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Does open customer innovation model hold for family firms?☆

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ABSTRACT

This study examines the propensity of family firms to employ the open customer innovation model as well as the benefits from collaboration with customers between family and non-family firms. It applies the geographical and firm size perspective as two boundary conditions for innovation in family firms and discusses the mechanism enabling family firms to achieve greater returns to open customer innovation model in domestic market. In doing so we provide a much-needed comparison on "how" family firms innovate, using longitudinal data of 21,140 observations with 17,859 most innovative UK firms during 2002–2014. We find that both family and non-family firms engage with customer in open innovation, however family firms benefit more from collaboration with customers in domestic markets, with firm size moderating this relationship. Implications for owner-managers and policymakers may help create region-specific open innovation policies with greater customer involvement in innovation process.

1. Introduction

Since Schumpeter (1934), policymakers and managers have used a "producers' model" of innovation. This model assumes that the most important innovations would originate from producers and be supplied to customers (users of innovation) (Von Hippel, 2010). This view has dominated the innovation landscape, with innovators who serve many customers investing more in innovation than any single user (Christofi, Vrontis, & Thrassou, 2018; Vrontis & Christofi, 2019). The producers' model has evolved with an increased emphasis on a unique position of users who benefit directly from innovations and increase market competition (Baldwin & von Hippel, 2010). The open user innovation model has been developed (Von Hippel, 2001) assuming that innovations are developed for users and users who may share the costs of innovation, reduce innovation development time and uncertainty in adoption of innovation.

Increasing scholarly attention has been devoted to different partners and types pf knowledge collaboration that enables firms to tackle their resource constraints and co-create value together with partners (Belyaeva et al., 2020; Leonidou, Christofi, Vrontis, & Thrassou, 2020). Yet, of equal importance and interest are the boundary conditions that enable or impede knowledge collaboration with users of innovation (Santoro, Messeni-Petruzzelli, & Del Giudice, 2021; Audretsch, Belitski, & Caiazza, 2021). To this end, scholars and practitioners have begun to focus on the open innovation strategies (Bogers et al. 2017), while the geographical and organizational dimensions of this research has remained underdeveloped (Audretsch & Belitski, 2020a; Un, Cuervo-Cazurra, & Asakawa, 2010). As a type of open innovation models, open customer innovation model is characterized by collaboration and co-location with customers, and therefore, insights from open innovation research may apply to co-creating new products and services with customers yet require further theorizing and validation.

To date, few studies have considered open customer innovation model beyond creating an economic and social value of such collaboration (De Massis, Frattini, Pizzurno, & Cassia, 2015; De Massis, Kotlar, Wright, & Kellermanns, 2018) and for different organizational governance in knowledge-intensive firms (Vrontis et al. 2016; Vrontis & Christofi, 2019).

And while we know that open innovation strategies play a focal role in shaping the business models of family firms (Casprini, De Massis, Di Minin, Frattini, & Piccaluga, 2017), the prior research did not answer what type of partner is most important for family firms and to what extent open innovation model across different partners facilitates innovation outcomes. It has also remained on the knowledge frontier

☆ The use of these data does not imply the endorsement of the data owner or the UK Data Service at the UK Data Archive in relation to the interpretation or analysis of the data. This work uses research datasets which may not exactly reproduce National Statistics aggregates.

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whether open customer innovation model provides additional returns to collaboration in family firms compared to non-family firms and how this relationship may change innovation diffusion within different geographical contexts (Baptista, 2001).

Additionally, few studies have combined internal (individual and organizational) and external (geographical) aspects of knowledge creation in family firms – such as knowledge availability and abundance of knowledge *spillovers* to understand organizational growth propensity (Natalicchio, Ardito, Petruzzelli & Del Giudice, 2019) or managing internal and external knowledge flows and family firms' ability to innovate through traditions, with the key factors such as networks, knowledge flow, track record of innovation, and employees' entrepreneurial attitude affecting innovation strategies in family firms (Del Vecchio, Secundo, Rubino, Garzoni, Vrontis, 2020).

Family business and open innovation literature therefore have remained inconclusive towards the size and the depth of knowledge collaboration with customers between family firms and non-family firms (Broekaert, Andries, & Debackere, 2016; Cooper, Upton, & Seaman, 2005; Lazzarotti et al, 2017; Vrontis, Andreano, Mazzitelli, & Papasolomou, 2020).

More research is needed on the role of firm governance (Pahnke & Welter, 2019), firm size (Daily & Dollinger, 1993) and geographical proximity to customers (Baptista, 2000) have remained attractive but understudied stream of research (Baptista, Lima, & Mendonça, 2011; Balland et al. 2015).

By integrating insights from different research streams, namely, marketing and consumer research, open innovation, and family business literature, the purpose of this study is i) to examine the differences between family and non-family firms in their propensity to engage in open customer innovation models (Markovic & Bagherzadeh, 2018; Pantano, Priporas, Viassone, & Migliano, 2019); ii) discuss the open customer innovation model and the benefits it returns to customer collaboration for family firms across different geographical proximities as the first boundary condition for innovation (Del Vecchio et al., 2020; De Massis, Eddleston, & Rovelli, 2020; Gamble, Clinton, & Díaz-Moriana, 2020); iii) investigate the role of firm size as the second boundary condition for innovation that enables greater innovation benefits for family firms compared to non-family firms (Sciascia et al. 2014).

This study makes two important contributions to open innovation and marketing and consumer research fields. Firstly, we evaluate the propensity of family firms to employ the open customer innovation model (Von Hippel, 2001). Secondly, we theoretically debate and empirically examine the benefits from the open customer innovation model for family vs. non-family firms, addressing the recent call for such research in the family business and consumer literature (Casprini et al. 2017; Covin, Eggers, Kraus, Cheng, & Chang, 2016; Calabrò et al., 2019).

Our results demonstrate that family firms are not less or more likely to apply the open customer innovation model than non-family firms; however, if family firms adopt the open customer innovation model in local and national markets, they achieve greater benefits from customer collaboration than non-family firms. In addition we show that family ownership is an important factor that explains i) the likelihood of collaboration with customers and ii) benefits from open customer innovation model; iii) differences in returns to open customer innovation model across different geographical proximities (Basco & Suwala, 2020).

The next section discusses the theoretical background, while section 3 introduces the data and sampling, while Section 4 presents the methodology. Section 5 reports the main results of the study, while section 6 discusses and concludes.

2. Theoretical framework

2.1. Open customer innovation models and family firms

What we know from the extant literature is that family firms generally have lower financial and human capital levels with their innovation activity is likely to be dependent on external partners (Baptista, 2001; Baptista et al. 2011; Beers & Zand, 2014; De Massis et al., 2015; Roper, Love, & Bonner, 2017). We also know that family members aim to keep closer control of their business (De Massis, Frattini, & Lichtenthaler, 2013; Gómez-Mejía et al., 2007), limiting the propensity of family firms to collaborate with external partners.

Like any organization, a family firm faces a choice between creating innovation internally or collaborating on innovation externally (Audretsch & Belitski, 2020a; 2020b). In fact, considering external collaboration, existing evidence indicates that family firms are, to some extent, not predisposed towards collaborative relationships due to their strong concerns about the potential loss of control (De Massis et al., 2013; Gómez-Mejía et al., 2007). For example, external collaboration may threaten the socio-emotional wealth (SEW) of family firms (Kotlar, Fang, De Massis and Frattini, 2014) and the desire to protect family wealth leads family business owners to become conservative in taking risks. These factors determine a lower propensity for collaboration in family firms.

While family and non-family firms may experience a lack of financial resources, financial constraints are more pronounced in family firms as the supply of equity and debt financing is limited due to a fear of diluting capital and losing control. Family firms are over-selective when applying open innovation model (Del Vecchio et al., 2020) and would prefer collaboration with customers, universities, and government – the external partner who provides non-equity capital and other forms of resources. Family firms will collaborate with customers to leverage resource constraints.

Personal relationships with customers are considered one of the top success factors of family firms. Particularly, several studies highlighted customer focus as a key antecedent of innovation (Newman et al., 2016). This implies a central role for the customer in the firm's thinking about strategy and operations. Previous evidence suggests that family businesses that can create and maintain superior customer relationships enjoy competitive advantages associated with customer loyalty, perceptions of trustworthiness, and goodwill. In this context, Newman et al. (2016) report that the relationship between customer relationship and exploratory innovation is stronger in family firms than non-family firms.

The stewardship perspective is also helpful in explaining why family businesses opt for collaborating with customers as they aim to strengthen human and social capital within the family and community (Miller, Miller et al., 2008; Santoro et al., 2021).

As pointed by Baù, Chirico, Pittino, Backman and Klaesson (2019), high local embeddedness of family firms contributes to an unusual incentive to achieve not only superior financial returns but also to fulfil their non-economic goals and contribute to the community (e.g. build a strong reputation, develop a greater sense of responsibility towards local stakeholders, etc.).

Family firms are driven by and concern for the success of the collective organization and the community, rather than being centered on individualistic gains of individual external investors and stakeholders. Family firms' orientation towards building the open collaboration model with customers gives them necessary freedom of choice and implementation of the community-oriented strategy (De Massis et al., 2015). It is seen as a source of tacit knowledge about market needs and develops innovation.

A higher social responsibility towards customers is their inclusion in the development, design, and management of their products and services by producing goods and services that enhance their consumers' health and quality of life.

We define open customer innovation as a form of knowledge

collaboration that involves exchanging resources and tacit knowledge between customer and producer to develop new products and services that do not exist in the market (Grant & Baden-fuller, 1995; Markovic & Bagherzadeh, 2018). It originates in the works of Von Hippel (2001), Eggers, Kraus, & Covin, (2014), Newman et al. (2016), Vrontis et al., 2020 and is rooted in systematic knowledge exploration with customers and throughout the ideation process. It involves the processes by which firms and customers engage in mutual innovation (Feranita, Kotlar, & De Massis, 2017).

Family firms are more likely to accept higher levels of R&D activities, particularly when facing an increasing buyers power which will push family firms to a higher level of R&D collaboration with customers (Kotlar et al. 2014). Employing an open customer innovation model is what actually constitutes a bona fide of the family firm, combined with the intractability of some characteristics, such as the extent to which the family firm is embedded in the local community (De Massis et al. 2018).

Establishing open customer innovation model reduces costs and risks for the family firm as well as shortens the time taken to experiment and introduce new products to markets. Unlike non-family firms, family-owned firms employ the model to improve service quality.

While there is substantial empirical evidence that demonstrates the advantages of collaboration with external partners, and specifically with customers, family firms are more reserved in collaboration, and they are more likely to have strong concerns about the potential loss of control when practicing open customer innovation model, stepping outside their "comfort zone" (Schamberger, Cleven, & Brettel, 2013; Scott, Hughes, & Kraus, 2019; Brinkerink & Bammens, 2018).

The mechanism which enables the implementation of an open customer innovation model in family firms is building long-term relationships with customers. This customer model is an advantage over non-family firms regarding the extent of engagement and customer's trust and loyalty (Cooper et al., 2005). A genuine desire of family firms to provide outstanding customer service requires strong customer relationships. We hypothesize:

H1: Family firms have a higher propensity to engage in open customer innovation models than non-family firms.

2.2. Returns to open customer innovation models

Two theoretical arguments can explain the relationship between collaboration with customers and innovation performance in family firms. The first argument is rooted in RBV. Family firms that are constrained in terms of their financial and human resources (De Massis et al., 2018; Miller, Le Breton-Miller, & Scholnick, 2008) will rely on customers' knowledge and advice to experiment with new products and introduce them to market (Baum, Calabrese, & Silverman, 2000; Rindova, Yeow, Martins, & Faraj, 2012). Also, knowledge collaborations enhance confidence in the value of the products and services created by firms, attracting customers and other corporate partners (Stuart, 2000).

De Massis et al. (2018) argue that family firms focus on a specific niche. The niche focus enables them to dominate their narrow market concerning innovation. The niche focus strategy also helps them closely collaborate with their existing customers, which has been linked to innovation. For example, Mittelstand firms often maintain close relationships with their existing customers to provide ongoing innovative services and cutting-edge technologies (Heider et al., 2021).

The second theoretical argument which explains greater returns to the open customer innovation model is the socio-emotional wealth (SEW) of family firms. Indeed, family firms are recognized to have idiosyncratic specificities that make them behave differently with their stakeholders to protect their SEW (Gómez-Mejía et al., 2007; Sirmon & Hitt, 2003; Santoro et al., 2021). Accordingly, family firms are concerned with preserving respect for the family name and reputation through good customer relationships (Cooper et al., 2005) with no "family brand" name associated with non-family firms. The family firm collaboration model is built on "special" trustworthy relations with customers over generations.

The differences in returns to collaboration with customers is also in their tradition (Vrontis, Thrassou, Santoro & Papa, 2016; Messeni Petruzzelli & Savino, 2014). Traditions incorporate the knowledge that a company can obtain by leveraging on history. Traditions in family firms are enriched by the cultural codes and beliefs and behaviors transmitted across generations, representing family firm identity, which other firms will not have. The importance of traditions and crating of identity have their unique source of competitive advantage and innovation (Messeni Petruzzelli & Albino, 2012), which non-family firms will not have to win the customer loyalty and trust. Unlike non-family firms, family firms innovate through traditions and create links between the past, present, and future for customers through generations, making their products particularly appealing and tailored for every generation of customers (Messeni Petruzzelli & Albino, 2012).

Family firms will use their management processes, traditions, cultural beliefs, trust, and socio-emotional wealth – characteristics that distinct them from non-family firms to develop customer-based offers and create an economic value of their tradition with customers. We hypothesize:

H2: Open customer innovation model increases innovation in family firms to a greater extent than in non-family firms.

2.3. The geographical perspective of open customer collaboration models

The number of internal and external factors determine whether family firms will be able to benefit from open innovation and how their ability to benefit from open customer innovation varies with an increasing (decreasing)geographical proximity. Most relevant studies on the role of geographical proximity in innovation include Asheim (2012), Beers and Zand (2014), Christofi, Leonidou, Vrontis, Kitchen and Papasolomou (2015) and Christofi et al. (2018).

Internal factors have been discussed in entrepreneurship literature on family firms (Cruz, Justo, & De Castro, 2012; Fernández & Nieto, 2005; James, Hadjielias, Guerrero, Cruz, & Basco, 2020; Miller, Steier, & Le Breton–Miller, 2016), which argued that family firms seem to be less inclined to grow in international markets. There are several reasons for this. First, insufficient capital to fund both family needs and business growth require prioritization of resource allocation (prioritization factor). Collaboration may be more cost-effective within close geographical markets such as domestic market (cost factor). Second, the resistance to change compared to non-family firms (Hauswald, Hack, Kellermanns, & Patzelt, 2016) as well as long-term family goals, values, and needs (flexibility reason), and potential conflicts among family members and successors (family-related factor). Third, family firms may be poorly positioned to obtain substantial financial debt financing, and families may be unwilling to lose control over their firm by trading the equity (capital control factor). Banalieva and Eddleston's (2011) offer a nuanced view of agency and stewardship theories and demonstrate that family leaders are most beneficial when pursuing a regional strategy while non-family leaders are most beneficial when pursuing an internationalization strategy.

External factors that enhance local collaborations include the role of interactions and localized knowledge flows in innovation performance (Asheim & Coenen, 2005). Knowledge spillovers are more likely to become regionally shaped (Audretsch & Feldman, 1996; Vestal & Danneels, 2018); for example, in the case of specialized supply chains, specific technology, and knowledge bases. Innovation success in family firms often depends on the transfer of tacit knowledge, face-to-face interactions, and trust often referred to as social capital (Arrègle, Hitt, Sirmon, & Very, 2007). In this perspective, exchanges among family members and within localized networks of customers and advisors are an efficient and rapid way to transfer tacit knowledge, which is spatially bounded.

The factors which prevent family firms from collaborating internationally may also overlap with factors preventing non-family firms from engaging in open innovation. For example, within regional entrepreneurial ecosystems (Audretsch & Belitski, 2017; O'Connor, Stam, Sussan, & Audretsch, 2018), firms of micro and small size can maximize R&D productivity and achieve innovation outputs more efficiently than large firms, and those that collaborate internationally (Vrontis & Christofi, 2019).

Besides, there are issues with intellectual property protection, foreign market uncertainty, and an expected change in the customer base. These elements challenge family firms regarding their readiness to grow, non-economic goals, and SEW (Zellweger, Nason, Nordqvist, & Brush, 2013).

For the above reasons, family firms have strong connections as they remain in their domestic markets and adopt traditional business strategies to ensure their SEW (Gómez-Mejía et al., 2007) and deep local roots (Bird & Wennberg, 2014). We hypothesize:

H3: Open customer innovation model in domestic market increases family firms' innovation.

2.4. Family firm size and the open customer innovation model

Family firm owner-managers have been focused on the firm's long-term plans (Daily & Dollinger, 1993) and the protection of their "socio-emotional wealth" of the owner-family (Arregle et al., 2017) rather than firm growth and achieving a large enterprise size. Owner-managers in small family firms may do better in pursuing their own interests (Santoro et al., 2021) and by collaborating more closely with customers exerting indirect influence over their customers, making them more loyal and more emotionally attached to the business. This could also be achieved in small family firms by creating a more informal organizational structure within a firm and with external partners (Goffee & Scase, 1985). Owner-managed family firms are less growth-oriented to sustain control and protect their market position, which customers may appreciate and be more willing to engage with a family firm (Ward, 1987). In contrast, managers in non-family firms would mainly focus on short-term personal goals such as promotion and bonuses, in competition with other managers in firms of relatively larger size as the promotion may be linked to companies increase in sales, profit, entering foreign markets, or managing larger teams- directly associated with an increase in firm size.

Agency theory is often used to analyze the benefits of the smaller size of owner-managed companies as it states it enables separating the decision process into initiation and implementation of decisions; ratification and monitoring and managing risk (Fama and Jensen, 1983). Small family firms are quicker in decision making related to changing the products as customers may want it, better communication and control, over product quality and reporting back to the customer. In small family firms, the information about the customer's preferences and feedback could be more detailed and better processed, complemented with events and local meetings that owner-managers may set up with local and regional customers, increasing their satisfaction and engagement. The risk of decision-making and engagement with more distant customers is greater than with local customers. Therefore, the benefits of the smaller size of owner-managed companies in the splitting the decision process and engagement with customers on innovation (Fama and Jensen, 1983) is likely to be most relevant for customers in domestic markets where social capital can be created and effectively managed and when institutions are common. However, as soon as the geographical distance between family-owners and customers grows, and institutional context changes, specific and tacit knowledge associated with the innovation process may be dissipated (Arregle et al. 2017). Therefore, smaller family firms will lose out their advantage of localness and engagement with customers with an increase in the distance, cognition and institutional differences in the context where innovators operate and where customers live (Balland et al. 2015). We hypothesize:

H4: Open customer innovation model in domestic market increases innovation in small family firms to a greater extent than in larger family firms.

Drawing on the literature review, three important questions should be answered. First, whether family firms are more (less) likely to employ open customer innovation model than non-family firms? Second, would family firms be able to achieve greater benefits from engaging in open customer innovation model than non-family firms, and how is the relationship changes with the geographical proximity to customers? Finally, whether small family firms achieve higher innovation performance if employed open customer innovation model in domestic market compared to larger family firms?

3. Data and sample description

3.1. Data matching

To test our hypotheses, we used six pooled cross-sectional datasets Business Structure Database known as Business Register and the UK Innovation Survey (UKIS) over 2002–2014. Although two datasets were pooled together and constructed from two different sources, they are matchable. First, we collected six consecutive UKIS waves (UKIS 4 2002–04, UKIS 5 2004–06, UKIS 6 2006–08, UKIS 7 2008–10, UKIS 8 2010–12 and UKIS 9 2012–14) each conducted every second year by the Office of National Statistics (ONS), United Kingdom (UK) on behalf of the Department of Business Innovation and Skills (BIS). Second, we used the Business Structure Database (BSD), a survey conducted annually by the Office of National Statistics (ONS) for the years 2002, 2004, 2006, 2008, 2010, and 2012. We matched each correspondent CIS survey wave with the data from BSD (2002, 2004, 2006, 2008, 2010 and 2012) taken for each UKIS period's initial year.

The match was done using the enterprise unit indicator and year shared by both BSD and UKIS. To be included in a final sample, all questions related to the variables of interest need to be completed with no missing values. All missing values and nonapplicable answers were labeled as missing and, therefore, not included in our sample.

Tables 1 illustrates the sample distribution by industry, region in the UK, firm size over 2002–2014 (six waves of UKIS), and provides information on the number of observations. The final sample is 21,140 observations after controlling for all missing values in a model. Our sample embraces a wide spectrum of industries, with most of the businesses coming from high-tech manufacturing (19.42%), construction (10.50%), wholesale and retail trade (16.19%), real estate, and business activities (12.63%). Most underrepresented sectors are mining and quarrying (0.79%), electricity (0.79%), education (0.38%), financial intermediation (3.27%). The distribution of firms across industries between population and estimation samples remains stable over 2002–2014. This is important as it enables us to generalize the results of estimation on a bigger sample. Firms are equally represented across the UK regions, with most firms come from the South East (11.11%), London (9.37%), and the North –West of England (9.39%). West Midlands and Eastern England follow with approx. 8% each in a final sample. At the same time, Wales and North-East of England are least represented in a sample with less than 6.39% and less than 5.43% accordingly of firm representation. As with the industry distribution, the relative proportions of firms across the UK regions remain stable across both populations and estimated samples over 2002–2014. The final part of Table 1 illustrates the distribution of firms by size measured as full-time employees (FTEs) from the BSD data. Most of businesses are small (<50 FTEs) (54.82%) and medium-size businesses (50–249 employees) – 26.87%. Large firms (>250 employees) contribute 18.32% of the sample. As one of our interests is a contribution to family firms to innovation, we calculate the number of firms that are family-owned (10.36% of

Table 1
Industrial / Regional and Firm size distribution in a sample.

Industry distribution Firms Share, %			*Regional distribution* Firms Share, %		
1 - Mining & Quarrying	166	0.79	North East	1147	5.43
2 - Manufacturing basic	1282	6.06	North West	1984	9.39
3 - High-tech manufacturing	4106	19.42	Yorkshire and The Humber	1750	8.28
4 - Electricity, gas and water supply	167	0.79	East Midlands	1704	8.06
5 - Construction	2220	10.50	West Midlands	1861	8.80
6 - Wholesale, retail trade	3422	16.19	Eastern	1912	9.04
7 - Transport, storage	1151	5.44	London	1981	9.37
8 - Hotels & restaurants	1150	5.44	South East	2348	11.11
9 - ICT	1437	6.80	South West	1796	8.50
10 - Financial intermediation	692	3.27	Wales	1350	6.39
11 - Real estate and other business activity	2669	12.63	Scotland	1671	7.90
12 - Public admin, defence	2133	10.09	Northern Ireland	1636	7.74
13 – Education	80	0.38	**Total**	**21,140**	**100.00**
16 - Other community, social activity	465	2.20			
Total	**21,140**	**100.00**			
Size distribution, including family firms					
small firms	11,588	54.82			
medium	5680	26.87			
large	3872	18.32			
Total	**21,140**	**100.00**			

Source: UKIS- UK Innovation survey; BSD- Business Structure Database. Number of observations 21,140 after controlling for missing values in all variables.

a sample) and small (7.89%) and medium (1.98%) family firms. The distribution of firms that perform product innovation was consistent across the six waves.

3.2. Variables

3.2.1. Dependent variable

The first step of our estimation includes examining the likelihood of collaboration with customers. We use binary variable equal one if the firm collaborates with customers across four geographical proximities, regionally, nationally, Europe, and internationally, zero otherwise. The second step evaluates the returns to open customer innovation models and uses a share of new to market products taken from UKIS as a dependent variable. This is the most appropriate measure of innovative performance and knowledge commercialization (Audretsch & Belitski, 2020; Frenz & Ietto-Gillies, 2009; Berchicci, 2013; Santamaría, Nieto, & Barge-Gil, 2009).

3.2.2. Explanatory variables

To measure the effect of innovation collaboration on innovation, we included four binary variables equal one if the firm collaborates with customers across four geographical proximities: regionally, nationally, in Europe and internationally, zero otherwise (Balland, Boschma, & Frenken, 2015; Beers & Zand, 2014). At this step, collaboration with customers is an explanatory variable. We also include a binary variable family firm equals one if the firm is a family-owned firm using the BSD data, zero otherwise.

For our analysis we operationalize family firms as owner-managed companies using the approach suggested to be used for the Mittelstand family firms in Germany by Wolter and Hauser (2001): a company is part of the family business if (i) up to two natural persons (and/or their close families) hold at least 50% of the voting shares of the company and (ii) these natural persons or families are at the same time members of the management board. Companies for which neither of the criteria hold are non-family firms. This may explain the fact that only 15% of observations in our sample belongs are family firms.

3.2.3. Control variables

We include several control variables known from previous research to drive innovation.

First, we control for knowledge collaboration with other partners (*enterprise group, suppliers, university, consultants, competitors, local and national government*). To control for the level of absorptive capacity, we used *'in-house R&D expenditure',* while we also controlled for purchases of R&D *(external R&D)* (Kleinknecht, van Montfort, & Brouwer, 2002; Santamaría et al., 2009; Vrontis & Christofi, 2019). Smaller firms are known to innovate more as well as engage in open innovation. We use two binary variables of firm size as small firms (FTEs < 50) and medium firms (between 50 and 249 FTEs) with large firms (>250 FTEs) as a reference category.

We use a binary variable *'Process innovation internal,'* which indicates whether a firm introduces process innovation. Process Innovations are new or significantly improved methods, although new to the business, it does not need to be new to the industry.

We control for *'Firm age'* measured as log of firm age, capturing potential decreasing marginal returns to firm age. We control the firm's absorptive capacity (Zahra & George, 2002) proxied by a share of employees with BSc degree and above in total employment (*'Scientist'*). Other knowledge intensity control includes *'design intensity'* and *'training intensity'*. We add a firm's *'Legal status'* as a binary variable for Sole-proprietorship, on-for-profit, and partnership (including family businesses) with limited liability company as a reference category. We also control for sales abroad to measure internationalization with a binary variable *'Exporter'* and 'Foreign' is the firm has headquarters abroad.

Finally, to capture the fixed effects between and within industries, we include 70 industry dummies (SIC code 2 digits) (mining and quarrying is a reference category), albeit they are suppressed to save space. We include 128 region-city fixed effects where firms are located (Aberdeen is a reference category) and six-year fixed effects (2002–2004 period as a reference category).

A full list of variables is in Table 2, while the descriptive statistics for knowledge collaboration variables are in Appendix A.

4. Methodology

We first estimate the logistic regression model with knowledge collaboration across four geographical dimensions and seven collaboration partners as dependent variables (step 1). This model is important to test the presence of the predisposition of family firms to apply open innovation models.

In the reduced form function of collaboration φ_i (binary variable = 1 if firm engages in collaboration across geographical proximity or with any specific partnership type, zero otherwise) is estimated as:

$$\varphi_i = \pi_0 + \beta_i x_i + \pi_i \varrho_i + v_i \quad (1)$$

Where x is a vector that represents family firms and ϱ_i are other exogeneous control variables which predict the propensity to collaborate across different geographies and partner types (Beers & Zand, 2014).

We used multilevel mixed-effects logistic model in step two by using a generalised estimation equation (Papke & Wooldridge, 2008) the bounded dependent variable y_{ijk} between [0,1] and a truncated distribution and the independent variable x_{ijk} such that:

Table 2
Descriptive Statistics.

Label		Description of variables	Survey used	Mean	Std. Dev.
Regional collaboration		DV for step 1: Firm collaborates with external partners on innovation regionally = 1, 0 otherwise	UKIS	0.14	0.35
National collaboration		DV for step 1: Firm collaborates with external partners on innovation nationally (country) = 1, 0 otherwise	UKIS	0.19	0.39
Europe collaboration		DV for step 1: Firm collaborates with external partners on innovation in European countries = 1, 0 otherwise	UKIS	0.09	0.28
World collaboration		DV for step 1: Firm collaborates with external partners on innovation in other world countries = 1, 0 otherwise	UKIS	0.08	0.26
Group		DV for step 1: Firm collaborates innovation with other businesses within enterprise group = 1, 0 otherwise	UKIS	0.03	0.06
Suppliers		DV for step 1: Firm collaborates innovation with suppliers of equipment, materials, services = 1, 0 otherwise	UKIS	0.09	0.09
Clients		DV for step 1: Firm collaborates innovation with clients or customers = 1, 0 otherwise	UKIS	0.14	0.11
Competitors		DV for step 1: Firm collaborates innovation with competitors = 1, 0 otherwise	UKIS	0.03	0.05
Universities		DV for step 1: Firm collaborates innovation with universities = 1, 0 otherwise	UKIS	0.02	0.04
Government		DV for step 1: Firm collaborates innovation with local or national government = 1, 0 otherwise	UKIS	0.02	0.03
Innovation sales		DV for step 2: Percentage of sales of products and services that are new to the market in total sales (0–100)	UKIS	0.40	0.12
Family firm		Binary variable equal one if firm is fully or partly owned by a family, zero otherwise	BSD	0.15	0.35
Small size firm		Binary variable equal one if employment is 10–49 FTEs, zero otherwise	BSD	0.45	0.49
Medium size firm		Binary variable equal one if firm has employment is 50–249 FTEs, zero otherwise	BSD	0.28	0.45
Training		Binary variable = 1 if firms does training activity for innovation, zero otherwise	UKIS	0.25	0.43
Design		Binary variable = 1 if firms has had any form of design expenditure on innovation, zero otherwise	UKIS	0.43	0.49
Entrepreneurial climate		New methods of organising work responsibilities and decision making (use of a new system of employee responsibilities, team work, decentralisation, integration or de-integration education/ training etc.)	UKIS	0.21	0.41
Process innovation internal		Binary variable = 1 if firm introduced any new or significantly improved processes for producing or supplying goods or services, zero otherwise.	UKIS	0.23	0.42
Process innovation external		Binary variable = 1 if firm introduced any new methods of organising external relationships with other firms or public institutions, zero otherwise.	UKIS	0.26	0.43
Legal Status	Company	Binary variable = 1 if firm's legal status is limited liability company, 0 otherwise	BSD	0.843	0.364
	Sole proprietor	Binary variable = 1 if firm's legal status is Sole-proprietor, 0 otherwise	BSD	0.041	0.199
	Public corporation	Binary variable = 1 if firm's legal status is *Public corporation*, 0 otherwise	BSD	0.001	0.028
	Non-for-profit body	Binary variable = 1 if firm's legal status is *Non for profit*, 0 otherwise	BSD	0.013	0.114
In-house R&D expenditure		Internal Research and Development expenditure (£) in logs	UKIS	1.31	2.13
External R&D		Binary variable = 1 if firm's buys R&D and other knowledge from external organizations, zero otherwise	UKIS	0.16	0.36
Scientists		The proportion of employees that hold a degree or higher qualification in science and engineering at BA / BSc, MA / PhD, PGCE levels	UKIS	7.47	17.26
Exporter		Binary variable = 1 if a firm sells its products in foreign markets, 0 otherwise	UKIS	0.37	0.48
Foreign		Binary variable = 1 if a firm has headquarters abroad, 0 otherwise	UKIS	0.41	0.49
Firm age		Age of a firm in logarithms	BSD	2.66	0.75
Variables used for Heckman selection model					
Goods range		how important was an increase of a range of goods and services to innovate? (0 – not important, 3 – high importance)	UKIS	1.42	1.19
Market share		how important was an increase in a market share to innovate? (0 – not important, 3 – high importance)	UKIS	1.50	1.20

Source: UKIS- UK Innovation survey; BSD- Business Structure Database.
Number of observations 21,140 after controlling for missing values in all variables.

$$y_{ijk} = \beta_0 + \beta_1 x_{ijk} + \beta_2 \tau_{ijk} + \varepsilon_{ijk} \quad (2)$$

where i is the firm level-1, j is the region level-2 and k serves to index the wave survey level-3. The dependent variable y_{ijk} – innovation output. The explanatory variables and interactions are in x_{ijk}. Other control variables, which represent firm-specific characteristics, as well as city-region, industry and wave fixed-effects described in Table 2 are presented in τ_{ijk}. Finally, ε_{ijk} is an error term that consists of three components in the hierarchical model:

$$\varepsilon_{ijk} = \gamma_i + \mu_j + t_k. + \nu_{ijk} \quad (3)$$

Where γ_i represents the omitted variables that vary across firms but not over regions and waves, μ_{ij}. denotes the omitted variables that vary over regions but are constant across firms and time, t_k represents omitted variables which vary across waves, but not across firms and regions, while finally ν_{ijk} is the error term. As noted by Srholec (2010), the presence of more than one residual term makes the standard multivariate model such as a fixed-effects specification inapplicable.

Additionally, a multilevel model enables to control for the effect that a city-region and time period shapes firm innovative performance. It also demonstrates that innovative performance is not independent from the influences of time and regional effects. The co-variation between firm innovative performance, sharing the same regional externalities can be expressed by the intra-class correlation (Goldstein, 2011). With this, the between-regions variance contributes to firm innovation performance in addition to the variance between firms.

Furthermore, when estimating equation (2), it was necessary to control for a sample selection bias which could have originated from the fact that we moved from 64,192 observations in a matched BSD-UKIS sample to 21,140 observations with no missing values.

Heckman (1979) procedure is used to test and correct for the selection bias using all available *n* observations, estimate the probit model of S_i on Z_i and obtain the estimates $\widehat{\gamma_h}$. S_i is a selection indicator which captures whether or not innovation output was observed in the initial model of 64,192 observations (S_i). S_i indicates we will use the observation in our analysis; $S_i = 0$ means the observation will not be used. Given missing and unreported values of innovation outputs we use less than n (64,192 observations) in our sample, say n_i (21,140 observations). In the selection equation of the Heckman (1979) procedure, our dependent variables y_i are binary, equal one if innovation was reported by a firm (i) (innovation output), zero otherwise. The inverse Mill's ratio $\widehat{\lambda_i} = \lambda(z, \widehat{\gamma})$ for each i is computed automatically. Using the selected sample, that is, the observations for which $S_i = 1$ we run the regression of.

$$y_i \text{ on } x_i \text{ and } \widehat{\lambda}_i \quad (4)$$

The equation provides a simple test of selection bias. We use the usual t-statistics on $\widehat{\lambda}_i$ as a test of null hypothesis: $\rho = 0$. Under null

hypothesis, there is no sample selection problem (Wooldridge, 2009, p. 610). In addition to x_i, we used two variables in the selection equation such as Increasing range of goods or services and Increasing market share (see Table 4). These variables are associated with propensity to innovate and most importantly to report innovation effort. Mills ratio calculated from Table 3 is further included in regression (2) to control for selection bias. There is an evidence of a sample selection problem as the coefficient $\widehat{\lambda}_i$ is statistically significant.

5. Results

Table 4 illustrates the results of estimation (1). First, we find evidence that family firms are not more or less likely to collaborate on innovation with customers ($\beta = 0.249$, $p > 0.10$) (specification 3, Table 4). as well as other partners. H1 is not supported. Family firms are less likely to collaborate on innovation with universities ($\beta = 0.348$, $p < 0.05$) (specification 5, Table 4). This result means family firms are three times less likely than non-family firms to collaborate on innovation in universities.

Would this behavior of family firms affect their returns to open customer innovation models? Table 5 presents estimation (2) with the Mills ratio included correcting for potential selection bias. The coefficient of collaboration with customers increases innovation sales between 0.18 and 0.35 percent, while family firms' coefficient is not statistically significant. This demonstrates that family firms are as innovative as non-family firms. Our H2 is partly supported as we find mixed evidence of additional returns to open customer innovation models for family firms. The results are significant for domestic markets (regional and national) (specification 5–6, Table 5), supporting H3, but are not significant for Europe and global customers (specification 7–8, Table 5). In economic terms, the open customer innovation model within a region increases innovation sales by 0.69% and within a country by 0.82 percent to sales.

This is an interesting finding as it adds to mixed evidence of returns to collaboration with customers for family firms (Eggers, Kraus, & Covin, 2014; Newman et al., 2016; Vrontis et al., 2020). Establishing open customer innovation model works for regional and national customers where family firms are more likely to prioritize resource allocation, and collaborations are most cost-effective (Hauswald et al., 2016). Our finding also supports Banalieva and Eddleston (2011), who found that using agency and stewardship theories, family leaders are most beneficial when pursuing a regional strategy. Our support for H3 is also driven by localized knowledge advantages of family firms supporting Asheim and Coenen (2005), Vestal and Danneels (2018) and a stronger advantage of family firms to access tacit knowledge via face-to-face interactions locally. The ability to effectively employ open customer innovation models adds to family firms' non-economic goals and SEW (Gómez-Mejía et al., 2007; Zellweger et al., 2013).

In order to test our H4 we retained a subsample of family firms only as we are required to compare how the firm size of family firms may affect their innovation performance and across four geographical proximities. First, we estimated equation (2) for family firms of small size (<50 FTEs) and calculated the expected values of innovation for firms that do and do not employ an open customer collaboration model. Second, we estimated equation (2) for family firms of medium and large sizes (>=50 FTEs) and calculated the expected values of innovation for firms who employ and do not employ the open customer innovation model (collaboration with customer variable). We combined the expected values of innovation performance for family firms (small and other) who engage and not in customer collaboration in Table 6.

Finally, we plotted the expected values of innovation for small and other (medium and large) family firms at a different level of customer collaboration on innovation. We find that there is a greater difference in innovation performance between small and large family firms who collaborate with customers in regionally and nationally, supporting H4. We do not find significant differences in innovation performance between small and large family firms who collaborate with customers in global markets, again confirming H4. The solid line represents small size family firms, while the dotted line represents all other family firms. Although both small and larger family firms benefit by collaboration with customers with innovation performance increases across all four geographical dimensions, the size of the benefit in terms of expected innovation level for small size family firms is greater (difference between collaboration and non-collaboration), than for larger family firms. For example, a small family firm has an additional premium from collaboration with customers regionally (0.062) and nationally (0.059), which other family firms (large and medium size) do not have (Fig. 1).

As part of the robustness check, we estimated equation (2) with the Tobit model instead of mixed effect GLS estimation to test whether the major results hold, and our hypotheses are supported. Our dependent variable is new to market product share, which is left-censored (some firms have zero innovation sales). The results of Tobit also supported our hypothesis.

Furthermore, we estimated equation (2) with logistic regression, which measures the likelihood of product innovation instead of innovation sales. Our dependent variable was converted into binary with one, equal to innovation sale, zero otherwise. The results of logistic regression support mixed effect GLS estimation when both regional and national collaboration with customers increases innovation output in family firms. We found that predicted values of product innovation for family firms that collaborate with regional and national (country) customers were higher than in the mixed-effect GLS estimation model.

Table 3
Random-effects Probit estimates.

Two-step Heckman approach	*Innovation active (D = 1)*		
	Coef.	SE	
Firm age	−0.006	0.001	***
Employment, in logs	0.458	0.010	***
Scientists	0.126	0.001	***
In-house R&D expenditure	4.239	0.400	***
Goods range	0.541	0.026	***
Market share	0.221	0.026	***
Constant	−2.348	0.182	***
sigma u	1.140	0.040	
Rho	0.508	0.014	
Observations	68,152		
Industry, wave and city-region fixed effects	Yes		
Wald chi2	1399.15		

Source: UKIS- UK Innovation survey; BSD- Business Structure Database. Note: ***,** and * Significance at the 1%, 5% and 10% levels, respectively. Industry = Foresting; Reference region = Cambridge; year = 2002–2004.

6. Conclusion

6.1. General discussion

The theoretical and empirical research on innovation in family firms has grown exponentially in recent years (Vrontis, Bresciani and Giacosa, 2016; Vrontis & Christofi, 2019; Belyaeva et al. 2020). While family firms favor knowledge co-creation processes with external stakeholders such as employees, customers, end-users, policymakers, industry and academic institutions (Del Vecchio et al., 2020) work together to create innovation (Santoro et al., 2018, 2021; Leonidou et al., 2020). Open customer innovation models as a form of stakeholder engagement have received a growing interest from academics and practitioners as a research topic (Pantano, Priporas, Viassone, & Migliano, 2019). Although family businesses may appear to already have an advantage in working with customers, our study demonstrates that family firms are more likely to benefit from open innovation with customers regionally and nationally despite similar willingness to use open innovation with customers.

Table 4
Logistic regression estimation for family firms across partner types. Dependent variables: collaboration with external partners. Results are reported in odd ratios.

Dependent variable	Collaboration partners					
Specification	(1)	(2)	(3)	(4)	(5)	(6)
Geography of collaboration	Enterprise Group	Suppliers	Customers	Competitors	University	Government
Family firm (H1)	**1.450**	**0.218**	**0.249**	**0.539**	**0.348****	**0.785**
	(1.00)	**(0.05)**	**(0.79)**	**(0.11)**	**(0.05)**	**(1.52)**
Firm age	1.028	0.862	0.760	1.103	1.384	1.119
	(0.13)	(0.11)	(0.11)	(0.10)	(0.44)	(0.41)
Process innovation internal	2.940**	2.275**	1.911**	1.680**	2.301**	3.485**
	(0.90)	(0.80)	(0.71)	(0.48)	(0.91)	(1.60)
Small-size firm	0.701	0.717	1.074	0.773	0.544	0.414
	(0.18)	(0.15)	(0.20)	(0.19)	(0.14)	(0.15)
Medium-size firm	0.480	0.574**	0.757**	0.575	0.361	0.304
	(0.15)	(0.17)	(0.10)	(0.23)	(0.13)	(0.15)
Training	0.955	0.347*	0.312*	2.136	2.059	0.963
	(0.19)	(0.18)	(0.17)	(0.47)	(0.44)	(0.16)
Design	1.805**	1.514**	1.616**	1.688**	0.817	1.255
	(0.12)	(0.13)	(0.15)	(0.10)	(0.36)	(0.11)
Scientist	1.006	1.004	1.010**	1.004**	1.014**	1.022**
	(0.32)	(0.30)	(0.28)	(0.29)	(0.20)	(0.31)
In-house R&D expenditure	1.143**	1.159**	1.097**	1.294**	1.272**	1.057
	(0.04)	(0.03)	(0.05)	(0.04)	(0.03)	(0.09)
Foreign	7.214**	3.267**	10.971**	2.631**	3.241**	2.261
	(0.54)	(0.59)	(1.12)	(0.30)	(0.29)	(0.47)
Industry controls (2 digit SIC)	Yes	Yes	Yes	Yes	Yes	Yes
Year controls	Yes	Yes	Yes	Yes	Yes	Yes
City-regions controls	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.08***	0.22***	0.12***	0.10***	0.05***	0.07***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Chi2	265.3	473.2	714.6	267.5	269.1	352.1
Log-likelihood	−319.3	−654.1	−907.3	−324.71	−198.70	−174.25

Note: standard errors are robust for heteroscedasticity in parenthesis. Industry (1 digit SIC) and year fixed effects are suppressed to save space. Estimation method: logistic regression. Note: reference category for legal status is Company (limited liability company). industry (mining), region (North East of England). Robust standard errors are in parenthesis. Significance level: * $p < 0.05$; ** $p < 0.01$, *** $p < 0.001$. No of observations 21,140.
Source: UKIS- UK Innovation survey; BSD- Business Structure Database.

This study argues that family firms are less likely to collaborate with external stakeholders outside their regional markets, but it does not create an economic limitation for family firms. This is an advantage for family firms and can be used to support innovation in family firms. This study answers the question - how managers can benefit from having a local orientation of open innovation models, adding to social capital, networking, informal collaboration, SEW. Family firms that decide to engage in open innovation models with customers nationally will also benefit from innovation sales when collaborating with regional customers, which adds to prior research on the Mittelstand, which is known to engage with supplier's and customers within localized communities. It appears that, unlike the Mittelstand in Germany, the bonus of the open customer innovation model for family firms extends beyond the immediate geographical proximity (Heider et al. 2021).

Using data on 17,859 firms from the UK Innovation Survey and Business Registry during 2002–2014, we argue that family firms inherit special behavior with their customers and go beyond profit maximization, allowing them to achieve greater innovation performance within the country. In many instances, family firms will continue to rely on customers to introduce new to market products locally and regionally, and they will use market niche and tacit knowledge transfer models to outcompete non-family firms.

6.2. Implications to theory

Our first contribution is in the innovation in family firms literature. Empirical test of our model has demonstrated that, unlike Mittelstand, family films in the United Kingdom would benefit from collaboration in the immediate neighborhood such as region or local market and from collaboration with customers nationally. This is a key difference between the community-oriented model of Mittelstand and the open customer innovation model of the family firms in the UK. Prior research has simplified the Mittelstand concept, sometimes referring to it as an SME or a small size family firm. Instead, it has a strong local embeddedness concept which is often supported by the family firm innovation strategy, but it is not the same. Family firms in the UK while adopting the Mittelstand strategy of working with the customer for innovation. The benefits from such collaboration go beyond the immediate proximity to the national market and are also related to the cognitive and institutional dimension of cust9omer knowledge. Our results have demonstrated that family firms in the UK and German Mittelstand have similar characteristics regarding the propensity to collaborate with customers for innovation, however, they are different in terms of benefits they receive from such collaboration and product commercialization (Heider et al. 2021).

Our second contribution is in and consumer research in family firms literature. Our empirical findings advance prior research that contributes to marketing and consumer research in the field of family firms as well as open innovation literature by explaining how family firms engage and benefit from the open customer innovation model (Del Vecchio et al., 2020; Christofi, et al., 2015). Previous research highlights different marketing, e.g. networking with customers (Covin et al., 2016), and innovation-related resources for innovation purposes in family vs. non-family firms. We extend this literature by showing that both family and non-family firms have equal potential to collaborate with customers for innovation purposes; however, different configurations of geographical location are required to produce innovation premium.

Our third contribution is in the geography of innovation by demonstrating how the geographical location of customers affects the

Table 5
Mixed-effect GLM estimation of product innovation. DV –innovation sales.

Specification	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Region of collaboration	Regional	National	Europe	World	Regional	National	Europe	World
Group	0.02	0.13	0.20	0.05	0.04	0.11	0.21	0.12
	(0.012)	(0.10)	(0.013)	(0.013)	(0.03)	(0.07)	(0.12)	(0.10)
Suppliers	0.09*	0.25**	0.21**	0.18**	0.08	0.24**	0.21**	0.18**
	(0.05)	(0.09)	(0.11)	(0.08)	(0.06)	(0.09)	(0.11)	(0.08)
Customers	0.33***	0.51***	0.18***	0.35***	0.26***	0.46***	0.16**	0.37***
	(0.01)	(0.11)	(0.05)	(0.01)	(0.05)	(0.10)	(0.06)	(0.06)
Competitors	0.12	0.13	0.07	0.01	0.10	−0.12	0.06	−0.01
	(0.08)	(0.07)	(0.06)	(0.01)	(0.08)	(0.07)	(0.06)	(0.01)
Universities	0.06	−0.05	−0.47	−0.07	0.07	−0.05	−0.32	−0.09
	(0.01)	(0.05)	(0.20)	(0.08)	(0.01)	(0.05)	(0.20)	(0.08)
Government	0.06	0.10	0.60	0.31	0.05	0.06	0.12	0.31
	(0.06)	(0.13)	(0.41)	(0.25)	(0.06)	(0.11)	(0.10)	(0.25)
Family firm	−0.20	−0.17	−0.19	−0.18	−0.29	−0.24	−0.20	−0.19
	(0.12)	(0.15)	(0.19)	(0.12)	(0.12)	(0.14)	(0.15)	(0.16)
Small	0.54***	0.56***	0.57***	0.56***	0.55***	0.59***	0.59***	0.51***
	(0.08)	(0.08)	(0.07)	(0.07)	(0.08)	(0.08)	(0.07)	(0.08)
Medium	0.38***	0.38**	0.40***	0.39***	0.38***	0.38**	0.40***	0.39***
	(0.00)	(0.03)	(0.00)	(0.08)	(0.00)	(0.03)	(0.00)	(0.08)
Training	0.33***	0.34***	0.37***	0.38***	0.33***	0.34***	0.37***	0.38***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Design	0.74***	0.73***	0.71***	0.69***	0.74***	0.70***	0.70***	0.65***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Entrepreneurial climate	0.09	0.08	0.09	0.10	0.09	0.05	0.08	0.10
	(0.05)	(0.05)	(0.06)	(0.07)	(0.05)	(0.05)	(0.06)	(0.07)
Process innovation external	0.68***	0.64***	0.68***	0.71***	0.68***	0.64***	0.68***	0.71***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Process innovation internal	0.25***	0.25***	0.26***	0.27***	0.25***	0.25***	0.26***	0.27***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
In-house R&D expenditure	0.23***	0.22***	0.22***	0.25***	0.25***	0.20***	0.22***	0.25***
	(0.00)	(0.00)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)
External R&D	0.18***	0.19***	0.19***	0.20***	0.18***	0.19***	0.19***	0.20***
	(0.00)	(0.00)	(0.02)	(0.02)	(0.00)	(0.00)	(0.02)	(0.02)
Scientists	0.005***	0.005***	0.006***	0.006***	0.005***	0.005***	0.006***	0.006***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Exporter	0.65***	0.61***	0.61***	0.52***	0.68***	0.63***	0.61***	0.52***
	(0.05)	(0.05)	(0.08)	(0.02)	(0.04)	(0.06)	(0.08)	(0.02)
Foreign	−0.07	−0.08	−0.07	−0.07	−0.07	−0.08	−0.08	−0.09
	(0.05)	(0.07)	(0.08)	(0.09)	(0.05)	(0.07)	(0.09)	(0.06)
Firm age	−0.07***	−0.08***	−0.07***	−0.07***	−0.07***	−0.08***	−0.07***	−0.07***
	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)
Family firm × Customers (H2 and H3)					**0.69*** **	**0.82*** **	**0.37**	**0.91**
					(0.25)	**(0.31)**	**(0.53)**	**(0.63)**
Mills ratio: Innovation active selection bias	0.18***	0.18***	0.18***	0.18***	0.19***	0.19***	0.19***	0.19***
	(0.02)	(0.02)	(0.03)	(0.02)	(0.023)	(0.023)	(0.023)	(0.023)
Constant	−1.93**	−1.98**	−1.90**	−1.89***	−1.91***	−1.97***	−1.90**	−1.88***
	(0.05)	(0.04)	(0.05)	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)
variance (year)	1.20	1.09	1.20	1.21	1.20	1.17	1.20	1.22
	(1.1)	(0.25)	(0.92)	(0.24)	(0.90)	(0.79)	(0.79)	(0.67)
variance (year / region)	0.07***	0.08***	0.08***	0.09***	0.07***	0.08***	0.08***	0.09***
	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)
LR test vs. logistic model: chi2	712.12	758.96	800.09	803.75	731.01	736.45	811.01	803.04
Overall model chi2	1922.85	1925.31	1915.10	1908.09	1925.49	1953.43	1916.28	1911.51
log likelihood	−5129.41	−5210.10	−5138.8	−5139.3	−5125.1	−5120.6	−5138.3	−5136.9

Note: Number of observations 21,140. SE are robust for heteroscedasticity. Reference category for firm size = large firm (250 + FTEs); Reference category for firm ownership status - public corporation. Industry (1 digit SIC) and year fixed effects are suppressed to save space. Product innovation regression/ LR test vs. logistic model supports use of Multi-level mixed-effects generalized linear model. Out of 21,140 obs. in a sample we have 15,959 obs. where zero share. Significance level: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$″.
Source: UKIS- UK Innovation survey; BSD- Business Structure Database.

returns from the open customer innovation model. Previous research debated the role of geographical proximity in firm'sa innovation (Bochma, 2005), with close relationships to external partners likely hindering innovation. We show that this reasoning holds for non-family firms. For family firms, closer geographical distance to customers (i.e. regional and national levels) is a condition of innovation success, with smaller family firms benefiting more from the open customer innovation model than larger family firms. This contribution highlights the geographical context as a condition surrounding marketing in family businesses. It also gives insights on the optimal level (in terms of geographical distance) of customer engagement in family businesses in an innovation context.

6.3. Implications to policy and practice

Our finding that family firms are not more innovative than other firms has implications for practice and policymaking. First, this could inform policymakers who aim to design programs to support innovation in family firms. Indeed, the innovation needs to be supported by providing incentives for family firms to realize their benefits from collaboration with customers. Second, we found that family firms, on average, do not recognize this competitive advantage. Another policy implication for managers in family firms is engagement with customers in the national market.

Third, the major takeaway for policy managers is the ability of family

Table 6
Differences in expected values of innovation between family-owned small firms and other size family firms (medium and large) who employ the open customer innovation model using mixed-effect GLM estimation.

Firm size	21,140 obs.			
Regional level (H4)			Total Effect	Net gain
	No-collaboration	Collaboration		
Large and medium family firms	0.440	0.468	0.028	0.062*
Small family firm	0.407	0.497	0.090	
National level (H4)			Total Effect	Net gain
	No-collaboration	Collaboration		
Large and medium family firms	0.434	0.486	0.052	0.059*
Small family firm	0.409	0.510	0.111	
Europe level			Total effect	Net gain
	No-collaboration	Collaboration		
Large and medium family firms	0.440	0.520	0.080	0.002
Small family firm	0.412	0.495	0.082	
World level			Total effect	Net gain
	No-collaboration	Collaboration		
Large and medium family firms	0.440	0.524	0.083	0.002
Small family firm	0.413	0.482	0.069	

Note: * $p < 0.01$ significance level.

firms to be more innovative than non-family firms if they are incentivized to engage in open innovation with customers regionally and nationally, while firm managers are less likely to do so. The leadership of family firms is in the hands of a small number of owners, and SEW usually dominates, so that there is a challenge in engaging in collaboration with external partners, with a fear of compromising internal political dynamics or convincing layers of management when external stakeholders are involved.

Moreover, family members who aim to transfer their business to the next generations are more prone to long-term-oriented investments. However, this needs to be done with care as building long-term collaboration beyond national markets may be uncertain regarding economic benefits for family firms.

While collaborating beyond the local customers is high, family firms are often reluctant to innovate with customers. They have a variety of financial and non-financial goals that influence their willingness to collaborate. If objectives are not aligned, this is what we observe when collaboration becomes geographically and institutionally limited.

Managerial implications should focus on expanding our knowledge of how family firms' collaboration with regional and national customers should be organized. Particularly, managers in family firms may face a challenge when growing the business since their size may substantially influence their ability to benefit from external collaborations.

Public and industrial policy in countries with economic structures dominated by family businesses aims to create supportive institutional conditions. Government and industrial associations may invest resources in creating knowledge and innovation communities within certain geographical locations. Such initiatives (e.g. the European Institute of Innovation & Technology) have been successfully adopted in some European countries by bringing together SMEs and different stakeholders (universities, research centers and SMEs) for innovation purposes.

Finally, in order to increase the propensity of engagement with external stakeholders in Germany, so-called Competence Centres have been created to provide family firms with information and training in a special field and for skills that are lacking for such engagement area (e.g. digitalization, planning, using equipment, labs and spaces by family firms, etc.). Such initiatives would strengthen the innovation capacity of family firms and help them create capabilities leveraging lack of resources and during the engagement with large scale customers, which family firms may perceive as a threat to firm control.

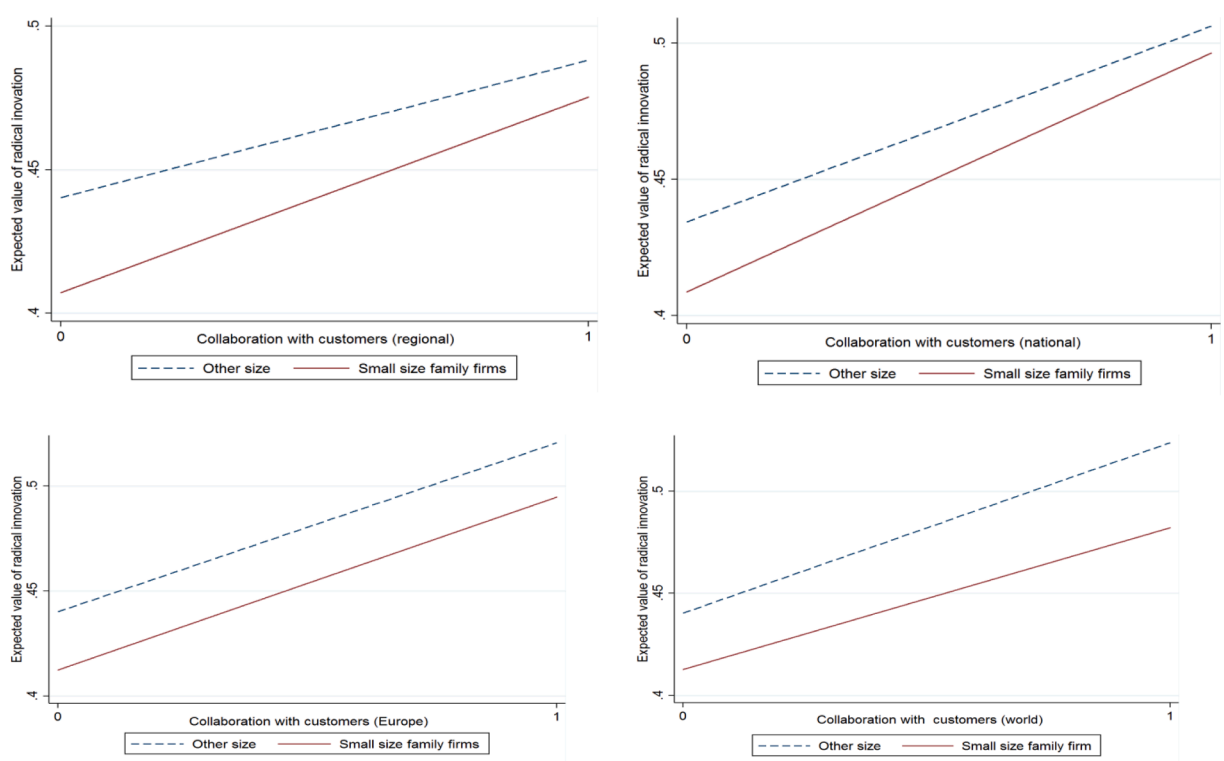

Fig. 1. Differences in knowledge collaboration in domestic and global markets between small-size family firms and medium and large size family firms.

6.4. Limitations and future research

One of the limitations of this study is that the panel data is unbalanced and does not include the same number of observations within the 2002–2014 period. For example, information on the forms, channels, and mechanisms of collaboration is not directly available. Future researchers may want to look into family firms' formal and informal learning mechanisms using individual customer and firm-level data.

More research is needed to explain the role of geographical proximity, which brings firms and customers together, favors interactions and facilitates the exchange of tacit knowledge. Finally, the data does not establish the type of relationship, including family links and the specific number of partners they collaborate with. It is important to determine whether these innovative collaborations are purely external or family members can limit this customer innovation model to family firm networks.

CRediT authorship contribution statement

Maksim Belitski: Conceptualization, Data curation, Formal analysis, Methodology, Validation. **Nada Khachlouf:** Validation, Resources, 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.

Appendix A. Descriptive statistics for knowledge collaboration variables used in this study

Label		Description of variables	Mean	Std. Dev.
UK Regional Binary variable = 1 if firm co-operates on innovation regionally	*Group*	With any of other businesses within enterprise group, 0 otherwise	0.057	0.218
	Suppliers	With any suppliers of equipment, materials, services, 0 otherwise	0.066	0.210
	Clients	With any clients or customers, 0 otherwise	0.085	0.216
	Competitors	With competitors or businesses in industry, 0 otherwise	0.034	0.135
	Consultants	With consultants, commercial labs or private R&D institutes, 0 otherwise	0.046	0.147
	Universities	With universities or high educational institutions, 0 otherwise	0.042	0.264
	Government	With government or public research institutes, 0 otherwise	0.022	0.171
UK National Binary variable = 1 if firm co-operates on innovation within national market	*Group*	with any of other businesses within enterprise group, 0 otherwise	0.062	0.283
	Suppliers	With any suppliers of equipment, materials, services, 0 otherwise	0.112	0.398
	Clients	With any clients or customers, 0 otherwise	0.122	0.325
	Competitors	With competitors or businesses in industry, 0 otherwise	0.053	0.222
	Consultants	With consultants, commercial labs or private R&D institutes, 0 otherwise	0.064	0.246
	Universities	With universities or high educational institutions, 0 otherwise	0.045	0.253
	Government	With government or public research institutes, 0 otherwise	0.046	0.264
European Countries Binary variable = 1 if firm co-operates on innovation within European countries	*Group*	With any of other businesses within enterprise group, 0 otherwise	0.037	0.171
	Suppliers	With any suppliers of equipment, materials, services, 0 otherwise	0.058	0.288
	Clients	With any clients or customers, 0 otherwise	0.059	0.229
	Competitors	With competitors or businesses in industry, 0 otherwise	0.020	0.123
	Consultants	With consultants, commercial labs or private R&D institutes, 0 otherwise	0.011	0.134
	Universities	With universities or high educational institutions, 0 otherwise	0.012	0.140
	Government	With government or public research institutes, 0 otherwise	0.003	0.057
Other Countries Binary variable = 1 if firm co-operates on innovation with other world (excluding Europe and UK)	*Group*	With any of other businesses within enterprise group, 0 otherwise	0.034	0.168
	Suppliers	With any suppliers of equipment, materials, services, 0 otherwise	0.035	0.179
	Clients	With any clients or customers, 0 otherwise	0.046	0.281
	Competitors	With competitors or businesses in industry, 0 otherwise	0.017	0.190
	Consultants	With consultants, commercial labs or private R&D institutes, 0 otherwise	0.018	0.195
	Universities	With universities or high educational institutions, 0 otherwise	0.010	0.095
	Government	With government or public research institutes, 0 otherwise	0.008	0.088

Source: UKIS- UK Innovation survey.

Number of observations 21,140 after controlling for missing values in all variables.

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