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# FAMILY FIRM HETEROGENEITY AND PATENTING. REVISING THE ROLE OF SIZE AND AGE

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# Family firm heterogeneity and patenting. Revising the role of size and age

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*Abstract* This study revises the moderating effect of size and age on the relationship between family ownership and innovation. The research hypotheses are tested on a large sample of Italian firms observed over the 2010–2017 period, using a zero-inflated non-linear count model. Results from a three-way interaction approach suggest that the patenting gap between family firms (FFs) and non-family firms is sensitive to size and age. Compared to non-FFs, FFs underperform when they are small and young or large and old, while there are no substantial differences for other types of firms. Much of the evidence is driven by the founder effect which differs over the firm life.

*JEL codes:* D22, L25, L60, O30

*Keywords:* innovation, patent, family firms, size, age

## 1. Introduction

Family firms (FFs) are ubiquitous around the world and dominant in many countries (De Massis et al., 2018; Schulze and Gedajlovic, 2010), but some aspects of their behaviour remain unexplored or only partially solved. One aspect which deserves more attention involves the innovation activities (Casado-Belmonte et al., 2021). In this area of research, some recent studies have analysed the relationship between family ownership and innovation output (e.g. Aiello et al., 2021a & 2022; Asaba and Wada, 2019; Bannò, 2016; Block et al., 2013; Decker and Günther, 2017; Jell et al., 2015; Matzler et al., 2015), whereas others have considered innovation input (among others, Aiello et al., 2020 & 2021b; Block et al., 2012; Brinkerink and Bammens, 2018; Yang et al., 2019). However, although the questions of whether, why and how much FFs and non-FFs differ in terms of innovation have been widely debated, the theoretical and empirical debate is still inconclusive.

Recent reviews summarise the state of art (Block et al., 2022; Calabrò et al., 2019; Casado-Belmonte et al., 2021; De Massis et al., 2013; Duran et al., 2016; Heider et al., 2022). For instance, Duran et al. (2016) published an influential meta-study showing that FFs produce more innovation output with less innovation inputs. To explain this evidence, they indicate that FFs have more efficient innovation processes because of both better monitoring and high levels of tacit knowledge. Conversely, Block et al. (2022) confirm that FFs use less innovation input

than non-FFs, but they do not find systematic differences in output because the firm growth opportunities are context-related. Along this line of reasoning, it is argued theoretically that the contrasting findings across studies are determined by specific factors of firm heterogeneity, which have not so far been properly considered in the empirical literature (Chua et al., 2012; Daspit et al., 2021; De Massis et al., 2014; Hernández-Linares et al., 2017; Patel and Chrisma, 2014).

Following this debate, a prominent field of research has explored modelling firm heterogeneity via influential variables. In this respect, the business dimension and the firm age have captured much attention (Block et al., 2022), and since the pioneering work by Schumpeter (1934), they have been among the most debated firm-level structural factors influencing innovation activities (Balasubramanian and Lee, 2008; Leal-Rodríguez et al., 2015; Sørensen and Stuart, 2000).

However, as far as FFs are concerned, the impact of size and age on FFs' innovation performance is evaluated in few papers (Aiello et al., 2022; Decker and Günther, 2017; De Massis et al., 2014; Laforet, 2013; Werner et al., 2018), without providing a complete understanding of how family ownership is related to innovation. Indeed, some studies assess the individual effect of age and/or size, yet few analyse their role as moderators, and no one considers them as contingent factors that jointly affect the family-innovation nexus.

Therefore, a new analytical framework is required to model better firm heterogeneity because the innovation performance changes among subgroups of firms (that is, combinations of FFs/non-FFs, old/young, large/small) and outcomes can hold in some dimensions but not in others. For example, the influence of the generational stage (proxied by age) is particularly sensitive for large FFs compared to small companies (Le Breton-Miller and Miller, 2013). Similarly, firm age matters when considering financing decisions. Indeed, FFs suffer more from financial constraints due to their considerable reluctance to use external resources in order to keep ownership control in the family (Serrasqueiro et al., 2016). These constraints are binding for young firms but not for old firms. In fact, being in the market for a longer time allows the acquisition of a reputation that contributes to gaining easier access to debt (Diamond, 1989; Hall et al., 2004). These examples prove not only that the group of FFs is far from being homogeneous, but they also highlight how FFs innovate differently from other businesses because of their specific characteristics (Carney et al., 2015; De Massis et al., 2013).

Based on the above considerations, the key research question of this study is as follows: *is the innovation gap between FFs and non-FFs (jointly) moderated by size and age?*

To address this issue, we proceed as follows: first, we assess the individual effect of ownership on patenting. This step allows verification of whether firm ownership matters, regardless of size and age; second, we consider the moderator effect of size and age separately; third and most importantly, the focus is on how size and age simultaneously exert an influence on the FFs' innovation relationship.

We provide solid arguments that the FFs' innovation performance is determined jointly by size and age: FFs underperform when they are small and young or when they are large and old,

while there are no substantial differences with their non-family counterparts in the other cases. The variety of innovation outcomes highlights that age and size determine the context in which firms work, thereby contributing to explaining previous contradictory findings on FFs' innovation gap (Chirico et al., 2020; O'Boyle et al., 2012).

The analysis is based on a sample of Italian manufacturing firms observed 2010–2017. Data are provided by the Bureau van Dijk, which has been linked to the European Patent Office's (EPO) PATSTAT dataset. Firm performance is gauged by the number of patent applications (Griliches, 1990; Hall et al., 1986). In order to take in account that patent distribution is highly skewed, reflecting overdispersion, the econometric analysis uses a zero-inflated non-linear count model.

The paper is organised as follows: Section 2 presents the theoretical background and the hypotheses; data, variables and empirical strategy are described in Section 3; the results are presented in Section 4; Section 5 discusses the results and draws some concluding remarks.

## **2. Theoretical background and hypotheses development**

### ***2.1 Family firms and innovation performance***

The literature on FFs' innovation has grown enormously in recent years (Casado-Belmonte et al., 2021; Heider et al., 2022) and has emphasised how FFs behave differently when compared to a non-family counterpart, suggesting that their typical characteristics can exert either a negative or a positive influence on innovation (Block et al., 2022; Calabrò et al., 2019; Carney et al., 2015; De Massis et al., 2013; Duran et al., 2016; Röd, 2016). Some scholars have observed that the negative influence of familiness on innovation performance is due to the conservatism and risk aversion of family owners (Broekaert et al., 2016; Chen and Hsu, 2009; Nieto et al., 2015), to FFs' limited resources (Muñoz-Bullón and Sanchez-Bueno, 2011; Nieto et al., 2015) and loss aversion with regard to their non-financial goals (Gómez-Mejia et al., 2007 & 2014). Nevertheless, some FFs are amongst the most innovative firms in the world (De Massis et al., 2013; Urbinati et al., 2017), and their long-term orientation acts as a stimulus to innovate (Diaz-Moriana et al., 2018).

Here, it is worth noticing that most studies have focused on innovation inputs (Aiello et al., 2020 & 2021b; Block, 2012; Brinkerink and Bammens, 2018; Chen and Hsu, 2009; Gomez-Mejia et al., 2007; Kotlar et al., 2014), while a few have considered the output (Aiello et al., 2021a & 2022; Asaba and Wada, 2019; Bannò, 2016; Block et al., 2013; Chirico et al., 2020; Czarnitzki and Kraft, 2009; Decker and Günther, 2017; Jell et al., 2015; Matzler et al., 2015). Output-related papers highlight how FFs behave differently from non-FFs when managing innovation and particularly when they strategically protect intellectual property. Indeed, compared to non-family peers, FFs adopt specific innovation strategies which take into account gains and losses not only in financial terms but also in relation to socioemotional wealth (SEW) (e.g. Calabro et al., 2018; Chrisman and Patel, 2012; Gomez-Mejia et al., 2014). This widens the number of goals to be considered, such as (a) enhancing and perpetuating family image and

reputation, (b) maintaining family control of ownership and management and (c) sustaining the family's dynastic aspirations and ensuring that the business remains viable across future generations (Chrisman et al., 2012). Hence, family involvement can give firms a long-term strategic motivation, thereby promoting firm innovation (Sirmon and Hitt, 2003). However, SEW goals do not always benefit firms; indeed, they often conflict with their economic interests, resulting in a lack of talent and bringing agency problems (Chrisman et al., 2014; Verbeke and Kano, 2012). In these cases, FFs reduce their innovative activities to avoid the associated high risks and protect their SEW (Gomez-Mejia et al., 2007).

In accordance with the SEW perspective, there are numerous reasons that FFs might decide to patent or not. On the one hand, patents and the protection that they provide can be viewed as a means to preserve both the wealth for family business owners and their descendants (Duran et al., 2016; Kellermanns et al., 2008; Zahra, 2005) and their reputation, thus affirming the family's name in the market. Moreover, the long protection of inventions assured by patents can be favoured by the long-term orientation typically found in FFs and their business-transfer process through hereditary succession (Hauck and Prügl, 2015). On the other hand, as patenting is expensive because of the costs involved (i.e., application/renewal costs and litigation costs), external financial capital is required, thereby diluting the family's ownership stake in the firm. Moreover, patenting entails disclosing information on the knowledge created, which can lead to losses of critical tacit knowledge, an important source of survivability capital and a critical condition for successful generational succession (e.g. Cabrera-Suàrez et al., 2001). Finally, patenting activities entail the greater involvement of specialised human capital, managerial talent and expertise commonly not available within the family (e.g. Chrisman et al., 2014; Verbeke and Kano, 2012).

From the empirical point of view, the few studies examining the link between family ownership and patenting provided somewhat mixed insights. Some authors find that family involvement positively affects patenting (Duran et al., 2016; Jell et al., 2015; Matzler et al., 2015), especially in the first generation of FFs (Memili et al., 2015). In contrast, in Bannò (2016), family ownership does not impact on the propensity to patent and on the citation intensity, respectively. Finally, FFs are less likely than other firms to introduce green patents (Aiello et al., 2021a) or have a negative influence on the number of patents granted (Aiello et al., 2022; Decker and Günther, 2017) and on the number of patent citations (Aiello et al., 2022; Block et al., 2013).

Following the theoretical arguments and the claims of the majority of the empirical literature, according to which FFs are more conservative, less prone to risk and more likely to preserve the status quo in terms of SEW and firm control, we contend that family involvement in business can decrease the propensity to engage strategies to protect intellectual property. According to the above arguments, we postulate the following hypothesis:

Hypothesis 1: *Family-owned firms patent less than non-FFs.*

## ***2.2 The moderating role of size and age***

A potential caveat of prior studies is that some specific factors of firm heterogeneity are not properly considered. Thus, an extension of Hypothesis 1 comes from the awareness that firms are far from being homogeneous.

Starting from the fact that FF is a label that includes a variety of firms (Daspit et al., 2021), many scholars advocate that in order to explain better the performance of FFs further research should focus on firm heterogeneity (Chrisman and Patel, 2012; De Massis et al., 2014). In this respect, Block et al. (2022) argue that size and age are key variables in specifying the contexts under which FFs outperform or underperform compared to their non-family counterparts, thereby becoming good candidates to moderate the relationship between family ownership and innovation.

Although it has been well established that firm size (Acs and Audretsch, 1990 & 1991; Cohen, 1995; Cohen and Klepper, 1996a & 1996b; Griliches, 1980; Pavitt et al., 1987) and age (Balasubramanian and Lee, 2008; Coad et al., 2016 & 2018; Rossi, 2016) affect innovation, the interest in family business research is limited (e.g., Aiello et al., 2022; Cruz and Nordqvist, 2012; Decker and Günther, 2017; Hillebrand, 2019; Rau et al., 2019; Werner et al., 2018; Zara 2015).

### ***2.2.1 Firm size, family firm and innovation performance***

It is widely shown that large organisations have more resources to conduct R&D activities and adopt innovation (Van de Ven, 1986). This is crucial for patenting as it entails several direct and indirect costs related to developing, attaining and maintaining patent protection that might dissuade small firms from returning to practices of intellectual protection. Furthermore, larger firms are more likely to patent due to their higher organisational innovation capabilities (Majchrzak et al., 2004). These differences can lead to differing patent strategies.

While these considerations hold true independently of ownership, as far as FFs are concerned, we know (cf. § 2.1) that they innovate differently because of their specific characteristics which can exert either a negative or a positive influence on innovation. For instance, financial and human capital are two factors that help to understand the link between size and the innovation capacity of FFs. Indeed, larger FFs mobilise human and financial resources in a suboptimal fashion, thereby weakening their innovation performance compared to their non-family counterparts.

In particular, when a business increases in size, more funding is required to innovate, but the search for additional financing is limited by FFs' reluctance to use external resources (Serrasqueiro et al., 2016). This is because FFs avoid sharing equity with non-family members (Sirmon and Hitt, 2003) in order to keep ownership control in the family (e.g., Gómez-Mejía et al., 2007). Moreover, as a firm grows, any production process increases in complexity, and new skills are needed. Family-owned firms differ from others because they avoid recruitment from outside the family circle, with the consequence of maintaining a direct control over strategic

decisions and SEW. Nepotism and entrenchment of mediocre family executives limit human capital availability with the result that corporate innovation can suffer from their inadequate expertise (Bertrand and Schoar, 2006; Gomez-Mejia et al., 2001; Pérez-González, 2006). Conversely, recruitment in non-FFs is from the market, that is, from a very large pool of potential candidates that can inject fresh energy and resources that will boost innovation (Nordqvist and Melin, 2010).

From the empirical point of view, the evidence is based on very few papers which analyse the moderating effect exerted by size and suggest that the conditions to patent work differently in large and small firms. For instance, Aiello et al. (2022) show that Italian FFs underperform compared to non-FFs when they are large. Werner et al. (2018) confirm this for German firms. Evidence is ambiguous for small firms: Aiello et al. (2022) find that small FFs and non-FFs perform similarly, whereas Werner et al. (2018) reveal some advantages for small FFs.

Based on this literature, we predict the following:

*Hypothesis 2: The innovation patents-related gap between FFs and non-FFs increases with size.*

### *2.2.2 Firm age, family firm and innovation performance*

When we consider age, some scholars suggest that younger firms have a lower propensity to translate inputs in innovation (Coad et al., 2013; Helfat and Peteraf, 2003). This is due to the low absorptive capacity to use external knowledge (Zahra and George, 2002) and the lack of complementary resources (Bolívar-Ramos, 2017). As companies age, they gain more experience, thereby developing dynamic capabilities and the ability to survive, with the expected result to be achieved over time (Rossi, 2016).

In looking at the literature focusing on FFs, it is worth mentioning that there is an additional narrative surrounding the role played by age. In many family-oriented papers, age is meant as a proxy of the generational stage (Beck et al., 2011; Fernández and Nieto, 2005; Fiss and Zajac, 2004; Kraiczy et al., 2015; Sánchez-Marín et al., 2020). The reason for this is that the participation of family generations in ownership and management is considered an important source of heterogeneity and thus an essential factor to understand FFs' strategic decisions and outcomes (Chrisman and Patel, 2012; Gomez-Mejia et al., 2007).

This literature highlights not only the positive founder effect (Adams et al., 2009; Barontini and Caprio; 2006; Villalonga and Amit; 2006) due to emotional attachment to the firm and its desire to preserve ownership, but it also shows that FFs benefit more from an age-related learning process because they usually start with a set of competencies and experiences smaller than non-FFs. As the learning process increases knowledge over time, firms improve the ability to adapt and to reshape strategy choices as the external environment changes (Cucculelli et al., 2014).

This positive effect is reduced in the post-founder generation since generational involvement alters the dynamics among family members, heightening conflicts within FFs (Gersik, 1997;

Le Breton-Miller and Miller, 2013). All this could restrict learning capacity by impeding knowledge integration (Chirico and Salvato, 2008), thus affecting innovation performance. Similarly, family ownership impedes the innovation output in companies as these become older, while non-family-owned firms do not suffer from this age effect (Decker and Günther, 2017). Rau et al. (2019) corroborate these findings. In contrast, Zahra (2005) points to a positive generation–innovation relationship by revealing that successors can contribute new knowledge to their FFs, facilitating the identification of novel market opportunities and innovation. The same is found in Cruz and Nordqvist (2012) and Hillebrand (2019). Finally, Arzubiaga et al. (2019) find mixed evidence: generational involvement positively moderates the relationship between explorative innovation and firm performance and, at the same time, negatively moderates the relationship between exploitative innovation and firm performance.

From these considerations, it emerges that the relationship between FFs and patents is conditioned by firm age. In particular, it is argued that the first-generation enterprises benefit more from an age-related learning process and the beneficial effect of the founder. The hypothesis considering the post-founder generation is more controversial, in which firm age could negatively or positively affect the innovation.

Considering these diverse standpoints, the third hypothesis is as follows:

*Hypothesis 3: The innovation gap between FFs and non-FFs decreases with age in the first-generation firms. In the post-founder generation of owners, the gap could increase or decrease as firms age.*

### *2.2.3 Joint effect of size and age on the relationship between family ownership and patenting*

What we have learned so far is that FFs have certain particularities that render them different from other businesses and that size and age can affect their innovative behaviour in several ways. In line with the above, we recognise the importance of size and age in predicting the impact of family ownership on innovation, but we believe that this relationship is more complex than that highlighted by prior research. Additional insights can be gained by assessing the impact on performance jointly determined by ownership, size and age.

Considering H1, H2 and H3, we expect that the innovation gap between FFs and non-FFs will decrease for smaller and younger firms. On the one hand, the first generation of FFs benefits more from an age-related learning process and, on the other hand, small FFs do not experience the disadvantages related to the suboptimal use of human and financial resources that they experience when they increase in size (are large).

Conversely, we expect that the innovation gap between FFs and non-FFs could increase for larger and older firms. Indeed, in the post-founder generation, the beneficial effect of the founder disappears and generational involvement alters the dynamics among family members, heightening conflict within FFs and so affecting innovation performance. Conversely, non-family-owned firms do not suffer from this age effect. Furthermore, being a large company means operating in a context which is characterised by higher complexity and formalisation. In



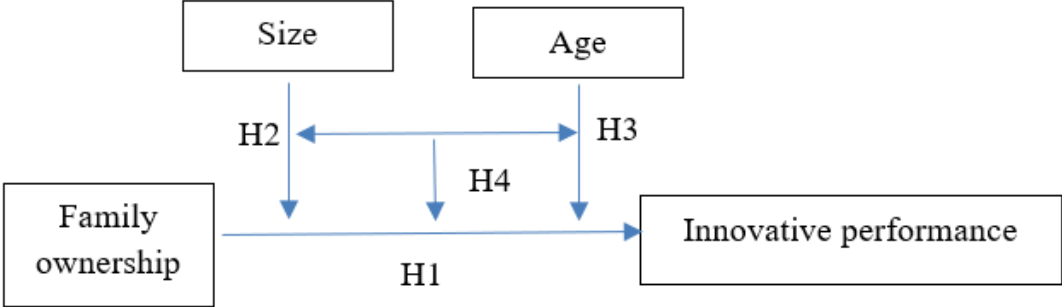
this case, the professionalisation of the organisation becomes an imperative, more difficult to satisfy for the FFs because they tend to recruit from inside the family circle, thereby making it hard for an FF to effectively innovate compared to a non-FF.

It is more difficult to anticipate any clear relationship between FFs and firm performance when we consider other ‘types’ of firms (for instance, smaller and older, larger and younger) due to the tensions between advantages and disadvantages. Hence, we predict the following:

*Hypothesis 4: The innovation gap between FFs and non-FFs decreases as the size and age increase in first-generation small firms, while it will increase as the size and age increase in post-founder generation large firms.*

Figure 1 illustrates a summary of the conceptual model and the hypotheses.

**Figure 1. Conceptual model and hypotheses**



**3. Methods**

**3.1 Sample and data**

We used secondary data obtained from the Orbis Europe database of Bureau van Dijk, which comprised an initial panel of about 26,000 firms which applied for at least one patent with the European Patent Office (EPO) between 1981 and 2017. The patents are from the Orbis Intellectual Property (Orbis IP) dataset (Bureau van Dijk), which was linked to PATSTAT released by the European Patent Office (EPO). The Orbis IP dataset makes available a unique firm identifier, which allows matching between firm-level patents and balance sheet data contained in Bureau van Dijk’s Orbis Europe archive, which also provides information on the ownership structure of the firms.

The number of patent applications per firm per year was considered. In our sample it takes an average of about three years for a patent to be granted by the EPO from the time of application. Therefore, we considered patent applications from 2010 to 2017, which were eventually granted by 2021. In this way, we do not introduce biases into the analysis due to the time lag of the examination process at the patent office and, at the same time, we limit the inclusion of the

lowest-quality patents (such as non-successful applications). This led to a sample of 22,761 observations (about 3,200 companies).

Table 1 shows the sample distribution among FFs (46.53% of the sample) and non-FFs (53.47%). As far as size is concerned, FFs are concentrated in the group of small and medium enterprises, while non-family companies are mostly medium and large. There are no differences between the two groups of companies when considering firm age: the sample is mainly composed of firms whose age is between 0 and 30 years (60.47%).<sup>1</sup> There is a high concentration of firms in the medium–high-tech companies (49.58%), located mainly in the north of Italy (84.59%), which is the most industrialised area of the country. The data reveal that the distribution of FFs and non-FFs does not substantially differ when considering geography and industry composition.

**Table 1.** Distribution of the sample of firms

			Family firms		Non-family firms	
	N.	%	N.	%	N.	%
Observations	22,761		10,591	46.53%	12,170	53.47%
Firm size						
Micro ( $\leq$ €2 m)	2,490	10.94%	2,021	19.08%	469	3.85%
Small ( $\leq$ €10 m)	7,806	34.30%	5,104	48.20%	2,702	22.21%
Medium ( $\leq$ €50 m)	8,424	37.01%	3,062	28.91%	5,362	44.06%
Large ( $>$ €50)	4,041	17.75%	404	3.81%	3,637	29.88%
Firm age						
$\leq$ 30 years	13,764	60.47%	6,319	59.66%	7,445	61.17%
$>$ 30	8,997	39.53%	4,272	40.34%	4,725	38.83%
Sectors						
High Tech	1,986	8.73%	623	5.88%	1,363	11.20%
Medium–high tech	11,284	49.58%	4,921	46.46 %	6,363	52.28%
Medium–low tech	6,415	28.18%	3,462	32.69%	2,953	24.26%
Low tech	3,076	13.51%	1,585	14.97 %	1,491	12.25 %
Territorial area						
Northeast	9,062	39.81 %	4,134	39.03%	4,928	40.49%
Northwest	10,193	44.78%	4,618	43.60 %	5,575	45.81%
Centre	2,703	11.88%	1,397	13.19%	1,306	10.73%
South	803	3.53 %	442	4.17 %	361	2.97%

**Source:** Authors' elaboration of data from Orbis Europe and Orbis IP (Bureau van Dijk)

<sup>1</sup> The threshold of 30 years comes from the classification of firms according to generation: FFs are in the first generation of their firm life when the age is less than 30 years. When age is more than 30 years, firms belong to the subsequent generation (Gersik, 1997).

### 3.2 Variables

The dependent variable to be analysed is the yearly number of patent applications filed by firms. Although patents do not fully capture firm innovation, they are commonly used as a measure of firm-level innovation because they are a relatively homogeneous indicator of innovative activity (as innovations have to satisfy specific requirements to be patented).<sup>2</sup> The key explanatory variables are family, firm size and age.

The literature proposes a variety of ways to classify FFs (Astrachan et al., 2002; Gersick et al., 1997). The criterion used in this paper to differentiate FFs from non-FFs is the absolute ownership majority (i.e., more than 50% of capital shares). The choice is well suited to our case because the structure of firm ownership in Italy is characterised by a limited number of shareholders with very large block holdings, thereby implying that a 50% stake is enough to achieve control of the company.<sup>3</sup> Size is measured by sales (in millions of euros), while age is the number of years since the company was established.

To control for other effects, regressions include the following controls: (a) an index of industry specialisation, and to this end we classify manufacturing industries into categories based on technological intensity proposed by the OECD (2011); (b) the firm location at the level of macro-regions (NUTS 1); and (c) time effects (year dummies). Finally, the stock of patents is used to control for the effect of knowledge accumulation<sup>4</sup> and the profit margin to control for the impact of firms' financial performance on patenting. Here it is worth pointing out that the variables size, stock of patents and profit margin are included with a one-year lag to take into account the likelihood that these factors will affect the propensity to patent with some lag.

The summary statistics and the correlation between the key variables used in this study are presented in Table 2.

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<sup>2</sup> Patents surely do not capture the entire output of innovation activity, as firms can develop non-patentable innovations and/or can decide to protect their innovations with alternative appropriability strategies (e.g. trade secrets, other forms of intellectual property, complementary assets) even if they are patentable. However, compared to other innovation indicators (i.e. the number of new products and/or processes), they do not reflect subjectivity in the assessment of what actually constitutes an innovation (Griliches, 1990).

<sup>3</sup> In the related literature, a threshold of at least 50% of the company's shares is commonly used for privately held companies (e.g. Arzubiaga et al., 2018; Broekaert et al., 2016; Classen et al., 2014; Memili et al., 2015; Meroño-Cerdán et al., 2018; Miller et al., 2013).

<sup>4</sup> The stock of patents is calculated by applying the perpetual inventory method to firm patents over the period 1981–2017, with a knowledge depreciation rate ( $\delta$ ) of 10%. It is a proxy of the knowledge endowment available at the firm level and also captures the effect of past R&D efforts made by firms to produce technology. As such, it is likely to influence the probability that a firm continues to produce a non-zero number of patents in the future.

**Table 2.** Descriptive statistics and correlations

Variable	Obs.	Mean	Std. Dev.	Min	Max	(1)	(2)	(3)	(4)	(5)	(6)
Number of patents	22,761	0.3861	1.7659	0	55	1					
Family firms	22,761	0.4653	0.4988	0	1	-0.1143*	1				
Size (in logs)	22,761	57.1833	405.2458	.5000	26,188.2700	0.2874*	-0.4702*	1			
Age (in logs)	22,761	28.1126	16.2237	1	120	0.0139	0.0572*	0.2158*	1		
Stock of patents	22,761	1.7708	5.8782	0	186.7814	0.7572*	-0.1253*	0.3053*	0.0446*	1	
Profit margins	22,761	4.2868	10.7059	-99.4620	90.9450	0.0205	0.0142	-0.0765*	0.0347*	0.0197	1

Source: Authors' elaboration of data from Orbis Europe and Orbis IP (Bureau van Dijk)

### 3.3 Empirical strategy

The use of patent data in econometric modelling can be problematic since they are counts (i.e., non-negative integers) and typically present a zero-inflated distribution (Hausman et al., 1984). We apply regression models that can account for these characteristics of the data. Among the two standard approaches, the Poisson regression and the negative binomial model, only the latter allows to handle data showing overdispersion, i.e., the mean is smaller than the variance (in our study: mean = 0.3861; variance = 3.1184).

However, zero patents are likely to be from two different data-generating processes from (a) firms that do not innovate at all and (b) firms that attempt to innovate but fail to generate patents (Cameron and Trivedi, 2013; Long and Freese, 2014). It is important to distinguish between these two types to understand better the different innovation behaviour of FFs compared to non-FFs. As our dependent variable exhibits a high number of zeros, meaning that many companies did not patent at all over the entire period, we applied the Zero-Inflated version of the Negative Binomial model (ZINB)<sup>5</sup>

In the zero-inflated negative binomial (NB) model, the probability of choosing to innovate or not is modelled in the inflated part through a logit model (B). The innovation outcome, i.e., the quantity of patents, is modelled by an NB process. The log likelihood function is thus constructed by combining the two processes. The zero-inflated model supplements NB density  $f_{NB}(\cdot)$  with a binary process that has density  $f_B(\cdot)$ . When firms do not attempt to innovate at all (i.e., the number of patents has a value of 0 with a probability of 1), the binary process takes a value of 0 with the probability  $f_B(0)$ .

When firms do attempt to innovate, i.e., the patent count takes values of 0, 1, 2, ..., the binary process takes a value of 1 with the probability  $f_B(1)$ , of  $1 - f_B(0)$ . The density function is defined as

$$g(pat_i) = \begin{cases} f_B(0) + (1 - f_B(0))f_{NB}(0) & \text{if } pat_i = 0 \\ (1 - f_B(0))f_{NB}(pat_i) & \text{if } pat_i \geq 1 \end{cases}$$

where  $f_B(\cdot)$  can be parameterised through a binomial model like the logit or probit and  $f_{NB}(\cdot)$  is NB density given by

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<sup>5</sup> We employ a ZINB as it is the most suitable method to model patent counts because of overdispersion (Greene, 2011). We use LR to test whether the overdispersion parameter is 0. The likelihood ratio test statistic is 1638.22 with a p-value of 0.000, indicating that the zero-inflated NB model is preferred to zero-inflated Poisson (ZIP) due to overdispersion. In addition, we test the specification between the standard NB model and the zero-inflated NB model. The Bayesian Information Criterion (BIC) indicates that zero-inflated NB is favoured over a standard NB. For a detailed discussion on zero-inflated count models, see Cameron and Trivedi (2013).

$$f_{NB}(pat_i) = pr(Y = pat_i | \mu_i, \alpha) = \frac{\Gamma(pat_i + \alpha^{-1})}{\Gamma(\alpha^{-1})\Gamma(pat_i + 1)} \left(\frac{1}{1 + \alpha\mu_i}\right)^{\alpha^{-1}} \left(\frac{\alpha\mu_i}{1 + \alpha\mu_i}\right)^{pat_i},$$

where  $E(Y_i) = \mu_i = \exp(x_i\beta)$ , and the parameter  $\alpha$  is the negative binomial overdispersion parameter.

To model the discrete choice to patent or not, we refer to a logit model:

$$f_B(0) = G(z'\gamma) = \frac{1}{1 + \exp(-z'\gamma)},$$

where  $z$  includes variables that determine whether a firm chooses to innovate or not, and  $\gamma$  are the corresponding coefficients. The likelihood function becomes

$$\begin{aligned} L(\beta, \gamma, x_i, z, pat_i) &= \sum_{pat_i=0} \ln[\exp(z'\gamma) + (1 + \alpha \exp(x_i\beta))]^{-\alpha^{-1}} \\ &+ \sum_{pat_i>0} \sum_{j=0}^{pat_i-1} \ln(j + \alpha^{-1}) \\ &+ \sum_{pat_i>0} \{-\ln(pat_i!) - (pat_i + \alpha^{-1}) \ln(1 + \alpha \exp(x_i'\beta)) + pat_i \ln(\alpha) + pat_i \\ &* x_i'\} + \sum_{i=1}^n \ln(1 + \exp(z'\gamma)) \end{aligned}$$

The vector  $x$  includes those variables used in the NB model and vector  $z$  in the logit model, both described in Section 3.2.

## 4. Results

### 4.1 Looking at the estimated coefficients

Table 3 presents the estimates for the ZINB regression (Models 1–6). The top part of the table presents the coefficients obtained when using the NB to study the number of patents (i.e., the intensive margin of innovation), whereas the middle part of the table presents the average marginal effects (AMEs) of the key variables (FFs, size and age).<sup>6</sup> Finally, the bottom part of the table reports the logit results of the inflated equation. It analyses the likelihood of observing (excess) zero patent counts and yields the extensive margins of innovation, i.e., the likelihood of entering the patenting market. In the following, we focus on the results of the second-stage NB distribution since it governs the actual realisation of the outcome.

Column 1 refers to the baseline Model 1, which includes only the ownership variable for FFs and the controls. Model 2 adds size and age to capture their individual impact. Model 3 and Model 4) are augmented with the product term FFs\*size and FFs\*age respectively. Model 5 is a two-way interaction model with FFs\*size, FFs\*age and size\*age. To better explain how size

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<sup>6</sup> As far as the intensive margin is concerned, an effective method for interpreting the count model results is to use factor and percentage changes in the rate rather than marginal effects (Long and Freese, 2006). Therefore, the AMEs are just reported for the three variables of interest.

and age jointly affect the relationship between FFs and patents, Models 6 consider three-way interactions.

Results from Model 1 indicate that, without controlling for size and age effects, family ownership has a significant and negative impact on the number of patent applications.<sup>7</sup> In particular, the FFs show a lower propensity to patent (-0.742), meaning that they obtain on average 0.476 times [ $\exp(-0.742) = 0.476$ ] as many patents as non-FFs (Table 1).<sup>8</sup>

In Model 2, size and age enter as fixed controls. The estimated coefficients and the AMEs indicate that the intensive margin of patents increases with size and decreases with age, suggesting that young firms have a higher ability to make the most of inputs in innovating. What is important in our discussion is that controlling for the size and age effects does not alter the sign of the ownership effect, albeit the magnitude of the effect varies considerably (i.e., passing from Model 1 to Model 2, the AME associated with family reduces from -7.062 to -0.173).

Compared to Model 2, Models 3 and 4 are to assess the moderating role of size and age, respectively. It is found that size moderates the effect of family ownership on patenting negatively: in Model 3, the product term FFs\*size has a negative and significant coefficient (0.093), suggesting that the association between firm size and innovation performance will be more negative for family *versus* non-FFs as size increases. Conversely, the interaction of FFs and firm age has a positive result (0.139 in Model 4), meaning that, *ceteris paribus*, the patent gap of FFs reduces with age.

In Model 5, age and size enter to moderate jointly the ownership effect on patents. It is a two-way interaction model and, thus, age and size interact with each other. With respect to previous results, the effects of FFs, size and age remain substantially unchanged, and the product terms family\*size and family\*age maintain the sign and the significance (the interaction family\*size becomes -0.166 and the interaction family\*age becomes 0.418).

The evidence related to the key research question, that is, how family, age and size simultaneously impact patenting, is provided by Model 6. This is because compared to Model 5, the three-way interaction model is an improvement in terms of fit. Indeed, we performed a likelihood ratio test under the null hypothesis, which showed that the three-way regression does not result in a statistically significant improvement in the model fit. The chi-squared statistics is 9.48 (p-value = 0.001), thereby indicating that the null hypothesis can be rejected and, thus, that Model 6 is the best performing regression. Furthermore, the three-way interaction term

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<sup>7</sup> It is worth pointing out that a negative value for the coefficients in the logit part indicates that an increase in a variable reduces the probability of belonging to the group that always makes zero patents and is thus interpreted as a positive impact on the likelihood to patent.

<sup>8</sup> Regarding firms that never patent (logit distribution), the negative sign of the coefficient indicates that FFs show a lower probability of not patenting. This means that FFs are more likely to belong to the group that patents, but when only the companies that patent are considered, they perform worse. This result could reflect the fact that although the FFs enter into the innovation market, innovation has not been successful compared to non-FFs.

presents a negative and significant coefficient (-0.117), meaning that the ownership effect on patents varies across different combinations of the values of size and age (column 6 of Table 3). The check on the significance of the coefficient associated to the triple interaction is an additional test to accept Model 6 as the best performing (Kaufman, 2019).

**Table 3.** Patent equations: zero-inflated model

Panel A						
Negative binomial model						
	(1)	(2)	(3)	(4)	(5)	(6)
Family firms (FFs)	-0.742*** (0.056)	-0.135** (0.063)	0.118 (0.132)	-0.613** (0.27)	-1.048*** (0.305)	-1.824*** (0.429)
Stock of patents	0.068*** (0.003)	0.045*** (0.002)	0.043*** (0.002)	0.045*** (0.002)	0.042*** (0.002)	0.042*** (0.002)
Profit margin	0.001 (0.002)	0.001 (0.002)	0.001 (0.002)	0.001 (0.002)	0.002 (0.002)	0.002 (0.002)
Medium-low Tech	-0.072 (0.092)	-0.012 (0.092)	-0.004 (0.092)	-0.011 (0.091)	0.012 (0.091)	0.024 (0.091)
Medium-high Tech	0.302*** (0.078)	0.28*** (0.078)	0.291*** (0.078)	0.275*** (0.077)	0.297*** (0.077)	0.308*** (0.077)
High Tech	0.451*** (0.097)	0.356*** (0.098)	0.367*** (0.099)	0.346*** (0.098)	0.357*** (0.098)	0.382*** (0.098)
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Age		-0.083** (0.034)	-0.074** (0.034)	-0.101*** (0.036)	-0.345*** (0.094)	-0.436*** (0.101)
Size		0.319*** (0.016)	0.339*** (0.018)	0.315*** (0.016)	0.176*** (0.06)	0.118* (0.065)
FF*Size			-0.093** (0.041)		-0.166*** (0.046)	0.221 (0.166)
Family firms*Age				0.139* (0.079)	0.418*** (0.102)	0.668*** (0.145)
Size*Age					0.057*** (0.019)	0.076*** (0.021)
Family firms*Size*Age						-0.117** (0.05)
Constant	-0.452*** (0.102)	-1.533*** (0.153)	-1.654*** (0.163)	-1.455*** (0.161)	-0.885*** (0.302)	-0.618* (0.318)
Negative binomial model (AMEs)						
Family firms (FFs)	-7.062** (2.975)	-0.173** (0.090)	-0.512*** (0.179)	-0.168** (0.089)	-0.620*** (0.185)	-0.624*** (0.183)
Age		-0.153*** (0.057)	-0.128*** (0.049)	-0.174*** (0.063)	0.053 (0.081)	0.105 (0.090)
Size		0.471*** (0.119)	0.441*** (0.107)	0.464*** (0.116)	0.458*** (0.111)	0.455*** (0.109)



Panel B						
Inflate: Logit						
Family firms (FFs)	-0.383*** (0.104)	-0.161 (0.118)	-0.084 (0.244)	-1.817*** (0.617)	-1.681** (0.682)	-4.153*** -1.067
Stock of patents	-0.515*** (0.027)	-0.489*** (0.028)	-0.489*** (0.028)	-0.491*** (0.028)	-0.49*** (0.028)	-0.488*** (0.028)
Profit margin	-0.011*** (0.003)	-0.008** (0.004)	-0.008** (0.004)	-0.008** (0.004)	-0.007* (0.004)	-0.007* (0.004)
Medium-low Tech	-0.116 (0.161)	-0.111 (0.169)	-0.107 (0.168)	-0.111 (0.168)	-0.104 (0.167)	-0.081 (0.167)
Medium-High Tech	-0.039 (0.138)	-0.053 (0.145)	-0.04 (0.145)	-0.063 (0.144)	-0.048 (0.143)	-0.026 (0.144)
High Tech	0.314* (0.17)	0.191 (0.187)	0.203 (0.186)	0.177 (0.186)	0.197 (0.186)	0.244 (0.185)
Regional dummies	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Age		0.282*** (0.07)	0.288*** (0.07)	0.193*** (0.074)	0.471** (0.198)	0.242 (0.193)
Size		0.031 (0.034)	0.022 (0.037)	0.019 (0.034)	0.368** (0.145)	0.196 (0.143)
FF*Size			-0.015 (0.08)		-0.127 (0.091)	1.088*** (0.408)
Family firms*Age				0.488*** (0.175)	0.562*** (0.216)	1.335*** (0.329)
Size*Age					-0.106** (0.046)	-0.049 (0.046)
Family firms*Size*Age						-0.363*** (0.119)
Constant	1.008*** (0.167)	-0.332 (0.305)	-0.354 (0.323)	0.006 (0.314)	-0.97 (0.643)	-0.288 (0.612)
/lnalpha	-0.079 (0.058)	-0.324*** (0.066)	-0.337*** (0.066)	-0.325*** (0.066)	-0.351*** (0.066)	-0.363*** (0.066)
Observations	23,138	22,761	22,761	22,761	22,761	22,761

Standard errors in parentheses; \*\*\* p < 0.01, \*\* p < 0.05, \* p < 0.1.

#### *4.2 Family firms patent less than non-family peers*

From the previous discussion, the first result to be highlighted concerns the ownership effect. Whatever the model, we find that FFs patent less than non-FFs: the AMEs reported in the middle part of Table 3 are always negative and significant in all models. Thus, we provide further empirical evidence to the previous literature on the negative effect of family involvement (Aiello et al., 2021a & 2022; Bannò, 2016; Block et al., 2013; Decker and Günther, 2017) and confirm that FFs can encounter greater difficulties in innovating (König et al., 2013). Based on this, it emerges that Hypothesis 1 is confirmed and holds, whatever the model specification.

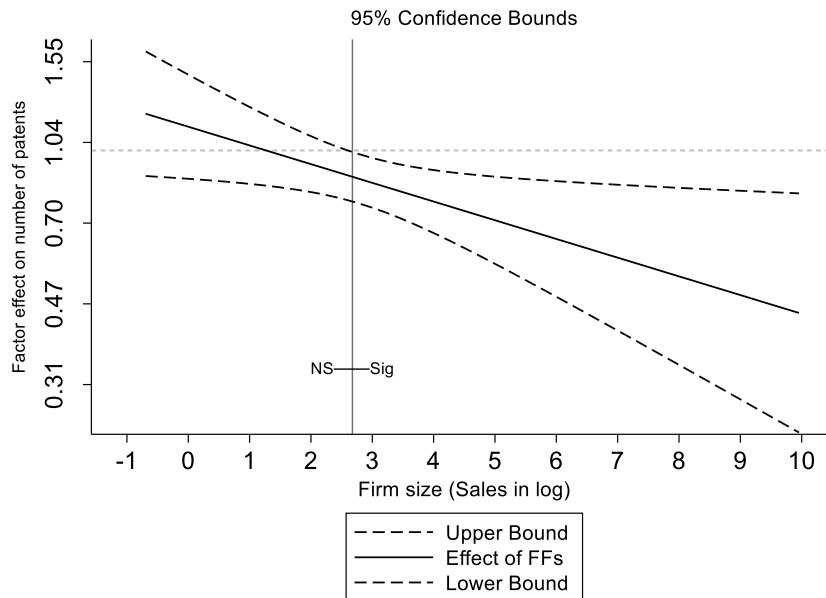
However, it is of interest to highlight that in a non-linear model, the coefficient estimates and AMEs do not provide answers to many questions of interest (Ai and Norton, 2003; Karaca-Mandic et al., 2012; Mize, 2019). For instance, they do not tell us where (if anywhere) there are significant differences between FFs and non-FFs across the range of size and/or age. It is possible that there are these differences only at certain values or that they hold across all levels of the moderators. This is to be verified empirically by going into depth on what happens at any value of size and age. Additionally, even when the patent gap is confirmed, whatever the moderators, it is important to investigate whether the gap in magnitude differs at distinct points of age and/or size. To address these issues, the following sections focus on the moderating role of size and age.

#### *4.3 Size positively moderates the relationship between ownership and patenting*

This subsection discusses the evidence concerning the moderating role of size in explaining the patenting gap of FFs. We refer to the estimates of Model 3 and convey the results of family, size and of its interactions in a graphical interpretation (Figure 2).

Figure 2 shows the factor-change effect of FFs as a solid line that slopes downward as size increases (it is traced by fixing age at its mean value). The interpretation is that the innovation gap increases as size increases, confirming the evidence from other studies (Aiello et al., 2022; Athreye et al., 2021; Hall et al., 2013; Pajak, 2016; Scherer, 1965; Symth et al., 1975). Interestingly, the vertical line at size = 2.8 marks the change from a non-significant to a significant moderating effect of size. Small firms (size < 2.8) perform similarly regardless of ownership. As size increases, FFs tend to have a lower number of patents than non-FFs, highlighting that size amplifies the disadvantages of familiness. For example, at a size value of 6, that is, with sales amounting to 400 million euro, FFs would be expected to have significantly fewer patents than non-FFs with about 0.7 times as many. These findings support Hypothesis 2.

**Figure 2.** Factor effect of firm ownership moderated by size

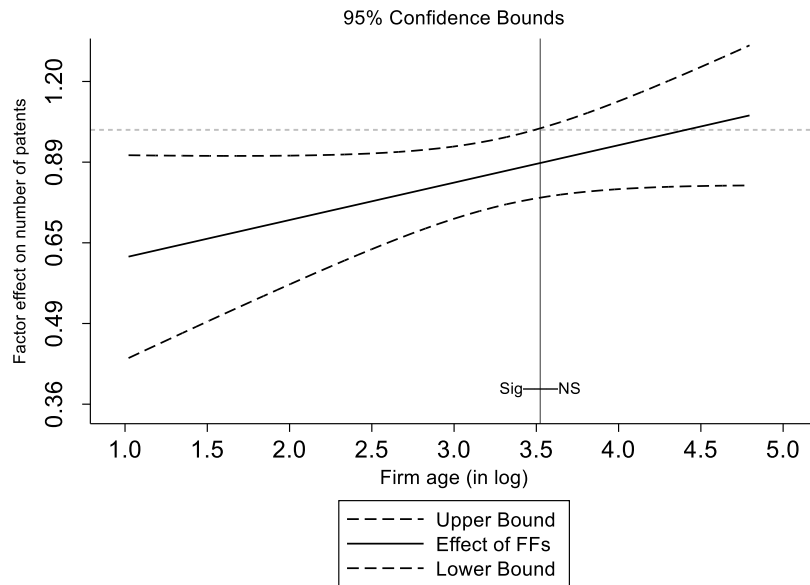


#### 4.4 Age moderates the relationship between ownership and patenting

Here, we refer to the estimates of Model 4 to present the age-moderating effect. Figure 3 shows the factor-change effect of FFs as a solid line that slopes upward as age increases, supporting the proposition that firm age has a positive moderating effect on patenting. In the same vein as what emerges when studying the size effect (cf. 4.3), Figure 3 highlights that the age effect is not always significant. Indeed, the innovation gap decreases as age increases in the first-generation firms (the effect of FFs is significant up to the 3.5 level of age, i.e., 33 years), while in the post-founder generation, age does not impact the patent gap. Stated differently, old FFs and non-FFs seem to behave similarly.

These results support Hypothesis 3 that the relationship between FFs and patents is conditioned by age and that the first-generation enterprises benefit more from an age-related learning process and from the beneficial effect of the founder (Adams et al., 2009; Barontini and Caprio, 2006; Villalonga and Amit, 2006). It is of interest to note that this evidence holds under the condition that size is fixed at a given value (Figure 3 is traced by fixing size at its mean value). In what follows, we explore what happens when size and age vary in their sample values.

**Figure 3.** Factor effect of firm ownership moderated by age



#### 4.5 Three-way interaction effect on patenting

What we have so far shown is that size and age distinctly moderate the ownership–patenting nexus. Although these are new results in the family business literature, the three-way interaction model allows us to obtain even broader evidence because it admits that the moderating effect is jointly rather than individually determined by size and age.

The interest lies, therefore, in detecting whether and to what extent FFs’ patenting activities differ from non-family peers at different values of size and age (Hypothesis 4). This more in-depth analysis is based on the estimates obtained from Model 6.

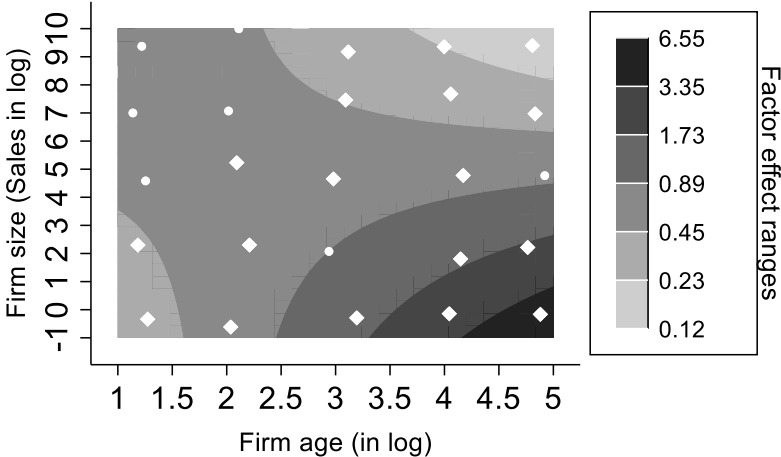
Table 4 displays the family-ownership effect on the intensive margin of patenting when size and age vary over the sample range. To allow easier reading of results, the regions of significance are shaded to differentiate between negative (lighter shades) and positive (darker shades) effects. The shaded area running on the diagonal from the top left to the lower right represents significant negative effects of FFs, that is, FFs’ number of patents is less than non-FFs. This area is defined essentially by the combinations of size and age in the bottom half of their respective ranges or in the top half of their ranges.

For example, in the top-left corner, there are firms of a minimal size and age. In such a case, the expected log count for FFs is 1.2594 lower than the expected log count for non-FFs, meaning that FFs obtained, on average, 0.3 times [ $\exp(-1.2594) = 0.2838$ ] as many patents as non-FFs, that is, 70% fewer patents. At the opposite extreme, there are firms of the greatest size

and age. The expected log count for FFs is 2.1206 lower than the expected log count for non-FFs, meaning that FFs obtain, on average, 0.12 times  $[\exp(-2.1206) = 0.12]$  as many patents as non-FFs, that is, 88% fewer patents.

In order to convey the results in a meaningful way, Figure 4 provides a visual representation of values of Table 4. Figure 4 displays different colourations, from lighter to darker shades, showing how the effect changes from negative to positive, or at least to a smaller negative. Furthermore, large diamonds mark a significant effect, whilst small circles denote no significant effect. The four lightest grey shades of the contours represent negative effects of FFs, with the lighter shades showing a more negative effect. The two darkest shades signify positive effects, with the darker shade showing a larger positive effect.

**Figure 4.** Effect of family ownership on the intensive margin of patenting moderated by the interaction of age and size



What clearly emerges from Table 4 and Figure 4 is that the innovation gap between FFs and non-FFs is substantial when size and age are both in the lower or the upper parts of their domains. The gap diminishes when size and age are in the middle of their distribution. In other words, the negative family effect is largest for two subgroups of firms: the first includes very small and young firms, whereas the second subgroup refers to very large and older firms.

Here, it is worth highlighting that Table 4 and Figure 4 allow the individual effect of size or age on the FFs to be detected as if they were treated as single moderators. This is similar to what Figures 2 and 3 allow, but the additional benefit from Figure 4 is to contemplate every value of each variable rather than only a given value.

**Table 4.** Effect of family ownership on the intensive margin of patenting at different value of age and size

At Size=	At Age=								
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
-1	-1.2594*	-0.8670*	-0.4745*	-0.082	0.310	0.7028*	1.0953*	1.4878*	1.8802*
0	-1.1556*	-0.8216*	-0.4876*	-0.154	0.180	0.5145*	0.8485*	1.1825*	1.5165*
1	-1.0518*	-0.7763*	-0.5007*	-0.2251*	0.051	0.3261*	0.6016*	0.8772*	1.1528*
2	-0.9480*	-0.7309*	-0.5138*	-0.2966*	-0.080	0.138	0.3548*	0.5719*	0.7891*
3	-0.8442*	-0.6855*	-0.5268*	-0.3681*	-0.2094*	-0.051	0.108	0.267	0.4254*
4	-0.7405*	-0.6402*	-0.5399*	-0.4397*	-0.3394*	-0.2391*	-0.139	-0.039	0.062
5	-0.637	-0.595	-0.553	-0.5112*	-0.4693*	-0.4275*	-0.3857*	-0.344	-0.302
6	-0.533	-0.549	-0.566	-0.5827*	-0.5993*	-0.6159*	-0.6325*	-0.6491*	-0.666
7	-0.429	-0.504	-0.579	-0.6542*	-0.7293*	-0.8043*	-0.8794*	-0.9544*	-1.0294*
8	-0.325	-0.459	-0.592	-0.7257*	-0.8592*	-0.9927*	-1.1262*	-1.2597*	-1.3932*
9	-0.222	-0.413	-0.605	-0.797	-0.9892*	-1.1811*	-1.3730*	-1.5649*	-1.7569*
10	-0.118	-0.368	-0.618	-0.869	-1.1191*	-1.3695*	-1.6199*	-1.8702*	-2.1206*

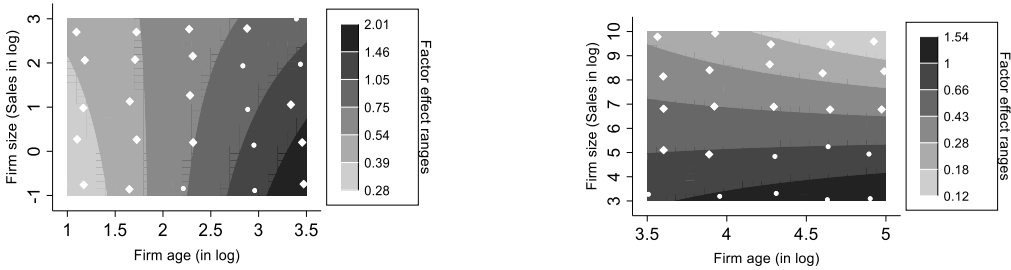
Variables values are expressed in log.

To isolate how age moderates the effect of FFs on the intensive margin of patenting, we fix size at a reference value. It is found that the age-moderating effect varies according to firm size: for small companies, the patenting gap decreases with age, while for large firms, the gap increases with age. The proof of this is as follows: fixing size at a low reference value and tracing a horizontal path upward (say, i.e., at size = 1), the colouration changes from lighter to darker shades, showing how the family-ownership effect moves from negative to a smaller negative. The opposite occurs for large firms (with, i.e., size = 8). In such as case, the colouration changes from darker to lighter shades. These results enrich the evidence retrieved from Figure 3, in which age was the only moderator and had a positive impact on the innovation gap.

Similarly, additional insights on the size effect come from comparing Figure 4 to Figure 2. On one side, it is easy to verify that for young firms (i.e., age = 1.5), FFs’ patent gap reduces as size increases. This is in contrast with Figure 2, as the moderating size effect was negative although not significant. On the other hand, for aged firms (i.e., age = 4.5), an increase in size determines a widening of FFs’ patent gap, thereby confirming what Figure 2 shows.

A more detailed representation of the lower-left corner (smaller and younger firms) and the upper-right corner (larger and older firms) is provided by Figure 5, which allows grasping better the differences between these two subgroups of companies and to assess clearly what happens if age and size increase jointly. It can be seen more clearly than in Figure 4 that in the case of small and young firms (Figure 5.a), the gap decreases (the colouration changes from lighter to darker shades), while in the case of large and old firms (Figure 5.b), the gap increases (the colouration changes from darker to lighter shades).

**Figure 5.** Focus on effect of family ownership on the intensive margin of patenting moderated by the interaction of age and size



(a) smaller and younger (first generation)

(b) larger and older (post-founder generation)

In a nutshell, Figures 4 and 5 help to highlight three results. First, there are two areas, that is, two combinations of age and size, in which FFs underperform compared to non-FFs. This occurs for the groups of small and young firms and of large and old firms. Second, in a narrowed area of Figure 4, that is, in the bottom-right corner, FFs perform more than non-FFs. Here firms are small and old. Third, in the group of large and young firms, i.e., the upper-left corner of Figure 4, there is no difference between FFs and non-FFs.

These differences in patenting prove that size and age jointly influence the context under which FFs outperform or underperform compared to non-FF peers. As the family-ownership effect on patents is determined by the various typologies of firms, Hypothesis 4 is confirmed. At the same time, this implies that Hypothesis 1 has to be validated taking into account firm heterogeneity. Indeed, this research demonstrates that the sign and magnitude of the ownership effect differs across firm groups and that a three-way interaction model helps to grasp fully the effect of the heterogeneity of FFs on innovation performance.

## **5. Discussion and conclusions**

Strong theoretical reasons suggest that innovation in FFs differs from that found in non-FFs. Differences emerge even among FFs due to their heterogeneity. Based on this, the paper aims to investigate the relationship between FFs and innovation by adopting a context-based approach. In this respect, size and age are meant to be key contingent factors in explaining the variability in firm behaviour. We take advantage of prior research, according to which size impacts the availability of resources and age is associated with experience and generational stage.

Departing from an assessment of the individual role of size and age, the evidence yielded in this paper indicates that they exert a joint effect on patenting and, in so doing, helps to identify the conditions under which FFs outperform or underperform with respect to non-FFs. In this vein, by employing a proper research design to grasp FFs' heterogeneity, we provide complementary rather than contradictory conclusions to prior family business studies.

In particular, it is shown that for small and young firms, the FFs patent less than non-FFs and the innovation gap decreases with size and age up to the threshold of first-generation firms. Here, FFs benefit more from an age-related learning process because they usually start businesses with a poor set of competencies and founder inexperience. Skills grow over time because founders acquire more market knowledge, improve their adaptation ability and reshape strategy choices as the external environment changes (Cucculelli et al., 2014).

Although the innovation gap persists, it increases for large and post-founder generation enterprises. This result can be explained by considering two aspects. On the one hand, when a business increases in size, any firm process increases in complexity, and new skills are needed. FFs avoid recruitment from outside the family circle, nepotism limits the human capital availability and corporate innovation can suffer on account of their inadequate expertise (Bertrand and Schoar, 2006; Gomez-Mejia et al., 2001; Pérez-González, 2006). Furthermore, FFs have major financial constraints due to their considerable reluctance to use external resources (Serrasqueiro et al., 2016) in order to keep ownership control in the family (e.g., Gómez-Mejía et al., 2007). Innovation activities are costly and therefore are an unattractive option for FFs which have limited financial resources. On the other hand, since these are post-founder companies, they are affected by problems related to the generational stage (Gersik, 1997). The emotional attachment of a family to the firm and its desire to preserve ownership



will likely reduce in the post-founder generation. Moreover, any negative effect that emerges among family members can be more damaging than when a respected powerful founder remains in charge as now it is possible that some family members can identify and be involved with the firm more than others, and that can create conflicts by compromising the viable conduct of the business (Le Breton-Miller and Miller, 2013).

Moreover, if the firm is very large, passing control on to succeeding generations often results in a more dispersed ownership structure (Van Aken et al., 2017). A principal–principal problem can arise due to conflict between the members of different nuclear families. This phenomenon is known as family opportunism: family members make decisions in view of their own nuclear household's welfare rather than the welfare of their extended family (Le Breton-Miller et al., 2011; Lubatkin et al., 2005; Miller et al., 2013). Furthermore, family conflicts in later generations could restrict learning capacity by impeding knowledge integration (Chirico and Salvato, 2008), thereby affecting innovation performance. Thus, FFs' increasing size should therefore result into comparatively lower innovation activities. This is unexpected for larger non-FFs (Werner et al., 2018).

Summarising, this study shows that size matters, whatever the firm type. However, for FFs the generational stage is also decisive, and in this respect, two facts emerge. For the first generation of firms, the patenting gap between FFs and non-FFs reduces as size increases. For the subsequent generation of owners, an increasing size can become a critical factor.

These findings have a number of potential theoretical and practical implications. From a theoretical point of view, the study suggests that a better understanding of FFs' innovation requires taking in account some aspects of firm characteristics, thereby contributing to the long-standing studies on the importance of firm age and size to innovation efforts. Scholars have mainly debated about age and size, paying less attention, however, to how these factors can jointly affect the FFs–innovation nexus. Additionally, this work contributes to the ongoing debate about the validity of SEW as an appropriate theoretical lens to study family business owners' behaviours in depth.

The paper also has important practical implications for FFs. FFs must grow in size, but the positive size-effect can be outweighed by conflicts between family members when the founder no longer leads the company. If the firm is large, passing control on to succeeding generations will often result in a more dispersed ownership structure that can generate conflicts between the members of different nuclear families. Therefore, FFs should adequately balance family logic with business logic.

A strategy should be to recruit from outside the firm the necessary talented professional manager to be charged with taking decisions in favour of innovation. This issue is particularly critical for Italy where entrepreneurs are reluctant to formally hand over the management of a firm to outsiders, possibly resulting in severe performance implications (Aiello et al., 2019; Baltraunaite et al., 2022). Thus, it will be important for future studies to replicate our findings in other countries in order to take in account cross-national differences in the attitude towards the propensity to patent.

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