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Green patenting and corporate social responsibility: Does family involvement in business matter?

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Abstract

This paper explores whether family and non-family firms differ in terms of their capability to introduce green patenting. By considering the environmental performance as a corporate social responsibility related concern, the analysis is based on a large data set of patenting activities carried out by Italian manufacturing firms over the period 2009–2017. Results show that family firms are less likely than non-family firms to implement innovations in green technologies. This holds true whatever the level of accumulation in green and non-green knowledge.

KEYWORDS

CSR, family firms, eco-innovation, green patent

1 | INTRODUCTION

Corporate social responsibility (CSR) is a multidimensional concept that embodies the relationship between firms and society, whereby companies voluntarily integrate social and environmental concerns in their business operations and in their interactions with stakeholders (Carroll, 1999; Dahlsrud, 2008; De Bakker et al., 2005). It comprises a variety of activities, which spans a wide set of issues related, for instance, to environment, product safety and to the relations with employees and customers (Cruz et al., 2014; Dyer & Whetten, 2006). Within this range of initiatives, strong interest has been documented in sustainability-related concerns because of the increased stakeholder pressure on firm environmental performance (European Commission, 2021; OECD/European Commission/Nordic Innovation, 2012).

Whether firms adopt CSR initiatives and what they do depend on many factors, one of which is their ownership, especially when considering the relationship between CSR and environmental performance (Dou et al., 2019; Lamb & Butler, 2016). Indeed, being owned by a family alters firm goals (Basco, 2017; Chrisman et al., 2012), changing the reference point for making strategic decisions (Cennamo et al., 2012), such as those related to the environment (Doluca et al., 2018).

Despite the recent progress that has been made in understanding the role of family in influencing firm green behavior, an open question is whether family firms (FFs henceforth) act better than their non-family counterparts in the field of environmental performance. We contribute to the debate by investigating whether and to what extent family and non-family firms differ when adopting eco-innovation.

The analysis departs from the socio-emotional wealth theories (SEWs; Gómez-Mejía et al., 2007), as they represent a widely adopted framework in family business literature to address CSR-related issues. The term "socio-emotional wealth" refers to the tendency of family businesses to pursue non-financial objectives to preserve their "affective endowments" (Gómez-Mejía et al., 2007). Recent works highlight that specific characteristics of family businesses either foster (the "bright side" of SEWs) or constrain (the "dark side") their ability to increase their environmental performance (Cruz et al., 2014; Kellermanns et al., 2012; Kim et al., 2017). Although SEWs explain how FFs adopt pro-environmental practices to protect their positive images and good reputation with stakeholders, at the same time the interest in preserving firm wealth affects FFs' risk profile and then limits environmental innovation activities.

However, a hypothesis can be formulated after jointly considering the distinctive traits of FFs and some peculiarities of green technology. On the one hand, green innovation uses more complex and diversified knowledge and skills and requires a greater propensity to take risks, a greater ability to access external sources of funding and more intensive external relationships than other kinds of innovation (Hojnik & Ruzzier, 2016). On the other hand, FFs' green behavior is affected by their conservative posture (Habbershon et al., 2003), organizational rigidity (Kets de Vries, 1993), high risk aversion (König et al., 2013; Munoz-Bullon & Sanchez-Bueno, 2011), low propensity to use investment capital to fund innovation projects (Block et al., 2013), and limited ability to cooperate with external partners for innovation (Nieto et al., 2015).

Bearing in mind all these considerations, it is reasonable to hypothesize that FFs are less likely than other firms to introduce green innovation.

The research hypothesis is tested on a sample of Italian manufacturing firms observed over the 2009–2017 period. Green innovation is gauged by patents, which are suited to identifying specifically environmental innovation (Haščič & Migotto, 2015; Oltra et al., 2010).

In so doing, we respond to the call for additional investigations into the innovation dynamics in FFs (De Massis et al., 2015; Duran et al., 2016) and specifically we address the issue raised by Calabrò et al. (2019) on the relationship between family involvement in business and green innovation output. To the best of our knowledge, no family business study has estimated the propensity to introduce a green patent to date.

Here, it is worth noting that Italy represents a suitable research setting. Indeed, it is not only the third largest national economy in the eurozone, but also FFs account for about 75% of all the active firms in Italy (http://www.europeanfamilybusinesses.eu/). Further, the green economy is acquiring growing relevance in the country. The Green Italy 2018 report (Fondazione Symbola-Unioncamere, 2018) shows that 30.7% of firms made green investments during the period 2014–2017 or planned to do so by the end of 2018. Furthermore, the number of Italian green patents filed with the European Patent Office (EPO) increased overall by 22% between 2006 and 2015. The increase in green technologies assumes a particular value, given that at the same time overall patent capacity fell by 10% (UnionCamere, 2017).

The results show that FFs are less likely than other firms to obtain a patent in green domains. Moreover, a robust positive association is found between the past capital of knowledge in green technology and the propensity to introduce a green patent. Importantly, FFs register a low propensity to green patenting, whatever the level of past knowledge.

The work is organized as follows. Section 2 presents the literature review. Data, variables and the econometric model are described in Section 3, while the results are presented and discussed in Section 4. Section 5 concludes.

2 | FAMILY BUSINESSES, CSR AND ECO-INNOVATION: LITERATURE REVIEW

This study is positioned at the intersection of three research fields: FFs, CSR and (eco)-innovation. Here, the scope is to present a brief conceptual framework on the link between CSR and eco-innovation when considering the case of FFs. The related papers are classified into two groups. The first group refers to the literature on the influence of family ownership on CSR, assuming that the environment is a dimension of CSR. The second group regards FFs' eco-innovative behavior.

2.1 | Corporate environmental responsibility in family firms

Although there is not yet an exact definition of CSR, scholars agree that firms have responsibilities to society that go beyond profit maximization (Carroll, 1999; Dahlsrud, 2008; De Bakker et al., 2005). If this is the case, recent increasing attention is paid to exploring the green dimension of CSR and whether FFs relate to the natural environment in a different way compared to their non-family counterparts (Berrone et al., 2010; Broccardo et al., 2019; Cruz et al., 2014; Dangelico et al., 2019; Kim et al., 2017; Pan et al., 2021; Samara et al., 2018).

In this regard, the SEW approach (Gómez-Mejía et al., 2007) represents a suitable theoretical framework to understand the FFs attitude toward environment-related issues. According to SEWs, family members benefit from a variety of non-financial and emotional outcomes associated with firm activity, such as: (a) viewing the firm as an extension of themselves as well as deriving a sense of identity from the firm; (b) creating a positive family image and reputation; and (c) building social capital. When these non-economic benefits are threatened, it is possible that family owners make strategic decisions aimed at protecting their socio-emotional wealth, without considering the firms' financial risk profile (Gómez-Mejía et al., 2007).

Building on the work by Kellermanns et al. (2012), the SEW approach can be seen as a double-edged sword that can reveal either its bright or its dark side (see, also Cruz et al., 2014; Kim et al., 2017).

On the one hand, family owners are concerned about a variety of non-financial aspects of firm ownership that can positively influence CSR. Examples of this are the desire to obtain a high social status in a local community (Block, 2010) and to fulfill needs related to organizational and family identification (Le Breton-Miller et al., 2011; Zellweger et al., 2010). Moreover, reputation and image are two essential elements of family businesses (Sageder et al., 2018). FFs are less likely to greenwash and more likely to follow through on their proclaimed environmental commitments (Kim et al., 2017). These arguments suggest that family businesses implement socially responsible behavior (Berrone et al., 2010). This is the bright side of SEW. On the other hand, the risk aversion of FFs (König et al., 2013; Munoz-Bullon & Sanchez-Bueno, 2011), induced by a more general long-term orientation (Gómez-Mejía et al., 2007; Le Breton-Miller & Miller, 2006; Lumpkin et al., 2010), negatively influences activities to eco-innovate. Bianco et al. (2013) argue that investments are significantly more sensitive to uncertainty in FFs than non-family firms. Along this line of reasoning, the high uncertainty of environmental innovations would increase the degree of risk of FFs, thereby compromising their longevity. Based on this, FFs are less environmentally responsible than non-family firms. This is the dark side of SEW.

In a nutshell, the environmental social performance of FFs can be contingent upon whether the bright or the dark side of SEW is prevalent.

2.2 | Eco-innovation in family firms

A large body of the literature has investigated the determinants of eco-innovation (Barbieri et al., 2016; De Jesús et al., 2016; Del et al., 2016; Hojnik & Ruzzier, 2016). However, an issue that has been overlooked is the effect of family ownership on green innovation: the scant comparative research on family versus non-family firms' environmental performance has produced competing evidence.

Some studies suggest that innovation in the context of FFs is characterized by a paradox: that is, FFs innovate less despite having the ability to do more (De Massis et al., 2015). Specifically, although their higher flexibility and their longer-term perspective would be in itself factors conducive to innovation, FFs are less willing to innovate due to their risk aversion, lack of resources and knowledge, and reluctance to ask for external financial investments (Aiello, Cardamone, et al., 2020). Additionally, some studies highlighted that FFs achieve higher innovation outputs compared with non-family firms (Duran et al., 2016), whereas others found that the returns to their R&D investments are low (Aiello, Mannarino, & Pupo, 2020).

A clearer picture comes from considering the specificities of eco-innovations and whether FFs' attributes facilitate or hinder green technology. This is because eco-innovations have different determinants from *tout court* innovations. For example, eco-innovations tend to be more complex than non-green innovations (De Marchi, 2012) and are grounded on higher levels of both inter- and intra-organizational collaborations (Messeni Petruzzelli et al., 2011). Additionally, they are characterized by high levels of novelty, uncertainty and variety (Cainelli et al., 2015) that increase the risks associated with them. Moreover, environmental innovations require more heterogeneous sources of knowledge compared to other innovations (Horbach et al., 2013). Empirical analyses support this view (Cainelli et al., 2015; De Marchi, 2012; De Marchi & Grandinetti, 2013; Fabrizi et al., 2018). Finally, the existence of financial barriers and the structured organization working on innovation are important distinctive drivers of eco-technologies (De Marchi, 2012; Del et al., 2016; Ghisetti et al., 2017). Given these specificities, green innovators are likely to have a greater need than non-environmental innovators for high-skilled employees and financial resources.

Summing up, the result is that the propensity to take risks, the capability to cooperate with external partners, the facility to access external sources of funding and the availability of human resources are very important for eco-innovations compared with other traditional and more established fields of knowledge.

These peculiarities do not match well with some FFs' traits and this should lead to weak performance in terms of eco-innovations. The desire to provide careers for family members (Schulze et al., 2001) makes it difficult to recruit qualified managers (Lubatkin et al., 2005), that is, managers who are charged with deciding on innovation processes. Moreover, because of the fear of losing decision-making control, FFs are not particularly inclined to allow the entry of other investors (Block et al., 2013; Kets de Vries, 1993) and are not particularly in favor of collaborative relationships (Nieto et al., 2015). This limits their ability to exploit the existing information ("absorptive capacity"), which is largely determined by past knowledge (Cohen & Levinthal, 1990). Furthermore, eco-innovations need complex and flexible structures, while FFs are less flexible and more conservative organizations (Zahra et al., 2004). Finally, investing in green technologies represents a higher risk, while FFs are notably risk averse (König et al., 2013; Munoz-Bullon & Sanchez-Bueno, 2011).

All these considerations lead to the hypothesis that FFs are less likely than other firms to implement innovations in green technologies.

3 | EMPIRICAL SETTING

This section presents the data (Section 3.1) and the variables (Section 3.2) used throughout the paper and describes the econometric strategy implemented in the analysis (Section 3.3).

3.1 | Data

The study is based on a panel data set built by combining multiple data sources on administrative patent data and firm-specific factors.

The sample is obtained from an initial panel of 26,000 firms in the Orbis Europe (Bureau van Dijk) database, comprising the applicants for at least one patent with the EPO between 1981 and 2017. This allows us to consider a homogeneous population of potentially innovative firms for which patenting is (or has been) a relevant tool to protect innovation.[1]

Patents are from the Orbis Europe data set provided by Bureau van Dijk, which has been linked to PATSTAT, the data set released by the EPO. The main advantage of using the Orbis–PATSTAT data set relates to the availability of a unique firm identifier, which allows the matching between firm-level patents and balance sheet data contained in Bureau van Dijk's Orbis Europe archive. Importantly, Bureau van Dijk's Orbis Europe provides information on the ownership structure of the firms.

We count the number of patents granted per firm per year, including only priority patents and excluding equivalent patent filings.[2] The fact that the focus is on granted patents implies that the sample is not likely to include the lowest-quality patents (such as non-successful applications). In addition, green patents in Orbis Europe are identified using the green inventory adopted by the World Intellectual Property Organization (WIPO). This inventory reports the International Patent Classification (IPC) classes that are associated with environment-friendly technologies in the fields of alternative energy production, transportation, energy conservation, waste management, agriculture/forestry, administrative regulatory and nuclear power generation.

After merging firms' financial data and patent portfolio from the Orbis Europe database, the final unbalanced panel comprises about 26,000 observations obtained from 4226 Italian manufacturing firms observed from 2009 to 2017.

Table 1 shows the sample distribution among FFs (2157 out of 4226 companies) and non-family firms (2069 companies). Firms with at least one green patent represent 4.71% of the sample; among these, 1.63% are FFs and 3.08% non-family firms. In terms of industry composition, the sample reflects the Italian economic structure, with a

TABLE 1 Distribution of the sample of firms

Firms	N.	%	Family firms N.	Family firms %	Non-family firms N.	Non-family firms %
Firms	4226	100.00%	2157	51.04%	2069	48.96%
Firms with at least						
One patent	2661	63,00%	1289	30.50%	1372	32.50%
One green patent	199	4.71%	69	1.63%	130	3.08%
Sectors						
High Tech	381	9.02%	146	3.45%	235	5.56%
Medium High Tech	2031	48.06%	983	23.26%	1048	24.80%
Medium Low Tech	1222	28.92%	705	16.68%	517	12.23%
Low Tech	592	14.01%	323	7.64%	269	6.37%
Territorial area						
North-East	1645	38.93%	840	19.88%	805	19.05%
North-West	1891	44.75%	919	21.75%	972	23.00%
Centre	514	12.16%	300	7.10%	214	5.06%
South	176	4.16%	98	2.32%	78	1.85%
Firm age						
Young (<6)	216	5.12%	86	2.04%	130	3.08%
Mature (6–20)	1174	27.78%	585	13.84%	589	13.94%
Old (>20)	2836	67.10%	1486	35.16%	1350	31.94%
*Firm size**						
Micro (<10)	431	10.32%	349	8.36%	82	1.96%
Small (10–49)	1616	38.65%	1136	27.18%	480	11.47%
Medium (50–249)	1554	37.18%	582	13.93%	972	23.25%
Large (>250)	579	13.85%	74	1.77%	505	12.08%

Note: *Due to missing data, there are 4180 firms with information on size.
Source: Authors' elaboration on data from Orbis Europe (Bureau van Dijk).

high concentration of firms in the medium-high-tech (48.06%) and medium-low-tech (28.92%).[3] To take into account Italy's well-known North–South divide (Eckaus, 1961), the geographical distribution is also considered. It emerges that the firms are mainly in the north of Italy (83.68%), the most industrialized area of the country. Data reveal that the proportion of family and non-family firms does not differ significantly when considering geography, industry composition and firm age. As far as size is concerned, FFs are concentrated in the groups with less than 50 employees.

3.2 | Variables

While patents have some drawbacks as indicators of technological activity—not all inventions are patented and the incentives to patent differ according to the sector and market—they present a number of advantages over alternative measures of innovation. Notably, patents are commensurable as they are based on an objective standard, that is the type of invention that can be patented is well defined, meaning that patents are probably the most definite measure of innovation (Wang, 2007). They also reflect the quality of an innovation, as any patentable idea is examined by experts who evaluate its novelty and utility. Moreover, differently from R&D expenditures, patents measure the outputs of the inventive process, thereby gauging better the market value of an R&D project. For these reasons, their use as a measure of the output of the inventive process has become standard in the literature (Griliches, 1990; Hall et al., 1986). These arguments hold true also when considering "environmental" innovations (Haščič & Migotto, 2015; Oltra et al., 2010). In this case, patent data can be disaggregated into specific technological fields, which are a key feature in studying green technology. In other words, patent classification systems are "technological" by nature (unlike commodity and industry classifications) and allow for a rich characterization of relevant technologies by describing the engineering features of an invention and its applications at a fine level of detail (Haščič & Migotto, 2015). All this implies that the use of patents in environmental fields of activity is very common (Brunnermeier & Cohen, 2003; Laurens et al., 2017; Montobbio & Solito, 2018; Nameroff et al., 2004; Wagner, 2007).

The key explanatory variable is the family dummy. There is no agreement on the definition of a family business (for a recent review, see Hernàndez-Linares et al., 2018). In this study, firms are classified as FFs when individuals or families record direct ownership of over 50%.

Recently, a conspicuous stream of literature has highlighted the importance of firm-level factors as key determinants of green patenting. Some of them are common to all innovations—such as the past stock of knowledge (Laurens et al., 2017; Montobbio & Solito, 2018)—and others are specific to eco-innovations, such as the presence of environmental management systems (EMSs; Dangelico et al., 2017; Montobbio & Solito, 2018; Wagner, 2007).

To assess the role of past knowledge accumulation, the analysis includes the stock of patents, distinguishing green and non-green technology to control for potential overlapping between the two categories. The stock of green patents (*K_G*) is meant to be a proxy for a firm's learning capacity in the field of green technology. The stock of non-green patents (*K_NG*) is based on all technological fields except green technologies and is a proxy for a firm's overall capacity to learn through patenting. To compute firm patent stocks, we refer to the period 1981–2017 and use the perpetual inventory method, with a knowledge depreciation rate $(\delta) = 10\%$.[4] The two patent stocks of the i-*th* firm at time t are measured as:

$$K\_G_{it} = PAT\_G_{it} + (1-\delta)K\_G_{it-1} \quad (1)$$

$$K\_NG_{it} = PAT\_NG_{it} + (1-\delta)K\_NG_{it-1} \quad (2)$$

where *K* is the stock, *PAT* denotes patents, *G* stands for green and *NG* for non-green.

As mentioned above, firm environmental behavior has been studied with respect to environment-related activities and best practices, such as EMSs. EMSs are a specific management process implemented voluntarily by private firms and based on the improvement of the environmental performance at firm level. Reputational and image-related reasons promote FFs' behavior regarding the adoption of EMS certification. However, given that FFs are smaller than their non-family counterparts (Block & Wagner, 2014; Zahra et al., 2004), the lack of human and financial resources that are potentially needed for certification hinders its adoption. These arguments are taken into account by the EMS certification, which is gauged through the ISO14001 standard.[5]

Furthermore, we include several controlling variables. The first is *Size*, measured as the number of employees (in log). This control is because large organizations are more likely to have resources to adopt new innovations (Kitchell, 1995) and to take an active role in natural environmental management (Aragón-Correa, 1998). Another control is *Profit Margin*, which is a profitability indicator that controls for the impact of firm financial performance on patenting. Age and gender of Chief Executive Officer (CEO) take into consideration executives' background characteristics. In the stream of CSR literature, studies found that several attributes of top executives, such as gender (Manner, 2010) and age (Fabrizi et al., 2014) might be instrumental in CSR.

Finally, regressions include variables of firm location (four dummies considering whether a firm is based in the *North-West*, *North-East*, *Centre* and *South* of Italy); industry specialization (four industry dummies signaling whether the firm belongs to high-tech manufacturing, medium-high-tech manufacturing, medium-low-tech manufacturing and low-tech manufacturing); and firm age to take in account that as an enterprise grows older, the efforts to adopt fresh innovation may be hindered by organizational inertia (Egri & Herman, 2000). Dummies for years are added to control for time fixed effects. Table 2 provides a description of all the variables used in the analysis.

3.3 | Empirical strategy

In order to verify the effect of being a family firm on the probability of introducing a green patent, the empirical strategy departs from

TABLE 2 Description of variables

Variable	Description
Dependent variables	
$Green\_Pat_{it}$	Dummy indicating whether firm *i* is engaged in green patent at time *t*, with $t = 2009, \ldots, 2017$
Explanatory variables	
$Family_{it}$	Dummy taking the value 1 if a firm is over 50% owned by individuals or families, and 0 otherwise
K_G_{it-1}	Stock of green patent calculated with perpetual inventory method
K_NG_{it-1}	Stock of non-green patent calculated with perpetual inventory method
D_EMS_{it-1}	Dummy equal to 1 if firm has an environmental management system certification (measured according to the International Organization for Standardization's ISO14001 standard) and 0 otherwise
Sectoral dummies: $High\ Tech_{it}$	It is 1 if the firm belongs to a high-tech manufacturing and 0 otherwise
$Medium\ High\ Tech_{it}$	It is 1 if the firm belongs to a medium high-tech manufacturing and 0 otherwise
$Medium\ Low\ Tech_{it}$	It is 1 if the firm belongs to a medium low-tech manufacturing and 0 otherwise
$Low\ Tech_{it}$	It is 1 if the firm belongs to a low-tech manufacturing and 0 otherwise
Territorial dummies: $North\ east_{it}$	It is 1 if firm is located in the North East of Italy and 0 otherwise
$North\ west_{it}$	It is 1 if firm is located in the North West of Italy and 0 otherwise
$Centre_{it}$	It is 1 if firm is located in the Centre of Italy and 0 otherwise
$South_{it}$	It is 1 if firm is located in the South of Italy and 0 otherwise
Age of CEO	Number of years since CEO's birth
Gender CEO	Dummy equal to 1 if CEO is female and 0 otherwise
Age_{it}	Number of years since the company was established
$Size_{it-1}$	Number of employees (in log)
$Profit\_margin_{it-1}$	Profit before tax/Operating revenue (%)

considering that the probability of green patenting is conditional on applying for a patent at all and controlling for firm-specific variables. At this point, we simultaneously estimate a selection equation (the probability of applying for a patent at all) and an outcome equation that is the probability of green patenting. These two models may by driven by unobserved heterogeneity, whatever the patent-type, thereby generating correlation of the error terms of selection and outcome equations. To correct from this potential bias, we use a probit model with sample selection for panel data.

Regressions have been run by referring to the Stata16 command xteprobit. The novelty of this routine is the generalization of the procedures to control for sample selection bias in probit models for panel data instead of cross-sectional and/or pooled data. Results are robust to different exclusion restrictions and show that the hypothesis of independence between the selection and the outcome equations may be not rejected.[6] The implication of the test is that the estimated probability of green patenting appears not to be affected by selection bias. This is why in the following we proceed the analysis by referring to panel random-effect probit model.

4 | RESULTS

The results obtained from different probit model specifications are displayed in Table 3. Models 1 and 2 refer to parsimonious models, while Model 3 is the full specification. Model 1 captures the mere effect of being an FF on the probability of green patenting. Model 2 adds the controls for sector, geographical and time fixed effects, while Model 3 includes the accumulation in green patents (*K_G*) and no-green patents (*K_NG*) and a set of observables to take into consideration the heterogeneity across firms.[7]

4.1 | Green patents and the effect of family involvement in business

The main finding is that the variable *Family* always shows a negative and significant coefficient, indicating that FFs are less likely than other firms to implement innovations in green technologies. This evidence is robust after controlling for the effects of industry, sector, firm location and other firm-level factors. In detail, the magnitude of FFs' average marginal effect is high (−2.1%) when regression is without any control and is −1.47% after controlling for any potential factor (Table 3).

The lower probability of green patenting for FFs confirms the hypothesis of this study. There are solid theoretical arguments in favor of our evidence. These refer to FFs' organizational rigidity (Kets de Vries, 1993), high risk aversion (König et al., 2013; Munoz-Bullon & Sanchez-Bueno, 2011) and low ability to cooperate with external partners for innovation (Nieto et al., 2015). Moreover, the willingness to keep control of the firm (Gómez-Mejía et al., 2007) hinders FFs from recruiting their managers effectively (Lubatkin et al., 2005) and limits their propensity to use investment capital to fund innovation projects (Block et al., 2013), which are necessary attributes for going green. This is because, eco-innovations are complex and characterized by higher levels of novelty, uncertainty and variety (De Jesús et al., 2016; Del et al., 2016; Hojnik & Ruzzier, 2016) and, therefore, require high-skilled employees and managers, the propensity to take risk, the capability to cooperate with external partners and the facility to access external sources of funding, which are less available in family than in non-family firms (Cainelli et al., 2015; De Marchi, 2012; Fabrizi et al., 2018; Ghisetti et al., 2015; Horbach et al., 2013).

From an empirical perspective, there are some difficulties in comparing our results with the pre-existing literature, as green innovation in FFs is still an unexplored research path (Calabrò et al., 2019). In particular, to be best of our knowledge no previous study focuses on FFs' propensity to introduce a green patent. However, some scholars have analyzed the relationship between family ownership and environmental innovation. For instance, Ardito et al. (2019) find a positive link between the involvement of FFs in R&D collaborations and the value of joint green patents in the “alternative energy production” field. In Craig and Dibrell (2006), FFs are more capable of translating their environmental policy into innovative outcomes than non-family firms. Huang et al. (2009) show that FF decisions to implement green innovations are positively influenced by the degree of natural environmental pressure from internal stakeholders, while for non-family firms, regulatory and market stakeholders are more relevant. More recently, Doluca et al. (2018) revealed that FFs are less likely than non-family firms to implement environment-related innovations in early diffusion phases, but they catch up with non-family firms later, displaying a more stable behavior over time.

4.2 | The role of the stock of knowledge

An important issue that this paper addresses is the impact on current green patenting exerted by the knowledge accumulated over time.[8] Model 3 shows that the stock of green technology has a positive effect on green patenting, confirming prior innovation activity in green technology is a key factor of current green patenting (Laurens et al., 2017). Conversely, the role played by the stock in non-green technologies is, on average, not significant.

However, results so far discussed are not informative on two potential channels through which the effect of patent stock acts. Indeed, it is of interest to verify whether the impact of patent stock differs between FFs and non-family firms and whether the results vary at different values of capital accumulation. In order to address these issues, we extend Model 3 with two interacting terms between family and green/non-green stock of knowledge. The corrected estimation of the standard error of the interaction terms are obtained by following the procedure proposed by Ai and Norton (2003), Karaca-Mandic et al. (2012) and Mize (2019).[9] The results of main interest for the discussion are summarized in Figures 1 and 2.

Figure 1 shows that the expected probability of green patenting increases as the stock of green knowledge increases. Furthermore, the curve for FFs is always lower than that of non-family firms, albeit the between-group difference depends on the level of patent stock:

TABLE 3 Probability of green patenting for Italian manufacturing firms

	Model 1		Model 2		Model 3	
Variables	**Coefficients**	**AME**	**Coefficients**	**AME**	**Coefficients**	**AME**
Dummy for Family Firms =1	−0.3755***	−0.02139***	−0.3997***	−0.02224***	−0.2217*	−0.01469*
	(0.1277)	(0.00693)	(0.1315)	(0.00694)	(0.1327)	(0.00851)
Stock of Non-Green Capital					0.0018	0.00013
					(0.0020)	(0.00013)
Stock of Green Capital					0.2841***	0.01936***
					(0.0451)	(0.00347)
EMS					0.4366***	0.03409***
					(0.1410)	(0.01213)
Firm size					−0.0458	−0.00312
					(0.0426)	(0.00289)
Profit margin					−0.0076*	−0.00052*
					(0.0042)	(0.00029)
Firm age					0.0019	0.00013
					(0.0034)	(0.00023)
Age of CEO					−0.0045	−0.00031
					(0.0046)	(0.00032)
Gender of CEO					−0.0250	−0.00169
					(0.1769)	(0.01181)
Constant	−2.7398***		−3.0851***		−1.7858***	
	(0.1611)		(0.2969)		(0.4066)	
Observations	5731	5731	5703	5703	4476	4476
Sectors	No		Yes		Yes	
Time	No		Yes		Yes	
Geography	No		Yes		Yes	
log Likelihood	−1061		−1039		−783.1	
Wald chi2	8.653		30.20		100.7	
p-Value	0.00326		0.00717		0	

Note: Standard errors are in parentheses. Estimated coefficients and the average marginal effect (AME) from panel random-effect probit model.
$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

there is no relevant impact for low levels of green accumulation, while non-family performs better as the stock increases. However, these differences lose statistical significance after a certain threshold of green capital, which is about 7. Importantly, the curves in which FFs perform less than non-family firms entail almost all of the sample. Indeed, 95% of enterprises have less than 7 of green stock, whatever firm-ownership type.

Figure 2 replicates the results for the stock of non-green patents. While the average marginal effect is not significant when interaction terms are not included (as in Model 3 of Table 3), the picture changes when focusing on each group of firms for different values of non-green technology. What emerges from regressions with interaction terms is that the expected probability of green patenting differs across firm-types at low level of non-green accumulation. Indeed, in such a case, the impact is higher for non-family firms than FFs. After a certain threshold, that is about 5 in the stock of non-green technologies, the FFs perform better than their counterparts, but results become not significant. Similarly to the evidence of green capital also in this case, the section of the curves with significant outcomes involves almost all the sample, as 98% of firms has <5 of non-green capital.

In brief, past investments in technology—green and non-green—is beneficial for producing green inventions, whatever the firm type. However, FFs gain less than non-family firms from green/non-green stock, thereby reinforcing our research hypothesis.

4.3 | The role of EMS and other controlling factors

As far as the role of EMS certification is concerned, we find that having environmental management certification is positively and highly

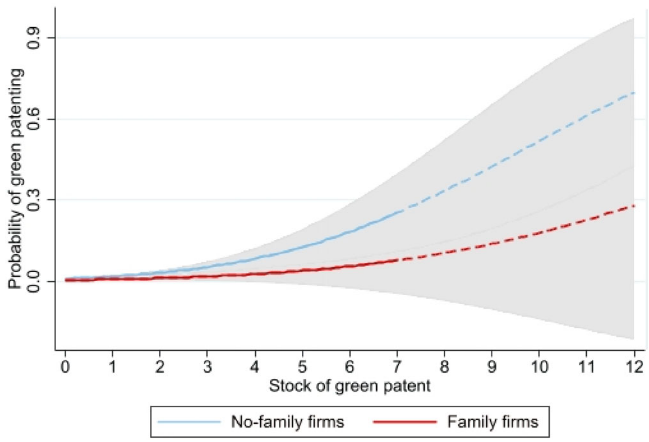

FIGURE 1 The predicted probability of green patenting at different values of green patent stock. Differences between family and non-family Italian firms [Colour figure can be viewed at wileyonlinelibrary.com]

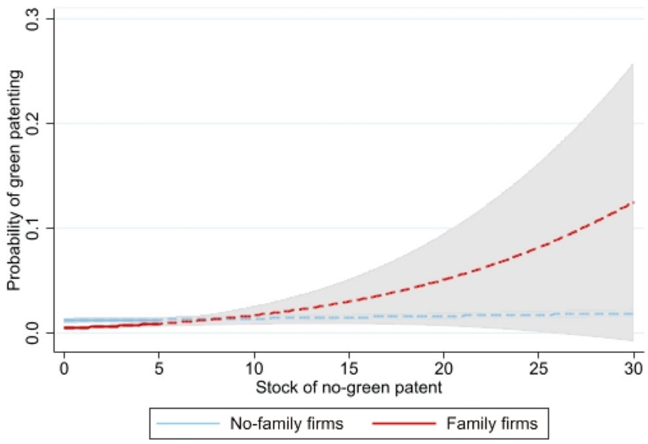

FIGURE 2 The predicted probability of green patenting at different values of no-green patent stock. Differences between family and non-family Italian firms [Colour figure can be viewed at wileyonlinelibrary.com]

significantly correlated with the probability of introducing green innovation. EMS certification has a 0.34% higher probability of registering a green patent than non-certified firms. This result might be driven by the fact that, as suggested by Horbach (2008) and Wagner (2007), EMS captures the technological and organizational capabilities in environmental management, thereby stimulating eco-innovations. Our evidence is in line with the findings for US (Chang & Sam, 2015) and EU firms (Montobbio & Solito, 2018). Wagner (2007) proves that EMS has a positive effect on environmental process.

With regard to the control variables, we find that the age of firms, the age and gender of CEOs do not exert any significant impact on green patenting. The same applies for firm size, as, on average, the significance of the marginal effect is low. The profit margin has a negative and significant influence on green innovation.

5 | CONCLUDING REMARKS

Although the literature on family business innovation has increased over the last decade, the role played by family involvement in green innovation is unexplored. This paper contributes to the existing research on the driving forces of eco-innovation by analyzing how family and non-FFs differ in terms of introducing innovation in green fields. We have based the analysis on the SEW theories, highlighting how the nature of family socio-emotional needs can affect the adoption of green innovation.

The results show that FFs are less likely than non-family firms to implement innovations in green technologies. When looking at the average marginal effect, only green stock plays a significant role in the probability of introducing green patents. However, the predicted probability of green patenting is sensitive to the level of capital accumulation and FFs always perform less than non-family firms.

It is well known that green innovation plays a key role in the smart and sustainable growth of a country. Here, the findings suggest that FFs are less likely than non-family firms to implement innovations in green technologies, because of the divergence between the characteristics required to produce green innovation and the characteristics of family businesses.

This result has some useful implications. On the one hand, it sheds additional light on the distinctive traits of family businesses by extending the understanding of how their attributes make FFs unable to implement green innovation. On the other hand, the analysis might help FF managers to recognize and address constraints and opportunities in order to increase FFs' capability to gain competitive advantages by pursuing green targets. For instance, FFs should deal with their low risk propensity. To this end, they should adopt procedures aimed at evaluating risky investments to understand better the opportunities from green riskier investments. Furthermore, FFs should share the risk through collaborative innovation and promote a better managerial culture and a more flexible organization to be able to manage the complexity of environmental innovations. In this respect, they should recruit from outside the family circle both the necessary talented professional managers with the specialized skills necessary to go green.

The paper offers some policy insights derived from the empirical results. Indeed, as patenting in green technologies is a value, then policymaking might be better oriented toward selecting the most promising R&D projects in terms of green patentable innovations. This also means setting up programs, which aims at fostering the capability of FFs to introduce environmental innovation. For instance, they could offer incentives to increase the cooperation with external partners in order to encourage knowledge sharing or they could ease access to external consulting services to cope with the greater complexity of green innovation.

Finally, while our main results are robust to different samples of observations, the study has some limitations. First, it focuses on a specific measure of green innovation. Future research is thus needed to extend our findings to other measures to identify environmental innovation, especially in low-tech industries, where patents do not represent a suitable proxy to capture innovative dynamics. Second, it does not take into account family firm heterogeneity. This is due to data constraints, as our data set does not allow the investigation of how results differ when considering founder CEOs, non-family CEOs, family-managed and family-owned firms. This would be an important extension of the research to better understand which family business model is best for firm environment strategies. Third, some caution must be exercised regarding the external validity of findings, because the analysis refers to Italy. In this respect, further research extending this study to other countries could provide valuable insights.

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ENDNOTES

[1] Patent data are widely used as a measure of green innovation (Oltra et al., 2010), albeit eco-innovation is a concept for which a standardized definition does not yet exist. Several definitions can be found in the literature. According to OECD/European Commission/Nordic Innovation (2012), green innovations are defined as innovations that "allow for new ways of addressing current and future environmental problems and decreasing energy and resource consumption, while promoting sustainable economic activity." This is a broad definition that makes it difficult to measure green innovation in a comprehensive way, even by means of ad hoc surveys.

[2] While the priority patent is the first patent filing made by applicants to protect the invention in a given country, equivalent patents are subsequent filings made in other patent offices where protection is sought.

[3] The classification adopted is from Eurostat, which uses an aggregation of the manufacturing industry based on technological intensity (https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:High-tech_classification_of_manufacturing_industries).

[4] The perpetual inventory method is widely used to calculate capital stocks by using investment flows and considering a depreciation rate to account for the fact that assets lose value over time (Dey-Chowdhury, 2008). Patent stocks were constructed using firm patents since 1981.

[5] ISO 14001 is the most widespread international standard that supports organizations in the implementation and maintenance of their environmental management system (EMS), defining a list of requirements to improve their environmental performance (source: ACCREDIA).

[6] The Likelihood-ratio test allows accepting the null hypothesis of independent equations either when the exclusion restriction is the debt ratio or the firm financial dependence (results are available on request or can be replicated by using the anonymized data that can be requested to the authors).

[7] Patent stocks, environmental certification dummy, size 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 in green technologies with a time lag.

[8] Here, it is important to highlight that the regressions do not include any innovation input, such as the investments in R&D. This is because of data unavailability in Orbis. In this regard, the stock of patenting also serves to capture the effect of past R&D efforts made by firms to produce technology.

[9] Because of the evidence-based conclusion on the absence of selection bias (see Section 3.3), the regression with interactions is also estimated with a panel random-effect probit model.

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