



When the paradox of openness meets the paradox of ability-willingness: family ownership and open innovation partnerships

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Abstract Although it is of great significance to investigate the paradox of openness in family firms, there remains a lack of research on how it differs when family firms engage in open innovation with different types of partners. By distinguishing open innovation with market- and science-based partners, this paper investigates the direct impact of family ownership on these two types of partnerships and the moderating role of intellectual property rights (IPR) protection and political ties. Based on the ability-willingness paradox framework, we hypothesize that family ownership has an inverted U-shaped impact on market-based partnerships while positively impacting science-based partnerships. In addition, the turning point of the relationship between family ownership

and market-based partnerships shifts to the right with greater IPR protection or stronger political ties. The positive impact of family ownership on science-based partnerships is strengthened by IPR protection and political ties. These hypotheses are tested using a sample of 649 manufacturing family firms in China. We clarify why and how both the openness and ability-willingness paradox change when family firms collaborate with different open innovation partners and under varying institutional contexts.

Plain English Summary Firms must align their internal processes with the external environment to engage in open innovation. This approach brings external knowledge into the firm and increases appropriability risks. Although such a challenging situation exists in family and nonfamily firms, little is known about how this paradox operates among family firms. We find that family ownership has an inverted U-shaped impact on market-based partnerships and a positive impact on science-based partnerships by distinguishing between open innovation partners as market- and science-based. These impacts evolve under two significant institutional contingencies: IPR protection and political ties. Our study demonstrates how family firms' ability and willingness can change with family ownership and institutional contexts. Policymakers and family firm practitioners should consider these findings to encourage family firms' open innovation partnerships.

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1 Introduction

With growing technology competition, open innovation is becoming increasingly important for family firms to innovate with limited resources (De Massis et al., 2018). Open innovation with external entities allows firms to pool their information, knowledge, and expertise to achieve common goals (van Beers & Zand, 2014), facilitating idea generation, problem-solving, and new product development (Ardito et al., 2019). However, openness is not without costs. The more open a firm is, the greater its challenge in implementing appropriability mechanisms to protect its knowledge and profits from innovations, also known as the paradox of openness (Laursen & Salter, 2014). This challenge can be even more severe for family firms, as they are extraordinarily sensitive to knowledge spillover and losing technological control (Bendig et al., 2020). It is not surprising that much of the literature on family firms, grounded in behavioral theory, argues that family firms tend to rely less on external sources of knowledge for innovation (Casprini et al., 2017; Classen et al., 2012; Kotlar et al., 2013).

However, from the resource-based view, the literature also indicates that family firms can use their unique family resources, such as familiness (Zellweger et al., 2010), family social capital (Herrero et al., 2022), and patient capital (Sirmon & Hitt, 2003), to engage in open innovation. With contradictory arguments and evidence, it has been suggested that family firms can experience a paradox of ability and willingness in their innovation behavior (Chrisman et al., 2015; De Massis et al., 2014). Although unique family resources give them a superior ability to identify opportunities and acquire knowledge beyond their boundaries, their idiosyncratic non-economic goals limit their willingness to engage in open innovation. However, little attention has been paid to how family characteristics and external contingencies alter the ability and willingness paradox when executing open innovation strategies.

In addition, family firms are not equal (Daspit et al., 2021). Recently, scholars have investigated the heterogeneity of family firms' open innovation behavior. For instance, family firms with more nonfamily members tend to collaborate more with external actors (Pellegrini & Lazzarotti, 2019). In contrast, family firms with higher family ownership are less likely to cooperate with external parties during the R&D process (Dong et al., 2022). Although these studies provide an initial understanding of how family firms exhibit varying levels of openness, they have largely ignored the heterogeneity originating from open innovation partnerships. Scholars have long called for distinctions between market-based (competitors, customers, and suppliers) and science-based partners (universities and public research institutions) because they may exhibit dissimilar threats to socioemotional endowment and appropriability (Chrisman et al., 2015), which can further influence the willingness to build open innovation partnerships. For example, compared to market-based partnerships, collaborations with universities or research institutions are believed to pose fewer threats to family control over new technology development (De Massis & Frattini et al., 2015; Kotlar et al., 2013; Miotti & Sachwald, 2003).

The current study addresses these gaps by distinguishing between market-based and science-based partnerships and examining the impacts of family ownership on them. From the ability-willingness paradox approach, family involvement in ownership, management, and governance gives family firms the ability to pursue family-oriented needs (De Massis et al., 2014). We argue that family ownership can lead to heterogeneous ability and willingness to engage in open innovation partnerships. Furthermore, while the ability-willingness paradox approach has contributed to the understanding of heterogeneous innovation behavior among family firms, how this paradox evolves under various institutional contexts remains largely unexplored (Chrisman et al., 2015). For example, robust IPR protection can reduce unexpected knowledge spillovers and mitigate imitation risks during open innovation partnerships (Veer et al., 2016), potentially altering the ability-willingness paradox of family firms.

We examine the direct impact of family ownership on open innovation partnerships and the moderating roles of institutional contexts using a sample of 649

manufacturing family firms in China. On one hand, manufacturing firms face rapidly changing technological competition, necessitating greater external cooperation (Obradović et al., 2021). On the other hand, the Chinese government controls admittance, subsidies, and low-interest loans which could affect business investments (Yan et al., 2020). Both formal and informal institutions can shape family firms' open innovation partnerships. Formal institutions, such as IPR protection, provide legal protection, ensuring the standardization of partnerships (Grimaldi et al., 2021). Informal institutions, such as political ties, foster identity and trust, reducing risks during partnerships (Zhang et al., 2020). Therefore, Chinese manufacturing family firms provide a valuable empirical setting to investigate family firms' open innovation partnerships and the contextual influences of institutions.

This study is positioned to provide a deeper understanding of an under-researched field in family firms' open innovation partnerships and contributes to the family firms' literature in the following ways. First, this study responds to calls for detailed empirical analysis of the types of open innovation partnerships among family firms (De Massis & Frattini et al., 2015). Family ownership leads to a dissimilar emphasis on appropriability, exerting a distinct impact on market- and science-based partnerships. Second, by introducing institutional settings, including IPR protection and political ties, into the ability-willingness paradox, the study contributes to how the paradox diverges across different institutional contexts. This provides potential solutions to the dilemma faced by family firms with high ability but low willingness, such as establishing robust IPR protection and developing stronger political ties. Finally, this study advances our understanding of how organizations address tensions and paradoxes in open innovation (Bertello et al., 2024), particularly the openness paradox in family firms. It provides evidence that family ownership influences concerns over appropriability risks. In addition, family firms encounter varying appropriability risks across different open innovation partnerships and institutional contexts. This deeper analysis of family firm heterogeneity helps explain why and how family firms vary in open innovation partnerships (Rovelli et al., 2022). These theoretical developments enhance understanding of the openness paradox, ability-willingness paradox, and

the heterogeneity of family firms' open innovation behavior.

2 Theoretical background

2.1 Family firms and open innovation partnership

Open innovation can boost innovation performance by incorporating information, knowledge, and financial capital from external partners. Studies have proven the positive effect of openness on both innovation performance (Fang, 2011; Mention, 2011) and financial performance (Faems et al., 2010; Lahiri & Narayanan, 2013). However, open innovation is not harmless; openness to external technology resources limits firms' control over technological trajectories and threatens their appropriability (Almirall & Casadesus-Masanell, 2010), also known as the "paradox of openness" (Laursen & Salter, 2014). In addition, because family owners value technology as a family legacy and exhibit an extraordinary desire for control, open innovation poses greater challenges for family firms.

Family firms are concerned not only with financial returns but also with a set of family-specific, non-financial goals (Gmez-Meja et al., 2007). Strong evidence indicates that family firms place high importance on maintaining control over capital, decision-making, and technologies (Calabrò et al., 2019; Gmez-Meja et al., 2007). Since open innovation disperses firms' control over technology trajectories, family firms tend to engage in external knowledge sourcing less than nonfamily firms (De Massis et al., 2015). This aligns with research comparing external technology acquisition between family and nonfamily firms, which suggests that family firms are more reluctant to acquire external technology (Kotlar et al., 2013).

However, not all open innovation partners are equal (Lambrechts et al., 2023). A more rigorous analysis should have been conducted to distinguish between open innovation with types of partners, especially market-based and science-based partners (De Massis et al., 2015), as they can exhibit varying threats to control loss and dissimilar risks to socioemotional wealth (SEW) endowments. Market-based partners refer to cooperative relationships with market participants, such as competitors, suppliers,

and customers (Gama et al., 2017). Open innovation with market-based partners enables the focal firm to access the latest market information and innovative knowledge. This facilitates the early identification of potential technology development issues, enhancing product reliability and performance (Bodas Freitas & Fontana, 2018). In addition, open innovation with customers can provide family firms with first-hand information on market demands, enabling them to respond quickly to market changes (Statsenko & Corral De Zubielqui, 2020). However, market-based partnerships can exhibit greater value-appropriation risks because the focal family firms and the market-based partners desire monopoly rents (Belderbos et al., 2014). Market-based partners tend to focus on short-term outcomes, preferring transaction-oriented collaboration (Cui et al., 2018).

Science-based partnerships are collaborations with scientific partners, such as universities and research institutions (Na et al., 2023). These partnerships involve R&D processes incorporating the latest scientific knowledge, encompassing tacit specialized knowledge and unpublished codified knowledge. Such collaboration leverages the latest research findings, enriching the firm's innovation capabilities (Montoro Sánchez et al., 2011). As a guide for applied research, scientific knowledge enables R&D personnel to understand the technological landscape they are navigating in their search for technical solutions. Compared to market-based partners, universities or research institutions prioritize knowledge exploration and long-term technology development. As a result, they are less likely to compete intensely for monopoly rents with the focal family firms.

In addition, for market-based partners, formal relationship management, such as regular monitoring and strict adherence to pre-set plans, is more conducive to the success of open innovation by preventing unnecessary knowledge spillover (Du et al., 2014). On the other hand, informal relationship management approaches foster exploratory and innovative research activities with science-based partners, as they focus more on open academic exchanges and knowledge sharing to raise scientific advancement and technological innovation.

Although collaborations with market-based and science-based partners carry risks, the predominant types differ. Market-based partners face less risk in technology development and gain a more predictable

future income due to their close alignment with market demands. However, they encounter a higher appropriability risk due to potential knowledge spillover and an emphasis on excess returns. In contrast, science-based partners face greater technological risks and longer times for technology commercialization, as their cooperation involves cutting-edge research and exploration of unknown fields. However, the appropriability risk from science-based partners is lower, as they possess leading knowledge, which is likely to yield substantial future profits compared to the focal firm. Therefore, we distinguish between market-based and science-based partnerships, with one prioritizing profit goals and the other prioritizing technological development.

2.2 The ability-willingness paradox

The ability-willingness framework is introduced to provide a more reliable and credible explanation of family-oriented particularistic behaviors (De Massis et al., 2014). For family firms to behave idiosyncratically compared to nonfamily firms, they must simultaneously possess the power to access, allocate, and dispose of resources, referred to as ability, as well as the propensity to drive the firms toward family-specific goals, intentions, and motivations, referred to as willingness. The ability-willingness paradox has been further applied to family firms' innovation (Chrisman et al., 2015), organizational ambidexterity (Veider & Matzler, 2016), product development (Chirico & Salvato, 2016), international joint venture formation (Debellis et al., 2021), and servitization (Rondi et al., 2021).

Compared to other capability frameworks, such as dynamic capabilities, the ability-willingness framework focuses on the paradoxical nature of both ability and willingness in family firms rather than isolated aspects of capability. Dynamic capabilities refer to the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments (Teece et al., 1997). Although both frameworks converge in explaining how firms' valuable and inimitable resources create core abilities, the underlying targets of these frameworks are not the same. The dynamic capabilities framework is aimed at answering how firms get sustainable competitive advantages in changing environments, whereas the ability-willingness framework strives to explain

family firms' particularistic behaviors. Table 1 overviews the two frameworks and their convergences and differences.

Family firms are an organic integration of the family system with the business system (Basco & Pérez Rodríguez, 2009). This integration provides the firm with unique resources, such as family social capital and patient capital, and unique behavioral intentions, such as family harmony, reputation, and values. Family involvement in ownership, management, and governance grants family firms the discretion to pursue family-oriented particularistic behaviors (De Massis et al., 2014). Both ability and willingness do not always change simultaneously with family involvement in the same pattern, leading to paradoxical situations, such as higher ability with lower willingness. This also contributes to a better understanding of the heterogeneous behaviors of family firms, as both ability and willingness vary considerably among family firms. In addition, varying external contexts, such as industrial sectors, institutional settings, and spatial contexts, can also alter the scenarios of ability and willingness (Chrisman et al., 2015). However, how external contexts shape the ability-willingness paradox to act differently remains unclear.

Regarding open innovation, it is believed that family firms possess high ability but low willingness for open innovation, resulting in lower openness than nonfamily firms (Casprini et al., 2017; Classen et al., 2012; Kotlar et al., 2013). On one hand, family firms are more capable of managing cooperative

relationships compared to nonfamily firms. Family firms are more flexible in managing resource exchange by relying on informal governance (Mustakallio et al., 2002). In addition, their long-term orientation can also enhance reputation and customer loyalty (Brigham et al., 2014), enabling mutual trust and high credibility in cooperation. On the other hand, due to strong concerns about control loss, family firms are less willing to innovate openly with external actors. Strong emotional attachment prompts family firms to focus more on protecting their SEW, such as family reputation, traditions, values, and control over the business (Kotlar et al., 2020). Therefore, family firms are more inclined to avoid risks that can threaten their non-financial goals, including building cooperative relationships with external parties. Consistent with this argument, family firms prefer utilizing their existing networks of external stakeholders rather than developing new relationships, known as relational inertia (Briscoe & Tsai, 2011). Other studies on family firms' conservatism also suggest that their conservative characteristics can limit their opportunities to acquire new knowledge and technology through external cooperation, protecting the independence of the business (Carney et al., 2015).

As mentioned above, previous research has largely neglected the heterogeneity from open innovation partnerships (De Massis et al., 2015). Differences in open innovation partnerships can lead to distinctive risks of knowledge spillovers and appropriability during open innovation processes. The

Table 1 Dynamic capabilities and the ability-willingness paradox framework

	Dynamic capabilities	The ability-willingness paradox
Definition	Dynamic capabilities: "The firms' ability to integrate, build and reconfigure internal and external competences to address rapidly changing environments" (Teece et al., 1997)	Ability: "the discretion of the family to direct, allocate, add to or dispose of a firm's resources" Willingness: "the favorable disposition of the involved family to engage in distinctive behavior" (De Massis et al., 2014)
Basic tenets	Core competencies should be used to modify short-term competitive positions that can be used to build longer-term competitive advantage	Ability and willingness are necessary but individually insufficient conditions to explain family firms' idiosyncratic behavior
Components	Sensing, seizing, and transforming capabilities	Ability and willingness
Scope	All types of firms	Family firms
Question to answer	Why some firms are systematically capable of keeping their resources and activities aligned with changing environmental dynamics while others are not	How family firms engage in family-oriented particularistic behaviors
Common arguments	Ability originates from a firm's unique, valuable, and inimitable resources	

ability and willingness of family firms to engage in open innovation can vary further with different partnerships, particularly market-based and science-based ones. In addition, family involvement in ownership, management, and governance gives family firms the ability to pursue family-oriented needs (De Massis et al., 2014). A part of family firm heterogeneity thus originates from their governance structure, and family ownership is likely to influence their open innovation partnerships (Rondi et al., 2021). Therefore, based on the ability-willingness framework, our theory elaborates on how family ownership influences the ability and willingness of family firms to engage in open innovation with market-based and science-based partners.

3 Hypothesis development

3.1 Family ownership and open innovation partnerships

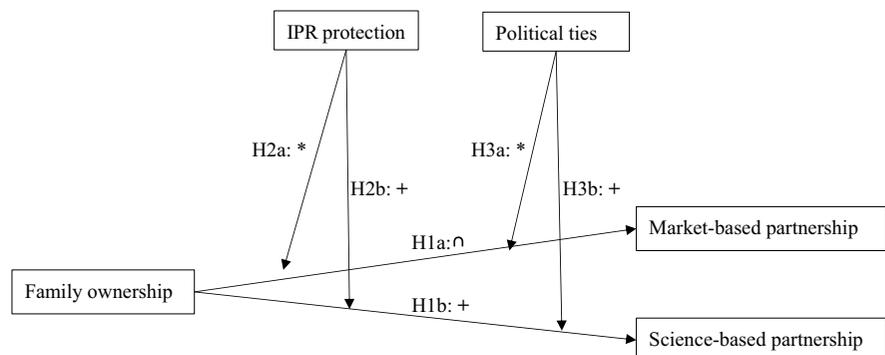
Figure 1 illustrates the theoretical framework derived from our arguments. As explained below, an increase in family ownership enhances family firms' ability to engage in market-based partnerships. However, this increase also corresponds with a lower willingness to do so. The paradox of ability and willingness becomes more prominent at extremely high or low levels of family ownership. Only at a moderate level of family ownership is the ability-willingness paradox mitigated, maximizing family firms' market-based partnerships. In contrast, an increase in family ownership enhances family firms' ability and willingness

to engage in science-based partnerships, resulting in a linear positive relationship between family ownership and science-based partnerships.

Specifically, family ownership increases access to resources and the flexibility of family firms, leading to a higher open innovation ability. First, family ownership provides patient capital and a long-term perspective for family firms (Dou et al., 2019). This long-term orientation can lead to a greater power to invest resources in open innovation projects that may not yield immediate outcomes (Sciascia et al., 2015). Family owners are more patient in waiting for returns on their investments. Second, family ownership ensures the stability of resource commitments in partnerships. Since family owners prioritize family legacy, they will consistently provide steady resources for open innovation activities, even in the face of challenges or setbacks (Hu et al., 2022). Third, family ownership grants access to unique family social capital (Herrero et al., 2022), contributing additional resources needed for open innovation, such as innovation opportunities, funding, and expertise.

However, family ownership also brings emotional attachment, particularly prominent in family firms. High family involvement in ownership enhances the sense of "our business" among family members, showing unique family intentions (Kotlar et al., 2020). Family ownership aggregates the socioemotional endowment within family firms. As family ownership increases, family owners are subject to the affectional effects of ownership. The greater the family wealth invested in the firm, the more likely it is to maintain a stable SEW endowment (Miller & Le Breton-Miller, 2005). This can also be found in intentions

Fig. 1 Theoretical model



* a right movement of the turning point of the inverted U-shaped relationship

for continued family control (Zellweger et al., 2012), familiness (Zellweger et al., 2010), longevity (Ahmad et al., 2021), transgenerational succession (Umans et al., 2021), family image (Deephouse & Jaskiewicz, 2013; Sageder et al., 2018), parsimony (Chrisman et al., 2006), and nepotism (Chen et al., 2021).

As family ownership increases, family firms tend to be less willing to expand market-based partnerships. Despite the benefits of accessing the latest market information and achieving rapid product development, market-based partnerships pose significant challenges, including control loss and appropriability risks (Du et al., 2014). Open innovation with market-based partners involves sharing sensitive information and intellectual property, which can conflict with pursuing family legacy and stability. In addition, market-based partners tend to focus on short-term revenue or transaction-oriented collaboration (Du et al., 2014), which could jeopardize the long-term goals of family firms. The potential misalignment with market-based partners who have different time horizons can further reduce the attractiveness of such collaborations. Finally, family firms are deeply rooted in their history and traditions, passed down through generations. This deep connection can lead to inertia, causing resistance to rapid change (Mitchell et al., 2009). In contrast, market-based partnerships typically strive to adapt quickly to changing market conditions (Zhu et al., 2019). Family members may prefer to maintain full control over the innovation process to ensure alignment with family values and traditions.

From the ability-willingness paradox, both ability and willingness are necessary but individually insufficient conditions to explain family firms' open innovation partnerships. In other words, family firms' market-based partnerships are limited under a combination of low ability with high willingness or high ability with low willingness. Increased family ownership enhances ability but reduces willingness to build market-based partnerships. This interplay of increasing ability and decreasing willingness in family firms to engage in market-based partnerships leads to the following hypothesis:

Hypothesis 1a: Family ownership has an inverted U-shaped relationship with market-based partnerships.

Although emotional attachment increases with the rise of family ownership, its effects on the willingness of family firms to engage in science-based partnerships differ. First, unlike market-based partnerships, intensive science-based partnerships provide scientific knowledge with significant differences and pose fewer threats to family control and appropriability (Belderbos et al., 2014). This is consistent with the family's emphasis on technological trajectory control. Second, family firms focus on stability and long-term development. Building strong partnerships with local research centers and universities can help develop new technologies and provide highly trained workers (De Massis et al., 2018). Third, open innovation with well-known universities or research institutions enhances the credibility and reputation of the focal family firms (Wang & Shapira, 2012). It signals to stakeholders that the firm is committed to innovation and continuous improvement. As a result, increased access to resources enhances the ability to collaborate with science-based partners, while heightened emotional attachment boosts the willingness to do so. Therefore, we propose the following hypothesis:

Hypothesis 1b: Family ownership has a positive relationship with science-based partnerships.

3.2 The moderating effect of formal institution: IPR protection

Formal institutions, such as IPR protection, are the established regulations that govern the behavior of individuals and organizations within a society, which are enforced by the legal system (North, 1990). Formal institutions are pivotal in shaping organizational behavior and actions because they establish a business environment with clear expectations and foster a reliable and predictable operating framework for all market participants. On one hand, IPR protection can improve a firm's competitive advantage and bargaining power (Belderbos et al., 2021). Family firms with strong IPR protection can allocate more resources to open innovation partnerships (Aiello et al., 2024). On the other hand, IPR protection reduces appropriability risks and raises trust. Family firms with strong IPR protection are more inclined to build open innovation partnerships (Martínez-Alonso et al., 2023).

IPR protection improves the ability of family firms to build open innovation partnerships. First, IPR protection increases the ability of family firms to generate revenue from intellectual properties, which enhances their competitive advantage. Firms with strong IPR protection signal that they hold important information and can attract more external partners (Yacoub et al., 2020). Second, IPR protection adds negotiation power and helps firms bargain for better partnership positions. For instance, IPR protection allows for safeguarding family firms' know-how and tacit knowledge, especially in the early stages of negotiating with R&D partners (Martínez-Alonso et al., 2023). Third, IPR protection defines the ownership of jointly developed IP and the distribution of royalties. This clarity increases the ability of firms to manage more open innovation partnerships (Du et al., 2014).

IPR protection helps reduce appropriability risks, build trust, and provide a secure environment for open innovation (Levie & Lerner, 2009). It thus mitigates the negative impact of family ownership on the willingness of family firms to build market-based partnerships while strengthening the positive impact of family ownership on the willingness to build science-based partnerships. As mentioned above, the willingness of family firms to build market-based or science-based partnerships is mainly determined by their concerns over family control and appropriability. IPR protection, such as patent law, not only regulates the owners' legal right to exclude others from making, using, or selling an invention for a limited period but also governs open innovation partnerships (Hong et al., 2022). It regulates open innovation processes throughout the entire life cycle of an invention, from idea creation to product commercialization, including potential disputes involving multiple patent owners (Lee, 2009). In other words, IPR protection safeguards the revenue of product development during open innovation partnerships and reduces the risk of opportunistic behavior (i.e., infringement of patent rights). Therefore, it preserves family control over open innovation outcomes (i.e., co-patents).

In addition, thorough IPR protection helps firms enhance their credibility and trustworthiness, enabling them to build long-term partnerships with others. For instance, IPR protection encourages tacit knowledge exchanges between partners without fear of losing control (Ali & Tang, 2023). This leads to

more fruitful collaborations where both parties contribute to and benefit from shared innovations. Meanwhile, with well-established IPR protection, family firms can take IPR seriously by establishing specific legal departments to safeguard their innovations and assets internally (Chirico et al., 2020; Martínez-Alonso et al., 2023). Potential external partners are, therefore, more likely to trust family firms with robust IPR protection. Family firms are naturally long-term oriented (Dou et al., 2019), and strong IPR protection aligns with this orientation by safeguarding their assets and encouraging collaborations with long-term potential.

Combined with the ability-willingness paradox, IPR protection increases the ability of family firms to build open innovation partnerships, alleviating the decrease in willingness to form market-based partnerships while strengthening the increase of willingness to build science-based partnerships. That is, for market-based partnerships, the paradox of high ability with low willingness appears at higher family ownership, under well-established IPR protection. For science-based partnerships, the positive impact of family ownership is further strengthened by IPR protection. Based on this, we propose the following hypotheses:

H2a: The turning point where the relationship between family ownership and market-based partnership changes from positive to negative occurs at a higher level of family ownership if there is a higher level of IPR protection.

H2b: The positive relationship between family ownership and science-based partnership is strengthened if there is a higher level of IPR protection.

3.3 The moderating effect of informal institution: political ties

Informal institutions, such as political ties, serve as significant channels for acquiring critical resources, information, market access, and regulatory compliance, particularly in emerging markets (Wang et al., 2021). In China, compared to state-owned enterprises, a large number of private-owned enterprises, including family firms, tend to build relationships with political actors to compensate for a lack of legitimacy (Lee, 2019; Wang et al., 2011). Similar

to formal institutions, political ties not only enhance family firms' ability to establish open innovation partnerships by providing extra resources and legitimacy but also increase their willingness by providing market dynamics and reducing appropriability risks.

For three reasons, political ties enhance family firms' ability to engage in open innovation partnerships. First, political ties provide access to valuable resources, such as government funding, grants, or subsidies (Yi et al., 2021), which can be utilized to foster more open innovation partnerships. Second, political ties provide insights into regulatory changes and emerging policies (Krammer & Jiménez, 2020). This foresight is crucial in China's fast-changing regulatory environment, enabling family firms to align their resources with government priorities. Such alignment facilitates both obtaining support and ensuring compliance for open innovation projects. Third, political ties enrich influential networks and associations (Carney et al., 2020), which help family firms build connections with potential partners or experts. These relationship-based contracts bring more investment opportunities to family firms (Wang et al., 2016).

Moreover, political ties can mitigate family firms' concerns over appropriability risks, alleviating the negative impact of emotional attachment on market-based partnerships while strengthening the positive impact on science-based partnerships. First, political ties can act as a deterrent to potential opportunistic behavior from partners. Political support can discourage market-based partners from unfair practices or attempting to take advantage of the firm (Berrone et al., 2020). Even when opportunistic behaviors occur, political ties can protect the profits of family firms, making it easier for them to navigate the challenging business environment. This thus increases a sense of perceived stability and confidence for focal firms (Ge et al., 2017). With strong political connections, family firms can be more willing to engage in open innovation partnerships. Second, political ties provide more market insights, such as industrial trends, risk assessment, and competitive intelligence, which can weaken family firms' concerns over appropriability risks. Political ties can grant family firms access to critical market information (Zhang et al., 2020). Such information can help family firms master market dynamics, including details about consumer behavior, competitors' strategies,

and technological development prospects (Wang et al., 2021). A better understanding of partners can help family firms execute open innovation strategies more effectively.

To sum up, with strong political ties, the ability effect of family ownership is accentuated, and the negative willingness effect of family ownership is alleviated. This can lead to the paradox of high ability with low willingness to build market-based partnerships appearing at higher ownership. In addition, the positive effect of family ownership on science-based partnerships will be stronger. In light of these arguments, we propose the following hypotheses:

H3a: The turning point where the relationship between family ownership and market-based partnership changes from positive to negative occurs at a higher level of family ownership if there are stronger political ties.

H3b: The positive relationship between family ownership and science-based partnership will be strengthened if there are stronger political ties.

4 Methodology

4.1 Sample and data

We use manufacturing firms publicly listed in the Chinese A-share market from 2009 to 2017 to test our hypotheses. Family firms were identified based on a minimum of 10% ownership and at least one additional family member serving as a director, supervisor, or senior executive¹ (Cucculelli et al., 2014). Governance data were obtained from the *Family Firms Database* of the China Stock Market and Accounting Research (CSMAR). Family member information was rechecked using internet search engines such as "Baidu" or "Google." The initial sample of Chinese manufacturing family firms included 5659 firm-year observations. To measure open innovation partnerships, we collected the

¹ Although we measure family ownership by the firm's equity owned by the owning family, a widely used definition of family firms requires a combination of family involvement in ownership, management, or governance (Hernández-Linares et al., 2018).

patent-level data from the Patent Search and Analysis system provided by the State Intellectual Property Office in China. This system provides detailed information, such as patent application dates, applicants, and technological classifications. Only inventions were retained to ensure actual open innovation partnerships. Information on IPR protection was collected from annual government reports for each province. Data on political ties were collected from the Corporate Governance Database and Figure Characteristic Database of the CSMAR. Financial, industrial, and regional data were also collected from the CSMAR database. The final sample includes 649 family firms representing 2250 firm-year observations² between 2009 and 2017.

4.2 Measurements

Following Brockman et al. (2018), we measure *open innovation partnerships* by the natural logarithms of joint patents with market-based or science-based partners within the next 3 years. Joint patents, or co-patents, are widely used to measure open innovation (Kwon et al., 2023). Patent documents provide information about the applicants and the patented technology (Belderbos et al., 2014; Meier et al., 2023). We identified market-based partnerships (customers, competitors, and suppliers) and science-based partnerships (universities and research institutions) by the names of their partners. Given the process of patent formation takes time since the open innovation partnerships start, we took a 3-year period to measure open innovation partnerships.

Following Chen & Hsu (2009), *family ownership* is measured using the percentage of equity held by the owning family.

The first moderating variable is *IPR protection*. Scholars previously used the Ginarte-Park index³ to measure the protection of IPR (Ginarte & Park, 1997). However, the index measures IPR protection at the country level, whereas this study focuses on the regional differences in IPR protection within China. Sub-national regions in emerging countries differ significantly in the degree of market development required for commercial activities and economic institutions, such as property rights protection (Du et al., 2008). IPR protection is measured by the natural logarithm of the total frequency of a list of words, including “patent,” “intellectual property rights,” and others, mentioned in the annual government report of each province in the same region, plus one.⁴ An annual government report is a standardized report published annually to review the government’s work in the past year and forecast future work. These reports reflect the government’s efforts. Text analysis is commonly employed to construct variables in previous research (Short et al., 2009; Uotila et al., 2009).

The second moderating variable is *political ties*. Scholars have measured political ties based on managers’ past or present political experience or identity (Fan et al., 2007). Following Zhu & Chung (2014), we measure political ties using formal position interlock, which refers to the number of directors, supervisors, and senior executives who are or have been government officials above the provincial level in the firm.

We control for other potential impacts on open innovation partnerships at three levels. First, we control for firm-level dynamics, including R&D (measured by the natural logarithm of R&D expenditure), firm size (measured by the natural logarithm of the number of employees), firm age (measured by the number of years since the firm was founded), and international market (measured by a dummy to indicate whether the firm operates in the international

² Since we use co-patents to measure open innovation partnerships, we restrict the sample with at least one co-patent existed in the next 3 years. As a result, over 50% of the initial sample were excluded. Although this dropped over half of our initial sample, it is reasonable given that co-patent is relatively rare worldwide (Briggs & Wade, 2014). And a low proportion of co-patent can also be found in previous research based on a Chinese sample, especially in SMEs (Lv et al., 2018). To address the potential sample selection biases, we added a Heckman two stage model in robustness analysis.

³ The Ginarte-Park Index is a metric developed by Ginarte and Park in 1997 to measure the level of patent rights protection across different countries. The index assesses the strength of patent law by counting the number of patent provisions included in a country’s national legislation, which contains coverage, memberships in international agreements, duration of protection, enforcement mechanisms, and restrictions.

⁴ We divided all the provinces into seven regions: Eastern China, South China, North China, Central China, Southwest, Northwest, and Northeast China.

market). We also control for financial constraints on firms using leverage as the ratio of debt to assets, ROA as the return on assets, and free cash as the ratio of free cash flows to total assets. Second, we control for the family chairman as a governance-level aspect, measured by whether the chairman is a family member. The family chairman is a source of family involvement (Block & Ulrich, 2023). Due to the lack of sound governance mechanisms in China, the separation of management and ownership is incomplete. The family chairman can hold decision-making power, act in an executive role within the company, and determine the open innovation partnership (Cao et al., 2023). Third, following the previous study (Guan & Yan, 2016), we control for the patent scale as a patent-level aspect, measured by the number of patents, which reflects a firm's innovation ability (Wu et al., 2022). Finally, we control for industrial effects using 29 industry dummies based on the two-digit industrial classification code and time effects using nine dummies per year from 2009 to 2017.

4.3 Analytical methods

We build the following model to examine our hypotheses. For firm i in industry j , its open innovation partnerships in year t , y_{it} , is modeled as

$$y_{it} = u + \gamma_t + \alpha_j + \beta_i + \delta x_{it} + \varepsilon_{it}. \quad (1)$$

where x_{it} stands for the firm i 's family ownership in year t , γ_t are year-fixed effects, α_j are industry-fixed effects, β_i are firm fixed effects, and ε_{it} is an error term.

Both Hausman tests of the market-based partnership ($p=0.000$) and science-based partnerships ($p=0.003$) suggest that the fixed-effect model is statistically different from the random-effect model, which supports the use of the fixed-effect model. We also control for year and industry-fixed effects. Following Aiken et al. (1991), we mean-centered the independent variables before constructing the interaction terms to limit the potential multicollinearity problem. Because we use joint patents to measure open innovation partnership, samples without joint patents are thus eliminated. Therefore, we applied a Heckman self-selection model to handle potential sample selection bias.

5 Results

5.1 Sample characteristics

Table 2 reports the mean, standard deviations, and correlation coefficients of all the variables. We also report variance influence factors (VIF) to avoid multicollinearity, with the highest VIF of 1.56, lower than the cut-off point of 10 (Lee & Song, 2012).

5.2 Regression analysis

Table 3 reports the results of the regression analyses for testing the hypotheses. Among these models, Models 1 to 3 use the market-based partnership as the dependent variable, and Models 4 to 6 use the science-based partnership as the dependent variable. Hypothesis 1a predicts that family ownership has an inverted U-shaped impact on market-based partnerships. We test this hypothesis by adding both family ownership and family ownership squared to the regression in Model 1. The regression coefficient of family ownership is positive and significant ($\beta=1.695$, $p<0.1$), while family ownership squared is negative and statistically significant ($\beta=-2.889$, $p<0.05$). This result provides support for Hypothesis 1a. To test the positive impact of family ownership on science-based partnership, Model 4 adds family ownership to the model. The coefficient of family ownership is positive and statistically significant ($\beta=0.554$, $p<0.05$).

Hypothesis 2a predicts that the turning point where the relationship between family ownership and market-based partnership changes from positive to negative occurs at a higher level of family ownership given a higher level of IPR protection. To test this, Model 2 adds the interaction between family ownership squared and IPR protection while simultaneously controlling for IPR protection and the interaction between family ownership and IPR protection. Following Haans et al. (2016), a positive numerator (32.708) of $\frac{\partial X^*}{\partial Z}$ gives a right movement as the moderator increases. To further illustrate this effect, in Fig. 2, we plotted the relationship between family ownership and market-based partnership with a high level of IPR protection (one standard deviation above its mean) and for firms with a low level of IPR protection (one standard deviation below its mean) based on the statistics in Model 2 of Table 2. As shown in Fig. 2, the

Table 2 Correlations, means, and standard deviations

Variable	Mean	S.D	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Market-based partnership	1.570	1.525	1													
Science-based partnership	0.748	0.965	-0.250	1												
Family ownership	0.366	0.157	-0.068	-0.146	1											
IPR protection	0.055	0.036	0.165	-0.093	0.019	1										
Political ties	2.513	1.859	0.035	0.043	-0.05	-0.072	1									
Firm scale	7.633	1.025	0.323	0.053	-0.116	-0.007	0.125	1								
Firm age	14.826	5.230	0.036	0.102	-0.073	-0.073	-0.072	0.109	1							
ROA	0.054	0.101	0.064	-0.041	0.075	0.019	0.032	0.054	-0.019	1						
Leverage	0.349	0.182	0.077	0.043	-0.140	-0.009	0.044	0.414	0.054	-0.394	1					
R&D	16.542	4.855	0.098	-0.058	0.071	0.018	-0.078	0.074	0.090	-0.023	-0.02	1				
International market	0.564	0.496	0.082	-0.007	-0.008	0.051	-0.064	0.220	0.145	-0.018	0.158	0.213	1			
Free cash	0.024	0.145	-0.03	-0.009	0.006	-0.001	-0.018	-0.039	-0.05	0.260	-0.147	-0.046	-0.055	1		
Patent scale	2.589	1.135	0.427	0.110	-0.126	0.112	0.076	0.323	0.021	0.065	0.134	0.091	0.096	-0.039	1	
Family chairman	0.854	0.353	-0.051	-0.072	0.238	0.090	-0.026	-0.142	-0.105	0.082	-0.147	0.043	-0.044	0.039	-0.061	1

N = 2250. All correlation coefficients above |0.073| are significant at $p < 0.05$ or below (two-tailed test)

Table 3 Fixed-effect regression for open innovation partnerships

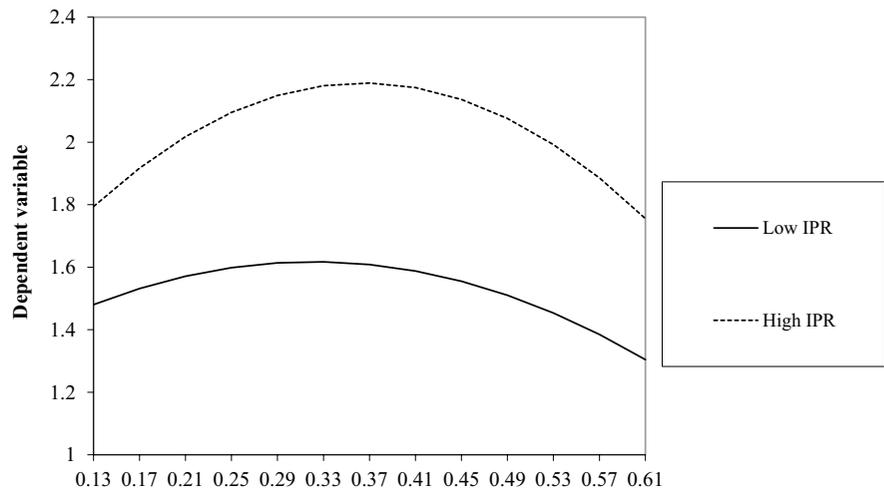
	Market-based partnership			Science-based partnership		
	(1)	(2)	(3)	(4)	(5)	(6)
Firm scale	0.086 (0.059)	0.079 (0.059)	0.088 (0.059)	-0.060 (0.048)	-0.059 (0.048)	-0.061 (0.049)
Firm age	0.089*** (0.016)	0.092*** (0.016)	0.087*** (0.016)	0.036*** (0.013)	0.036*** (0.013)	0.036*** (0.013)
ROA	-0.571 (0.396)	-0.569 (0.396)	-0.583 (0.396)	-0.151 (0.325)	-0.169 (0.325)	-0.145 (0.325)
Leverage	-0.075 (0.199)	-0.074 (0.199)	-0.076 (0.199)	0.044 (0.163)	0.043 (0.163)	0.035 (0.163)
R&D	0.008* (0.004)	0.007 (0.004)	0.008* (0.004)	-0.003 (0.004)	-0.004 (0.004)	-0.003 (0.004)
International market	-0.033 (0.062)	-0.039 (0.062)	-0.022 (0.062)	-0.020 (0.051)	-0.022 (0.051)	-0.023 (0.051)
Free cash	-0.095 (0.116)	-0.104 (0.116)	-0.097 (0.116)	0.085 (0.095)	0.097 (0.095)	0.085 (0.095)
Patent scale	0.270*** (0.026)	0.270*** (0.026)	0.273*** (0.026)	0.045** (0.021)	0.044** (0.021)	0.043** (0.021)
Family chairman	-0.037 (0.093)	-0.053 (0.093)	-0.036 (0.093)	0.264*** (0.076)	0.261*** (0.076)	0.273*** (0.077)
Family ownership	1.624 (1.001)	1.695* (1.002)	1.386 (1.007)	0.547** (0.266)	0.554** (0.266)	0.538** (0.266)
Family ownership squared	-2.763** (1.142)	-2.889** (1.143)	-2.479** (1.150)			
IPR protection		0.045 (0.752)			0.562 (0.617)	
Family ownership × IPR protection		39.389** (17.403)			3.543 (3.303)	
Family ownership squared × IPR protection		-47.839** (20.553)				
Political ties			-0.002 (0.015)			-0.008 (0.012)
Family ownership × political ties			0.630 (0.383)			0.074 (0.069)
Family ownership squared × political ties			-0.877* (0.451)			
Constant	-1.213* (0.662)	-1.189* (0.663)	-1.166* (0.662)	0.617 (0.524)	0.576 (0.525)	0.659 (0.524)
R^2	0.210	0.213	0.212	0.038	0.039	0.039

$N=2250$. Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

turning point shifts to the left for firms with a low level of IPR protection (family ownership ≈ 0.3), while the turning point shifts to the right for firms with a high level of IPR protection (family ownership

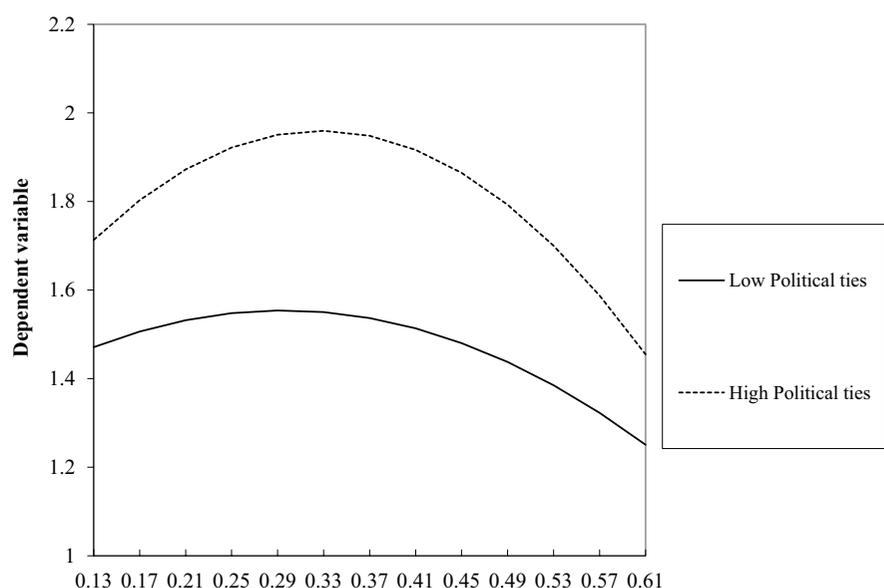
≈ 0.35). Thus, Hypothesis 2a is supported. Hypothesis 2b predicts that the positive relationship between family ownership and science-based partnership will be strengthened with a higher level of IPR protection.

Fig. 2 The moderating role of IPR protection

To test this, Model 5 adds the interaction between family ownership and IPR protection while controlling for IPR protection. The coefficient of interaction is positive but not significant ($\beta=3.543$, *n.s.*); therefore, Hypothesis 2b is not supported.

Hypothesis 3a predicts that political ties will moderate the inverted U-shaped relationship between family ownership and market-based partnership, causing the shifting point to move to a higher level of family ownership. To test this, Model 3 adds the interaction between family ownership squared and political ties while

simultaneously controlling for political ties and the interaction between family ownership and political ties. Similarly, a positive numerator (0.346) of $\frac{\partial X^*}{\partial Z}$ gives a right movement of the turning point as political ties increase. We also plotted the relationship between family ownership and market-based partnership with a high level of political ties (one standard deviation above its mean) and for firms with a low level of political ties (one standard deviation below its mean) based on the statistics in Model 3 of Table 2. As shown in Fig. 3, the turning point shifts to the left for firms with a low level

Fig. 3 The moderating role of political ties

of political ties (family ownership ≈ 0.3), while the turning point shifts to the right for firms with a high level of political ties (family ownership ≈ 0.35). Thus, Hypothesis 3a is supported.

To test Hypothesis 3b, political ties strengthen the positive relationship between family ownership and science-based partnership, Model 6 adds the interaction between family ownership and political ties while controlling for political ties. The coefficient of interaction is positive but not significant ($\beta=0.074$, *n.s.*); therefore, Hypothesis 3b is not supported.

5.3 Robustness analysis

To ensure that our results are robust and to rule out possible alternative explanations, we conducted several robustness tests. We also ran some additional analyses to examine the boundary conditions of our theoretical arguments.

To ease the impact of the 2008 financial crisis, we reran all the regression from 2010 to 2017 (report in Table 4), and the results remained consistent.

Although it is reasonable to measure IPR protection by text analysis of annual government reports, the selection of a word list may bias the measurement. To address this concern, we use an alternative measurement of IPR protection, which is the law development sub-index of the National Economic Research Institution of China (NERI) marketization index. The NERI marketization index provides an objective indicator system to measure the level and extent of market-oriented development in a region of China (Gang et al., 2011). It is composed of the following five aspects: Government and Market Relationship, Development of Non-State-Owned Economy, Development Level of Product Market, Development Level of Factor Market, Development of Market Intermediary Organizations, and Legal Environment. The results of using an alternative measurement were consistent with our main results (report in Table 5).

Finally, to address the sample selection biases, Table 6 presents the results of the Heckman model. The IMR from the first-stage probit model (Report in Model 7 of Table 6) was controlled for in the second-stage model, taking market- and science-based partnerships as dependent variables. The results also remained consistent.

6 Discussion and conclusion

It is important to investigate the heterogeneity of family firms' open innovation behavior (Lambrechts et al., 2023). Unfortunately, research on family firms' open innovation has ignored the heterogeneity originating from partnerships. To provide a better understanding of how the openness and ability-willingness paradoxes interact, the study delves into the impact of family ownership on market- and science-based partnerships. More importantly, we introduce IPR protection and political ties as two important institutional contingencies to answer how the ability-willingness paradox can evolve under various institutional contexts (Chrisman et al., 2015).

One interesting finding of our study is the moderating effects of both formal institutions, IPR protection, and informal institutions, political ties, in family ownership on market-based partnerships. That is the turning point of the inverted U-shaped relationship between family ownership and market-based partnerships shifts to the right, given greater IPR protection or more political ties. This indicates that IPR protection and political ties can strengthen family firms' ability and willingness to build open innovation partnerships. Compared to Western countries, China is rooted in Confucian philosophy and a collectivist culture, which largely depends on informal governance, such as *guanxi* or social networks. Our results thus affirm the important role of informal institutions in China (Chan et al., 2015). This aligns with previous studies indicating that informal institutions in China are substitutive for formal institutions rather than competing (Estrin & Prevezer, 2011). Informal institutions function where formal institutions are ineffective, but their goals remain compatible.

Furthermore, our findings echo those of previous studies that IPR protection works as an important contingency to mitigate family managers' concerns about control loss and involuntary knowledge spillovers (Martínez-Alonso et al., 2023). This aligns with our argument that IPR protection improves family firms' bargaining power in collaboration and reduces appropriability risks, enhancing their ability and willingness to build open innovation partnerships. With the fast-developing economy in China, the country has long been criticized for failing to enforce IPR protection, such as imitation and

Table 4 Accounting for time shock

	Market-based partnership			Science-based partnership		
	(1)	(2)	(3)	(4)	(5)	(6)
Firm scale	0.066 (0.061)	0.061 (0.061)	0.068 (0.061)	-0.066 (0.050)	-0.064 (0.050)	-0.067 (0.050)
Firm age	0.075*** (0.015)	0.076*** (0.015)	0.073*** (0.015)	0.043*** (0.013)	0.044*** (0.013)	0.043*** (0.013)
ROA	-0.395 (0.414)	-0.413 (0.414)	-0.398 (0.414)	-0.226 (0.339)	-0.233 (0.339)	-0.224 (0.339)
Leverage	-0.056 (0.204)	-0.065 (0.204)	-0.053 (0.204)	0.030 (0.166)	0.034 (0.167)	0.020 (0.167)
R&D	0.010** (0.005)	0.009** (0.005)	0.010** (0.005)	-0.005 (0.004)	-0.005 (0.004)	-0.005 (0.004)
International market	-0.034 (0.063)	-0.038 (0.063)	-0.023 (0.063)	0.003 (0.051)	-0.001 (0.051)	-0.002 (0.051)
Free cash	-0.101 (0.118)	-0.105 (0.118)	-0.107 (0.118)	0.070 (0.097)	0.076 (0.097)	0.070 (0.097)
Patent scale	0.263*** (0.026)	0.263*** (0.026)	0.266*** (0.026)	0.048** (0.021)	0.047** (0.021)	0.046** (0.021)
Family chairman	-0.011 (0.097)	-0.021 (0.097)	-0.010 (0.098)	0.234*** (0.080)	0.230*** (0.080)	0.243*** (0.080)
Family ownership	1.700* (1.019)	1.734* (1.019)	1.469 (1.024)	0.599** (0.273)	0.601** (0.273)	0.587** (0.273)
Family ownership squared	-3.079*** (1.155)	-3.155*** (1.155)	-2.811** (1.163)			
IPR protection		0.312 (0.785)			0.693 (0.642)	
Family ownership × IPR protection		35.596** (18.112)			3.177 (3.496)	
Family ownership squared × IPR protection		-46.256** (21.416)				
Political ties			-0.001 (0.015)			-0.009 (0.012)
Family ownership × political ties			0.620 (0.387)			0.090 (0.069)
Family ownership squared × political ties			-0.865* (0.455)			
Constant	-0.742 (0.652)	-0.730 (0.661)	-0.695 (0.652)	0.235 (0.516)	0.149 (0.524)	0.273 (0.517)
R^2	0.189	0.191	0.191	0.034	0.035	0.036

$N=2250$. Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

patent infringement (Brander et al., 2017). Compared to state-owned enterprises, private-owned enterprises in China, including family firms, face even higher risks of expropriation due to a lack of

legitimacy (Cao, 2014; Fang et al., 2017). There is a salient imbalance in the enforcement of IPR protection between regions in China. Our study indicates that with solid IPR protection, family

Table 5 Using an alternative IPR protection measurement

	Market-based partnership	Science-based partnership
	(1)	(2)
Firm scale	0.066 (0.059)	-0.066 (0.048)
Firm age	0.085*** (0.019)	0.017 (0.015)
ROA	-0.675* (0.396)	-0.162 (0.324)
Leverage	-0.111 (0.199)	0.050 (0.163)
R&D	0.008* (0.005)	-0.003 (0.004)
International market	-0.023 (0.062)	-0.006 (0.051)
Free cash	-0.099 (0.115)	0.087 (0.095)
Patent scale	0.273*** (0.026)	0.048** (0.021)
Family chairman	-0.057 (0.093)	0.261*** (0.076)
Family ownership	1.607 (1.055)	0.576** (0.266)
Family ownership squared	-2.869** (1.230)	
Law development	0.007 (0.013)	0.024** (0.011)
Family ownership × law development	0.687*** (0.178)	0.071* (0.037)
Family ownership squared × law development	-0.743*** (0.211)	
Constant	-1.002 (0.662)	0.631 (0.523)
R^2	0.218	0.043

$N=2250$. Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$,

*** $p < 0.01$

firms are less concerned with appropriability risks, engaging in more open innovation partnerships, particularly market-based ones. Our results prove that formal and informal institutions act as important contingencies for family firms to build open innovation partnerships in emerging economies such as China. We therefore respond to calls in

family business research for further examination of family firms in an Asian context (Kim et al., 2023).

6.1 Theoretical implications

This study contributes to the extant literature in three important ways. First, we shed new light on the research of open innovation partnerships in family

Table 6 Using the Heckman two-stage model

	Market-based partnership			Science-based partnership			Dummy
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Firm scale	0.285*** (0.095)	0.276*** (0.095)	0.296*** (0.096)	-0.043 (0.078)	-0.042 (0.078)	-0.052 (0.079)	0.307*** (0.059)
Firm age	0.146*** (0.027)	0.148*** (0.027)	0.146*** (0.027)	0.040* (0.022)	0.041* (0.022)	0.038* (0.022)	0.028** (0.014)
ROA	-0.743* (0.401)	-0.738* (0.401)	-0.763* (0.401)	-0.167 (0.330)	-0.184 (0.330)	-0.153 (0.330)	-0.309 (0.503)
Leverage	0.245 (0.233)	0.242 (0.232)	0.259 (0.233)	0.071 (0.190)	0.070 (0.190)	0.050 (0.190)	0.407 (0.274)
R&D	0.008* (0.004)	0.007* (0.004)	0.008* (0.004)	-0.003 (0.004)	-0.003 (0.004)	-0.003 (0.004)	0.005 (0.007)
International market	-0.032 (0.062)	-0.038 (0.062)	-0.020 (0.062)	-0.020 (0.051)	-0.022 (0.051)	-0.023 (0.051)	0.006 (0.088)
Free cash	-0.297** (0.138)	-0.303** (0.139)	-0.307** (0.138)	0.068 (0.114)	0.080 (0.114)	0.076 (0.114)	-0.252 (0.179)
Patent scale	0.483*** (0.084)	0.480*** (0.084)	0.495*** (0.085)	0.064 (0.069)	0.062 (0.069)	0.053 (0.070)	0.322*** (0.036)
Family chairman	-0.202* (0.112)	-0.215* (0.112)	-0.209* (0.112)	0.250*** (0.092)	0.247*** (0.092)	0.265*** (0.092)	-0.243* (0.126)
IMR	0.942*** (0.356)	0.931*** (0.356)	0.982*** (0.357)	0.082 (0.292)	0.080 (0.292)	0.044 (0.293)	
Family ownership	1.709* (1.000)	1.780* (1.000)	1.457 (1.005)	0.533** (0.271)	0.540** (0.271)	0.531* (0.271)	
Family ownership squared	-3.059*** (1.145)	-3.181*** (1.147)	-2.768** (1.153)				
IPR protection		0.031 (0.750)			0.561 (0.617)		
Family ownership × IPR protection		38.716** (17.372)			3.540 (3.304)		
Family ownership squared × IPR protection		-47.121** (20.516)					
Political ties			0.001 (0.015)			-0.008 (0.012)	
Family ownership × political ties			0.632* (0.382)			0.073 (0.069)	
Family ownership squared × political ties			-0.893** (0.450)				
Constant	-5.572*** (1.773)	-5.496*** (1.773)	-5.712*** (1.782)	0.242 (1.434)	0.210 (1.434)	0.459 (1.443)	-4.972*** (0.573)
R ²	0.213	0.216	0.216	0.038	0.039	0.039	

$N=2250$. Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

firms. Scholars have called for research on types of open innovation partnerships among family firms (De Massis et al., 2015), but empirical studies remain scarce. Responding to their call for distinguishing types of partnerships, this paper first focuses on market- and science-based partnerships and examines the impact of family ownership on them. Our findings prove that family ownership exerts heterogeneous impacts on market- and science-based partnerships. Although unique family resources and emotional attachment effects increase as family ownership rises, their impacts on the two types of partnerships differ.

Second, by disentangling the effects of family ownership on open innovation partnerships, the study expands the implication of the ability-willingness paradox approach to open innovation (Chrisman et al., 2015). Although studies have applied the ability-willingness paradox to family firms' innovation behavior, they have neglected the changing scenario of family ownership and types of open innovation partnerships. Both ability and willingness are necessary but individually insufficient to explain family firms' idiosyncratic behavior (De Massis et al., 2014). Family ownership determines the ability and willingness of family firms to build diverse types of partnerships during open innovation processes. In addition, by exploring the moderating role of formal and informal institutions, we develop the boundaries of the ability-willingness paradox. Our findings indicate that under well-established IPR protection and strong political ties, the paradox of high ability with low willingness to build market-based partnerships will appear at a higher level of family ownership. Scholars have called for insights on how and under which conditions the ability-willingness paradox can change (Chrisman et al., 2015). This study responds to these calls by bringing both formal and informal institutions into consideration.

Finally, we advance our understanding of how the openness paradox diverges in family firms by integrating the openness and ability-willingness paradox in the setting of open innovation partnerships. Although scholars have paid attention to the appropriation strategies of family firms (Chirico et al., 2018), how the paradox of openness evolves remains largely unexplored. Our study indicates that as family ownership increases, family firms' concerns over appropriability rise. In addition, our findings confirm that, compared to market-based partners, science-based

partners pose lower appropriability risks. In other words, family firms' partnerships with science-based partners tend to experience less of the openness paradox. Furthermore, our findings indicate that IPR protection and political ties are possible contingencies for reconciling the openness paradox. Thus, the current study contributes to our understanding of how the openness paradox may change under different institutional contexts.

6.2 Managerial implications

A key managerial implication of our study lies in its findings that family ownership can enhance open innovation using family-specific advantages and competencies. That is family ownership provides family owners greater legitimacy and discretion to allocate sufficient resources for open innovation and facilitates their ability to seize timely collaboration opportunities. However, our findings also indicate that the emotional attachment associated with family ownership plays a significant role. Family firms with higher family ownership can restrict their scope of open innovation with market-based partners, avoiding threats to their control of the technological trajectory and minimizing potential appropriability risks.

Our findings regarding the contexts of IPR protection and political ties have implications for the governance of family firms. For instance, weak IPR protection can constrain family firms' open innovation partnerships, particularly with market-based partners. This constraint can reduce the novelty and diversity of family firms' open innovation partners. Therefore, policymakers must carefully design and enforce IPR protection mechanisms to reduce the appropriability risks inherent in open innovation. The findings also hold relevance for family firm practitioners in China. It is insufficient for family firms to rely only on formal institutions to ensure robust IPR protection. With the ongoing development and transition of the Chinese institutional environment, family firms must effectively utilize external resources, such as political ties. These connections can provide family firms with additional resources and legitimacy, enabling them to navigate market dynamics and counter potential appropriability risks.

6.3 Limitations and future research directions

Despite its contributions, our study has several limitations that should be considered in future research. First, our empirical results are based on the analysis of manufacturing family firms in China. China's growing economy provides a dynamic environment for studying family firms' open innovation partnerships and the contingent role of institutional contexts (Dinh & Calabrò, 2019). The regional institutional development in China exhibits significant variation and complexity, leading to the unique effects of formal and informal institutions. For instance, the influence of political ties in the Chinese context can differ from that in other contexts, such as Western ones. These country-specific settings can affect how family firms collaborate with market-based and science-based partners and the role of institutions. Future studies can expand the research scope to examine whether our findings still hold in other contexts.

Second, due to reliance on secondary data, we were unable to directly measure family firms' ability and willingness. We used family ownership as a proxy for the ability and willingness to engage in open innovation partnerships. Although indirect proxies (family ownership) are commonly employed in family firm research (Gomez-Mejia et al., 2018), scholars have emphasized the need for directly measuring constructs and have highlighted the potential mismatch between constructs and empirical correlations (Schulze & Kellermanns, 2015). Moreover, our arguments regarding the role of willingness rely on the emotional attachment of family ownership; however, the extent of family ownership is only one source of this emotional attachment. Succession planning or family continuity can also influence emotional attachment (Kotlar et al., 2020). Future research can develop new scales or utilize established measurement scales to capture the underlying power and emotion, generating more robust empirical findings.

Third, since we measure open innovation partnerships by joint patents, this outcome-based measurement limits partnerships' scope to patentable innovation. However, not all open innovation partnerships lead to joint patents. Future research can capture other open innovation partnerships, such as technology agreements, outsourcing, or alliances. In addition, we only measure political ties by formal position interlock. However, apart from formal interlock,

unobserved political ties can also impact the relationship between family ownership and open innovation partnerships. Future research can explore the impact of other complex and latent social networks.

6.4 Conclusion

Although scholars have paid attention to family firms' open innovation strategies, the heterogeneity originating from partners is mainly absent. By distinguishing open innovation from market-based and science-based partnerships, this study explores the divergent relationships between family ownership and these partnerships. Our hypotheses are tested through a series of analyses of data from the open innovation partnerships of Chinese manufacturing family firms from 2009 to 2017. The results showed that family ownership has an inverted U-shaped impact on market-based partnerships and a positive impact on science-based partnerships, reinforcing the ability-willingness paradox argument that determines the open innovation of family firms. Compared to science-based partners, family firms are especially likely to be subject to the ability-willingness paradox when collaborating with market-based partners. In addition, under strong IPR protection or with more political ties, such paradoxes in collaborating with market-based partners are mitigated. These findings create broad implications for family firms and open innovation partnerships by highlighting the critical importance of taking both ability and willingness into consideration and empirically testing how this occurs through family ownership. Based on the findings of this study, more insights can be brought by examining the influence of other family-specific characteristics or contingencies, especially those potentially related to the ability and willingness of family owners, on family firms' heterogeneous innovation behavior.

Author contribution FD: conception of the study, collecting data, analysis and interpretation of data, and preparation of all versions of the manuscript; MT: collecting data and analysis and interpretation of data; XW: conception of the study, analysis and interpretation of data, and preparation of the manuscript of an earlier version; JC: interpretation of data and preparation of the manuscript at a later stage.

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Data availability Contact the authors.

Declarations

Conflict of interest The authors declare no competing interests.

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