

**The impact of family-based human capital on corporate innovation:
Evidence from sibling-chairpersons in China***

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Abstract

We examine the impact of family-based human capital stemming from a chairperson's having siblings vis-à-vis not having siblings on corporate innovation in Chinese family firms. Using hand-collected data, we document that when a firm has a sibling-chairperson, it holds more patents, receives more total citations to their patents, and has greater innovation efficiency and innovation quality than an otherwise equivalent firm with a chairperson with no siblings. The results are economically significant and robust to a battery of alternative methods. Specifically, the findings remain intact after using China's one-child policy as an exogenous shock to apply a regression discontinuity research design to mitigate endogeneity. Additional analysis suggests that the mechanisms behind the impact of siblings on innovation are consistent with family-based human capital embedded in the sibling relationships such as competition and knowledge spillover among siblings. Furthermore, we show that sibling co-management, sibling gender diversity, and siblings' collaborative behavior matter in corporate innovation. Overall, family-based human capital from siblings impacts corporate innovation.

Keywords: Innovation; Siblings; Family-Based Human Capital; One-Child Policy

1. Introduction

Corporate innovation promotes a country's economic development (Aghion et al. 2005; Pástor and Veronesi 2009). At the firm-level, corporate innovation is vital to maintaining a competitive edge and it creates value to shareholders (Porter 1992). Among the drivers of corporate innovation, human capital receives much attention (Liu, Mao, and Tian 2017; Derrien, Kecskes, and Nguyen 2018; Chemmanur et al. 2019) because it is one of the most important elements in innovation and explains why some firms are consistently successful corporate innovators (Liu, Mao, and Tian 2017).

Studies on the impact of human capital on corporate innovation focus on two perspectives. The first type of study focuses on human capital factors that are exogenous to firms such as the age structure of workers in the labor market (Derrien et al. 2018; Anelli et al. 2019), the extent of low-cost labor supply (Bena and Simintzi 2017), and the extent of skilled labor supply (Bianchi and Giorcelli 2019; Khanna and Lee 2018). The second type of study focuses on human capital factors stemming from the characteristics of firm employees, such as executives' education level (Chemmanur et al. 2019), the availability of inventive executives (Liu, Mao and Tian 2017), and collaboration and spillover effects of the innovative team (Baghai, Silva, and Ye 2017; Zacchia 2020).

We argue that, in the context of corporate innovation, employee-related human capital is a general human capital concept (Becker 1993), that is, human capital is embedded in the employees and it can be easily transplanted to another firm. The impact on corporate innovation of human capital derived from the family structure of firm owners has not yet been explored in the innovation literature. We call this *family-based human capital* because the human capital originates from the owner's family structure, which is different from the owner's education, innovative executives, or collaboration of the innovative team. We expect that family-based human capital plays a significant role in a firm's innovation relative to employee-related human

capital for two reasons. First, family-based human capital is a type of specialized intangible asset that contributes to a family firm's success, including innovation, while the employee-related human capital does not have such a role (Bennedsen et al. 2015). Second, the employee-related human capital embedded in employees is highly mobile and it may not always stay in the firm. In contrast, family-based human capital is stable and persistent in supporting a family firm. Therefore, examining the impact of family-based human capital on a firm's innovation should yield useful insights. Among various sources of family-based human capital, we focus on whether a chairperson in a family firm has siblings (hereafter we refer to sibling-induced human capital) for two reasons.¹ First, in 1979, China implemented a one-child policy (OCP), which has led to substantial drop in siblings since then. Consequently, there is a large variation of sibling-induced human capital across firms. Second, there is ample of anecdotal evidence that illustrates the importance of sibling-induced human capital stemming from the chairperson's having a sibling to a firm's innovation. For instance, brothers Charles and Frank Duryea worked together and invented the first gasoline engine car in the United States in the late nineteenth century. Similarly, over a thirty-year span, siblings Feng Hailiang and Feng Yali of China's Hailiang Group built their copper factory into a conglomerate whose sales made it one of the top 500 firms in the world as of 2018.

The purpose of our paper is to examine the impact of sibling-induced human capital, as revealed in a chairperson's having siblings, on innovation in family firms. In addition to the full sample analysis, we leverage the OCP to examine the impact of a decrease in sibling-induced human capital due to fewer siblings of chairpersons on corporate innovation in family firms. The OCP in 1979 effectively limited Chinese families to one child (Qin et al. 2017). Consequently, the chairpersons of many family firms who were born around the OCP have no

¹ Chairpersons are the most powerful individuals in Chinese family firms. Hence, we focus on siblings of chairpersons.

siblings. The OCP changes the behavior of children without siblings (Cameron et al. 2013) and alters an individual's sibling-induced human capital. In fact, some studies suggest that the impact of siblings on children's character is lifelong (Cicirelli 2013), which is consistent with our interpretation of sibling-induced human capital. Hence, the OCP exogenously alters sibling-induced human capital and changes the competition and knowledge spillover effects among siblings. Therefore, our analysis of the impact of sibling-induced human capital on innovation is less prone to endogeneity.

Our motivation to study sibling-induced human capital also stems from the well-documented impact of siblings in psychology and sociology literature that finds that siblings shape individual characteristics related to innovation, especially those related sibling competition and knowledge spillover (Alwin 1989; Butcher and Case 1994; Dunn et al. 1991; Howe and Ross 1990; Hetherington et al. 1999; Altonji et al. 2017). Further, chairpersons do not self-select into having siblings; that decision was made by the chairperson's parents and thus it is exogenous to the chairperson. Hence, our findings are not due to a chairperson's self-selection behavior.

We conduct our analysis using a sample of family firms in China from 2008–2016. Using the Chinese sample offers two advantages. First, we leverage the 1979 OCP to use a regression discontinuity (RD) research design (Qin et al. 2017) to mitigate endogeneity. Second, the 5,000 years of Confucian culture makes the concept of family and relationship harmony widespread, especially in family firms (Yeung and Tung 1996). Consequently, the impact of family-based human capital embedded in the sibling relationship on corporate innovation is particularly relevant in China or Asian countries with strong family settings.

Our core findings suggest that a family firm with a sibling-chairperson is more innovative than an otherwise equivalent firm with a no-sibling chairperson. Essentially, a firm with a sibling-chairperson holds more patents and receives more total citations to its patents. The

estimated economic impact of the sibling effect is relatively large. Depending on the model specifications, the number of patents increases by 8.6% and the number of citations increases by 26.1% for a sibling-chairperson firm relative to an average firm. We also find that the impact of siblings on corporate innovation has an effect up to four years in the future when compared to firms with no sibling-chairpersons, and a firm with a sibling-chairperson has greater innovation efficiency and innovation quality than an otherwise equivalent firm with a no-sibling chairperson. Our findings from the full sample are robust to a battery of robustness tests in which we address survivorship bias, conduct a placebo test, and address other sample selection concerns. Using the RD research design with chairpersons born around the OCP years suggests that family firms experience a significant increase of no-sibling chairpersons and significant decrease in their firms' innovation in terms of patents held after the implementation of the OCP. Hence, our RD research design should be helpful to address the endogeneity issue and support our core findings.

Additional analysis suggests that the mechanisms behind sibling-chairpersons and innovation are consistent with siblings' competition and knowledge spillover effects, which corroborate the psychology and sociology literature that finds siblings are competitive with each other (Alwin 1989; Becker and Lewis 1973), and they enjoy positive spillover effects through their interactions growing up (Hetherington et al. 1999; Altonji et al. 2017). For instance, we find that when a chairperson has a brother sibling, being a younger sibling, or having a smaller age gap between the chairperson and other siblings, his or her firm's innovation is better than a firm with a no-sibling chairperson. The results are consistent with the positive effect on innovation due to sibling competition. Similarly, when a chairperson has a sibling with previous R&D experience or overseas experience, her firm's innovation is better than a similar firm with sibling that has no previous R&D experience or overseas experience.

In further analysis, we explore the impacts of several interesting aspects of sibling-

induced human capital on corporate innovation. First, we examine the effect on innovation of sibling co-management and different corporate positions held by siblings. We find that when siblings co-manage the firm, innovation is better, especially when a sibling is the CEO or the head of R&D. Second, based on the finding by Griffin et al. (2021) that firms with gender-diverse boards have more patents and more novel patents, we examine whether a sibling-chairperson will imprint the experience of sibling gender diversity (brother-sister) and implement board gender diversity in her firm. We find that sibling gender diversity increases the board's gender diversity, which indicates that sibling gender diversity may promote innovation by increasing board gender diversity. Third, Li and Wang (2021) show that collaboration between acquirer and target inventors post-merger is important in improving innovation capability. Thus, we investigate whether having a sibling-chairperson improves a firm's ability to collaborate in innovation. Our findings show that a sibling-chairperson is more likely to work collaboratively with other firms and to have joint patents than a no-sibling chairperson. Finally, we test the effect of a sibling on firms' approach to innovation to determine whether they pursue an internal approach by developing innovation organically (Chemmanur et al. 2019) or an external approach by acquiring innovative firms (Bena and Li 2014; Guo et al. 2019). The results show that a sibling-chairperson is more likely to engage in innovation using internal innovative staff by hiring more R&D staff than a no-sibling firm.

Overall, the findings are consistent with the notion that, by having siblings, a chairperson has greater competitive and knowledge spillover behavior than one without siblings, and such behavior enhances corporate innovation. Family structure, in terms of having sibling-induced human capital, matters in corporate innovation.

We contribute to the literature in three ways. First, we introduce the concept of family-based human capital and incorporate a sibling-induced human capital framework to explain innovation in family firms. Sibling-induced human capital is a new perspective in the

innovation literature. Our robust findings support our sibling-induced human capital hypothesis of innovation. Most important, using the RD research design that is based on the OCP mitigates the endogeneity between sibling-induced human capital and innovation. Our findings advance the literature on human capital and innovation by extending the external labor supply and employee-embedded human capital findings (Liu, Mao, and Tian 2017; Derrien, Kecskes, and Nguyen 2018; Chemmanur et al. 2019) to sibling-induced human capital.

Second, we advance the literature regarding the impact of executives' personal interests and background on a firm's corporate policy. In addition to the impact of a military background, having a pilot's license, experiencing childhood famine, and economic status on various corporate practices (Cain and McKeon 2016; Benmelech and Frydman 2015; Feng and Johansson 2018), we document that having sibling-induced human capital significantly affects corporate practices in terms of corporate innovation. Specifically, we explore several interesting aspects of sibling-induced human capital and their impact on corporate innovation, including sibling co-management (especially holding different corporate positions), siblings' collaborative behavior, and sibling gender diversity. These new perspectives and findings complement those in Griffin et al. (2021) and Li and Wang (2021) by documenting the effect of sibling gender diversity on board gender diversity and the impact of siblings' collaborative behavior on innovation. Thus, we provide new evidence on how cultural imprints, specifically, sibling gender diversity and sibling collaboration, promote corporate innovation.

Last, we enrich the family firm literature through the lens of sibling-induced human capital. Studies suggest that second generation of founder involved in the management (Bertrand et al. 2008), network marriage (Bunkanwanicha et al. 2013), spouse co-management (Amore et al. 2017), or CEOs having daughters (Cronqvist and Yu 2017) influences a firm's corporate policies. Sibling relationships are more complicated than many other family relationships. Conceptually, siblings can be collaborators or rivals, which may lead to siblings

promoting or impeding corporate innovation in family firms. The effect of having family-based human capital (in terms of siblings) on corporate innovation is new and interesting in the family firm literature. In addition, some family firm literature focuses on comparing family and non-family firms (Anderson and Reeb 2003; Hsu et al. 2015) without paying attention to the effect of executives' sibling-induced human capital. Our findings complement these studies and highlight the importance of sibling-induced human capital in corporate practices.

2. Literature review and hypothesis development

2.1 Brief literature review

2.1.1 The impact of human capital on corporate innovation

Given the importance of corporate innovation to a firm, a large body of literature examines drivers of corporate innovation, including a nation's law and policies (Moser 2005; Segal and Whinston 2007), the culture of a society or a corporation (Bénabou, Ticchi and Vindigni 2015; Manso 2011; Tian and Wang 2014), market development and firms' incentives and abilities (Tadesse 2006; Hsu, Tian and Xu 2014), and human capital (Derrien, Kecskes and Nguyen 2018; Chemmanur et al. 2019). We focus on two strands of literature that focus on the relationship between human capital and corporate innovation.

The first strand of literature stresses the labor market. Using the age structure of labor markets, Derrien, Kecskes, and Nguyen (2018) report that when the market consists of younger workers, firm innovation is better in terms of patents held and patent citations. Similarly, Anelli et al. (2019) examine migration-driven labor outflows and find supporting evidence for Derrien et al. (2018). Bianchi and Giorcelli (2019) find that when a region has disproportionately more STEM-background (science, technology, engineering, and math) employees, firms' corporate innovation is better. Hunt and Gauthier-Loiselle (2010) show that when a region has more immigrants that hold science or engineering degrees, firms located in the region have better corporate innovation. Similarly, when a firm has more H-1B visa employees (i.e., those with

foreign backgrounds who are allowed to legally work in the United States), its corporate innovation is better (Dimmock, Huang, and Weisbenner 2021; Khanna and Lee 2018).

The second strand of literature focuses on the impact of employee-embedded human capital on corporate innovation. Chemmanur et al. (2019) find that firms with high-quality executives (in terms of education, prior professional experience, and professional networks) have better innovation, and they hire more R&D staff. Liu, Mao, and Tian (2017) document that R&D staff (human capital) is more important than noninnovative organizational capital in corporate innovation. Several studies suggest that team-specific human capital or teamwork plays a role in corporate innovation (Baghai, Silva, and Ye 2017; Jaravel, Petkova, and Bell 2018; Zacchia 2020). Specifically, Baghai, Silva, and Ye (2017) find that inventors' past collaboration experience is critical for future innovation. Zacchia (2020) shows that knowledge spillovers among R&D staff contribute to more corporate innovation.

Collectively, the literature on the impact of human capital and innovation provides ample evidence on the relation of external drivers and employee-embedded human capital to innovation. It is not clear how the family structure of the owner of a family firm affects its innovation. Although there are different family structures that could be considered, such as marriage or having children, we examine siblings of an owner because there is less concern about selection bias than in the other family structures. In addition, siblings may collaborate among themselves or become rivals leading to a positive or negative effect on corporate innovation. Hence, it is necessary to examine the impact of siblings on corporate innovation.

2.1.2 How executives' personal characteristics affect corporate practices

According to the upper echelons theory (Hambrick and Mason 1984), firms' decisions are made by senior executives after their evaluations of the internal and external business environments. Senior executives' decisions are unavoidably shaped by their personal experience. Several strands of literature provide ample evidence to support this notion.

The first strand suggests that CEOs' own professional expertise contributes to their ability and consequently the performance of their firms. For instance, CEOs' different functional backgrounds (e.g., marketing, production, finance, or law) lead to different decisions (Liu et al. 2020). Similarly, having or not having a government background matters for firm performance (Fisman 2001; Ang and Boyer 2007).

The second strand suggests personal interests or early life experiences shape CEO traits, which lead to specific managerial styles that reveal themselves in specific corporate policies. For instance, Benmelech and Frydman (2015) show that when a CEO has a military background, her firm is more conservative and more ethical than one managed by a nonmilitary CEO. Koch-Bayram and Wernicke (2018) echo the results in Benmelech and Frydman (2015) that ex-military CEOs are more likely to follow rules and regulations. Similarly, Cain and McKeon (2016) report that when a CEO has pilot's license, her firm takes on more risk, suggesting personal preference in risky endeavors reflects a CEO's managerial style. Moreover, Feng and Johansson (2018) find that executives who were born in famine years are more conservative, suggesting hardship in childhood creates specific attributes that shape executive preferences and ultimately play a role for executives' corporate practices. As an extension of Feng and Johansson (2018), Zhang et al. (2021) shows that IPOs of a firm with a chairperson born in a famine year have larger IPO underpricing. Investors interpret the conservative managerial style as bad signals for IPO pricing. Chuprinin and Sosyura (2018) study the relation between mutual fund managers' family backgrounds and their fund performance and find that managers from poor families deliver higher alphas than those from rich families.

The third strand of literature examines the impact of family structure on executive managerial style. Cronqvist and Yu (2017) report that when a CEO has daughters, her firm engages in more corporate social responsibility activities than a firm whose CEO has no daughters. Similarly, Amore et al. (2017) show that family firms led by married couples

perform significantly better than family firms not led by married couples. Although the findings in Cronqvist and Yu (2017) and Amore et al. (2017) are interesting, we contend that having daughters or getting married is subject to self-selection of the CEO. In addition, the impact of the CEO or chairperson having siblings is underexplored despite the long-lasting nature of siblings compared to having children or a spouse. From the perspective of human capital, we call the family structure “family-based human capital” because the nature of the family structure, such as having siblings, induces the human capital of the CEO (or owner) that in turn drives innovation.

2.2 Hypothesis development

In behavioral science, studies show that early childhood and youth experiences shape adult behavior (Locke 1974) and clearly, family is the primary place that most individuals experience their childhood and youth. Parent-child relationships, siblings, parenting styles, and social environments all contribute to children’s experiences (Belsky 1981). In the context of family structure, siblings play an important role in shaping individual behavior because siblings grow up together and have ample time to interact among themselves over their lifetimes.

If a chairperson has siblings, his or her growing-up process includes competition between the siblings. A chairperson without siblings does not have the same experiences. Hence, we expect a sibling-chairperson be more competitive than a no-sibling chairperson (Cameron et al. 2013). These personal experiences, borne from a chairperson’s growing up with a sibling positively contributes to corporate innovation. We argue that there are two reasons that a sibling-chairperson is more innovative than a no-siblings chairperson.

First, siblings experience competition. A family’s resources may be limited, which can lead to sibling rivalry (Alwin 1989; Butcher and Case 1994). Siblings need to compete for the scarce family resources such as education funding, psychological support, and opportunities in family firms (Field and Reite 1984; Morduch 2000). When they experience competition,

siblings learn the importance and consequence of competition in a business environment. A strong competitive spirit prepares a chairperson to make decisions about innovations (Spulber 2013). We expect that having a sibling makes a chairperson more likely to innovate and most important, allows the chairperson to make better innovation decisions than chairpersons without siblings.

Second, siblings learn from each other both explicitly and subconsciously (Hetherington et al. 1999; Altonji et al. 2017). Siblings may serve as “partners in crime” and exhibit similar risky behaviors (Slomkowski et al. 2005). Nicoletti and Rabe (2019) provide supportive evidence of a sibling effect in school achievement using administrative data on 230,000 siblings in England. Heissel (2017) documents that a teen sister giving birth leads to adverse outcomes for her siblings, such as higher high school dropout. Van der Vleuten et al. (2020) argue that sibling similarities in fields of study arise because older siblings transfer field-specific resources to their younger siblings. Essentially, siblings share their knowledge and experience among themselves. Our arguments echo findings on the positive contribution of corporate innovation due to knowledge spillover effects among R&D staff (Zacchia 2020). Thus, a sibling-chairperson has an edge over a no-sibling chairperson in corporate innovation because the former has more valuable family resources in terms of knowledge spillover from siblings than the latter.

Collectively, our baseline testable hypothesis is:

H1a: When a chairperson has siblings, her firm engages in more innovation relative to a firm whose chairperson has no siblings.

Alternatively, siblings compete for family resources leading to internal conflicts between them (Gersick et al. 1997). These family conflicts may impede corporate innovation due to conflicting decisions in innovation management and wasting firm resources (Aronoff and Astrachan 1996). In addition, sibling rivalries worsen when siblings are competing for firm

succession, resulting in siblings' paying less attention to the long-term goals of their firms. Consequently, innovation is not a priority in the family. Thus, our competing hypothesis is:

H1b: When a chairperson has siblings, her firm engages in less innovation relative to a firm whose chairperson has no siblings.

3. Research design

3.1 Sample selection

We use publicly traded Chinese family firms from 2008–2016. Following Anderson and Reeb (2003), we use two criteria to define family firms: (1) the controlling shareholder is an individual or a family; and (2) at least two family members are shareholders or employed by the firm or its subsidiaries. We obtain the data from the China Stock Market and Accounting Research database (CSMAR). Our study begins in 2008 because it was the first year that CSMAR reported some information regarding a chairperson's family members in the database. Then, we complement the information with additional manual collection from public sources. We retrieve all other financial and accounting information from the CSMAR and RESSET databases and delete financial firms, financially distressed firms, and firms with missing information. The final sample has 1,641 firms with 7,531 firm-years. We winsorize the data at the 1% and 99% levels.

3.2 Variable construction

3.2.1 Innovation

Following Balsmeier et al. (2017) and He and Tian (2013), we focus on using firm-level patents held ($Patent_{i,t+1}$) and patent citations ($Citation_{i,t+1}$) to gauge a firm's innovation quantity and quality. We define $Patent_{i,t+1}$ as the natural logarithm of 1 plus the total number of patents held by firm i in year $t+1$ and $Citation_{i,t+1}$ as the natural logarithm of 1 plus the total number of citations received by all patents by firm i in year $t+1$. We obtain the patent and citation information for 2009–2017 from the National Patent Bureau to match the family and firm-level

data.

3.2.2 Sibling effects

We manually collected data on siblings of a chairperson. Specifically, we collected chairperson family tree information for family firms through public sources such as annual reports and IPO prospectuses and also examined the Chinese Research Data Services Platform (CNRDS) and CSMAR to identify the name and characteristics of each chairperson and chairperson's siblings. Then, we supplemented the information using internet search engines, firm websites, and magazine reports, among others. In the search process, we noted the chairperson's and their siblings' age, birth order, gender, education, and work experience. If a chairperson has siblings, then $Chair_Sibling_{i,t} = 1$, and 0 otherwise.

3.3 Model

We use the following multiple regression model to examine the impact of siblings on corporate innovation:

$$Patent_{i,t+1} \text{ (or } Citation_{i,t+1}) = \beta_0 + \beta_1 Chair_Sibling_{i,t} + \beta_2 Controls_{i,t} + Year + Industry + \varepsilon_{i,t} \quad (1),$$

where $Patent_{i,t+1}$, $Citation_{i,t+1}$, and $Chair_Sibling_{i,t}$ is defined earlier. We follow Balsmeier et al. (2017) by including a set of control variables to account for the impact of firm and chairperson characteristics such as firm size ($Log(Asset)$), financial leverage ($Leverage$), profitability ($EBIT$), firm age ($Firm_Age$), firm liquidity ($Liquidity$), ownership concentration (Z_Index), board independence ($Indep_Ratio$), chairperson and CEO duality ($Dual$), chairperson gender ($Chair_Gender$), chairperson age ($Chair_Age$), chairperson education level, ($Chair_Degree$), chairperson ownership ($Chair_Sharehd$), and chairperson's innovation experience ($Chair_RD$). We present detailed definitions in Appendix 1. Eq. (1) includes year and industry fixed effects. The standard errors of estimates are clustered at the firm level. If H1a (H1b) is valid, then β_1 is positive (negative).

4. Results and discussion

4.1 Summary statistics and univariate analysis

We present the summary statistics of the sample in Panel A of Table 1. The means of $Patent_{i,t+1}$ and $Citation_{i,t+1}$ are 1.418 and 0.249, which are equivalent to approximately 3.13 patents held and 0.28 citations before natural logarithm. The respective standard deviations are 1.480 and 0.697, with some firms having no innovation, suggesting that there is some variability in corporate innovation. The summary statistics are comparable with corporate innovation among family firms in Hsu et al. (2015). For siblings, the mean of $Chair_Sibling$ is 0.513, indicating that 51.3% of chairperson have siblings.

Panel B of Table 1 depicts the results of univariate tests on mean values of corporate innovation by $Chair_Sibling$. Using both $Patent_{i,t+1}$ and $Citation_{i,t+1}$, the mean values of sibling-firms are significantly larger than those of no-sibling firms using both a t -test and a nonparametric Wilcoxon test. The results offer preliminary support to H1a.

We present the means of $Patent_{i,t+1}$ and $Citation_{i,t+1}$ by the number of siblings (0, 1, 2, 3, and 4 or more) in Panel C of Table 1 and Figure 1. The means of both innovation metrics monotonically increase as the number siblings increases, corroborating the findings in Panel B.

4.2 Baseline results

We present the baseline findings of Eq. (1) in Table 2. For robustness, we include the full Eq. (1) and simplified models without control variables. Across all four columns, the coefficients of $Chair_Sibling$ are consistently positive and significant at the 1% or 5% level. The findings support H1a. Sibling-firms exhibit better future innovation than no-sibling firms. The estimated economic impact of the sibling effect is large. According to columns (3) and (4), the number of patents increases 8.6% ($0.122/1.418$) and the number of citations increases 26.1% ($0.065/0.249$) relative to an average firm. Control variables, if significant, carry the expected signs. For instance, the coefficients of $Log(Asset)$ and $Chair_Degree$ are positive and

significant at the 1%, 5%, or 10% level in columns (3) and (4), which is consistent with the findings in Balsmeier et al. (2017) and Hsu et al. (2015), who find that a larger firm or a highly educated chairperson has more resources or a greater ability to innovate. In contrast, the coefficients of *Firm_Age* are negative and significant at the 1% level, indicating that an older firm is less innovative, which is also consistent with Balsmeier et al. (2017). The coefficients of *Chair_RD* are positive and significant at the 1% level, suggesting that chairpersons with R&D work experience exhibit better future innovation.

4.3 Regression discontinuity (RD) design

Although the selection bias of having siblings is not a concern, there may still be unobservable omitted variables bias. To mitigate the identification concern, we use the OCP as a natural experiment and apply an RD research design to examine the impact of having siblings on innovation. We discuss this below.

4.3.1 Historical background of the natural experiment of the one child policy (OCP)

Birth control is a major public concern in China. Before 1979, the government did not impose strict birth control measures. In late 1979, China adopted a strict OCP, which drove most families to have only one child (Qin et al. 2017; Cameron et al. 2013). In 2013, the Chinese government relaxed the OCP to a two-child policy. From 1979 to 2012, the OCP was successful, as most families had only one child (Cameron et al. 2013). Given that the time lag of childbearing is about ten months, we expect a discontinuity point of families with two or more children to one child only in 1981 (Qin et al. 2017).

4.3.2 Empirical strategy and diagnostic tests

As opposed to other common methods, such as instrumental variables, difference-in-differences, and propensity score matching techniques, a regression discontinuity (RD) design has been deemed to be a close cousin of randomized control trials and have the greatest internal validity among the alternative quasi-experimental estimators (Hahn et al. 2001).

There are two types of RD designs: “sharp” designs and “fuzzy” designs. In our context, the sample probability of being a single child increases discontinuously but not from 0 to 1, which suggests the use of fuzzy RD designs in accordance with many prior studies (Angrist and Lavy 1999). Following Qin et al (2017), we resort to the fuzzy RD framework and estimate the local average treatment effect for the impact of the OCP on innovation.

Before conducting an RD design, we examine the identifying assumption of the RD that agents cannot precisely manipulate the forcing variable near the known cutoff (Imbens and Lemieux 2008). If this identifying assumption is satisfied, the variation in recognition status is as good as that from a randomized experiment. Because the OCP is an exogenous event, the RD design does not have selection bias issue, and our choice of OCP is similar to Qin et al (2017), which uses OCP and RD design to study the impact of having siblings on education.

Another important assumption of the RD design is that there should not be discontinuity in other covariates that are correlated with the innovation variables. We perform the diagnostic test by comparing the covariates of firms. The covariates include all the control variables in Eq. (1). The results are reported in Panel A of Table 3. The results show that most covariates are not significantly different between firms whose chairperson was born before the OCP and firms whose chairperson was born after OCP. The exceptions are *Firm_Age* and *Chair_Age*, whose differences are natural due to the time trend, and *Z_Index*, *Chair_Gender*, and *Chair_Sharehd*. Overall, there does not appear to be a manipulation near the OCP with respect to having siblings. Further, there is generally no discontinuity in other covariates at the cutoff point.

4.3.3 RD results

Following Qin et al. (2017), we use an RD to examine the impact of OCP on innovation. Since we are interested in the local average effect of the OCP, we first narrow the sample to a smaller subsample in which all observations were born just five years before and after the 1981 cutoff, using the same approach used in Qin et al. (2017). Second, we exclude ethnic minorities

as the OCP did not apply to them; we also exclude rural residents because (1) the OCP was not strictly implemented in many rural areas (Li 1995); and (2) the large-scale rural land reform (“household responsibility system” reform) occurred at approximately the same time as the OCP and would complicate the RD estimation (Almond et al. 2013). Third, we exclude the provinces where the OCP implementation was less strict, which meant that couples were allowed to have two or more children.² Our final sample size is 197. Since $Citation_{t+1}$ is almost zero during this period, we only use $Patent_{t+1}$ as the innovation metric to conduct the RD.

Figure 2 shows the discontinuities of the single-child ratio and $Patent_{t+1}$ at the policy cutoff point in 1981. Specifically, the single-child ratio jumps in the left-hand plot, and $Patent_{t+1}$ drops in the right-hand plot after the implementation of the OCP. We interpret the profiles of the single-child ratio and $Patent_{t+1}$ to be consistent with having more single-child executives after the OCP, leading to lower $Patent_{t+1}$ among firms.

Panel B of Table 3 presents the RD estimates, which are obtained from nonparametric local regressions using a triangular kernel.³ The dependent variable is $Patent_{t+1}$. The results in column (1) show that the OCP instantly increases the tendency to be a single child among the respondents born around the cutoff point, with a significant 37.1% jump in probability, and the increase in the single-child probability significantly decreases the respondents’ $Patent_{t+1}$ by 0.871, indicating that the local average treatment effect (LATE) estimate is 2.346. The results are robust when we use twice the optimal bandwidth based on Imbens and Kalyanaraman (2012) in column (2). Furthermore, prior literature shows that the triangle kernel is optimal for the point estimates at boundaries (Imbens and Lemieux 2008). Hence, we use the triangle kernel in our main estimation and the rectangular kernel for robustness checks in column (3). Finally, the result in column (4) remains robust when the RD estimates incorporate covariates, which

² Based on Guo (2003), the less restricted provinces were Henan, Guangxi, Gansu, Hebei, Inner Mongolia, Yunnan, Qinghai, Ningxi, Hainan, and Xinjian.

³ Statistical literature shows that the triangle kernel is optimal for the point estimates at boundaries (Imbens and Lemieux 2010).

include the chairperson's gender and birth province. Furthermore, we conduct placebo tests to examine whether our results disappear when we artificially assume the OCP was implemented in 1979, 1980, 1982, or 1983 instead of the actual year of 1981. We report the results in columns (1)–(4) of Panel C. The coefficients of *Weighted LATE* are not significant, suggesting our results from the exogenous shock of the OCP remain intact.

Finally, we plot the RD estimators and their 95% confidence intervals over the spectrum of bandwidths in Figure 3. We notice that the RD estimates of $Patent_{t+1}$ are consistently negative and stable, suggesting robustness of our results in Panel A. Therefore, the results in Table 3 strongly suggest that, as an exogenous shock, having a chairperson who is a single child significantly decreases a firm's $Patent_{t+1}$, which is consistent with the findings based on economics experiments conducted with 421 individuals born just before and after the OCP that when an individual is a singleton, she is less competitive (Cameron et al. 2013).

4.4 Robustness checks

4.4.1 Long-term effect

In our baseline findings, we capture the effect of a firm's having a sibling-chairperson on future innovation in $t+1$ (Lerner and Wulf 2007; Hall et al. 1986). For robustness, we consider innovation in $t+2$, $t+3$, and $t+4$ years to reveal the long-term effects of a firm's having a sibling-chairperson. We replace $Patent_{t+1}$ and $Citation_{t+1}$ in Eq. (1) by respective metrics in $t+2$, $t+3$, and $t+4$. The results are presented in Table 4, Panel A. The coefficients of *Chair_Sibling* are consistently positive and significant at the 1% or 5% level across all columns. Thus, the impact of siblings on innovation extend over the long term.

4.4.2 Innovation efficiency and quality

Our baseline results focus on innovation in terms of patents held and patent citations. For robustness, we alternatively use innovation metrics by innovation efficiency and quality. To gauge a firm's innovation efficiency, we follow Cohen et al. (2013) and Hirshleifer et al. (2013)

to divide $Patent_{i,t+1}$ and $Citation_{i,t+1}$ by a firm's research and development expense ($R\&D_{i,t}$). Then, we have $Patent_{i,t+1} / R\&D_{i,t}$ and $Citation_{i,t+1} / R\&D_{i,t}$. For innovation quality, we follow Balsmeier et al. (2017) to use the number of the top 1% cited patents ($_Top1\%$) and the number of exploratory innovation patents that do not belong to a firm's current year patent class ($Newclass$).

We present the findings in Panel B of Table 4. Consistent with the baseline findings in Table 2, the coefficients of $Chair_Sibling$ are positive and significant at the 5% or 10% levels. Thus, using alternative metrics of innovation yields the same conclusions that a sibling-firm produces more innovation than that of a no-sibling firm in terms of efficiency and quality.

4.4.3 Survivorship bias

We address the impact of survivorship bias on our baseline findings because some firms with a sibling-chairperson may not survive long enough to go public due to their low innovation and bad performance, causing the remaining sibling-firms to have higher innovation performance compared to those of no-sibling firms. To address potential survivorship bias, we examine subsamples of first- and second-generation chairperson firms.

Chinese family firms began to take off after the re-opening of stock markets in the early 1990s. Hence, most family firms are still under the control of first-generation chairpersons. The first-generation chairperson samples have some survivorship bias because some of them are unable to go public. In addition, if survivorship bias is severe, we expect the impact of having a sibling-chairperson on $Patent_{t+1}$ and $Citation_{t+1}$ will become more pronounced for those "survived" firms. When first-generation firms transition into second-generation firms there is minimal survivorship bias because the transition does not involve listing bias. The results in Panel C of Table 4 show that the coefficients of $Chair_Sibling$ are positive and significant in first- and second-generation chairperson subsamples. Thus, the impact of having siblings on innovation remains qualitatively similar for the subsample of second-generation

firms. Collectively, survivorship bias, if any, is minimal and does not change our baseline findings.

4.4.4 Placebo test

We conduct a placebo test in which we randomly assign a sibling to each chairperson based on the sample distribution of chairpersons' siblings. We measure the sibling effect at this randomly generated family structure, re-run the analysis in Table 2, and repeat the exercise 1000 times. Table 4, Panel D reports the average coefficient for the main independent variables over the 1000 repetitions and the percentage of coefficients that are significant at the 5% level. Consistent with our expectations, approximately 6% of the coefficients are significant at the 5% level, and those cases are split roughly equally between positive and negative. Moreover, attesting to the significance of our main results, the estimated coefficients are statically significant and in the "right direction" in none of the replications. This evidence strongly suggests that our measure of sibling effect likely reflects an economically meaningful characterization of chairpersons' attitudes toward innovation as opposed to random noise.

4.4.5 Other robustness tests

We conduct several additional robustness checks on the baseline results. First, we augment Eq. (1) by contemporaneous innovation ($Patent_t$ and $Citation_t$) to capture the omitted variable effect. The results in columns (1) and (2) of Panel E in Table 4 indicate the coefficients of $Chair_Sibling$ remain positive and significant at the 1% level. Second, we include provincial fixed effect in Eq. (1) to account for the impact of provincial characteristics on innovation. The coefficients of $Chair_Sibling$ continue to be positive and significant at the 1% or 5% level in columns (3) and (4). Third, despite that some firms have no innovation, we include all firms in Table 2. To exclude firms with no innovation, we reexamine Eq. (1) for firms with only nonzero innovation. The findings in columns (5) and (6) of Panel E are similar to those in Table 2. Fourth, it may take two to three years for a firm to hold a patent. We also recognize that a two-

to three-year lag may exist between the patent application date and the final approval date. To exclude the impact of a patent delay, we examine a reduced sample from 2008–2013. The findings in columns (7) and (8) of Panel E show that the coefficients of *Chair_Sibling* are positive and significant at the 1% or 5% level. Last, we control industry-year joint fixed effects to absorb any time-varying industry-specific factor in columns (9)–(10) and double-cluster standard errors by firm and year in columns (11)–(12). The findings in columns (9)–(12) are similar to the baseline findings in Table 2.

4.5 *The mechanisms*

We examine the underlying logic of the testable hypothesis in terms of sibling competition and knowledge spillover effects for the impact of a firm's chairperson having at least one sibling on corporate innovation and discuss the findings below.

4.5.1 *Sibling competition effect*

We proxy the extent of sibling competition effect through three metrics: 1) whether the chairperson has one or more brothers (*Brother* = 1 if the chairperson has brother, and 0 otherwise), 2) whether the chairperson is a younger child (*Young* = 1 if the chairperson is not the eldest child, and 0 otherwise), and 3) the average age gap between the chairperson and the other siblings (*Age_gap*). Some missing values of siblings' birthdates reduces the sample size.

We contend that the Chinese culture emphasizes and prefers male children. Thus, having one or more brothers suggests the chairperson has strong sibling competition. When a child is the eldest, he or she has an edge in receiving family resources. In addition, an eldest child enjoys the most respected status in a family. Thus, a younger (non-eldest) sibling needs to have outstanding qualities to take the helm of the family business over an eldest sibling. Thus, we expect when the chairperson is a younger child, the firm is more innovative. When the age gap between a chairperson and the other siblings is smaller, competition for family resources and family business succession opportunities naturally becomes fiercer. This should induce the firm

to innovate more.

To examine the sibling competition effect, we augment Eq. (1) with $Chair_Sibling \times Brother$, $Chair_Sibling \times Young$, and $Chair_Sibling \times Age_gap$. We present the findings in Table 5. In columns (1) and (2), the coefficients of $Chair_Sibling \times Brother$ are positive and significant at the 5% level, suggesting that, conditional on a chairperson's having siblings, when the chairperson has one or more brothers, the firm has additional innovation output. For the young sibling effect, we find only the coefficient of $Chair_Sibling \times Young$ is positive and significant at the 5% level in column (3) when using patent as the dependent variable. Hence, when a non-eldest child is the chairperson, that person is more innovative in terms of patents held. In columns (5)–(6), the coefficients of $Chair_Sibling \times Age_gap$ are negative and significant at the 1% and 5% levels, suggesting that when the age gap becomes smaller, the firm has more innovation output.

Collectively, the findings in Table 5 suggest a sibling competition effect. That is, when a chairperson has a brother, being a younger sibling or having a smaller age gap between the chairperson and other siblings enhances his or her firm's innovation further due to sibling competition.

4.5.2 Knowledge spillover effects

Siblings share their know-how and experience within their firms. Given the risky and high failure rate innovative projects, we consider related-knowledge spillover be an important contributor to the success of innovation (Zacchia 2020). We contend that sibling behavior is interdependent as siblings share learning formally and informally among themselves. In addition, when compared to employee-to-employee interactions, siblings are closer, are more permanent, and are expected to be more influential in a firm's innovation. Thus, if one of the siblings has valuable innovation experience, we expect the firm will have more successful innovation.

Specifically, we consider a sibling's R&D experience and overseas experience. In the spirit of Zacchia (2020), we define *R&D_Exp* as a (1, 0) indicator with a value of 1 if a chairperson's sibling has R&D-related work experience (such as being an R&D staff member), and 0 otherwise. Similarly, *Overseas_Exp* is a (1, 0) indicator variable if a chairperson's sibling has overseas study or work experience, and 0 otherwise. The R&D work experience directly captures the innovation-related experience while overseas experience indirectly captures the innovative vision of a sibling.

We augment Eq. (1) with *Chair_Sibling*×*R&D_Exp* and *Chair_Sibling*×*Overseas_Exp*. The results are presented in Table 6. Across all four columns, the coefficients of *Chair_Sibling*×*R&D_Exp* and *Chair_Sibling*×*Overseas_Exp* are consistently positive and significant at the 1%, 5%, or 10% level, indicating that, conditional on a chairperson's having siblings, having a sibling with R&D experience or overseas experience further enhances the family firm's innovation. Therefore, siblings offer a knowledge-sharing effect to enhance a family firm's innovation.

4.6 Further analysis

In this section, we explore the impact of several interesting aspects of family-based human capital from siblings on corporate innovation and the effect of a chairperson's having a sibling on a firm's approach to innovation.

4.6.1 The effect of sibling co-management and different corporate positions on innovation

Siblings sometimes co-manage their family firms. Unlike outside professional managers who are more myopic in management due to their incentives to establish their own status and reputation in firms quickly and maintain their transferable job market value (Miller and Le Breto-Miller 2005; Bertrand and Schoar 2006), family members usually have a longer horizon and more family-specific knowledge about the firm (Fan et al. 2012). Specifically, studies suggest that having family members as a CEO has lower coordination costs (Becker and

Murphy 1992) and agency costs (Jensen and Meckling 1976). In addition, when siblings head the R&D department, the family is more likely to focus on long-term benefits. We conjecture that sibling co-management, especially when siblings are the CEO or the head of R&D, could align family and shareholder interests to advance firm value through more innovation.

We examine the effect of siblings' holding different positions in their firm on innovation by matching hand-collected sibling information with top-managers information from CSMAR to get sibling-specific co-management information.⁴ We present the distribution of sibling managerial positions in Panel A of Table 7. Within a board, siblings make up approximately 37.66% of directors. In terms of managerial roles, siblings make up approximately 9.34% of CEOs and 15.43% of R&D department heads; these figures in line with the notion that the CEO and the R&D head play essential roles in a firm's innovation. Specifically, we denote *Sibling_cowork*, *Sibling_CEO*, and *RD_Head* as (1, 0) indicator variables with values of 1 if a sibling is involved in co-management, is the CEO, or is the R&D department head, respectively; and 0 otherwise.

We present the findings in Panel B of Table 7. Across columns (1)–(4), the coefficients of *Chair_Sibling* × *Sibling_cowork* and *Chair_Sibling* × *Sibling_CEO* are positive and significant at the 5% level in the patent equations in columns (1) and (3). Hence, when a firm has a sibling-chairperson and another sibling co-manages the firm or is the CEO, it has more patents. However, the results for citations are not significant in columns (2) and (4). In terms of R&D department heads, the coefficients of *Chair_Sibling* × *RD_Head* are positive and significant at the 1% and 10% levels in columns (5) and (6). Thus, having a sibling as the head of R&D is essential to innovation as measured in patents and patent citations.

4.6.2 Does sibling gender diversity affect board gender diversity?

Griffin et al. (2021) find that firms with gender-diverse boards (that is, a higher female

⁴ The data are at the firm-year-sibling level. Each sibling may have more than one role in his or her family firm.

director to board size ratio) hold more patents and more novel patents and have greater innovative efficiency. Their findings suggest that gender-diverse boards are associated with more failure-tolerant and long-term incentives. Does sibling gender diversity affect board gender diversity? We have two conjectures. First, relative to sister-sister or brother-brother siblings, brother-sister siblings are more likely to realize the benefits of gender diversity. Brother-sister siblings, through their interactions throughout their childhood, have open minds regarding gender diversity. Second, according to the female socialization hypothesis in recent literature (Cronqvist and Yu 2017; Washington 2008; Glynn and Sen 2014), we argue that when a male (female) chairperson has a female (male) sibling co-manage a firm, the sibling benefits are more salient due to the female socialization process. In both scenarios, a sibling-chairperson is more likely to appoint opposite-gender board members. Therefore, we define *Sibling_Diversity* as a (1, 0) indicator variable with a value of 1 if siblings are of opposite genders, and 0 otherwise. Following Griffin et al. (2021), we use the ratio of women directors to board size (*Board_Diversity*) to gauge a firm's board diversity.

We present the findings in Table 8. For the full sample in column (1) and the subsample of male chairpersons in column (2), the coefficients of *Sibling_Diversity* are positive and significant at the 5% or 10% level, which is consistent with our conjecture. However, the coefficient of *Sibling_Diversity* is not significant when the chairperson is a female (in column (3)). We attribute the results in column (3) to the notion that a female chairperson does not value a gender-diverse board as much given her value to the board. Our results complement those in Griffin et al. (2021) by documenting the effect of sibling gender diversity on board gender diversity.

4.6.3 *The effect of siblings' collaboration effect on successful joint patents*

Siblings positively contribute to individual psychological development, social interaction, and collaborating behavior (Harper, Padilla-Walker, and Jensen 2016). The literature suggests

that siblings spend more time among themselves than with their parents (McHale and Crouter 1996). Despite some siblings' developing hostility or aggressive behavior, they generally exhibit prosocial behavior, which enhances their social interaction and collaborating behavior. Studies show that good interpersonal skills play a role in corporate innovation success (Baghai, Silva, and Ye 2017; Jaravel, Petkova, and Bell 2018). Li and Wang (2021) show that collaboration between acquirer and target inventors post-merger is associated with more groundbreaking patents, indicating that collaboration is important in improving innovation capability. Thus, we predict that having siblings makes a chairperson more willing to collaborate and that chairperson is more inclined to innovate jointly than a no-sibling chairperson.

To examine the effect of a chairperson's having siblings on joint innovation, we use a firm's joint patents ($Joint_Patent_{t+1}$) and the ratio of joint patents to total patents held ($Joint_Patent_{t+1_ratio}$) to gauge a firm's collaborative innovation. We confine our analysis to patents held because the data source (CNRDS) does not provide information on joint patent citations.

We present the findings in Table 9. The coefficients of $Chair_Sibling$ are positive and significant at the 1% or 5% level, suggesting that having a sibling-chairperson improves a firm's ability to collaborate on innovation.

4.6.4 Does innovation channel through the internal or external approach?

In terms of innovation, a firm can pursue an internal approach by developing innovation organically (Chemmanur et al. 2019). In contrast, a firm can also use an external approach by acquiring innovative firms (Bena and Li 2014; Guo et al. 2019). It is interesting to examine the effect of having a sibling on a firm's approach to innovation.

For this test, we define $R\&D\ staff$ as the number of R&D staff scaled by the total number of staff in a firm to gauge the propensity to use an internal approach to innovation. To gauge

the external approach, we follow Guo et al. (2019) to define: (1) *M&A_Dum*, a (1, 0) indicator variable with a value of 1 if there is an innovation-related merger or acquisition, and 0 otherwise in year $t+1$; (2) *M&A_Num* as the natural logarithm of 1 plus the total number of innovation-related mergers or acquisitions in year $t+1$; and (3) *M&A_Ratio*, calculated as the number of innovation-related mergers or acquisitions scaled by the total number of mergers or acquisitions in year $t+1$.

We present the findings in Table 10. In column (1), the coefficient of *Chair_Sibling* is positive and significant at the 5% level for the *R&D staff* equation, suggesting that sibling-firms hire more R&D staff than no-sibling firms. This finding corroborates those in Table 9 that a sibling-induced human capital chairperson is effective in collaborating with innovative staff. For the results in columns (2)–(4), the coefficients of *Chair_Sibling* are not significant. Hence, a sibling-firm does not engage in more innovation-related mergers and acquisitions than a no-sibling firm.

5. Summary

We study the impact of sibling-induced human capital on a family firm's innovation. Specifically, we compare the effect of a chairperson's having siblings vis-à-vis no siblings on a firm's innovation. Drawing from the psychology and sociology literature, we hypothesize that sibling-induced human capital shapes the character of a chairperson and ultimately impacts a firm's innovation. The core findings suggest that when a firm has a sibling-chairperson, its innovation is better than a firm without a sibling-chairperson. The results are economically significant and are robust after addressing survivorship bias, running a placebo test, and addressing other sample concerns. We also find that the impact of a chairperson's having siblings on corporate innovation has long-term effects up to four years in the future and a firm with sibling-chairperson has higher innovation efficiency and innovation quality than an otherwise equivalent firm with a no-sibling chairperson. Leveraging from the 1979 OCP that

exogenously limited most families to having only one child, we use a regression discontinuity research design to examine the OCP's impact on firm innovation for chairpersons born around the event. The findings from the regression discontinuity are consistent with the core findings, suggesting our baseline results are robust to endogeneity.

Additional analysis suggests that the mechanisms behind the impact of sibling-chairpersons on innovation are consistent with the interpretations of competition and knowledge-spillover effects of siblings. In further analysis, we find that: (1) when siblings co-manage the firm, innovation is better, especially when a sibling is the CEO or the head of R&D; (2) sibling gender diversity may promote innovation by increasing board gender diversity; (3) a sibling-chairperson is more likely to work collaboratively to obtain joint patents than a no-sibling chairperson; and 4) a sibling-chairperson is more likely to engage in innovation using internal innovative staff.

Collectively, we interpret our findings as being supportive of a sibling-induced human capital view of firm innovation. When a chairperson has siblings, he or she has more sibling-induced human capital than an otherwise equivalent firm with a no-sibling chairperson. Hence, our conceptual framework and related evidence complement the role of human capital in firm innovation. In addition to labor supply and employee-embedded human capital, sibling-induced human capital plays a role in enhancing a firm's innovation.

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Appendix A: Variable definitions

Variable	Definition	Source
Dependent variables		
<i>Patent_{t+1}</i>	The natural logarithm of 1 plus the total number of successful patent applications that are filed by firm <i>i</i> in year <i>t+1</i> and that are approved by the National Patent Bureau from year <i>t+1</i> to 2017.	National Patent Bureau of China
<i>Citation_{t+1}</i>	The natural logarithm of 1 plus the total number of citations received by all patents that are filed by firm <i>i</i> in year <i>t+1</i> and that are approved by the National Patent Bureau from year <i>t+1</i> to 2017.	National Patent Bureau of China
Independent variable		
<i>Chair_Sibling</i>	A dummy variable equal to 1 if the chairperson has siblings, and 0 otherwise	CSMAR/CNRDS/Prospectus/Annual Report/Websites
Firm characteristics		
<i>Log(Asset)</i>	Natural logarithm of total assets.	CSMAR
<i>Leverage</i>	Financial leverage	CSMAR
<i>EBIT</i>	The ratio of earnings before interest and tax to sale	CSMAR
<i>Firm_Age</i>	Natural logarithm of firm age	CSMAR
<i>Liquidity</i>	The ratio of current assets to current liabilities	CSMAR
<i>Indep_Ratio</i>	The ratio of independent directors	CSMAR
<i>Z_Index</i>	The ratio of shareholdings of the largest shareholder to that of the second shareholder	CSMAR
<i>Dual</i>	Dual role for the board chairperson	CSMAR
<i>Chair_Gender</i>	The gender of the chairperson	CSMAR
<i>Chair_Age</i>	The age of the chairperson	CSMAR
<i>Chair_Degree</i>	The education level of the chairperson that takes a value of 1 to 5 for high school, post-secondary, undergraduate, master's degree, and doctoral degree, respectively	CSMAR
<i>Chair_Sharehd</i>	The shareholding ratio of the chairperson	CSMAR
<i>Chair_RD</i>	An indicator variable that equals 1 if the chairperson has R&D work experience, and 0 otherwise.	CSMAR/CNRDS/Prospectus/Annual Report/Websites
Mechanisms		
<i>Young</i>	An indicator variable that equals 1 if the chairperson is not the oldest sibling, and 0 otherwise	CSMAR/CNRDS/Prospectus/Annual Report/Websites
<i>Brother</i>	An indicator variable that equals 1 if there are two or more brothers, and 0 otherwise	CSMAR/CNRDS/Prospectus/Annual Report/Websites
<i>Age_gap</i>	The average age gap between the chairperson and the other siblings	CSMAR/CNRDS/Prospectus/Annual Report/Websites
<i>R&D_Exp</i>	An indicator variable that equals 1 if one of the chairperson's siblings has R&D work experience, and 0 otherwise	CSMAR/CNRDS/Prospectus/Annual Report/Websites

<i>Overseas_Exp</i>	An indicator variable that equals 1 if one of the chairperson's siblings has overseas study or work experience, and 0 otherwise.	CSMAR/CNRDS/ Prospectus/Annual Report/Websites
Robustness Tests		
<i>Patent_{t+1}/R&D_t</i>	The number of patent filings (see variable “ <i>Patent_{t+1}</i> ” for more details) in year <i>t+1</i> scaled by the logarithm of R&D in year <i>t</i>	National Patent Bureau of China
<i>Citation_{t+1}/R&D_t</i>	The number of citations (see variable “ <i>Citation_{t+1}</i> ” for more details) in year <i>t+1</i> scaled by the logarithm of R&D in year <i>t</i>	National Patent Bureau of China
<i>_Top1%</i>	The number of patents that fall into the 1% of most- cited patents within a given class and year	National Patent Bureau of China
<i>Newclass</i>	The number of patents filed in classes where the given firm has filed no other patent previously	National Patent Bureau of China
Further Analysis		
<i>Sibling_cowork</i>	A dummy variable equal to 1 if a chairperson has a sibling co-manager (siblings serve on board of directors, on board of supervisors, or as managers in the same firm), and 0 otherwise	CSMAR/CNRDS/ Prospectus/Annual Report/Websites
<i>Sibling_CEO</i>	A dummy variable equal to 1 if a chairperson has a sibling serving as CEO in the same firm, and 0 otherwise	CSMAR/CNRDS/ Prospectus/Annual Report/Websites
<i>RD_Head</i>	A dummy variable equal to 1 if a chairperson has a sibling serving as CEO in the same firm, and 0 otherwise	CSMAR/CNRDS/ Prospectus/Annual Report/Websites
<i>Sibling_Diversity</i>	A dummy variable equal to 1 if the siblings are of different genders, and 0 otherwise.	CSMAR/CNRDS/ Prospectus/Annual Report/Websites
<i>Board_Diversity</i>	The fraction of female directors on a board	CSMAR
<i>Joint_Patent_{t+1}</i>	The natural logarithm of 1 plus the total number of successful joint patent applications applied for by firm <i>i</i> and another firm in year <i>t+1</i>	CNRDS
<i>Joint_Patent_{t+1}_ratio</i>	Ratio of successful joint patent applications to the total number of successful patent applications that are filed by firm <i>i</i> in year <i>t+1</i>	CNRDS
<i>M&A_Dum</i>	An indicator variable that equals 1 if the firm has an innovation-related merger or acquisition, and 0 otherwise in year <i>t+1</i>	CSMAR/National Patent Bureau of China
<i>M&A_Num</i>	The natural logarithm of 1 plus the total number of innovation-related mergers and acquisitions in year <i>t+1</i>	CSMAR/National Patent Bureau of China
<i>M&A_Ratio</i>	The number of innovation-related mergers and acquisitions scaled by the total number of mergers and acquisitions in year <i>t+1</i>	CSMAR/National Patent Bureau of China

Table 1. Summary statistics and univariate analysis

The table reports summary statistics of the main variables. Panel A presents the distribution of the main variables in the listed family-firm sample for period of 2008–2016. The data on the chairperson’s siblings and their characteristic are from a diverse set of available databases and have been cross-checked by searching the internet using Google, Baidu, news reports, and genealogy. The data on patents and citations are from the National Patent Bureau of China. The data on firm and chairperson characteristics are from the CSMAR database. Panel B depicts the results of univariate tests on mean values of corporate innovation by *Chair_Sibling*. Panel C presents the means of $Patent_{t+1}$ and $Citation_{t+1}$ by the number of siblings. See Appendix A for variable definitions.

Panel A. Summary statistics								
variable	N	mean	std	p5	p25	p50	p75	p95
<i>Patent_{t+1}</i>	7531	1.418	1.480	0.000	0.000	1.099	2.639	3.932
<i>Citation_{t+1}</i>	7531	0.249	0.697	0.000	0.000	0.000	0.000	1.946
<i>Chair_Sibling</i>	7531	0.513	0.500	0.000	0.000	1.000	1.000	1.000
<i>Log(Asset)</i>	7531	21.483	0.951	20.174	20.772	21.352	22.054	23.263
<i>Leverage</i>	7531	0.344	0.196	0.068	0.182	0.319	0.482	0.697
<i>EBIT</i>	7531	0.138	0.117	0.008	0.067	0.120	0.192	0.353
<i>Firm_Age</i>	7531	3.694	1.101	1.609	3.045	3.850	4.394	5.347
<i>Liquidity</i>	7531	3.752	4.298	0.849	1.409	2.203	4.100	12.447
<i>Indep_Ratio</i>	7531	0.376	0.053	0.333	0.333	0.333	0.429	0.444
<i>Z_Index</i>	7531	2.704	3.410	0.482	0.898	1.541	2.966	9.146
<i>Dual</i>	7531	0.606	0.489	0.000	0.000	1.000	1.000	1.000
<i>Chair_Gender</i>	7531	0.054	0.226	0.000	0.000	0.000	0.000	1.000
<i>Chair_Age</i>	7531	3.927	0.155	3.689	3.829	3.932	4.025	4.174
<i>Chair_Degree</i>	7531	3.256	0.972	1.000	3.000	3.000	4.000	5.000
<i>Chair_Sharehd</i>	7531	0.163	0.169	0.000	0.000	0.126	0.284	0.495
<i>Chair_RD</i>	7531	0.301	0.459	0.000	0.000	0.000	1.000	1.000

Panel B. <i>t</i> -test and Wilcoxon test comparisons				
Variables	<i>Sibling=0</i>	<i>Sibling=1</i>	<i>t</i> -test	Wilcoxon Test
<i>Patent_{t+1}</i>	1.294	1.535	-0.241***	-6.143***
<i>Citation_{t+1}</i>	0.211	0.285	-0.074***	-2.240**
#Obs	3669	3862		

Panel C. Number of siblings				
Number of siblings	Frequency	Percent	<i>Patent_{t+1}</i>	<i>Citation_{t+1}</i>
0	3669	48.72	1.294	0.211
1	2256	29.96	1.466	0.265
2	972	12.91	1.547	0.273
3	350	4.65	1.670	0.365
≥4	284	3.77	1.871	0.383
Total	7531	100		

Table 2. Sibling effect and innovation: Baseline regressions

The data are from listed family firms for the period 2008–2016. $Patent_{t+1}$ and $Citation_{t+1}$ are the dependent variables. $Chair_Sibling$ is an indicator variable that equals 1 if the chairperson has siblings, and 0 otherwise. In columns (1)–(2), only controls for industry and year dummies are included. Columns (3) and (4) present the results that include firm characteristics and chairperson characteristics, respectively. Appendix A provides detailed definitions for all variables. Standard errors are clustered at the firm-level. ***, **, and * indicate 1%, 5%, and 10% significance, respectively.

	$Patent_{t+1}$	$Citation_{t+1}$	$Patent_{t+1}$	$Citation_{t+1}$
	(1)	(2)	(3)	(4)
<i>Chair_Sibling</i>	0.184*** (3.44)	1.285** (2.43)	0.122** (2.35)	0.065*** (3.19)
<i>Log(Asset)</i>			0.235*** (6.11)	0.064*** (4.47)
<i>Leverage</i>			-0.714*** (-3.90)	-0.077 (-1.00)
<i>EBIT</i>			-0.140 (-0.74)	0.006 (0.07)
<i>Firm_Age</i>			-0.155*** (-6.14)	-0.034*** (-3.04)
<i>Liquidity</i>			-0.018*** (-2.76)	-0.003 (-1.15)
<i>Indep_Ratio</i>			-0.141 (-0.31)	-0.177 (-1.12)
<i>Z_Index</i>			0.009 (1.04)	-0.000 (-0.11)
<i>Dual</i>			-0.024 (-0.46)	-0.030 (-1.40)
<i>Chair_Gender</i>			-0.128 (-1.29)	-0.076** (-2.30)
<i>Chair_Age</i>			-0.064 (-0.39)	-0.059 (-0.96)
<i>Chair_Degree</i>			0.062** (2.30)	0.021* (1.95)
<i>Chair_Sharehd</i>			0.304* (1.76)	0.007 (0.10)
<i>Chair_RD</i>			0.162*** (2.69)	0.067*** (2.73)
<i>Intercept</i>	0.709*** (3.58)	5.577*** (3.38)	-3.260*** (-3.25)	0.006 (0.01)
Industry FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Obs.	7531	7531	7531	7531
Adj R^2	0.326	0.035	0.350	0.253

Table 3. Sibling effect and innovation: Using a regression discontinuity design

This table reports the validity of the assumption and the main results of the RD. Panel A shows differences in observable characteristics between firms with a chairperson born before 1981 versus those with a chairperson born after 1981. The period is 1976–1986 (five years before and after the cutoff point of 1981). The data on firm and chairperson characteristics are from the CSMAR database. Panel B presents the nonparametric regression discontinuity (RD) estimates, which are obtained from kernel regressions using a triangular kernel. We use 197 observations (those born five years before and after the cutoff point of 1981) to draw the optimal bandwidth. The first column corresponds to the optimal band by following Imbens and Kalyanaraman (2012). The results remain robust using twice the optimal band in column (2). Columns (3)–(4) show the result remains robust when the RD estimates use rectangle kernel regression or incorporate covariates, which include gender and province of birthplace. Panel C reports the result of placebo tests when we artificially assume the OCP occurs in years other than the actual year. Z-statistics are in parentheses. ***, **, and * indicate 1%, 5%, and 10% significance, respectively.

Panel A. Difference in observable characteristics between firms with chairperson born before and after OCP				
Variables	Year>1981	Year≤1981	Difference	p-value
<i>Log(Asset)</i>	21.693	21.669	0.024	0.860
<i>Leverage</i>	0.377	0.37	0.007	0.804
<i>EBIT</i>	0.152	0.138	0.013	0.539
<i>Firm_Age</i>	4.514	3.821	0.693	0.000
<i>Liquidity</i>	2.871	2.583	0.288	0.513
<i>Indep_Ratio</i>	0.372	0.38	−0.008	0.381
<i>Z_Index</i>	3.206	2.151	1.055	0.021
<i>Dual</i>	0.533	0.608	−0.075	0.203
<i>Chair_Gender</i>	0.099	0.246	−0.147	0.012
<i>Chair_Age</i>	3.458	3.574	−0.116	0.000
<i>Chair_Degree</i>	3.479	3.365	0.114	0.323
<i>Chair_Sharehd</i>	0.087	0.158	−0.071	0.003
<i>Chair_RD</i>	0.244	0.213	0.031	0.532

Panel B: Nonparametric local polynomial estimates for the effect of the OCP				
	<i>Patent</i> _{t+1} (1)	<i>Patent</i> _{t+1} (2)	<i>Patent</i> _{t+1} (3)	<i>Patent</i> _{t+1} (4)
<i>Jump in Patent</i>	−0.871** (−2.22)	−0.705** (−2.21)	−1.292*** (−3.25)	−0.733* (−1.96)
<i>Rise in Single-child Ratio</i>	0.371** (2.43)	0.343*** (2.95)	0.348** (2.16)	0.296*** (3.92)
<i>Weighted LATE</i>	−2.346* (−1.74)	−2.057** (−1.97)	−3.715* (−1.88)	−2.477* (−1.88)
Optimal band	100% of IK	200% of IK	100% of IK	100% of IK
covariates	No	No	No	YES
kernel	triangle	triangle	rectangle	triangle
cutoff point	1981	1981	1981	1981
Obs.	197	197	197	197

Panel C: Placebo test				
	$Patent_{t+1}$	$Patent_{t+1}$	$Patent_{t+1}$	$Patent_{t+1}$
	(1)	(2)	(3)	(4)
<i>Jump in Patent</i>	2.356*** (3.42)	-0.325 (-0.61)	-0.424 (-0.92)	-0.507 (-0.93)
<i>Rise in Single-child Ratio</i>	0.045 (0.43)	-0.531*** (-2.81)	0.067 (0.80)	-2.333 (-2.45)
<i>Weighted LATE</i>	52.235 (0.42)	0.612 (0.57)	-6.289 (-0.58)	2.172 (0.92)
Optimal bandwidth kernel	100% of IK triangle	100% of IK triangle	100% of IK triangle	100% of IK triangle
cutoff point	1979	1980	1982	1983
Obs.	305	241	187	164

Table 4. Robustness checks

The table reports a battery of robustness checks. The data are from listed family firms for the period 2008–2016. Panel A reports the long-term effect of a firm’s having a chairperson-sibling on innovation. Columns (1)–(2), (3)–(4), and (5)–(6) show the innovation results for $t+2$, $t+3$, and $t+4$, respectively. Panel B presents the results for innovation efficiency and innovation quality. Columns (1)–(2) show the results for innovation efficiency, where $Patent_{t+1}/R\&D_t$ is calculated by the number of patent filings (see variable “ $Patent_{t+1}$ ” for more details) in year $t+1$ scaled by the logarithm of R&D in year t , and $Citation_{t+1}/R\&D_t$ is calculated by the number of citations (see variable “ $Citation_{t+1}$ ” for more details) in year $t+1$ scaled by the logarithm of R&D in year t . Columns (3)–(5) show the results for innovation quality; the measure of innovation quality includes $Top1\%$, which is the number of patents that fall into the 1% of most-cited patents within a given class and year, and $Newclass$, the number of patents that are filed in classes where the given firm has filed no other patent previously. Panel C presents the regression of innovation output in first-generation and second-generation subsamples to address survivorship bias. Panel D reports summary statistics of the regression estimates for the baseline models in Table 2, when we randomly assign siblings to each chairperson based on the observed distribution of CEO family siblings (with replacement). For each replication, we record the estimated coefficient and associated p -value. We repeat the procedure 1000 times. We report the mean coefficient estimate for the main independent variables across the 1000 replications. In brackets, we report the percentage of coefficient estimates that are positive and significant at the 5% level ($\beta > 0$ and $\alpha < 5\%$) or negative and significant at the 5% level ($\beta < 0$ and $\alpha < 5\%$). In parentheses, we report the percentage of coefficient estimates that have larger absolute values than and the same sign as our baseline estimates from Table 2 and are significant at the 5% level ($|\beta| > |\beta^*|$ and $\beta \times \beta^* > 0$ and $\alpha < 5\%$). The dependent variable is indicated in the column title. Panel E shows the results for other robustness tests. In columns (1)–(2), we address the omitted variables issue by including lagged patents and citations. Any omitted long-term variables driving both innovation and the chairperson’s number of siblings should be absorbed by lagged innovation. In columns (3)–(4), we further include province fixed effects to control regional factors. In columns (5)–(6), we address the distribution and availability of innovation by focusing on firm-year observations with nonzero innovation measures. In columns (7)–(8), we restrict our sample to 2008–2013 because there could be a two- or three-year lag between each patent application’s date and its final approval. In columns (9)–(10), we control $Industry \times Year$ fixed effects. In columns (11)–(12), Standard errors are double-clustered at the firm level and year level. $Patent_{t+1}$ and $Citation_{t+1}$ are the dependent variables. $Chair_Sibling$ is an indicator variable that equals 1 if a chairperson has siblings, and 0 otherwise. For brevity, we do not report the coefficients of control variables. Appendix A provides detailed definitions for all variables. Standard errors are clustered at the firm level. ***, **, and * indicate 1%, 5%, and 10% significance, respectively.

Panel A: Long-term effects						
	$Patent_{t+2}$	$Citation_{t+2}$	$Patent_{t+3}$	$Citation_{t+3}$	$Patent_{t+4}$	$Citation_{t+4}$
	(1)	(2)	(3)	(4)	(5)	(6)
<i>Chair_Sibling</i>	0.124**	0.057***	0.131**	0.051***	0.128**	0.036***
	(2.21)	(2.94)	(2.18)	(2.91)	(2.05)	(2.61)
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES
N	5857	5857	4497	4497	3426	3426
Adj R^2	0.357	0.235	0.359	0.231	0.368	0.209

Panel B: Innovation efficiency and innovation quality				
	Innovation Efficiency		Innovation Quality	
	$Patent_{t+1}/R\&D_t$	$Citation_{t+1}/R\&D_t$	$Top1\%$	$Newclass$
	(1)	(2)	(3)	(5)
<i>Chair_Sibling</i>	0.006** (1.97)	0.003** (2.25)	0.018** (2.27)	0.032* (1.65)
Industry FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Controls	YES	YES	YES	YES
Obs.	6386	6386	7531	7531
Adj R^2	0.349	0.297	0.084	0.107

Panel C: Survivorship bias				
	First generation		Second generation	
	$Patent_{t+1}$	$Citation_{t+1}$	$Patent_{t+1}$	$Citation_{t+1}$
	(1)	(2)	(3)	(4)
<i>Chair_Sibling</i>	0.095* (1.73)	0.443*** (2.22)	0.055** (2.59)	0.109* (1.73)
Industry FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Controls	YES	YES	YES	YES
Obs.	7057	7057	474	474
Adj R^2	0.345	0.245	0.498	0.577

Panel D: Placebo test		
	$Patent_{t+1}$	$Citation_{t+1}$
	(1)	(2)
<i>Mean β for Chairperson with Family Sibling</i>	0.0022	-0.0003
[% $\beta > 0$ and $\alpha \leq 5\%$; % $\beta < 0$ and $\alpha \leq 5\%$]	[2.8%; 2.9%]	[3.0%; 2.9%]
(% $ \beta > \beta^* $ and $\beta \times \beta^* > 0$ and $\alpha \leq 5\%$)	0%	0%

Panel E: Other robustness tests												
	Lagged innovation		Province FE		Delete if innovation = 0		If year < 2014		Industry × Year FE		Double-clustered	
	<i>Patent</i> _{t+1}	<i>Citation</i> _{t+1}	<i>Patent</i> _{t+1}	<i>Citation</i> _{t+1}	<i>Patent</i> _{t+1}	<i>Citation</i> _{t+1}	<i>Patent</i> _{t+1}	<i>Citation</i> _{t+1}	<i>Patent</i> _{t+1}	<i>Citation</i> _{t+1}	<i>Patent</i> _{t+1}	<i>Citation</i> _{t+1}
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
<i>Chair_Sibling</i>	0.069*** (3.42)	0.054*** (4.79)	0.110** (2.20)	0.065*** (3.19)	0.130** (2.43)	0.321*** (5.02)	0.147** (2.05)	0.116*** (3.00)	0.122** (2.35)	0.068*** (3.34)	0.122* (2.29)	0.065* (1.94)
<i>Patent</i> _t	0.587*** (55.41)											
<i>Citation</i> _t		0.392*** (18.83)										
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES	NO	NO	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	NO	NO	YES	YES
Province FE	NO	NO	YES	YES	NO	NO	NO	NO	NO	NO	NO	NO
Obs.	7531	7531	7531	7531	4257	1049	3981	3981	7531	7531	7531	7531
Adj R ²	0.620	0.438	0.374	0.256	0.101	0.164	0.230	0.183	0.365	0.278	0.350	0.253

Table 5. Mechanism test: Sibling competition effect

The table presents the results for the sibling competition effect. $Patent_{t+1}$ and $Citation_{t+1}$ are the dependent variables. $Chair_Sibling$ is an indicator variable that equals 1 if a chairperson has siblings, and 0 otherwise. $Brother$ is an indicator variable that equals 1 if the chairperson has brother, and 0 otherwise. $Young$ is an indicator variable that equals 1 if the chairperson is not the oldest sibling, and 0 otherwise. Age_gap is defined as the average age gap between the chairperson and the other siblings. For brevity, we do not report the coefficients of control variables. Appendix A provides detailed definitions for all variables. Standard errors are clustered at the firm level. ***, **, and * indicate 1%, 5%, and 10% significance, respectively.

	$Patent_{t+1}$	$Citation_{t+1}$	$Patent_{t+1}$	$Citation_{t+1}$	$Patent_{t+1}$	$Citation_{t+1}$
	(1)	(2)	(3)	(4)	(5)	(6)
<i>Chair_Sibling</i> × <i>Brother</i>	0.166** (2.01)	0.065** (2.08)				
<i>Chair_Sibling</i> × <i>Young</i>			0.207** (2.41)	0.071* (1.80)		
<i>Chair_Sibling</i> × <i>Age_gap</i>					-0.058** (-2.22)	-0.009 (-0.81)
<i>Chair_Sibling</i>	-0.005 (-0.07)	0.015 (0.56)	0.052 (0.95)	0.042** (1.96)	0.225* (3.63)	0.108** (2.64)
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES
Obs.	7531	7531	7531	7531	5003	5003
Adj R^2	0.351	0.253	0.352	0.254	0.328	0.241

Table 6. Mechanism test: Sibling knowledge spillover effect

The table presents the results for the sibling knowledge-spillover effect. $Patent_{t+1}$ and $Citation_{t+1}$ are the dependent variables. $Chair_Sibling$ is an indicator variable that equals 1 if a chairperson has siblings, and 0 otherwise. $R\&D_Exp$ is an indicator variable that equals 1 if one of chairperson's siblings has R&D work experience, and 0 otherwise. $Overseas_Exp$ is an indicator variable that equals 1 if one of chairperson's siblings has overseas study or work experience, and 0 otherwise. For brevity, we do not report the coefficient of control variables. Appendix A provides detailed definitions for all variables. Standard errors are clustered at the firm level. ***, **, and * indicate 1%, 5%, and 10% significance, respectively.

	$Patent_{t+1}$ (1)	$Citation_{t+1}$ (2)	$Patent_{t+1}$ (3)	$Citation_{t+1}$ (4)
$Chair_Sibling \times R\&D_Exp$	0.303*** (3.30)	0.081* (1.72)		
$Chair_Sibling \times Overseas_Exp$			0.282** (2.53)	0.113* (1.83)
$Chair_Sibling$	0.042 (0.75)	0.044** (2.06)	0.071 (1.34)	0.045** (2.23)
Industry FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Controls	YES	YES	YES	YES
N	7531	7531	7531	7531
Adj R^2	0.352	0.252	0.352	0.252

Table 7. Further analysis: Sibling co-management and innovation

The table presents the results for the effect of sibling co-management on innovation. $Patent_{t+1}$ and $Citation_{t+1}$ are the dependent variables. $Chair_Sibling$ is an indicator variable that equals 1 if a chairperson has siblings, and 0 otherwise. Panel A presents the distribution of the chairpersons' siblings' positions in the same firm. Panel B shows the results for the effect of sibling co-management and specific important positions of a chairperson's siblings in the same firm. $Sibling_cowork$ is a dummy variable that equals 1 if a chairperson has a sibling co-manager (siblings serve on board of directors, on board of supervisors, or is a manager in the same firm), and 0 otherwise. $Sibling_CEO$ is a dummy variable equal to 1 if a chairperson has a sibling serving as CEO in the same firm, and 0 otherwise. RD_Head is a dummy variable equal to 1 if a chairperson has a sibling serving as the CEO in the same firm, and 0 otherwise. For brevity, we do not report the coefficients of control variables. Appendix A provides detailed definitions for all variables. Standard errors are clustered at the firm-level. ***, **, and * indicate 1%, 5%, and 10% significance, respectively.

Panel A Distribution of chairpersons' siblings' positions in the same firm			
Sibling co-manager	Sibling Position	Number	Percent
Board of directors	Board director	964	37.66%
	Vice Chairperson	277	10.82%
	Board Secretary	43	1.68%
Management	Deputy General Manager	458	17.89%
	Head of R&D	395	15.43%
	CEO	239	9.34%
	CFO	70	2.73%
	Manager assistant	10	0.39%
	Department manager	4	0.16%
Board of supervisors	Supervisor	100	3.91%
Total		2,560	100.00%

Panel B The effect of sibling's position on innovation						
	$Patent_{t+1}$	$Citation_{t+1}$	$Patent_{t+1}$	$Citation_{t+1}$	$Patent_{t+1}$	$Citation_{t+1}$
	(1)	(2)	(3)	(4)	(5)	(6)
$Chair_Sibling \times Sibling_cowork$	0.178** (2.10)	0.001 (0.01)				
$Chair_Sibling \times Sibling_CEO$			0.365** (2.20)	0.048 (0.66)		
$Chair_Sibling \times RD_Head$					0.518*** (3.30)	0.109* (1.68)
$Chair_Sibling$	0.066 (1.19)	0.065*** (2.82)	0.099* (1.90)	0.062*** (2.99)	0.086* (1.67)	0.058*** (2.75)
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES
Obs.	7531	7531	7531	7531	7531	7531
Adj R^2	0.352	0.252	0.352	0.253	0.354	0.253

Table 8. Further analysis: Sibling gender diversity and board gender diversity

The table presents the results for the effect of sibling gender diversity on board gender diversity. *Board_Diversity* is the dependent variable, which is defined as the fraction of female directors on a board. *Sibling_Diversity* is a dummy variable equal to 1 if the siblings are of different genders, and 0 otherwise. Columns (1)–(2) show the results for full sample, the male-chairperson subsample, and the female-chairperson subsample, respectively. For brevity, we do not report the coefficient of control variables. Appendix A provides detailed definitions for all variables. Standard errors are clustered at the firm-level. ***, **, and * indicate 1%, 5%, and 10% significance, respectively.

	<i>Board_Diversity</i> (1)	<i>Board_Diversity</i> (2)	<i>Board_Diversity</i> (3)
	Full Sample	Chairperson = Male	Chairperson = Female
<i>Sibling_Diversity</i>	0.012* (1.89)	0.014** (2.11)	-0.025 (-1.27)
Industry FE	YES	YES	YES
Year FE	YES	YES	YES
Controls	YES	YES	YES
Obs.	6256	5912	344
Adj R^2	0.085	0.069	0.254

Table 9. Further analysis: Sibling's collaboration effect on successful joint patents

The table presents the results for the sibling collaboration effect. *Joint_Patent_{t+1}* and *Joint_Patent_{t+1}_ratio* are the dependent variables. *Joint_Patent_{t+1}* is defined as the natural logarithm of 1 plus the total number of successful patent applications that are jointly applied for by firm *i* and another firms in year *t+1*. *Joint_Patent_{t+1}_ratio* is defined as the ratio of successful joint patent applications to the total number of successful patent applications that are filed by firm *i* in year *t+1*. *Chair_Sibling* is an indicator variable that equals 1 if a chairperson has siblings, and 0 otherwise. For brevity, we do not report the coefficient of control variables. Appendix A provides detailed definitions for all variables. Standard errors are clustered at the firm-level. ***, **, and * indicate 1%, 5%, and 10% significance, respectively.

	<i>Joint_Patent_{t+1}</i>	<i>Joint_Patent_{t+1}_ratio</i>
	(1)	(2)
<i>Chair_Sibling</i>	0.051** (2.09)	0.260*** (2.80)
Industry FE	YES	YES
Year FE	YES	YES
Controls	YES	YES
Obs.	7531	7531
Adj <i>R</i> ²	0.042	0.002

Table 10. Further analysis-innovation channels: Internal innovation or external innovation

The table presents the results for the innovation channels. *Chair_Sibling* is an indicator variable that equals 1 if a chairperson has siblings, and 0 otherwise. Column (1) shows the results for the internal innovation channel, where *R&D staff* refers to the number of R&D staff scaled by the total number of staff. Columns (2)–(4) show the results for the external innovation channel, which means the listed firm gains high-quality patents through mergers or acquisitions. The measures of external innovation include *M&A_Dum*, an indicator variable that equals 1 if the firm has an innovation-related merger or acquisition, and 0 otherwise in year $t+1$, *M&A_Num*, defined as the natural logarithm of 1 plus the total number of innovation-related mergers and acquisitions in year $t+1$ and *M&A_Ratio*, calculated as the number of innovation-related mergers and acquisitions scaled by the total number of mergers and acquisitions in year $t+1$. For brevity, we do not report the coefficients of control variables. Appendix A provides detailed definitions for all variables. Standard errors are clustered at the firm-level. ***, **, and * indicate 1%, 5%, and 10% significance, respectively.

	Internal Innovation		External Innovation	
	<i>R&D staff</i> (1)	<i>M&A_dum</i> (2)	<i>M&A_num</i> (3)	<i>M&A_ratio</i> (4)
<i>Chair_Sibling</i>	1.410** (2.21)	-0.000 (-0.27)	-0.001 (-0.39)	-0.001 (-0.69)
Industry FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Controls	YES	YES	YES	YES
N	6603	7531	7531	7531
Adj R^2	0.334	0.007	0.006	0.006

Figure 1. Histogram of average $Patent_{t+1}$ and $Citation_{t+1}$ grouped by number of siblings

The figure reports the average number of patents and citations grouped by number of siblings.

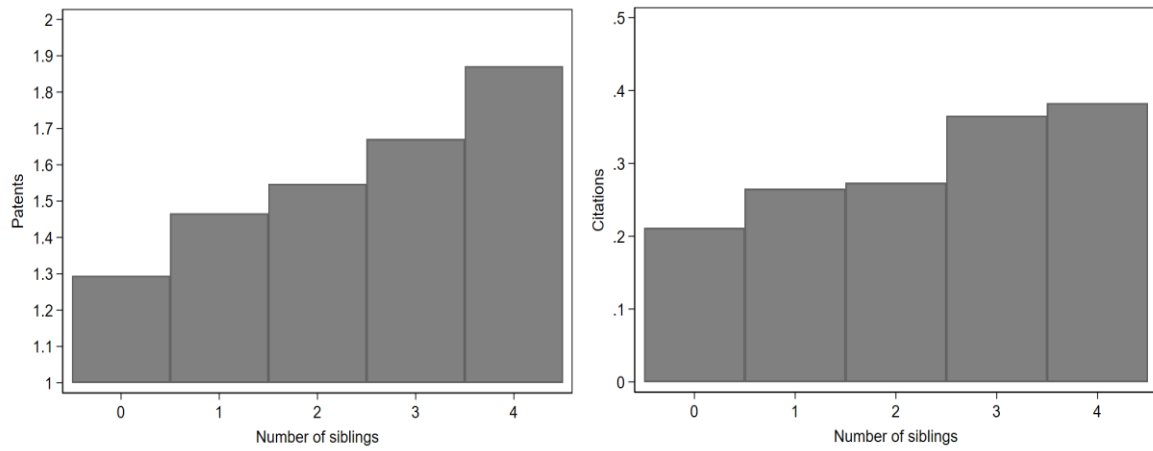


Figure 2. RD plots of single-child ratio and patents on China's one-child policy

The figure plots RD graphs of the single-child ratio and patents on China's one-child policy.

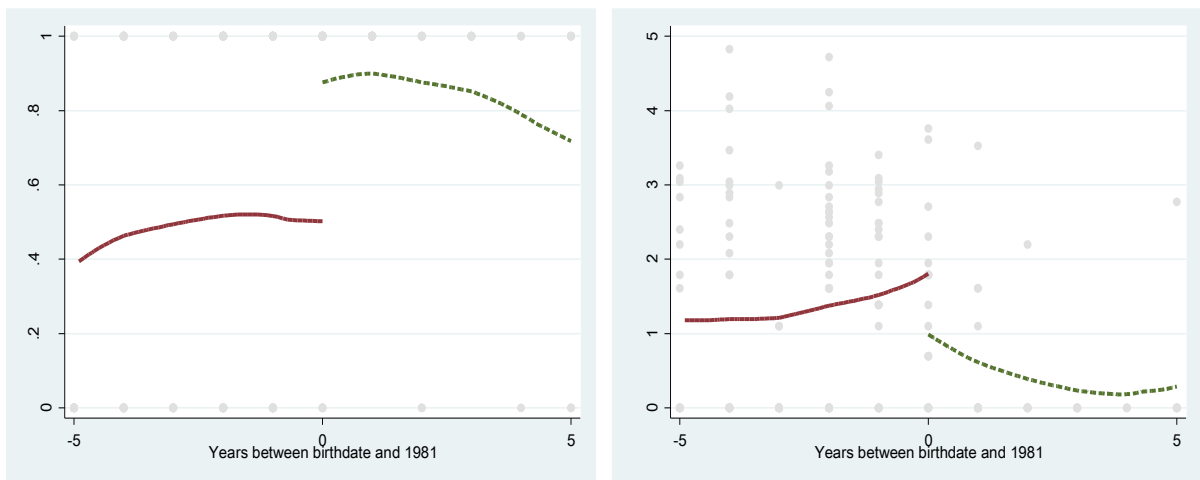


Figure 3. Regression discontinuity (RD) bands

This figure plots the RD estimates with different bands using the local polynomial regression models. The x axis represents the bands where “100” is the optimal band reported in Table 3, “200” is two times the optimal band, etc. The y axis represents the coefficient estimates and their upper/lower 95% confident limits.

