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Process innovation in family firms: Family involvement in management, R&D collaboration with suppliers, and technology protection

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ABSTRACT

Drawing on insights from the upper echelon theory, this article aims to examine the impact of family involvement in management on process innovation within family firms, considering the mediating role of R&D collaboration with suppliers and the moderating role of technology protection. Conducting a panel data analysis on 5,332 firm-year observations of Spanish manufacturing family firms for the period 2007–2016, we find that the negative relationship between family involvement in management and process innovation is mediated by R&D collaboration with suppliers. Furthermore, we find that the negative effect of family involvement in management on R&D collaboration with suppliers and ultimately on process innovation is mitigated by technology protection and even becomes positive for high levels of technology protection.

1. Introduction

Family firms - the most ubiquitous forms of business organization around the world – are currently operating in a very turbulent environment conditioned by crises induced by the COVID-19 pandemic climate change and the war in Ukraine (Brunelli, Gjergji, Lazzarotti, Sciascia, & Visconti, 2022; De Massis & Rondi, 2020; Leppäaho & Ritala, 2022). Process innovation, usually defined as the implementation of a new or significantly improved production or delivery method (OECD, 2005), has, thus, emerged as a key strategy for family firms to enhance efficiency, increase production flexibility, reduce costs, drive the successful development of other forms of innovations (e.g., product and service innovations) and ultimately contribute to higher firm performance (Ayllón & Radicic, 2019; Classen, Carree, Van Gils, & Peters, 2014; Diéguez-Soto, Garrido-Moreno, & Manzaneque, 2018). Process innovation improves a firm's ability to exploit, maximize and reconfigure resources and capabilities and ensures the achievement of sustained competitive advantage (Chang, Bai, & Li, 2015; Hervas-Oliver, Sempere-Ripoll, & Boronat-Moll, 2014; Un & Asakawa, 2015). Therefore, there is an urgent need to better understand the family-specific antecedents and factors that can help family firms to successfully drive their process innovations (Casado-Belmonte, Capobianco-Uriarte, Martínez-Alonso, & Martínez-Romero, 2021; Diéguez-Soto et al., 2018).

Family involvement in management, understood as the active participation of the family that controls the business in the firm's top management team (Kotlar, De Massis, Fang, & Frattini, 2014a), could be an important factor in explaining differences in the achievement of process innovation in family firms (Diéguez-Soto et al., 2018; Sánchez-Famoso, Maseda, & Iturralde, 2017). Family managers exert an immediate and direct impact on firms' strategic behaviour, and the outcomes of process innovation are a reflection of values and cognitive bases of these powerful actors (D'Allura, 2019; Rovelli, Rossi-Lamastra, Longoni, & Cagliano, 2020; Vandekerkhof, Steijvers, Hendriks, & Voordeckers, 2019). Surprisingly, however, very little attention has so far been given to the influence of family involvement in management on process innovation. A noteworthy exception is represented by the paper of Diéguez-Soto et al. (2018), who found that family management moderates the link between innovation inputs and process innovation. To the best of our knowledge, no study to date has explicitly explored whether and under which conditions family involvement in management influences process innovation in family firms, leaving us with an incomplete theoretical and practical understanding of how the distinctive

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goals and typical traits of family managers influence the strategic decision-making mechanisms underlying process innovation.

Drawing on upper echelon theory (Hambrick & Mason, 1984), we address this gap in the literature by examining how family involvement in management affects process innovation through the intermediate step of strategic choices made by family managers. In this study, we focus on a specific open innovation (OI) strategy, namely R&D collaboration. R&D collaborations, defined as a form of inter-firm relationship established to mutually benefit from each other's resource complementarities in order to achieve innovation (Bigliardi & Galati, 2018), are key OI strategic choices that depend on the behavioural characteristics of firm managers (Classen, Van Gils, Bammens, & Carree, 2012; Röd, 2019). R&D collaborations, in particular, have received attention from family firm scholars, because family involvement in management can distinctively influence firms' external relationships (Rondi, De Massis, & Kraus, 2021). Moreover, family managers' behaviour is often motivated by non-economic goals (Gómez-Mejía, Haynes, Núñez-Nickel, Jacobson, & Moyano-Fuentes, 2007), which tend to be incompatible with the risks, uncertainties and failures associated with OI strategies (Feranita, Kotlar, & De Massis, 2017; Lambrechts, Voordeckers, Roijakkers, & Vanhaverbeke, 2017).

On the other hand, not all R&D partners are equal (Broekaert, Andries, & Debackere, 2016; Un & Asakawa, 2015); suppliers are less likely to erode family managers' monitoring power and non-economic goals (Pellegrini & Lazzarotti, 2019; Röd, 2019). Moreover, suppliers are the most suitable partner with whom to develop process innovation (Un & Asakawa, 2015), as they often share compatible knowledge in terms of operations, technologies, equipment and design (Murtha, Lenway, & Hart, 2001), which is critical to improve production process efficiency or cost reduction (Skippari, Laukkanen, & Salo, 2017). Therefore, we contend that R&D collaboration with suppliers is a potential underlying (mediating) mechanism in the family involvement in management-process innovation relationship, which might help to provide a richer explanation of how family managers achieve process innovation in family firms.

In addition, upper echelon theory also suggests the inclusion of situational conditions that motivate the strategic choices of family managers and the ensuing impact on innovation performance. Accordingly, this study also aims to capture situational conditions by considering the contingent role of technology protection, conceptualized as the level of protection of the firm's proprietary technologies (Hertzfeld, Link, & Vonortas, 2006). Up to now, empirical evidence on the manner in which technology protection affects family managers' OI decisions has been limited, with the notable exception of Kotlar, De Massis, Frattini, Bianchi, and Fang (2013) work that explored the moderating role of technology protection in the relationship between family management and external technology acquisition. We argue that the successful implementation of OI strategies may be more appealing to family managers when their inventions are protected by intellectual property (IP) mechanisms (Martínez-Alonso, Martínez-Romero, & Rojo-Ramírez, 2022a). In this sense, technology protection may influence family managers' aversion to adopting R&D collaboration with suppliers and, in turn, affect the achievement of process innovation. Thus, by incorporating technology protection as a contingent factor in our model, we can gain a more comprehensive view of the OI behaviour of family managers.

Utilizing a sample of 5,332 firm-year observations of Spanish manufacturing family firms for 2007–2016, the present study tests the above mentioned relationships. Our paper makes several contributions to the literature. First, it advances current knowledge on the heterogeneity of family firms in terms of innovation by reaffirming family involvement in management as an antecedent of innovation performance (Casado-Belmonte et al., 2021; Kammerlander, Patzelt, Behrens, & Röhm, 2020; Martínez-Alonso, Martínez-Romero, & Rojo-Ramírez, 2022b). Second, it deepens the understanding of both the underresearched phenomenon of process innovation and the nascent field of OI within family firms (Diéguez-Soto et al., 2018; Gjergji, Lazzarotti, & Visconti, 2022; Rondi et al., 2021), by revealing how the link between family involvement in management and process innovation is mediated by R&D collaboration with suppliers. Moreover, our study takes a step further by identifying IP mechanisms as a means to enhance (process) innovation (Brinkerink, Van Gils, Bammens, & Carree, 2017; Kotlar et al., 2013) thanks to the possibilities they provide family managers to adopt riskier innovation-related strategies, such as R&D collaboration with suppliers. Last, we contribute to enriching the comprehension and use of the upper echelon theory in the family firm context (Ensley & Pearson, 2005), by providing an empirically grounded model. Our model brings new insights into family managers' distinctiveness regarding the achievement of process innovation, directly and through OI strategic choices, considering situational conditions.

2. Literature review and hypothesis development

2.1. Family involvement in management and process innovation

Given the prominence of innovation for the long-term success and survival of firms (Kammerlander, Dessì, Bird, Floris, & Murru, 2015), it is highly relevant to delve into the family-specific antecedents and factors that explain discrepancies in the deployment of process innovation in family firms. Among the antecedents of innovation studied to date, family involvement in management is the one that has gained increasing momentum, becoming the focus of attention of today's family firm scholars (Arzubiaga, Maseda, & Iturralde, 2019; Kammerlander et al., 2020; Rondi & Rovelli, 2021). This is because top management teams play a crucial role in driving process innovation activities, as top managers are the most powerful actors in the organization when it comes to making strategic decisions on the implementation, execution and evaluation of business process improvements (Diéguez-Soto et al., 2018; Rovelli et al., 2020; Vandekerkhof et al., 2019). Moreover, the top management team represents the most important intersection between family and firm subsystems (Martínez-Romero, Diéguez-Soto, & Vandekerkhof, 2022). Given the family's strong interest in preserving its influence (Morgan & Gómez-Mejía, 2014), top managers have significant impact on shaping the firm's strategic behaviour and outcomes (Rovelli et al., 2020; Sánchez-Famoso et al., 2017). In particular, the involvement of family members in management positions has been identified as a main source of heterogeneity among family firms (Garcés-Galdeano & García-Olaverri, 2020). The family has the power and ability to reflect its own values, goals, aspirations and emotions in the top management team decision-making process (D'Allura, 2019), which leads to substantial differences in the way family firms carry out their process innovations.

Understanding organizational outcomes requires an investigation of managerial characteristics, as upper echelon theory suggests that managers' idiosyncrasies determine their strategic decisions and choices (Hambrick & Mason, 1984). Therefore, the managers' family influence could impact process innovation outcomes (Finkelstein & Hambrick, 1990). In Ensley and Pearson (2005) work, in which they extended the upper echelon perspective to the context of family firms, they noted that 'the family business creates a unique management situation that results in both advantages and disadvantages to the firm' (p. 267). Consequently, family involvement in management can have different implications for process innovation strategies (Diéguez-Soto et al., 2018; Sánchez-Famoso et al., 2017). In practice, however, research into the direct impact of family involvement in management on process innovation within family firms remains scarce and unclear (Casado-Belmonte et al., 2021).

Prior literature indicates that family managers' desire to maintain control and influence within the firm (Gómez-Mejía, Makri, & Larraza-Kintana, 2010) leads them to adopt a conservative approach (Duran, Kammerlander, van Essen, & Zellweger, 2016), for example by restricting access to the external labour market (Liang, Li, Yang, Lin, &

Zheng, 2013). Family managers are often reluctant to hire external staff, including executives, and the resulting lack of more talented employees to manage innovation projects (Manzaneque, Diéguez-Soto, & Garrido-Moreno, 2018) may limit the efficient sharing, absorption, and combination of knowledge (Liang et al., 2013; Patel & Cooper, 2014), negatively affecting process innovation. Indeed, not having such expertise may be detrimental to family firms' innovation performance, as managers are responsible for evaluating whether new improvements introduced in production processes have met or exceeded expectations (Un & Asakawa, 2015). In this sense, family involvement in management is likely to worsen internal procedures (task specifications, information flow mechanisms, etc.), raising costs or lowering quality (Reichstein & Salter, 2006). Besides, family managers often engage in nepotism to satisfy family preferences, for example, by accommodating other family members in the firm management for the 'good' of the team (Amason & Sapienza, 1997). This, in turn, limits merit-based human capital, intensifies conflicts and compromises people's ability to generate alternative ideas (Carnes & Ireland, 2013; Kellermanns & Eddleston, 2004).

Moreover, the presence of family members in management results in asymmetric altruism, encouraging shirking and free-riding behaviour (Minichilli, Corbetta, & MacMillan, 2010), which impairs the absorption of dispersed knowledge held by non-family members, compromising the efficiency of process innovation strategies (Diéguez-Soto et al., 2018). Accordingly, a high level of family involvement in management may lead to restricted availability of diverse knowledge and multiple perspectives (De Massis, Kotlar, Campopiano, & Cassia, 2013), constraining process innovation activities.

Against this negative view, there are also reasons to believe that family involvement in management could positively influence process innovation. The high commitment of family managers to the firm, as well as their tacit knowledge (Azizi, Salmani Bidgoli, Maley, & Dabić, 2022; Nieto, Santamaria, & Fernandez, 2015), favour mutual learning within the firm (Muñoz-Bullón, Sánchez-Bueno, & De Massis, 2020). Moreover, family managers' idiosyncratic characteristics, such as unusual motivation, increased trust, efficient communication and the fact of exchanging ideas with greater privacy (Tagiuri & Davis, 1996; Tiberius, Stiller, & Dabić, 2021) might favour the success of process innovation.

Despite the possible advantages indicated, we contend that the conservative approach, nepotism and asymmetric altruism of family managers will prevail in the achievement of process innovation in family firms, so that the greater the family involvement in management is, the lower the likelihood of obtaining process innovation seems to be. Therefore, we propose that:

H1. Family involvement in management negatively influences process innovation

2.2. R&D collaboration with suppliers: An enlightening intermediate step

Looking at the effect of family involvement in management on process innovation only from a direct perspective might lead to a rather limited understanding of such a link. In fact, this approach is not conducive to elucidating the 'real' mechanisms through which family involvement in management may support or inhibit process innovation strategies within family firms. In this regard, upper echelon theory argues that the strategic choices made by firm managers influence innovation outcomes (Hambrick & Mason, 1984).

Within the OI literature, we identify R&D collaborations as key strategic choices because the decision to include external actors in the innovation process largely depends on the behavioural characteristics of firm managers (Classen et al., 2012; Röd, 2019). R&D collaborations become peculiar in the context of family firms, as the presence of family members in the firm management can distinctively influence the organization's external relationships (Rondi et al., 2021) and increase the likelihood that the firm's behaviour is driven by family non-economic goals (Gómez-Mejía et al., 2007). These family priorities are, in most cases, incompatible with the risks, uncertainties and failures associated with R&D collaboration (Feranita et al., 2017; Lambrechts et al., 2017), which explains why R&D collaborations have not been considered advisable in this context. OI studies have shown that family managers' fear of losing control over innovation processes and involuntary knowledge spill-overs reduce their willingness to collaborate in R&D (Kotlar et al., 2013; Nieto et al., 2015; Urbinati, Franzo, & De Massis, 2017).

Nevertheless, this trend is changing, and more and more attention is being paid to OI in family firms, with recent calls for more research on the topic (Gjergji et al., 2022; Rondi et al., 2021). This growing interest is due to the fact that, although risky and challenging, R&D collaborations represent one of the most important strategic weapons in achieving innovation, by helping to broaden the knowledge base or to access complementary assets (Lazzarotti, Manzini, Nosella, & Pellegrini, 2017; Röd, 2019). All this encourages us to consider the openness of the innovation process in the form of R&D collaborations as the possible underlying mechanism to explain the (negative) relationship between family involvement in management and process innovation. In other words, we argue that R&D collaboration is an effective means (i.e., the mediator) that will help to shed new light on the distinctive behaviour of family firms regarding process innovation.

Extant OI literature recognizes that not all types of R&D collaborators exert the same influence on (process) innovation (Broekaert et al., 2016; Nieto & Santamaría, 2007; Triguero, Córcoles, & Fernández, 2020; Un & Asakawa, 2015). Each R&D partner varies considerably in the nature and breadth of transferred knowledge, has distinct needs and demands, and plays different roles along the innovation pathway (Belderbos, Gilsing, & Lokshin, 2012; Hsieh, Ganotakis, Kafouros, & Wang, 2018; Triguero et al., 2020). For example, suppliers and research centres can support firms in solving internal technical issues or identifying new opportunities and developments to explore and exploit, while customers and competitors can provide businesses with a richer and more accurate understanding of the latest market trends (Nieto & Santamaría, 2007; O'Connor, Doran, & McCarthy, 2021). In this sense, one might expect that family managers' willingness to collaborate in R&D will depend on whether their priorities are in line with the objectives of the different R&D partners. Moreover, family managers will also be interested in selecting the most successful R&D partners in achieving (process) innovation. Consequently, the type of knowledge and technologies that these partners can bring to the firm will be critical in the family managers' decision to collaborate with one partner or another (Martínez-Alonso, Martínez-Romero, & Rojo-Ramírez, 2022c). Accordingly, our study focuses on collaboration with suppliers, as these are one of the types of R&D partners least likely to undermine family managers' monitoring power and non-economic objectives (Pellegrini & Lazzarotti, 2019; Röd, 2019).

Suppliers are one of the most usual R&D partners for family firms (e.g., De Massis, Frattini, et al., 2015). Suppliers generally belong to the same industry segment as the focal firm, so the economic objectives and incentive systems of both parties are often closely related (Criscuolo, Laursen, Reichstein, & Salter, 2018). Family managers tend to have strong social ties with their suppliers, which are often preserved and transferred from one generation to the next (Mazzelli, Kotlar, & De Massis, 2018; Miller & Le-Breton-Miller, 2005). However, there are also compelling reasons why family managers tend to be cautious about collaborating with suppliers in R&D terms. When a system or process is opened up to suppliers, the choices and decisions that could have been made by family managers are made by external firms that probably pursue their own self-interest and profit maximization (Almirall & Casadesus-Masanell, 2010). As a result, family managers would lose some control and freedom over the trajectory that technology follows over time. Moreover, since suppliers are often committed to upgrading production processes other than those of the focal firm, including those of competitors, the risk of knowledge leakage to these 'rivals', in terms of

key resources, efficiency targets or internal secrets, is particularly high. Accordingly, and based on the above reasons, we expect that higher family involvement in management will imply greater aversion to engaging in R&D collaboration with suppliers. Thus, we formulate our H2:

H2. Family involvement in management negatively influences R&D collaboration with suppliers

Although family firms are often reluctant to engage in OI strategies (e.g., Rondi et al., 2021), if family managers are able to embrace collaboration with suppliers, those R&D partners can provide a valuable opportunity to gain new technologies and knowledge that would not otherwise be possible (Feranita et al., 2017; Martínez-Alonso et al., 2022c), leading to a greater likelihood of achieving process innovation. R&D collaboration with suppliers is particularly crucial for driving process innovation (Un & Asakawa, 2015), as suppliers tend to share compatible knowledge with firms in terms of operations, technologies, equipment, and design (Murtha et al., 2001), which is critical for enhancing production process efficiency, cost reduction and time-to-market (Skippari et al., 2017). In addition, since suppliers have extensive experience in the current production processes of a given industry (De Leeuw, Lokshin, & Duysters, 2014), engaging in OI strategies with them can enable firms to reduce risks and process development times, while improving flexibility, input quality and market adaptability (Gjergji et al., 2022; Nieto & Santamaría, 2007). Hence, we expect to find a positive and direct effect of R&D collaboration with suppliers on process innovation. Thus, we propose our H3:

H3. R&D collaboration with suppliers positively influences process innovation

Combining the hypothesized relationships between family management, R&D collaborations and process innovation, we thus suggest that R&D collaboration with suppliers constitutes an important overlooked mediator in the family involvement in management-process innovation relationship. In other words, we suppose that the negative relationship between family involvement in management and process innovation is explained by the low propensity of family managers to collaborate with suppliers: collaboration can provide a positive influence on process innovation, but family involvement tends to prevent it.

2.3. The moderated mediating role of technology protection

So far, we have argued that family involvement in management negatively influences process innovation due to the fact that family managers are generally reluctant to engage in R&D collaboration with suppliers. Nevertheless, the upper echelon theory also posits that managers' strategic choices are a reflection of the situational conditions confronted by firms (Hambrick & Mason, 1984). Therefore, the inclusion of contingent factors in the analysis will help to explore the conditions under which family managers can adopt risky competitive actions without hindering their family priorities of power and control. In this light, we consider the level of protection of firms' own technologies through intellectual property (IP) mechanisms as a contingent factor that shapes the dynamic environments in which family managers' decisions to engage in R&D collaboration with suppliers are made. Hence, IP mechanisms may potentially have an impact on family managers' willingness to enter R&D collaborations, affecting in turn, process innovation. The presence of effective IP mechanisms is key when examining the relationships between family managers and R&D collaboration with suppliers, as such mechanisms may increase managers' openness to collaborate with this type of R&D partner (De Massis, Frattini, Pizzurno, & Cassia, 2015; Drechsler & Natter, 2012). Likewise, these IP mechanisms can also increase family managers' perceptions of control and influence preservation along the innovation pathway (Gambardella, Giuri, & Luzzi, 2007; Kotlar et al., 2013).

Accordingly, the adoption of OI strategies is more likely to be attractive to family managers when their technologies are protected by IP mechanisms (Martínez-Alonso et al., 2022a). This is due to the fact that IP mechanisms allow for the protection of family managers' know-how and tacit knowledge, especially in the early stages of negotiating with R&D partners (Hertzfeld et al., 2006). Indeed, in contexts characterized by high technology protection, family managers are less fearful of involuntary knowledge spill-overs (Brinkerink et al., 2017); this contributes to increasing their perception of control over innovation processes and to mitigating their negative attitude towards R&D collaboration with suppliers. Moreover, when managers feel more confident in their ability to control the results of strategic choices, riskier innovation-related strategies are pursued (Kotlar et al., 2013). Consequently, these IP mechanisms can be seen as a potential form of defence against the uncertainty related to control losses and the resulting knowledge leakage, while increasing the perceived power and authority of family managers regarding suppliers.

Based on these arguments, we formulate the following hypothesis:

H4. Technology protection moderates the negative and indirect effect of family involvement in management on process innovation through R&D collaboration with suppliers, so that the relationship becomes less negative when technology protection is higher

Fig. 1 presents our hypothesized conceptual model.

3. Methods

3.1. Data and sample

We use data extracted from the Spanish Survey on Business Strategies (SSBS) to test the proposed hypotheses. Conducted annually by the SEPI Foundation with the support of the Spanish Ministry of Finance and Civil Service, the SSBS database is designed to be representative of the population of Spanish firms with 10 or more employees operating in all the country's manufacturing industries (according to the NACE Rev.2 classification). The SSBS is an unbalanced panel, as each year some firms exit the survey (due to mergers, takeovers, spin-offs, or cessation of activity) while new ones join it, in order to maintain the sample representativeness. The SSBS contains data on, for example, business processes and products, technological activities, foreign trade, and accounting. Notably, all information included in the SSBS is subject to quality and consistency checks, which makes it particularly appropriate for empirical purposes.

The effective sample, after selecting those family and innovation variables of interest for our analysis, as well as eliminating firms with missing, incomplete or outlier data, consisted of 5,332 firm-year observations of Spanish manufacturing family firms for 2007–2016. We consider as family firms those in which a family group is actively involved in the control or management of the firm (Garcés, Pilar, & Torres, 2022; Kotlar et al., 2013). This family firm definition allows for the proper identification of firms whose managerial behaviour is influenced by an owning family and is consistent with previous family firm literature using the same dataset (Campos-García, Muñoz-Bullón, Sanchez-Bueno, & Zúñiga-Vicente, 2021; Sánchez-Marín, Pemartín, & Monreal-Pérez, 2020).

3.2. Variable measurement

3.2.1. Dependent variable

The dependent variable is process innovation. In line with prior studies (Martínez-Ros & Labeaga, 2009; Un & Asakawa, 2015), process innovation is measured with a dummy variable indicating whether or not the firm has introduced significant changes in the production process, mainly through the implementation of new machinery, equipment, new techniques and/or methods, during the year. Firm-year observations are thus coded 1 if the firm has undertaken process innovations, 0 otherwise.

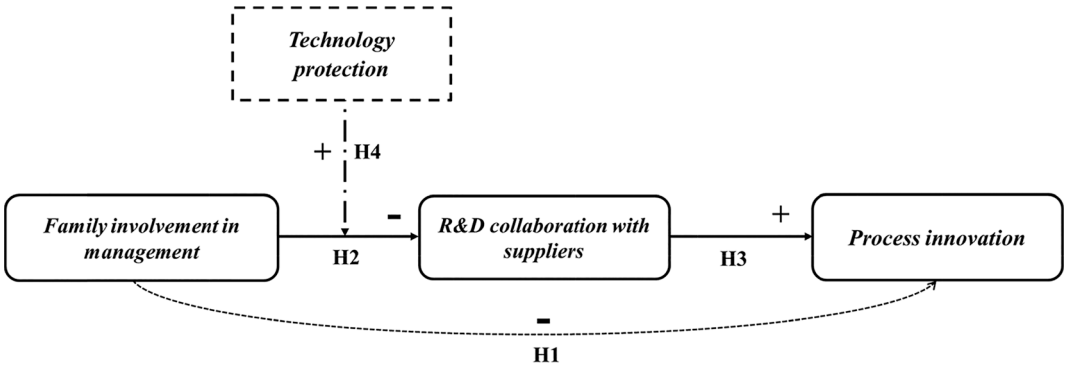

Fig. 1. Conceptual model.

3.2.2. Independent variable

The independent variable is family involvement in management. Consistent with extant literature (Kotlar et al., 2014a; Manzaneque, Rojo-Ramírez, Diéguez-Soto, & Martínez-Romero, 2020), family involvement in management is measured as a continuous variable including the number of family-owner members and their immediate relatives participating in the firms' top management team (Kotlar et al., 2013).

3.2.3. Mediating variable

The mediating variable of interest is R&D collaboration with suppliers. It is measured with an indicator that takes on two values: 1 if the firm reports that during the year it has engaged in collaboration with suppliers for innovation purposes and 0 otherwise (Bodas-Freitas & Fontana, 2018; Nieto & Santamaría, 2007).

3.2.4. Moderating variable

The moderating variable is technology protection. Patents are important legal mechanisms to protect proprietary products and processes and to prevent rivals from commercially using a firm's invention without its authorization (Beneito, 2006). Family managers increasingly view patents as an effective means for protecting firms' innovation processes against competitors' imitations, as well as for increasing defences against rivalry issues that may arise from linkages with external partners (Bannò, 2016; Kotlar et al., 2013). Following previous studies suggesting a two- to five-year lag in the effect of patents on firms' outcomes (Artz, Norman, Hatfield, & Cardinal, 2010; Chirico et al., 2020; Ernst, 2001), technology protection is measured as the sum of a firm's patent registrations over the prior three years, that is, the number of accumulated patents in t-3, t-2 and t-1.

3.2.5. Control variables

This article also controls for other factors that can affect process innovation. First, we control for generational stage, as the propensity to engage in innovation activities might be especially prominent in later generation family firms (Alayo, Iturralde, & Maseda, 2022). To determine which generation controls the family firm, we classified the firms into three categories according to a 30-year cut-off point: first generation, second generation, and third and later generations. Accordingly, three dummy variables were created (Cruz & Nordqvist, 2012; Umans, Lybaert, Steijvers, & Voordeckers, 2020). Second, we control for firm size because large firms have advantages compared to small firms (economies of scale and scope, internal knowledge or market power, etc.), which are expected to increase the performance of innovation strategies (Coluccia, Dabić, Del Giudice, Fontana, & Solimene, 2020). Firm size is measured using the natural logarithm of total assets. Third, we control for financial slack, measured by the ratio of current assets to current liabilities, because firms with greater financial slack resources are more likely to develop innovation (Ashwin, Krishnan, & George, 2015). Fourth, we control for supplier bargaining power, as it affects managers' ability to exercise decision-making control, and thus has an impact on innovation strategies (Kotlar, Fang, De Massis, & Frattini, 2014). Supplier bargaining power is calculated as the percentage of purchases a business makes from its top three suppliers. Fifth, we control for R&D employment, measured as the ratio of the number of R&D-focused employees to the total number of employees, since firms are more likely to innovate when they have more specialized personnel dedicated to innovation (Diéguez-Soto et al., 2018). Sixth, we control for joint ventures (also known as equity-based collaborative agreements; Oxley, 1997), because equity relationships foster an alignment of interests and reduce opportunistic behaviour between the interested parties (Fischer, Greven, Tornow, & Brettel, 2021), with a positive effect on process innovation. This variable is calculated as a dummy that takes value 1 when the firm has joint venture agreements, and 0 otherwise. Seventh, we control for public R&D funding, which is commonly viewed as financial aid to organizational innovation efforts (Yıldız, Dabić, Stojčić, Dindaroğlu, & Temel, 2021). Moreover, firms' ability to raise R&D funds could be a sign of strong interest in innovation (Afcha & León-López, 2014), inasmuch as these funds are homogeneously available for all the sample firms. Accordingly, public R&D funding is measured as the total amount of subsidies for innovation received from the Spanish central government in thousands of euros. We also control for industry effects, because there are differences across subindustries in terms of propensity to innovate and innovation protection (Cuervo-Cazurra & Un, 2010). Twenty dummy variables representing the subindustries the firms refer to are included. Finally, we include dummy variables to control for territorial specificities or context conditions. These territorial specificities make it possible to capture the effect of geographical opportunities for the implementation and development of innovation processes and activities (Camagni & Capello, 2013). Specifically, we use dummy variables representing seven Spanish territorial subdivisions (NUTS, Nomenclature of territorial units for statistics).[1] Appendix A provides more details on these variables, including their measurements and original labels in the SSBS dataset.

The mean, standard deviation and correlations of the variables described are shown in Table 1.

3.3. Analysis strategy

The model and proposed hypotheses are tested using generalized structural equation modelling (GSEM) with STATA. GSEM is a technique that combines the versatility and power of generalized linear models and structural equation models in an integrative modelling framework (Mostafa, Farley, & Zaharie, 2021). The use of GSEM is of great value for our study, as it allows us to specify probit regression equations for our dependent variable, test relationships simultaneously, and prove

[1] Regions of the European Union-NUTS 2013/EU-28. https://ec.europa.eu/eurostat/web/nuts/background (Accessed 1 of November of 2021).

Table 1
Mean, standard deviation and correlations.

Variable	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12
1. Process innovation	0.36	0.48												
2. Family involvement in management	1.23	1.12	-0.04***											
3. R&D collaboration with suppliers	0.21	0.41	0.31***	-0.09***										
4. Technology protection	0.61	5.34	0.03	-0.02	0.06***									
5. First generation	0.57	0.50	-0.09***	0.03*	-0.18***	-0.06***								
6. Second generation	0.33	0.47	0.04***	-0.02	0.11***	-0.02	-0.81***							
7. Third and later generations	0.10	0.30	0.07***	-0.02	0.12***	0.14***	-0.38***	-0.24***						
8. Firm size	15.85	1.75	0.31***	-0.14***	0.43***	0.12***	-0.26***	0.16***	0.18***					
9. Financial slack	3.13	6.56	-0.05***	0.04***	-0.05***	-0.01	-0.06***	0.06***	0.01	-0.04***				
10. Supplier bargaining power	45.58	22.46	-0.15***	-0.02	-0.22***	-0.06***	0.11***	-0.06***	-0.09***	-0.28***	0.06***			
11. R&D employment	22.21	57.79	0.16***	-0.01	0.29***	0.14***	-0.10***	0.05***	0.08***	0.22***	-0.03*	-0.15***		
12. Join ventures	0.03	0.16	0.13***	-0.03**	0.23***	0.10***	-0.07***	0.02	0.09***	0.18***	-0.02*	-0.11***	0.15***	
13. Public R&D funding	35.39	303.96	0.09***	-0.03**	0.16***	0.14***	-0.06***	0.01	0.08***	0.17***	-0.02	-0.05***	0.14***	0.13***

***Significant at 1%; **Significant at 5%; *Significant at 10%.

mediating and moderating effects with Sobel (1982) and bootstrapping tests (Dabić et al., 2021; Weck, Veltrop, Oehmichen, & Rink, 2022). In addition, we included robust standard errors (Huber-White) to control for heteroscedasticity. We also applied one-year lags between the dependent variable and other variables to avoid potential endogeneity problems and facilitate causal inference. This reduced our sample to an unbalanced panel of 4,553 firm-year observations. Regarding multicollinearity, variance inflation factors (VIF) and condition index were computed for each model. The highest observed VIF is 1.28, and the highest value of the condition index is 8.07, well below values that might suggest multicollinearity concerns (Hair, Black, Babin, & Anderson, 2010).

To verify the mediating role of R&D collaboration with suppliers on the family involvement in management-process innovation relationship, we follow Baron and Kenny (1986) mediation framework, using simultaneous path models (Skrondal & Rabe-Hesketh, 2004). This framework supports mediation when four conditions are fulfilled: first, the independent variable must exert a significant influence on the dependent variable ($X \rightarrow Y$); second, the independent variable must exert a significant influence on the mediating variable ($X \rightarrow M$); third, the mediating variable must exert a significant influence on the dependent variable ($M \rightarrow Y$); and fourth, the influence of the independent variable must be less significant (partial mediation) or become non-significant (full mediation) regarding the dependent variable, when the mediating variable is entered into the model ($X \rightarrow M \rightarrow Y$).

Furthermore, we utilized Sobel (1982) test and bootstrapping confidence intervals (CIs) to check the significance of the mediating effect and verify that the coefficients of the independent and mediating variables were valid. The Sobel test assumes that the indirect effect of the independent variable is normally distributed, which may make it a conservative test (MacKinnon, Warsi, & Dwyer, 1995). On the other hand, bootstrapping is a nonparametric procedure that does not impose the assumption of normality on the sampling distribution (Preacher & Hayes, 2008). Specifically, we used percentile CIs and bias-corrected CIs to avoid problems arising from skewed and non-normal sampling distributions of indirect effects (Umans et al., 2020). The bootstrapping test is statistically significant if the CIs limits have the same sign (either positive or negative). This denotes that zero is not a likely value, and thus, the null hypothesis stating that the indirect effect is zero could be rejected. Given that Sobel and bootstrapping tests rely on different assumptions, it is convenient to utilize both in the mediation analysis.

To evaluate the proposed moderated mediation (Baron & Kenny, 1986), we first checked that the interaction term of the independent and the moderating variable exerts an effect on the mediating variable ($XW \rightarrow M$). We then calculated conditional indirect effects at different values of the moderating variable, i.e., low (mean – one standard deviation), medium (mean), high (mean + one standard deviation), and tested the significance of these effects by estimating percentile CIs and bias-corrected CIs using bootstrapping. The use of these CIs improves results' accuracy and better reflects the sampling distribution of such conditional effects (Santulli, Gallucci, Torchia, & Calabrò, 2022).

4. Results

4.1. Results from mediation analysis

Table 2 shows the results of the GSEM regressions to test the mediating effect. Model 1 is the baseline model and includes only the control variables. Model 2 displays the direct effect of family involvement in management on process innovation. The relationship between family involvement in management and process innovation is found to be negative and significant ($\beta = -0.042$; $p < 0.05$), i.e., the likelihood of performing process innovation activities is lower when there are more family members in the firm management, thus H1 is confirmed. In Model 3, the effect of family involvement in management on R&D collaboration with suppliers is revealed. The negative and significant coefficient

Table 2
GSEM results for the mediation model of family involvement in management on process innovation through R&D collaboration with suppliers.

	Baseline	Process innovation	R&D collaboration with suppliers	Process innovation
	Model 1	Model 2	Model 3	Model 4
Direct effect				
Family involvement in management		−0.042** (0.018)	−0.089*** (0.022)	−0.024 (0.018)
Mediating effect				
R&D collaboration with suppliers				0.789*** (0.054)
Controls				
Second generation[a]	0.120*** (0.044)	0.118*** (0.044)	0.357*** (0.051)	0.049 (0.045)
Third and later generations[a]	0.145** (0.072)	0.143** (0.072)	0.395*** (0.080)	0.063 (0.073)
Firm size	0.191*** (0.014)	0.197*** (0.014)	0.415*** (0.019)	0.142*** (0.015)
Financial slack	−0.008* (0.005)	−0.007* (0.004)	−0.033*** (0.011)	−0.006 (0.004)
Supplier bargaining power	−0.006*** (0.001)	−0.006*** (0.001)	−0.010*** (0.001)	−0.005*** (0.001)
R&D employment	0.003*** (0.000)	0.003*** (0.000)	0.004*** (0.001)	0.002*** (0.000)
Joint ventures	0.710*** (0.142)	0.706*** (0.142)	0.996*** (0.149)	0.456*** (0.143)
Public R&D funding	0.001* (0.000)	0.001* (0.000)	0.001*** (0.000)	0.001 (0.000)
Constant	0.369*** (0.150)	0.436*** (0.107)	−0.670*** (0.123)	0.284*** (0.108)
Log likelihood	−2732.852	−2730.052	−1855.516	−2621.638

[a] First generation is the suppressed comparison category. Robust standard error in parentheses. Subindustry and territorial specificity dummies are included in all the models. ***Significant at 1%; **Significant at 5%; *Significant at 10%.

of family involvement in management (β = -0.089; $p < 0.01$) indicates that family firms exhibit a lower propensity to collaborate in R&D-related activities with suppliers when the number of family managers increases. Therefore, H2 is supported. Model 4 shows the influence of R&D collaboration with suppliers on process innovation. The positive and significant coefficient of R&D collaboration with suppliers (β = -0.789; $p < 0.01$) reveals that family firms undertaking R&D collaboration with suppliers are more likely to develop process innovations. Thus, H3 is confirmed. In addition, Model 4 reveals that, after entering the variable R&D collaboration with suppliers, the relationship between family involvement in management and process innovation becomes non-significant (β = -0.024; *n.s.*). Hence, our data support a full mediation effect of R&D collaboration with suppliers on the family involvement in management-process innovation relationship (Baron & Kenny, 1986), confirming our mediation hypothesis. The results in Table 2 also satisfy the conditions required by Baron and Kenny (1986) for mediation to exist: Model 2 substantiates the first condition; Model 3 represents the second condition; and Model 4 allows the third and fourth conditions to be examined.

Moreover, Table 3 presents the results of Sobel (1982) test and bootstrapping CIs. The Sobel test demonstrates that R&D collaboration with suppliers (z = -3.90, p < 0.01) has a negative and significant mediating effect on process innovation. The bootstrapping results confirm Sobel's test, as the 95 % CIs do not contain 0.

4.2. Results from moderated mediation analysis

Table 4 reports the results of the GSEM regressions to test the moderated mediating effect. We mean centred the independent and moderating variables to facilitate the interpretation of the interaction effects (Aguinis, Edwards, & Bradley, 2017). Model 5 reveals that the effect of family involvement in management on R&D collaboration with suppliers is contingent on the level of technology protection, as demonstrated by the positive and significant interaction term obtained by multiplying family involvement in management and technology protection (β = 0.035; p < 0.01). Therefore, H4 is confirmed.

Furthermore, in Table 5, we examine the conditional indirect effects of family involvement in management on process innovation through R&D collaboration with suppliers for low, medium, and high levels of

Table 4
GSEM results for the moderated mediation model of family involvement in management on process innovation through R&D collaboration with suppliers considering technology protection as a moderator.

	R&D collaboration with suppliers	Process innovation
	Model 5	Model 6 (cf. Model 4)
Direct effect		
Family involvement in management	−0.140*** (0.026)	−0.024 (0.018)
Mediating effect		
R&D collaboration with suppliers		0.789*** (0.054)
Moderating effect		
Technology protection	−0.021** (0.007)	
Family involvement in management × technology protection	0.035*** (0.009)	
Controls		
Second generation[a]	0.359*** (0.058)	0.049 (0.045)
Third and later generations[a]	0.623*** (0.100)	0.063 (0.073)
Firm size	0.419*** (0.023)	0.142*** (0.015)
Financial slack	−0.040*** (0.010)	−0.006 (0.004)
Supplier bargaining power	−0.011*** (0.001)	−0.005*** (0.001)
R&D employment	0.004*** (0.001)	0.002*** (0.000)
Joint ventures	1.155*** (0.196)	0.456*** (0.143)
Public R&D funding	0.001*** (0.000)	0.001 (0.000)
Constant	−0.639*** (0.151)	0.284*** (0.108)
Log likelihood	−1327.420	−2621.638

[a] First generation is the suppressed comparison category. Robust standard error in parentheses. Subindustry and territorial specificity dummies are included in all the models. ***Significant at 1%; **Significant at 5%.

Table 3
Mediation test statistics.

Process innovation	Effect	SE	Sobel test Z	CI(P)[a]		CI(BC)[b]	
				LL	UL	LL	UL
R&D collaboration with suppliers	−0.070	0.018	−3.90***	−0.104	−0.034	−0.105	−0.036

LL = lower limit. UL = upper limit. [a]Percentile confidence interval. [b]Bias-corrected confidence interval. ***Significant at 1 %.

Table 5
Conditional indirect effects of technology protection.

Moderator level	Coefficient	Bootstrap SE	CI(P)[a]		CI(BC)[b]	
			LL	UL	LL	UL
Low	−0.242	0.069	−0.419	−0.158	−0.389	−0.157
Medium	−0.094	0.023	−0.145	−0.046	−0.142	−0.045
High	0.054	0.065	−0.031	0.214	−0.038	0.161

LL = lower limit. UL = upper limit. [a]Percentile confidence interval. [b]Bias-corrected confidence interval.

technology protection. Table 5 shows that the 95 % CIs do not contain zero for low and medium levels of technology protection, which denotes significant conditional effects. On the other hand, for high levels of technology protection, the conditional indirect effect is not significant. This procedure reveals that the conditional indirect effects slowly decrease as the value of the moderating variable increases. In other words, top management teams with a greater number of family members show a higher propensity to collaborate in R&D with suppliers when the level of technology protection increases.

4.3. Robustness checks

To further validate the results and check their consistency, several robustness checks were performed, the results of which are available upon request to the authors. First, we used a simplified version of our independent variable by constructing a dummy variable that takes the value 1 when one or more members of the owning family hold posts in the firm management and 0 otherwise (Cruz & Nordqvist, 2012). The results were similar to those obtained in the main analyses, but in this case, a partial mediation is supported. Second, we utilized an alternative mediating variable, namely R&D collaboration with research centres. The results were similar for H1, H2, and H3, including the mediation hypothesis, but were not significant for H4. Third, we replaced our two control variables related to generational stage (second generation and third and later generations) with a dummy variable that is equal to 1 if the family firm is in second or subsequent generational stage and 0 if the family firm is in the first generational stage. The results are comparable with the original results of the main analysis. Finally, we tested each hypothesis using OLS and logit regressions with robust standard errors and the results obtained were similar to those of the GSEM analysis.

5. Discussion and conclusion

5.1. Summary of results

Understanding the role of family involvement in process innovation activities has become a central issue in the lively debate on family firm innovation (Casado-Belmonte et al., 2021; Diéguez-Soto et al., 2018). We take a further step in contributing to this debate by explaining whether and under which conditions family involvement in management influences process innovation in family firms. Drawing on upper echelon theory, and considering the mediating role of R&D collaboration with suppliers and the moderating role of technology protection, our findings suggest that a higher presence of family members in management is related to a lower likelihood of process innovation. Our results also show that a higher presence of family members in management is related to a lower probability of R&D collaboration with suppliers and that this low propensity to collaborate fully mediates the relationship between family involvement in management and process innovation. Despite the fact that collaboration with suppliers could provide a positive influence on process innovation, the involvement of family members in management does not allow this opportunity to be grasped. However, we find that the negative effect of family involvement in management on R&D collaboration with suppliers, and ultimately on process innovation, is alleviated by technology protection and even becomes positive for high values of technology protection. This shows that IP mechanisms provide a viable option to take advantage of collaborations with suppliers.

5.2. Theoretical contributions

The results of this research make several contributions to the literature. First, they offer new insights into the sources of heterogeneity among family firms with regard to their innovation behaviour (Calabrò et al., 2019; Casado-Belmonte et al., 2021). We add to the ongoing debate by explaining the reasons why family firms differ in terms of innovation achievements, linking these differences to their level of family involvement in management. In particular, family involvement in management has been found to be an important antecedent of family firms' innovation performance (Kammerlander et al., 2020; Martínez-Alonso et al., 2022b).

Second, this study contributes to both the under-researched phenomenon of process innovation, as well as to the nascent OI literature within family firms (Casado-Belmonte et al., 2021; Diéguez-Soto et al., 2018; Gjergji et al., 2022). With regards to process innovation, this article is, to our knowledge, the first to propose and test the impact of family involvement in management on process innovation. In this vein, this paper empirically demonstrates that, although a priori family involvement in management may entail both disadvantages and advantages for innovation processes (Calabrò et al., 2019; Diéguez-Soto et al., 2018; Röd, 2016), family managers reduce the likelihood of achieving process innovation. Thus, we go beyond existing studies, primarily focused on product or service innovations (Martínez-Alonso et al., 2022c; Rondi et al., 2021), to provide new insights into how family firms handle their process innovation.

With respect to the OI literature, this study adds to previous studies (Feranita et al., 2017; Gjergji et al., 2022) by introducing R&D collaboration with suppliers as an underlying mechanism that helps explain the intricate inhibitory effect of family managers on process innovation. Moreover, by examining R&D collaboration with suppliers in isolation, our work surpasses extant OI studies that combine collaborations with different types of R&D partners into a single variable through measures of 'breadth' or 'depth' (Alberti, Ferrario, Papa, & Pizzurno, 2014; Classen et al., 2012). In so doing, we bring a novel standpoint in family firm OI literature (Bigliardi & Galati, 2018; Rondi et al., 2021), providing a first theoretical and empirical attempt to better understand how family managers relate to this specific R&D partner and how this relationship impacts process innovation. Additionally, our study contributes to the literature on IP mechanisms in family firms' OI decisions (Brinkerink et al., 2017; Martínez-Alonso et al., 2022a). In the OI environment, when some IP mechanisms are implemented, family managers can keep their particularistic objectives safe and, simultaneously, make riskier and more complex choices. Thus, our study reveals that when family managers decide to open their firms' technological frontiers to suppliers, IP mechanisms make goals more compatible and less conflicting, ultimately resulting in enhanced process innovation.

Third, our study advances the comprehension and use of the upper echelon theory in the family firm context (Ensley & Pearson, 2005), by offering new knowledge into family managers' distinctive behaviour related to the pursuit of process innovation. We also add new insights to the understanding of upper echelon theory in the OI context by identifying R&D collaboration with suppliers as a specific strategic choice that

increases family managers' aversion to control losses and potential knowledge leakage. Last, we extend the upper echelon theory by recognizing IP mechanisms as a salient situational condition that helps to explain under which circumstances family managers reduce their aversion to engaging in R&D collaboration with suppliers.

5.3. Practical implications

Apart from the theoretical implications, this study aims to be of great practical relevance in helping family managers and practitioners to improve firms' production processes. First, the achievement of process innovations depends on the number of family members in the management. The appointment or exclusion of family managers has become a crucial issue at a practical level, as it is a decision faced by virtually every family firm worldwide (Sciascia, Mazzola, & Kellermanns, 2014). Thus, when appointing relatives as managers to improve process innovation effectiveness, priority should be given to the inclusion of members with appropriate technical qualifications and competences, minimizing nepotistic actions and practices.

Second, our findings point out the need to develop R&D collaboration with suppliers to enhance process innovations. Although family managers are initially reluctant to make these strategic choices, they may find in R&D collaboration with suppliers a powerful tool to make the most of their process innovation activities. In this regard, if family firms want to survive and remain competitive in today's turbulent and competitive environment, one potential solution for family managers could be to find the right balance between keeping their family priorities and opening the doors of the innovation process to suppliers. An effective way to do this is to leverage on established relationships with suppliers, and develop a mutually beneficial innovation climate that favours the transfer of resources and knowledge between all parties.

Third, our findings also advocate the need to implement IP mechanisms to enhance family managers' OI behaviour, and thus improve process innovations. In this sense, our results show that the presence of IP mechanism makes family managers less likely to perceive control losses and knowledge leakages, which increases their willingness to make riskier decisions, such as R&D collaboration with suppliers. Therefore, to the extent that these mechanisms are a crucial tool contributing to the improvement of family firms' process innovations, family managers should deploy them when innovating.

5.4. Limitations and future research

Despite the interesting results of our study, it has some limitations, which also point to interesting opportunities for future research. First, our work is based on data from the SSBS database, which has already been used in previous research (e.g., Campos-García et al., 2021; Manzaneque et al., 2020; Triguero et al., 2020). However, the SSBS is updated every year, so that the new available data for subsequent periods usually include additional firm observations to maintain the sample representativeness. In any case, given that our data focus specifically on Spanish family firms, cultural and social factors may affect our results. We consequently encourage academics to replicate our study in other geographical contexts to test the generalizability of the results presented here. Second, by considering family participation merely as the number of family managers, we do not take into account disparities in the internal top management team composition in terms of education, aspirations, gender, generations represented, family branches, or ownership shares, thus implicitly assuming an equitable distribution of power. Hence, future studies might adopt qualitative methods and in-depth interviews to shed light on how top management team composition and diversity influence process innovation. Longitudinal qualitative studies would also be ideal to provide further insights into the underlying dynamics that connect family managers' goals to behaviour in process innovation. Specifically, we invite family firm scholars to deepen the study of process innovation, for example, by distinguishing between different forms of it, such as process innovations in new equipment, new techniques or software. Similarly, differentiating between radical and incremental process innovations could further add to our understanding of process innovation in family firms. Third, we do not have specific insights into the family dynamics that could explain why R&D collaboration with suppliers mediates the effect of family involvement in management on process innovation. Since identifying these dynamics could help to shed new light on the topic, future researchers should rely on longitudinal case studies. Finally, alternative mediating and moderating variables, such as internationalization or diversification, could be adopted in future research to better understand family managers' choices and behaviours regarding process innovation. Considering the scarce research into the family involvement in management-process innovation link in family firms, there are many opportunities for further research.

CRediT authorship contribution statement

Rubén Martínez-Alonso: Writing – review & editing, Writing – original draft, Validation, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **María J. Martínez-Romero:** Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Investigation, Formal analysis, Conceptualization. **Alfonso A. Rojo-Ramírez:** Writing – review & editing, Validation, Supervision, Project administration, Investigation, Conceptualization. **Valentina Lazzarotti:** Writing – review & editing, Visualization, Supervision, Project administration, Investigation, Conceptualization. **Salvatore Sciascia:** Writing – review & editing, Visualization, Supervision, Project administration, Investigation, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Variables and measures

Variables	Measures	Original labels in the SSBS dataset
Dependent variable		
Process innovation		IPR

(continued on next page)

(*continued*)

Variables	Measures	Original labels in the SSBS dataset
	Dummy variable indicating whether the firm introduced any major modification in the production and/or distribution process	
Independent variable		
Family involvement in management	Number of owners and working relatives in management positions	PAFDG
Mediating variable		
Collaboration with suppliers	Dummy variable indicating whether there was technological collaboration with suppliers	CTPR
Moderating variable		
Technology protection	Number of patents the firm has registered in Spain	PATESP
Control variables		
Second generation	Dummy variable indicating whether the firm age is between 30 and 60 years	AEMP
Third and later generations	Dummy variable indicating whether the firm age is higher than 60 years	AEMP
Firm size	Log of total assets	PASIVO
Financial slack	The ratio of current assets to current liabilities	PASIVO, IN, DCECVA, DCRVA
Supplier bargaining power	Percentage of the purchases coming from the three largest suppliers	CPROV
R&D employment	Percentage of employees dedicated to R&D	ETRID
Joint ventures	Dummy variable indicating whether the firm had technological cooperation agreements/joint ventures	ACT
Public R&D funding	Amount of public financial resources for R&D that the firm obtained from the central government	FPIDES

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