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Heterogeneous collaborative networks and firm performance: Do the contingent effects of family management and intellectual property rights matter?

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Abstract

Purpose – The aim of this study is to investigate the relationship between heterogeneous collaborative networks and firm performance, using the resource-based view (RBV) and its extension through the knowledge-based view (KBV) as theoretical lens. Moreover, the authors examine family management and intellectual property rights (IPRs) as contingent factors that enhance the effectiveness of heterogeneous collaborative networks in achieving superior firm performance.

Design/methodology/approach – The hypotheses are developed and checked by using a panel data sample of 10,985 firm-year observations from 1,766 Spanish manufacturing firms over the period 2007–2016.

Findings – The results indicate that heterogeneous collaborative networks positively influence firm performance. Furthermore, the positive impact of these innovation networks on firm performance is reinforced by high levels of family management, and such effect is even stronger when there exists high levels of IPRs.

Originality/value – This research is the first, to our knowledge, to provide important new insights into the manner in which the effect of both family management and IPRs have the potential to amplify the performance gains attained from heterogenous collaborative networks.

Keywords Firm performance, Heterogeneous collaborative networks, Innovation partners, Family management, Intellectual property rights

Paper type Research paper

Introduction

The last decade has witnessed the growing importance that firms are granting to the adoption of open innovation models to face the ongoing challenges of a competitive and ever-changing marketplace (Bigliardi *et al.*, 2020; Dahlander *et al.*, 2021). Firms are now increasingly relying on collaborations to complement and supplement their internal innovation efforts (Moaniba *et al.*, 2020). Indeed, recent literature indicates that firms are constantly seeking to build "interactive" networks and the innovation support of different partners (Puliga *et al.*, 2020). In particular, collaborating with a variety of innovation partners (i.e. suppliers, customers, competitors and universities) is key to access a wider variety of resources and knowledge that allow successful innovations (Faems *et al.*, 2010; Zeng *et al.*, 2010). More specifically, heterogeneous collaborative networks, i.e. networks comprising

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collaborations with more than one type of partner, allow firms to obtain better innovation outcomes than homogenous networks, i.e. networks composed of only one type of partner, as the former promote access to diverse sources of information and enable knowledge transfer and application (Nieto and Santamaría, 2007).

Despite the importance attached to collaborations in the open innovation literature (Gkypali *et al.*, 2017; Moaniba *et al.*, 2020), there are still important research gaps left to be filled. For example, although attractive and promising, there is a particular paucity of evidence on whether collaborative innovation networks lead to improved firm performance (Sisodiya *et al.*, 2013). While most studies have found a clear positive incidence of collaborative networks on innovation outcomes (e.g. Garcia Martinez *et al.*, 2017), their impact on firm performance has not been investigated in depth (Faems *et al.*, 2010; Gargiulo, 2004). Previous research suggests that heterogeneous collaborative networks can enable firms to access more diverse knowledge, enhance collaborative skills and increase innovation productivity (e.g. Ferreras-Méndez *et al.*, 2015; Jiang *et al.*, 2010), which is beneficial for boosting performance gains. Nevertheless, collaborating with more than one type of partner could be also disadvantageous to firm performance to the extent that these heterogeneous networks might lead to unwanted knowledge spillovers or risk of opportunistic behaviour (e.g. Hsieh *et al.*, 2018; Stefan and Bengtsson, 2017). Thus, more research is needed to fully understand the manner in which heterogeneous collaborative networks impact firm performance. Furthermore, it would be of great interest to provide a further comprehension of the contingent factors that shed light on the conditions under which such relationship can be clarified (Sisodiya *et al.*, 2013). Detecting these contingencies remains a major challenge at the forefront of open innovation research (Bigliardi *et al.*, 2020; Liao *et al.*, 2020).

This study aims to fill these research gaps by proposing a theoretical model to deepen the understanding of the heterogeneous collaborative network–firm performance relationship, including two under-explored contingent factors in such linkage, namely family management and intellectual property rights (IPRs). In this regard, because of the economic success of heterogeneous collaborative networks depends on appropriate governance mechanisms (Huang and Chiu, 2018), we argue that family management, understood as the active involvement of family members in a family firm's top management team (Ramírez *et al.*, 2021), substantially improves the potential performance gains obtained through such collaborative networks. Moreover, performance outcomes derived from heterogeneous collaborative networks that family managers obtain also depend on factors that enable dealing with the tension between sharing and protecting knowledge (Bogers, 2011). Thus, we postulate that IPRs, i.e. the degree of technical protection of the firm's own knowledge (Hertzfeld *et al.*, 2006), favour family management to amplify the performance benefits of heterogeneous networks.

Accordingly, this article addresses the following research questions: (1) Do heterogeneous collaborative networks improve firm performance? (2) Does family management strengthen the link between heterogeneous collaborative networks and firm performance? (3) Could IPRs reinforce the moderating effect of family management on the main relationship? To answer these questions, we conduct an empirical study with distinct econometric models that cover the hypotheses, using a panel data sample of 10,985 firm-year observations from 1,766 Spanish manufacturing firms over the period 2007–2016. To examine these issues, we rely on the resource-based view (RBV; Das and Teng, 2000) and its extension through the knowledge-based view (KBV; Grant and Baden-Fuller, 2004). According to these theories, the possession of firm-specific knowledge, as well as the ability to create and transfer it, is considered one of the most strategically important resources for sustaining the long-term competitive advantage of firms involved in collaborative networks (Cabrera-Suárez *et al.*, 2001). Thus, we propose that the firms' capability to collect, accumulate, integrate, disseminate and exploit the knowledge embodied in heterogeneous collaborative networks is key to superior firm performance (Teece *et al.*, 1997). Moreover, we also extend these theoretical approaches by

focussing on how the synergistic effect of family management and IPRs can lead to significant competitive advantages that reinforce the realisation of higher performance gains of heterogeneous collaborative networks.

With supporting empirical results, this study makes several important contributions to the literature. First, building on RBV in combination with insights of KBV (e.g. Cabrera-Suárez *et al.*, 2001), we extend the ongoing debate on the link between heterogeneous collaborative networks and firm performance by analysing two contingent factors, namely family management and IPRs. Second, by examining the moderating impact of family management, we add to the emerging research stream of collaborative innovation in family firms (Feranita *et al.*, 2017). Third, by analysing the moderated moderating role of IPRs, we contribute to the research path examining IPRs in family firms' open innovation strategies (De Massis *et al.*, 2015). Finally, this research confirms that the synergistic effect of family management and IPRs is quite relevant to comprehend the intricate nuances related to the core relationship examined (Liao *et al.*, 2020).

Theoretical background and hypotheses development

Heterogeneous collaborative networks and firm performance

Continuous pressures to shorten innovation cycle time and costs, together with the increasing need to enhance product quality and economic returns (Bodas-Freitas and Fontana, 2018), force firms to engage in collaborative networks, rendering the boundaries of innovation processes permeable to the outside environment (Alberti *et al.*, 2014; Mazzola *et al.*, 2016). Nowadays, more and more firms seek to gain competitiveness by effectively combining their own knowledge with that obtained through different interfirm cooperation strategies (Gkypali *et al.*, 2017). In line with RBV and its extension through KBV, collaborating with a variety of partners, that is, with more than one type of partner (i.e. heterogeneous collaborative network) is a key strategy to increase firm value through the exchange and sharing of resources (Das and Teng, 2000; Nieto and Santamaría, 2007), and is a possible solution for the usual lack of available knowledge within a firm (Miotti and Sachwald, 2003; Tsai, 2009). Moreover, these collaborative networks are an important vehicle for developing the dynamic capabilities a firm needs to pool and deploy both internal and external resources in its changing environment to gain economic advantages (Bogers, 2011; Teece *et al.*, 1997).

Prior research indicates that firms networking with functionally different partners in their innovation processes (Classen *et al.*, 2012; Nieto and Santamaría, 2007) can benefit from a more diverse set of knowledge, capabilities, resources and commercialisation opportunities (Garcia Martinez *et al.*, 2017; Jiang *et al.*, 2010). For instance, suppliers and universities can provide knowledge about firms' production processes, whereas customers and competitors can give firms greater market insights (O'Connor *et al.*, 2021). In this collaborative context, the potential for achieving improved firm performance would (mainly) come from exploiting synergies arising from complementarities between organisations located in distinct parts of the supply chain (Van Beers and Zand, 2014). These synergies can enrich firms' existing knowledge base by adding distinctive new variations and can therefore help them to gain more innovative opportunities (Ferreras-Méndez *et al.*, 2015). Hence, participating in heterogeneous collaborative networks is considered to be a fundamental driver of successful innovations (Garcia Martinez *et al.*, 2017) and thus, a potential source of increased performance outcomes.

Heterogeneous collaborative networks can provide a number of benefits to a firm, such as expanded search options, heterogeneous knowledge access and learning capabilities development (Jiang *et al.*, 2010; Moaniba *et al.*, 2020), which are helpful for superior firm performance. Establishing links with diverse partners can help firms improve their ability to manage and avoid pitfalls in new collaborations (Das and Teng, 2002), increase the efficiency of partnering strategies (Faems *et al.*, 2005), and achieve greater familiarity and trust between

partners (Van Beers and Zand, 2014), which together may lead to reduced transaction costs (Nooteboom, 1999). Likewise, firms networking with different partners are better able to develop useful specific competencies that allow them to capture as much relevant external knowledge as possible (Zahra and George, 2002), arguably benefiting the development of novel innovations. Moreover, collaborating with at least two types of partners can also motivate firms to enhance their absorptive capacity (Moaniba *et al.*, 2020), which is an essential competence in cooperation strategies (Spithoven *et al.*, 2010), to better assimilate, exploit and combine the varied sources of new knowledge provided by these partners (Laursen and Salter, 2006). In fact, the effective absorption of these knowledge inputs might enable firms to shorten their development cycles, propose more innovative solutions and increase their innovation productivity (Ferreras-Méndez *et al.*, 2015; Sisodiya *et al.*, 2013), circumstances that may lead to higher performance outcomes.

Whereas heterogeneous collaborative networks can provide these benefits, they are not a panacea and may in fact cause firms certain costs and problems that can compromise the functioning of the cooperation (Van Beers and Zand, 2014; Hottenrott and Lopes-Bento, 2016). Networking with more than one type of partner increase the risk of imitation or misappropriation, fear of free riding and more opportunistic behaviour (Stefan and Bengtsson, 2017), which may lead to significant leakage of sensitive knowledge (Chen *et al.*, 2011). Also, firms collaborating with different partners often face communication complexities that increase functional difficulties and hinder knowledge sharing and learning (Hsieh *et al.*, 2018). Similarly, the costs associated with coordinating and monitoring collaborations and integrating acquired external knowledge are likely to be compounded when engaging in a heterogeneous network (Laursen and Salter, 2014; Oerlemans *et al.*, 2013).

Notwithstanding these potential drawbacks, we contend that, under normal conditions, engaging in heterogeneous collaborative networks should provide firms with the required knowledge to gain substantial competitive advantages that lead to increased performance outcomes. Stated formally:

H1. The heterogeneous collaborative network positively influences firm performance.

Moderating role of family management

The success of heterogeneous collaborative networks depends on the appropriate leveraging of knowledge, synergies and partners relationships (Van Beers and Zand, 2014). In turn, such leverage requires the implementation of adequate governance mechanisms that enable value creation and appropriation of networks agreements (Huang and Chiu, 2018). Effective governance mechanisms are crucial to address knowledge acquisition and sharing problems, such as unintended knowledge spillovers, and to support the achievement of desired innovation goals (Feranita *et al.*, 2017). Appropriate governance can also facilitate interactions between different innovation partners along the supply chain, thereby promoting more sustainable and cooperative relationships that can lead to richer knowledge (Huang and Chiu, 2018).

In particular, governance mechanisms have gained much attention in the family firm context (for an overview see Chrisman *et al.*, 2018). This is because the active and simultaneous involvement of a family in the firm through ownership, management and control, results in unique objectives and values that influence firm strategies and choices (Goel *et al.*, 2014). Specifically, we identify family management as a governance mechanism that gives family members sufficient discretion over major business decisions (Ramírez *et al.*, 2021), and thus can exert a contingent impact on shaping the performance outcomes derived from heterogeneous collaborative networks.

Consistent with studies applying RBV and KBV in family firms (e.g. Cabrera-Suárez *et al.*, 2001), we argue that family managers are able to generate "familiness", a set of idiosyncratic resources and dynamic capabilities (Daspit *et al.*, 2019), which can endow family firms with competitive advantages to enhance the heterogeneous collaborative network–firm performance relationship (Feranita *et al.*, 2017). This familiness is likely to be magnified as the interplay between the family and the firm becomes stronger (Le Breton-Miller *et al.*, 2011), i.e. as the number of family members involved in management increases.

Family managers are characterised by an affective or emotional commitment to the firm and stakeholders (Gottardo and Moisello, 2015), as part of the socioemotional wealth endowment that such managers derive from its controlling position (Gómez-Mejía *et al.*, 2007). This commitment encourages them to work with initiative and devotion (Miller *et al.*, 2015), and in turn, allows building a profound and shared comprehension of how operations are conducted inside and outside the firm (Muñoz-Bullón *et al.*, 2020). Consequently, family managers possess a deeply embedded tacit knowledge about the firm's intangible resources, routines and environment (Nieto *et al.*, 2015). This tacit knowledge, created through family managers' long-term interactions with the organisational stakeholders, fosters knowledge transfer and mutual learning, and is key to strengthening bonds in a heterogeneous collaborative network (Muñoz-Bullón *et al.*, 2020). Likewise, the social capital of family managers is characterised by the tested ability to cultivate, nurture and develop long-standing linkages across generations with firms' stakeholders (Miller and Le-Breton-Miller, 2005). In fact, this social capital is a crucial resource that can contribute to higher firm performance derived from heterogeneous collaborative networks, because it promotes knowledge management (Yli-Renko *et al.*, 2001) and facilitates sharing and utilisation of tacit knowledge (Holste and Fields, 2010). Particularly, family managers have been proven to boost firms' economic motivation to learn from its environment and make the most of unique external opportunities (Zahra, 2012). This motivation may contribute to improved knowledge management, relational and collaboration capabilities (Duran *et al.*, 2016; Sisodiya *et al.*, 2013), resulting in higher quality linkages within a collaborative network (Roessl, 2005). Thereby, a higher number of family managers will maximise the benefits derived from collaborating with more than one type of partner, resulting in a richer variety of knowledge (Feranita *et al.*, 2017), while reducing the negative effects of unwanted resource spillovers or misappropriation risks (Tsao and Lien, 2013), potentially leading to superior firm performance. Hence, the performance gains from heterogeneous collaborative networks are expected to become more important as the presence of family managers in the firm increases. Thus, we posit:

H2. Family management strengthens the positive relationship between the heterogeneous collaborative network and firm performance.

The influence of intellectual property rights for the moderating effect

We believe that the effect of family management on the heterogeneous collaborative network–firm performance link could be reinforced in a technically secure environment. In this regard, we argue that the increased performance outcomes stemming from collaborative innovation strategies that family managers achieve also depend on factors that allow coping with the tension between sharing and protecting knowledge (Bogers, 2011). Therefore, a specific factor that can impact on family management to enhance the relationship between heterogeneous collaborative network and firm performance is IPRs.

IPRs have the potential to shape the competitive setting in which the decision of family managers to participate in a heterogeneous collaborative network is made, and can therefore affect the willingness and ability of these managers in their choice to open their firms' door to different partners (Gjergji *et al.*, 2019). The presence of effective IPRs is an important

contingency when examining heterogeneous collaborative networks, as these rights are key to protecting the know-how and tacit knowledge of family managers, especially in the early stages of negotiation (Hertzfeld *et al.*, 2006). Similarly, IPRs are essential to augment family managers' awareness of their ability to appropriate performance gains from collaborations with more than one type of partner (Carney *et al.*, 2019; Cohen *et al.*, 2000). Moreover, a high degree of technical protection, in the form of IPR, can help family managers prevent potential imitations or misappropriations of their technologies and increase their security against problems of unintended knowledge spillovers or opportunistic behaviour (Kotlar *et al.*, 2013). A high level of technical protection can also be viewed as a safeguard against uncertainty related to control losses over the path that technology follows over time (Gambardella *et al.*, 2007), increasing managers' perception of power relative to the different partners, and lowering family managers' cognition of risks linked to potential losses of socioemotional wealth (Kotlar *et al.*, 2013). In this light, IPRs has become an effective means not only to strengthen the family name and reputation vis-à-vis different partners in a competitive environment, but also to preserve the family socioemotional wealth (Bannò, 2016; Gómez-Mejía *et al.*, 2011). For the above reasons, we consider that IPRs will enable family managers to reinforce the effect of the heterogeneous collaborative network on performance outcomes. Hence, we hypothesise:

H3. IPR reinforces the strengthening effect that family management exerts on the heterogeneous collaborative network–firm performance relationship.

Our theoretical framework is shown in Figure 1.

Research method

Sample and data sources

The data source for this study is the Survey on Business Strategies (ESEE), assembled by the SEPI Foundation in cooperation with the Spanish Ministry of Industry. The ESEE constitutes a representative sample of the Spanish manufacturing industry in the form of an unbalanced panel. Firms in the ESEE database are chosen through a combination of census schemes (firms employing more than 200 people) and random sampling (firms employing between 10 and 200 people). The emphasis on the Spanish manufacturing industry is particularly suitable to analyse firm performance in a collaborative innovation environment, since 4 of 10 Spanish firms conducting innovation belong to this industry (CEOE, 2018), 47.50% of total innovation investment made in Spain is developed by manufacturing firms (CEOE, 2018), and in these industries firms' products are often composed of components or subsystems produced by innovation partners (Gjergji *et al.*, 2020). Additionally, the quality

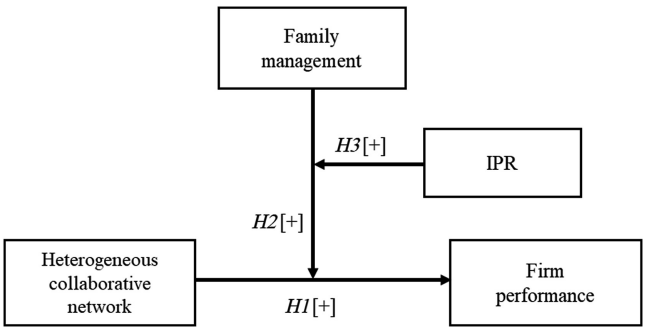

Figure 1.
Theoretical framework

and consistency of the information included in the ESEE is guaranteed because it emanates from a public body through a process that ensures a high level of participation, a high response rate and a good representation of the population (Dorling and Simpson, 1999). Our sample includes 10,985 firm-year observations from 1,766 Spanish manufacturing firms, over the 2007–2016 period. A total of 45.19% of the sample are considered to be family firms, and 54.81% are considered non-family firms.

Variables

Dependent variable. Firm performance. Return on assets (ROA) is chosen to measure the dependent variable, as it reflects the ability of a firm's assets to generate profit and is the most common performance indicator in strategic management literature (López-Delgado and Diéguez-Soto, 2015). We calculate each firm's ROA as earnings before interest and taxes to total assets. In addition, to avoid potential endogeneity problems and to facilitate causal inference, a one-year lag between independent and dependent variables is selected.

Independent variable. Heterogeneous collaborative network. The ESEE reports with four dichotomous variables whether firms have engaged in collaborative innovation with suppliers, customers, competitors and/or universities. Following Gjergji *et al.* (2020), to measure the heterogeneous nature of collaborative networks, we created the dichotomous variable *heterogeneous collaborative network* for those firms that collaborate with more than one type of partner. This variable takes the value 1 if the firm has collaborated with at least two different innovation partners and zero otherwise (Nieto and Santamaría, 2007).

Moderating variables. Family management. For all those firms that belong to a family group, the ESEE database reports the number of owners and owner's relatives who hold managerial positions. Accordingly, family management is measured as a continuous variable counting the number of family members in top managerial positions within the family firm (Kotlar *et al.*, 2013; Muñoz-Bullón *et al.*, 2020).

IPR. Patents represent an important IPR mechanism to protect proprietary knowledge (Beneito, 2006) and are an effective means to increase defences against rivalry problems that may arise in collaborative innovation networks (Bigliardi and Galati, 2018). Following previous studies (e.g. Bannò, 2016), we consider the propensity to patent as a suitable indicator to capture a firm's attitude towards using patents as an IPR mechanism. Accordingly, we measure IPR as the ratio of patents filed during the year and firms' research and development (R&D) expenditures (Scherer, 1983).

Control variables. The study also controls for variables that could affect firm performance. Because size is likely to influence a firm's ability to engage in collaborative networks, and thus its performance, we control for *firm size* calculated as the natural log of the number of employees (Caputo *et al.*, 2016). As firm performance depends on firm capabilities formed through experience over time (Cruz-Cázares *et al.*, 2013), we control for *firm seniority*, using a dummy variable that takes the value 1 if the firm is older than 30 years and 0 otherwise. To the extent that internationalisation and diversification have become two key strategies choices to improve firm performance (Arte and Larimo, 2022), we control for internationalisation, measured by the ratio of export sales to total sales, and for diversification, calculated using a binary indicator operationalised as 1 if the firm is diversified (including related diversification and/or unrelated diversification), and 0 otherwise. Given that businesses with richer resource endowments have higher levels of financial slack to initiate collaborations and achieve greater performance, we control for *firm leverage*, calculated as the ratio of the firm's debt to total assets (Kotlar *et al.*, 2013). Since customer dependence can influence firm performance, we control for *customer bargaining power (CBP)*, measured as the percentage of sales obtained from the three major customers (Martínez-Alonso *et al.*, 2020). Furthermore, as differences between subindustries can lead to

varying degrees of firm performance (Muñoz-Bullón and Sanchez-Bueno, 2011), we control for *industry effects* by including 20 dummy variables representative of the subindustry to which the firm belongs. Finally, to control for potential *year effects*, we add a set of dummy variables for the years considered in our study.

Data analysis method

Because of the panel structure of the sample, i.e. repeated cross-sectional observations of the same set of firms over time, we use a panel data methodology (Greene, 2000). Even though it is often necessary to distinguish between fixed-effects and random-effects when using panel data, the time invariant nature of the industry dummies prevents us from using fixed-effects (Diéguez-Soto and López-Delgado, 2019; Martínez-Alonso *et al.*, 2020). Accordingly, we use random-effects general linear squares (GLS) panel models. In addition, we calculate robust standard errors using the Huber–White Sandwich estimator for clustered data to control for heteroskedasticity and potential serial correlation problems.

Results

Descriptive statistics

Table 1 presents descriptive statistics and correlations of the variables. In terms of dependent and independent variables, firm performance is 0.10 on average and about 27.00% of the sampled firms collaborate with more than one type of innovation partner. As for moderators, family management is 0.91 on average, and IPR is 0.05 on average. Regarding correlations, worth is noting that heterogeneous collaborative network, family management and IPR are positively correlated to firm performance. An examination of the variance inflation factor (VIF) scores show that multicollinearity is not a concern. The VIF scores range from 1.01 to 1.20, well below the critical value of 10 suggested by Neter *et al.* (1989). Additionally, to alleviate multicollinearity problems arising in interaction models and to achieve more easily interpretable estimates, we use mean-centred variables in our analysis (Aiken and West, 1991).

Regression results

Table 2 reports the results of the random-effects GLS regressions, allowing us to test H1 and H2. We begin the regression analysis by adding only control variables (Model I). Both firm size ($\beta = 0.073$; $p < 0.01$) and CBP ($\beta = 0.003$; $p < 0.01$) have a positive and significant impact on firm performance. We also observe that firm seniority ($\beta = -0.219$; $p < 0.01$) and firm leverage ($\beta = -0.656$; $p < 0.01$) have a negative and significant influence on the dependent variable. Model II permits us to test H1. Heterogeneous collaborative network has a positive and significant effect on firm performance ($\beta_1 = 0.136$; $p < 0.01$), which confirms H1. Therefore, collaborations with more than one type of partner will lead to improved firm performance.

Model III includes the variable family management. The results indicate that the participation of family members in the firm's TMT has no significant direct effect on firm performance. Model IV then introduces the two-way interaction effect *heterogeneous collaborative network*$_{t-1}$ × *family management*$_{t-1}$ to capture the extent to which family management moderates the heterogeneous collaborative network–firm performance relationship. The coefficient of the two-way interaction term is positive and significant ($\beta_{31} = 0.060$; $p < 0.05$), supporting H2. Hence, as the coefficient of the two-way interaction term is significant, and the direct effect of family management on firm performance is not significant, the presence of a pure moderating effect is revealed (Baron and Kenny, 1986). Figure 2 also reveals that firm performance is optimised when firms collaborate with at least two different partners and the level of family management is high.

Table 1.
Descriptive statistics and correlation matrix

Variables	Mean	SD	1	2	3	4	5	6	7	8	9	10
1. Firm performance	0.10	0.16	1.00									
2. Heterogeneous collaborative network	0.27	0.44	0.03***	1.00								
3. Family management	0.91	1.05	0.03***	−0.12***	1.00							
4. IPR	0.05	0.64	0.06***	0.01	0.05***	1.00						
5. Firm size	4.12	1.39	0.02**	0.35***	−0.27***	−0.05***	1.00					
6. Firm seniority	0.41	0.49	−0.04***	0.09***	−0.04***	−0.03**	0.21***	1.00				
7. Internationalisation	0.26	0.30	0.03***	0.24***	−0.16***	−0.01	0.41***	0.16***	1.00			
8. Diversification	0.15	0.35	−0.01	0.06***	−0.02**	0.05***	0.08***	0.07***	0.03***	1.00		
9. Firm leverage	0.50	0.23	−0.05***	0.04***	−0.04**	−0.01	0.10***	−0.11***	0.01	−0.01	1.00	
10. CBP	45.46	28.46	0.06***	−0.02**	−0.10***	−0.02	−0.02**	−0.09***	−0.05***	−0.05***	0.05***	1.00
Variance inflation factor				1.05	1.11	1.01	1.20	1.04	1.06	1.02	1.07	1.05

Note(s): SD = standard deviation. ***$p < 0.01$., **$p < 0.05$

Table 2.
Random-effects GLS regression results

DV: Firm performance—ROA	Hypothesis	Model I	Model II	Model III	Model IV
Main effect					
Heterogeneous collaborative network$_{t-1}$ (β_1)	H1 (+)		0.136***(0.039)	0.137***(0.039)	0.087**(0.049)
Moderator					
Family management$_{t-1}$ (β_{21})				0.033 (0.020)	0.016 (0.024)
Interaction effect					
Heterogeneous collaborative network$_{t-1}$ × family management$_{t-1}$ (β_{31})	H2 (+)				0.060**(0.030)
Controls					
Firm size		0.073***(0.023)	0.056** (0.023)	0.060***(0.023)	0.062***(0.023)
Firm seniority		−0.219***(0.048)	−0.204***(0.049)	−0.207***(0.049)	−0.202***(0.049)
Internationalisation		0.055 (0.100)	0.087 (0.101)	0.090 (0.101)	0.090 (0.101)
Diversification		0.056 (0.065)	−0.010 (0.060)	0.001 (0.060)	0.003 (0.060)
Firm leverage		−0.656***(0.117)	−0.653***(0.122)	−0.651***(0.122)	−0.652***(0.122)
CBP		0.003***(0.001)	0.004***(0.001)	0.003***(0.001)	0.003***(0.001)
Industry and year dummies		Included	Included	Included	Included
Intercept		1.246***(0.152)	1.200***(0.153)	1.135***(0.159)	1.143***(0.159)
Number of observations		10,985	10,985	10,985	10,985
R^2 within, between, overall		0.03;0.03;0.03	0.02;0.04;0.03	0.02;0.04;0.03	0.02;0.04;0.03
Wald chi-square		294.90***	268.36***	274.87***	280.69***

Note(s): DV = Dependent variable. Robust standard errors in parentheses. ***$p < 0.01$., **$p < 0.05$., *$p < 0.10$

Table 3 presents the results of the random-effects GLS regressions, enabling us to test H3. Model VI shows that the coefficient of the three-way interaction term *heterogeneous collaborative network*$_{t-1}$ × *family management*$_{t-1}$ × *IPR*$_{t-1}$ is positive and significant ($\beta_{34} = 0.138, p < 0.05$). IPR thus positively moderates the effect that family management has

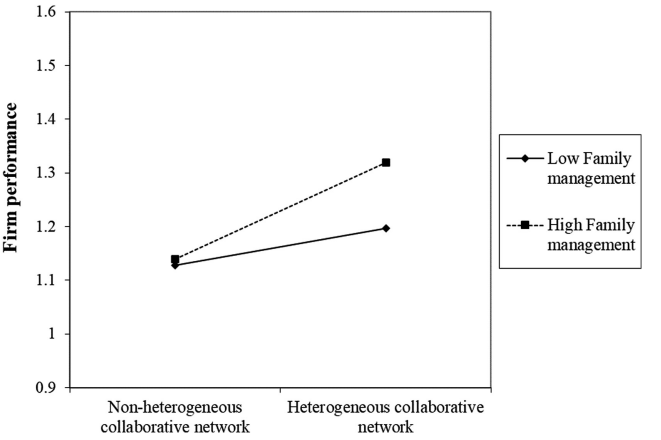

Figure 2.
Two-way interaction among heterogeneous collaborative network and family management, and its effects on firm performance

DV: Firm performance—ROA	Hypothesis	Model V	Model VI
Main effect			
Heterogeneous collaborative network$_{t-1}$ (β_1)		0.097** (0.045)	0.059 (0.054)
Moderator			
Family management$_{t-1}$ (β_{21})		0.013 (0.021)	−0.012 (0.029)
IPR$_{t-1}$ (β_{22})		0.085** (0.038)	0.020 (0.091)
Interaction effect			
Heterogeneous collaborative network$_{t-1}$ × family management$_{t-1}$ (β_{31})			0.044 (0.035)
Heterogeneous collaborative network$_{t-1}$ × IPR$_{t-1}$ (β_{32})			0.031 (0.095)
Family management$_{t-1}$ × IPR$_{t-1}$ (β_{33})			0.003 (0.023)
Heterogeneous collaborative network$_{t-1}$ × family management$_{t-1}$ × IPR$_{t-1}$ (β_{34})	H3 (+)		0.138** (0.068)
Controls			
Firm size		−0.001 (0.030)	−0.003 (0.030)
Firm seniority		−0.157** (0.065)	−0.154** (0.065)
Internationalisation		0.181* (0.109)	0.184* (0.109)
Diversification		0.064 (0.081)	0.075 (0.081)
Firm leverage		−0.804***(0.158)	−0.799***(0.158)
CBP		0.002 (0.002)	0.002 (0.002)
Industry and year dummies		Included	Included
Intercept		1.505***(0.220)	1.527***(0.221)
Number of observations		3,963	3,963
R^2 within, between, overall		0.02;0.06;0.06	0.03;0.07;0.06
Wald chi-square		122.03***	140.38***

Note(s): DV = Dependent variable. Robust standard errors in parentheses. ***$p < 0.01$., **$p < 0.05$., *$p < 0.10$

Table 3.
Random-effects GLS regression results

on the relationship between heterogeneous collaborative network and firm performance. This result provides support for H3. We also plotted the significant three-way interaction effect in Figure 3, verifying that firm performance is optimised when firms collaborate with more than one type of partner and the levels of family management and IPR are high.

To make our results robust, we conducted additional tests (results available upon authors' request). First, we estimated the full (three-way interaction) model using structural equation modelling (SEM) to minimise potential endogeneity problems (Liu *et al.*, 2019). The results were similar to those of Model VI (Table 3). Second, we followed the approach suggested by Landis and Dunlap (2000) and assessed the reverse causality between heterogeneous collaborative network and firm performance. Accordingly, we set firm performance as the independent variable and heterogeneous collaborative network as the dependent variable. Neither firm performance nor the two- and three-way interaction terms on heterogeneous collaborative network were significant in any of the models, thus supporting the causal directions argued in our theorising. Third, we replicated the models using the natural log of ROA (e.g. Cruz *et al.*, 2014) and an alternative performance measure, i.e. ROI (e.g. Martínez-Romero and Rojo-Ramírez, 2017), as dependent variables. The results obtained are quite similar to those reported in Tables 2 and 3, but less significant in the case of ROI.

Discussion and conclusions

This paper, grounded on RBV and its extension through KBV, aims to advance extant knowledge on the link between heterogeneous collaborative networks and firm performance. Moreover, this study also examines the conditions under which family management and IPRs can facilitate richer firm performance derived from heterogeneous collaborative networks. To do so, we apply random-effects GLS regressions to a panel data sample of 10,985 firm-year observations from 1,766 Spanish manufacturing firms from 2007 to 2016.

In line with our first hypothesis, we find empirical evidence on the beneficial effect of heterogeneous collaborative networks on firm performance. This result follows prior research showing that networking with different types of partners is a potential source of knowledge and capabilities that firms need to be competitive in terms of innovation (Nieto and Santamaría, 2007; Tsai, 2009; Zeng *et al.*, 2010) and, consequently, to achieve better performance outcomes (Sisodiya *et al.*, 2013; Wang *et al.*, 2015). Regarding our second hypothesis, our findings show that high levels of family management strengthen the positive incidence of the heterogeneous collaborative network on firm performance. This is consistent with previous findings revealing that, because of their unique tacit knowledge and social

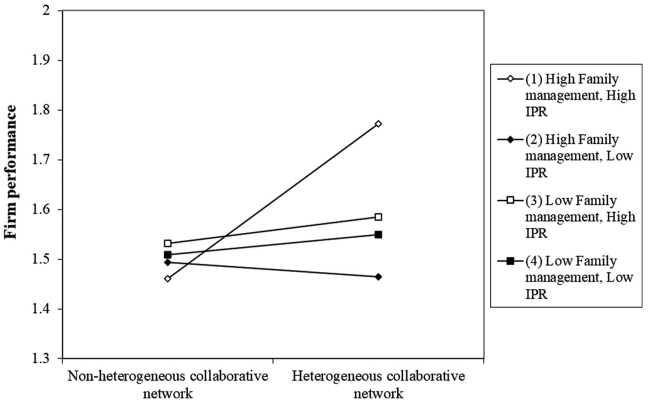

Figure 3.
Three-way interaction among heterogeneous collaborative network, family management, and IPR and its effects on firm performance

capital, family managers are able to derive higher returns from collaborative networks (Llach and Nordqvist, 2010; Muñoz-Bullón *et al.*, 2020; Nieto *et al.*, 2015). As for our third hypothesis, our results reveal that technical protection, in the form of IPRs, reinforces the positive effect of family management on the heterogeneous collaborative network–firm performance relationship. This is in line with previous studies showing that high degrees of technical protection reduce family managers' cognition of risks related to loss of socioemotional wealth, which increases the likelihood of improved performance outcomes due to the adoption of open innovation strategies (Kotlar *et al.*, 2013; De Massis *et al.*, 2015).

Accordingly, this research makes valid contributions to the academic sphere. First, by building on the RBV with insights from KBV, it enriches the lively debate on the effect of heterogeneous collaborative networks on firm performance. In doing so, this study reveals that the heterogenous nature of the collaborative network is the key to improve firm performance. Being embedded in a heterogeneous collaborative network opens firms' eyes to the imperative of accessing ideas and information from diverse sources to broaden their knowledge base. When this occurs, firms are in a better position to enhance their performance outcomes.

Second, our study also advances the notion that the heterogeneous collaborative network–firm performance relationship is not always straightforward (Cruz-González *et al.*, 2015; Liao *et al.*, 2020; Sisodiya *et al.*, 2013). In this regard, our study highlights two under-explored contingent factors, namely family management and IPRs, with the potential to assist in better capturing performance outcomes obtained through collaborative innovation strategies. This is of paramount importance, as improved firm performance depends not only on establishing collaborations with different types of partners, but also on appropriate bundles of firms' resources and dynamic capabilities (Ahn *et al.*, 2018; Martínez-Alonso *et al.*, 2020).

Third, by examining the contingent role of family management in the heterogeneous collaborative network–firm performance relationship, this paper adds to the emerging research stream on collaborative innovation in family firms (Feranita *et al.*, 2017). In doing so, this study demonstrates that family management is a powerful governance mechanism that unleashes the benefits of heterogeneous collaborative networks to generate superior firm performance. In fact, despite the relevance of family firms worldwide (Family Firm Institute, 2018), collaborative innovation remains a sparingly research topic within this type of businesses (Bigliardi and Galati, 2018; Gjergji *et al.*, 2019).

Fourth, by adding IPRs in a three-way interaction model and testing their effect on firm performance, we also contribute to the ongoing research path analysing IPRs in family firms' openness decisions (Kotlar *et al.*, 2013; De Massis *et al.*, 2015). To the best of the authors' knowledge, this is one of the first studies revealing that IPRs is a key factor to enhance the role of family managers in boosting the performance gains derived from heterogeneous collaborative networks.

Finally, it is important to highlight that the synergistic combination of family management and IPR when studying the relationship between heterogeneous collaborative network and firm performance (Liao *et al.*, 2020) is essential to obtain more fine-grained results regarding such a complex relationship.

Managerial implications

The findings of this study also have implications for firms and their managers. We find that participating in heterogeneous collaborative networks improve performance outcomes; therefore, firm managers in charge of leading and coordinating these collaborative activities should pay special attention to the network composition, as it is a determining factor for the development of competitive advantages and the derived performance gains. Our study also advocates increasing the number of family members within the firm management, since they

have proven to be an effective means of boosting the performance gains derived from heterogeneous collaborative networks. Nevertheless, the inclusion of more family managers in the running of collaborations requires caution. This is because the rushed inclusion of family managers who do not possess sufficient technical skills (Zahra, 2005), or who have a high potential for free-riding and shirking behaviours (Ramírez *et al.*, 2021), may result in reduced performance due to the mismanagement of heterogeneous collaborative networks. Moreover, our study calls for the adoption of more IPRs, as through them family managers can be more confident to open the firms' door to partners, which in turn, might improve performance outcomes. Additionally, public authorities could promote mechanisms, associations and networks to facilitate collaborative innovation, either through funding or through the creation of research consortiums, to train family managers in collaborative skills to establish more prosperous and long-standing bonds with different partners.

Limitations and future lines of research

This study is not free from limitations that, in turn, give rise to future fruitful lines of research. The ESEE is conducted in Spain and is focused on manufacturing firms. Thus, other geographical settings and other types of industries might exhibit distinct characteristics in relation to the examined variables in this paper. Hence, future studies may test our models to see whether our findings hold in other contexts. Moreover, future studies could delve deeper into the contingent factors underlying the heterogeneous collaborative network–firm performance relationship. First, with respect to the firms' family nature, due to database limitations, we were not able to measure the percentage of family ownership nor the percentage of family management. Thus, future studies should consider these variables and could also explore the internal structure of family firms in terms of generations represented, gender or educational diversity. Second, future research could analyse other IPRs, such as copyrights, trademarks and trade secrets, to help family managers keep their distinctive goals safe to improve performance gains.

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