*First Draft*

# Family-managed firms, External Source of Knowledge and Innovation: An Exploration of the Manufacturing Industry in Spain

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Innovation is generally regarded as a highly interactive activity, where firms absorb, generate and apply knowledge by relying on both internal and external sources. We hypothesize that because of firm familiness specificities, family firms create a positive environment for R&D cooperation increasing the probability to have process and product innovations. On the other hand, based on regional familiness arguments we hypothesize that firms, in general, increase their probability to have process or product innovation as result of being placed in context where family firms act as catalyst of knowledge and information at local, industrial and regional level.

We use a large panel dataset of Spanish manufacturing firms covering the period 2000-2015. Our results reveal that the probability of engage in both product and process innovations is higher for family-managed firms involved in technological collaboration. Hence, does emerge a particular ability of family firms to leverage external source of knowledge at the foundation of higher innovation propensity. Additionally, our findings provide support for the so called "regional familiness" arguments. In fact, our estimations show the higher family firm density spending in R&D in a particular region, is associated with greater product and process innovation propensity for firms located in that region.

Keywords: family firms, innovation, R&D cooperation, spillovers, manufacturing

JEL classifications: D22, L6, 030

## 1. INTRODUCTION

In the knowledge-based economy firm survival and competitiveness is strongly dependent upon firm's capacity to innovate. Innovation is generally regarded as the resulting of a highly interactive process whereby firms generate, absorb and apply knowledge by relying on both internal and external sources (Triguero & Fernández, 2018). While internal sources lean mostly on the knowledge developed within the organization boundaries of the firm, external sources of knowledge can be acquired by establishing formal inter-firm R&D cooperation (Propris, 2002) or being exchanged freely beyond the intended boundary as a result of the interaction with geographically and socially proximate economic actors (Balland, Boschma, & Frenken, 2017; Boschma, 2005). Hence, two levels of analysis of external source of knowledge can be identified. The first one, at firm level, focusing on the firm ability to appropriate and exploit knowledge arising from formal R&D cooperation and to be converted in innovation (Cantner, Conti, & Meder, 2010; Propris, 2002). The second one, at meso level of analysis, consisting on local knowledge spillovers stemming from the concentration of firms in spatially bounded areas such as regions, industrial clusters and *innovative milieu* among others (Dicken & Malmberg, 2008; Parr, 2002).

How firms manage, intercept, and fruitfully exploit the external sources of knowledge is crucial for their innovation behaviour (Cantner et al., 2010). In this perspective, the ability to capitalize on both the knowledge embedded in inter-firm linkages (i.e., cooperation) and that available through informal interaction with socially and geographically proximate firms is strongly reliant on the quality of these social interactions and networking established by the firm (Hauser, Tappeiner, & Walde, 2007). In particular, this contribution emphasises the relational dimension of social capital which is based on trust, obligations, and norms of reciprocity that facilitates the exchange and transmission of knowledge among partners involved in cooperative networks (Bathelt, Malmberg, & Maskell, 2004) so exerting an indirect impact on the innovative capacity of the participant firms (Cantner et al., 2010;

Capello & Faggian, 2005). Beyond the cooperative innovative activities, the presence of localized tacit knowledge can spill over among independent nearby firms with the space that, thus "becomes important as platform for knowledge exchange" (Hauser et al., 2007, p. 77). In this respect, the informal social interactions among economic actors serve as main channel for the process of transferring and dissemination of this context-specific knowledge (Lambooy, 2010). In particular, it is from the embeddedness of economic activity in this web of social relations that some actors are deemed to play a differential roles in making connections and facilitating the knowledge flow across firms and other organizations (Feldman & Zoller, 2012) contributing in this way to the creation of a regional environment particularly supportive of innovation (Hauser et al., 2007).

Despite its salience in the process of generation, exchange, and dissemination of innovation-relevant knowledge, not all firms are endowed with same social capital being able to differ according to some firm-specific characteristics. Among these, the involvement of a family in the managerial position – i.e. the family status of the firm - represents a prominent source of firm's heterogeneity. The juxtaposition of two highly interrelated domains, namely the family and business, results in a unique social capital which is based on closure, obligation, common identity among family members (Salvato & Melin, 2008) and on long-lasting and trust-based relationships with external parties (Arregle, Hitt, Sirmon, & Very, 2007) which is likely to influence the innovation behaviour and outcomes (Calabrò et al., 2018; Feranita, Kotlar, & De Massis, 2017). Our conjecture is twofold. First, at firm level, we hypothesize that family firms developing cooperative network, as a result of their strong social capital, benefit more from external source of knowledge than non-family counterparts as reflected in a higher innovation propensity (Feranita et al., 2017). Second, at regional level, by building socially embedded relations (i.e., social proximity) with physically and technological proximate economic actors (Boschma, 2005), it is inferred that family firms facilitate the dissemination of information and knowledge relevant for innovation (i.e. local knowledge spillovers), thus serving as "catalyst" for innovation in the region in which are located.

Our article rely on micro-level data of Spanish manufacturing firms over the period 2003-2015. The results reveal that despite family firms do not differ from non-family counterparts in terms of innovation propensity, formal R&D cooperation are more conducive of both product and process innovation than their non-family counterpart. Additionally, the regional presence of R&D-oriented family firms is positively associated with firm probability to engage in product and process innovations. This finding suggests the crucial role of family firms in disseminating information and knowledge among other firms thereby contributing in the creation of a regional environment conducive of innovation.

Our study contributes to the growing interest in investigating the intersection between regional economics and family business research. In particular, the main contributions of this paper are two-fold. First, it provides new evidence about the positive implications of the variety (i.e. breadth) of R&D collaborative agreements with external parties on firms's innovation propensity. But even more importantly, it is being shown how these advantages are not uniformly distributed across firms. In this perspective, the ownership and managerial composition – that is the family status of the firm - arise as a relevant firm-specific characteristic underpinning the differential benefits, in terms of probability of engaging in innovation, of R&D cooperation. Second, the present study contributes to the knowledge spillovers literature for the comprehension of the role played by the geographically bounded knowledge in fostering learning and innovation. However, by moving forward the approach treating indistinctly the firms among which knowledge flows, our study unveils the role of family firms as socially embedded actors being in a position to alter the mechanisms of knowledge and information transmission at the foundation of agglomeration economies. Finally, our findings have a number of policy implications. Whether from one side, innovation policy should promote the creation or strengthening of R&D collaborative agreements and the knowledge creation and transferring across firms within a spatially bounded region, from the other these interventions cannot neglect family firms as peculiar regional actors from which the effectiveness of the measures themselves depends.

The paper is organized as follows. In section two, the existing empirical research is being discussed. The third section describes the data, variables and the econometric specification. In the fourth section, the empirical results are presented. Conclusions are drown in the fifth and final section.

## 2. REVIEW OF LITERATURE

### *2.1. R&D cooperation, family firms, and innovation propensity*

R&D cooperation typically involves firm's active participation in joint R&D and technological innovation projects with other organizations (Tether, 2002). The external knowledge acquisition stemming from formal co-operative arrangements tend to complement the internal one generated by the in-house R&D (Cassiman & Veugelers, 2006) and firms typically resort to them as way to overcome internal resources constraints (including knowledge) and/or reducing the risks associated with innovation (Freel & Harrison, 2006; Tether, 2002).

Empirical evidence supports the view that R&D cooperation represents a valuable device aims at increasing the chance of introducing innovation (López-Bazo & Motellón, 2018; Propris, 2002; Triguero & Fernández, 2018) or improving innovation performance (Cantner et al., 2010; Grimpe & Kaiser, 2010). This is particularly true for firms limited in size, and hence physical and financial resources such as small-and medium-sized enterprises (SMEs)(Freel & Harrison, 2006) and for those operating in regions characterized by week innovative environment (López-Bazo & Motellón, 2018). However, a balancing between internal and external knowledge is needed. That is because a dilution of firm's resource base, the atrophy of firm's integrative capabilities (Grimpe & Kaiser, 2010) and costly managing external relationships (Cantner et al., 2010) can offset the benefits expected from complementarities.

R&D cooperation is intrinsically related to proximity dimensions because it reduces uncertainty and solves the problem of coordination, facilitating “interactive learning and innovation” (Boschma, 2005, p. 62). Despite geographical proximity has been traditionally regarded as crucial for the emergence of collaboration (Fritsch, 2001; Marek, Titze, Fuhrmeister, & Blum, 2017) other non-spatial forms of proximity can either substitute for (Drejer & Østergaard, 2017; Hansen, 2015) or overlap with geographical propinquity (Hansen, 2015) such as social proximity.

Social proximity is found impacting positively on the emergence of R&D collaborative activities (Hansen, 2015) and firm’s innovative performance (Cantner et al., 2010). Stemming from the embeddedness literature (Granovetter, 1985), social proximity refers to trust-based social relationships among economic actors at micro-level that, by lowering transactions costs and facilitating the exchange of tacit knowledge for firms involved in innovative cooperation networks, influence positively organizational learning capabilities and, hence, innovation (Boschma, 2005). By modelling relationships on trust, reciprocity and closeness among cooperating firms, social proximity portrays the quality of their broader social capital (Capello & Faggian, 2005; Nahapiet & Ghoshal, 1998) thereby empowering the transfer of fine-grained information and joint problem-solving solutions (Uzzi, 1999) and the mitigation of tensions in R&D alliances (Steinmo, 2015). Hence, conceived as a relational assets focused on social interaction (Lambooy, 2010) “between individuals and organizations that facilitate action and create value” (Arregle et al., 2007, p. 75), social capital arises as critical firm’s attribute for capitalizing on the knowledge exchange arising from formal R&D cooperation (Steinmo, 2015). However, some firm-specific characteristics may result in a unique social capital underling the way socially proximate relationships with R&D partners are built, managed and evolve over time. Among these, the family status of the firm as a result of the involvement of a family in ownership and managerial positions.

As compared to non-family counterparts, in family firms at least two forms of social capital coexist: that of the family and that of the firm (Salvato & Melin, 2008). Because of the juxtaposition between the two domains, the family social capital – based on dimensions of trust, reciprocity and exchange among family members – influences the development of the social capital of the firm with the latter that resembles the former in terms of structure, climate and behavioural focus (Arregle et al., 2007). Each of these dimensions is embedded not only in family unit but also in social ties that firm establish with external parties (Sirmon & Hitt, 2003) influencing the span and the value, in terms of complementary resources, attainable from these relationships (Zahra, 2010).

Despite risk-aversion, parsimony and reluctance to sharing confidential information with potential co-operators could prevent family firms from establishing R&D technological agreements (Nieto, Santamaria, & Fernandez, 2015) or limiting the cooperation breadth (Classen, Van Gils, Bammens, & Carree, 2012) evidence shows as dependability, trust, long-term relationships and exchanges characterize R&D cooperation of family firms (Harms, Memili, & Steeger, 2015). The freedom and ability to make adaptive decisions in conjunction with continuity and reliability in the pursuit of long-term and uncertain activities such as R&D cooperation, provides a credible signal to the partners (Pucci, Brumana, Minola, & Zanni, 2017). This, in turn, ease the exchange of information and complementary resources and the effectiveness with which new knowledge is generated and shared among R&D partners, hence, boosting firm's innovation potential (Ardito, Messeni Petruzzelli, Pascucci, & Peruffo, 2018) and, ultimately, the innovation outcomes stemming from R&D cooperation. Hence, given the aforementioned arguments, we infer as due to their richer social capital, family firms are likely to benefit more than non-family counterparts from R&D alliances. Thus:

*Hypothesis 1: The probability to engage in innovation arising from R&D cooperation agreements is higher for family than in non-family firms.*

### *2.2. Local knowledge spillovers, family firms, and innovation propensity*

In investigating additional source of knowledge and mechanisms of learning relevant for innovation, both theoretical and empirical literature (Audretsch & Feldman, 2004; Triguero & Fernández, 2018) suggest how the concentration of firms in spatially bounded areas (e.g., clusters, industrial districts or region) provides opportunities for the transmission of knowledge. Defined as free of charge-knowledge flow occurring either spontaneously – that is without any intent – or through intentional behaviour (Kesidou & Romijn, 2008), knowledge spillovers are at the foundation of agglomeration economies or external economies, that is competitive advantages as reflected in cost-saving, productivity gains or higher innovation performance resulting from firm’s co-location within a place or region (Audretsch & Feldman, 2004; Galliano, Magrini, & Triboulet, 2015).

The processes of knowledge acquisition is facilitated by spatial proximity among local actors that, by simplifying the repeat and frequency of personal contacts, enables the transmission of knowledge (Audretsch & Feldman, 2004; Malmberg & Maskell, 2006). In particular, geographical propinquity provides the opportunity for the dissemination of sticky, non-articulated and tacit knowledge otherwise inaccessible in presence of physical distance among actors involved (Bathelt et al., 2004). However, the space understood only in terms of spatial distance offers a partial explanation of the mechanisms beneath the dissemination of such geographical-bounded of knowledge flow and their influence on innovation behaviour and performance (Balland et al., 2017; Boschma, 2005). In this perspective, the relational capital arises a missing piece of the puzzle on firms, knowledge spillovers and innovation (Capello, 2002). In fact, what that really matters in the process of production, dissemination and appropriation of this locally embedded knowledge is the set of trust-based social relationships between geographically proximate firms, people and institutions that "stem from a strong sense of belonging and a highly developed capacity of cooperation typical of culturally similar people and institutions" (Capello & Faggian, 2005, p. 79). Hence, in the spatial-relational approach *à la* Capello (2002), element of social or relational proximity complement the classical geographical propinquity underlying the diffusion of territorial knowledge relevant for innovation.

In examining the social dimension of proximity, do exist some processes of localized learning that are inherent in the everyday life of peoples working and living in any local settings and that are fuelled by continuous, unintended and spontaneous exchange of information. Known as "local buzz" (Bathelt et al., 2004) they refer to the network of communication and information linkages arising from face-to-face contacts, co-presence and co-location of people and firms within the same place of region that promotes the exchange of knowledge and new ideas relevant for innovation (Cooke, Clifton, & Oleaga, 2005; Kesidou & Romijn, 2008). In particular, the co-presence in the same economic and social context gives the opportunities for local social interactions – mostly informal such as personal meetings or communication – as conduit of specific information and continuous update of this information (Malmberg & Maskell, 2006), which are particularly important especially in environment characterized by imperfect, rapidly changing, and not easily codified information (Storper & Venables, 2004). Firms located in the same local settings are able to understand local buzz in a purposeful and useful way. That is because geographical propinquity fosters the development of the same knowledge base, expertise and similar language together with shared cultural traditions, conventions and habits in a particular technological field (Boschma, 2005). However, physical and technological proximity are necessary but not sufficient conditions for the diffusion of buzz. That is because either the smoothness or, conversely, the hurdle with which information can flow among local actors, is mostly depending on the structure and quality of social relations and the history of interactions among them (Bathelt et al., 2004). In other words, the extent to which economic relations are embedded in the social context (i.e., social proximity) (Boschma, 2005) is essential in explaining how firms contribute to the diffusion of innovation-relevant information by just being and operating in their local setting (Malmberg & Maskell, 2006).

Despite the unquestionable contribution of the "relational-space" approach in shedding new light the way in which knowledge spill over a local area (Capello, 2002; Capello & Faggian, 2005), some economic actors might prove playing a differential role in creating and easing the information and knowledge flows that increase the vibrancy of the regional setting in which innovation occurs. As a result of their unique social capital, as reflected in a rich and trust-based set of relationships, some local actors may be in the position not only to intercept singularly this spatially-bounded flow of knowledge but also to assist in a unique way to its diffusion (Lambooy, 2010) contributing in such a way to the creation of a regional environment particularly conducive to the innovation (Morgan, 2007). As peculiar regional actors, family firms would play a pivotal role in this respect.

A broad evidence suggests as in family firms the long-term, reciprocal, and trustworthy relationships among family members tend to be replicated outside the organizational boundaries (e.g. Arregle et al., 2007; Sirmon & Hitt, 2003) so shaping uniquely how family firms and their local setting interact (Backman & Palmberg, 2015; Salvato & Melin, 2008). The economic activity of family firms is strongly embedded in a dense, stable, and durable set of social relations (Baù, Chirico, Pittino, Backman, & Klaesson, 2018) that provides access to critical tangible and intangible resources (Backman & Palmberg, 2015). In particular, the centrality of family members in their social and professional networks is found to facilitate the access and the exchange of external valuable resources such as business opportunities (Zahra, 2010) and up-to-date information and knowledge (Salvato & Melin, 2008) relevant for innovation (Calabrò et al., 2018) and, therefore, for the value creation across generation (Salvato & Melin, 2008).

Due to the strong social, cultural and historical connections with the community in which are located, family firms are able to leverage tacit and hard-to-replicate localized knowledge. For instance, it has been shown that the ability of family firms to build socially proximate relationships with close local economic and social actors assist them in rural areas to identify and exploit tangible resources and information and deal with the low level of resource endowment that traditionally characterise these regional environment (Bird & Wennberg, 2014). Additionally, the social embeddedness of family firms is found facilitating the exchange of knowledge and information with local actors (Cucculelli & Storai, 2015; Pucci et al., 2017) affecting the innovation performance at both firm (Pucci et al., 2017) and regional level (Berlemann & Jahn, 2016; Block & Spiegel, 2013). That is because reciprocal and trust-based relationships, by reducing the risk of opportunistic behaviour and minimizing communications costs, enhance interactive learning and, hence, firm's innovative behaviour (Boschma, 2005; Camagni & Capello, 2013). Consequently, family firms are in a unique position to alter proximity dimensions and so, hence, the mechanisms of knowledge and information transmission at the foundation of agglomeration economies (Basco, 2015; Stough, Welter, Block, Joern, Wennberg, & Basco, 2015) thus, contributing to the creation of an enabling regional environment of innovation to the benefit of all firms. Therefore:

> *Hypothesis 2: The regional presence of R&D-oriented family firm's is positively related to the likelihood to innovate.*

## 3. DATA, VARIABLES AND EMPIRICAL MODEL

### *3.1. Data*

In testing our hypothesis, we relied on yearly data at firm level covering the period 2003-2015. The data come from the Survey on Business Strategies (ESEE) carried out jointly by the Ministry of Economy, Industry and Competitiveness and the SEPI Foundation[1] on a

[1] For more information about SEPI Foundation and ESEE database, please refer to: www.fundacionsepi.es.

sample of Spanish manufacturing firms. ESEE discriminates between firms employing 10-to-200 workers (small and medium-sized enterprises, SMEs) and those with more than 200 employees (large firms). In order to ensure representativeness of the Spanish manufacturing firms' universe, ESEE combines exhaustiveness and random criteria sampling whereby all large companies were surveyed whereas SMEs were selected through a stratified, proportional and systematic sampling with random seed. By providing fine-grained information on the firm's technological activities, activity, products and manufacturing processes, ESEE dataset results particularly suitable for innovation studies (e.g. Kotlar, De Massis, Frattini, Bianchi, & Fang, 2013; Triguero & Fernández, 2018). The final samples consisted of 2,955 firms surveyed yearly, distributed across 20 manufacturing industries (NACE Rev. 2-digit level)[2] and the 17 Spanish autonomous communities (NUTS 2)[3] resulting in 18,740 firm-years observations.

*3.2. Variables*

*Dependent variable*

*Innovation*. Among the several measures of innovation activity available from ESEE, this study focuses on product and process innovations achieved during the financial year. ESEE defines product innovation as the introduction of entirely new goods in terms of materials, components, intermediate products or functions. Likewise, process innovation is defined as the implementation of new machineries and equipment, techniques and/or method of productions and computer programs associated with industrial processes. Accordingly, following previous studies (López-Bazo & Motellón, 2018; Triguero & Fernández, 2018) we

[2] NACE is acronym of *Nomenclature statistique des activités économiques dans la Communauté européenne* and represents the European standard classification of productive economic activities.
[3] NUTS stand for Nomenclature of Territorial Units for Statistics and represents the level of territorial division. Spanish territory is articulated in the following level: NUTS 1, consisting of 7 groups of autonomous communities (*Agrupación de comunidades autónomas*); NUTS 2, comprising 19 Autonomous communities and cities (*Comunidades y ciudades autónomas*); NUTS 3 made up of 59 among Provinces, Islands, Ceuta and Melilla (Provincias, *Islas, Ceuta y Melilla*). However, ESEE survey keeps out from the investigation the autonomous city of Ceuta and Melilla hence covering 17 Autonomous communities.

introduced a binary response variable equal to 1 if the firm has introduced a product or a process innovation, 0 otherwise.

*Independent variables*

*Breadth*. R&D cooperation is measured by an indicator capturing the number of external sources or search channels with which firm maintains formal joint innovative activities. In particular, following previous contributions (Cantner et al., 2010; Laursen & Salter, 2006), the aforementioned variable was built by summing up the numbers of each partner category, namely: cooperation with competitors, customers, suppliers, universities and technological centres and joint-ventures;

*Family-managed firm*. For the definition of family firms, we adopted a "demographic approach" (Basco, 2013) that considers the family involvement in the firm (e.g. in the ownership, board of directors and management) as a sufficient condition to capture the family influence on the firm. ESEE, for each firm surveyed, reports the number of family members occupying managerial positions. Therefore, according previous studies (Baù et al., 2018; Kotlar et al., 2013), we introduced a dummy variable taking value 1 if at least two family members are in the management of the firm, 0 otherwise;

*Knowledge spillovers*. With the aim to measure knowledge spillovers arising from the spatial concentration of R&D-oriented family firms, we followed the study of Triguero & Fernández (2018) according to which spillovers depend on the following factors: the industry in which the family firms operate and the region in which the same are located. Hence, we consider three types of knowledge spillovers. *Local knowledge spillovers*, calculated as share of family firms R&D expenditures in the same industry and in the same region with respect to the total of R&D expenses spent in the region. *Regional knowledge spillovers*, captured by the share of family firms R&D expenditures in different sectors and in the same region on the total of R&D expenses at regional level. Finally, *industrial knowledge spillovers*, measured by the share of family firms R&D expenditures in the same industry but outside of the region corresponding to the firm. While *local* and *regional knowledge spillovers* are spatial-bounded flow of knowledge occurring respectively at intra and inter-industry level, *industrial knowledge spillovers* are referred as extra-regional spillovers because of considering the same industry yet occurring beyond regional boundaries.

*Control variables*

*Previous innovation*. Innovation behaviour is characterized by the so-called "true" state dependence implying the decision to innovate in one period enhance the probability of innovating in the subsequent period. That is because innovation success widens technological opportunities that, in turn, make subsequent innovation more likely. Additionally, knowledge has a cumulative nature such that experience in innovation is associated with dynamic increasing return in terms of learning effect influencing innovative capabilities. Finally, R&D investments represent sunk-cost that prevent persistent R&D performers to exit from innovative-related activities thus having higher probability to innovate than discontinuous R&D performers (Peters, 2009). In order to account for the true state dependence, we introduced a dummy variable taking value equal to 1 if the firm has introduced product and process innovation in the previous year, 0 otherwise;

*Absorptive capacity*. We controlled for the ability of firms not only to generate new knowledge internally but also to scanning, assimilate and exploit existing knowledge and information from the external environment. Access to external know-how may not only leverage the efficiency of internal R&D activities but also appropriate some returns of knowledge generated by external parties (Cassiman & Veugelers, 2006). Following previous contributions (López-Bazo & Motellón, 2018; Triguero & Fernández, 2018), absorptive capacity is expressed as expenditures on R&D as percentage of total sales;

*Size*. The size of the firm is generally regarded as an important control variable. In fact, in addition to higher ability to invest in R&D activities larger firms may enjoy scale and scope economies in R&D affecting the innovative performance. We expressed size as logarithm transformation of the total number of employees (Cantner et al., 2010; López-Bazo & Motellón, 2018);

*Age*. While new ventures typically tap into less specialized but more flexible deployable resources, mature firms rely on higher specialization pioneering new products or process solutions. Therefore, in order to account for the trade-off between asset specialization and flexibility, we controlled for the age of the firm measured as the number of years between its foundation and the observation year (Kotlar et al., 2013; Triguero & Fernández, 2018);

*Export intensity*. It has been shown as internationalization improves firm's innovative performance (López-Bazo & Motellón, 2018). That is because highly internationalized firms benefit of additional source of information and knowledge and increased organization learning providing, also, the opportunity to optimize the costs of R&D inputs (Kafouros, Buckley, Sharp, & Wang, 2008). Therefore, we controlled for export intensity as measured by the percentage of export on total sales (Cassiman & Veugelers, 2006);

*Leverage*. The capital structure composition has been found affecting firms innovation with high level of indebtedness inducing more efficient allocation of technological and human resources towards innovation activity (Choi, Kumar, & Zambuto, 2016). Therefore, we controlled for indebtedness of the firm as measured by book value of the total debt divided by total assets;

*Public R&D funding.* Public funding of R&D can contribute to the firm's innovation trajectory by either substituting or complementing private R&D expenditures (David, Hall, & Toole, 2000). Hence, we controlled for the financial resources provided by regional government for research and technological purposes (Pucci et al., 2017).

*Industry, Region, and Time*. In order to control for whether the probability to innovate is affected by unobserved heterogeneity across industries and regions we included dummy variables respectively corresponding to the branch of manufacturing activity and the Spanish communities in which firms are located. Finally, for accounting the business cycle effect, time-specific dummy variables are included. Table 1 summarizes the variables employed in this study.

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*3.3. Econometric approach*

We are interested in estimating, at firm level, the ability of family-managed firms to benefit differently from the participation to R&D collaborative agreements and, at regional level, the influence of knowledge spillovers induced by a high concentration of R&D-oriented family firms on the innovation propensity. Therefore, the econometric equation to be estimated can be written as follows:

$$Y_{i,t} = \alpha_0 + Y_{i,t-1} + \beta_1 B_{i,t-1} + \beta_2 F_{i,t} + \beta_3 (B_{i,t-1} * F_{i,t}) + \beta_4 LK_{i,t} + \beta_5 RK_{i,t} + \beta_6 IK_{i,t}$$
$$+ \beta' C_{i,t-1} + \beta' T_i + \beta' S_i + \beta' R_i + \varepsilon_{it} \quad (1)$$

where $i = 1, \ldots, N$ firms and $t = 1, \ldots, T$ years; $Y_{i,t}$ is the observed binary that takes value one if the firm has introduced a product innovation (process innovation). Among the explanatory variables displayed in equation (1), $B_{i,t-1}$ is the breadth; $F_{i,t}$ is the dummy variable indicating the family status of the firm and $B_{i,t} * F_{i,t}$ is the interaction term. $LK_{i,t}$ represents the local knowledge spillovers, $RK_{i,t}$ the regional knowledge spillovers and $IK_{i,t}$ the industrial knowledge spillovers. $Y_{i,t-1}$ is the previous innovator status included to account for the true state dependence, $C_{i,t-1}$ is a vector of control variables introduced in order to capture heterogeneity among firms influencing innovation propensity; $T_i$, $S_i$ and $R_i$ are time-specific, industry-specific and region-specific dummy effects. Finally, $\varepsilon_{it}$ is the independent and identically distributed (i.i.d.) error term.

However, it is worth nothing that a source of endogeneity represented by the simultaneity issue may arises. Therefore, with the aim of lessen this potential econometrics issue that may produce severely biased results, we lagged by one period the breadth variable ($B_{i,t-1}$) and all control variables ($C_{i,t-1}$) with the exception of geographical and technological proximity and the family status of the firm that we consider being as very stable over the years (Triguero & Fernández, 2018).

We estimate equation (1) by using a linear probability model (LPM). Although non-linear model regressions such as probit and logit are commonly employed in the case of binary dependent variable, OLS estimations is deemed well-suited to get consistent and unbiased coefficients even with a dichotomous response variable (Wooldridge, 2010). Our preference for LPM is basically based on the following arguments. First, when there is an excessive amount of "0" in the dependent variable, the parameter estimates obtained by non-linear models might not be consistent (King & Zeng, 2001). Second, the straightforward interpretation of the coefficient of an interaction term, as opposed to nonlinear model in which the interpretation of such interaction term is problematic due to unclear signs or incorrect standard errors (Ai & Norton, 2003; Greene, 2010). Third, the marginal effects obtained from OLS estimation are very close to those obtained from a nonlinear estimation (Fackler, Schnabel, & Wagner, 2013). Finally, the problem of heteroscedasticity as generally stated as potential drawback in LPM is being addressed by calculating heteroscedasticity-robust standard errors (Wooldridge, 2010).

### *3.4. Descriptive statistics*

Table 2 displays the summary statistics for the variables used in the analysis. Nearly 17% of the firms in our sample execute product innovation while this percentage increases to 32% for the process innovation. With regard to our explanatory variables, 25% of sampled firms are family-managed whose R&D expenditures account for 14% of the total at industry and regional level. This share shrinks to 6% if only the total of regional R&D expenditures are considered. On average the firms in our sample displays low absorptive capacity – less than 1% of R&D costs as proportion of total sales – whilst more than one fifth of sales are made abroad. Finally, the mean age of the sampled firms is equal to 28 years.

--- INSERT TABLE 2 AROUND HERE ---

In Table 3 the pairwise correlation results are reported. The table indicates moderate correlation between the variables. Inspection of the variance inflection factor (VIFs) reveals no serious multicollinearity issue. That is because the VIFs of the coefficients stay well behind the critical value of 10, which is generally viewed as existence of multicollinerity in the data

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## 4. RESULTS

### *4.1. Regression results*

Table 4 presents the estimates for product and process innovation. Firstly, our results reveal, as past innovation is conducive of both type of innovation. Indeed, the coefficients of lagged dependent variables are positive and highly significant suggesting the persistency of innovation activity (Peters, 2009; Triguero & Fernández, 2018).

Among our explanatory variables, *Breadth* is positive and statistically significant. However, as shown in Model (1) the external information sources stemming from R&D cooperation appear to affect mostly product innovation ($\beta$=0.010, $p$<0.01). Conversely, the result does not show any association between the family status of the firm and innovation propensity: *Family-managed firm* coefficient is not statically significant. In order to test Hypothesis 1, we introduced a two-way interaction between *Breadth* and *Family-managed firm*. The results displayed in Model (2) and (5) reveal as the interaction term is positive and statistically significant – respectively for both product and process innovation - suggesting as family managed-firms benefit more than non-family counterparts from R&D cooperation with external parties. Thus, Hypothesis 1 is supported. Finally, to test Hypothesis 2, the knowledge spillovers variables are introduced in the regressions. The empirical findings shown in Model (3) and (6) reveal a composite influence exerted by the regional concentration of R&D-oriented family firms on innovation propensity. First, *local knowledge spillovers* – arising from the presence of geographically and technologically proximate family firms – affect positively firm's innovation propensity. Indeed, the coefficients are large and highly significant ($p$<0.001) for both product and process innovation. Conversely, the existence of *regional knowledge spillovers* influence negatively only product innovation (β=-0.086, $p$<0.001) while does not exist any significant association between the mere geographical concentration of R&D-oriented family firms and process innovation. Finally, *industrial knowledge spillovers* related to technological proximity have a positive impact (β= 0.113, $p$<0.001) on product innovation only. As shown in Model (6), there is no any statistical evidence of the influence exerted by extra-regional flow of knowledge - due to technologically proximate family firms - on the probability of firms to engage in process innovations. Our findings confirm the intra-industry nature of knowledge spillovers (Marshall-Arrow- Romer externalities) with this flow of knowledge that is larger in industries using the same technology as opposed to the exchange of complementary knowledge across different firms (Jacobs externalities). Therefore, Hypothesis 2 is only partially supported.

Regarding firm specific characteristics, our results show how *Absorptive capacity* affect positively the process innovation with the exception of product innovation. By contrast, *Age* has a negative influence on the probability to engage in process innovations. This results suggests that when firms become more mature, organizational rigidity overcome the benefits of asset specialization therefore, representing an impediment for innovation (Kotlar et al., 2013; Triguero & Fernández, 2018). The size of firm enhances the probability of product and process innovation. This result is in accordance with previous evidence showing a positive association between the dimension of the firm and its ability to innovate (Cantner et al., 2010; Cassiman & Veugelers, 2006). Neither export orientation nor the level of indebtedness are found affecting firm's innovation propensity. Conversely, regional R&D subsidies impact positively only on the process innovation capability of the firm, while having an opposite effect on product innovation. This finding suggests as governmental subsidies are mainly directed toward stimulating the technological capabilities of the firms.

--- INSERT TABLE 4 AROUND HERE ---

### *4.3. Robustness checks*

We carried out several robustness checks in order to validate our results. First, we adopted a continuous measure of family involvement in managerial position rather than the dummy variable employed in the main analysis (*Family-managed firm*). Second, because of the persistency in the innovative behaviour of the firm, we assessed whether both the sign and magnitude of two-way interaction and kwowledge spillovers coefficients are sensitive to the previous product/process innovation. Finally, we estimated the parameters of equation (1) by means of non-linear model (i.e. Probit) as alternative model specification. Overall, the results were similar to those obtained in the main analysis hence, confirming the reliability of our results.

## 5. CONCLUSION

### *5.1. Discussion*

This paper examines the influence of external source of knowledge on the innovation propensity on a sample of Spanish manufacturing firms during the period 2003-2015. Innovation can hardly be regarded as outcome of a process occurring in isolation being instead an interactive activity whereby the in-house knowledge produced by means of R&D activities tend to be complemented with an external one as arising from formal R&D cooperation and that freely transferred among geographically and socially proximate actors. While collaborative innovation can be an effective means of overcoming the innovation barriers – mainly financial constraints associated with the limited size – the regional co-location enables firms to exchange ideas and acquire new and sticky knowledge. Having said that, the ability of firms to exploit both the knowledge embedded in inter-firm cooperation and that available through informal interaction with physically proximate firms is strongly dependent upon their social capital meant as kind of individual (of the firm) relationships based on reciprocity, trust and exchange. Firms are not endowed with the same social capital being able to differ according to their family status resulting from the involvement of family members in managerial position.

Our results reveal that R&D cooperation is more conducive of both product and process innovation for family-managed firms than non-family counterparts thus, providing support for our first hypothesis. Despite the less willingness to engage in technological collaboration (Nieto et al., 2015) or sharing confidential information to potential partners (Classen et al., 2012), once decided to participate actively in joint R&D projects with other organizations, family firms are found to extract more value from the R&D cooperation as reflected in higher probability to innovate. Indeed, due to their long-term orientation family firms are continuously committed to invest in long-lasting and trust-based relationships with external parties. In particular, the "patient capital" put family firms in a better position to devote the proper time to cultivating knowledge transfer and problem-solving sharing processes with collaborating partners while limiting opportunistic behaviours.

In the pursuit of innovation, firms are affected also by the spatial context in which are located whereby a free of charge and mostly tacit knowledge is either spontaneously or intentionally exchanged. Our findings reveal the role of R&D oriented family firms – locally embedded economic actors with valuable social capital – in altering the mechanisms of knowledge and information transmission at the foundation of geographical knowledge spillovers. In particular, it is being shown as the regional amount of R&D expenditures from geographically and technologically proximate family-managed firms – proxy of local knowledge spillovers – is positively associated with the firm's probability to engage in product and process innovation. Whilst the region serves as platform in which knowledge relevant for innovation related-activities flows, R&D-oriented family firms play a pivotal role in the diffusion of such knowledge thus, contributing to the creation of regional environment particularly conducive to the learning and innovation. The strong social capital derived from strong ties that lie in family relations, tend to be replicated outside the organizational boundaries hence, permeating the way the firm itself and its surroundings interact and that, ultimately serves as conduit for the dissemination of information and knowledge. Because of the socialized nature of the knowledge production function and its mechanisms (e.g. social interaction) beneath its diffusion, the physical proximity needs to be complemented with the relational or social proximity that is the extent with which the economic activity is embedded in a dense, stable, and durable set of social relations. In this perspective, the strong social, connections with the region in which are located, put family-managed firms in the position to not only leverage tacit localized knowledge but contributing to its dissemination to the benefit of both product and process innovation of all firms.

*5.2. Contribution and policy implications*

Our study has several theoretical implications. First, for family business research, our work addresses the call of Feranita et al. (2017) for further research on how family firms engage in an “open” approach to collaborations in order to innovate. In doing so, we embraced the relational view on collaborative innovation – as opposed to the strategic and transactional ones – according to which family firms are able to capitalize on their unique characteristics such like social capital and long-term orientation to build successful collaborative innovation. Second, for regional studies, our study shed new light on the role of local knowledge spillovers and the spatial dimension of innovation activity whereby external knowledge flows, induced by spatial and technological proximity, emerge as crucial mechanisms for learning and innovation alongside cooperation and in-house R&D. However, differently from traditional approach of knowledge spillovers and geography of innovation approach in which enterprises arises as undistinguished entities, our study brings to the forefront the family status of the firms as peculiar regional actors that are in a privileged position to alter the underlying mechanisms through which knowledge spreads over a local area. In this perspective, we attempted contribute to the recent efforts aiming at connect regional and family business research (e.g. Basco, 2015; Baù et al., 2018; Stough et al., 2015). To conclude, this study has a number of policy implications. In this perspective, regional governments should promote the establishment of solid collaborative linkages in an attempt to induce higher level of innovation. Additionally, regional policies should geared towards the promotion of intra-regional R&D and innovative networks to benefit from the face-to-face communications among competing and non-competing firms having, at the same time, a priority on the strengthening of territorial infrastructures that also enhance knowledge flows. That is because besides efforts internal to the firms – mainly in the form of human and financial resources devoted to innovative related-activities, innovation depends also on "structural, institutional and relational factors that are localized and specific to geographical contexts" (Cantner et al., 2010, p. 1939). In doing so, policy maker cannot neglect the role of family-managed firms as distinctive regional actors shaping uniquely the advantages of inter-firm relationships and the promotion of knowledge spillovers within a region.

*5.3. Limitations and future research lines*

The present study has also several limitations that indicate important directions for future research. First, firm's innovation performance is proxied solely by product and process innovation so, offering a partial view of the types of innovation achieved. Hence, future studies should may adopt a multi-dimensional perspective of innovation by considering the organizational innovation (Cantner et al., 2010) together with a distinction among incremental and radical innovations (Laursen & Salter, 2006; Propris, 2002). Second, our study focuses exclusively on the component of "breadth" as component of openness of individual firm's external search strategy while omitting the external search "depth", that is the extent to which firms draw intensively from different search channels or sources (Laursen & Salter, 2006). Therefore, future studies should integrate this component reflecting the importance – for both family and non-family firms – of deep use of key sources for the internal innovation processes. Third, due to data limitations we did not measure the mechanisms through which knowledge spillovers occurs, namely: labour market mobility, firm spin-off and informal interactions among local actors (Kesidou & Romijn, 2008). Despite the unquestionable attempts to open the "black box" of geographical knowledge spillovers, the type of mechanism on which family-managed firms rely mostly on remains unexplored and unknown. Fourth, our study assumes as spatial unit of observation the region within with the innovation activity take place, where the direct knowledge-generating inputs are the greatest and where knowledge spillovers are the most prevalent (Audretsch & Feldman, 2004). Therefore, future studies should seize the opportunity to investigate the relationships among family firms, knowledge spillovers and innovation activity in specialized local production systems such as industrial districts (Cucculelli & Storai, 2015) and clusters (Malmberg & Maskell, 2006). In fact, it is in these location that knowledge linkages extend beyond market transactions and "are facilitated by conventions, social rules and common language and culture" (Kesidou & Romijn, 2008, p. 2004) and, consequently, the relational capital is deemed to play a crucial role (Capello & Faggian, 2005). In summary, we believe that our study provides important insights and has the potential to stimulate further work on the interesting but underexplored topic of innovation performance, R&D cooperation, knowledge spillovers and geography of innovation in family versus non-family firms.

Table 1. Description of variables

| Variables | Descriptions |
|---|---|
| **Dependent variable** | |
| *Product innovation* | Dummy variable coded "1" if the firm has achieved product innovations during the fiscal year; "0" otherwise |
| *Process innovation* | Dummy variable coded "1" if the firm has achieved process innovations during the fiscal year; "0" otherwise |
| **Explanatory variables** | |
| *Breadth* | Variable ranging from 1 to 5 depending on the number of external sources or search channels: competitors, customers, suppliers, universities and technological centres and joint-ventures |
| *Family-managed firm* | Dummy variable coded "1" if two or more family members are involved in the management of the firm; "0" otherwise |
| *Local knowledge spillovers* | Share of family firms R&D expenditures by sector *j* in region *m* with respect to the total R&D expenditures of region *m*. |
| *Regional knowledge spillovers* | Share of family firms R&D expenditures in different sector *j* (≠ *j*) in region *m* with respect to the total R&D expenditures of region *m*. |
| *Industrial export spillovers* | Share of family firms R&D expenditures in the same sector *j* but outside of the region *m* (≠ *m*) corresponding to the firm. |
| **Firm-level control variables** | |

| | |
|---|---|
| *Previous product innovation* | Dummy variable which is "1" if the firm has achieved product innovation in *t-1*, "0" otherwise |
| *Previous process innovation* | Dummy variable which is "1" if the firm has achieved process innovation in *t-1*, "0" otherwise |
| *Absorptive capacity* | Ratio of firm's R&D expenditures to sales |
| *Size*[L] | Number of employees |
| *Age* | Number of years a firm exists since its incorporation |
| *Export intensity* | Percentage of export sales on total sales |
| *Leverage* | Book value of debt divided by total assets |
| *Public R&D funding* | Total amount of regional subsidies for R&D |
| **Other controls** | |
| *Time-invariant industry effect* | Dummies for each two-digit industry |
| *Time-invariant regional effect* | Dummies for each region in which firms are located |
| *Time effect* | Year dummies |

Expressed in natural logarithm[L].

Table 2. Descriptive statistics

| Variable | Obs. | Mean | Median | St. Dev. | Min | Max |
|---|---|---|---|---|---|---|
| *Product innovation* | *19,107* | 0.168 | 0 | 0.374 | 0 | 1 |
| *Process innovation* | *19,107* | 0.326 | 0 | 0.469 | 0 | 1 |
| *Breadth* | *19,107* | 0.636 | 0 | 1.103 | 0 | 5 |
| *Family-managed firm* | *19,107* | 0.251 | 0 | 0.433 | 0 | 1 |
| *Absorptive capacity* | *19,107* | 0.008 | 0 | 0.025 | 0 | 0.989 |
| *Size*$^{L}$ | *19,107* | 4.099 | 3.850 | 1.436 | 0 | 9.574 |
| *Age* | *19,107* | 28.483 | 24 | 20.094 | 0 | 174 |
| *Export intensity* | *19,089* | 21.327 | 6.2 | 28.076 | 0 | 100 |
| *Leverage* | *19,107* | 0.542 | 0.554 | 0.235 | 0 | 100 |
| *Public R&D funding* | *19,107* | 19.443 | 0 | 425.639 | 0 | 36581 |
| *Local knowledge spillovers* | *19,107* | 0.145 | 0.005 | 0.264 | 0 | 1 |
| *Regional knowledge spillovers* | *19,107* | 0.059 | 0.026 | 0.102 | 0 | 1 |
| *Industrial export spillovers* | *19,107* | 0.123 | 0.059 | 0.165 | 0 | 1 |

Expressed in natural logarithm$^{L}$.

Table 3. Pearson correlation coefficients

| | VIF | *Product innovation* | *Process innovation* | *Breadth* | *Family-managed firm* | *Absorptive capacity* | *Size* | *Age* | *Export intensity* | *Leverage* | *Public R&D fund.* | *Loc. Know. Spill.* | *Reg. Know. Spill.* | *Ind. Know. Spill.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Product innovation* | - | 1 | | | | | | | | | | | | |
| *Process innovation* | - | 0.382 | 1 | | | | | | | | | | | |
| *Breadth* | 1.59 | 0.104 | 0.078 | 1 | | | | | | | | | | |
| *Family-managed firm* | 1.07 | -0.007 | -0.007 | -0.082 | 1 | | | | | | | | | |
| *Absorptive capacity* | 1.27 | 0.077 | 0.060 | 0.386 | -0.029 | 1 | | | | | | | | |
| *Size* | 1.25 | 0.079 | 0.085 | 0.491 | -0.153 | 0.176 | 1 | | | | | | | |
| *Age* | 1.82 | 0.038 | 0.021 | 0.198 | -0.020 | 0.082 | 0.299 | 1 | | | | | | |
| *Export intensity* | 1.45 | 0.066 | 0.057 | 0.340 | -0.091 | 0.168 | 0.401 | 0.174 | 1 | | | | | |
| *Leverage* | 1.07 | -0.005 | -0.002 | -0.004 | -0.001 | 0.002 | 0.019 | -0.149 | -0.033 | 1 | | | | |
| *Public R&D fund.* | 1.03 | -0.002 | 0.029 | 0.088 | -0.018 | 0.082 | 0.109 | 0.054 | 0.063 | 0.016 | 1 | | | |
| *Loc. Know. Spill.* | 1.25 | 0.114 | 0.056 | -0.001 | 0.138 | -0.003 | -0.029 | 0.022 | 0.008 | -0.024 | -0.015 | 1 | | |
| *Reg. Know. Spill.* | 1.80 | 0.014 | -0.025 | -0.075 | 0.095 | -0.062 | -0.052 | 0.016 | -0.074 | -0.009 | -0.022 | 0.125 | 1 | |
| *Ind. Know. Spill.* | 1.54 | -0.016 | -0.001 | -0.034 | 0.056 | -0.033 | -0.034 | 0.020 | 0.013 | -0.046 | 0.022 | 0.107 | 0.062 | 1 |

*Note:* Number of observations: *19,089*. Mean VIF=2.13. Value greater than |0.015| are significant at $p < 0.05$.

Table 4. Breadth, family managed-firms and innovation propensity

| | Model (1) | Model (2) | Model (3) | Model (4) | Model (5) | Model (6) |
|---|---|---|---|---|---|---|
| *Previous product innovation* | 0.090*** | 0.088*** | 0.083*** | | | |
| | (0.010) | (0.010) | (0.010) | | | |
| *Previous process innovation* | | | | 0.118*** | 0.118*** | 0.117*** |
| | | | | (0.008) | (0.008) | (0.008) |
| *Absorptive capacity* | 0.182 | 0.174 | 0.161 | 0.472** | 0.465** | 0.449** |
| | (0.144) | (0.144) | (0.142) | (0.170) | (0.170) | (0.171) |
| *Age* | -0.000 | -0.000 | -0.000 | -0.001** | -0.001** | -0.001** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| *Size* | 0.005* | 0.005** | 0.004* | 0.007** | 0.007*** | 0.007** |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| *Export intensity* | -0.000 | -0.000 | -0.000 | 0.000 | 0.000 | 0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| *Leverage* | -0.006 | -0.005 | -0.002 | 0.000 | 0.001 | 0.002 |
| | (0.012) | (0.012) | (0.012) | (0.014) | (0.014) | (0.014) |
| *Public R&D funding* | -0.000** | -0.000* | -0.000* | 0.000*** | 0.000*** | 0.000*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| *Breadth* | 0.010** | 0.004 | 0.005 | 0.007+ | 0.002 | 0.003 |
| | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) |
| *Family-managed firm* | 0.003 | -0.010 | -0.015* | 0.008 | -0.003 | -0.005 |
| | (0.006) | (0.007) | (0.007) | (0.008) | (0.008) | (0.008) |
| *Breadth*Family-managed firm* | | 0.027*** | 0.017* | | 0.022** | 0.015+ |
| | | (0.008) | (0.008) | | (0.008) | (0.008) |
| *Local knowledge spillovers* | | | 0.134*** | | | 0.100*** |
| | | | (0.012) | | | (0.014) |
| *Regional knowledge spillovers* | | | -0.086*** | | | -0.041 |
| | | | (0.024) | | | (0.035) |
| *Industrial knowledge spillovers* | | | 0.113*** | | | -0.024 |
| | | | (0.022) | | | (0.024) |

| | | | | | | |
|---|---|---|---|---|---|---|
| Industry | Yes | Yes | Yes | Yes | Yes | Yes |
| Region | Yes | Yes | Yes | Yes | Yes | Yes |
| Year | Yes | Yes | Yes | Yes | Yes | Yes |
| | | | | | | |
| Constant | 0.105** | 0.101** | 0.015 | 0.271*** | 0.267*** | 0.252*** |
| | (0.037) | (0.037) | (0.037) | (0.043) | (0.043) | (0.044) |
| WaldChi2 | 2572.78 | 2554.55 | 2803.03 | 2664.12 | 2655.32 | 2874.44 |
| Prob>Chi2 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Number of firms | 2,954 | 2,954 | 2,954 | 2,954 | 2,954 | 2,954 |
| Observations | *18,740* | *18,740* | *18,740* | *18,740* | *18,740* | *18,740* |

*Note*: The table presents linear probability model estimations based on a panel dataset with at least 10 employees over the period 2003-2015. Robust clustered standard errors are reported in parentheses. Level of significance + $p < 0.10$, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Table 5. Robustness check: Breadth, family management and innovation propensity

| | Model (1) | Model (2) | Model (3) | Model (4) | Model (5) | Model (6) |
|---|---|---|---|---|---|---|
| *Previous product innovation* | 0.090*** | 0.088*** | 0.083*** | | | |
| | (0.010) | (0.010) | (0.010) | | | |
| *Previous process innovation* | | | | 0.118*** | 0.117*** | 0.116*** |
| | | | | (0.008) | (0.008) | (0.008) |
| *Absorptive capacity* | 0.181 | 0.158 | 0.148 | 0.470** | 0.451** | 0.437** |
| | (0.144) | (0.142) | (0.141) | (0.170) | (0.169) | (0.170) |
| *Age* | -0.000 | -0.000 | -0.000 | -0.001** | -0.001** | -0.001** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| *Size* | 0.005* | 0.005** | 0.004* | 0.007** | 0.008*** | 0.007** |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| *Export intensity* | -0.000 | -0.000 | -0.000 | 0.000 | 0.000 | 0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| *Leverage* | -0.006 | -0.005 | -0.002 | 0.000 | 0.001 | 0.002 |
| | (0.012) | (0.012) | (0.012) | (0.014) | (0.014) | (0.014) |
| *Public R&D funding* | -0.000** | -0.000* | -0.000* | 0.000*** | 0.000*** | 0.000*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| *Breadth* | 0.010** | 0.001 | 0.001 | 0.007+ | -0.001 | -0.000 |
| | (0.004) | (0.003) | (0.003) | (0.004) | (0.004) | (0.004) |
| *Family management* | 0.002 | -0.006* | -0.008** | 0.004 | -0.003 | -0.004 |
| | (0.003) | (0.003) | (0.003) | (0.003) | (0.004) | (0.004) |
| *Breadth*Family management* | | 0.015*** | 0.011*** | | 0.012*** | 0.010** |
| | | (0.003) | (0.003) | | (0.003) | (0.003) |
| *Local knowledge spillovers* | | | 0.132*** | | | 0.098*** |
| | | | (0.012) | | | (0.014) |
| *Regional knowledge spillovers* | | | -0.087*** | | | -0.040 |
| | | | (0.024) | | | (0.035) |
| *Industrial knowledge spillovers* | | | 0.113*** | | | -0.024 |
| | | | (0.022) | | | (0.024) |

| | | | | | | |
|---|---|---|---|---|---|---|
| Industry | Yes | Yes | Yes | Yes | Yes | Yes |
| Region | Yes | Yes | Yes | Yes | Yes | Yes |
| Year | Yes | Yes | Yes | Yes | Yes | Yes |
| | | | | | | |
| Constant | 0.102** | 0.103** | 0.019 | 0.265*** | 0.266*** | 0.253*** |
| | (0.038) | (0.037) | (0.038) | (0.043) | (0.043) | (0.045) |
| WaldChi2 | 2574.62 | 2557.61 | 2798.33 | 2667.60 | 2664.83 | 2874.91 |
| Prob>Chi2 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Number of firms | 2,954 | 2,954 | 2,954 | 2,954 | 2,954 | 2,954 |
| Observations | *18,740* | *18,740* | *18,740* | *18,740* | *18,740* | *18,740* |

*Note*: The table presents linear probability model estimations based on a panel dataset with at least 10 employees over the period 2003-2015. *Family management* is a continuous variable indicating the number of family members occupying managerial positions. Robust clustered standard errors are reported in parentheses. Level of significance + $p < 0.10$, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Table 6. Robustness check: sensitivity to previous innovation activity

| | Model (1) | Model (2) | Model (3) | Model (4) | Model (5) | Model (6) |
|---|---|---|---|---|---|---|
| *Previous product innovation* | - | - | - | | | |
| *Previous process innovation* | | | | - | - | - |
| *Absorptive capacity* | 0.237 | 0.234 | 0.221 | 0.524** | 0.521** | 0.508** |
| | (0.154) | (0.154) | (0.153) | (0.189) | (0.188) | (0.189) |
| *Age* | 0.000 | 0.000 | 0.000 | -0.001** | -0.001** | -0.001** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| *Size* | 0.007* | 0.008** | 0.007* | 0.012*** | 0.012*** | 0.012*** |
| | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) |
| *Export intensity* | -0.000 | -0.000 | -0.000 | 0.000 | 0.000 | 0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| *Leverage* | -0.002 | -0.001 | 0.001 | 0.003 | 0.004 | 0.004 |
| | (0.013) | (0.013) | (0.013) | (0.016) | (0.016) | (0.016) |
| *Public R&D funding* | -0.000** | -0.000* | -0.000* | 0.000*** | 0.000*** | 0.000*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| *Breadth* | 0.009* | 0.003 | 0.004 | 0.007 | 0.002 | 0.003 |
| | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) |
| *Family-managed firm* | 0.001 | -0.012+ | -0.017* | 0.009 | -0.003 | -0.005 |
| | (0.007) | (0.007) | (0.007) | (0.008) | (0.009) | (0.009) |
| *Breadth*Family-managed firm* | | 0.026** | 0.016+ | | 0.024** | 0.017+ |
| | | (0.008) | (0.008) | | (0.009) | (0.009) |
| *Local knowledge spillovers* | | | 0.144*** | | | 0.098*** |
| | | | (0.012) | | | (0.015) |
| *Regional knowledge spillovers* | | | -0.070** | | | -0.006 |
| | | | (0.026) | | | (0.035) |
| *Industrial knowledge spillovers* | | | 0.101*** | | | -0.036 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | (0.022) | | | (0.025) |
| Industry | Yes | Yes | Yes | Yes | Yes | Yes |
| Region | Yes | Yes | Yes | Yes | Yes | Yes |
| Year | Yes | Yes | Yes | Yes | Yes | Yes |
| Constant | 0.160*** | 0.160*** | 0.069* | 0.370*** | 0.370*** | 0.358*** |
| | (0.028) | (0.028) | (0.029) | (0.033) | (0.033) | (0.036) |
| WaldChi2 | 1838.00 | 1839.51 | 2086.61 | 1894.36 | 1895.85 | 2072.20 |
| Prob>Chi2 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Number of firms | 2,999 | 2,999 | 2,999 | 2,999 | 2,999 | 2,999 |
| Observations | *19,089* | *19,089* | *19,089* | *19,089* | *19,089* | *19,089* |

*Note*: The table presents linear probability model estimations based on a panel dataset with at least 10 employees over the period 2003-2015. Robust clustered standard errors are reported in parentheses. Level of significance + $p < 0.10$, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Table 7. Robustness check: panel probit estimations

| | Model (1) | Model (2) | Model (3) | Model (4) | Model (5) | Model (6) |
|---|---|---|---|---|---|---|
| *Previous product innovation* | 0.042*** | 0.042*** | 0.039*** | | | |
| | (0.008) | (0.008) | (0.008) | | | |
| *Previous process innovation* | | | | 0.110*** | 0.110*** | 0.109*** |
| | | | | (0.008) | (0.008) | (0.008) |
| *Absorptive capacity* | 0.170 | 0.165 | 0.153 | 0.440** | 0.435** | 0.420** |
| | (0.107) | (0.108) | (0.106) | (0.153) | (0.154) | (0.154) |
| *Age* | 0.000 | 0.000 | 0.000 | -0.001** | -0.001** | -0.001** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| *Size* | 0.005* | 0.005** | 0.005* | 0.007** | 0.007*** | 0.007** |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| *Export intensity* | -0.000 | -0.000 | -0.000 | 0.000 | 0.000 | 0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| *Leverage* | 0.001 | 0.001 | 0.003 | -0.001 | -0.000 | 0.001 |
| | (0.012) | (0.012) | (0.012) | (0.015) | (0.015) | (0.014) |
| *Public R&D funding* | -0.000 | -0.000 | -0.000 | 0.000* | 0.000* | 0.000* |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| *Breadth* | 0.008** | 0.003 | 0.005 | 0.006 | 0.002 | 0.003 |
| | (0.003) | (0.003) | (0.003) | (0.004) | (0.004) | (0.004) |
| *Family-managed firm* | 0.002 | -0.010 | -0.015* | 0.008 | -0.003 | -0.005 |
| | (0.007) | (0.007) | (0.007) | (0.008) | (0.009) | (0.009) |
| *Breadth*Family-managed firm* | | 0.020*** | 0.011+ | | 0.021** | 0.014+ |
| | | (0.006) | (0.006) | | (0.008) | (0.008) |
| *Local knowledge spillovers* | | | 0.135*** | | | 0.101*** |
| | | | (0.010) | | | (0.013) |
| *Regional knowledge spillovers* | | | -0.120** | | | -0.037 |
| | | | (0.039) | | | (0.042) |
| *Industrial knowledge spillovers* | | | 0.110*** | | | -0.028 |
| | | | (0.022) | | | (0.024) |

| | | | | | | |
|---|---|---|---|---|---|---|
| Industry | Yes | Yes | Yes | Yes | Yes | Yes |
| Region | Yes | Yes | Yes | Yes | Yes | Yes |
| Year | Yes | Yes | Yes | Yes | Yes | Yes |
| WaldChi2 | 1285.55 | 1299.16 | 1421.76 | | | |
| Prob>Chi2 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Number of firms | 2,954 | 2,954 | 2,954 | 2,954 | 2,954 | 2,954 |
| Observations | *18,740* | *18,740* | *18,740* | *18,740* | *18,740* | *18,740* |

*Note*: The table presents probit model estimations based on a panel dataset with at least 10 employees over the period 2003-2015. Robust clustered standard errors are reported in parentheses. Level of significance + $p < 0.10$, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

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