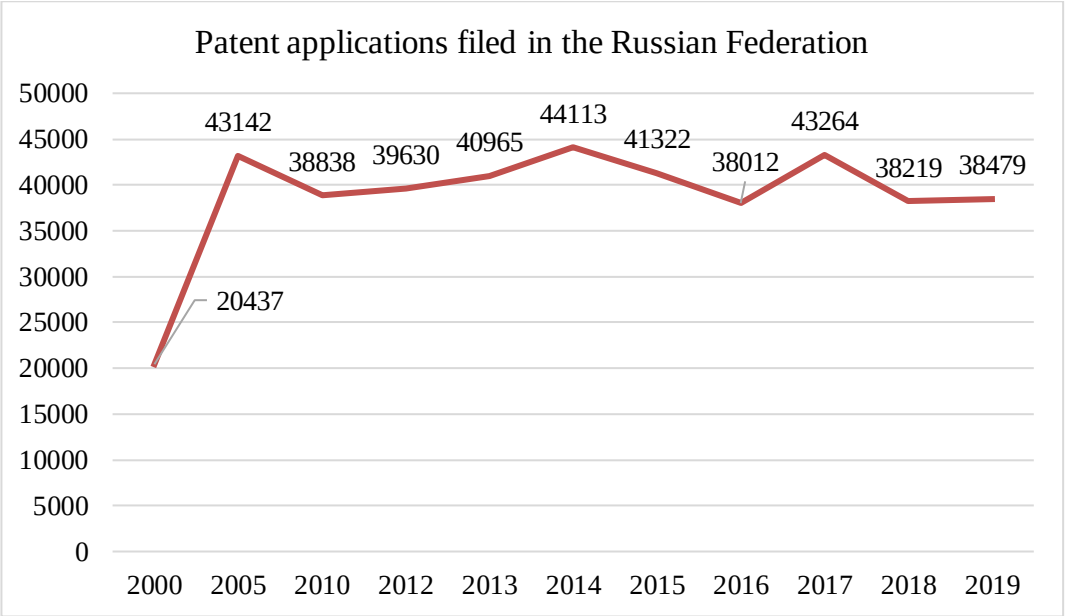


***Fig. 2.*** *Patent applications filed in the Russian Federation*

*Source: Science and Technology Indicators in the Russian Federation 2021*

Thus, innovation is an important topic for Russia, and the government, as well as the largest companies, are interested in the creation and implementation of new products and processes. The relevance of the topic of innovation in Russia is due to economic, foreign policy and technological reasons, and in the near future, as part of the development of domestic analogues of various software and equipment, the relevance of innovation will only increase.

**Measurement of company innovativeness**

Innovation as something measurable was first presented in the 1960s in the works “Research expenditures, education, and the aggregate agricultural production function” [Griliches Z., 1964] and “Research and development, production functions, and rates of return" [Minasian J.R., 1969]. Thus, innovativeness began to be considered in scientific works as one of the indicators of a company that can be measured, like profit. These works use the terminology as Research and Development, which means as a set of works aimed at obtaining new knowledge and practical application when creating a new product or technology.

Since today in all financial reports of the company, it can be seen, therefore, the expenditures of the enterprise for R&D have become indicators of how much the company can spend and how much it wants to be innovative in its field.

The McKinsey article “Taking the measure of innovation” [Guttorm Aase and Sri Swaminathan, 2018] states that innovativeness measure is a combination of indicators such as gross profit, R&D expenditures and sales of new products that can provide information about the success of innovation in a company.

In Digital Leadership magazine, “How to measure innovation? Innovation Metrics For Companies” [Stefan Mitzkus, 2022], it is said that the level of innovation is measured as the ratio of the share of innovation revenue divided by total revenue. This equation shows the innovative activity of the company in relation to the sales of the company, as well as the success of research and development. However, innovation revenue is not a common measure that is established and can be found for a list of companies. Each company displays it’s innovation outcomes in a unique numbers and figures.

Since R&D involves many different processes and different costs, the more factual ones are patents. A patent is a security document certifying the exclusive right, authorship and priority of an invention, utility model, industrial design or selection achievement, that is, a patent is a documented result of an innovation that has gone all the way from an idea to implementation and possible application within a company to obtain specific benefits on market. Thus, since the 1970s, the number of patents a company has also become one of the indicators of a company's innovativeness, for example, in the empirical work "Patents and R&D at the Firm Level: a First Look"[Pakes A. and Griliches Z. ,1984]. The definition of a patent in Russian legislation was given in the previous section, as well as the enumeration of types of patents.

Since the various characteristics are mostly individual for the company, and are in the public domain. In general, research uses the more common measures for innovation. Therefore, by analyzing the number and the types of patents owned by a legal entity, one can assume the level of its innovativeness. At the same time, studies based on the number of patents also have a limitation. Many innovations are not eligible for a patent under Russian law, so the number of registered patents will always be somewhat less than the number of innovations in the company as a whole.

The second common metric is R&D expenditures, and this value also has its limitations. Thus, large expenditures on R&D may turn out to be ineffective, in this case, it can be only said about the company's desire to join innovations, and not about successful innovation activities.

## 1.2. CEO characteristics and interrelation with innovations

**The role of CEO in company innovativeness**

Business leaders say innovation is a key indicator of business success and performance. But there is a problem, which lies in the fact that many CEOs do not pay due attention to innovations in their companies, and engage in them only when it is really necessary due to changing market realities, the introduction of restrictions on the import or export of products and other factors that have an effect on the production cycles of the enterprise.

According to the How companies approach innovation study [McKinsey Global Survey, 2007], the slowdown in the process of innovation is due to the fact that CEOs who are primarily interested, do not help, are unwilling or afraid to take risks, and also have a hard time accepting new proposed projects. It also stands out as a problem that CEOs need results and numbers now in order to control all processes and make a minimum of mistakes in the research process.

However, the study says that if CEOs are willing to take responsibility for implementing innovation, the process will be much easier and the fear of making a mistake is reduced, since all decisions are made jointly with employees from different departments responsible for using this innovation.

In an interview with Forbes magazine "The new role of the CEO in innovation" on 02/25/2022, Jim Euchner, head of breakthrough innovation at Goodyear, Pitney Bowes and Verizon, say that the CEO must personally participate in innovation to avoid dangers and fears that create innovations. For an innovation to be viable, all participants in this process should only count on winning, despite possible financial losses during implementation. Jim Euchner divides the role of CEO into several roles. The first role is to get rid of the fears of innovation, the CEO must be sure that the new project meets the goals of the companies.

The second role of the CEO is to ensure that the innovation does not interfere with the existing culture of the parent business. And finally, the third role is that the head of the company must be sure that the new project will not cause problems with the existing business, that is, if it is a start-up, it will not be identical, and also will not create uncomfortable situations for the board of directors.

According to Jim Euchner, the most important role of the CEO among control, analysis and financing is to attract people to the top management of the company who are more inclined towards innovation, they have the time that the process of creating innovation requires, and who are very interested in this process.

**CEO characteristics influencing innovativeness**

The success of the company directly depends on the personality of the CEO. Great and long experience, understanding of the specifics of the market and the company's business area, indicate that the director is involved in the company's business processes. However, a long stay in the position of CEO can lead to a decrease in the adaptive and motivational characteristics of the leader. What characteristics of the CEO are significant for maintaining the innovativeness of the enterprise, many scientists and economists argue, and here are some of works considered.

Referring to the study [Kaplan et al, 2012] "Which CEO Characteristics and Abilities Matter?" professors from the University of Chicago Booth School of Business, a successful CEO must meet four characteristics:

1. The CEO must have basic knowledge in management and other management areas;
2. Fulfill the goal to the end;
3. Have the charisma to be able to convince people and lead them;
4. Be able to think strategically in order to control all the processes of the company.

Approximately the same conclusions were reached in the Harvard Business Review article “The CEO Next Door: What It Takes to Get to the Top and Succeed” [Elena Botelho, Kim Powell, 2018], the authors also point to charisma. They examined 316 directors and identified the following characteristics:

1. Know how to achieve your goals;
2. Be charismatic.

In his interview with Bgoal magazine, Dmitry Andreev, CEO of Creative Call Project, agrees with Kaplan, but he already highlights the following four characteristics:

1. Achieve results;
2. Build a system;
3. Generate new ideas and a unique selling proposition for products;
4. Inspire the team, be a leader.

In his study “Good to great: Why Some Companies Make the Leap and Others Don't” [Jim Collins, 1993], he concluded that CEOs should have two characteristics:

1. Firm determination;
2. Great modesty.

Also, the question of the qualitative characteristics of the CEO was investigated in the work "CEO charismatic leadership: Levels-of-management and levels-of-analysis effects" [Waldman, DA and FJ Yammarino, 1999]. The authors came to the following conclusions:

1. Get new knowledge and quickly master it and use it;
2. Personally participate in the processes to get the result;

3. Be very sociable.

The study [Borghans, et al, 2008] “The economics and psychology of personality traits” has already identified four key characteristics of a CEO:

1. The ability of the director as a whole;

2. Fulfillment of obligations and interpersonal skills;

3. Attractiveness and ability to think critically;

4. Look to the future and managerial qualities.

According to You Ya et all (2020), CEO personality characteristics that have an influence on innovativeness, should include overconfidence, sensation seeking, military background, and political ideology.

A study by Hui Jianga,b and Caiyun Liua (2020) shows that the education of CEOs, their studies and work experience abroad interact with the index of economic policy uncertainty, increasing firms' R&D expenditures.

A study by KwangJoo(KJ) Koo (2019) found that having a CEO of a firm with a background in the field in which the business operates is positively associated with an approximately 7 percent increase in patents compared to a CEO with no background in the field.

The was also a relevant study by Ricotta, F., Golikova, V., & Kuznetsov, B. (2021) that was exploring the role of CEO characteristics in firm innovative performance. Apart from classic demographical characteristics like age and gender, authors also take CEO status as family owner-manager in the research.

There are also scientific works in which only one significant characteristic of the CEO was revealed. Thus, the article “Military CEOs” [Benmelech and Frydman, 2015] indicates a significant characteristic as the fact of serving in the army. And in article "Life Cycle of a CEO Career" [M. Guenzel and U. Malmendier, 2005] the main factor influencing the emergence of innovation is already the CEO's self-confidence. In “Overconfidence and early-life experiences: The effects of managerial traits on corporate financial policies” [Malmendier et al., 2011] he points out as a significant characteristic as a director’s early life experience, and in the study “Shaped by Booms and Busts: How the Economy Impacts CEO Careers and Management Styles” [Schoar, Antoinette and Luo Zuo, 2017] in turn indicate the start date for the career path of the future CEO.

## 1.3. CEO characteristics and innovations in Russian public companies: hypotheses statement

Based on some assumptions from research papers that were studied., a list of hypotheses was formed that can be tested in this study. The hypotheses are grouped according to the types of CEO characteristics they apply to.

The first hypothesis is related to demographic indicator - age.

Most research [Bertrand and Shoar, 2003] suggests that the older a person is, the less willing they are to take risks. Older people, including CEOs, prefer more traditional and safer paths.

**H1**. **CEO age** negatively relates to the company innovativeness.

The next and the biggest group of hypotheses is associated with education. As it is discussed, any relevant education, that might help either in the industry or in the innovation process in general, is usually positively associated with the company innovativeness [Lin et al, 2011].

**H2**. Innovativeness of companies where CEO has received an e**ducation in the same field where the company works** is higher than innovativeness of companies where CEO is not educated in that field.

**H3**. Innovativeness of companies where CEO has received a **technical education** is higher than innovativeness of companies where CEO is not educated in that field.

**H4**. Innovativeness of companies where CEO has received a **managerial or economic education** is higher than innovativeness of companies where CEO is not educated in that field.

**H5**. Innovativeness of companies where CEO has received an **MBA degree** is higher than innovativeness of companies where CEO is does not have that degree.

**H6**. Innovativeness of companies where CEO has received a **PhD degree** is higher than innovativeness of companies where CEO is does not have that degree.

Some researchers believe that for developing innovations in the company the CEO should have a deep knowledge about the company [Waldman, DA and FJ Yammarino, 1999].

**H7**. Innovativeness of companies where CEO was **assigned from inside** of the company is higher than innovativeness of companies where CEO is assigned from outside of the company.

There is reason to believe that involving the CEO on other external boards of directors will reduce the amount of time that the CEO can spend managing his company and this will have a negative impact on innovation [Hui Jianga,b and Caiyun Liua, 2020].

**H8**. The number of **external boards** where CEO has a membership negatively relates to the company innovativeness.

As some authors believe, being involved in governmental structures can have a long-effect and make the person opened to innovations [Benmelech and Frydman, 2015].

**H9**. The number of years that CEO has been **working in governmental structures** positively relates to the company innovativeness.

# CHAPTER 2: EMPIRICAL STUDY ON RUSSIAN PUBLIC COMPANIES

## 1.4. Research methodology: regression model

As part of the preparation for an empirical study, one of the important steps is the choice of a research method for the study. In this case, to select a research method, studies describing and exploring similar relationships were studied. There are studies that examine the similar relationships through conducting an empirical study. One of the studies, that talks about CEO research orientation, organizational context, and innovation uses regression model to determine the relationship between concepts [Wal, N. et al., 2020]. In that study dependent variable is the number of patent applications, to show the innovation outcome, independent variables are CEO characteristics, control variables are the firm age and the ratio between company's assets and liabilities. Other study [Koo, K., 2019], that provides an empirical study on relationship between CEO's human capital and innovations, also uses regression model as a basis for the research. In this study the author strengthens the fact that different industries are initially predisposed to innovation in different ways - for some industries this is typical, for others it is not, therefore, as control variables, it also introduces dummy variables characterizing the affiliation of companies to the industry.

Based on the reviewed works, regression, or rather, panel regression, was chosen as a research method, which allows to analyze the observation for each of the companies over a certain period of time.

The dependent variables are chosen to measure the company innovativeness. They are R&D expenditures and the number of new patents obtained in a chosen year.

***Table 2.*** Dependent variables: innovativeness measures

| Variable | Description |
|---|---|
| **randd** | A discrete variable that indicates the R&D expenditures of the company i for the period t. |
| **patents** | A discrete variable that indicates the number of new patents that were obtained by a company i during the period t. |

One of the reasons for choosing these indicators for measuring a company's innovativeness is that one of the indicators is an input parameter of innovativeness, measuring the interest of companies in the innovation process, how much material resources have been invested in the process of innovation activity itself, while the second indicator is an output parameter of innovation, reflecting the direct result of innovation. activities - a registered right to own a new

product, technology, etc., in accordance with the patent law of the Russian Federation. Also, it was data on these indicators of innovation that could be collected for Russian companies from open sources, since these are standardized measurements.

Independent variables are the characteristics of the CEO, that potentially are interrelated with the company innovativeness. The characteristics of the CEO were chosen in such a way that the hypotheses listed earlier could be explored. For each of the hypotheses, there are one or more independent variables that will help establish the relationship between specific characteristics of the CEO and the innovativeness of companies. These are the main relationships that will be studied.

***Table 3.*** Independent variables: CEO characteristics

| Variable | Description |
|---|---|
| **ceoage** | A discrete variable that indicates the age of the CEO of company i at the end of the time period t. Calculated as the period t minus the year of the CEO birth |
| **sex** | A dummy variable that indicates the sex of the CEO of the company i at a time period t. 1 – female, 0 – male. |
| **tenure** | A discrete variable that indicates the number of years that CEO is in the position of CEO of a company i at the end of the period t. Calculated as the period t minus the year when CEO was assigned (if CEO is the first time CEO of the company)/ |
| **reled** | A dummy variable that indicates whether CEO of company i has a relevant education, that corresponds with the industry of company i. 1 – education is related to the industry, 0 –education is not related to the industry. |
| **ited** | A dummy variable that indicates whether CEO of company i has a technical or IT education. 1 – has, 0 – does not have |
| **maneced** | A dummy variable that indicates whether CEO of company i has a management or economical education. 1 – has, 0 – does not have |
| **mba** | A dummy variable that indicates whether CEO of company i has an MBA degree. 1 – has, 0 – does not have |
| **doced** | A dummy variable that indicates whether CEO of company i has a PhD degree. 1 – has, 0 – does not have |

| Variable | Description |
|---|---|
| **insider** | A dummy variable that indicates whether CEO was assigned on the position after working in the company for some time, or assigned from outside of the company. 1- from inside, 0 – from outside. |
| **indtenure** | A discrete variable that indicates the number of years of the experience in the industry of company i that CEO has. Calculated as the sum of years CEO has been working in the industry. |
| **shares** | A discrete variable that indicates the percentage of shares of company i that CEO possesses at the period t. |
| **exboards** | A discrete variable that indicates how many memberships in other board of directors CEO has, excluding the company i, at the period t. |
| **govtenure** | A discrete variable that indicates the number of years that CEO was working in governmental structures. Calculated as the sum of years CEO has been working in the positions. |
| **govcont** | A dummy variable that indicates whether CEO is related to a top politician or governmental worker through friends or family members. 1 – is related, 0 – not related |

There are also control variables used, to make the model more relevant. In this case, the revenue of the company and its age are the control variables, that can reflect the size of the company and the experience. The other studies that were listed at the beginning of Chapter 2 when choosing a research method also used similar control variables, suggesting that they are inherently related to the dependent variables and should be included in the model.

***Table 4.*** Control variables

| Variable | Description |
|---|---|
| **revenue** | A discrete variable that indicates the revenue of company i at the end of the time period t, in rubles. |
| **compage** | A discrete variable that indicates the number of years that the company i is existing. Calculated as the period t minus the year of company establishment. |
| **miningmetals** | A dummy variable that indicates whether company is related to Mining and Metals industry. 1 – is related, 0 – not related |

| Variable | Description |
|---|---|
| **energy** | A dummy variable that indicates whether company is related to Energy industry. 1 – is related, 0 – not related |

There are two models of regression that will be used. Models will be separately built for each of the dependent variables in order to separately assess the relationship of the characteristics of the CEO with the input and output parameters of innovation. In addition to the need to separately evaluate the models, there is a slight difference in the models themselves.

For the dependent variable – R&D expenditures the following model will be used:

$$y_i = \alpha + \beta_1 CEO_i + \beta_2 contol\_variable_i + \varepsilon_i$$

Where $y_i$ is dependent variable;

$\alpha$ is an unknown scalar quantity;

$CEO_i, contol\_variable_i$-they are independent variables and control variables;

$\beta$ – coefficients of regression;

and $\varepsilon_i$- random error.

For the second dependent variable – Number of patents – there will be a similar model, but with a time lag of 1 year, as in most cases the decisions of CEO cannot immediately convert into patents – there is time needed to work on the innovation, develop it and register a patent.

$$y_i = \alpha + \beta_1 CEO_{i-lag} + \beta_2 contol\_variable_{i-lag} + \varepsilon_i$$

Where $y_i$ is dependent variable;

$\alpha$ is an unknown scalar quantity;

$CEO_i, contol\_variable_i$-they are independent variables and control variables;

$\beta$ – coefficients of regression;

Lag=1;

and $\varepsilon_i$- random error.

For each of the regression models there are three models to be made:

- Pooled Regression Model - this is a conventional linear regression model, it is considered that the dependent variable is linearly dependent on all variables at the same time;
- Fixed Effects Model - within the framework of this approach, the individual features of each object are considered as parameters unknown to the researcher, individual effects are correlated with the explanatory variables included in the model, the effects are interpreted as an interfering parameter and the evaluation aims to eliminate them;

- Random Effects Model - individual differences are random, errors in the random effects model are heteroscedastic.

There are appropriate tests to choose the best model for each of the pairs.

All three tests are evaluated relative to the level of significance, in this case 0.05. If the test score exceeds the significance level, then the null hypothesis is accepted; if below the significance level, then the alternative hypothesis is accepted. The hypotheses for each test are given below.

F-test serves for comparison of Pooled Regression Model and Fixed Effects Model.

H0: Pooled Regression Model is more preferrable.

H1: Fixed Effects Model is more preferrable.

Breusch - Pagan Lagrangian multiplier test serves for comparison of Pooled Regression Model and Random Effects Model.

H0: Pooled Regression Model is more preferrable.

H1: Random Effects Model is more preferrable.

Hausman specification test serves for comparison of Random Effects Model and Fixed Effects Model.

H0: Random Effects Model is more preferrable.

H1: Fixed Effects Model is more preferrable.

## 1.5. Data and sample description

The companies included in the broad market index of the Moscow Exchange were taken for the study.[1] This index includes a list of 100 securities rated as shares with the highest capitalization and liquidity, as well as the assessment is made on the proportion of shares in free float. This index displays a balanced assessment of the market, including companies from different sectors of the economy.

Thus, the corresponding list of companies was taken from the list of 100 securities. Financial organizations such as banks and investment companies were excluded from the list of companies. Also, those for which it was not possible to find the data necessary for the study were excluded from the list of companies, for example, for this reason, Polymetal International plc and Ozon Holdings Plc were excluded from the list of companies under study.

The final list for the study included 61 companies, the full list of the studied companies can be found in the appendix 1. Most of the companies are oil and gas companies, energy companies, mining and metal companies. Other industries are present in the sample, but in a smaller proportion. The industry distribution can be seen in the Figure below.

[1] Broad Market Index RUBMI. Moscow Exchange. Retrieved May 10, 2022, from https://www.moex.com/en/index/RUBMI

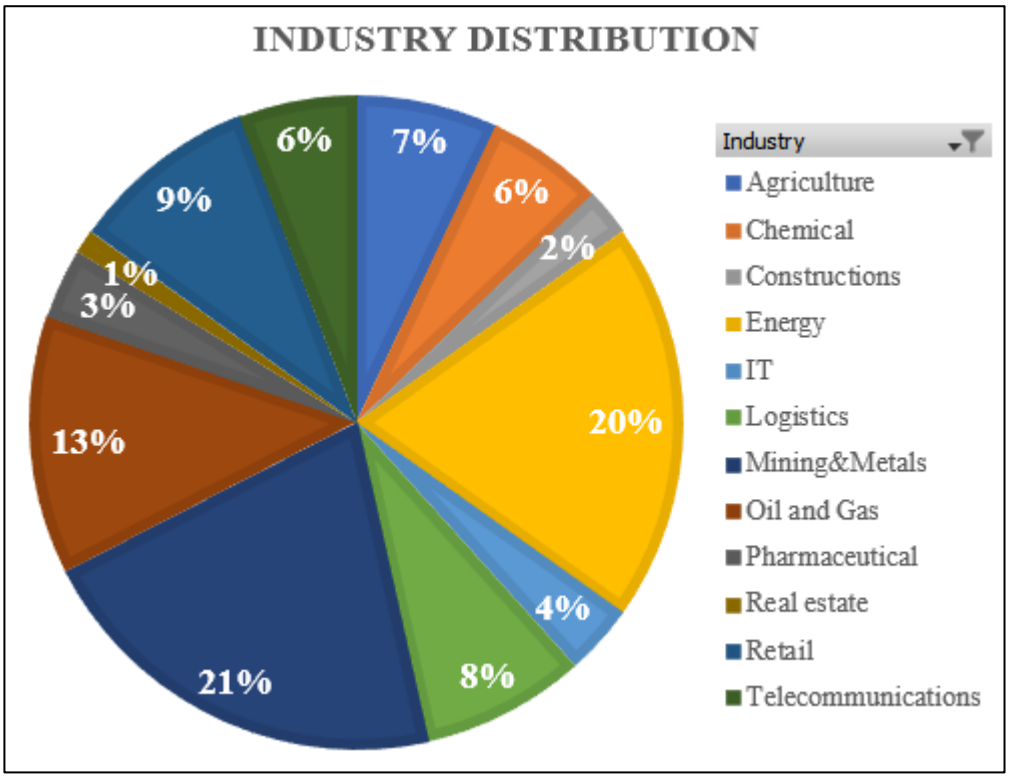


***Fig. 3.*** *Industry distribution in the data sample*

It is important for research to use the most up-to-date data in terms of time. However, it must be understood that some periods are not suitable for consideration. So, if 2020 and 2021 years were considered, the results of the study could be very distorted due to many external factors, such as coronavirus, changes in supply chain logistics, an unstable situation and various restrictions, frequent changes in company management and the disappearance of some companies in principle. In this regard, the time period from 2015 to 2019 inclusive was taken for the study. This period makes it possible to identify the dependences that are most relevant to reality, without taking into account the influence of uncertain external factors that are not directly related to the subject of the study.

Data on R&D expenditures were taken from the companies' annual financial statements under the Russian accounting system, namely, line 1120 of the balance sheet reflects the costs of research and development (R&D) as of December 31 of the reporting year. This line is called "Research and Development Results" and it refers to non-current assets.

Data on the number of patents was taken from other issuer reports. For example, in the quarterly reports of companies, especially for the third quarter, the section "Information on the financial and economic activities of the issuer" contains the item "Information on the policy and expenses of the issuer in the field of scientific and technological development, in relation to licenses and patents, new developments and research." In addition to a general description of the company's policy in the field of development, this paragraph listed all patents held by the company

for the year of the report, indicating the date of registration of the patent or the period of validity, with a typical period of validity of 20 years.

Also, the quarterly report of the issuers contains general information about the CEO: last name, first name and patronymic, year of birth, work experience and membership in the boards of directors over the past 5 years, for the share of the company's shares owned by the CEO.

The rest of the data related to the experience of the CEO and his education were taken from open sources. Due to the fact that the list of the studied companies mainly included the largest Russian public companies, the CEOs of these companies are public figures, and information about them, their biography is actively published in the press. Often, all information about the CEO can be found on one of the pages of the company's official website.

After collecting and sorting the data, descriptive statistics were made in Stata for this sample. Descriptive statistics showed that the range of values for two variables significantly exceeded the range for other variables. As a result, in order to bring the data to a normal distribution, the natural logarithm was taken for the dependent variable "R&D costs" and for the control variable "Revenue", the variables were recorded in Stata as new variables ln rd and ln revenue, below are updated descriptive statistics. It should be mentioned, that all the revenue observations are more than zero, but there are randd variable observations, that are equal to zero. As it is not possible to take natural logarithm from zero, there was taken natural logarithm from “randd+1”. In this case, if randd is zero, then a natural logarithm from 1 can be taken, and will be equal to zero as well.

Descriptive statistics were then compiled for all variables. The table below shows the arithmetic mean, maximum and minimum values for each variable. It is worth highlighting several values. Firstly, the average age of CEOs is 49 years old, while the sample includes both young CEOs from 31 years old and people over the age of 70 years. Such a spread in age is interesting for research, since there are conflicting opinions about the relationship between the age of the CEO and the innovativeness of the company.

Further, it should be noted that there are practically no female CEOs in the sample. This sample reflects the reality of the Russian market well - the main management positions are dominated by men, especially in industries that dominate in this study - energy, mining, metallurgy and oil and gas.

In the sample under consideration, there are CEOs with different experience in the position of CEO in the same company - from 1 year to 26 years. Also, some general directors have experience in government structures, the arithmetic average for this variable is a little more than 5 years.

***Table 5.*** Descriptive Statistics

**Descriptive Statistics**

| Variable | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|
| year | 2017 | 1.415 | 2015 | 2019 |
| randd | 2.508e+08 | 8.830e+08 | 0 | 8.950e+09 |
| patents | 7.314 | 31.104 | 0 | 299 |
| compage | 41.635 | 37.997 | 0 | 139 |
| revenue | 5.885e+11 | 4.570e+12 | 85000 | 7.395e+13 |
| ceoage | 49.439 | 8.749 | 31 | 72 |
| sex | .018 | .135 | 0 | 1 |
| tenure | 5.952 | 5.346 | 1 | 26 |
| reled | .454 | .499 | 0 | 1 |
| ited | .465 | .5 | 0 | 1 |
| maneced | .616 | .487 | 0 | 1 |
| mba | .166 | .373 | 0 | 1 |
| doced | .018 | .135 | 0 | 1 |
| insider | .768 | .423 | 0 | 1 |
| indtenure | 18.598 | 10.565 | 0 | 48 |
| shares | 4.423 | 13.87 | 0 | 74.59 |
| exboards | 3.03 | 3.651 | 0 | 22 |
| govtenure | 5.052 | 7.645 | 0 | 36 |
| govcont | .531 | .5 | 0 | 1 |
| miningmetals | .203 | .403 | 0 | 1 |
| energy | .185 | .389 | 0 | 1 |
| company | 28.148 | 16.497 | 1 | 59 |
| ln rd | 7.315 | 9.18 | 0 | 22.915 |
| ln revenue | 24.087 | 3.338 | 11.35 | 31.934 |

As for the variables that describe the presence or absence of a certain level or bias of education in the CEO, the arithmetic mean of the data of binary variables can be used to determine what education the majority of the CEOs from the sample have. So, about half of CEOs have education related to the industry where the company operates. Also, about half of CEOs have an education related to technical skills - these include specialties such as mathematics, programming, etc. In more than half of the observed cases, CEOs have an education related to economics or management. Looking at specific degrees of education, a very small proportion of CEOs have an MBA, and literally a handful have received a Ph.D.

The vast majority of CEOs worked in the same company in other positions, and were appointed from within the company. Also, not all CEOs own ordinary shares of the companies they manage. The average is just under 5%. Also, some of the CEOs are employed on other boards of directors not related to the company. Basically, most have 2-4 external memberships. It is also worth noting that more than half of the CEOs in the sample have connections with high-ranking civil servants and politicians.

Next, an outlier's test was carried out. Since most of the variables are binary, and the other part has a small spread, special attention was paid to the logarithmic variables of revenue and R&D costs, as well as a variable indicating the share of the company's shares owned by the CEO. As it can be seen in the picture, most of the observation points that go beyond the boundaries are

crowded, and can be taken into the model as valid data. The only outlier excluded is the high value for the shares variable, as this value is very different from the mean and can make the results less realistic. As a result, two observations were removed for one of the companies.

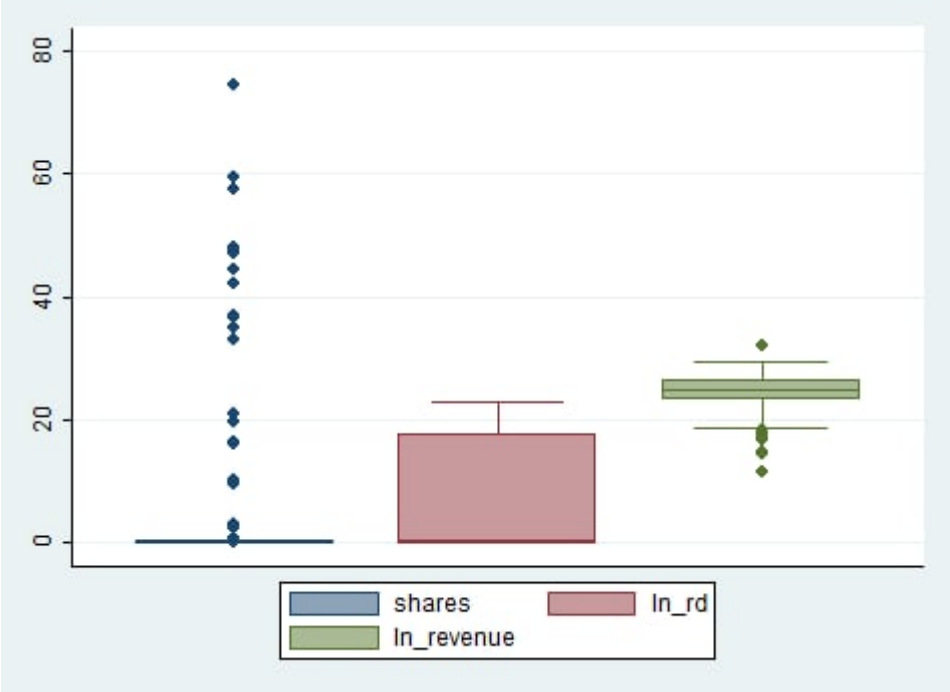


***Fig. 4.*** *Boxplot check for outliers*

Next, a correlation matrix was built to check how the variables are related to each other. An asterisk indicates correlation coefficients with a significance level of 0.1. There are no coefficients with a significance level of 0.05 and 0.01, all coefficients are below 0.75, which means that there is no strong correlation. Some of the variables are related, at least because of what years/experience means, or because of binary variables that take values of 0 and 1. Thus, some correlation is justified, and all of these variables can be included in the model.

***Table 6.*** Pairwise correlations (1)

| Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| (1) ln_rd | 1.000 | | | | | | | |
| (2) ceoage | 0.137* | 1.000 | | | | | | |
| (3) sex | -0.111 | -0.161* | 1.000 | | | | | |
| (4) tenure | -0.078 | 0.285* | -0.097 | 1.000 | | | | |
| (5) reled | -0.114 | 0.322* | -0.071 | 0.093 | 1.000 | | | |
| (6) ited | 0.199* | 0.423* | -0.129* | 0.199* | 0.380* | 1.000 | | |
| (7) maneced | 0.014 | -0.486* | 0.053 | -0.011 | -0.329* | -0.433* | 1.000 | |
| (8) mba | -0.176* | -0.255* | -0.062 | 0.204* | -0.012 | -0.121* | 0.254* | 1.000 |
| (9) doced | -0.111 | -0.054 | -0.019 | -0.025 | -0.126* | -0.129* | 0.109 | -0.062 |
| (10) insider | -0.060 | -0.001 | -0.184* | 0.162* | 0.155* | -0.079 | 0.228* | 0.060 |
| (11) shares | -0.243* | -0.097 | -0.043 | 0.363* | -0.113 | -0.176* | 0.134* | 0.169* |
| (12) exboards | 0.040 | -0.206* | -0.100 | 0.050 | -0.029 | -0.054 | 0.216* | 0.133* |
| (13) govtenure | 0.326* | 0.336* | -0.091 | 0.245* | 0.144* | 0.163* | 0.093 | -0.194* |
| (14) govcont | 0.381* | 0.153* | -0.146* | 0.127* | 0.016 | 0.082 | 0.060 | -0.115 |
| (15) compage | 0.000 | -0.076 | -0.127* | -0.219* | 0.134* | 0.002 | -0.019 | 0.098 |
| (16) ln_revenue | 0.536* | 0.246* | 0.052 | -0.136* | -0.175* | 0.234* | -0.070 | -0.335* |
| (17) miningmetals | 0.211* | -0.185* | -0.070 | -0.119 | -0.095 | 0.078 | 0.213* | 0.143* |
| (18) energy | 0.117 | -0.149* | -0.066 | -0.223* | -0.208* | -0.123* | 0.124* | -0.009 |

***Table 7.*** Pairwise correlations (2)

| Variables | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) |
|---|---|---|---|---|---|---|---|---|---|
| (1) ln_rd | | | | | | | | | |
| (2) ceoage | | | | | | | | | |
| (3) sex | | | | | | | | | |
| (4) tenure | | | | | | | | | |
| (5) reled | | | | | | | | | |
| (6) ited | | | | | | | | | |
| (7) maneced | | | | | | | | | |
| (8) mba | | | | | | | | | |
| (9) doced | 1.000 | | | | | | | | |
| (10) insider | 0.076 | 1.000 | | | | | | | |
| (11) shares | 0.569* | 0.050 | 1.000 | | | | | | |
| (12) exboards | -0.055 | 0.145* | -0.075 | 1.000 | | | | | |
| (13) govtenure | 0.017 | 0.041 | -0.121* | 0.159* | 1.000 | | | | |
| (14) govcont | 0.130* | 0.145* | 0.022 | -0.052 | 0.566* | 1.000 | | | |
| (15) compage | -0.064 | 0.014 | -0.144* | 0.109 | -0.127* | -0.129* | 1.000 | | |
| (16) ln_revenue | -0.030 | -0.136* | -0.353* | -0.104 | 0.279* | 0.283* | -0.008 | 1.000 | |
| (17) miningmetals | -0.070 | -0.046 | -0.033 | 0.079 | -0.137* | -0.074 | 0.168* | -0.078 | 1.000 |
| (18) energy | -0.066 | -0.074 | -0.149* | -0.067 | -0.089 | -0.046 | 0.046 | 0.161* | -0.242* |

*** *p<0.01, ** p<0.05, * p<0.1*

This completes the description and preparation of the data, and there is everything needed to conduct an empirical study. It is worth highlighting this stage, that data collection turned out to be the most difficult and labor-intensive stage of work, which took a long period of time. Since some data differed from source to source, an additional check was made for questionable values to ensure that the final results were as reliable as possible.

## 1.6. Empirical results

For each of the models, for R&D expenditures and for the number of patents, three models were built on the panel data: Pooled Regression Model, Fixed Effects Model and Random Effects Model. For both situations, according to the F-test, Fixed Effects Model was better than Pooled Regression Model, and according to the Breusch-Pagan Lagrange Multiplier Test Random Effects Model is better than Pooled Regression Model. The final choice was made with assistance of the Hausman Specification Test, that has shown that the Random Effects Model is more preferable than Fixed Effects Model. So here are the two Random Effects regression models. Other models and tests can be seen in appendix. It should also be noted that when building models in Stata, the robust statistics option was chosen so that the models are robust to possible outliers, and also that disparate data collected from real companies that cannot create ideal conditions do not affect the reliability of the model and the validation of results. Also, for both models VIF is less than 10, so there is no multicollinearity.

First, consider the model that was built for the dependent variable R&D expenditures. Among the coefficients for independent variables, several significant ones came out.

CEO age - the ceoage variable has a positive coefficient, that is, the older the CEO, the more the CEO spends on R&D. This coefficient is significant at the lowest significance level of 0.01, but nevertheless can be taken as a relatively significant result.

Also, at a significance level of 0.01, the coefficient -0.145 is significant for the variable govcont. Thus, the fact that the CEO has connections among high-ranking officials negatively affects the amount of R&D spending.

Next come the coefficients with a higher significance level, at a significance level of 0.05 - a significant coefficient for the mba variable and at a significance level of 0.01 a significant coefficient for the doced variable. It should be noted that both coefficients are negative. For example, a CEO with an MBA and/or a PhD spends less on R&D than a CEO without an MBA and/or a PhD.

As well, among the independent variables, a significant coefficient at the level of 0.05 was obtained for the govtenure variable. The coefficient is positive, so a CEO with more government experience spends more on R&D. It does not correspond with the result for the govcont variable, but firstly, these variables are not correlated, so working in governmental structures does not mean that the CEO does know a high-positioned politician, secondly, the level of significance for govcont variable is much less than for the govtenure variable.

***Table 8.*** Regression results – for R&D expenditures

| ln_rd | Coef. | St.Err. | t-value | p-value | [95% Conf | Interval] | Sig |
|---|---|---|---|---|---|---|---|
| ceoage | .054 | .033 | 1.66 | .097 | -.01 | .118 | * |
| sex | .382 | 1.435 | 0.27 | .79 | -2.431 | 3.195 | |
| tenure | .025 | .086 | 0.29 | .77 | -.144 | .195 | |
| reled | .379 | .682 | 0.56 | .579 | -.959 | 1.716 | |
| ited | -.992 | .729 | -1.36 | .174 | -2.421 | .437 | |
| maneced | .564 | .372 | 1.52 | .129 | -.165 | 1.292 | |
| mba | -1.213 | .998 | -1.22 | .048 | -3.169 | .743 | ** |
| doced | -4.984 | 1.633 | -3.05 | .002 | -8.186 | -1.782 | *** |
| insider | .282 | .687 | 0.41 | .682 | -1.064 | 1.628 | |
| shares | -.012 | .009 | -1.39 | .166 | -.03 | .005 | |
| exboards | .044 | .046 | 0.97 | .33 | -.045 | .134 | |
| govtenure | .115 | .053 | 2.15 | .031 | .01 | .22 | ** |
| govcont | -.145 | .308 | -0.47 | .078 | -.749 | .46 | * |
| compage | -.008 | .028 | -0.28 | .776 | -.063 | .047 | |
| ln_revenue | .302 | .18 | 1.68 | .093 | -.051 | .655 | * |
| miningmetals | 6.813 | 2.696 | 2.53 | .011 | 1.529 | 12.097 | ** |
| energy | 5.74 | 2.793 | 2.06 | .04 | .266 | 11.213 | ** |
| Constant | -5.271 | 4.761 | -1.11 | .268 | -14.602 | 4.06 | |

| | | | |
|---|---|---|---|
| Mean dependent var | 7.369 | SD dependent var | 9.192 |
| Overall r-squared | 0.257 | Number of obs | 298 |
| Chi-square | 76.952 | Prob > chi2 | 0.000 |
| R-squared within | 0.022 | R-squared between | 0.276 |

**** p<.01, ** p<.05, * p<.1*

Next, consider the second model, for the number of patents. Here, the dependent variable is taken without a lag, and all independent and control variables are taken with a lag of one year.

There are fewer significant coefficients in this model, and there are no coefficients significant at the level of 0.01.

The coefficients for two variables mba and doced, indicating the presence/absence of an MBA or doctoral degree in the CEO, are significant at the level of 0.01. This level of significance is less than in the previous model, however, the coefficients also have a negative value, that is, a CEO without an MBA and a PhD tends to register more patents, and vice versa.

At a significance level of 0.05, the coefficients for the variables insider and govtenure were significant in the model. In both cases, the coefficients are positive, which means that a CEO hired from within the company and/or with government experience achieves a greater number of registered patents for the company.

***Table 9.*** Regression results – for the number of patents

| patents | Coef. | St.Err. | t-value | p-value | [95% Conf | Interval] | Sig |
|---|---|---|---|---|---|---|---|
| ceoage | .106 | .09 | 1.18 | .237 | -.07 | .282 | |
| sex | 1.665 | 3.508 | 0.47 | .635 | -5.21 | 8.541 | |
| tenure | -.151 | .221 | -0.68 | .495 | -.583 | .282 | |
| reled | 1.388 | 2.394 | 0.58 | .562 | -3.304 | 6.081 | |
| ited | -.433 | 2.155 | -0.20 | .841 | -4.658 | 3.791 | |
| maneced | -.337 | 2.07 | -0.16 | .871 | -4.393 | 3.719 | |
| mba | -.95 | 2.34 | -0.41 | .085 | -5.536 | 3.635 | * |
| doced | -12.641 | 7.587 | -1.67 | .096 | -27.511 | 2.228 | * |
| insider | 2.737 | 1.369 | 2.00 | .046 | .054 | 5.42 | ** |
| shares | .067 | .052 | 1.29 | .198 | -.035 | .169 | |
| exboards | -.205 | .195 | -1.06 | .291 | -.587 | .176 | |
| govtenure | .192 | .213 | 0.90 | .047 | -.225 | .609 | ** |
| govcont | 2.251 | 1.904 | 1.18 | .237 | -1.48 | 5.983 | |
| compage | .055 | .08 | 0.69 | .493 | -.102 | .212 | |
| ln_revenue | .787 | .705 | 1.12 | .264 | -.593 | 2.168 | |
| miningmetals | -4.589 | 8.227 | -0.56 | .577 | -20.714 | 11.537 | |
| energy | -5.692 | 9.722 | -0.59 | .558 | -24.747 | 13.363 | |
| Constant | -20.479 | 13.22 | -1.55 | .121 | -46.39 | 5.432 | |

| | | | |
|---|---|---|---|
| Mean dependent var | 7.100 | SD dependent var | 28.673 |
| Overall r-squared | 0.103 | Number of obs | 238 |
| Chi-square | 12.428 | Prob > chi2 | 0.774 |
| R-squared within | 0.011 | R-squared between | 0.105 |

**** p<.01, ** p<.05, * p<.1*

Thus, both models gave similar results - significant coefficients were found, first of all, for variables characterizing the presence or absence of an MBA degree and a doctoral degree in the CEO, as well as for variables characterizing the experience of the CEO in government structures.

There is also a difference in the results - the first model indicated the relative importance of the coefficients for variables characterizing the age of the CEO and the presence of ties, while the second model highlights the coefficient for the insider variable.

## 1.7. Research results: findings and discussions

In this section, research returns to the hypotheses listed in the first chapter. In order to be able to draw a complete conclusion about each of the hypotheses, a table is formed below that compares the result of the two models. If the coefficient of the variable was not significant at least at the level of 0.01, then there is no way to either reject the hypothesis or accept the hypothesis. Otherwise, depending on the positive or negative value of the significant coefficient, the hypothesis is rejected or accepted.

***Table 10.*** Hypothesis evaluation

| Hypothesis | R&D expenditures model | Number of patents model |
|---|---|---|
| H1. CEO age negatively relates to the company innovativeness. | Rejected | Cannot be accepted or rejected |
| H2. Innovativeness of companies where CEO has received an education in the same field where the company works is higher than innovativeness of companies where CEO is not educated in that field. | Cannot be accepted or rejected | Cannot be accepted or rejected |
| H3. Innovativeness of companies where CEO has received a technical education is higher than innovativeness of companies where CEO is not educated in that field. | Cannot be accepted or rejected | Cannot be accepted or rejected |
| H4. Innovativeness of companies where CEO has received a managerial or economic education is higher than innovativeness of companies where CEO is not educated in that field. | Cannot be accepted or rejected | Cannot be accepted or rejected |
| H5. Innovativeness of companies where CEO has received an MBA degree is higher than innovativeness of companies where CEO is does not have that degree. | Rejected | Rejected |
| H6. Innovativeness of companies where CEO has received a PhD degree is higher than innovativeness of companies where CEO is does not have that degree. | Rejected | Rejected |

| Hypothesis | R&D expenditures model | Number of patents model |
|---|---|---|
| H7. Innovativeness of companies where CEO was assigned from inside of the company is higher than innovativeness of companies where CEO is assigned from outside of the company. | Cannot be accepted or rejected | Accepted |
| H8. The number of external boards where CEO has a membership negatively relates to the company innovativeness. | Cannot be accepted or rejected | Cannot be accepted or rejected |
| H9. The number of years that CEO has been working in governmental structures positively relates to the company innovativeness. | Accepted | Accepted |

Summing up the consideration of the table, it should be noted that many hypotheses can neither be accepted nor rejected. At the same time, in terms of hypotheses, the final result for the two models coincided. These results are the most reliable. If we take results that differ from model to model, then the results of the second model, in terms of the number of patents, should be given priority. The number of patents is a direct result of innovation, which is success, while R&D spending may not always be prudent and efficient, and therefore the first model should not be considered separately.

Thus, as a result, hypotheses 5 and 6 are rejected, and hypotheses 7 and 9 are accepted.

The reason why hypotheses 5 and 6 were rejected may be that obtaining an MBA or a PhD is more of an academic process built traditionally, while for an innovation orientation, practice-only training would be better suited. Moreover, perhaps the time spent on obtaining degrees could be successfully spent in direct practice in the company and in the implementation and development of innovations.

The fact that hypothesis 9 was accepted may be due to the fact that work in government structures is associated with constant changes in rules and legislation, and employees must be able and willing to quickly reorient themselves to new conditions.

## 1.8. Managerial implications

The practical contribution can potentially be divided into two conditional parts: firstly, this is a practical application for companies (for those, who choose the CEO – boards of directors,

investors, other shareholders and recruiters), and secondly, a practical contribution for people applying for the position of CEO.

As mentioned earlier in the literature review, it is important for a company these days to be innovative, as it is directly related to the company's competitiveness. The person who is responsible for making innovative strategies and investment decisions is the CEO of the company. In the course of this research, it was investigated, which characteristics of the CEO positively or negatively affect the company's innovativeness, and these findings can help many companies when choosing a CEO in the future.

So, if a company intends to conduct and expand innovative activities, if innovation is a part of the company's strategy, then the results of this study can be used to appoint a CEO that meets the company's plans and strategy. In the course of the study, it was collectively determined that the CEO, whose characteristics will positively influence the innovativeness of the company, should preferably be:

1) Without an MBA degree;

2) Without PhD;

3) Must be hired from within the company;

4) Must have experience of work in governmental structures.

At the same time, it must be emphasized that no clear relationship between the age, gender of the CEO and the innovativeness of the company has been established. In this regard, when choosing a person for the position of CEO, there should not be paid attention to the demographic characteristics of the candidate. First of all, it is necessary to pay attention to the experience of the candidate. Perhaps in the future, when selecting CEOs, there will be more equity between young candidates and older candidates, as well as between female and male candidates.

The results of the study are rather applicable to larger companies that seek to increase their competitiveness in the Russian and international markets, and which are currently not satisfied with the level of innovation of the company. Since such a study has not been conducted in Russia before, the results will be unique and useful for practical application.

There is also a practical application for people who apply for the position of CEO. There are many stereotypes in the world that can create inequality between candidates. The results of this study show a real relationship, and perhaps can solve the problem of some inequality between candidates applying for the position of CEO.

Based on the study, it can be said that if a person in the future would like to take the position of CEO of a large company, then first of all, a person should focus on gaining experience in government agencies, as well as in an interested company. This will come in handy to get to know the inside of the company and be more aware of the processes, products, successes and problems

of the company. At the same time, candidates should not put too much emphasis on studying, because earning a PhD or an MBA won't directly make a candidate more suitable for a CEO position in a company that is focused on innovation.

## 1.9. Limitations and further research

This study has a number of limitations that should be noted:

- **Measurement of innovation.**

  As discussed in the first chapter, there are many indicators that characterize innovation. Only two of the possible indicators were selected for this study. If you take other indicators, then the results may differ. For example, as an output parameter, you can take not the number of registered patents, but the number of patent applications filed. Or take another indicator that will take into account some type of innovation, for example, the number of technology startups acquired. In the case of a study on the Russian market, one may encounter the problem of closed and inaccessible data, and therefore this study was limited in the choice of measures of innovation.

- **Availability and reliability of data**.

  Data regarding the characteristics of CEOs was taken from open sources. In addition to objective data such as gender, year of birth, percentage of shares owned, there were also data regarding education, work experience and connections. The published data could be incomplete or out of date - some CEOs may have received additional education, but the company's website and news sources will not necessarily contain accurate and timely information about this. Also, in terms of assessing the presence of ties with high-ranking politicians and civil servants, even family ties are not always exposed openly, and if we are talking about friendly ties, then such ties can be even more difficult to detect and evaluate. In this study, every possible effort has been made to collect complete and reliable information, but the author does not deny that any facts about the characteristics of CEOs could be distorted.

- **Industry specific.**

  This study is based on companies in the broad market index. The index includes companies representing all the main sectors of the Russian market, respectively, this study presents a picture and dependencies in the whole Russian market, without taking into account the attitude of companies to specific industries. Accordingly, when applying the results of this study to any particular industry, the results should be critically considered and discussed, and then informed decisions should be made, adjusted for the company's industry. For some companies, such as energy, telecommunications, mining, IT companies, innovation is more common. In industries such as retail, innovation is either less developed or has a different manifestation -

in retail, it is more likely to register trademarks than patents. So, for a deeper analysis, separate studies should be done for each of the major sectors of the Russian market. For each industry, you should collect your own sample of at least 30-50 companies, determine your own measurements of innovation for each of the industries and conduct research.

- **The size of the companies under study.**

  Mainly the largest Russian public companies were considered. On the one hand, the experience of large companies can be a good example for medium-sized companies, because the innovation created can serve as an impetus for the company to move from a number of medium-sized businesses to a number of large Russian businesses. On the other hand, large companies can afford to spend a large percentage of their revenue on R&D and spend organizational resources on creating and filing patents, while midsize companies may need to focus on other more important issues and cannot afford to spend resources companies for research and development. In one of the future studies, it would be useful to study only medium-sized companies separately, and then compare with the results of this study - conclusions and recommendations may be different. Here, again, the question of data availability will arise. In this case, part of the data will have to be obtained through communication with CEOs and companies, and the data, returning to the second paragraph of the restrictions, may be transmitted incompletely and distorted.

- **Research period.**

  As mentioned earlier, in order to obtain averaged data for the Russian market without taking into account the influence of external unforeseen circumstances, in this study data were taken for years that were not affected by a pronounced crisis or other events. At the same time as this study was nearing completion, it became clear that 2020-2021 was only the beginning of a temporary period of uncertainty, and various uncharacteristic changes will occur in the Russian economy and society in the coming years. In such conditions of uncertainty, it is difficult to determine relationships, as well as to properly use the results of previous studies.

# CONCLUSION

Within the framework of this study, all the tasks set were completed:

1) A review of the literature was made, during which various interpretations of innovation and related concepts were studied, the role of the CEO in innovation was highlighted, and the characteristics of the CEO that affect innovation according to various authors were highlighted. A review of the Russian market from the point of view of innovations was also made.

2) Based on the literature review, hypotheses were formulated for further empirical research.

3) Data were collected on R&D spending, number of patents, and characteristics of CEOs for 61 Russian public companies, the data was structured as panel data for 5 years, and was prepared for empirical research.

4) Panel regression was chosen as the main research method, and the features of several regression models are also separately prescribed. As a result of the empirical study, two models of random effects were selected and presented.

5) The results of the empirical study were interpreted, the hypotheses were evaluated, and based on the results of the study, conclusions were drawn for practical application both from the point of view of the board of directors, investors, shareholders, and from the point of view of potential candidates for the post of CEO.

With the help of the completed research tasks, the main goal of the research was also achieved - the relationship between the characteristics of the CEO in Russian public companies and the innovativeness of the company in terms of the number of patents and R&D expenditures was determined and studied.

Despite the significant results obtained, the limitations of this study are highlighted, and additional branches of continuation and deepening of the study in the future are proposed.

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# APPENDICES

**Appendix 1. The list of sample companies**

| № | Company name |
|---|---|
| 1 | O'KEY Group S.A. |
| 2 | Public Joint Stock Company "Acron" |
| 3 | Public Joint Stock Company "Aeroflot-Russian Airlines" |
| 4 | Public Joint Stock Company "ALROSA" |
| 5 | Public Joint Stock Company "Ashinskiy metallurgical works" |
| 6 | Public Joint Stock Company "Beluga Group" |
| 7 | Public Joint Stock Company "Company Enel Russia" |
| 8 | Public Joint Stock Company "Detsky mir" |
| 9 | Public Joint Stock Company "Federal Grid Company of Unified Energy System" |
| 10 | Public Joint Stock Company "Federal Hydro-Generating Company – RusHydro" |
| 11 | Public Joint Stock Company "Gazprom" |
| 12 | Public Joint Stock Company "Group of Companies "Segezha" |
| 13 | Public Joint Stock Company "Inter RAO UES" |
| 14 | Public Joint Stock Company "Lenta" |
| 15 | Public Joint Stock Company "Lenzoloto" Lena Gold-Mining Public |
| 16 | Public Joint Stock Company "LSR Group" |
| 17 | Public Joint Stock Company "M.video" |
| 18 | Public Joint Stock Company "Magnit" |
| 19 | Public Joint Stock Company "Magnitogorsk Iron & Steel Works" |
| 20 | Public Joint Stock Company "Mechel" |
| 21 | Public Joint Stock Company "Mining and Metallurgical Company "NORILSK NICKEL" |
| 22 | Public Joint Stock Company "Mobile TeleSystems" |
| 23 | Public Joint Stock Company "Moscow City Telephone Network" |
| 24 | Public Joint Stock Company "MOSENERGO" |
| 25 | Public Joint Stock Company "Nizhnekamskneftekhim" |
| 26 | Public Joint Stock Company "NOVATEK" |
| 27 | Public Joint Stock Company "Novolipetsk Steel" |
| 28 | Public Joint Stock Company "Novorossiysk Commercial Sea Port" |
| 29 | Public Joint Stock Company "Novorossiysk Grain Plant" |

| | |
|---|---|
| 30 | Public Joint Stock Company "Oil company "LUKOIL" |
| 31 | Public Joint Stock Company "Oil Company Bashneft" |
| 32 | Public Joint Stock Company "OR GROUP" |
| 33 | Public Joint Stock Company "Organichesky sintez" Kazan |
| 34 | Public Joint Stock Company "Pharmacy Chain 36,6" |
| 35 | Public Joint Stock Company "PhosAgro" |
| 36 | Public Joint Stock Company "PIK-specialized homebuilder" |
| 37 | Public Joint Stock Company "Polyus" |
| 38 | Public Joint Stock Company "Quadra - Power Generation" |
| 39 | Public Joint Stock Company "Raspadskaya" |
| 40 | Public Joint Stock Company "Research and production corporation "United Wagon Company" |
| 41 | Public Joint Stock Company "Rosneft Oil Company" |
| 42 | Public Joint stock company "Rosseti Lenenergo" |
| 43 | Public Joint stock company "Rosseti" |
| 44 | Public Joint Stock Company "Rostelecom" |
| 45 | Public Joint Stock Company "Russian Aquaculture" |
| 46 | Public Joint Stock Company "RussNeft" |
| 47 | Public Joint Stock Company "Samolet Group" |
| 48 | Public Joint Stock Company "Saratov Oil Refinery" |
| 49 | Public Joint Stock Company "Seligdar" |
| 50 | PUBLIC JOINT STOCK COMPANY "SEVERSTAL" |
| 51 | Public Joint Stock Company "SOLLERS Auto" |
| 52 | Public Joint Stock Company "Sovcomflot" |
| 53 | Public Joint Stock Company "TATNEFT" |
| 54 | Public Joint Stock Company "Tattelecom" |
| 55 | Public Joint Stock Company "TERRITORIAL GENERATING COMPANY № 1" |
| 56 | Public Joint Stock Company "The Second Generation Company of the Wholesale Power Market" |
| 57 | Public Joint Stock Company "Transneft" |
| 58 | Public Joint Stock Company "Unipro" |
| 59 | Public Joint Stock Company "VSMPO-AVISMA Corporation" |
| 60 | Public Limited Company "ETALON GROUP" |
| 61 | Public Limited Company "FAR-EASTERN SHIPPING COMPANY" |

## Appendix 2. Stata – Models for R&D

**Pooled Regression Model**
**Linear regression**

| ln_rd | Coef. | St.Err. | t-value | p-value | [95% Conf | Interval] | Sig |
|---|---|---|---|---|---|---|---|
| ceoage | .016 | .076 | 0.21 | .834 | -.135 | .167 | |
| sex | -3.45 | 1.96 | -1.76 | .08 | -7.311 | .411 | * |
| tenure | -.099 | .11 | -0.90 | .371 | -.316 | .118 | |
| reled | -.874 | 1.029 | -0.85 | .397 | -2.9 | 1.152 | |
| ited | .701 | 1.004 | 0.70 | .486 | -1.277 | 2.678 | |
| maneced | -1.188 | 1.188 | -1.00 | .319 | -3.528 | 1.153 | |
| mba | -.413 | 1.057 | -0.39 | .696 | -2.495 | 1.669 | |
| doced | -8.475 | 2.693 | -3.15 | .002 | -13.78 | -3.171 | *** |
| insider | .126 | 1.143 | 0.11 | .912 | -2.124 | 2.377 | |
| shares | .04 | .05 | 0.80 | .423 | -.058 | .139 | |
| exboards | .193 | .112 | 1.72 | .086 | -.028 | .414 | * |
| govtenure | .162 | .105 | 1.55 | .123 | -.044 | .368 | |
| govcont | 4.148 | 1.237 | 3.35 | .001 | 1.712 | 6.585 | *** |
| compage | -.007 | .013 | -0.50 | .617 | -.033 | .019 | |
| ln_revenue | 1.161 | .17 | 6.83 | 0 | .827 | 1.496 | *** |
| miningmetals | 6.96 | 1.033 | 6.74 | 0 | 4.926 | 8.993 | *** |
| energy | 3.309 | 1.594 | 2.08 | .039 | .171 | 6.448 | ** |
| Constant | -25.331 | 5.503 | -4.60 | 0 | -36.168 | -14.493 | *** |

| | | | |
|---|---|---|---|
| Mean dependent var | 7.369 | SD dependent var | 9.192 |
| R-squared | 0.468 | Number of obs | 298 |
| F-test | 53.254 | Prob > F | 0.000 |
| Akaike crit. (AIC) | 1821.872 | Bayesian crit. (BIC) | 1886.577 |

*** *p<.01, ** p<.05, * p<.1*

**Variance inflation factor**

| | VIF | 1/VIF |
|---|---|---|
| shares | 2.534 | .395 |
| govtenure | 2.304 | .434 |
| maneced | 2.128 | .47 |
| ceoage | 2.076 | .482 |
| tenure | 1.958 | .511 |
| doced | 1.837 | .544 |
| ln revenue | 1.797 | .557 |
| ited | 1.767 | .566 |
| govcont | 1.747 | .572 |
| reled | 1.656 | .604 |
| miningmetals | 1.433 | .698 |
| mba | 1.383 | .723 |
| energy | 1.354 | .739 |
| insider | 1.337 | .748 |
| exboards | 1.274 | .785 |
| sex | 1.203 | .831 |
| compage | 1.191 | .84 |
| Mean VIF | 1.705 | . |

**Fixed effects Regression Model**
**Regression results**

| ln_rd | Coef. | St.Err. | t-value | p-value | [95% Conf | Interval] | Sig |
|---|---|---|---|---|---|---|---|
| ceoage | .072 | .027 | 2.68 | .01 | .018 | .126 | *** |
| sex | -.025 | .985 | -0.02 | .98 | -1.996 | 1.947 | |
| tenure | -.031 | .056 | -0.57 | .574 | -.143 | .08 | |
| reled | 1.191 | .496 | 2.40 | .02 | .198 | 2.184 | ** |
| ited | -2.011 | .448 | -4.49 | 0 | -2.907 | -1.116 | *** |
| maneced | .439 | .198 | 2.22 | .03 | .044 | .834 | ** |
| mba | -1.648 | .735 | -2.24 | .029 | -3.12 | -.176 | ** |
| o | 0 | . | . | . | . | . | |
| insider | -.247 | .266 | -0.93 | .357 | -.78 | .285 | |
| shares | .001 | .008 | 0.11 | .916 | -.015 | .016 | |
| exboards | .073 | .048 | 1.53 | .132 | -.023 | .169 | |
| govtenure | .057 | .05 | 1.14 | .259 | -.043 | .158 | |
| govcont | -.732 | .212 | -3.45 | .001 | -1.156 | -.307 | *** |
| compage | .137 | .131 | 1.05 | .299 | -.125 | .399 | |
| ln_revenue | -.102 | .091 | -1.12 | .267 | -.284 | .08 | |
| o | 0 | . | . | . | . | . | |
| o | 0 | . | . | . | . | . | |
| Constant | 1.185 | 4.781 | 0.25 | .805 | -8.385 | 10.756 | |

| | | | |
|---|---|---|---|
| Mean dependent var | 7.369 | SD dependent var | 9.192 |
| R-squared | 0.052 | Number of obs | 298 |
| F-test | 5.719 | Prob > F | 0.000 |
| Akaike crit. (AIC) | 952.838 | Bayesian crit. (BIC) | 1003.164 |

*** *p<.01*, ** *p<.05*, * *p<.1*

Breusch - Pagan Lagrangian multiplier test

```
. xttest0

Breusch and Pagan Lagrangian multiplier test for random effects

        ln_rd[company,t] = Xb + u[company] + e[company,t]

        Estimated results:
                         |       Var     sd = sqrt(Var)
                 --------+------------------------------
                   ln_rd |    84.49914        9.192341
                       e |    2.501219        1.581524
                       u |    59.73335        7.728735

        Test:   Var(u) = 0
                                 chibar2(01) =   411.51
                              Prob > chibar2 =   0.0000
```

**Cluster-Robust Hausman Test**
(based on 100 bootstrap repetitions)

b1: obtained from xtreg ln_rd ceoage sex tenure reled ited maneced mba doced insider shares exboards govtenure govcont compage ln_revenue miningmetals energy, r fe
b2: obtained from xtreg ln_rd ceoage sex tenure reled ited maneced mba doced insider shares exboards govtenure govcont compage ln_revenue miningmetals energy, r re
Excluded (not identified, or only identified in one model): doced miningmetals energy

Test: Ho: difference in coefficients not systematic

chi2(15) = (b1-b2)' * [V_bootstrapped(b1-b2)]^(-1) * (b1-b2)

= 11.11

Prob>chi2 = 0.7446

## Appendix 3. Stata – Models for Patents

### Pairwise correlations

| Variables | (1) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (1) patents | 1.000 | | | | | | | |
| (2) L.ceoage | 0.178* | 1.000 | | | | | | |
| (3) L.sex | -0.035 | -0.163* | 1.000 | | | | | |
| (4) L.tenure | -0.049 | 0.255* | -0.104 | 1.000 | | | | |
| (5) L.reled | 0.150* | 0.325* | -0.063 | 0.088 | 1.000 | | | |
| (6) L.ited | 0.192* | 0.438* | -0.131 | 0.177* | 0.414* | 1.000 | | |
| (7) L.maneced | -0.162* | -0.511* | 0.038 | -0.003 | -0.377* | -0.424* | 1.000 | |
| (8) L.mba | -0.061 | -0.286* | -0.063 | 0.209* | -0.041 | -0.113 | 0.248* | 1.000 |
| (9) L.doced | -0.035 | -0.062 | -0.020 | -0.032 | -0.133 | -0.131 | 0.110 | -0.063 |
| (10) L.insider | 0.097 | -0.018 | -0.182* | 0.158* | 0.147* | -0.044 | 0.162* | 0.048 |
| (11) L.shares | -0.077 | -0.106 | -0.044 | 0.389* | -0.095 | -0.171* | 0.120 | 0.182* |
| (12) L.exboards | -0.035 | -0.228* | -0.100 | 0.033 | -0.065 | -0.067 | 0.221* | 0.183* |
| (13) L.govtenure | 0.101 | 0.338* | -0.092 | 0.238* | 0.141* | 0.188* | 0.074 | -0.197* |
| (14) L.govcont | 0.213* | 0.144* | -0.147* | 0.113 | -0.002 | 0.123 | 0.042 | -0.113 |
| (15) L.compage | 0.066 | -0.080 | -0.127 | -0.235* | 0.099 | 0.025 | -0.037 | 0.083 |
| (16) L.ln_revenue | 0.220* | 0.247* | 0.040 | -0.157* | -0.180* | 0.236* | -0.057 | -0.327* |
| (17) miningmetals | -0.058 | -0.202* | -0.072 | -0.136 | -0.114 | 0.079 | 0.213* | 0.146* |
| (18) energy | -0.052 | -0.122 | -0.064 | -0.227* | -0.204* | -0.175* | 0.177* | -0.001 |

### Pairwise correlations

| Variables | | | | | | | | | (17) |
|---|---|---|---|---|---|---|---|---|---|
| (1) patents | | | | | | | | | |
| (2) L.ceoage | | | | | | | | | |
| (3) L.sex | | | | | | | | | |
| (4) L.tenure | | | | | | | | | |
| (5) L.reled | | | | | | | | | |
| (6) L.ited | | | | | | | | | |
| (7) L.maneced | | | | | | | | | |
| (8) L.mba | | | | | | | | | |
| (9) L.doced | 1.000 | | | | | | | | |
| (10) L.insider | 0.073 | 1.000 | | | | | | | |
| (11) L.shares | 0.590* | 0.023 | 1.000 | | | | | | |
| (12) L.exboards | -0.052 | 0.152* | -0.063 | 1.000 | | | | | |
| (13) L.govtenure | 0.019 | 0.025 | -0.131 | 0.121 | 1.000 | | | | |
| (14) L.govcont | 0.133 | 0.109 | -0.003 | -0.089 | 0.560* | 1.000 | | | |
| (15) L.compage | -0.068 | -0.005 | -0.146* | 0.122 | -0.155* | -0.177* | 1.000 | | |
| (16) L.ln_revenue | -0.029 | -0.136* | -0.373* | -0.106 | 0.290* | 0.292* | -0.002 | 1.000 | |
| (17) miningmetals | -0.072 | -0.072 | -0.023 | 0.094 | -0.145* | -0.074 | 0.160* | -0.075 | 1.000 |
| (18) energy | -0.064 | -0.008 | -0.143* | -0.033 | -0.058 | 0.001 | 0.077 | 0.140* | -0.242* |

**** p<0.01, ** p<0.05, * p<0.1*

**Pooled Regression Model**

**Linear regression**

| patents | Coef. | St.Err. | t-value | p-value | [95% Conf | Interval] | Sig |
|---|---|---|---|---|---|---|---|
| L | .302 | .206 | 1.46 | .145 | -.105 | .708 | |
| L | 6.909 | 4.108 | 1.68 | .094 | -1.195 | 15.013 | * |
| L | -.987 | .417 | -2.37 | .019 | -1.809 | -.165 | ** |
| L | 4.9 | 2.785 | 1.76 | .08 | -.594 | 10.394 | * |
| L | 4.251 | 2.469 | 1.72 | .087 | -.62 | 9.121 | * |
| L | -4.063 | 2.328 | -1.75 | .082 | -8.654 | .528 | * |
| L | 5.502 | 2.111 | 2.61 | .01 | 1.339 | 9.665 | *** |
| L | -29.49 | 10.71 | -2.75 | .006 | -50.615 | -8.365 | *** |
| L | 9.683 | 3.588 | 2.70 | .008 | 2.606 | 16.761 | *** |
| L | .412 | .153 | 2.69 | .008 | .11 | .714 | *** |
| L | .277 | .326 | 0.85 | .396 | -.365 | .919 | |
| L | -.213 | .328 | -0.65 | .518 | -.86 | .434 | |
| L | 11.817 | 5.459 | 2.16 | .032 | 1.049 | 22.585 | ** |
| L | .055 | .039 | 1.38 | .168 | -.023 | .132 | |
| L | 1.995 | .62 | 3.22 | .002 | .771 | 3.219 | *** |
| miningmetals | -4.642 | 3.578 | -1.30 | .196 | -11.699 | 2.414 | |
| energy | -5.496 | 3.983 | -1.38 | .169 | -13.351 | 2.36 | |
| Constant | -67.998 | 22.544 | -3.02 | .003 | -112.465 | -23.531 | *** |

| | | | |
|---|---|---|---|
| Mean dependent var | 7.100 | SD dependent var | 28.673 |
| R-squared | 0.163 | Number of obs | 238 |
| F-test | 3.795 | Prob > F | 0.000 |
| Akaike crit. (AIC) | 1993.680 | Bayesian crit. (BIC) | 2053.842 |

*** *p<.01, ** p<.05, * p<.1*

**Variance inflation factor**

| | VIF | 1/VIF |
|---|---|---|
| L.shares | 2.904 | .344 |
| L.govtenure | 2.297 | .435 |
| L.tenure | 2.137 | .468 |
| L.ceoage | 2.127 | .47 |
| L.doced | 2.1 | .476 |
| L.maneced | 2.088 | .479 |
| L.ln revenue | 1.823 | .549 |
| L.ited | 1.803 | .555 |
| L.govcont | 1.751 | .571 |
| L.reled | 1.72 | .581 |
| miningmetals | 1.446 | .692 |
| L.mba | 1.389 | .72 |
| energy | 1.345 | .743 |
| L.exboards | 1.29 | .775 |
| L.insider | 1.283 | .779 |
| L.compage | 1.202 | .832 |
| L.sex | 1.193 | .838 |
| Mean VIF | 1.759 | . |

**Fixed effects Regression Model**
**Regression results**

| patents | Coef. | St.Err. | t-value | p-value | [95% Conf | Interval] | Sig |
|---|---|---|---|---|---|---|---|
| L | .112 | .194 | 0.58 | .564 | -.272 | .497 | |
| L | 5.366 | 10.384 | 0.52 | .606 | -15.162 | 25.894 | |
| L | .147 | .45 | 0.33 | .744 | -.743 | 1.038 | |
| L | 1.417 | 4.583 | 0.31 | .758 | -7.643 | 10.478 | |
| L | -1.669 | 5.457 | -0.31 | .76 | -12.457 | 9.119 | |
| L | -.12 | 3.569 | -0.03 | .973 | -7.175 | 6.935 | |
| L | -.725 | 7.96 | -0.09 | .928 | -16.461 | 15.012 | |
| oL | 0 | . | . | . | . | . | |
| L | 1.93 | 4.007 | 0.48 | .631 | -5.99 | 9.851 | |
| L | .012 | .182 | 0.07 | .947 | -.347 | .371 | |
| L | -.22 | .26 | -0.85 | .397 | -.734 | .293 | |
| L | .331 | .327 | 1.01 | .314 | -.317 | .978 | |
| L | 1.3 | 3.166 | 0.41 | .682 | -4.959 | 7.558 | |
| L | -.406 | .537 | -0.76 | .451 | -1.468 | .657 | |
| L | .125 | 1.258 | 0.10 | .921 | -2.362 | 2.612 | |
| o | 0 | . | . | . | . | . | |
| o | 0 | . | . | . | . | . | |
| Constant | 11.794 | 34.51 | 0.34 | .733 | -56.429 | 80.017 | |

| | | | |
|---|---|---|---|
| Mean dependent var | 7.100 | SD dependent var | 28.673 |
| R-squared | 0.019 | Number of obs | 238 |
| Akaike crit. (AIC) | 1280.679 | Bayesian crit. (BIC) | 1330.814 |

*** *p<.01*, ** *p<.05*, * *p<.1*

Breusch - Pagan Lagrangian multiplier test

```
. xttest0

Breusch and Pagan Lagrangian multiplier test for random effects

        patents[company,t] = Xb + u[company] + e[company,t]

        Estimated results:
                         |       Var     sd = sqrt(Var)
                ---------+------------------------------
                patents  |    822.1293        28.6728
                       e |    34.46026       5.870286
                       u |     939.871       30.65731

        Test:   Var(u) = 0
                                 chibar2(01) =    279.10
                              Prob > chibar2 =    0.0000
```

**Hausman (1978) specification test**

| | Coef. |
|---|---|
| Chi-square test value | 3.844 |
| P-value | .996 |