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THE ROLE OF CEO CHARACTERISTICS IN FIRM INNOVATIVE PERFORMANCE: A COMPARATIVE ANALYSIS OF EU COUNTRIES AND RUSSIA [4]

In this paper, we investigate whether CEO characteristics (owner-manager status, age and gender) influence firm innovative performance and test empirically if the effect differs for market and transition economies. We use cross-sectional data of manufacturing firms in six EU countries and in Russia. To address heterogeneity, we explore innovation performance by size among SMEs and large businesses and by Pavitt sector. In both institutional settings, the presence of a family CEO either has no effect or improves innovative performance. On the contrary, the role of CEO gender is different in Russia and in the EU. In the EU, female CEOs are associated with less innovation, especially in SMEs and in the traditional sector. In Russia, CEO gender is not associated with differences in innovative performance and when it is (for the traditional sector), it favors female-run firms. For CEO age, considering product innovations, the oldest group of CEOs are less active in European firms while mature CEOs are more innovative in Russia.

Keywords: CEO age, gender, manager-owner status, innovation, manufacturing firms

JEL codes D21, L60, P50

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1. Introduction

In developed economies, innovations are considered the main drivers of firm competitiveness and sustainable economic growth. Nevertheless, there is considerable heterogeneity in innovation activity as well as in other firms' performance indicators. Theoretical and empirical research has shown links between innovations and different features of a firm, such as size, quality of human resources, R&D spending, and international activity. Yet the impact of CEO characteristics on innovation has been studied less intensively, although the role of the CEOs on the strategic choice and the implementation of innovation is crucial. This paper aims to add to the knowledge of the role of CEO characteristics in innovation by conducting a comparative analysis of six developed European economies and one transition economy—Russia.

Although the role of CEOs had been extensively studied, especially in the context of publicly traded US companies, several gaps in this area of research still remain (Bertrand, 2009). In particular, little is known about how similar the CEOs of transition economies are to their peers in the West in terms of basic characteristics such as age, gender, educational level, tenure, and owner-manager status and how significant these characteristics are in overall firm performance, including innovation output. After more than 25 years of transition from a planned to a market economy, a substantial part of the former Soviet managerial elite has obtained the status of key owners of their enterprises and, by combining owner-manager status, transformed their firms into family businesses. The process of succession has begun but is at a very early stage. Another cohort of Russian CEOs, hired managers without a stake in ownership, is now replacing those who built their career within the Soviet system. Senior management have changed significantly during the transition period as a new generation of managers with a modern, market-oriented educational background appeared.

The main purpose of the paper is to analyze the influence that CEO individual characteristics, including family manager-owner status, have on firm innovative performance and to test empirically whether the effect differs for market and transition economies. The focus on CEO characteristics is important as strategic choices of whether to launch costly innovation projects are made by senior management.

The theoretical background of the paper is based on the upper echelons theory, while owner-manager incentives and the opportunities and costs of innovation are analyzed through the lens of agency theory. Such a combination of theories can be fruitful in overcoming the limitations of each theory separately (Wright et al., 2012).

To date, there has been little research into the role of CEOs on innovation, taking into account CEO family owner-manager status and demographic characteristics. First, we explore how the

innovative performance of firms is associated with the role of CEOs who are the most powerful decision-makers in firms. We build our research on the intersection of upper echelon and agency theories taking into account CEO family owner-manager status. This status gives the CEO more managerial discretion in the identification and implementation of strategy. Second, as regards innovation and the CEO, we explore the role of age which is not only a demographic indicator but also a proxy for professional expertise and a stock of intangible capabilities like network relations with different stakeholders, which could serve as an important source of knowledge, especially in transition economies. Third, we pay special attention to gender and innovation. Despite progress in recent years, women are still underrepresented in senior management positions all over the world. Emerging economies, however, demonstrate better gender diversity in senior management than EU countries. According to a Grant Thornton survey (2018) in Eastern Europe, including Russia, 36% of senior management roles are held by women. This share is even higher (41%) in Russia, while it is only 27% in EU countries (Grant Thornton, 2018, p. 10–11). The share of women is significantly lower in CEO positions than in other senior management positions both in EU and in Russia. Still, we presume that the impact of CEO gender on innovative activity may depend on the different institutional and socio-cultural contexts of mature and transition economies, which support or hinder the innovation performance of firms managed by female CEOs.

For the empirical analysis, we use two databases that collect data from two surveys sharing a comparable survey design and questionnaire, covering manufacturing firms with more than 10 employees in the EU and in Russia. Our cross-sectional data cover small, medium and large firms, both private and publicly listed. The surveys report information on product and process innovation, and a set of CEO characteristics (age, gender and ownership status). Our empirical strategy considers the fact that firms could be involved in product and process innovations simultaneously.

The rest of the paper is organized as follows. Section 2 discusses the theoretical background and formulates the hypotheses. Section 3 presents the data, the econometric model, and the empirical results. Section 4 concludes the paper.

2. Background and hypotheses

Whether to be involved in innovation according to upper echelons theory (Hambrick and Mason, 1984; Finkelstein & Hambrick, 1996) is the CEO's strategic choice, generated by the analysis of information on market opportunities. Scanning, filtering and generalizing information are subjective assessments of the external business environment (Cho and Hambrick, 2006). The

outcomes of these processes are not free from cognitive bias due to mental constructs based on individual characteristics. For instance, CEOs with technical backgrounds are interested in new technologies and pay more attention to R&D (Barker and Mueller, 2002). According to upper echelons theory, the unobservable cognitive attitudes of CEOs or other senior management are associated with observable demographic or other individual characteristics (level of education, work experience etc.) and thus the former could be used as proxies bearing in mind the bounded rationality of subjects (Hambrick, 2007).

Innovation activities are an outcome of firm strategic choices made by CEOs, which reflect their level of entrepreneurial orientation and ability to develop and implement a strategy that will strengthen the firm's competitiveness. The role of CEO entrepreneurial orientation (EO), conceptualized as the senior management's strategy, is crucial. EO was initially treated as a three-dimensional construct of innovativeness, proactiveness, and risk taking (Miller, 1983; 2011; Miller & Friesen, 1978, Cools and Van den Broeck, 2007), while later researchers added two further characteristics, competitive aggressiveness and autonomy (Lumpkin and Dess, 1996; Pearce, Fritz, and Davis, 2010).

The CEO contributes to innovation performance by (Tellis et al, 2012):

- identifying new market opportunities,
- making decisions on investments in innovation,
- coordinating and managing relations with key stakeholders (customers, investors, partners and employees)
- creating a corporate culture with shared values and attitudes.

Uncertainty regarding the outcomes of innovation, especially of R&D projects, requires CEOs to have a long-term orientation, confidence, profound industrial expertise and a deep understanding of the firm's current and future capabilities. This means that a fruitful approach to studying the role of CEOs in innovation performance is to take into account not only mental constructs as proposed in upper echelons theory, but also the incentives of key-decision makers addressed in agency theory. This intersection of theories provides opportunities for a more profound understanding of the CEOs' role from different perspectives (Wright et al., 2012). In the following sections, we discuss our hypotheses concerning the three CEO characteristics analyzed in this paper.

2.1. CEO status as family owner-manager

CEO-owners are powerful players due to their role in the corporate behavior of firms. Agency theory (Fama and Jensen, 1983) suggests that the owner-manager duality has both positive and negative consequences. The former are associated with lower agency costs of monitoring, longer time horizons, the ability to raise sizeable amounts of investment for R&D and innovation on

which to build up firm capabilities. Family owner-managers might be more able to initiate the rapid implementation of these strategic decisions. However, family CEOs with ownership control might ignore the interests of minority shareholders and appropriate their resources (Shleifer and Vishny, 1997), be excessively risky or concentrate on socio-emotional wealth preferences (Le Breton Miller et al, 2015). As EO and talent are key resources for successful innovation (Le Breton Miller et al, 2015), empirical evidence provides support for the positive role of family-managed firms, especially founder-CEO firms (Block et al., 2013; Duran et al., 2016; Puri and Robinson, 2013). These CEOs are less risk averse and more likely to value and provide an EO in their management style (Mousa and Wales, 2012). After the founder's departure, the EO of successors tends to weaken. Results of large-scale surveys provide evidence of the negative role of descendants in firm performance (Villalonga and Amit, 2006; Bloom and Reenen, 2007; Block, 2012, Pérez-González, 2006, Bennedsen et al., 2007) due to nepotism and the lack of competent managers within the family group.

A meta-analysis of 108 studies covering 42 countries provided by Duran et al. (2016) showed that family firms had significantly smaller innovation inputs than non-family firms, but obtained more outputs, i.e., more effectively managed their available resources. According to upper echelon theory, this is due to executives' power and managerial discretion (Finkelstein and Hambrick, 1990) in the absence of the separation of family ownership and control. Early generations of family firms have been found to demonstrate higher levels of risk propensity (Kraiczy, Hack, & Kellermanns, 2015) and in this sense we might expect that family owner-managers in Russia, where family businesses have appeared only since the beginning of 1990s, might be more disposed to start risky ventures. However, the institutional setting in which firms operate provides a strong boundary condition (Hoskisson et al., 2017). In the extremely turbulent business environment and institutional voids in Russia's transition economy,[5] innovations are not rewarded in the short and medium term. This may reduce incentives for innovation and weaken the first-generation CEO-owner effect. The discussion in this section implies:

Hypothesis 1. Both for EU countries and Russia, we expect that the presence of a CEO from the family who owns the firm to be associated with more active firm innovative performance by virtue of higher levels of managerial discretion, i.e., more opportunities to concentrate family firm resources, implement independent decisions and monitor outcomes.

2.2. CEO demographic characteristics: Age

Regarding age, older chief executives tend to be more conservative and risk adverse (Hambrick and Mason, 1984; Bertrand and Shoar, 2003) and may be less amenable to new ideas and new

[5] Weak protection of property rights and high level of corruption are among the most severe obstacles that hinder risk-propensity of Russian entrepreneurs.

behaviors. Younger CEOs, having completed their education more recently are, therefore, more likely to have acquired new technical skills and are more disposed to using new knowledge from open innovation sources. The incentives for CEOs of different ages also differ. Innovation may be risky and the benefits, if any, will come in the long term, by which time older CEOs may have retired. Therefore, younger CEO invest more in R&D (Barker & Muller, 2002; Serfling, 2014).

CEO age might be also treated as a proxy for accumulated industry and professional expertise which could help to recognize and seize new market opportunities and trends. Moreover, older CEOs are likely to have more social and political networks with related institutions and people (partners, banks, business-associations, skilled workers, government officials). Faleye et al. (2014) using a sample of 1,532 firms indexed by Standard & Poors, found that better-connected CEOs invest more in R&D and create more innovation measured by the number of patents. The quality of their patents is also higher suggesting benefits from access to network information.

In the context of transitional economies, the value of networks and political connections may be even higher as they could leverage to some extent the burden of the unstable institutional environment and in that way could contribute positively to innovation performance. Empirical evidence for China (Lin et al., 2011) demonstrates that political connections are positively associated with innovation.

For transition economies specific selection effects of CEO-owners, besides the networking effect, must be taken into account due to privatization. In Russia, privatization initially benefited the senior management of enterprises and the redistribution of property rights often led to the concentration of ownership and management in hands of former Soviet executives. Thus, this category of CEOs still constitutes a considerable proportion of the older group of senior management in Russian manufacturing.

Due to managerial incentives and accumulated human capital these managers navigated the transition of their firms from a planned to a market economy. The most successful adjusted to the new market environment (Iwasaki et al., 2018).[6] Further, under competitive pressure, managerial ownership in Russian manufacturing was found to be associated with R&D and innovation (Bessonova and Gonchar, 2017). The discussion to this point suggests:

Hypothesis 2. The age of CEOs has an impact on innovative performance in mature and transition economies. In developed market economies, such as the EU, firms with the older CEOs are less active in innovation than firms with younger CEOs, while in Russia, on the contrary, we expect to find superior innovation performance.

[6] Usually, these firms have undergone considerable restructuring

2.3. CEO demographic characteristics: Gender

From a theoretical perspective, the influence of CEO gender on innovation can be seen through the lens of risk-propensity, educational background, and economic opportunity.

The literature on gender differences in risk-taking demonstrates that women, on average, are more risk-adverse than men (Crozon and Gneezy, 2009), especially in corporate risk-taking (Faccio et al, 2016; Jeong and Harrison, 2017). Female managers more often choose less risky industries for their career (Hoang et al, 2019). In relation to innovation inputs, Elsaid and Ursel (2011), using a sample of North American firms, found out that a change in CEO from male to female is associated with a decrease in R&D spending. Similar results were revealed in the surveys of business owners in the US and Germany which demonstrated gender-related differences in relation to R&D expenditure even when a large set of controls was incorporated in the estimations (OECD, 2012, p. 338). Since innovation is a risky activity, we could, therefore, expect that firms with a female CEO are less innovative than firms with a male CEO.

A second strand of literature argues that the type of formal education is likely to influence innovation. Here both the level of education and the field matters. For Denmark, Smith et al. (2006) showed that a higher proportion of females in senior management or having a female as CEO had a positive effect on performance, and this positive effect is driven by the qualifications of female senior managers. For innovation, not only might the general level of CEO qualifications matter, but also whether the field of their technical expertise helps to identify new market opportunities. In the manufacturing sector, engineering, natural or computer science graduates may facilitate innovation more than arts graduates (Marvel, 2015). Research has shown that women in tertiary education tend to pursue degrees in education, cultural studies and health and welfare to a greater extent than men, who are more drawn to technical fields of study (Marvel, 2015; Strohmeyer and Tonoyan, 2005). Therefore, gender differences in educational background could translate into a 'female-male innovation gap' at the career stage (Strohmeyer and Tonoyan, 2005). Moreover, differences in economic opportunities for women may influence the presence of a female CEO in firms (Elango, 2017)[7] and the effect of gender on innovation (Ritter-Hayashi et al, 2016).

Russia may represent a unique case. First, in the OECD ranking of countries according to the percentage of women with at least upper secondary education, Russia appears at the top of the ranking and for tertiary education is second after Canada (OECD, 2019). Traditionally, Russia also has a high share of female students in engineering and construction (Baskakova, 2005). Second, in the planned

[7] For a sample of emerging economies (Russia not included), he found the probability of female CEO selection is higher in the case of higher country wealth and favorable institutional environment providing gender egalitarianism and humane orientation.

economy model, nearly 100% women were employed and the phenomenon of 'occupational sex segregation' (Strohmeyer and Tonoyan, 2005) was less severe. Finally, the presence of women in senior management roles (41%) is higher in Russia than the EU (27%) (Grant Thornton, 2018, p. 10–11). An explanation of the higher presence of female CEOs in Russia lies in the Soviet legacy where women often occupied positions of chief accountants or chiefs of departments for planning, which were not prestigious positions in the planned economy era. Due to the transition to a market economy in the 1990s, financial, accounting and planning skills and experience became much more valued, leading to the promotion of female managers to CEO positions. During periods of crises, start-ups with female CEOs have also played a significant role as former white-collar workers were pushed into entrepreneurship. According to Maltseva (2005, p. 34) the share of women in the professional group "CEO and General Directors at SME firms" increased from 24.2% in 1994 to 45.06% in 2002 while the share of women in total employment increased from 50.39% to 52.31%.

Empirical research devoted to gender and innovation is scant (Strohmeyer et al, 2017, Jennings and Brush, 2013, Alsos et al, 2013, Na and Shin, 2019) and the vast majority of the studies focus on Anglo-Saxon countries (Alsos et al., 2013) or Western economies (Yadav and Unni, 2016). Empirical studies in Western economies evidence a lower level of risk-taking by female CEOs (Elsaid and Ursel, 2011) and a lower level of product and process innovation, but not in marketing and organization innovation (OECD, 2012). The gender gap in innovation, in terms of breadth and depth, may be attributed to educational background and the under-representation of women in engineering and natural science (Strohmeyer and Tonoyan, 2005, Blau et al., 2014; Strohmeyer et al, 2017).

In developing countries, the gender-innovation nexus is related primarily to self-employment and small business with few exceptions. Dohse et al. (2019), based on firm-level data from more than 100 emerging and developing economies, found female owners to be more likely to introduce innovations compared with female managers. In another large single-country study of 1,043 manufacturing firms in Thailand (Singhatep and Pholphirul, 2015) female CEOs were associated with less product and process innovations compared to male ones.

As far as transition economies are concerned, research on the role of CEO gender in innovation performance is scarce. For Russia, Gundry et al. (2014), using a sample of 310 firms, demonstrated for female-owned businesses that risk-taking and entrepreneurial intensity affect opportunity recognition and innovation. Their findings challenge the notion of reduced levels of risk taking in family firms operating in the turbulent environment of transition economies at least for family firms owned and managed by women. Due to the design of the sample no evidence of male-managed firms is provided and the existence of gender gap in innovation performance

remains unknown. The small sample size limits the possibility to generalize the results to the entire population of firms in Russia. In sum, based on the literature, we expect that the impact of CEO gender on product and process innovation in manufacturing industries may exhibit differences between Western countries and Russia due to the different socio-cultural contexts and educational backgrounds and the challenges of economies in transition, which require high levels of risk taking irrespective of gender. So, we formulate:

Hypothesis 3. Female CEOs in Russia demonstrate the same level of innovation performance as male CEOs while in mature economies female CEOs are less inclined to implement product and process innovations than their male counterparts.

3. Empirical Analysis

3.1 Sample and data

The empirical analysis is based on two databases. The first is the EU-EFIGE/Bruegel-UniCredit dataset that contains data from a sample of about 14,000 manufacturing firms from seven European countries (Austria, France, Germany, Hungary, Italy, Spain and the UK). The second database is RUFIGE, which collects data on a sample of about 2,000 Russian manufacturing firms.

The main advantage of using these two datasets is that they share a comparable survey design and questionnaire. Both survey samples were constructed on the basis of the Bureau van Dijk AMADEUS database and stratified by industry (11 NACE-CLIO industry codes) and size class (10–19; 20–49; 50–250; more than 250 employees). Given the importance of large firms in national economies, their number was oversampled for both surveys. Another advantage is that both samples are based on a similar general population of firms (all firms in manufacturing industries with more than 10 employees) and, thus, consider small, medium, and large firms, both private and publicly listed.

The survey for EFIGE countries, conducted in 2010, covers mainly the three-year-period 2007–2009 and, for some questions, only 2008 (see, Altomonte & Aquilante 2012). In our empirical analysis for the EU, we do not examine Hungary which as a former ‘socialist’ country cannot be considered a mature market economy.

RUFIGE’s survey was conducted in 2014 and covers mostly 2011–2013 and for some questions to 2014. Consequently, there is a time gap of about 4 years between the European and Russian surveys. While we can presume that some characteristics, such as ownership structure (Pindado et al, 2011), age and gender of CEO tend to be relatively stable over 4 years, other indicators such as innovation may be influenced by the macroeconomic conditions. Moreover, the EFIGE

data mostly refer to 2007–2009, a period characterized by an international financial crisis. As far as the Russian survey is concerned, the innovation data refer to the period before the first wave of economic sanctions. When interpreting the results these limits have to be taken into consideration.

3.2 Econometric model

This paper contributes to the empirical literature on the role of the owner-manager status, age and gender of CEOs on innovation performance by estimating a bivariate probit model which takes into account the possibility that firms can engage simultaneously in both types of innovation: product and process innovation.[8] Firms that introduce both types of innovation represent 30% and 28% of the total for Russia and EU countries, respectively. In both surveys the standard definitions of product and process innovations are based on OECD Oslo Manual (2005).

There may be a correlation in the errors terms if there is complementarity or substitutability between product and process innovation. A correlation may also arise if there are unobservable firm-specific characteristics (e.g., technological opportunities, managerial abilities, and risk attitudes) which affect both decisions to innovate but that are not captured by the covariates. If a correlation exists, the estimates of separate equations for product and process innovation might be inefficient. The bivariate probit model allows a joint estimate of the two decisions, while taking into account the correlation between the error terms in the product and process innovation equations. The dependent variables of the model are two dummy variables that take the value 1 if the firm has carried out a product or process innovation during the three years covered by the survey and 0 otherwise. The indicators capture only the fact of innovation activities. Thus, they reflect output rather than input measures of innovation, representing successful innovative efforts and may also include the innovations occurring without formal R&D activity or patents/citations.

The focus of the paper is the analysis of the role of CEO characteristics in explaining innovative performance. The first characteristic is the CEO-ownership relationship, i.e., whether the CEO is also a controlling owner (or is a member of the family which owns the firm) or he/she is a hired manager. The second CEO characteristic is the age category: young—the reference category (less than 34 years old), mature CEOs (between 35 and 64 years old) and old CEOs (over 65s).[9]

[8] Product innovation - introduction of a good which is either new or significantly improved with respect to its fundamental characteristics; the innovation should be new to your firm, not necessarily to the market.
Process innovation - the adoption of a production technology which is either new or significantly improved; the innovation should be new to your firm; your firm has not necessarily to be the first to introduce this process.

[9] We use classes and not the number of years because the latter information is not available in the EFIGE database. By using classes, we catch the non-linear relationship between CEO age and innovation performance.

The third CEO parameter considered is gender, as a dummy variable coded as 1 if the CEO is a female and 0 if male.

The empirical model controls for certain firm characteristics selected in accordance with the literature. The first group of variables relates to the resource endowment of the firm such as R&D and Human Capital. The first is measured by the share of employees involved in R&D and the second is proxied by the share of university graduates in total number of employees. These two variables capture the ability of firms to create, exploit and transform new knowledge into new products or processes and to absorb new technologies (Becheikh, Landry & Amara, 2006).

The second group of variables is related to structural characteristics, such as size and age. Size is measured by the number of employees (in log), there are arguments supporting the innovative superiority of large firms and arguments supporting the superiority of small firms (Acs & Audretsch, 1987). Large firms may have more resources to invest in innovation, yet some authors note that small firms may have a less rigid management structure and less bureaucracy and, thus, may be more efficient innovators. This suggests a possible non-linear effect of the size (e.g., mid-size firms innovate less than both small and large firms) and this should be taken into consideration.

For age, a twofold effect on innovation may occur. Firm age, as a measure of the accumulated experience and knowledge necessary to innovate, is expected to influence firm performance positively. However, older firms may also be more likely to have developed procedures and routines that may represent a barrier to innovation (Becheikh et al, 2006). Younger firms may be more flexible, aggressive and proactive than older ones. Two classes of firm age enter the model as a dummy, one for mature firms (6–20 years) and another for old firms (over 20 years). The missing class is that of younger firms (under 6 years). For the Russian sample, we consider age grade ‘old’ as ‘before 1991’, to capture the heterogeneity of Russian firms by origin or genesis (Golikova & Kuznetsov, 2016). In our model we also consider a dummy which is coded as 1 when the firm is part of a group and 0 otherwise, as membership can provide access to more resources and knowledge that ultimately affect the individual firm’s ability to innovate.

The next group of control variables are related to the firm’s position in international markets. First, a dummy variable, coded as 1 if the firm is an exporter and 0 otherwise, is included. As knowledge takes time to filter back to the firm and to be incorporated in its activities (Salomon & Shaver 2005), a firm is considered an exporter if it has exported before the year of the survey. Competition in international markets may promote innovativeness through technological spillovers and learning by exporting (Salomon & Shaver, 2005). Second, a dummy variable is included that is coded as 1 if the firm uses imported inputs and 0 otherwise. The use of imported

inputs may allow the firm to learn new technologies and broaden its technology frontier and, thus, increase innovation output (Castellani et al. 2010; Gonchar and Kuznetsov, 2018).

Innovation inputs (i.e., R&D expenditure) are subject to the availability of financial resources. A lack of financial resources may limit the possibility to maintain innovation and attract qualified staff. This additional control on resources is necessary in order to check whether firms have opportunities to bear innovation costs regardless of the CEO's intention and ability to implement an innovation strategy. Firms in developed market economies differ radically from the firms in transition economies in the availability of external financial resources: the former have easier access to bank credit, while the latter prefer to use their own financial resources because of the high cost of borrowing. Credit constrained manufacturing firms in Central and East European countries were found to be about 30% less likely to undertake R&D than other firms (Männasoo and Meriküll, 2020). In several country and cross-country empirical studies, including those on innovation in emerging economies, strong evidence was found for the negative role of financial constraints (Savignac, 2008; Gorodnichenko and Schnitzer, 2013; Guariglia and Liu, 2014; Ayyagari et al., 2011). To control for a firm's access to external finance, we incorporate a dummy variable coded as 1 if the firm used external financing and 0 otherwise.

In addition, sector dummies have been inserted to control for industry heterogeneity.

Since the number of large firms was oversampled for both surveys, unless otherwise specified, the statistics and models are computed by applying the survey design weights. Descriptive statistics for the variables used in the models in Table 1 provide evidence for the basic differences in the structure of manufacturing firms in the EU and Russia. Russian firms innovate less than their European peers. The largest gap is in process innovation where the share of innovators among Russian firms is 1.5 times lower (43.4% vs 27.5%). There are two possible explanations. First, Russian firms are younger than European peers (the share of young firms is twice that of Europe) and, therefore, have less need to change or update technology. Another explanation is that Russian firms are more limited in their access to external finance and cannot afford large investment programs.

Table 1. Descriptive statistics for 6 EU countries and Russia

	6 EU countries		Russia	
	Mean	Std. Err.	Mean	Std. Err.
Product innovation	48.8%	0.005	40.9%	0.016
Process innovation	43.4%	0.005	27.5%	0.014
Family CEO	64.6%	0.004	21.2%	0.014
Gender CEO: male	89.5%	0.003	81.1%	0.013
Gender CEO: female	10.4%	0.003	18.9%	0.013
CEO age: young	3.1%	0.002	10.4%	0.009
CEO age: mature	85.9%	0.003	85.9%	0.011
CEO age: old	10.7%	0.003	3.7%	0.006
R&D	8.1%	0.131	2.3%	0.263
Human Capital	9.0%	0.121	34.7%	0.685
Exporter	61.7%	0.005	15.6%	0.010
Importer	38.8%	0.005	15.3%	0.011
Employees	49.83	0.605	108.34	7.090
Firm age: young (less than 6 years)	6.9%	0.002	14.2%	0.012
Firm age: mature (6-20 years old)	34.5%	0.005	61.7%	0.015
Firm age: old (more than 20 years old)	58.6%	0.005	24.1%	0.013
Group affiliation	19.4%	0.004	9.1%	0.007
External Financing	44.7%	0.005	38.7%	0.016
Family firm	72.3%	0.004	26.3%	0.015

Source: authors' elaboration on EFIGE and RUFIGE survey results

CEO characteristics also differ: Russian firms have a larger share of young CEOs and smaller share of old ones. Interestingly, women are almost twice as likely to be represented in senior management in Russia: 18.9% of CEOs in Russia are female versus 10.4% in Europe. The share of family CEOs corresponds to the level of the development of family businesses in market and transition economies. According to survey results, in Europe the majority of manufacturing companies are family firms (72.3%) mainly governed by family CEOs. On the contrary, Russia is in the nascent stage of family business development with 26.3% of firms represented by family businesses, the majority of which have a family member as CEO.

Structural characteristics also differ considerably. Russian manufacturing firms are larger in terms of employment and have a much higher share of employees with university degrees than in European firms (34.7% vs 9.0%). Russian firms are half as likely to belong to business groups and are much less globalized, especially regarding exports. Correlations of indicators used in the analysis are in Table A2 in the Annex for the sample of European firms and in Table A3 in the Annex for the Russian sample.[10]

[10] We verify the potential presence of collinearity among predictors by using variance inflation factor (VIF) values: they are no higher than about 2, suggesting that there is no multicollinearity problems among the explanatory variables.

Finally, the model also controls for federal okrugs (districts) for Russia and for countries for EFIGE. In Table A1 in the Annex, we present description of indicators in the model.

3.3. Results

The results of the bivariate estimates for EU countries and Russia are provided in Table 2.

Table 2 Main results

Variables	6 EU countries		Russia		6 EU countries				Russia			
					SMEs		Large		SMEs		Large	
	Product innovation	Process innovation	Product innovation	Process innovation	Product innovation	Process innovation	Product innovation	Process innovation	Product innovation	Process innovation	Product innovation	Process innovation
Family CEO	0.1036***	0.0401	0.0078	0.2663**	0.1048***	0.0490*	0.1961	-0.2134*	-0.0289	0.2824**	1.0500***	0.1756
	(0.0307)	(0.0294)	(0.1047)	(0.1193)	(0.0321)	(0.0291)	(0.1295)	(0.1286)	(0.1138)	(0.1205)	(0.3321)	(0.2562)
CEO Age: mature	-0.1094	-0.0092	0.2277*	-0.0475	-0.1085	-0.0078	0.5767	0.3871	0.2637*	-0.0141	-0.1556	-0.3216
	(0.0766)	(0.0709)	(0.1276)	(0.1260)	(0.0772)	(0.0713)	(0.5433)	(0.4134)	(0.1434)	(0.1389)	(0.2658)	(0.3058)
CEO Age: old	-0.1653**	-0.0353	0.1847	0.1486	-0.1603**	-0.0379	0.1818	0.4882	0.2025	0.1357	-0.2109	0.4175
	(0.0810)	(0.0843)	(0.2253)	(0.2159)	(0.0815)	(0.0844)	(0.5421)	(0.4851)	(0.2496)	(0.2430)	(0.4458)	(0.5101)
Gender CEO	-0.1311***	-0.1204***	0.1091	-0.0923	-0.1356***	-0.1235***	0.3020	0.1943	0.1255	-0.0862	0.0704	-0.1534
	(0.0389)	(0.0438)	(0.0888)	(0.1142)	(0.0392)	(0.0461)	(0.2676)	(0.3424)	(0.1012)	(0.1272)	(0.2623)	(0.2318)
R&D employees share	0.0148***	0.0096***	0.0394***	0.0310***	0.0152***	0.0100***	0.0049	0.0024	0.0378***	0.0304***	0.1011***	0.0701***
	(0.0023)	(0.0015)	(0.0124)	(0.0056)	(0.0022)	(0.0015)	(0.0072)	(0.0034)	(0.0129)	(0.0057)	(0.0288)	(0.0231)
Graduate employees share	0.0090***	0.0040***	0.0055**	-0.0001	0.0094***	0.0043***	0.0047	-0.0004	0.0055**	-0.0005	0.0071	0.0018
	(0.0011)	(0.0011)	(0.0024)	(0.0025)	(0.0011)	(0.0011)	(0.0033)	(0.0030)	(0.0024)	(0.0027)	(0.0049)	(0.0043)
Exporter	0.3866***	0.1673***	0.4181***	0.3836***	0.3804***	0.1612***	0.6664***	0.3479**	0.4366***	0.3888***	0.5427**	0.3983**
	(0.0398)	(0.0375)	(0.1328)	(0.1303)	(0.0405)	(0.0373)	(0.1761)	(0.1353)	(0.1440)	(0.1488)	(0.2187)	(0.1554)
Importer	0.2731***	0.2004***	0.3089**	0.0726	0.2713***	0.1893***	0.2428*	0.4624***	0.3087**	-0.0100	0.2431	0.6713***
	(0.0224)	(0.0297)	(0.1398)	(0.1024)	(0.0230)	(0.0296)	(0.1246)	(0.1347)	(0.1500)	(0.1077)	(0.2961)	(0.2083)
Size (log of employees)	0.1601***	0.1847***	0.2231***	0.2698***	0.1857***	0.2170***	0.2362	0.1625	0.2495***	0.3083***	0.3074**	0.2881**
	(0.0181)	(0.0191)	(0.0413)	(0.0442)	(0.0208)	(0.0212)	(0.1645)	(0.1290)	(0.0566)	(0.0629)	(0.1320)	(0.1179)
Mature Firm (6-20 years old)	-0.0581	-0.0589	-0.0176	-0.0027	-0.0655	-0.0559	0.2300	-0.3882	-0.0441	0.0024	0.3682	-0.1482
	(0.0570)	(0.0473)	(0.1209)	(0.1131)	(0.0579)	(0.0494)	(0.2294)	(0.3141)	(0.1286)	(0.1155)	(0.4594)	(0.4541)
Old firm (> 20 years old)	-0.0407	-0.1026**	-0.0713	-0.0422	-0.0461	-0.1008**	0.1024	-0.3629	-0.0520	-0.0348	-0.1546	-0.2200
	(0.0577)	(0.0432)	(0.1229)	(0.1462)	(0.0583)	(0.0453)	(0.2276)	(0.2703)	(0.1267)	(0.1588)	(0.4924)	(0.4871)
Group	-0.0267	-0.0049	0.1176	0.0339	-0.0273	-0.0075	0.0252	-0.0731	0.1404	0.0349	0.2092	0.1882
	(0.0345)	(0.0382)	(0.1182)	(0.1132)	(0.0353)	(0.0397)	(0.1324)	(0.1279)	(0.1505)	(0.1437)	(0.1523)	(0.1406)
External Financing	0.1301***	0.2245***	0.2541***	0.2828***	0.1314***	0.2211***	-0.0117	0.2356*	0.2534***	0.2896***	0.3274**	0.3176**
	(0.0340)	(0.0204)	(0.0741)	(0.0986)	(0.0358)	(0.0214)	(0.1180)	(0.1409)	(0.0800)	(0.1021)	(0.1434)	(0.1551)
Constant	-0.6485***	-0.7790***	-1.5291***	-1.6856***	-0.7341***	-0.9163***	-2.0524*	-0.2570	-1.6599***	-1.8444***	-1.7808*	-1.6611*
	(0.1365)	(0.1164)	(0.2665)	(0.2561)	(0.1425)	(0.1208)	(1.2103)	(0.9840)	(0.3036)	(0.3071)	(1.0538)	(0.9561)
Rho		0.341***		0.724***		0.338***		0.396***		0.731***		0.795***
Observations	13284	13284	1526	1526	12486	12486	798	798	1102	1102	424	424

Robust standard errors in parentheses. Clustering at the region level. *** p<0.01, ** p<0.05, * p<0.1. Sector and region/country dummies included.

The correlation coefficient estimates are all positive and significant both for Russia and the EU countries. Thus, there is empirical justification for estimating a bivariate probit model.

The combination of ownership and executive power in one person's hands is a benefit for product innovation in EU countries and for process innovation in Russia, supporting Hypothesis 1.

As far as age is concerned (Hypothesis 2), European firms with the oldest CEOs are significantly less efficient in product innovations than those with young CEOs. In Russia, the middle-aged group demonstrates better results in product innovations, but the association is significant only at the 10% level.

As expected, we find that the gender impact on the probability of innovation in EU countries and Russia differs (Hypothesis 3). For the EU sample, firms with female CEOs are less innovative while for Russia there is no difference between female and male CEOs.

Overall, the estimated effect of the control variables on innovative performance has a statistically significant effect for R&D, human capital, external financing, export or import status both for Russia and the EU, with the exception of human capital and importing for process innovation in Russia. For human capital, Capozza and Divella (2019) found the same result for a group of emerging economies. The size of the firm has a positive and significant effect on both innovation decisions, which means that larger enterprises have a higher probability of product and process innovation. We checked the hypothesis about a possible nonlinear relationship between innovations and firm size. It was checked by (a) including the squared size variable (log of the number of employees) into the regression and (b) by including size as a categorical variable – small firms (below 100 employees) – medium (100–249) and large firms (above 249) groups. We also estimated models with the log employment and log employment squared for subsamples of SME and large firms. For Russian firms, we found no evidence of a nonlinear relationship. While for the group of EU countries only in one case – the full sample of firms – were the coefficients for log employment and squared log employment both significant and of opposite signs, pointing to an inverted U-curve relationship. Nevertheless, we believe that this result is not robust as it was not confirmed by further estimations for small-medium-large firms or for SME and large sub-samples.[11] Group affiliation does not affect innovative performance.

The results show that for EU countries there is no difference in terms of firm age for product innovation, while for process innovation older firms perform worse. Procedures and routines developed over the years may become more rigid and limit the introduction of new processes (Becheikh et al., 2006). However, this result does not hold for Russian firms, where the age of the firm has no effect on innovation.

[11] We do not report the results here, but they are available on request.

Keeping in mind the significant role of size in innovation and the larger concentration of female CEOs in small businesses (OECD, 2012) it is reasonable to check the heterogeneity of innovative performance by splitting SMEs and large firms (Table 2). The inferior innovative performance of female European CEOs seems to be driven by SMEs. For large companies there is no difference between firms managed by men or women. For Russia, the lack of difference between CEO by gender is confirmed by the estimates by size.

As regards family CEOs, for Europe the evidence confirms that firms managed by a family CEO are more likely to innovate but this does not hold for large companies, where the presence of a family CEO affects the introduction of new processes negatively. For Russia, it is confirmed that family CEOs perform better in process innovation but only in SMEs. For large companies a positive gap exists for product innovation while in the whole sample no difference in product innovations was evidenced between family and non-family CEOs. The negative coefficient for older CEOs for product innovation in the EU seems to be due to SMEs as they represent a significantly larger share in European manufacturing than in Russia. For Russia, mature CEOs in SMEs perform better in terms of product innovation. No difference was found in all the other cases.

We have not interpreted the differences between sectors, but it would be of interest to see whether these relationships between innovation and CEO individual characteristics depend on the type of industry. In Table 3, we report estimation results for selected EU countries and Russia by the Pavitt taxonomy. Differences between firms managed by women or by men are found only in traditional sectors, albeit in the opposite direction.

In Russia, where women manage 28% of the firms in the traditional sector, the difference is positive for product innovation. In the EU, where firms in the traditional sector with a female CEO represent 9% of the total, not far from the percentage in the other sectors (range 6–7%), female CEOs innovate less. In the EU, family CEOs perform better (i.e. innovate more often) in traditional sectors.[12]

[12] We do not comment on results for age because few observations for old CEOs are available in each Pavitt sector, especially the traditional one.

Table 3 Estimates by Pavitt sector

Panel A: 6 EU countries	Traditional		Economies of scale		Specialized and High-tech	
Variables	Product innovation	Process innovation	Product innovation	Process innovation	Product innovation	Process innovation
Family CEO	0.1486***	0.0506	0.0313	0.0370	0.0380	0.0527
	(0.0416)	(0.0403)	(0.0553)	(0.0439)	(0.0504)	(0.0534)
CEO Age: mature	-0.1002	0.0514	-0.3405**	-0.1055	-0.1051	-0.1289
	(0.0994)	(0.0830)	(0.1709)	(0.1501)	(0.1314)	(0.1380)
CEO Age: old	-0.2110*	0.0440	-0.4295**	-0.1016	-0.0172	-0.2635*
	(0.1109)	(0.0952)	(0.1902)	(0.1524)	(0.1364)	(0.1384)
Gender CEO	-0.1223**	-0.2 002***	0.0022	0.0633	-0.0809	-0.0915
	(0.0492)	(0.0611)	(0.0684)	(0.1297)	(0.0941)	(0.1076)
Other firm variables	Yes	Yes	Yes	Yes	Yes	Yes
Sector	No	No	No	No	No	No
Country	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-0.6124***	-0.8115***	-0.6025**	-0.5874***	-1.0663***	-0.7375***
	(0.1942)	(0.1116)	(0.2690)	(0.2219)	(0.2275)	(0.1987)
Observations	6406	6406	3320	3320	3066	3066
Panel B: Russia	Traditional		Economies of scale		Specialized and High-tech	
Variables	Product innovation	Process innovation	Product innovation	Process innovation	Product innovation	Process innovation
Family CEO	0.2527	0.3175	-0.1436	0.1520	0.1354	0.2687
	(0.2497)	(0.2643)	(0.1193)	(0.1615)	(0.2413)	(0.2865)
CEO Age: mature	0.0488	-0.1061	0.3216*	0.1193	0.3443	-0.2913
	(0.2838)	(0.3263)	(0.1812)	(0.2048)	(0.2832)	(0.1961)
CEO Age: old	0.2042	-6.1323***	0.0749	0.7218**	0.2114	-0.1181
	(0.4959)	(0.7376)	(0.3801)	(0.3192)	(0.3955)	(0.3930)
Gender CEO	0.5360***	-0.1341	0.0527	0.0221	0.2289	0.0586
	(0.1840)	(0.2397)	(0.1561)	(0.1593)	(0.3571)	(0.3360)
Other firm variables	Yes	Yes	Yes	Yes	Yes	Yes
Sector	No	No	No	No	No	No
Region	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-1.6782***	-1.0536*	-1.7073***	-2.0077***	-2.0642***	-2.5176***
	(0.5063)	(0.5656)	(0.3212)	(0.3460)	(0.5757)	(0.4105)
Observations	299	299	840	840	376	376

Robust standard errors in parentheses. Clustering at the region level. *** p<0.01, ** p<0.05, * p<0.1

The European countries are heterogeneous (Table A4 in the Annex). A positive coefficient of family CEO was found in France and the UK (product innovation), in Spain (process innovation), in Italy (for both types) while the coefficient was negative for Germany (process innovation) and not significant for Austria. Significantly worse innovation outcomes for older CEOs were found in France (for both types) and in Italy and Spain (product innovation). In Germany older managers performed better for process innovation. Mature CEOs appear to influence the propensity to introduce new processes in Austria positively and negatively for product innovation in France. For the remaining countries no difference in innovation performance is found. Regarding the negative association between female CEOs and innovation, the coefficient is either not significant or negative, in particular, for process innovation in France

and Italy; for product innovation in Austria and the UK; and in Germany for both types of innovation.

3.4. Robustness checks

To examine the robustness of our core variables, CEO demographic and owner-manager characteristics, we performed several robustness checks. First, instead of a bivariate probit, we estimated a probit model specification and the results were confirmed (Table 4).

Second, we augmented the model with two control variables that might capture regional heterogeneity: GDP per capita and share of population with tertiary education. These two variables could help us to capture whether the regional environment is more or less conducive to promoting innovation. The coefficient of GDP per capita is positive and significant for product innovations in the European sample and for process innovations in the Russian sample. For share of population with tertiary education, it is positive and significant for European firms only. Overall, the inclusion of regional controls does not qualitatively change our main results (Table 4).

Table 4 Robustness Checks

	Probit model				Regional variables			
	6 EU countries		Russia		6 EU countries		Russia	
Variables	Product innovation	Process innovation	Product innovation	Process innovation	Product innovation	Process innovation	Product innovation	Process innovation
Family CEO	0.1036***	0.0409	0.0041	0.2246*	0.1043***	0.0410	0.0027	0.2734**
	(0.0306)	(0.0295)	(0.1091)	(0.1168)	(0.0306)	(0.0293)	(0.1040)	(0.1171)
CEO Age: mature	-0.1076	-0.0125	0.2082	-0.0546	-0.1086	-0.0066	0.2205*	-0.0369
	(0.0761)	(0.0701)	(0.1339)	(0.1272)	(0.0771)	(0.0706)	(0.1272)	(0.1251)
CEO Age: old	-0.1612**	-0.0391	0.1797	0.1354	-0.1647**	-0.0332	0.1926	0.1436
	(0.0806)	(0.0839)	(0.2388)	(0.2205)	(0.0812)	(0.0840)	(0.2237)	(0.2160)
Gender CEO	-0.1326***	-0.1206***	0.1005	-0.0883	-0.1328***	-0.1225***	0.1109	-0.0977
	(0.0387)	(0.0435)	(0.0893)	(0.1101)	(0.0392)	(0.0439)	(0.0899)	(0.1121)
R&D employees share	0.0150***	0.0096***	0.0384***	0.0312***	0.0148***	0.0097***	0.0386***	0.0320***
	(0.0024)	(0.0016)	(0.0131)	(0.0056)	(0.0023)	(0.0015)	(0.0124)	(0.0057)
Graduate employees share	0.0090***	0.0040***	0.0056**	0.0000	0.0089***	0.0038***	0.0054**	-0.0000
	(0.0011)	(0.0011)	(0.0024)	(0.0024)	(0.0011)	(0.0011)	(0.0024)	(0.0025)
Exporter	0.3856***	0.1653***	0.4225***	0.3938***	0.3869***	0.1683***	0.4258***	0.3810***
	(0.0399)	(0.0376)	(0.1367)	(0.1298)	(0.0397)	(0.0373)	(0.1345)	(0.1295)
Importer	0.2732***	0.2001***	0.3339**	0.0486	0.2733***	0.2006***	0.2988**	0.0841
	(0.0225)	(0.0294)	(0.1482)	(0.1067)	(0.0224)	(0.0297)	(0.1421)	(0.1015)
Size (log of employees)	0.1597***	0.1840***	0.2223***	0.2682***	0.1598***	0.1841***	0.2248***	0.2670***
	(0.0180)	(0.0191)	(0.0429)	(0.0426)	(0.0182)	(0.0191)	(0.0417)	(0.0449)
Mature Firm (6-20 years old)	-0.0580	-0.0579	-0.0025	0.0111	-0.0603	-0.0628	-0.0126	-0.0127
	(0.0560)	(0.0474)	(0.1186)	(0.1146)	(0.0574)	(0.0473)	(0.1200)	(0.1108)
Old firm (> 20 years old)	-0.0405	-0.1017**	-0.0622	-0.0486	-0.0402	-0.1006**	-0.0683	-0.0488
	(0.0572)	(0.0434)	(0.1255)	(0.1443)	(0.0578)	(0.0437)	(0.1208)	(0.1444)
Group	-0.0267	-0.0042	0.1228	0.0433	-0.0265	-0.0041	0.1157	0.0363
	(0.0346)	(0.0382)	(0.1205)	(0.1102)	(0.0345)	(0.0382)	(0.1192)	(0.1128)
External Financing	0.1290***	0.2231***	0.2398***	0.2860***	0.1306***	0.2252***	0.2481***	0.2892***
	(0.0340)	(0.0203)	(0.0800)	(0.1024)	(0.0340)	(0.0204)	(0.0768)	(0.0993)
GDP per capita					-0.0000	-0.0000**	0.0002	-0.0003
					(0.0000)	(0.0000)	(0.0003)	(0.0006)
Education					0.0042	0.0070**	0.0003	-0.0009
Constant	-0.6481***	-0.7737***	-1.5028***	-1.6627***	-0.6509***	-0.7501***	-1.6216***	-1.5534***
	(0.1365)	(0.1154)	(0.2669)	(0.2501)	(0.1382)	(0.1373)	(0.3627)	(0.4156)
Observations	13284	13284	1526	1526	13284	13284	1526	1526

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Sector and region dummies included.

Next, we estimate a model in which, instead of the share of employees involved in R&D, we use R&D expenditure as a percentage of the total turnover. Results are confirmed, except the mature CEO coefficients, that are always negative, though it is significant at 10% (results available upon request).

We also check whether our results hold by estimating a multinomial probit model, which allows each unique combination of innovation type to be estimated separately (Table A5 in the Annex). We consider three combinations that represent three different innovation strategies: 'only product innovation', 'only process innovation' and 'both product and process innovation'. The group of firms that have not introduced either a product or process innovation was used as a reference category for the dependent variable. Results on family CEO and female CEO are consistent with the main results. For EU countries, family CEOs have no effect on 'only process innovation', while the coefficient is positive and significant for 'only product innovation' and 'both product and process innovation'. For female CEOs, the probability of innovating is lower for all three innovation strategies. For Russia, a positive effect of family CEO on 'only process innovation' is found and no difference exists between female/male CEO and where it exists, it is in favor of women CEOs. The age of the CEO does not affect innovation strategy either in the EU or Russia.

For the Russian sample[13] only, an additional check on the CEO's experience in the surveyed firm was carried out by incorporating a new control variable 'Years in the firm' as an indicator of specific human capital.[14] The coefficient of this variable is not significant and main results do not change (results available upon request).

4. Conclusions, discussion, and future research

The particular focus of our research is the impact the individual characteristics of CEOs have on innovation decisions in developed economies, represented by six EU countries and in a transitional economy, Russia. Significant attention was paid to revealing firms' heterogeneity in innovation performance which may reflect innovation specificities in SMEs and large businesses, or the different structure of manufacturing in developed market economies and in transition economies. Our results are robust to different model specifications and the inclusion of additional regional controls. Hypothesis 1 on the superior performance of firms with a family CEO was largely confirmed, the strongest evidence for both types of innovation was revealed for

[13] Data on work experience of CEO is unavailable in EFIGE questionnaire.
[14] We used the answer to this question: "How many years you have worked for this enterprise" which refers to the respondent, so for this estimation we consider the subgroup of firms where the CEO was the respondent (674 firms).

SMEs and traditional industries. Hypothesis 1 for Russia was also supported by our results; we note that family CEO-owners in Russia manage to overcome the unfavorable business environment and succeed, in general, in process innovations. The same is true for SMEs while in large firm, family-owner CEOs are more active in product innovations.

An important caveat to our findings is that, due to the lack of data, we had no opportunity to divide the pool of family CEOs into founders and successors. This is an important point to be investigated in future research. The literature suggests that founders are more inclined to follow more entrepreneurial strategies (Mousa and Wales, 2012). Successors are usually less entrepreneurial than the founders and perform less effectively (Villalonga and Amit, 2006; Bloom and Reenen, 2007; Block, 2012). Keeping in mind that the development of family businesses in Russia is at an early stage and the succession process in its infancy, we believe that results for Russia are mainly due to founder-managed firms.

Hypothesis 2, that CEO age may have a different impact in developed and in transitional economies, found some support. European firms run by older CEOs are less active in product innovations than ones run by younger CEOs and the same is true for SMEs. For Russia we expected to find older managers performing significantly better, due to network and self-selection effects, but we found no difference whatsoever regarding any type of innovations either in the manufacturing sector as a whole, or among SMEs and large firms separately.

Finally, we verified the possible impact of CEO gender on innovation in Europe and in Russia. We found full support for Hypothesis 3. In Europe, firms headed by female CEOs are significantly less innovative in terms of process and product innovations, for SMEs and in the traditional sector. In Russia, female-headed firms demonstrate the same level of innovative performance as the firms headed by male CEOs; in the traditional sector they perform even better. The results for CEO gender can be explained, first, by the path-dependence effect of the planned economy model with nearly 100% of women involved in the labor market. Second, by the lower level of female involvement in technical and engineering education in Europe compared to Russia. Third, Russian women-managers with financial and accounting skills were promoted to top management positions in the era of transformation from a planned to a market economy. Our empirical results for Russia are in line with the view that the effect of the gender diversity on a firm's likelihood of innovating could be influenced by women's employment opportunities (Ritter-Hayashi, 2016). The significant presence of highly educated women even in engineering and less historical gender discrimination may explain the lack of the female-male innovation gap in Russia.

We believe that our results could be of interest to researchers exploring the role of CEO characteristics in firm innovation by taking into account both the upper echelon and the corporate governance perspectives which are usually explored separately. By using unique, comparable data from representative surveys, we investigated the innovation performance of firms from countries with different institutional backgrounds, structures of the manufacturing sector and a different evolution of the role of the CEO.[15]

We found, first, that individual characteristics of CEOs both demographic—age and gender—and those relating to ownership status are significant for innovations in both institutional settings, but their role may be different for mature market economies and transition economies. Second, from a methodological point of view, our research has demonstrated that a proper assessment of the 'CEO effect' in innovation performance needs to take into account two important points. The first refers to the level of technological advancement of industries. We found that family owner-manager and gender effects are most evident in the case of traditional sector. The second point concerns differences between SMEs and large firms. Our results clearly demonstrate that effects on the whole sample of firms in the manufacturing sector often mask heterogeneous trends inside businesses of different size.

Our empirical strategy has certain limitations. First, there is the time gap of about 4 years between the European and Russian surveys. While we can presume that the ownership, age and gender structure of the CEO population is more or less stable, the innovation indicators may be influenced by different countries' economic environments. Second, the lack of data on CEO work experience as regards both current and former positions limits our understanding of the role of specific human capital in innovation performance. Third, we are aware of possible endogeneity concerns in our results. Firms may look for and appoint CEOs, whom they consider capable of solving particular tasks (for instance, raising innovative performance)[16]. Additionally, cross-sectional data and a lack of historical records on CEO family-owner status as founder or

[15] We are grateful to the anonymous reviewer for pointing out that CEO characteristics (at least those included in the analysis) have lower explanatory power for firm innovations in Russian than in European countries. This may be due to the difference of ownership structure in mature and transition economies. In particular, in Russia ownership is often highly concentrated even in large companies (Iwasaki and Mizobata, 2020; Iwasaki et al, 2018). The concentration of ownership may be important in case when the actual decisions on innovations are made by controlling/blocking owner who is not a CEO. Our data does not allow us to investigate in details the decision-making process on innovations in a firm. Nevertheless, we have checked the robustness of our results by including into the model the "Decision power" dummy variable which combines data on ownership concentration and CEO's ownership status (1 – CEO is free to make decisions, 0 – CEO may be limited by control or blockholders).
This dummy is insignificant in the specifications for the whole sample and for subsamples of large firms and SMEs. Thus, we got no evidence that combinations of control power and CEO status add significantly to our models and does not change our main findings. Results available upon request.

[16] To deal with a potential problem of endogeneity, additional checks with instrumental variables are needed. As recommended by Hambrick (2007), one of the potential candidates as instrumental variable might be an assessment of propensity of new family (or non-family) CEO appointment and then using this propensity score in estimating CEO effects on performance. Unfortunately, this approach is not feasible for both samples due to lack of the available data on CEO change in EFIGE data base.

successor limits our opportunities to explore the heterogeneity in firm innovation performance due to the generational aspect of family-managed firms.

It is worth noting that the CEO's role in providing effectiveness and competitiveness of the firm is not static. As argued by Quigley and Hambrick (2014), the dynamic effect is most significant for countries undergoing radical transformation of political regimes and institutions, including privatization. The dynamic aspect of 'CEO effect' in a comparative perspective is a challenging task for future research.

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Annex

Table A1

Independent variables	
Family CEO	Dummy variable: 1 – Family CEO, 0 - otherwise.
CEO Age	CEO age young – less than 34 years old (reference category) CEO age mature: 1 - CEO 35 -64 years old, 0 - otherwise CEO age old: 1 - CEO more than 65 years old, 0 - otherwise
Gender CEO	Dummy variable: 1 – CEO female, 0 – CEO male
Control variables	
R&D employees share	Share of employees in R&D in the total number of employees, %
Graduate employees share	Share of university graduates, %
Firm age	Firm age_young – firm established less than 6 years ago (reference category) Firm_age_mature: 1 – firm established 6 – 20 years ago, 0 - otherwise Firm_age_ old – firm established more than 20 years ago, 0 - otherwise
Exporter	Dummy variable: 1 - exporter, 0 - otherwise
Importer	Dummy variable: 1 - importer, 0 - otherwise
Group	Dummy variable: 1 – part of a business group, 0 - otherwise
Size	Number of employees (log)
External Financing	Dummy equal 1 if the firm recurred to external financing, 0 - otherwise
Sector	Dummy for each sector
Country	Dummy for country in which firm is located for EU
Region	Dummy for federal okrugs in which firm is located for Russia

Table A2 Correlation matrix for 6 EU countries

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1) Family CEO	1													
2) Gender CEO	0.071**	1												
3) R&D employees share	0.006	0.006	1											
4) Graduate employees share	-0.101**	-0.026**	0.278**	1										
5) Exporter	-0.041**	-0.033**	0.192**	0.194**	1									
6) Importer	-0.078**	-0.041**	0.112**	0.121**	0.287**	1								
7) CEO age: young	0.025**	0.062**	0.016	0.014	-0.018**	-0.016	1							
8) CEO age: mature	-0.092**	-0.007	0.008	0.012	-0.031**	0.017*	-0.451**	1						
9) CEO age: old	0.092**	-0.027**	-0.017*	-0.025**	0.046**	-0.009	-0.061**	-0.849**	1					
10) Firm age: young	-0.087**	0.013	-0.013	0.015	-0.070**	-0.012	0.061**	0.013	-0.051**	1				
11) Firm age: mature	-0.019*	0.008	0.020**	0.011	-0.076**	-0.044**	0.02	0.070**	-0.079**	-0.196**	1			
12) Firm age: old	0.063**	-0.001	-0.013	-0.018*	0.109**	0.049**	-0.030**	-0.075**	0.103**	-0.324**	-0.864**	1		
13) Group	-0.317**	-0.064**	-0.002	-0.101**	0.123**	0.162**	-0.026**	0.055**	-0.049**	0.039**	-0.016	-0.05	1	
14) External finance	0,041**	-0,05	0,012	0.024**	0.044**	0,030**	0,008	0,005	-0.008	0.006	0.028**	-0.30**	-0.066**	1

Note: Spearman non-parametric correlation, rho

Table A3 Correlation matrix for Russia

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1) Family CEO	1													
2) Gender CEO	0.047	1												
3) R&D employees share	-0.022	-0.078**	1											
4) Graduate employees share	0.006	0.002	0.146**	1										
5) Exporter	-0.003	-0.082**	0.267**	0.070**	1									
6) Importer	-0.024	0.023	0.165**	0.005	0.193**	1								
7) CEO age: young	-0.002	-0.018	-0.040	0.022	-0.005	0.004	1							
8) CEO age: mature	0.019	0.010	-0.025	-0.022	-0.012	-0.013	-0.845**	1						
9) CEO age: old	0.040	0.010	0.112**	0.005	0.032	0.018	-0.068*	-0.476**	1					
10) Firm age: young	0.033	0.004	-0.034	-0.047	-0.099**	0.025	0.044	0.006	-0.082**	1				
11) Firm age: mature	0.030	0.003	0.078**	0.079**	-0.051	-0.015	-0.024	0.063*	-0.078**	-0.541**	1			
12) Firm age: old	-0.062*	-0.007	0.120	-0.052	0.143**	0.004	-0.010	-0.078**	0.161**	-0.227**	-0.696**	1		
13) Group	-0.110**	0.015	-0.002	-0.025	0.071**	-0.019	0.056*	-0.050	0.000	-0.015	-0.027	0.044	1	
14) External finance	0.020	-0.088**	0.065*	-0.015	0,071**	0.129**	-0.026	0.041	-0.034	-0.-12	0.045	-0.042	-0.031	1

Note: Spearman non-parametric correlation, rho

Table A4 Estimates by country

Variables	Austria		France		Germany		Italy		Spain		UK	
	Product innovation	Process innovation	Product innovation	Process innovation	Product innovation	Process innovation	Product innovation	Process innovation	Product innovation	Process innovation	Product innovation	Process innovation
Family CEO	0.0567	0.3359	0.1695*	0.0050	-0.0180	-0.1721***	0.1758***	0.1218**	0.0574	0.1216**	0.1489**	0.0886
	(0.2547)	(0.5196)	(0.0940)	(0.0714)	(0.0429)	(0.0557)	(0.0580)	(0.0491)	(0.0619)	(0.0536)	(0.0694)	(0.0566)
CEO Age: mature	0.1589	0.3903*	-0.3658***	-0.1424	-0.0716	0.0989	-0.2727	0.1207	-0.1423	-0.1905	0.2425	-0.0726
	(0.2991)	(0.2173)	(0.1090)	(0.1538)	(0.2049)	(0.1298)	(0.2255)	(0.1261)	(0.1120)	(0.1206)	(0.1686)	(0.1838)
CEO Age: old	0.2316	0.1826	-0.3881**	-0.2918*	-0.0054	0.2386*	-0.3602*	0.0232	-0.3228**	-0.2389	0.2628	0.0034
	(0.2850)	(0.4456)	(0.1689)	(0.1759)	(0.2168)	(0.1337)	(0.1901)	(0.1622)	(0.1560)	(0.1719)	(0.1750)	(0.2519)
Gender CEO	-0.5654***	-0.3324	-0.1789	-0.3315**	-0.1565*	-0.2322***	0.0050	-0.0777**	-0.1231	0.0466	-0.2832***	-0.0163
	(0.2010)	(0.7886)	(0.1088)	(0.1312)	(0.0812)	(0.0793)	(0.0645)	(0.0314)	(0.0768)	(0.0932)	(0.0880)	(0.1114)
R&D employees share	0.0168***	0.0140***	0.0257***	0.0148***	0.0071***	0.0039**	0.0302***	0.0176***	0.0132***	0.0094***	0.0165***	0.0152***
	(0.0040)	(0.0041)	(0.0044)	(0.0016)	(0.0019)	(0.0017)	(0.0043)	(0.0019)	(0.0029)	(0.0020)	(0.0032)	(0.0021)
Graduate employees share	0.0154	0.0299***	0.0065**	0.0033**	0.0066***	0.0006	0.0121***	0.0023	0.0113***	0.0036	0.0135***	0.0120***
	(0.0189)	(0.0098)	(0.0029)	(0.0015)	(0.0016)	(0.0023)	(0.0030)	(0.0031)	(0.0024)	(0.0024)	(0.0022)	(0.0027)
Exporter	0.0274	0.1976	0.2219***	0.0812	0.5296***	0.2926***	0.4733***	0.0480	0.2814***	0.1144**	0.4887***	0.2478**
	(0.3441)	(0.1368)	(0.0724)	(0.0926)	(0.0477)	(0.0478)	(0.1049)	(0.0687)	(0.0323)	(0.0474)	(0.1185)	(0.1057)
Importer	0.5296**	0.3567***	0.2784***	0.1537**	0.2835***	0.0962	0.2062***	0.1071***	0.2814***	0.2471***	0.2531***	0.3817***
	(0.2625)	(0.1216)	(0.0423)	(0.0607)	(0.0647)	(0.0623)	(0.0700)	(0.0394)	(0.0349)	(0.0575)	(0.0694)	(0.0879)
Size (log of employees)	0.3132*	0.5320***	0.0871***	0.1149***	0.1598***	0.1274***	0.2015***	0.2291***	0.1819***	0.2244***	0.2067***	0.2614***
	(0.1870)	(0.1060)	(0.0243)	(0.0417)	(0.0337)	(0.0151)	(0.0373)	(0.0289)	(0.0421)	(0.0516)	(0.0383)	(0.0460)
Mature firm (6-20 years old)	0.0123	0.7016	-0.2776	-0.1235	-0.0540	-0.2056***	0.0983	-0.0271	0.0177	-0.0563	-0.0927	0.0435
	(0.2239)	(0.6494)	(0.1696)	(0.1791)	(0.0896)	(0.0749)	(0.0859)	(0.0633)	(0.1963)	(0.0710)	(0.0964)	(0.0819)
Old firm(more than 20 years old)	0.0168	0.5587	-0.1489	-0.1149	-0.0268	-0.1954***	0.0619	-0.1819*	0.0001	-0.0410	-0.0805	0.0049
	(0.1037)	(0.3691)	(0.1498)	(0.1528)	(0.1321)	(0.0646)	(0.1233)	(0.0968)	(0.1948)	(0.0584)	(0.1353)	(0.0921)
Group	-0.0251	0.0825	-0.0121	0.0284	-0.0453	-0.1169	-0.0127	-0.0293	-0.0108	0.0030	0.0230	-0.0070
	(0.2096)	(0.1633)	(0.0655)	(0.0692)	(0.0598)	(0.0827)	(0.1049)	(0.1168)	(0.0789)	(0.1038)	(0.0748)	(0.1181)
External Financing	0.1520	0.2985*	0.0890	0.2373***	0.1226***	0.2847***	0.0698	0.2114***	0.2215***	0.2174***	0.0905	0.1817**
	(0.2217)	(0.1617)	(0.0969)	(0.0451)	(0.0467)	(0.0503)	(0.0719)	(0.0270)	(0.0515)	(0.0309)	(0.0751)	(0.0921)
Constant	-1.2375***	-3.4225***	-0.2438	-0.8623***	-0.8255***	-0.8788***	-1.2466***	-1.1777***	-1.2369***	-0.9437***	-0.9349***	-1.5368***
	(0.3605)	(0.3376)	(0.2104)	(0.2239)	(0.2147)	(0.1688)	(0.2226)	(0.1152)	(0.3053)	(0.2243)	(0.2577)	(0.2781)
Rho		0.295***		0.527***		0.298***		0.200***		0.151***		0.579***
Observations	362	362	2772	2772	2751	2751	2862	2862	2704	2704	1833	1833

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Sector and region dummies included.

Table A5 Multinomial model

	6 EU countries			Russia		
Variables	Only product	Only process	Product and process	Only product	Only process	Product and process
Family CEO	0.1145**	0.0190	0.1508***	0.1135	0.7924***	0.1242
	(0.0456)	(0.0442)	(0.0480)	(0.1821)	(0.2482)	(0.1602)
CEO Age: mature	-0.0355	0.1397	-0.1234	0.2639	-0.3549	0.1456
	(0.1291)	(0.1411)	(0.1202)	(0.1742)	(0.2454)	(0.2114)
CEO Age: old	-0.0546	0.1734	-0.2037	0.3126	0.3100	0.2631
	(0.1254)	(0.1428)	(0.1374)	(0.3279)	(0.3784)	(0.3763)
Gender CEO	-0.1805***	-0.1701**	-0.2537***	0.2667*	-0.0948	-0.0114
	(0.0617)	(0.0680)	(0.0631)	(0.1421)	(0.1992)	(0.1508)
R&D employees share	0.0204***	0.0142***	0.0259***	0.0280	-0.0106	0.0612***
	(0.0043)	(0.0039)	(0.0046)	(0.0186)	(0.0257)	(0.0169)
Graduate employees share	0.0110***	0.0045	0.0136***	0.0088**	-0.0014	0.0047
	(0.0016)	(0.0028)	(0.0019)	(0.0035)	(0.0051)	(0.0037)
Exporter	0.5360***	0.2269***	0.5291***	0.4427**	0.3673	0.7318***
	(0.0446)	(0.0486)	(0.0686)	(0.2103)	(0.3288)	(0.2180)
Importer	0.2838***	0.1831***	0.4760***	0.5598**	0.2490	0.3298**
	(0.0367)	(0.0504)	(0.0396)	(0.2536)	(0.2500)	(0.1678)
Size (log of employees)	0.1515***	0.1896***	0.3459***	0.1576**	0.2437***	0.4359***
	(0.0283)	(0.0283)	(0.0355)	(0.0710)	(0.0757)	(0.0684)
Mature Firm (6-20 years old)	-0.0451	-0.0429	-0.1094	-0.0393	-0.0048	0.0276
	(0.0765)	(0.0635)	(0.0852)	(0.1976)	(0.2332)	(0.1705)
Old firm (> 20 years old)	0.0132	-0.0672	-0.1376	0.0702	0.3251	-0.1271
	(0.0695)	(0.0742)	(0.0869)	(0.1995)	(0.3278)	(0.1947)
Group	-0.0279	0.0015	-0.0360	0.1100	-0.1141	0.1547
	(0.0604)	(0.0666)	(0.0611)	(0.1864)	(0.2174)	(0.1785)
External Financing	0.1862***	0.3364***	0.3474***	0.3162**	0.5164***	0.4261***
	(0.0577)	(0.0489)	(0.0476)	(0.1404)	(0.1918)	(0.1379)
Constant	-1.1684***	-1.4093***	-1.4082***	-2.1523***	-2.7724***	-2.7338***
	(0.2000)	(0.2154)	(0.2319)	(0.4257)	(0.5056)	(0.4257)
Observations	13,284	13,284	13,284	1,526	1,526	1,526

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Sector and region dummies included.

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