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The impact of the ownership structure on the innovative activity of Russian companies

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Capital structure determines a company's growth prospects by affecting its investment activity. The article examines what type of capital, foreign or state-owned, stimulates a company's innovative activity as measured by its number of patent applications. The study was carried out using data from 238 public Russian companies in the period 2012–2020. The results of the study show that state and foreign investors influence innovation to different degrees: state capital positively affects the number of patent applications filed, while foreign capital does not. The impact of political connections and board structure on research and development was investigated. The political ties of the CEOs and the board chairs are expressed by the experience of working in the public service. The presence of such experience in the company's management increases the company's innovation activity. However, political connections are effective only in companies with state capital, or in specific industries. The company's state capital and political connections have a positive impact on the number of patent applications filed in the energy and industrial sectors. The presence of political ties has a positive impact on the role of foreign capital in innovation. The share of foreign directors has a positive effect on patents. Also, the presence of patents from previous years, as well as the age and size of the company, affects the receipt of patents in the future. The younger and larger the company, the more patent applications there will be.

Keywords: R&D, innovations, patents, foreign investment, government ownership, political ties.

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Introduction

Foreign capital provides access to complementary knowledge, international networks, and management skills in emerging markets. Meanwhile, domestic capital with geographic proximity to investment targets better understands local market conditions and provides better access to local resources. It is therefore natural to ask whether there are systematic differences in innovation between foreign capital-supporting firms and domestic capital-supporting firms, and which are better at promoting innovation. Globalization has brought technological progress and increased information flow, with the result that knowledge has become one of the main engines of economic growth. Investment in technology and innovation is aimed to improve economic performance through sales of new products in the market or new methods for higher efficiency and reduced costs of production, which consequently increases living standards. In this regard, countries wishing to make progress in innovation are focusing on investment in innovation.

One of the main indicators used to describe the level of innovative development is Research & Development (R&D) intensity. Research and development spending is one of the most widely used indicators of innovative investment. R&D intensity is used as an indicator of the relative degree of an economy's investment in new knowledge creation. Some countries set target value of this indicator for funding purposes and policy making.

The purpose of this paper is to investigate the effects of foreign and state capital on a company's innovation activity and the determination the presence and magnitude of the impact of government relations on R&D. This study is conducted only for Russian companies to take into consideration country specifics, which are represented by high state involvement, high concentration of business activity in certain industries, and country risk. We focus on Russia's unique market with its unique institutional environment. Only 1 % of Russian national income is spent on R&D, which is far below average. Furthermore, 75 % of R&D is performed by the public sector, according to the Organization for Economic Co-operation and Development (OECD, 2012)[1].

Russia's economy should be investigated separately from other countries, because of high state interventions in many spheres of the economy. The state could have significant ownership in the equity of a company, which allows it to control business activity or even control the industry if that particular company is a monopoly. Another form of state intervention in the life of a company is more disguised. The chairman of the board of directors or chief executive officer (CEO) could be either a former government official or a member of the party of power, or that company's key persons could be affiliated with certain government officials and represent their interests.

Due to a high concentration of companies with state ownership, it is also necessary to take into account indirect state involvement, represented by political ties. According to the Deloitte Report on corporate governance of Russian companies in 2015, 21 % of boards of directors of companies with state ownership are current government officials and 42 % are politically related directors[2].

[1] Diversifying Russia. (2012) *European Bank for Reconstruction and Development*. P. 67–77. URL: https://www.ebrd.com/cs/Satellite?c=Content&cid=1395237440546&d=&pagename=EBRD%2FContent%2FDownloadDocument (accessed: 20.02.2021).

[2] Deloitte. Corporate Governance Structures of Public Russian Companies Survey. (2015) *Deloitte CIS Centre for Corporate Governance.* URL: https://www2.deloitte.com/content/dam/Deloitte/ru/Documents/risk/corporate-governance-structures-survey-eng.pdf (accessed: 20.02.2021).

We focus on a frequently ignored factor of types of ownership in scope with industrial differences. State-owned companies tend to have higher resource availability, which is crucial for R&D. In contrast, state-owned companies are more likely to accept inefficient R&D projects. Political ties should be considered, because they might enhance innovation activity. Industrial differences are taken into account, because the importance of technological progress varies across different sectors of the economy. For this reason, this paper's exceptionality can be described along three dimensions. First, there is a limited literature on innovation performance of Russian companies alone. State relations are more prevalent, contrary to foreign ownership. Furthermore, the structure of boards of directors was analyzed in order to understand the role of the state and foreigners. The effect of political ties is studied in a more detailed manner than is usually done. Different variables were created to understand this relationship more precisely. Second, there is an attempt to evaluate the significance of an R&D intensity proxy, measured by intangibles assets, in modelling patent applications. Third, two different econometric approaches were conducted to evaluate innovation activity: one treats patent applications as a continuous variable, and the second assumes a Poisson distribution with high overdispersion in the data.

Understanding key drivers of innovation activity will help investors to evaluate growth opportunities of a company. Given information about change in ownership structure and governance, the investor will be able to predict an increase or decrease in the growth rate. Growth rate is a key factor that affects the enterprise value of the company, and consequently equity value and share price. Since these factors are not usually considered by investors and the indirect effect of government relations and foreign investments on a firm's performance through effect on innovation output are not well-studied, corresponding corporate events would not immediately be incorporated into share price. So, a reliable investment strategy could be implemented.

This paper consists of an introduction, literature review, theoretical methodology, empirical results, robustness check, and a conclusion. Theoretical methodology section describes hypotheses and corresponding relevant models.

1. Literature review

1.1. R&D and ownership structure

Foreign investors are more advanced in technological progress, especially for emerging economies. They can also share knowledge and experience from different countries. However, foreign investors from another perspective are supposed to be relatively short-term in comparison to domestic investors, which is why some articles propose that they are more likely to prefer current gains to prospects achieved from R&D. A later paper on the Chinese market by Da Teng and Jingtao Yi found a strong negative effect of foreign ownership on innovation activity [Teng, Yi, 2017]. Another paper on this topic and using the Chinese market, by Jiangjing Que and Xueyong Zhang, focused on foreign and domestic venture capital investment in Initial Public Offering (I)firms. It and confirms that foreign Venture Capital investment negatively affects innovation output and innovation efficiency, measured as ratio of patents to R&D expenditures and personnel [Que, Zhang, 2020]. Aneta Hintošovaa and Zuzana Kubíkova find that R&D activity increases with foreign ownership, yet only up to a point, as the square of ownership happens to

be negative. Although the results provide insights on non-linear dependence, they still should be treated with caution due to absence of control variables in the ordinary least squares regression [Hintošovaa, Kubíkova, 2016]. Denis Yongmin Joe, Frederick Oh and Heechan Yoo analyze this relationship on the basis of 10 years when South Korea was not developed but the fastest developing economy, so at that time foreign capital was crucial for the Korean economy. Providing the need to control for firm size, as it may lead to structural bias when estimating patents, for spillover effects that account for influence of a firms' innovation on its competitors, and for a foreign presence in the industry, they prove that foreign ownership increases innovation activity, even when innovation is measured with utility models [Joe, Oh, Yoo, 2019].

Jan Bena and co-authors prove that foreign institutional investors enhance innovation output, through more efficient monitoring aimed at involving long-term projects. Moreover, they find evidence that an increase in innovation is higher when the country-level protection is lower, meaning lower political ties, which is also our variable of interest [Bena et al., 2015]. Kong, Zhu, and Yang confirm the same results for China's energy sector and prove that the share of revenues spent for R&D is positively related to foreign ownership; however, unlike in previous paper, the presence of state ownership decreases the positive effect of foreign investors on innovation [Kong, Zhu, Yang, 2020]. Shin and Park analyze this effect by taking into account only institutional investors and find that foreign institutional investors are insignificant in modelling R&D intensity, if domestic institutional investors are included, meaning stand-alone significance only [Shin, Park, 2020]. Institutional investors are typically larger and thus invest in larger firms, seeking lower risk and stable returns, while private investors, such as Venture Capital firms, usually look for risky projects with higher returns. Thus, intuitively, private investors are more likely to invest in R&D, hoping for future profits. According to Li Mengya, Yan Taihua and Hao Chen, venture capital firms not only promote R&D, but also navigate it in a most efficient way; and venture capital firms with a foreign background outperform domestic VC firms in terms of R&D [Li, Taihua, Chen, 2021].

Foreign capital provides access to complementary knowledge, international networks, and management skills in emerging markets [Makela, Maula, 2005; Fernhaber, Mcdougall-Covin, 2009]. Meanwhile, domestic capital with geographic proximity to investment targets better understands local market conditions and has better access to local resources [Makela, Maula, 2006]. Firms backed by foreign capital can perform better, due to their distinctive capabilities. Access to international networks allows domestic firms to establish contacts with foreign firms and institutions [Hochberg, Yang, 2007; Fernhaber, Mcdougall-Covin, 2009], promote knowledge diffusion [Tu, Zhao, 2012], and further stimulate innovation in domestic firms [Guadalupe, Thomas, 2012]. Foreign capital can provide additional knowledge-based resources and information on foreign business issues [Makela, Maula, 2005], useful resources for seizing new opportunities and driving innovation and incentive mechanisms. Tan found that foreign capital supporting firms are more likely to grant stock options to employees than domestic firms, which allows companies to attract more talented R&D personnel to support innovation [Tan, Xia, 2008]. From other perspectives, geographic distance creates a lack of information and makes it difficult to closely monitor companies, while domestic capital backed firms, due to the advantage of geographic proximity, can more easily assess and track them [Sorenson, Stuart, 2001] and offer additional services [Makela, Maula, 2006]. Foreign capital supported firms spend

less time meeting their investment goals due to higher transaction costs [Fritsch, Schilder, 2008], stop investing in their investment objectives much faster when companies' outlook deteriorates [Makela, Maula, 2006], and have less detailed understanding of the institutional environment, state intervention, and corporate governance structures [Pukthuanthong, Walker, 2007].

Former government connections of directors appeared to have a negative effect on R&D intensity in Chinese public companies, which is explained by the fact that public firms tend to use direct financing via capital markets, rather than benefits of political ties for financing their R&D activity [Wang et al., 2018]. Victoria Cherkasova and Anna Ivanova argue that in Russia, political connections of chairmen of boards or CEOs lead to investment inefficiency. The reason is that state-related managers or directors try to achieve goals set by the government or power elite, which may not coincide with value maximization of the company [Cherkasova, Ivanova, 2019]. However, political ties of firms could be also value-enhancing, because of synergy between the government and the company. State-owned enterprises (SOEs) have a significant role in the Chinese and Russian economies. Wu, Liang and Shen analyze the effect of political connections and state ownership on investments in R&D, facility upgrading, and marketing, and they confirm the positive effect of close political ties of top managers and directors on R&D intensity and facility upgrading intensity, and the opposite effect of the state [Wu, Liang, Shen, 2018]. Political connections may promote R&D activity through different channels: access to resources, government subsidies, attractive bank loans, and use of existing state technologies. The hypotheses of a positive impact of political connection and a negative impact of state ownership is also confirmed by Meta-Analytic Structural Equation Modeling [Tihanyi et al., 2019].

1.2. Control variables for modelling innovation activity

Big companies benefit from economies of scale and participate in innovation activity, while small companies tend to take risky projects and invest in R&D to get a bigger market share [Lu, 2020]. Another important variable that might affect willingness to participate in large-scale R&D activity is company age [Tihanyi et al., 2019]. In addition to these control variables, Wang and co-authors used industry and profitability for modelling R&D intensity. Return to assets, as a measure of profitability, showed a positive and significant effect on R&D intensity, and firms from manufacturing industries have fewer R&D expenditures than firms from service industries [Wang et al., 2018]. Kwon and Park measured age of the company by logarithm of age, which appeared to have a positive and significant effect; instead of company size they used a logarithm of the number of employees and an expanded set of control variables with export intensity and advertising intensity, which also significantly and positively affects R&D intensity [Kwon, Park, 2018]. Corsi and Prencipe analyzed the non-linear effect of company age and included squared age in the model. A U-shaped form of age is explained by the fact that young companies try to apply for more patents to make their name more sound, and mature companies have more experience and resources in applications for patents. In a one-step Generalized method of moments (GMM) model, both age and squared age showed significant results [Corsi, Prencipe, 2017]. In addition to return to assets, return to equity could be used as measure of profitability. Some industries by their natures are more R&D intensive, but in

Table 1. **Influence of control variables on innovations according to previous studies**

Dependent variable	Control variables	Research
R&D intensity	Size (+/–)	[Lu, 2020]
	Age (+), Size (+)	[Tihanyi et al., 2019]
	Size (+), Age (–), Industry (–), Return on Assets (+)	[Wang et al., 2018]
	Age (+), Advertising expenditure intensity (+), Export intensity (+), Number of employees (+)	[Kwon, Park, 2018]
	Capital intensity, Size (+), Return on Assets, Leverage (–), Herfindahl index (–), Age (–), Book to Market ratio, Volatility of sales, Dividend yield, Property, plant and equipment/Total Assets (–)	[Shin, Park, 2020]
	Export intensity (+), Import intensity, Size (–), Size^2 (+), Age (–), Age^2 (+), Capital intensity (+), Leverage (+), Profit before tax (+), Herfindahl index	[Khachoo, Sharma, 2015]
	Size (+), Age (+), Leverage (–), Employee training (+), Capital intensity (+), Return on Assets (–)	[Teng, Yi, 2017]
Number of patents	Size (+), Age (+), Age^2 (–), R&D intensity, Sectors, Return on Equity (–),Return on Assets (–)	[Corsi, Prencipe, 2017]
	Size (+), R&D intensity (+), Herfindahl index HHI, HHI^2	[Qiao, Li, 2019]
	R&D intensity, Size (+), Current ratio, Leverage	[Rahul, Parthiban, 1996]
	Insider ownership (–), Foreign-to-total sales (+), Sales (+), Capital to Labour ratio (+), R&D intensity (+), Tobin's Q (+), Free cash flow (–), Leverage (–), Cash (+),Property, plant and equipment (–)	[Bena et al., 2015]
	R&D intensity (+), Size (+), Return on Assets, Property, plant and equipment, Leverage (–), Age, Tobin's Q (–), Capital intensity	[Que, Zhang, 2020]
	Size (+), Leverage (–), Return on Assets (+), Property, plant and equipment (–), Herfindahl index (+), Duality, Number of directors (+), Independent directors share (+), Managers holding	[Kong, Zhu, Yang, 2020]

common, industry influences innovation activity because of competition, which enhances innovations. A widely used measurement of competition is the Herfindahl index. Greater market competition affects R&D intensity in a positive manner (lower Herfindahl index, bigger concentration of firms in the industry) [Shin, Park, 2020]. There is also evidence that the Herfindahl index in square power should be included in the model to check for a non-linear effect of market competition on innovation activity. The squared form of competition showed its significance in a model with utility product patent applications as the dependent variable [Qiao, Li, 2019].

Leverage and liquidity are crucial in modelling innovations, because firms need available funds to finance R&D [Rahul, Parthiban, 1996]. The significance of these variables on innovation output was not detected [Rahul, Parthiban, 1996]. Export and import intensity is lower in companies with large foreign ownership [Khachoo, Sharma, 2015]. Khachoo and Sharma also included location of the firm in the selection equation to solve the overidentification problem of Heckman's selection model, since location influences probability

of undertaking R&D but does not influence R&D intensity, which is a dependent variable in the outcome equation [Khachoo, Sharma, 2015]. Export-oriented firms tend to invest in R&D more, which can be represented by significance of export sales [Bena et al., 2015]. Also, Bena and co-authors suggest free cash flow captures profitability, but results were ambiguous [Bena et al., 2015]. In order to measure a firm's growth opportunities, Tobin's Q or ratio of capital expenditures to total assets could be used [Que, Zhang, 2020]. Kong and co-authors, analyzing the effect of foreign investors on patent applications in the energy sector, used such control variables as tangibility of assets, a dummy variable for state-owned enterprises, number of members of the board of directors, ratio of independent directors to the board directors, and CEO who is simultaneously chairman of the board of directors. All these variables, except the dual role of CEO as board chairman, were significant. Tangibility and state ownership appeared to have negative effects on patent applications. A logarithm of the board of directors showed a positive effect on patent applications, meaning that a greater number of directors enhance innovation activity [Kong, Zhu, Yang, 2020]. One more non-standard control variable is employee training, which comprises of training expenditures to total sales and represents learning of new technologies by employees and appears to be significant [Teng, Yi, 2017].

A summary of key empirical findings on control variables for modelling innovations is presented in Table 1.

2. Hypotheses

Following the research described in the previous section, it is important to highlight the main hypothesis to be tested in the empirical results section.

H_1: *The foreign participation in the share capital of the firm will positively affect the innovation activity of a firm.*

Foreign firms are also more active in R&D than their local counterparts, as has been proven in empirical studies discussed earlier [Corsi, Prencipe, 2017; Choi, Williams, 2011; Kong, Zhu, Yang, 2020]. Corsi and Prencipe look at the number of patents registered by the company, in order to assess the effectiveness of R&D conducted; they found that foreign ownership increases R&D intensity of small and medium-sized firms [Corsi, Prencipe, 2017]. Moreover, Choi and Williams, using data from the emerging Chinese economy, showed a strong influence of the presence of foreign ownership on a firm's innovation, proxied by the number of patterns, due to the exchange of knowledge and experiences of different countries [Choi, Williams, 2011].

H_2: *The participation of the state in share capital of the firm positively affects the innovation activity of a firm.*

Teng and Yi show the negative effect of foreign ownership on R&D intensity and new product sales in China, which is a good proxy for innovation output. They find evidence that state ownership improves patent applications, and they find that the state increases production of new products in the market [Teng, Yi, 2017]. In China, the state tries to maintain control over the most well-performing and innovative enterprises. After the period of privatization, the Chinese state still owns the majority of equity in utility, resource, and energy sectors. Moreover, the top 500 Chinese companies without state equity have a total income in 2020 of twice less than two SOEs: China Mobile and China National Petroleum Corporation. In India, state ownership also increases innovation activity, because

the biggest companies in the Indian economy are SOEs, which have more resources and productive capacity than smaller companies without state equity; they can collaborate with public research institutions and delegate some fraction of R&D activity [Nagaraj, 2016].

H_3: Political connections of directors and CEOs have a positive effect on innovation performance.

Political connections appear to increase patent applications, as this helps provide additional financing and state guarantees, which is crucial for R&D. Analyzing political connections in Chinese companies, Wu and co-authors found that political connections increase R&D intensity as well as investment in upgrading facilities and marketing [Wu, Liang, Shen, 2018]. In line with Tihanyi and co-authors, whose work is based on firms from 139 countries, political connections do affect innovation performance, because it helps provide additional financing and state guarantees, which are crucial to R&D [Tihanyi et al., 2019]. The politically related person would like to perform better in order to have a bigger position in the state in the future. That is why he or she will bet on innovations and new technologies. If a project is successful and a new product is created, the chairman or CEO can be rewarded with a higher position in the state. Further, political connections can help delegate some research to public research institutes and laboratories or simply obtain access to current development that is unattainable to others.

H_4: The presence of foreign members on the board of directors will promote innovations.

It could also be the case that the presence of foreign members on the board of directors will enhance innovation. This effect is represented by the coefficient of foreign directors' share in the board, which is expected to be positive and significant. The main purpose of this hypothesis is to define what affects innovation performance more: political ties of CEOs and directors on the board, or foreign members on the board. Foreign directors can help with communication with foreign corporations and obtaining access to technologies that can be finished and integrated in Russia.

H_5: Interaction of political connections and state ownership does not enhance innovation activity of a firm.

State ownership, in connection with political ties of management or directors, can have a negative effect on innovation. SOEs unavoidably integrate political ties, which can lead to interruption of daily operational activity by the state, reducing efficiency. This may lead to a situation where the CEO's aim is not maximizing value, achieving state goals, which can be socially useful, for example upgrading public facilities or developing problematic regions, but could also be connected to personal interests and corruption. Wu and co-authors argue that the CEO has less an incentive, because his position could be treated as secured and irremovable in SOEs. They provide evidence that the effect of political connections decreases with the presence of government ownership in Chinese case [Wu, Liang, Shen, 2018].

H_6: State ownership and political connections have a stronger effect in resource and utility sectors.

Due to specifics of the Russian economy and the high importance of certain industries (e. g., oil and gas), it is reasonable to analyze the effect of state ownership, foreign ownership, and political connections in certain industries. Furthermore, industrial difference affects the amount of financing available. The Russian state pays much attention to such industries as oil and uses various tools to maintain price and revenue stability,

such as tax maneuvers or dampening options. The industrial sector comprises 32.4 % of GDP, and most companies from that industry still have state ownership since privatization[3]. Most exported goods are petroleum, natural gas, metals, and military equipment and weapons. This explains wide state involvement in the materials and energy sectors. Industrial companies connected with military output are controlled by the state. Another specific of industry that affects innovations is market structure. Energy, materials, and utilities sectors are the most monopolistic. Until 2008, all electricity generation was conducted by Unified Energy System of Russia (UES), which has 50 % state-owned. However, in 2008 UES was re-organized and privatized to obtain enormous investments for capital expenditures on upgrading facilities. Due to these reform, new public companies were organized, such as RusHydro (67 % state ownership), Federal Grid Company Unified Energy System of Russia (75 % state ownership), Inter Russian Joint Stock Power and Electrification company (9.24 % state ownership through FGC UES and 27.63 % through Rosneftegaz), and another 20 companies. The biggest power generation companies still have a significant amount of state ownership and involvement.

H_7: *Companies with over 50 % foreign shareholding have comparatively higher levels of R&D activity.*

According to Nagaraj, who analyzed the effect of foreign ownership on R&D activity among Indian firms, foreign ownership of more than 50 % increases the probability of new R&D activity, but does not increase R&D intensity. Foreign investors, who buy controlling shares in Indian firms, attempt to undertake R&D, but this does not increase intensity [Nagaraj, 2016].

H_8: *Foreign ownership reduces innovation activity in companies with political ties.*

Bena and co-authors, analyzing 30,000 firms in 30 countries, found that the combination of foreign ownership and the state is bad for patents [Bena et al., 2015]. Moreover, in China, according to Kong, Zhu and Yang, political connections in cooperation with foreign ownership decrease the number of patents in the energy sector [Kong, Zhu, Yang, 2020].

3. Methodology

3.1. Identifying the "innovation" variable

Before clarifying our model, we identify the "innovation" variable. James Love and Stephen Roper define innovation as "the number of new or improved products introduced at the plant level" [Love, Roper, 1999]. Patents can serve as a reliable indicator of the technological aspect of innovation, while the commercial aspect of innovation is related to and influences competitive positions and economic advantages of firms [Love, Roper, 1999]. In addition, innovation metrics, such as R&D spending or employment, are disadvantageous due to the lack of the necessary link to any tangible innovation outcomes [Mansfield, 1984]. Therefore, in our analysis we use the number of a company's patents as a key dependent variable representing R&D activity. During the collection of financial and company-specific information in Orbis Bureau Van Dijk, we found that the patent could be represented in two forms: patents filed (submitted applications for a patent to govern-

[3] Central Intelligence Agency (CIS). GDP — composition, by sector of origin. (2017) URL: https://www.cia.gov/the-world-factbook/field/gdp-composition-by-sector-of-origin/ (accessed: 20.02.2021).

ment agencies) and granted (approved applications for a patent by government agencies). Although there is no available information about the share of approved patents for Russia, according to the most recent statistics from the United States Patent and Trademark Office, approximately 52 % of all patents filed in the United States are approved[4]. Moreover, given the high share of state participation in companies in various sectors of the Russian economy, and its predominant share in the defense and natural resource extraction, refining, transportation sectors, which represent a significant share of the GDP, it is reasonable to expect a high share of filed applications for patents to be approved. Therefore, it was decided to use the sum of filled patents as the dependent variable in the econometric model. Moreover, the lag from starting research and a final patent application is smaller than the lag of patent grants and for public companies' rate of approval the patent applications is much higher by common sense.

3.2. Model description

The analysis of panel data is used by implementing the Fixed, Random effect models with special standard errors and GMM model. First, we conduct panel unit root tests to verify the stationarity of the variables. When conducting an ordinary least squares regression to estimate the model, the first-step differential GMM method is vulnerable to weak instrumental variables, thus providing biased estimates [Blundell, Bond, 1998]. To overcome the impact of weak instrumental variables, the GMM estimation method is proposed.

The main form of the econometric models used during the investigation are:

$$\begin{aligned}\mathrm{Ln}(1 + \textit{Number of Patents}) = {} & \beta_0 + \beta_1 GO_{i,t} + \beta_2 FO_{i,t} \\ & + \beta_3 LVG_{i,t-1} + \beta_4 i,t-1 + \beta_5 Growth_{i,t-1} + \beta_6 ROE_{i,t-1} + \\ & + \beta_7 CAPEX_{i,t-1} + \beta_8 AGE_{i,t} + \beta_9 FD_i + \beta_{10} DirectorPC_i + \beta_{11} CEOPC_i + \\ & + \beta_{12} ChairmanPC_i + \beta_{13} Patents_{i,t-1} + \alpha_i + u_{i,t} \end{aligned} \quad (1)$$

and

$$\begin{aligned}\mathrm{Ln}(1 + \textit{Number of Patents}) = {} & \beta_0 + \beta_1 PC_i + \\ & + \beta_2 PC_i \times \left(GO|i,t \vee FO_{i,t}\right) + \beta_3 LVG_{i,t-1} + \beta_4 i,t-1 + \beta_5 Growth_{i,t-1} + \beta_6 Profitability_{i,t-1} + \\ & + \beta_7 CAPEX_{i,t-1} + \beta_8 AGE_{i,t} + \beta_9 Patents_{i,t-1} + \alpha_i + u_{i,t}. \end{aligned} \quad (2)$$

A description of all the variables can be found in Table 2.

GMM uses differentiation to transform data to avoid discrepancies due to unobservable or missing variables and correlations between explanatory variables. When the choice of instrumental variables is appropriate, the use of GMM tracking method models can effectively manage problems of endogeneity of explanatory variables.

[4] United States Patent and Trademark Office. (2021) *U.S. Patent Statistics Chart Calendar Years 1963–2020*. URL: https://www.uspto.gov/web/offices/ac/ido/oeip/taf/us_stat.htm (accessed: 20.02.2021).

Table 2. **Description of variables used in the Generalized Method of Moments regression model**

Content of econometric model	Variables	Description
Coefficients	$\hat{a}_0$	Constant
	$\acute{a}$	Element with fixed time effects
	u	Random error term
Independent	*FO*	Share of foreign ownership (Source: Amadeus-BVD[5], Thomson Reuters[6], self-calculation)
	GO	Share of State ownership (Source: Amadeus-BVD, Thomson Reuters, self-calculation)
	GEO PC	Dummy variable for whether CEO has a public service experience (Source: self-calculation)
	Chairman PC	Dummy variable for whether Chairman of the board has a public service experience (Source: self-calculation)
	Director PC	Share of state representative in the Board of directors (Source: self-calculation)
	FD	Share of foreign shareholder representative in the Board of directors (Source: self-calculation)
	PC	Dummy variable for whether either a CEO or chairman of the board is a current or past politician, or a member of board is a state official
Control	*LVG*	Leverage of the company (Source: Bloomberg[7])
	Growth (Revenue growth)	Compounded annual growth rate of revenues (Source: Bloomberg)
	ROE	Return on equity (Source: Bloomberg)
	Age	Age of the company (Source: Bloomberg)
	CAPEX (CAPEXTA)	Capital intensity, ratio of Capital expenditures to Total Assets (Source: Bloomberg)

This paper includes return on equity, firm size, debt ratio and total revenue growth, capital intensity, and firm age as the model's explanatory variables. Leverage is an important indicator of a company's capital structure. A substantially high debt ratio indicates potential bankruptcy risks and problems with debt servicing. Specifically, potential problems with debt servicing may influence the ability of a company to finance R&D activity. On the other hand, a company can improve efficiency of its assets by increasing financial leverage to operate in high-tech industries, such as semiconductors and biotechnology, and subsequently support R&D activity. The distribution in our sample indicates that there are four of the most widely represented industries in the Russian economy, including oil and gas, materials, utilities, and industrials. However, all these industries are similar in nature, and is it not necessary to create specific dummy variables for every industry due to the lack of large and long data samples. The dummy variable *IND1* will represent the group of these

[5] Amadeus-BVD. URL: https://amadeus.bvdinfo.com/version-20211122 (accessed: 20.02.2021).

[6] Thomson Reuters. URL: https://eikon.thomsonreuters.com/index.html (accessed: 20.02.2021).

[7] Bloomberg database. URL: https://www.bloomberg.com/europe (accessed: 20.02.2021).

industries and will equal 1 if a company operates in at least one of these industries and 0 otherwise. A completely different business model is used in the IT sector, which requires much investment for digital transformation of business, high IT costs, etc. Therefore, the technology industry is represented by *IND2*, which is equal to 1 if a company operates in the technology sector and 0 otherwise. Since other industries are not as well represented in the sample, it was decided to group them all into one category. Another important explanatory variable is size, which is usually measured based on total assets. Generally, the larger the firm, the higher opportunities to invest in R&D, which translates into a higher number of patents and intangible assets. In our model, we use the natural logarithm of this variable. Next, total revenue growth reflects a company's growth trend. High growth companies can do much of research and development. In our analysis, we use the compounded annual growth rate of revenues as a natural logarithm of revenue to its past value ratio, as this it captures dynamics of company development. Capital intensity can be used as a control variable for modelling R&D intensity [Shin, Park, 2020]. Innovation activity requires capital expenditures in building special research centers, so there could be a positive relation to patent applications. Moreover, capital intense industries are more innovative, especially Russian resource extraction companies. In the short-term period, the profitability of a company plays an important role in the firm's ability to distribute profits into R&D activity and to finance all investments and IT costs. In the analysis, we use return on average equity as a metric of financial performance. The company's net profit shows the financial result and can be used as an indicator of the company's efficiency. However, net income can vary greatly depending on the size of the company, the industry in which the company operates, and so on. For this purpose, we use other control indicators. In addition, return on average equity can strongly depend on the capital structure of the company, which can complicate the search for the dependence of the dependent variable on the capital structure and the presence of foreign capital in it. The control variables are taken with a lag of one year, because the effect of firm's performance volatility does not immediately influence R&D. Usually, it takes for a year of negotiating and confirmation of research and development project, since it is resource intensive.

The share of foreign ownership is a key explanatory variable and represents the share of foreign rights in share capital of the company. In the model, the format of this variable represents the percentage from 0 to 100. The higher the ratio, the greater foreign ownership in the company. Similar to the share of foreign ownership, state shareholding represents the share of government rights in share capital. This variable lies between 0 and 100 and represents the percentage of government ownership. Both foreign and state ownership translates into the corresponding representation of shareholders on the board of directors of the company.

Nevertheless, ownership structure could be ignored. If the CEO of a company or chairman of the board of directors is a representative of the state, regardless of the share in the capital, it may influence the behavior of the firm in the field of R&D activity and investments, since she or he may have broad powers and make adjustments to the company's investment strategy. Additionally, a chairman or CEO with political ties can increase efficiency of cooperation of the company with the corresponding industry-specific authority. This can be represented in different ways, for example obtaining a permit on a certain activity, such as resource extraction. Another example is adjusting laws in favor of a company's business line. In order to increase demand native IT-companies, the law on

mandatory pre-installation of Russian software was introduced in 2021. Moreover, political ties can enhance larger and faster financing from banks, such as VEB. RF, for large and strategically important projects with budget over $ 2 billons[8]. In project finance, state relations are extremely important, because of state support proposed by the Ministry of Finance, which is unavoidable in such a type of financing. It is clear that such projects require deep research activity for developing new innovative mechanisms and products. The first two dummy variables relate to characteristics of a company's key people: CEO and chairman. The dummy variable *CEO PC* will be 1 if a CEO is a current or past state official, and 0 otherwise; similarly, the dummy variable *Chairman PC* will be 1 if a chairman is a current or past state official, and 0 otherwise. Experience of public service was obtained by analyzing the biographies of CEOs and chairmen. Most frequently chairmen and CEOs with political ties had been heads or deputy heads of ministries of related sectors, either at the federal or regional levels. Sometimes political ties were determined by being in a significant political power for a significant amount of time, or a deputy in a state council. The share of foreigners and share of current state officials' variables lie between 0 and 100 and represent the percentage value. This was calculated by analyzing the company's board of directors. State officials in the board of directors are representative of the state and usually have a high position in the Russian administration.

As the dependent variable, the number of patents as proxy for R&D activity should be used. To avoid the violation of normality assumption, dependent variable was transformed as: $\left(1+Number\ of\ Patents\right)$, since initially the variable was skewed to the right [Kong, Zhu, Yang, 2020; Bena et al., 2015; Qiao, Li, 2019].

3.3. Econometric approach

At the first step, Fixed Effect and Random effect estimation of panel dataset was conducted to check issues that can violate important assumptions. It is reasonable to expect that differences across firms do affect innovation activity, and so random effect models should be more reliable. Moreover, this model allows us to include time-invariant variables, contrary to fixed-effects model, which omits them through differencing process.

1. Heteroscedasticity issue is checked by applying the Wald test in a fixed effect model.
2. The Wooldridge test for autocorrelation was used to detect the presence of serial correlation.
3. Another important issue that might influence results is *cross-sectional dependence* or violation of $cor\left(u;u_{jt}\right)=0, for i\neq j$ assumption. An approach proposed by John Driskoll and Aart Kraay assumed that cross-sectional dependence caused by unobserved certain factors which do not correlate with included independent variables [Drisckoll, Kraay, 1998].
4. Stationarity is analyzed using the Augmented Dickey — Fuller test.
5. All predictors were checked for exogeneity. For that purpose, the Durbin — Wu — Hausman endogeneity test was applied.

[8] VEB.RF. (2021) *White paper on bank activities.* URL: https://veb.ru/en/white-paper-on-our-activities/ (accessed: 20.02.2021).

To compare Fixed and Random effect models, the Hausman Test was used. Based on the checks above, corresponding standard errors were used: Dickey — Fuller standard errors. In addition to Fixed and Random effect models with different standard errors, GMM estimation methods were used. The number of lags of dependent variable included in regression is analyzed using test for serial correlation. In order to obtain consistent estimation, the following condition should be satisfied: $E\left(\Delta y_{i(t-j)}; \Delta \varepsilon_{ij}\right) = 0\, j \geq 2$.

6. To check the validity of instruments in Difference GMM model, proposed by Blundell — Bond, the difference in Hansen/Sargan test for overidentifications of restrictions was used.

4. Data

For this study we used the Bloomberg database, Amadeus Bureau Van Dijk, Orbis Bureau Van Dijk and Thomson Reuters Eikon in order to gather: (1) number of patent applications and grants; (2) information about the balance sheet of companies considered (total assets, intangible assets, and goodwill), the industry where the firm operates, information about the financial performance and capital structure for 238 Russian-based companies; (3) data on direct and indirect foreign institutional ownership and state ownership; and (4) certain characteristics, such as political ties of the directors in the board, chairman and CEO.

This investigation examines data from 2012 to 2020 for 238 Russian companies operating in various sectors of the economy. Tables 3 and 4 show the average values of the explanatory variables by year. One of the main observations is that there are no definite dynamics in the values of indicators in the period under review.

Table 3. **Mean values of explanatory variables by year**

Variable	2012	2013	2014	2015	2016	2017	2018	2019
LVG	7.07	6.88	4.92	6.09	6.17	16.8	17.8	8.6
Size	6.01	6.04	5.64	5.51	5.73	5.84	5.77	5.94
Revenue Growth, %	–0.5	–0.4	–7.9	–3.7	0.9	19.8	0.5	–0.3
Ln(1+ Int/TA)	0.014	0.012	0.021	0.029	0.019	0.022	0.022	0.023
CAPEXTA, %	6.3	6.2	7.6	5.5	4.7	4.9	5.6	4.9
ROE, %	10.3	7.8	2.6	7.3	12.8	8.6	12.4	10.2

Based on: Bloomberg database.

Table 4. **Mean values of foreign and state capital by year**

Variable	2013	2014	2015	2016	2017	2018	2019	2020
FO, %	8.4	9	8.8	8.8	9.4	9.5	8.9	8.6
GO, %	29.6	29.9	30.3	28.9	29.6	30.1	30.3	30.6

Based on: Amadeus BVD; Thomson Reuters database.

Profitability indicators return to equity have minimal values (although they remained in the positive zone on average) during the financial crisis of 2014–2015 in Russia. In the same period, one can observe a decrease in the value of assets of companies which may be associated with weakening of Russian ruble, as well as sharp decrease of revenue growth.

Share of foreign and state capital in Russian companies remained on average unchanged from 2013 to 2020. About 30 % of the capital of Russian companies is controlled by the state, about 9 % is controlled by foreign investors.

Table 5. **Mean number of patents filed for Russian companies by year**

Patents	2013	2014	2015	2016	2017	2018	2019	2020
Granted	5.24	4.81	4.95	4.7	4.39	4.96	3.87	0.98
Applied	6.18	5.42	5.55	5.41	5.42	5.42	4.17	1

Based on: Orbis BVD database. URL: https://orbis.bvdinfo.com/ (accessed: 20.02.2021).

Table 5 shows the dynamics of the average number of filed patents across companies. This indicator as a whole in the period from 2013 to 2019 decreased from 6.1 to 4.2. This decline is more likely due to an increase in the share of companies, as well as the emergence of new companies on the market that do not have a large number of patents (more than half of all companies in our sample do not have any patents). In 2020 research and development activity decreased due to the lack of finance, caused by distress related to the COVID-19 pandemic; hence, the number of patents dropped significantly. The average value of patents granted decreased in the period from 2013 to 2019, from 5.2 to 3.8. In general, the number of filed and granted patents for companies is nearly identical. Moreover, effect of pandemic on patents is almost similar, and on average, during 2020, Russian company has one patent application and one patent granted.

Table 6. **Summary statistics of number of all patents by year**

Measure	2012	2013	2014	2015	2016	2017	2018	2019	2020
Min	0	0	0	0	0	0	0	0	0
1st quantile	0	0	0	0	0	0	0	0	0
Median	0	0	0	0	0	0	0	0	0
Mean	10.7	9.7	8.9	9.2	8.7	8.5	9.2	7.0	2.0
3rd quantile	6	4	4	4	4	4	4	4	1
Max	530	409	501	493	409	454	405	366	90

Based on: Orbis BVD database.

Table 6 provides summary table of descriptive statistics on the number of all patents held by Russian companies by year. On average, the total number of all patents fell between 2012 and 2019 from 10.7 to 7.0, and to 2.0 in 2020. It is also worth noting that the maximum value of patents for companies also decreased from 530 to 366 in 2019 and 90 in 2020, which could have a significant impact on the average value. About 75 % of all companies in our sample have no more than 4 patents during 2012–2019 and in 2020 year 75 % of companies have no more than 1 patent.

Table 7. **Summary statistics of regressors**

Variable	Min	1st quantile	Median	Mean	3rd quantile	Max
Revenue Growth, %	–432	–16.1	–2.1	–2.9	11.8	313
Size	1.63	4.14	5.5	5.8	7.3	12.9
LVG	0	1.5	2.2	9.3	4.3	2321.8
CAPEXTA	0	0.014	0.04	0.06	0.08	0.74
ROE, %	–102	0.1	7.7	8.9	19.3	413
FO, %	0	0	1	8.9	6.7	100
GO, %	0	0	5	29.9	60.9	100
Chairman PC	0	0	0	0.176	1	1
CEO PC	0	0	0	0.168	0	1
FD, %	0	0	0	0.051	0	80
Director PC, %	0	0	0	0.042	0	81.8

Based on: Bloomberg database; Amadeus BVD; Thomson Reuters database.

Table 7 shows descriptive statistics for all explanatory variables used in the regression analysis. Particularly, about 17 % of companies in the period under review were managed by a CEO from the state, and about 18 % has a politically related chairman of the board. The average company size is 5 billion rubles, the maximum value of this indicator was early 4.1 trillion rubles, reached in 2019.

Figure shows the share of companies operating in different industries. As mentioned in the previous chapter, the regression model uses two dummy variables to represent the type of industries in which a particular company in our sample operates. 78 % of all companies (*IND1* dummy variable) operate in industries such as "Energy," "Utilities," "Materials," and "Industrials." Only about 3 % of companies are engaged in IT (*IND2* dummy variable), and about 19 % in other industries. The most prevail sectors are "Industrials" and "Materials".

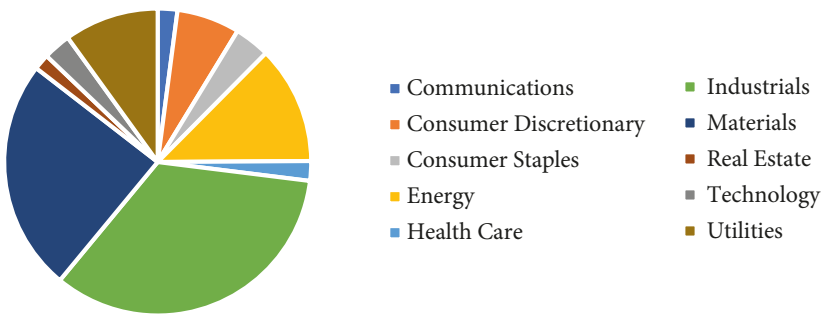

Fig. Distribution of companies by sector

Based on: Amadeus BVD.

Table 8 shows the results of the correlation analysis. It is worth noting that there is no significant relationship between the variables, although there are pairs of variables that have a moderate relationship.

Table 8. **Correlation matrix**

	Patents filled	Patents granted	*R&D Intensity*	*FO*	*GO*	*Age*	*Revenue Growth*	*Size*	*CEO political*	*Chairman political*	Foreignes share	Current politicians share	*ROE*	*Leverage*	*CAPEXTA*	*Industry*
Patents filled	1															
Patents granted	0.9853	1														
R&D Intensity	0.0318	0.0223	1													
FO	0.0215	0.0196	0.063	1												
GO	0.0706	0.0787	–0.083	–0.251	1											
Age	–0.143	–0.148	–0.079	–0.003	0.0352	1										
Revenue Growth	0.0102	0.0089	–0.031	0.0346	0.0242	0.0175	1									
Size	0.3533	0.347	0.1144	0.0413	0.0383	–0.071	0.0725	1								
CEO political	0.1793	0.1805	–0.037	–0.089	0.146	0.011	0.0137	0.2152	1							
Chairman political	0.2799	0.2842	0.0083	–0.029	0.1324	–0.016	0.025	0.3582	0.2635	1						
Foreignes share	0.1039	0.0947	0.0744	0.3659	–0.199	–0.056	0.0083	0.3423	–0.031	0.0358	1					
Current politicians share	0.2909	0.2797	–0.024	–0.054	0.1971	–0.055	0.0198	0.2412	0.2176	0.4436	–0.035	1				
ROE	0.0256	0.0127	–0.008	0.0428	–0.061	0.0526	0.0901	0.0464	–0.019	0.0158	0.0989	–0.017	1			
Leverage	–0.007	–0.008	0.0242	–0.024	0.0947	0.0495	0.0181	0.0214	0.0329	–0.015	–0.02	0.0168	–0.03	1		
CAPEXTA	0.0604	0.0656	0.0091	0.0395	–0.01	–0.102	0.0162	0.2605	0.0766	0.132	0.1914	0.0245	0.1146	–0.04	1	
Industry	–0.065	–0.069	–0.093	–0.071	0.1208	–0.149	0.0294	0.0811	0.0323	0.006	–0.1	0.0044	0.0192	0.0049	0.0851	1

5. Results

5.1. Ownership effect on patent applications

After the most appropriate models were chosen (random effect with Dickey — Fuller standard errors, Blundell — Bond GMM) the ownership type effect on patent application was estimated. Foreign ownership does not show significance in model with Government ownership, as well as in the model without. Due to high government involvement, it may be the case, that the State tries to control innovations, by not allowing to invest much in companies, that conduct different kind of research, especially in the field of defense industrial complex. The idea is, that some fraction of foreign ownership is essential, as source of financing, but it is not allowed to be greater than some fraction of equity ownership. The result of foreign ownership insignificance of Russian companies coincides with results of Kwon & Park, who studied Japanese firms' ownership structure and R&D intensity. However, they analyzed the effect of having foreign parent company from G7 countries, rather that fraction of ownership [Kwon, Park, 2018]. Their explanation is, that investors from technologically advanced companies diminish R&D intensity, because the efficiency of conducting R&D is higher in their countries. Even if foreign companies invest in domestic companies, they will prefer to receive knowledges and current development and continue developing at their research institutes. Anyway, this explanation can be extrapolated to our case, only for companies with more than 50 % of foreign ownership, meaning control rights. If we compare the results with study on Indian companies, foreign equity is insignificant [Khachoo, Sharma, 2015]. One more possible explanation is that foreign institutions invest in Russian companies due to reasons, other than innovations. Up-stream companies, from natural resource sector are attractive investment, if there is an expectation of commodity price increase. Alternatively, the investment in Russia could be conducted due to diversification reasons. Anyway, there is no evidence that foreign equity deteriorates innovations, it could simply be not such an important variable, as for example state holdings. Generally, Russian economy should be compared with such economies as Indian and Chinese, due to big role in world economy and large fraction of national companies. If we refer to China, foreign ownership does not increase number of utility patents [Qiao, Li, 2019]. Since number of patents are not divided into utility or invention, the reason for foreign ownership insignificance in Russian case could be due to prevailing number of utility patents. Teng and Yi proved negative effect of foreign ownership on R&D intensity and new product sales in China, which is a good proxy for innovation output [Teng, Yi, 2017].

Contrary to foreign ownership, there is evidence that government ownership improves patent applications. It goes with the results of other paper on Indian companies [Nagaraj, 2016]. Interestingly, that foreign ownership in paper of P. Nagaraj (2016) in model with government ownership appears to be insignificant, similarly to our case [Nagaraj, 2016]. Russia and India are developing countries, with the biggest companies in the economy — State-owned enterprises (SOEs). For that reason, most innovations are developed by companies with government ownership. Similar, relationship is observed in China [Teng, Yi, 2017].

According to Table 9, bigger and younger companies with higher government ownership have higher innovation activity in terms of patent applications. Moreover, there is a

Table 9. **Estimates of the ownership type models**

Variables	Blundell — Bond	Driscoll — Kraay RE
Lag of patents	0.151**	0.000
	(0.0666)	0.000
FO	–0.0146	0.0249
	(0.144)	(0.108)
GO	0.214**	0.244**
	(0.0975)	(0.0971)
Age	–0.0156**	–0.0192**
	(0.00705)	(0.00773)
Size	0.248***	0.265***
	(0.0301)	(0.0420)
Revenue Growth	0.00260	–0.0189
	(0.0577)	(0.0197)
ROE	0.0421	0.0243
	(0.115)	(0.0536)
Leverage	–0.000333	–6.43e-05
	(0.000290)	(5.78e-05)
CAPEXTA	–0.218	–0.300**
	(0.453)	(0.105)
Constant	–1.449***	–1.502***
	(0.348)	(0.307)

Note. Robust standard errors in parentheses; *** — $p < 0.01$; ** — $p < 0.05$; * — $p < 0.1$.

significance of lagged value of patent applications, which means, that company with high number of patent applications in certain year is expected to have high number of patent applications in the following year too. Non-linear effect of age was included in the additional model, but no evidence of non-linear relationship was found [Corsi, Prencipe, 2017]. There is evidence that younger firms tend to innovate in higher degree, than mature companies in China and India [Wang et al., 2018; Khachoo, Sharma, 2015]. Thought, the coefficient is not big, in Russia there is also evidence that younger firms innovate heavier. The logic, that younger firms more are more likely participate in risky projects with R&D holds. But there are no too mature companies in Russia, since the registration date is usually in 90s, during the period of privatization. That is why, non-linear effect of age was not confirmed.

Capital intensity's negative coefficient in Driscoll — Kraay model represents, that firms with larger capital to total assets ratio innovate less [Shin, Park, 2020]. The only reason for such results is that companies, that have huge amount of total assets have already conducted the necessary amount of capital expenditures. That is why, ratio of capital expenditures to total assets is low. It is reasonable, since there is a big lag of time between capital expenditures and R&D activity. Furthermore, there is no evidence of significance of capital intensity in dynamic model. Both regressions control for time and industry. Industries are

significant, except real estate industry. It is quite reasonable, since real estate industry is not innovative industry. Time is significant in Blundell — Bond model only at year 2020. It is also very expected, due to COVID-19 and critical drop of innovation activity in Russia.

5.2. Relationship of political ties and foreign directors with patents

Positive effect of political ties is confirmed in Russia, in line with Chinese study [Wu et al.; Liang, Shen, 2018]. Chinese and Russian companies need assets renovation, which is boosted by presence of political ties; consequently it helps to increase R&D activity. However, Wu and co-authors do not separate the politically related chairman of the board and CEO. Political connections of CEO and Chairman are different: chairman has better control on company's governance, while CEO makes strategic actions. Positive effect of chairman of the board of directors with political connections, represented by work experience in public sector, is under no doubt. According to the System-GMM model, company with politically related chairman has 0.36 patent applications more, on average, at 1 % significance level (Table 10). However, political ties of CEO of the company are significant only at 10 %. According to this, it is possible to conclude, that political ties of chairman affect innovation activity more, than CEO's. Since there is a common opinion of higher importance of chairman in comparison to CEO due to more power, the results are believable. Moreover, there is evidence that current government officials in the board of directors do not lead to higher number of patent applications. At the same time, the share of foreign ownership in the company has nothing with patent applications of the firm. This result can be explained in terms of lack of bargaining power of foreign investors in Russia and coincides with the results of insignificance of foreign ownership. Our results contradict the results of Wang and co-authors, who determine negative influence of political connections on R&D intensity [Wang et al., 2018]. Nevertheless, there are different issues in two approaches. They analyzed a sample of Chinese private companies, while in our case; the sample consists of public companies only. This means that there is a difference in political connections, since more powerful past state officials worked in public companies, rather than in private firms. A project, that requires deep research activity is commonly referred to as highly important and is not a day-to-day operational activity. This is why chairmen of boards control the fulfilment of all project targets and goals during all relevant stages. Given the relatively large scale of a project, it is the competence of chairmen, rather than CEOs. As R&D does not increase operational revenue immediately and is risky, CEOs prefer to concentrate on management and increasing production efficiency. Today, the Russian state has a vector of digitalization, and directors of SOEs are more likely to lobby innovations.

Thus, the general conclusions on the hypotheses 1–4:

H_1: *The foreign participation in share capital of the firm will positively affect the innovation activity of the firm* — Rejected.

H_2: *The participation of the state in share capital of the firm positively affects the innovation activity of the firm* — Not rejected.

H_3: *Political connections of directors and CEO have a positive effect on innovation performance* — Not rejected.

H_4: *Presence of foreign member in the board of directors will promote innovations of the company* — Rejected.

Table 10. **Estimates of political ties and foreign directors**

Variables	Blundell — Bond
CEO PC	0.205*
	(0.113)
Chairman PC	0.358***
	(0.132)
FD	0.00670
	(0.310)
Director PC	0.538
	(0.584)
Age	–0.0137**
	(0.00682)
Revenue Growth	0.00588
	(0.0555)
Size	0.198***
	(0.0276)
ROE	0.0343
	(0.114)
Leverage	–0.000239
	(0.000290)
CAPEXTA	–0.299
	(0.441)
Lag of Patents	0.183***
	(0.0679)
Constant	–1.1949 (0.000)

Note. Robust standard errors in parentheses: *** — $p < 0.01$; ** — $p < 0.05$; * — $p < 0.1$.

In order to analyze the interaction of state ownership and political connections vis-à-vis a firm's innovative activity, a new variable was constructed that is equal to the product of state ownership and political connections. Political connection is the new dummy variable, which is equal to 1 if either a CEO or chairman of the board is a current or past politician, or a member of board is a state official. The idea is to check whether political ties have effectiveness for companies with no state ownership or if the positive effect political ties is stronger for companies with state ownership. Unlike the results of Wu and co-authors, who found that the effect of political connections decreases with the presence of state ownership in China, our results suggest that state ownership boosts the effect of political connections [Wu, Liang, Shen, 2018] (Table 11). The possible explanation is that there is a possible efficiency in cooperation between managers and shareholders, since they both represent The Government, thus a reduction in agency problem.

Table 11. **Estimates of interaction of political ties and State ownership**

Variables	Driscoll — Kraay RE	Blundell — Bond Dynamic nature
PC	0.279*	0.122
	(0.137)	(0.0995)
GO×PC	0.222**	0.471**
	(0.0664)	(0.198)
Age	–0.0172**	–0.00764
	(0.00641)	(0.00698)
Revenue Growth	–0.0181	0.0281
	(0.0182)	(0.0597)
Size	0.240***	0.181***
	(0.0345)	(0.0296)
ROE	0.0248	0.0630
	(0.0535)	(0.102)
Leverage	–6.30e-05	–0.000234
	(6.51e-05)	(0.000376)
CAPEXTA	–0.335**	–1.026**
	(0.105)	(0.486)
Lag of patents	–	0.162**
	–	(0.0673)
Constant	–1.461***	–0.381**
	(0.300)	(0.178)

Note. Robust standard errors in parentheses: *** — $p < 0.01$; ** — $p < 0.05$; * — $p < 0.1$; *GO×PC* — Government ownership with political connections.

The Blundell — Bond model reveals significance of both chairmen and CEOs with political ties for innovation activity in the natural resource industry. The reason for the high importance of relations with the state lies in the high concentration of state holdings in such sectors of the economy, and in connection with the political course of Russia, which pays the greatest attention to mining throughout its history. Contrary to research on the Chinese energy sector by D. Kong and co-authors [Kong, Zhu, Yang, 2020], government relations promote patent applications. The reason for the difference between China and Russia in patent determinants in the energy sector is level of state ownership. The biggest Russian companies with state ownership have state holdings of approximately 45–50 %, while the Chinese government owns nearly 85–88 % of shares of energy and oil companies. this leads to a lack of power for minority shareholders and, as we can see from the results, deteriorates innovations. In comparison to China, the Russian state's share in energy sector companies is optimal (Table 12).

In Russia, in contrast to India, controlling foreign ownership does not increase innovations (Table 13) [Nagaraj, 2016]. Companies with over 50 % foreign shareholding do not have a comparatively higher level of R&D activity, according to the Blundell — Bond model. The business climate for companies with dominant foreign ownership is rather

Table 12. **Estimates of political ties and government ownership in resource industry**

Variables	Blundell — Bond	
	Resource industries	Other industries
GO	0.197**	–0.112
	(0.0903)	(0.0982)
Chairman PC	0.348***	0.289
	(0.134)	(0.261)
CEO PC	0.232*	–0.241
	(0.134)	(0.155)
Directors PC	0.600	0.240
	(0.588)	(1.061)
Age	–0.0119*	0.00803
	(0.00709)	(0.0106)
Revenue Growth	0.0430	0.0570
	(0.0813)	(0.0579)
Size	0.190***	0.0573**
	(0.0299)	(0.0252)
ROE	0.0714	–0.218
	(0.108)	(0.136)
Leverage	–0.000240	0.000912
	(0.000302)	(0.00653)
CAPEXTA	–1.417**	0.0736
	(0.596)	(0.355)
Lag of patents	0.202***	0.157
	(0.0743)	(0.182)

Note. Robust standard errors in parentheses: *** — $p < 0.01$; ** — $p < 0.05$; * — $p < 0.1$.

severe. This can be due to unwillingness of firms from the same industry and public organizations to cooperate on research activity. Also, it can be more efficient and cheaper to do R&D outside Russia through subsidiaries that are registered abroad and thus are not represented in the sample. If a foreign company has a controlling share in a Russian company (assuming it is not a financial organization), it will more likely undertake innovation activity and register it abroad.

There is small evidence of a negative effect of foreign ownership becoming positive with the presence of political ties. The presence of political connections is beneficial not only for state-owned companies, but also for foreign companies. This means that cooperation between foreign investors and political related managers and directors exists at the 10 % significance level, and we have proved that political ties are a good predictor of innovations.

Thus, general conclusions for hypotheses 5–7:

H_5: *Interaction of political connections and state ownership does not enhance innovation activity of a firm* — Rejected.

Table 13. **Estimates of controlling foreign ownership and political ties in companies with foreign equity**

Variables	Blundell — Bond	
	Foreign ownership	Political ties
FO	–0.0974	–0.270**
	(0.140)	(0.122)
FO 50	0.108	–
	(0.118)	–
FO×PC	–	1.139*
	–	(0.636)
Age	–0.0151**	–0.0124*
	(0.00718)	(0.00686)
Growth	0.00401	0.00888
	(0.0572)	(0.0555)
Size	0.256***	0.239***
	(0.0313)	(0.0301)
ROE	0.0325	0.00197
	(0.114)	(0.0992)
Leverage	–0.000271	–0.000261
	(0.000291)	(0.000278)
CAPEXTA	–0.263	–0.151
	(0.459)	(0.426)
Lag of patents	0.155**	0.155**
	(0.0677)	(0.0677)

Note. Robust standard errors in parentheses: *** — $p < 0.01$; ** — $p < 0.05$; * — $p < 0.1$; *FO 50* — Foreign ownership of more than 50 %; *FO×PC* — Foreign ownership with political connections.

H_6: *Presence of state ownership and political connections has a stronger effect in resource and utility sectors* — Not rejected.

H_7: *Companies with over 50 % of foreign shareholding have a comparatively higher level of R&D activity* — Rejected.

H_8: *Foreign ownership deteriorates innovation activity in companies with political ties* — Rejected.

5.3. Robustness test

The number of patents from the dataset is subject to overdispersion. This means that conditional variance of patents is much higher than its conditional mean value. A negative binomial model can be used to cover overdispersion in a count data model. To apply a negative binomial model, a regression with dependent variable equal to number of patents applied without logarithmic transformation was used. Since there is no opportunity to specify overdispersion precisely, Generalized Negative Binomial model, rather than Negative Binomial 1 model, is consistent [Hall, Griliches, Hausman, 1984]. Since our dataset is subject to heteroscedasticity and autocorrelation, bootstrap standard errors were used to

Table 14. **Estimates in generalized negative binomial model (dependent variable is number of patents applied)**

Variables	Applied patents	Granted patents
FO	–0.0213	–0.0129
	(0.479)	(0.345)
GO	0.496*	0.607***
	(0.269)	(0.224)
Age	–0.0295**	–0.0330**
	(0.0118)	(0.0153)
Revenue Growth	–0.0528	–0.0602
	(0.115)	(0.114)
Size	0.244***	0.261***
	(0.0370)	(0.0386)
ROE	0.0551	0.0952
	(0.0917)	(0.112)
Leverage	7.62e-05	7.87e-05
	(0.00503)	(0.00407)
CAPEXTA	–0.438	–0.313
	(1.311)	(1.380)
Constant	–1.276***	–1.313***
	(0.393)	(0.479)

Note. Robust standard errors in parentheses: *** — $p < 0.01$; ** — $p < 0.05$; * — $p < 0.1$.

obtain the most appropriate estimates. Moreover, the dependent variable was represented by filled and granted number of patents to check whether there is some difference in results (Table 14).

Results are almost similar: state ownership is significant and foreign ownership is not. Furthermore, there is evidence of a significant negative effect of age of patents granted and applied that does not tell much, since a prevailing number of Russian companies have foundation dates during privatization of the 1990's. This does not necessarily mean that a firm's activity started at the foundation date, because it could have operated earlier as a public organization or subsidiary of a certain Ministry or had been comprised of state assets, especially in the natural resource sector. Also, the significance of the size variable is confirmed in a robust check, and bigger firms tend to innovate more. Generalized negative binomial model gives the opportunity to calculate margins for different levels of state ownership or foreign ownership, given all other variables at their mean values.

The resulting margins suggest a linear effect of state ownership for R&D. All margins are significant, so we can conclude that, for a firm with 20 % state ownership, the average number of patent applications for a year is equal to 1 and granted patents is equal to 1, given that all other predictors are at their means, except foreign ownership (Table 15).

Moreover, a proxy for R&D intensity is the form of $log\left(1+\frac{IntangibleAssets_{i,t-1}}{TotalAssets_{i,t-1}}\right)$ as a predictor of patent applications or grants in the following year. The same logic was

Table 15. **Government ownership margins**

GO, %	*FO*, %	Margins	
		Patents filled	Patents grants
0	0	0.9039*	0.9292*
20	0	0.9732*	1.0266*
40	0	1.0479*	1.1343*
60	0	1.1283*	1.2533*
80	0	1.2149*	1.3846*
100	0	1.3082*	1.5299*

Note. Robust standard errors in parentheses: * — $p < 0.01$.

covered by Corsi and Prencipe, but they did not find any significance of R&D intensity in modelling patent applications in European firms [Corsi, Prencipe, 2017]. In addition, there is no evidence of a relationship between innovation input, covered by R&D intensity and innovation output, covered by patent applications in listed companies in NYSE (New York Stock Exchange) and National Association of Securities Dealers Automated Quotation NASDAQ [Rahul, Parthiban, 1996]. However, studies of Chinese R&D provide different results [Qiao, Li, 2019].

The usage of a proxy for R&D intensity is n doubt, since this variable is not significant. However, there is still evidence of the significance of state ownership on the issue of patents. The evidence of the superiority of political ties of chairman over those of the CEO is justified again (Table 16).

Table 16. **Estimates in generalized negative binomial model (dependent variable is the form of log)**

Variables	Patents	
	Applied	Granted
Model without political connections		
FO	0.0831	0.144
	(0.681)	(0.565)
GO	0.593**	0.713***
	(0.277)	(0.268)
R&D intensity	–0.0533	0.363
	(1.409)	(1.697)
Age	–0.0434***	–0.0469***
	(0.0167)	(0.0139)
Growth	–0.00771	0.00438
	(0.128)	(0.133)
ROE	0.131	0.162**
	(0.0932)	(0.0797)
Leverage	6.64e-05	8.00e-05
	(0.00585)	(0.00522)

Variables	Patents	
	Applied	**Granted**
Constant	0.650	0.722**
	(0.397)	(0.352)
Model with political connections		
CEO PC	0.274	0.281
	(0.323)	(0.296)
Chairman PC	0.522**	0.581*
	(0.254)	(0.347)
FD	2.101***	2.032***
	(0.664)	(0.555)
Director PC	0.389	0.678
	(0.928)	(1.145)
R&D intensity	0.345	0.804
	(2.105)	(1.390)
Age	–0.037**	–0.0406***
	(0.0166)	(0.0144)
Growth	0.0225	0.0318
	(0.121)	(0.120)
ROE	0.0703	0.0946
	(0.0671)	(0.0879)
Leverage	0.0002	0.0002
	(0.0026)	(0.003)
Constant	0.351	0.419
	(0.383)	(0.423)

Note. Robust standard errors in parentheses: *** — $p < 0.01$; ** — $p < 0.05$; * — $p < 0.1$.

Foreign directors appear to have a positive effect on a company's innovations. Margins of foreign directors is significant up to 60 % only, so we can conclude that companies with a foreign share in the board equal to 60 % will apply for 2 patents, on average, holding other variables at their mean values (Table 17).

Table 17. **Foreign directors margins**

Share of foreign directors, %	Margins	
	Patents filled	**Patents grants**
0	0.9201***	0.9819***
20	1.4662***	1.5459***
40	2.3365***	2.4337***
60	3.7234***	3.8315***
80	5.9334**	6.032**
100	9.4551*	9.4964*

Note. Robust standard errors in parentheses: *** — $p < 0.01$; ** — $p < 0.05$; * — $p < 0.1$.

Conclusion

In this paper was conducted that clearly reveals the relationship between the type of capital (foreign and domestic) and of a company's innovation activity. We found that state participation in share capital of a firm will positively affect R&D, but foreign ownership has a rather weak effect on innovation performance. Moreover, it has not been proven for certain that companies with over 50 % foreign shareholding have a comparatively higher level of R&D activity. There is evidence that foreign directors alter innovations in a positive manner. Since foreign directors are representatives of foreign investors, we can conclude that there is an effect of foreign ownership, but it is less pronounced. An increase in state ownership is a good signal of a company's upcoming future innovation performance. Foreign ownership has less importance in determining innovation activity. Foreign investment in Russian companies is low due to high country risk. Instability rises from international sanctions, political crises in CIS countries, and certain events, such as Russian interference in U. S. elections or usage of chemical weapons. Consequently, two possible reasons for non-significance of foreign ownership on patent applications are possible: first, foreign ownership is rather low in comparison to state ownership, so it is not indicative; and second, business activity in Russia with associated R&D activity can be conducted by foreign companies' affiliates directly. Furthermore, the portion of foreign investment in Russian companies could be minor, relative to investment of special purpose vehicles registered abroad for tax savings and beneficiary ownership concealment. From the perspectives of foreign ownership, Russia is similar to India, China, and South Korea, since other authors also found insignificance of foreign investment on innovations. We have found a negative relationship between age of a company and patent applications and a positive effect of size.

Next, companies with a chairman of the board of directors who has political ties has a higher level of R&D activity. The significance of a politically related CEO was also noticed, but to a lower extent. The chairman of the board is more important than the CEO, so his/her political ties are more efficient and pronounced. An alternative model highlighted the share of foreign directors to the total board of directors as a significant predictor. The possible reason is that only industry-leading companies have foreign directors on the board and the model does not control for a size variable.

There is evidence that political connections are effective only for companies with some fraction of state ownership. Consequently, the most innovative companies are state-owned firms with chairmen in the board who have political ties. Concentration in industries connected with resource extraction and manufacturing is a specific of the Russian economy. State ownership and political ties play a role only in resource-based industries.

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Роль иностранного и национального капитала в инновационной деятельности российских компаний

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Традиционно структура капитала определяет перспективы роста компании, оказывая влияние в том числе на ее инвестиционную активность. В статье рассматривается, какой вид капитала (иностранный или национальный) в большей степени стимулирует инновационную активность компании, в качестве индикатора которой выступает количество заявок на патент. Исследование выполнено на основе 238 публичных российских компаний в период 2012–2020 гг. по разным отраслям. Результаты исследования показывают, что национальные и иностранные инвесторы влияют на инновации в разной степени: национальный капитал положительно влияет на количество поданных заявок на патент, а зарубежный капитал подобного влияния не оказывает. В дополнение исследуется влияние политических связей и структуры совета директоров на процедуру R&D (Research and Development, исследования и разработки). Политические связи руководителей (генеральных директоров и председателей совета директоров) выражены наличием опыта работы на государственной службе. Наличие такого опыта у руководства компании повышает инновационную деятельность компании. Установлено, что влияние политических связей генерального директора и председателя совета директоров неоднородны. Вместе с тем доказано, что данные связи эффективны только в компаниях с государственным капиталом в некоторых отраслях. Государственный капитал и политические связи руководства компании положительно влияют на количество поданных заявок на патент в энергетических и промышленных отраслях. При этом наличие данных связей положительно сказывается также и на роли иностранного

капитала в инновациях. Доля иностранных директоров, в отличие от доли чиновников в совете директоров, положительно влияет на получение патентов, хотя эта связь подтверждается только одной эконометрической моделью. Кроме того, выявлено, что на получение патентов в будущем влияет наличие патентов прошлых лет, а также возраст и размер компании влияет на получение патентов в будущем.

Ключевые слова: R&D, инновации, патенты, иностранные инвестиции, государственный капитал, политические связи.

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