The current issue and full text archive of this journal is available on Emerald Insight at:
https://www.emerald.com/insight/1029-807X.htm

China Accounting and Finance Review

Robot adoption of family firms: the role of family non-executive directors

Shanzhong Du
International School of Business and Finance, Sun Yat-Sen University, Zhuhai, China, and
June Cao
School of Accounting, Economics, and Finance, Curtin University, Perth, Australia

Received 16 August 2023
Revised 15 February 2024
23 May 2024
Accepted 13 June 2024

Abstract

Purpose – Industrial robots are of great significance to the long-term development of family firms. Drawing on the lens of the principal–principal conflict, this paper aims to investigate the influence of family non-executive directors on robot adoption in Chinese family firms.

Design/methodology/approach – This paper selects the family firms in China from 2011 to 2019 as the sample. Furthermore, the authors manually collected the family non-executive directors and constructed the robot adoption variable utilizing data sourced from the International Federation of Robotics. In brief, this paper constructs a comprehensive framework of the mechanisms and additional tests pertaining to the influence of family non-executive directors on robot adoption.

Findings – This paper finds that family non-executive directors can promote robot adoption in family firms. The underlying mechanism analysis shows that family non-executive directors promote robot adoption by exerting financial and human effects. This paper further finds that the characteristics of family non-executive directors, such as kinship, differential shareholding and excessive directors, affect the role of family non-executive directors. Finally, robot adoption can improve future performance, and the promotional effect is more evident when family members are non-executive directors.

Originality/value – This paper contributes to the related literature from the following two aspects. Firstly, this paper decomposes the types of family directors to understand the role of family non-executive directors, which challenges the assumption that family board members are homogeneous in family firms. Second, this paper expands the research on the factors that influence robot adoption in emerging economies from the micro-enterprise level. In addition, the findings in this paper have managerial implications for family firms to optimize their strategic decisions with the help of the mode of board right allocation.

Keywords Family non-executive directors, Robot adoption, Family firms

Paper type Research paper

1. Introduction

With the mining and application of big data resources, the improvement of cloud computing capabilities and the breakthrough of deep learning algorithms, industrial robot adoption stands as the cornerstone of contemporary manufacturing (Fan, Hu, & Tang, 2021). While the

© Shanzhong Du and June Cao. Published in *China Accounting and Finance Review*. Published by Emerald Publishing Limited. This article is published under the Creative Commons Attribution (CC BY 4.0) licence. Anyone may reproduce, distribute, translate and create derivative works of this article (for both commercial and non-commercial purposes), subject to full attribution to the original publication and authors. The full terms of this licence may be seen at http://creativecommons.org/licences/by/4.0/legalcode

The first author would like to acknowledge financial support from the National Natural Science Foundation of China (grant no. 72172063).

We certify that all authors have approved the final version of the manuscript being submitted. We warrant that the article is our original work, hasn't received prior publication and is not under consideration for publication elsewhere.

We certify that there is no financial or personal interest that could affect the work reported in this paper.

China Accounting and Finance Review
Vol. 26 No. 4, 2024
pp. 533-561
Emerald Publishing Limited
e-ISSN: 2307-3055
p-ISSN: 1029-807X
DOI 10.1108/CAFR-08-2023-0089

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026

USA and other advanced industrial countries have traditionally spearheaded development and embraced robot adoption, China has emerged as a crucial player in this transformative landscape. Data from the International Federation of Robotics (IFR) show that China has been the world's largest country utilizing industrial robots since 2016 (Cheng, Jia, Li, & Li, 2019). With the increasingly prominent role of industrial robots in creating competitive advantages and fostering long-term development for enterprises, a growing number of enterprises have introduced robots in widespread use (Bessen, 2015; Acemoglu & Restrepo, 2020a; Fan *et al.*, 2021). Investigating the drivers of robot adoption is thus a critical but underexplored question.

Family firms exist worldwide and play a substantial role in the economies of various countries. In the USA, more than 30% of listed firms on the Standard & Poor's 500 are either controlled or managed by families (Anderson & Reeb, 2003; De Massis, Ding, Kotlar, & Wu, 2018). Over 80% of private firms in China are family-owned (Jiang, Shi, & Zheng, 2020; Cao, Li, Dai, & Li, 2023). Over the past four decades of reform and opening, the family firm has made an essential contribution to China's economic development (Allen, Qian, & Qian, 2005; Jiang *et al.*, 2020; Du, Ma, & Li, 2022). For those family firms, achieving long-term sustainable development is an aspiration of family practitioners and a reasonable expectation from all walks of life (Burkart, Panunzi, & Shleifer, 2003; Lumpkin & Brigham, 2011). The pursuit of an "everlasting foundation" has become a crucial goal pursued by increasing family firms (Sharma, Salvato, & Reay, 2014; Du *et al.*, 2022, Du, Ma, Li, & Ma, 2024). Recognizing that introducing industrial robots is integral to enterprises' long-term development and enduring growth (Fan *et al.*, 2021), this strategy is internally consistent with the commitment of family firms to enhancing long-term orientation and fostering sustained development. PricewaterhouseCoopers' (2021) global research report on family firms in China shows that nearly 45% of family firms had implemented significant technological shifts, bolstering their capacities for technological innovation and digital transformation. Consequently, incorporating robots is a pivotal strategy for family firms striving for sustained success. However, the decision to adopt robots is intricate in family firms, posing a challenge for several reasons.

Although industrial robots are of great significance to the long-term development of family firms, the majority of enterprises lack the capacity to manufacture industrial robots independently, necessitating substantial financial investments to purchase them (Acemoglu & Restrepo, 2018). The operational intricacies and the ongoing evolution of industrial robots further demand the involvement of specialized talents, adding another layer of complexity (Acemoglu & Restrepo, 2020b).

However, family firms encounter severe external financing constraints and a shortage of specialized talent (Anderson & Reeb, 2004; Amit, Ding, Villalonga, & Zhang, 2015). Robot adoption necessitates dependence on external investment, which prompts external investors to impose supervision requirements on corporate strategy, capital utilization and management, thereby posing a threat to family control (Miller & Le Breton-Miller, 2014). Given the distinctive nature of family firms in terms of intergenerational inheritance direction (Burkart *et al.*, 2003), they consistently strive to expand their business scope and enhance their professional level. This often requires the infusion of more external capital and management resources (Franks, Maye, Volpin, & Wagner, 2012). However, this pursuit is accompanied by the dilution of family equity and the relinquishment of management rights. This, thus, leads to an inherent conflict between the pursuit of long-term orientation and the preservation of family control. Therefore, the challenge faced by family firms lies in finding a balance between advancing robot adoption and maintaining control within the family structure.

Viewed through the principal–principal conflicts lens, the agency conflicts between large family and non-family shareholders emerge as a main factor affecting the strategic decision-making of family firms (Shleifer & Vishny, 1997; La Porta, Lopez-de-Silanes, & Shleifer, 1999).

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026

Due to the separation of control and ownership, the controlling shareholder often does not personally participate in the day-to-day operation and management of the company (Fama & Jensen, 1983). The board of directors is the centre of the rights struggle between the representatives of all parties and shareholders typically use the board of directors as a channel to control managers and ensure that managers make decisions that align with shareholders' interests (Allen & Gale, 1999). Therefore, paying attention to the directors' behaviour of family shareholders can provide insights and potential solutions for optimizing strategies. The overarching goal is to achieve sustainability of family firms by balancing the relationship between the controlling families and external investors.

Furthermore, unlike developed countries such as the UK and the USA, the centralized ownership structure of listed companies in China leads to the widespread presence of non-independent non-executive directors on the board of directors (Jiang & Kim, 2015). Compared with executive directors who represent the interests of management and independent directors whose interests are independent of the company, non-executive directors are directly appointed by the large shareholders and hold supervisory rights rather than managerial responsibilities (Mira, Goergen, & O'Sullivan, 2019; Hearn, Mohr, Kaur, & Khawar, 2023). Therefore, non-executive directors play a crucial role in ensuring that the management aligns with the long-term development goals of the family firm, fostering a greater consistency of interests among insiders and external small and medium investors (Gaspar, Massa, & Matos, 2005). Family non-executive directors contribute to implementing scientific and modern management practices to ensure that the management direction adheres to the long-term development orientation of family firms. Thus, when family members serve as non-executive directors, they can attract external capital to participate in business decision-making and maintain family control over the firm by occupying non-executive director positions.

Therefore, we focus on the influence of family non-executive directors on robot adoption of family firms from the perspective of the right allocation of the board of directors. We analyse the specific characteristics of family non-executive directors to provide more abundant empirical evidence for evaluating the rationale behind having family members as non-executive directors. We selected the family firms in China from 2011 to 2019 as the sample and found that family members as non-executive directors can promote robot adoption in family firms. The underlying mechanism shows that family non-executive directors promote robot adoption in family firms by exerting financial and human effects.

Drawing insights from the characteristics of family non-executive directors, we find that, firstly, compared with blood-related family non-executive directors, the positive effect of marriage family non-executive directors on robot adoption is more pronounced. The conservative characteristics brought about by blood relationships are the reasons why blood family non-executive directors inhibit robot adoption. Secondly, an over-concentration of family ownership tends to inhibit the positive effects of family non-executive directors on robot adoption. However, after distinguishing family ownership modes, we find that relative holding of family shareholders can strengthen the positive impact of family non-executive directors on robot adoption compared with strategic holding and absolute holding of family shareholders. Thirdly, excessive family non-executive directors have adverse effects on robot adoption. Finally, we find that robot adoption contributes to improved future performance, and the promotion effect is more evident when family members are non-executive directors. Overall, our findings collectively provide holistic insights into the dynamics between family non-executive directors and the adoption of robots in family firms.

This study makes three contributions, as follows. Firstly, this study deviates from the previous studies, which predominantly focus on the influence of the differences between family members and non-family members on the strategic decision-making of family firms

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026

(Anderson & Reeb, 2003; Ho, Huang, & Karuna, 2020; Cao *et al.*, 2023). Instead, we stratify the agency conflicts arising from large shareholders and focus on the role of family non-executive directors in combination with the heterogeneity of family members. We thoroughly investigate the specific characteristics of family non-executive directors from various dimensions. This response responds to the call for attention to the heterogeneity of family firms (Chua, Chrisman, Steier, & Rau, 2012; Arregle, Hitt, & Mari, 2019) and expands the related studies on the board of directors of family firms.

Secondly, we expand the research on the influencing factors of robot adoption in emerging economies from the micro-enterprise level. While previous studies mainly focus on robot adoption from the macroeconomic level (Bessen, 2019; Furman & Seamans, 2019) and its economic consequences (Acemoglu & Restrepo, 2020a, b), we explore the reasons for the rapid growth of robot adoption in emerging economies exemplified by China. We define the objective of robot adoption as family firms, which enriches the research on the influencing factors of robot adoption. Additionally, unlike previous studies, which mainly use the number of imported robots as the proxy index to measure robot adoption (Acemoglu & Restrepo, 2018), we contribute to this area by taking an innovative approach. We construct an enterprise-level robot adoption measurement index based on the robot data provided by IFR. This novel measurement index provides a useful reference for evaluating the industrial automation level of micro-firms and offers a more nuanced and accurate perspective on the adoption of robotics in this context.

Thirdly, we contribute novel theoretical evidence on enhancing the long-term development orientation of family firms. Fostering long-term orientation is an important goal for family firms (Sharma *et al.*, 2014; Du *et al.*, 2024). Diverging from previous studies, which primarily focus on the role of traditional innovation strategy and risk-taking in promoting the long-term orientation of family firms (Jiang *et al.*, 2020; Du *et al.*, 2024), we uniquely choose robot adoption—reflecting the core characteristics of the modern manufacturing industry—as the focal point (Fan *et al.*, 2021). We explore the pathways to realizing the long-term orientation of family firms through the lens of the right allocation of the board of directors. We not only construct a comprehensive understanding of the mechanisms and additional tests pertaining to the influence of family non-executive directors on robot adoption but also form a coherent research framework. This framework provides a robust theoretical and empirical foundation for assessing how family non-executive directors impact robot adoption, offering a more reliable basis for future investigations into this area.

2. Literature review and hypothesis development

2.1 Literature review

2.1.1 Board of directors of the family firm. The board of directors, serving as the intermediary between shareholders and management, is generally acknowledged as a company's most crucial internal governance mechanism (Allen & Gale, 1999). In the context of family firms, governance mechanisms, such as management salary contracts and the merger and acquisition market, might face challenges in playing their roles (Shivdasani, Zimmerman, Kothari, Lys, & Watts, 1993; Kole, 1997). The board of directors thus plays a more important role in supervising and restricting the family members in family firms.

Given the kinship ties between family members, family firms not only tend to allocate board seats to family members to strengthen family control (Villalonga & Amit, 2009) but also have the motivation to let family members serve as directors to keep socio-emotional wealth (SEW) (Jiang *et al.*, 2020; Combs, Jaskiewicz, Ravi, & Walls, 2023). Previous studies have found that the more shares owned by the family shareholders, the more likely family members play an important role in the management and the board of directors (Anderson & Reeb, 2003; Ho & Kang, 2013; Ho *et al.*, 2020).

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026

Specifically, the higher the family controls the enterprise, the lower the proportion of non-family members on the board of directors, and the higher the salary of family members (Bartholomeusz & Tanewski, 2006). Family management rights and ownership rights involvement affect the composition, functions and powers of the board of directors of family firms (Nordqvist, Sharma, & Chirico, 2014; Ahluwalia, Mahto, & Walsh, 2017), including deciding whether to retain profits or increase dividend payments (Vandemaele & Vancauteren, 2015). At the same time, there is a U-shaped relationship between family executive directors and family business performance (Basco, Campopiano, Calabrò, & Kraus, 2019). Moreover, faultlines, based simultaneously on family membership, type of directorship and gender, are negatively related to board role performance (Vandebeek, Voordeckers, Lambrechts, & Huybrechts, 2016). In contrast, non-family directors can be more objective supervisors, help to find and hire new managers, improve resource allocation decisions and prevent family members from entrenching on the company's wealth (Bammens, Voordeckers, & Van, 2011; González-Cruz & Cruz-Ros, 2016).

However, an abundance of family directors may lead to excessive family control. This can lead the controlling families to entrench the interests of non-family members by enlarging the control rights, potentially resulting in the loss of corporate value (Villalonga & Amit, 2009; Amit *et al.*, 2015; Gómez-Mejía, Neacsu, & Martin, 2019). Therefore, increasing the proportion of independent directors has become an effective way to mitigate the "insider control" issue within family firms (Anderson & Reeb, 2004; Bammens *et al.*, 2011). Introducing independent directors could bring external perspectives and oversight, fostering a more balanced governance structure that safeguards the interests of both family and non-family stakeholders of family firms.

Furthermore, previous studies also document that the controlling families have a stronger opportunity to pursue private benefits of control and are more inclined to strengthen family control when SEW is lost (Du *et al.*, 2022). At the same time, compared with non-family firms, the controlling families can maintain their control rights by appointing directors, improving the governance efficiency of family firms (Voordeckers, Van Gils, & Van den Heuvel, 2007; Bauweraerts & Colot, 2017). Compared with the family chairman, the non-family chairman tends to engage in more intensive tax avoidance (Cao *et al.*, 2023).

The literature reviewed above reveals that the existing studies on the board of directors of family firms focus on the differences between family directors and non-family directors, ignoring the heterogeneity of family directors. Particularly, the related research on family directors pays insufficient attention to the role played by the controlling families. It ignores the fact that shareholders can control managers with the help of the board of directors and ensure that managers act in shareholders' interests. Therefore, it is more than important to redirect attention to the rights allocation of the board of directors within family firms to understand the dynamics of family firms and their governance structures.

2.1.2 Influencing factors of robot adoption. A new wave of scientific and technological revolutions, represented by artificial intelligence technology, is emerging globally, and the participation of robots in industrial production is one of the most remarkable features (Acemoglu & Restrepo, 2020a). Studies on robot adoption and economic development originated from research on the impact of technological progress on the economy (Katz & Margo, 2013). The existing literature on robot adoption mainly pays attention to the economic consequences of robot adoption from the perspectives of the labour market (Acemoglu & Restrepo, 2020a, b), economic growth (Furman & Seamans, 2019) and population (Abeliansky & Prettner, 2017). Relatively little attention is paid to the factors influencing robot adoption from the perspective of family firms. Our study bridges this gap by exploring the motivation behind robot adoption in family firms. In doing so, we review relevant research on the factors that influence the adoption of robots in various organizational contexts.

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026

Acemoglu and Restrepo (2018) discuss the relationship between the ageing population and industrial robots from the perspective of demography. They found that the ageing population would lead to more intensive use and development of industrial robots. Cheng *et al.* (2019) used enterprise survey data and found that labour shortage and rising labour costs are the fundamental reasons for enterprises in China to use robots. Fan *et al.* (2021) use the matching data of China's industrial enterprise and customs databases to study the influence of labour cost (minimum wage) on robot adoption in China's enterprises. Fan *et al.* (2021) found that the minimum wage has time differences in robot adoption, and the relationship between them can also be affected by production efficiency, location, enterprise nature and industry characteristics.

Previous research review indicates that the existing studies mainly focus on the economic consequences of robot adoption (Acemoglu & Restrepo, 2020a, b; Furman & Seamans, 2019; Abeliansky & Prettner, 2017). Although some studies have begun to pay attention to the influencing factors of robot adoption (Cheng *et al.*, 2019; Fan *et al.*, 2021), the above research is relatively few and does not fully combine the specific nature of the enterprise (such as the family firm in this paper) for in-depth discussion. Given the increasing prevalence of robot adoption, exploring the motivation for robot adoption is more important. At the same time, robot adoption plays an increasingly prominent role in helping enterprises promote competitive advantages (Bessen, 2015; Fan *et al.*, 2021), which is consistent with the pursuit of long-term orientation of family firms. Therefore, our study explores the possible influence of family non-executive directors on robot adoption in family firms, thus providing a reference for family firms to improve their long-term orientation by optimizing their robot adoption strategies.

2.2 Hypothesis development

The agency conflict of major shareholders caused by the controlling family has an essential impact on the strategic decision-making of the family firm (Shleifer & Vishny, 1997). The agency conflict caused by large shareholders can be further dealt with by combining the right distribution of the board of directors. The reason is that the board of directors is the centre of the rights struggle between the representatives of all parties and is the primary way for shareholders to control managers and safeguard their interests (Allen & Gale, 1999).

For the board of directors of China's enterprises, except independent directors, the board members include non-executive directors and executive directors (Jiang & Kim, 2020). Compared with the executive director, who represents the interests of management, the non-executive director does not hold the management position but is directly appointed by the large shareholder (Jiang & Kim, 2015). Meanwhile, the non-executive director has the right of supervision rather than management (Mira *et al.*, 2019), which is consistent with the board of directors' resolution and can reduce agency conflicts (Hearn *et al.*, 2023).

Furthermore, the existing research on the heterogeneity of board members of family firms has not fully revealed the internal mechanism that affects the investment activities of family firms. The main reason is that the previous studies do not fully combine the characteristics of the specific investment activities of family firms to analyze how the family board members play their roles. In fact, investment activities, including robot adoption, are one of the enterprises' most important business decisions and are also the key contents of the board of directors' resolutions. Previous research finds that robot adoption needs abundant resources and human capital (Acemoglu & Restrepo, 2018). In contrast, agency cost is an essential factor that leads to the conflict between financing constraints and employees' interests (Kaplan & Zingales, 1997; Masulis, Wang, & Xie, 2020). In the principal–principal conflict lens framework, stimulating the financial and human effects is the key to improving robot adoption. Therefore, we discuss that family members as non-executive directors may impact robot adoption in family firms from financial and human effects.

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026

2.2.1 Analysis of the financial effect of family non-executive directors. Implementing robot adoption serves as a crucial investment choice that mirrors the extent of a company's transformation in digital intelligence (Du *et al.*, 2024). However, family firms encounter severe financing constraints, compelling controlling families to bring in external investors to fulfill the capital requirements (Allen *et al.*, 2005). External investors often put forward supervision requirements for corporate strategy, capital utilization and management, thus threatening the exclusive control of the family on the enterprise (Gómez-Mejía *et al.*, 2019).

Given the distinctive characteristics of family firms, a large number of family members may be unable to bring in external funds (Audretsch, Hülsbeck, & Lehmann, 2009). Thus, it is necessary to separate family supervision from family management. Firstly, by appointing family members as non-executive directors, they can effectively supervise without excessively intervening in operational matters (Bammens *et al.*, 2011). Meanwhile, the agency conflicts within the family firms come from the inconsistent goals and differentiated interests of family members (Wilson, Wright, & Scholes, 2013). If more family members are appointed as executive directors and have management rights at the same time, it is difficult to avoid that they may have different opinions on the investment proposal. In contrast, it is easy for the management to reach an agreement on the investment proposal by allocating more family members to the positions of non-executive directors, and the family non-executive directors are responsible for supervising the voting. This protects the interests of stakeholders in family firms to the greatest extent, so it can attract more investors to ease the financing constraints. Secondly, family non-executive directors can effectively balance the relationship between maintaining family control and introducing external capital (Franks *et al.*, 2012; Miller & Le Breton-Miller, 2014). Therefore, the controlling family can actively attract external investors to meet the development needs of the family business through external financing. Finally, from the signal perspective, the supervision of family non-executive directors can ensure that family firms pursue long-term orientation in decision-making, which conforms to the long-term development goal of the controlling families. As the insiders of the family firms, the controlling families can be encouraged to pursue longer-term business goals, which makes the interests of the family controlling shareholders and external investors more consistent (Gaspar *et al.*, 2005). This can send a positive signal to the external capital market to attract more external investors. On the other hand, family members as non-executive directors can optimize the internal board governance mechanism of family firms (Jiang & Kim, 2020). This improves the governance efficiency and information transparency of family firms to a certain extent and then sends a positive signal to the external capital market, indicating that family firms have good development prospects, thus attracting more external funds.

With the entry of external investors, the financing constraints faced by family firms can be alleviated to some extent. This can further strengthen their emphasis on long-term orientation (Chrisman & Patel, 2012; Miller & Le Breton-Miller, 2014). Previous studies have found that robot adoption can improve production efficiency and expand the labour demand for non-automated tasks, thus enhancing corporate competitiveness (Bessen, 2019; Acemoglu & Restrepo, 2020b). This is consistent with family firms' long-term orientation. Therefore, we posit that family firms can actively allocate more funds to strategic decisions related to robot adoption, thus improving robot adoption in family firms.

2.2.2 Analysis of the human effect of family non-executive directors. Given their intricate nature, operating industrial robots requires higher expertise and professionalism (Bessen, 2015). Controlling families often lack the requisite professional qualities and skills (Anderson & Reeb, 2004), posing challenges in promoting robot adoption effectively. At the same time, the controlling families prioritize safeguarding the interests of family members, creating obstacles in harnessing the full potential of non-family human capital for optimizing corporate strategic decision-making (Verbeke & Kano, 2012; Majocchi, D'Angelo, Forlani, &

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026

Buck, 2018; Du *et al.*, 2022). Therefore, given the specialization and complexity of industrial robots, it becomes imperative for family enterprises to incorporate more specialized human capital (Franks *et al.*, 2012).

Although the management is not directly involved in production, it is still an important human capital of the enterprise and can have an important impact on the financial decision-making and operating performance of the enterprise (Bertrand & Schoar, 2003; Attig & Cleary, 2014). Therefore, the rational allocation of the board seats of family firms can better exert the human capital effect of managers, thus affecting robot adoption. The delegation of additional executive director seats to high-calibre non-family human capital becomes more prevalent when family members serve as non-executive directors. Therefore, family non-executive directors can provide more opportunities for non-family professionals to participate in the strategic decision-making of family firms. On the one hand, this can stimulate non-family members' enthusiasm (Kano & Verbeke, 2018; Jennings, Dempsey, & James, 2018) and enhance the interest consistency between family and non-family shareholders (Gaspar *et al.*, 2005), thus optimizing the human capital structure. On the other hand, although non-family members as executive directors have replaced the seats of family members as executive directors to some extent, this cannot threaten the family's control over the enterprise. The reason is that the composition of the board of directors of family firms is largely determined by the controlling families (Anderson & Reeb, 2003), which largely guarantees the family's control over the enterprise. At the same time, the supervision of family non-executive directors ensures that the business decision-making of the enterprise is long-term, which conforms to the long-term development goal of the controlling family and will not harm the interests of family members because of the self-interest of non-family management.

With the optimization of the human capital structure, labour costs also show an upward trend to a certain extent (Fan *et al.*, 2021). This dynamic prompts family firms to proactively seek advanced technologies and equipment, such as robots, to compensate for the pressure brought on by the rising labour costs (Acemoglu & Restrepo, 2020a, b). At the same time, promoting an enterprise's average human capital also implies an optimization of the labour structure. We posit that it can encourage enterprises to actively improve robot adoption, thus effectively realizing the complementarity of capital and skills. Therefore, we formulate the first hypothesis.

H1. Family non-executive directors can promote robot adoption in family firms.

3. Methods

3.1 Sample and data

We sample Shanghai and Shenzhen A-share manufacturing family firms in China from 2011 to 2019. The reason why 2011 is the initial year is that China promulgated a new national economy industry and code in 2011, and the reason why 2019 is the end of the research year is to exclude the influence of the COVID-19 epidemic (Amore, Pelucco, & Quarato, 2022). In addition, since industrial robots are mainly used in the manufacturing industry (Acemoglu & Restrepo, 2020a, b), we exclusively focus on the family firms within the manufacturing industry.

Further, consistent with Anderson and Reeb (2003), Villalonga and Amit (2009) and Du *et al.* (2022), we define a company as a family firm that meets the following conditions: (1) The ultimate controller can be traced back to a natural person or family; (2) The natural person or family directly or indirectly owns at least 10% of the control right of the family firm [1]; (3) At least two or more family members hold senior management positions in listed family firms. Adhering to our definition of family firm, we have included all family firms that meet the requirements in this study.

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026

We eliminate ST (*ST) companies and exclude companies with missing values and insolvency. Additionally, to mitigate the influence of outliers, we winsorise all continuous variables at the 1st and 99th percentiles. The essential family attribute data, such as family directors, are obtained by manual collection, and other financial data are obtained from the China Stock Market and Accounting Research and WIND databases.

3.2 Measures

3.2.1 Dependent variable. The prevalent method in literature uses industrial robot imports to measure robot adoption (Acemoglu & Restrepo, 2018). However, this measure fails to reflect the specific level of enterprise robot adoption fully. The data from the IFR form a more accurate and reliable measurement of robot adoption for multiple reasons.

Firstly, the IFR conducts an annual survey of global robot manufacturers and forms "country-industry-year" robot data according to the data statistics provided directly by the manufacturers, yielding authoritative statistics. Secondly, an industrial robot is a complex multi-objective type of machinery that involves a relatively complex process from import to installation and subsequent use. Therefore, the number of robot imports cannot accurately represent the actual use of robots by enterprises. Thirdly, certain studies attempt to construct enterprise robot adoption indicators using IFR data (Acemoglu & Restrepo, 2020a, b), providing a theoretical foundation for our approach. Finally, although the Chinese Industrial Enterprise database has special advantages in studying the behaviour of industrial enterprises in China, and Zhong, Zhang, Chan, and Yan (2023) also use the Chinese Industrial Enterprise database to match the Chinese Customs microdata, the robot adoption in China only showed a rapid upward trend after 2010 (Wang, Liao, & Wu, 2023). The data in the Chinese Industrial Enterprise database were obviously missing since 2007. Therefore, there may be noise when using the method of the Chinese Industrial Enterprise database with the Chinese Customs microdata to measure robot adoption.

Acemoglu and Restrepo (2020a) use the general equilibrium model to examine the impact of robot adoption on the US labour market and construct the index of robot penetration to measure the US region. On this basis, an increasing number of studies have adopted this method to measure robot adoption (Gan, Liu, Qiao, & Zhang, 2023; Wang, Liao *et al.*, 2023, Wang, Zhou, & Chiao, 2023; Zhou, Li, Du, & Cao, 2024) and we followed those previous studies to construct the robot adoption variable utilizing data sourced from the IFR.

Specifically, we first calculate the penetration of robots at the industry level as an exogenous share based on 2010 (the impact of exogenous industry technology shocks on China's labour market, the reason for choosing 2010 is that it is not within the research range, excluding the possible impact of time factors), and then multiply it by the proportion of employees in the production department of enterprise j in industry i in 2011 (baseline period) and the proportion of employees in the production department of all manufacturing enterprises in 2011.

Given that industrial robots are predominantly used in the manufacturing industry (Acemoglu & Restrepo, 2020a), we take listed companies in that industry as the sample and segment the industry into two-digit codes. Based on this, we use the general equilibrium model to construct a robot penetration index at the enterprise level in the manufacturing industry in China from the perspective of installation as follows:

Firstly, we calculate the penetration index of robots at the industry level ($IRP_{i,t}$):

$$IRP_{i,t} = \frac{RC_{i,t}}{LP_{i,t=2010}}$$

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026

where $IRP_{i,t}$ represents the installation of robots of industry i in China in year t; $RC_{i,t}$ represents the robot stock of industry i in China in year t; and $LP_{i,t=2010}$ indicates the number of employees of industry i in China in 2010 (base period).

Secondly, we use the robot penetration index at the industry level to further construct the robot penetration index at the enterprise level ($CRP_{j,t}$):

$$CRP_{j,t} = \frac{ML_{j,i,t=2011}}{AML_{j,i,t=2011}} \times \frac{RC_{i,t}}{LP_{i,t=2010}}$$

where $\frac{ML_{j,i,t=2011}}{AML_{j,i,t=2011}}$ represents the proportion of production employees in enterprise j of industry i in the manufacturing industry in 2011 (base period) to the median proportion of production employees in all manufacturing enterprises in 2011. This ratio is used as a weight to decompose the penetration of industrial robots at the industry level to the enterprise level. On this basis, it is used to investigate the penetration of industrial robots at the enterprise level, and it also represents the importance of enterprise j in its industry.

Finally, we obtain the measurement index of enterprise robot adoption ($Robot_{j,t}$) by calculating the logarithm of the sum of robot penetration at the enterprise level and one:

$$Robot_{j,t} = LN(1 + CRP_{j,t})$$

3.2.2 Independent variable. In the case of listed companies in China, the board of directors usually consists of three parts: independent directors, non-executive directors and executive directors (Jiang & Kim, 2020). Following the regulations of the China Securities Regulatory Commission, listed companies appoint independent directors, and the proportion of independent directors on the board of directors is relatively stable.

The China Securities Regulatory Commission issued the Guiding Opinions on Establishing the Independent Director System in Listed Companies in 2001. This stipulates that the number of independent directors in listed companies should account for more than 1/3 of the board of directors. An executive director is actively involved in the company's operation and management, assumes responsibility for implementing board decisions and is commonly regarded as the representative of the company's management on the board. Unlike developed countries such as the UK and the USA, the dominant ownership structure of listed companies in China leads to the widespread existence of non-executive directors on the board of directors in listed companies (Jiang & Kim, 2015). Therefore, we manually identify the family non-executive directors in family firms.

Specifically, we first consolidated information from the company's annual report and manually ascertained the composition of the board of directors in the family firm. Secondly, we further judge the identity of family directors according to the positions of directors disclosed in the annual report. When family members only serve as directors but not as executives, they are family non-executive directors. Finally, we use the ratio of the number of family non-executive directors to the number of the board of directors as the proxy for family non-executive directors (*Fned*).

3.2.3 Control variables. We control the related variables from corporate characteristics, corporate governance, family attributes and external environment, which may affect our results. Company characteristic variables include company size (*Size*), which is measured by the logarithm of total assets (Villalonga & Amit, 2009); Financial leverage (*Lev*) is measured by asset-liability ratio (Du *et al.*, 2022); Growth rate (*Growth*) is measured by the growth rate of operating income (Du *et al.*, 2024); The age of the company (*Age*) is measured by the logarithm of the company's establishment time (Jiang *et al.*, 2020); Corporate performance (*ROA*) is measured by return on total assets (Chen, Chittoor, & Vissa, 2021).

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026

Corporate governance variables include board size (*Board*), which is measured by the logarithm of the number of board members (Du *et al.*, 2022); Independent directors (*Indep*) is measured by the ratio of the number of independent directors to the number of board members (Huson, Parrino, & Starks, 2001); Duality (*Dual*) when the same person holds the chairman and CEO, it is recorded as one, and it is recorded as zero otherwise (Anderson & Reeb, 2004); The proportion of management shareholding (*Mshare*) measures management shareholding (Dong, Wang, & Xie, 2010).

Family attribute variables include family management (*FM*), which is measured by the proportion of family members as directors, supervisors and executives (Li, 2018); Intergenerational inheritance (*Child*), when the descendants of the family participate in the management of the family firm, it is recorded as one, and as zero otherwise (Huang, Lee, Lyu, & Zhao, 2020).

External environment variables include industry type (*HT*), which is recorded as one when the family firm belongs to the high-tech industry, and zero otherwise (Brown, Fazzari, & Petersen, 2009). The legal environment (*Law*) is measured by the legal environment index in China's marketization index (Amit *et al.*, 2015). At the same time, we also control the year-fixed effect and industry-fixed effects. The definitions of all of the variables used in this study are provided in Appendix.

3.3 Model specification

To test H1, we establish Model (1), where *Control* represents control variables, α_0 represents interceptions and ε represents residuals. For H1, if the coefficient of α_1 is significantly positive, it shows that the family non-executive directors have significantly improved robot adoption. This then indicates that H1 is supported.

$$Robot_{i,t} = \alpha_0 + \alpha_1 Fned_{i,t} + \sum \alpha_i Control_{i,t} + Year + Industry + \xi \quad (1)$$

3.4 Summary statistics

Table 1 presents the descriptive statistics. The mean of *Fned* is 0.085, indicating that the average proportion of family non-executive directors on the board of directors of family firms during the sample period was 8.5%. At the same time, the mean of *Fned* (0.085) is lower than its median (0.111), indicating that the proportion of family members serving as non-executive directors is relatively low during the sample period. The mean of *Robot* (2.162) is higher than the median (1.666), indicating that more and more family firms tend to use robots, and the speed of robot adoption in family firms has improved.

4. Empirical results

4.1 Baseline regression results

Table 2 shows the baseline regression results. Column (1) is the baseline regression result without control variables. Column (2) is the baseline regression result with control variables. In Column (1) of Table 2, the coefficient of *Fned* is significantly positive at the 1% level. Furthermore, in Column (1) of Table 2, the coefficient of *Fned* is significantly positive at the 5% level. Therefore, family non-executive directors can significantly promote robot adoption in family firms. This is consistent with H1. Taken together, our empirical findings show that family members as non-executive directors can promote robot adoption in family firms.

4.2 Endogeneity tests

4.2.1 Instrumental variable method. The instrumental variable (IV) method is employed to better address endogeneity concerns arising from potential simultaneity and omitted

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026

Variable	N	Mean	Median	SD	Max	Min
Robot	1,129	2.162	1.666	1.743	5.838	0.000
Fned	1,129	0.085	0.111	0.094	0.429	0.000
Size	1,129	21.710	21.640	0.908	26.000	19.560
Lev	1,129	0.330	0.315	0.170	0.836	0.031
Growth	1,129	0.168	0.121	0.353	4.806	−0.592
Age	1,129	2.728	2.773	0.413	3.555	1.386
ROA	1,129	0.045	0.042	0.057	0.222	−0.415
Board	1,129	2.078	2.197	0.179	2.708	1.609
Indep	1,129	0.381	0.364	0.057	0.600	0.333
Dual	1,129	0.537	1.000	0.499	1.000	0.000
Mshare	1,129	0.262	0.243	0.235	0.705	0.000
FM	1,129	0.176	0.188	0.099	0.400	0.000
Child	1,129	0.588	1.000	0.492	1.000	0.000
HT	1,129	0.369	0.000	0.483	1.000	0.000
Law	1,129	9.770	10.110	2.653	14.130	1.936

Note(s): Table 1 presents descriptive statistics of key variables of interest for the sample of family firms included in our study. The sample covers firm-year observations with non-missing values for all variables for the period 2011–2019. All variables are defined in Appendix
Source(s): Table by authors

Table 1.
Summary statistics

variables. We use the IV method to alleviate the possible endogeneity arising from possible simultaneity and omitted variables. We follow previous studies (Chahine & Goergen, 2013) and adopt regional marital status (*Marriage*) as the IV of family non-executive directors. The regional marital status reflects people's attitude towards family relations (Chahine & Goergen, 2013), which can affect the allocation of family non-executive directors in family firms. Theoretically, there is no correlation between regional marital status and the strategic decisions of listed companies. Specifically, we use the natural logarithm difference between the number of registered marriages and divorce cases per 10,000 people in the region to measure the strength of family relationships. The greater value of *Marriage* indicates the closer the regional family relations. The data on regional marital status are from the *China Civil Affairs Statistical Yearbook*.

Column (1) of Table 3 presents the regression results of the IV method. We find that Kleibergen-Paap rk LM statistics are all significant at the level of 1%, which shows that the original hypothesis of insufficient identification of IV is rejected; Cragg-Donald Wald *F* statistics are all higher than the critical value of Stock-Yogo weak IV identification *F* test at 10% significance level, which suggests that the original hypothesis of weak IV is rejected. The coefficient of *Fned* is significantly positive at the level of 10%. This suggests that the IV method results are consistent with the baseline findings. The self-selection problem is thus not a concern for the baseline conclusion.

4.2.2 Multi-dimensional fixed effects. In order to ensure the stability of the baseline, we also control the firm-fixed effect and the annual-industry fixed effect. The regression results are shown in Column (2) of Table 3, and the coefficient of *Fned* is significantly positive at the level of 10%, which shows that the result after controlling the multi-dimensional shareholder effect is still consistent with the baseline results.

4.2.3 Omitted variables test. According to Oster (2019), when there may be unobservable missing variables in the Model, the estimator, $\beta^* = \beta^*(R_{max}, \delta)$, can be used to obtain a consistent estimate of the true coefficient. The estimator needs to set two parameters: δ and R_{max}. Among them, δ is selection proportionality, which is used to measure the strength of the correlation between observable variables and concerned variables compared with the

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026

Variable	(1)	(2)
Fned	1.250***	0.753**
	(3.61)	(2.01)
Size		0.063
		(1.62)
Lev		0.337
		(0.85)
Growth		−0.159
		(−1.57)
Age		−0.315**
		(−2.54)
ROA		1.307*
		(1.71)
Board		0.214
		(1.07)
Indep		−0.257
		(−0.45)
Dual		0.172***
		(2.92)
Mshare		0.644***
		(6.41)
FM		1.114***
		(3.28)
Child		0.202***
		(4.82)
HT		−0.377***
		(−8.97)
Law		−0.028**
		(−2.05)
Year	N	Y
Industry	N	Y
Cons	2.057***	−1.271
	(6.58)	(−0.82)
N	1,129	1,129
R^2	0.005	0.459

Note(s): Table 2 reports the baseline regression results. Column (1) reports the result of family non-executive directors on robot adoption without the controlling variables. Column (2) reports the result of family non-executive directors on robot adoption with the controlling variables. We report *t*-statistics in parentheses. All models include year and industry-fixed effects. *, ** and *** indicate two-tailed statistical significance at the 10%, 5% and 1% levels, respectively. All variables are defined in Appendix
Source(s): Table by authors

Table 2. Baseline regression results

correlation between unobservable missing variables and concerned variables; R_{max} means the maximum goodness of fit of regression equation if the unobservable missing variables can be observed.

Referring to Oster's (2019) method, we take the following methods to test the robustness of the possible missing variables in the empirical results: (1) δ is set to -1 and R_{max} to 1.3 times the current regression goodness. If $\beta^* = \beta^*(R_{max}, \delta)$ falls within the 95% confidence interval of the estimated parameters, the result is robust. (2) The R_{max} value method is the same as that used in the first step, and the value of δ is calculated to make $\beta = 0$. If the value of δ is greater than or equal to one or less than zero (when the value of δ is less than zero, the coefficient adjusted by deviation should be greater than the coefficient of the previous regression, which proves the robustness of the result), the result is robust.

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026

Variable	IV (1)	Multiple fixed effects (2)
Fned	36.699***	0.302*
	(3.51)	(1.72)
Size	0.145	−0.062**
	(1.34)	(−2.46)
Lev	0.914	−0.282*
	(1.64)	(−1.70)
Growth	−0.407*	0.038
	(−1.78)	(1.12)
Age	−0.376*	−0.020
	(−1.88)	(−0.19)
ROA	3.240**	−0.267
	(2.10)	(−0.97)
Board	1.355**	−0.056
	(2.07)	(−0.56)
Indep	2.009	−0.106
	(1.07)	(−0.32)
Dual	2.656***	0.024
	(3.60)	(0.83)
Mshare	1.628***	−0.070
	(3.64)	(−0.62)
FM	−23.743***	−0.132
	(−3.26)	(−0.67)
Child	0.365**	−0.034
	(2.27)	(−1.20)
HT	−0.155	−0.000
	(−0.94)	(−0.74)
Law	−0.054*	−0.010
	(−1.70)	(−1.04)
Year	Y	Y
Industry	Y	N
Firm	N	Y
Year-Industry	N	Y
Cons	−6.221	4.138***
	(−1.59)	(7.20)
N	1,129	1,129
Kleibergen-Paap rk LM statistic	16.947*** (0.000)	
Cragg-Donald Wald F statistic	16.672	
R^2/*Pseudo* R^2	–	0.774

Note(s): This table reports the results of the endogeneity test. Column (1) shows the second stage of the IV regression results of the effect of family non-executive directors on robot adoption. Meanwhile, I show the Kleibergen-Paap rk LM statistic and Cragg–Donald Wald *F* statistic in this table. Column (2) shows the result of the multiple fixed effects. We report *t*-statistics in parentheses. All models include year and industry-fixed effects. *, ** and *** indicate two-tailed statistical significance at the 10%, 5% and 1% levels, respectively. All variables are defined in Appendix
Source(s): Table by authors

Table 3. Endogeneity test results

Table 4 presents the results of the omitted variable test. As can be seen from row (1), $\beta^*(R_{max}, \delta) = 0.015$, which falls within the 95% confidence interval of the estimated parameters, indicating that the robustness test has been passed. As shown in row (2), $\delta = 24.483$ is more than 0 and indicates that the robustness test has been passed. Therefore, the key variables are not omitted.

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026

4.3 Other robustness results

4.3.1 Variable advanced regression. Recognizing that the characteristic factors of the family firm in a given year may affect the robot adoption, we adopt the method of advancing the dependent variable (*Robot*) by one period to alleviate this problem. The regression result is shown in Column (1) of Panel A of Table 5. *Fned* and *Robot* are still positively correlated with a significant level of 10%, consistent with the baseline regression results. So, our baseline result is robust.

4.3.2 Elimination of the board size. The role of family non-executive directors may also be affected by the board size because when the board of directors is small, the dominance of family members may have a greater impact on the board of directors. To rule out this possible explanation, we re-examine the influence of family non-executive directors on robot adoption by taking a sample with at least nine board members (the median of the board size is 9).

The regression result is shown in Column (2) of Panel A of Table 5. It can be seen from Column (2) that the coefficient of *Fned* is significantly positive, indicating that when the board of directors is large, the family non-executive directors also reflect the governance role, and the alternative explanation mentioned above can be ruled out.

4.3.3 Replacement of the measurement of the key variables. To enhance the robustness of the conclusion, we changed the measurement method of the independent and dependent variables. For family non-executive directors, we directly use the number of family non-executive directors plus one to take the natural logarithm to measure *Fned*. As for robot adoption, considering that the direct consequence of robot adoption lies in the improvement of the book value of enterprise machinery and equipment, we adopt the book value of enterprise machinery and equipment as the proxy variable of robot adoption. Specifically, the family enterprise machinery and equipment plus one logarithm is used to measure *Robot*. At the same time, we also tested the correlation between the book value of enterprise machinery and equipment and the proxy variable of robot adoption in the dependent variable. The regression results are shown in Columns (3) - (4) of Panel A of Table 5. The coefficients of *Fned* are significant and positive, indicating that the baseline conclusion persists with changing the variable measurement method. The correlation of the two variables is shown in Panel B of Table 5. The proxy variable (the dependent variable, *Fned*) is positively correlated with the replacement variable of robot adoption (*Fned_BV*) at a significant level of 1%, which shows that they have a high correlation. Therefore, our results show that it is also feasible to use the book value of enterprise machinery and equipment as another method to measure robot adoption.

5. Underlying mechanisms and additional tests

5.1 Underlying mechanisms

Drawing on the principal–principal conflict lens, we analyse the influence of family non-executive directors on robot adoption from financial and human effects. We further test whether the above two underlying mechanisms are established. Specifically, referring to Hayes (2022), we construct Model (2) to test whether the underlying mechanism is established. In Model (2), *Channel* represents the mechanism variables (financial effect and

Method	Judgment standard	Actual calculation result	Whether it passes or not
(1)	$\beta^{*}(R_{max},\delta) \in [-0.131,0.161]$	$\beta^{*}(R_{max},\delta) = 0.015$	Pass
(2)	$\delta \geq 1$ or $\delta < 0$	$\delta = 24.483$	Pass

Note(s): This table shows the regression results for the omitted variables test: Line (1), δ test; Line (2), $\beta^{*}(R_{max}, \delta)$ test
Source(s): Table by authors

Table 4. Omitted variable test results

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026

Table 5. Other robustness test results

Panel A				
Variable	Variable advanced regression (1)	Elimination of the board size (2)	Replacement of key variables (3)	(4)
Fned	0.821*	2.040***	0.309***	1.010***
	(1.93)	(3.03)	(4.18)	(5.59)
Size	0.098*	0.131***	0.060	0.878***
	(1.75)	(2.98)	(1.53)	(53.59)
Lev	0.450	−0.474	0.356	0.687***
	(1.01)	(−1.23)	(0.90)	(8.11)
Growth	−0.238**	−0.139	−0.156	−0.173***
	(−2.16)	(−0.84)	(−1.56)	(−3.30)
Age	−0.317**	−0.266	−0.317**	0.186***
	(−2.28)	(−1.55)	(−2.53)	(7.89)
ROA	2.260**	1.544	1.313*	−0.133
	(2.15)	(0.97)	(1.70)	(−0.26)
Board	0.177	1.243	0.147	0.498***
	(0.43)	(1.57)	(0.74)	(2.94)
Indep	0.348	0.827	−0.191	1.270***
	(0.32)	(0.39)	(−0.33)	(2.73)
Dual	0.199***	0.210***	0.219***	0.011
	(3.31)	(4.14)	(4.90)	(0.54)
Mshare	0.677***	0.698***	0.659***	−0.408***
	(4.50)	(3.07)	(6.74)	(−7.53)
FM	1.119***	0.537	0.662***	−0.226
	(4.97)	(0.46)	(3.02)	(−1.59)
Child	0.155**	0.275***	0.208***	0.017
	(2.23)	(3.62)	(5.15)	(1.08)
HT	−0.450***	−0.291***	−0.375***	0.071***
	(−12.18)	(−5.94)	(−8.91)	(3.29)
Law	−0.013	−0.054**	−0.029**	−0.017***
	(−1.23)	(−2.25)	(−2.19)	(−4.14)
Year	Y	Y	Y	Y
Industry	Y	Y	Y	Y
Cons	−3.042	−1.919	−1.098	−1.068
	(−1.16)	(−0.99)	(−0.70)	(−1.49)
N	839	610	1,129	1,854
R^2	0.456	0.469	0.460	0.698

Panel B Variable	*Fned*	*Fned_BV*
Fned	1	
Fned_BV	0.223***	1

Note(s): This table reports the results of other robustness tests. Column (1) in Panel A shows the result of variable advanced regression. Column (2) in Panel A shows the result of the elimination of the board size. Columns (3) and (4) in Panel A show the results of the replacement of the key variables. Panel B lists the correlation of between the proxy variable (dependent variable, *Fned*) and the replacement variable of robot adoption (*Fned_BV*). We report *t*-statistics in parentheses. All models include year and industry-fixed effects. *, ** and *** indicate two-tailed statistical significance at the 10%, 5% and 1% levels, respectively. All variables are defined in Appendix
Source(s): Table by authors

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026

human effect). *Control* represents the control variables, which are consistent with the control variables of Model (1).

$$Channel_{i,t} = \theta_0 + \theta_1 Fned_{i,t} + \sum \theta_i Control_{i,t} + Year + Industry + \varepsilon \quad (2)$$

To measure the financial effect, we use financing constraints as proxy variables. After comprehensively considering the existing research on the financing constraint index, Hadlock and Pierce (2010) suggest that the asset size and age of the company should be mainly considered when measuring the financing constraint. Therefore, referring to Hadlock and Pierce (2010), we calculate the proxy variable (*FC*) of financing constraint, which is a continuous variable and reflects the probability of financing constraint of the family firm. The specific calculation steps are as follows.

Firstly, we sort and group companies according to the dimensionless average of three indicators: company size, cash dividend payment rate and listing time. The upper and lower three-point points are used as the dividing points of financing constraints, and *FCDum* is determined. Further, the companies above the one-third point are defined as the low financing constraint group (*FCDum* = 0). Then Logit regression is carried out according to Model (3). The probability of financing constraints of each company in the current year is fitted according to the regression results (the value of *FC* is between 0 and 1), and the greater the value of *FC*, the higher the degree of financing constraints of the company. In Model (4), *DIV* represents the cash dividend announced by the company in the current year; *MB* represents the ratio of the company's market value to book value; *NWC* represents the company's net working capital; *EBIT* represents earnings before interest and tax; and *TA* represents the company's total assets.

$$P(FCDum = 1|Z_{i,t}) = e^{Z_{i,t}} / \left(1 + e^{Z_{i,t}}\right) \quad (3)$$

$$Z_{i,t} = \delta_0 + \delta_1 Size_{i,t} + \delta_2 Lev_{i,t} + \delta_3 (DIV/TA)_{i,t} + \delta_4 MB_{i,t} + \delta_5 (NWC/TA)_{i,t} + \delta_6 (EBIT/TA)_{i,t} \quad (4)$$

To assess the human effect, we refer to a previous study (Du *et al.*, 2022) and measure it by using the proportion of non-family members as directors and senior managers of family firms. The reason is that in the section on hypothesis development, we think that family members as non-executive directors can transfer key management positions in family firms to high-quality non-family human capital so that they can give full play to the positive role of human capital in the process of robot adoption. Therefore, we directly tested the influence of family non-executive directors on non-family human capital.

Table 6 shows the regression results of the underlying mechanism tests. About the mechanism of financial effect, it can be seen from Column (1) that *Fned* has a significant negative correlation with *Robot* at the level of 10%. This shows that family non-executive directors can effectively exert a financial effect, thus solving the problem of insufficient funds in adopting robots in family firms. As for the mechanism of human effect, it can be seen from Column (2) that *Fned* is positively correlated with *Robot* at a significant level of 1%. This suggests that family non-executive directors can effectively exert a human effect, thus providing more human capital support for robot adoption in family firms. Overall, family non-executive directors contribute to the widespread adoption of robots in family firms by leveraging both financial and human effects.

5.2 Additional tests

5.2.1 Characteristics of family non-executive directors. 5.2.1.1 Effect of kinship. In the previous section, we pay attention to the influence of family non-executive directors on robot

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026

Variable	Financial Effect (1)	Human Effect (2)
Fned	−0.229*	0.226***
	(−1.81)	(6.39)
Size	0.010	0.004**
	(0.79)	(1.99)
Lev	−0.094	−0.024***
	(−1.60)	(−3.36)
Growth	0.007	0.001
	(0.94)	(0.32)
Age	−0.021***	0.006*
	(−2.66)	(1.73)
ROA	0.309***	0.015
	(6.67)	(0.36)
Cashflow	0.006	0.006
	(0.06)	(0.44)
Board	−0.054***	−0.120***
	(−2.92)	(−3.17)
Indep	0.097	−0.016***
	(1.07)	(−9.00)
Dual	−0.009	0.006
	(−1.13)	(0.51)
Mshare	0.061***	−1.515***
	(6.83)	(−24.40)
FM	0.464***	0.001
	(5.34)	(0.36)
Child	0.009	0.009***
	(0.53)	(2.66)
HT	0.030**	−0.001**
	(2.16)	(−2.42)
Law	0.003***	0.939***
	(3.58)	(13.28)
Year	Y	Y
Industry	Y	Y
Cons	0.227	1129
	(0.70)	(0.192)
N	1,129	1,129
R^2	0.213	0.883

Note(s): This table shows the regression results for the underlying mechanism test. Column (1) is used to test the resource effect and Column (2) is used to test the human effect. We report *t*-statistics in parentheses. All models include year and industry-fixed effects. *, ** and *** indicate two-tailed statistical significance at the 10%, 5% and 1% levels, respectively. All variables are defined in Appendix
Source(s): Table by authors

Table 6. Underlying mechanisms test results

adoption from an overall perspective, but the family system has high heterogeneity (Dyer & Dyer, 2009), which is embodied in the heterogeneity of family structure, that is, family members can be divided into blood relationship and marriage relationship according to kinship (Amore, Miller, Le Breton-Miller, & Corbetta, 2017; Bird & Zellweger, 2018). Therefore, we further divide the family non-executive directors into blood type and marriage type and further observe whether the two types of family non-executive directors can have a differentiated impact on robot adoption.

For the blood family non-executive directors, conflicts and disputes are very likely to occur between blood relatives because of the differences between their personal goals and their respective family interests (Gersick, Davis, Hampton, & Lansberg, 1997). They can not

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026

only distract the blood relatives from managing the enterprise but also consume the enterprise resources internally (Aronoff & Astrachan, 1996), thus intensifying the agency conflicts within the enterprise. Furthermore, the family owners prefer to make conservative strategic decisions, which is not conducive to robot adoption.

For the marriage non-executive directors, related studies find that the performance of family firms managed by marriage relatives is better than that managed by blood relatives (Saito, 2008). At the same time, because marriage relatives are less constrained by non-economic goals than blood relatives in the course of business operation, marriage family members can help family firms achieve higher business performance (Hsu, Wiklund, Anderson, & Coffey, 2016). Therefore, we expect that the blood of non-executive directors may have a negative impact on robot adoption. In contrast, the marriage of non-executive directors may promote robot adoption.

The regression results are shown in Columns (1) and (2) of Table 7. From Column (1), it can be seen that *Fned* has a negative correlation with *Robot* at a significant level of 1%, which shows that the blood family non-executive directors are really not conducive to the improvement of robot adoption. It can be seen from Column (2) that *Fned* has a positive correlation with *Robot* at a significant level of 1%, which shows that the marriage non-executive directors can effectively help family firms to improve robot adoption.

Furthermore, we use corporate risk-taking to verify whether kinship has different influences on robot adoption due to conservative differences caused by agency costs. The reason is that agency theory holds that managers have the motivation to avoid risks, and they may choose conservative investment strategies in order to avoid losses caused by investment failure (John, Litov, & Yeung, 2008). Specifically, referring to Koerniadi, Krishnamurti, and Tourani-Rad (2014) and Du *et al.* (2022), we use the annual volatility of monthly stock returns to measure corporate risk-taking (*RiskT*). The higher the value of *RiskT*, the higher corporate risk-taking. The calculation formula of *RiskT* is as follows:

$$RiskT_{i,j,t} = \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(r_{i,j,t} - \frac{1}{T}\sum_{t=1}^{T} r_{i,j,t}\right)^2} \quad (5)$$

$r_{i,j,t}$ is the rate of return of company i in the t week of year j, and t is the total number of weeks in each fiscal year. The regression results are shown in Columns (3) and (4) of Table 8. From Column (3), $Fned \times RiskT$ is negatively correlated with *Robot* at a significant level of 10%, indicating that higher corporate risk-taking can further strengthen the inhibitory effect of blood family non-executive directors on robot adoption of family enterprise robots. It can be seen from Column (4) that there is no significant correlation between $Fned \times RiskT$ and *Robot*, indicating that corporate risk-taking cannot affect the relationship between marriage family non-executive directors and robot adoption. Therefore, the conservative characteristics brought about by blood relationships are the reasons why blood family non-executive directors inhibit robot adoption.

5.2.1.2 Heterogeneity of family shareholding mode. The effect of family non-executive directors can be restricted by family ownership to a great extent, given that family shareholders appoint family non-executive directors and represent their interests. In fact, due to the high concentration of family ownership, the shareholders who hold centralized shares undertake governance functions (Denis & McConnell, 2003). When the controlling families have absolute control over the firm, the role of the family non-executive directors may not be significant in robot adoption.

However, with family firms' continuous growth, external investors can enter, which dilutes family ownership (Anderson & Reeb, 2003; Du *et al.*, 2022). With the decreasing family shareholding ratio trend, the family's position in ownership gradually changes from absolute

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026

Variable	*Blood* (1)	*Marriage* (2)	*Blood* (3)	*Marriage* (4)	*FO* (5)	*FO1* (6)	*FO2* (7)	*FO3* (8)	*Nfoc* (9)
Fned	−1.543***	2.944***	−1.560***	4.616***	1.191***	0.840**	0.688	0.972**	−1.339***
	(−3.01)	(4.54)	(−2.70)	(2.88)	(3.23)	(2.49)	(1.63)	(2.39)	(−3.71)
RiskT			−0.633***	−0.369**					
			(−2.91)	(−2.42)					
Fned×FO			−4.851*	−11.871					
			(−1.84)	(−1.38)					
FO					0.000				
					(0.04)				
Fned×FO					−0.104***				
					(−6.33)				
FO1						0.019			
						(0.32)			
Fned×FO1						0.974			
						(1.46)			
FO2							0.011		
							(0.29)		
Fned×FO2							2.005**		
							(2.27)		
FO3								−0.003	
								(−0.07)	
Fned×FO3								−3.234***	
								(−4.97)	
Size	0.068	0.083**	0.062	0.075*	0.053	0.059	0.080*	0.075	0.054
	(1.56)	(2.00)	(1.61)	(1.79)	(1.05)	(1.39)	(1.79)	(1.54)	(1.51)
Lev	0.346	0.353	0.343	0.367	0.393	0.345	0.272	0.274	0.372
	(0.85)	(0.89)	(0.90)	(0.91)	(0.90)	(0.84)	(0.70)	(0.69)	(0.97)
Growth	−0.169	−0.168*	−0.130	−0.146	−0.157	−0.160	−0.167*	−0.179*	−0.136
	(−1.44)	(−1.75)	(−1.24)	(−1.43)	(−1.56)	(−1.59)	(−1.65)	(−1.65)	(−1.37)
Age	−0.307**	−0.325***	−0.326**	−0.342***	−0.235**	−0.300**	−0.338***	−0.309**	−0.280**
	(−2.34)	(−2.99)	(−2.59)	(−3.09)	(−2.40)	(−2.39)	(−2.91)	(−2.39)	(−2.56)
ROA	1.266	1.302*	1.134	1.242*	1.228*	1.264	1.219*	1.001	1.441*
	(1.48)	(1.87)	(1.63)	(1.68)	(1.71)	(1.63)	(1.71)	(1.49)	(1.84)
Board	0.157	0.112	0.092	0.091	0.277*	0.205	0.243	0.241	0.221
	(0.72)	(0.54)	(0.48)	(0.43)	(1.77)	(1.11)	(1.09)	(1.17)	(1.14)
Indep	−0.418	−0.484	−0.536	−0.442	−0.549	−0.289	−0.321	−0.482	−0.381
	(−0.65)	(−0.86)	(−0.95)	(−0.81)	(−0.99)	(−0.49)	(−0.57)	(−0.83)	(−0.63)
Dual	0.123*	0.168***	0.040	0.170***	0.123**	0.167***	0.172***	0.157***	0.079
	(2.25)	(2.90)	(1.06)	(3.14)	(2.00)	(2.96)	(2.75)	(2.66)	(1.30)
Mshare	0.678***	0.698***	0.621***	0.705***	0.657***	0.657***	0.667***	0.694***	0.535***
	(6.93)	(8.04)	(6.32)	(8.10)	(6.28)	(6.33)	(7.72)	(7.94)	(6.35)
FM	1.250***	0.950***	2.329***	0.877***	0.324	1.039**	1.060***	0.693**	1.792***
	(3.73)	(3.34)	(6.42)	(3.31)	(1.04)	(2.59)	(3.33)	(2.12)	(6.98)
Child	0.206***	0.199***	0.193***	0.209***	0.169***	0.198***	0.212***	0.207***	0.184***
	(5.14)	(5.97)	(4.54)	(6.46)	(3.43)	(4.71)	(4.66)	(5.11)	(3.95)
HT	−0.339***	−0.351***	−0.384***	−0.353***	−0.388***	−0.378***	−0.368***	−0.370***	−0.398***
	(−6.67)	(−7.30)	(−7.64)	(−7.01)	(−8.40)	(−8.84)	(−9.06)	(−8.10)	(−8.13)
Law	−0.031*	−0.027**	−0.025*	−0.027**	−0.031**	−0.028**	−0.027**	−0.029**	−0.030*
	(−2.26)	(−2.14)	(−1.85)	(−2.31)	(−2.58)	(−2.20)	(−2.07)	(−2.41)	(−1.93)
Year	Y	Y	Y	Y	Y	Y	Y	Y	Y
Industry	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cons	−1.205	−1.387	−0.818	−1.144	−1.123	−1.142	−1.633	−1.334	−1.126
	(−0.70)	(−0.86)	(−0.54)	(−0.70)	(−0.70)	(−0.68)	(−0.94)	(−0.75)	(−0.79)
N	1,129	1,129	1,129	1,129	1,129	1,129	1,129	1,129	1,129
R^2	0.463	0.466	0.462	0.468	0.473	0.459	0.461	0.465	0.468

Note(s): This table shows the regression results for the characteristics of family non-executive directors. Columns (1)–(4) are used to test the effect of kinship; Columns (5)–(8) are used to test the heterogeneity of family shareholding mode; Column (9) reports the result of the effect of excessive family directors. We report *t*-statistics in parentheses. All models include year and industry-fixed effects. *, ** and *** indicate two-tailed statistical significance at the 10%, 5% and 1% levels, respectively. All variables are defined in Appendix
Source(s): Table by authors

Table 7.
Characteristics of family non-executive director test results

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026

Variable	(1) *FP*	(2) *Fnedum* = 1	(3) *Fnedum* = 0
Robot	0.002***	0.002*	0.002
	(3.04)	(1.70)	(1.45)
Size	−0.000	0.001	−0.003
	(−0.35)	(1.07)	(−1.17)
Lev	−0.016	−0.037***	0.017
	(−1.33)	(−5.86)	(1.65)
Growth	0.009	0.011	0.013***
	(1.24)	(1.28)	(3.55)
Age	−0.003	−0.001	−0.008***
	(−1.30)	(−0.27)	(−4.22)
ROA	0.642***	0.690***	0.533***
	(10.68)	(9.63)	(8.22)
Board	0.051***	0.063**	0.030*
	(3.98)	(2.41)	(1.79)
Indep	0.099**	0.129*	0.084***
	(2.37)	(1.70)	(4.66)
Dual	0.001	−0.004*	0.008*
	(0.27)	(−1.75)	(1.72)
Mshare	−0.004	−0.005	−0.010***
	(−1.38)	(−0.91)	(−5.16)
FM	−0.006	−0.004	0.052
	(−0.94)	(−0.34)	(1.29)
Child	−0.003	−0.006	−0.000
	(−1.65)	(−1.59)	(−0.20)
HT	−0.006***	−0.007***	−0.007**
	(−3.11)	(−2.61)	(−2.05)
Law	0.000	0.000	−0.001
	(0.12)	(0.32)	(−0.80)
Year	Y	Y	Y
Industry	Y	Y	Y
Cons	−0.108**	−0.184**	−0.006
	(−2.17)	(−2.58)	(−0.10)
N	610	424	186
R^2	0.485	0.447	0.662

Note(s): This table reports the regression results of the economic consequence test. Column (1) reports the result of robot adoption on future performance. Columns (2) and (3) report the results of the impact of family non-executive directors on the relationship between robot adoption and future performance. We report *t*-statistics in parentheses. All models include year and industry-fixed effects. *, ** and *** indicate two-tailed statistical significance at the 10%, 5% and 1% levels, respectively. All variables are defined in Appendix
Source(s): Table by authors

Table 8. Economic consequence test results

holding to relative holding and strategic holding, leading to the executive director being a strategic investor or professional manager. Consequently, it becomes crucial for the board of directors to exert influence through family non-executive directors to maintain family firms' long-term and stable development.

We thus examine the influence of family ownership on the relationship between *Fned* and *Robot*. We further tested the impact of controlling families on the relationship between *Fned* and *Robot* under different family shareholding modes. We use the shareholding ratio of the controlling family (Schmid, Achleitner, Ampenberger, & Kaserer, 2014) to measure family ownership (*FO*). Since whether shareholders can appoint directors and the number of appointed directors depends on their shareholding ratio (Du *et al.*, 2022, 2024), we group *FO*

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026

according to the shareholding ratio of family shareholders. Specifically, when $FO < 34\%$, family shareholders are in the state of strategic shareholding (*FO1*); When $34\% \leq FO < 51\%$, family shareholders are in a state of relative holding (*FO2*); When $FO \geq 51\%$, the family shareholders are in absolute holding state (*FO3*).

The regression results are shown in Columns (5) to (8) of Table 7. Column (5) results show that the coefficient of $Fned \times FO$ is significantly positive at the 10% level, indicating that family ownership weakens the positive influence of family non-executive directors on robot adoption. As is shown in Column (6), no significant correlation exists between $Fned \times FO1$ and *Robot*, indicating that family strategic shareholding has not affected the positive influence of family non-executive directors on robot adoption. The result in Column (7) suggests that the coefficient of $Fned \times FO$ is significantly positive at the 5% level, indicating that the relative family holding strengthens the positive influence of family non-executive directors on robot adoption. In Column (8), the coefficient of $Fned \times FO3$ is significantly positive at the 1% level, indicating that absolute family holding weakens the positive influence of family non-executive directors on robot adoption.

Taken together, excessive concentration of family ownership can have a negative impact on the relationship between family non-executive directors and robot adoption. However, further distinguishing the family shareholding mode, we show that the relative holding of family shareholders can strengthen the positive influence of family non-executive directors on robot adoption compared with the strategic holding and absolute holding of family shareholders.

5.2.1.3 Effect of excessive family directors. Although we find that family non-executive directors can encourage family firms to use robots more actively, too many family members as non-executive directors may lead to excessive family directors. Excessive control of family board seats can amplify family control rights, leading to the loss of corporate value (Villalonga & Amit, 2009; Amit *et al.*, 2015). At the same time, excessive family directors can also aggravate the behaviour of the controlling families to seek personal interests (Villalonga & Amit, 2010; Lin, Ma, Malatesta, & Xuan, 2012). The excessive number of family non-executive directors thus may have a detrimental impact on the strategic decision-making of family firms. We further tested the influence of excessive family non-executive directors on robot adoption.

We follow Villalonga and Amit (2009) and measure the excessive family non-executive directors (*Nfoc*) by using the difference between the proportion of family non-executive directors and family control rights. The result in Column (9) of Table 7 shows that the coefficient of *Nfoc* is significantly negative at the 5% level, indicating that excessive family non-executive directors can hinder family firms from adopting robots. Therefore, excessive family non-executive directors can adversely affect robot adoption, and family firms thus should avoid the phenomenon of excessive family directors.

5.2.2 Effect of economic consequence. Robot adoption has the potential to reduce production costs, improve production efficiency and expand the labour demand for non-automated tasks (Bessen, 2019; Acemoglu & Restrepo, 2020b). Therefore, exploring the impact of robot adoption on the future performance of family firms holds significant value. We verify whether family non-executive directors can further improve future performance while improving robot adoption in family firms.

Firstly, we test whether robot adoption can improve the future performance of family firms. Secondly, according to the median of family non-executive directors, we further divided the sample family firms into two groups: the group with a high level of family non-executive directors ($Fnedum = 1$) and the group with a low level of family non-executive directors ($Fnedum = 0$). Employing group regression analysis, we then examine the impact of robot adoption on the operational efficiency of family firms within these distinct groups.

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026

We use the average return on total assets of enterprises in the next two years (*FP*) as the proxy variable of future performance. The higher *FP*, the higher the future performance. The regression results are shown in Table 8. It can be seen from Column (1) that the coefficient of *Robot* is significantly positive at the 1% level, indicating that robot adoption in family firms can improve future performance. It can be seen from Column (2) that when *Fnedum* = 1, the coefficient of *Robot* is significantly positive at the 10% level. Meanwhile, as is shown in Column (3), there is no significant correlation between *Robot* and *FP* when *Fnedum* = 0, which shows that robot adoption plays a more significant role in improving the future performance of family firms when there are more family non-executive directors. Thus, family non-executive directors can further enhance the future performance of family firms alongside increasing levels of robot adoption.

6. Conclusion and discussions

6.1 Conclusions

Robot adoption has a profound impact on economic and societal development. This study intricately links the pivotal strategic decision of robot adoption with the governance structure of family firms, particularly focusing on the right allocation of the board of directors. Drawing on the principal–principal conflicts lens, we explore the influence of family non-executive directors on robot adoption in family firms in China, one of the largest countries using robots.

We find that family members as non-executive directors play a substantial role in promoting robot adoption in family firms. The detailed underlying mechanisms show that family non-executive directors promote robot adoption by exerting financial and human effects. Examining the characteristics of family non-executive directors, we identify factors affecting their effectiveness, including kinship, family differential shareholding and excessive directors. In addition, we find that robot adoption enhances the future performance of family firms. This promotion effect is more pronounced when family members are non-executive directors.

6.2 Theoretical implications

Our study provides critical theoretical implications and insights into the existing studies. Firstly, we decompose the types of family directors to understand the role of family non-executive directors, which challenges the assumption that family board members are homogeneous (Bammens*et al.*, 2011). At the same time, we also enrich the related studies on the heterogeneity of the board of directors of family firms (González-Cruz & Cruz-Ros, 2016; Vandebeek *et al.*, 2016).

Secondly, we provide references for how to optimize the right allocation mode of the board of directors of family firms. Balancing the relationship between external capital and family control is a key issue that must be considered when family firms face risky decisions. Combining the principal-principal conflicts lens and the characteristics of family heterogeneity, we find that family non-executive directors can effectively balance the relationship between external capital and family control, thus providing a reference for family firms to optimize the composition of board seats.

Finally, we provide an effective way to maximize the positive effects of family directors. Although previous studies believe that the self-interest behaviour of family directors can entrench the interests of non-family members (Villalonga & Amit, 2009; Amit *et al.*, 2015), the family nature makes it impossible for the board of directors to exclude family directors. We find that family directors do not always have negative effects. That is, family non-executive directors have positive effects. This provides some evidence for the positive impact of family directors.

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026

6.3 Managerial implications

Our findings have managerial implications for family businesses to optimize their strategic decisions with the help of the mode of board right allocation. We have found that when family members serve as non-executive directors, family businesses will more actively implement the robot adoption strategy. Therefore, when family businesses need to balance the relationship between family control and long-term growth with the help of external capital, it is an effective solution to rationally allocate board rights among family members.

6.4 Limitations and future research

We acknowledge that this study may have limitations that suggest avenues for future research. Firstly, our study focuses on Chinese family firms and while our findings offer valuable insights, it remains uncertain whether our conclusions can also be universally applied to other emerging economies. Therefore, future studies should consider the specific contexts and institutional environments of different countries to understand the driver of robot adoption. Secondly, we innovatively constructed an enterprise-level robot adoption index through "country-industry". To further refine the robot adoption measure, future studies could conduct field research, case studies and other methods to construct a robot adoption index. By utilizing diverse research methods, we could get a more granular and accurate measurement to capture robot adoption within family firms.

Notes

1. The reason why we take 10% as the criterion is that according to the *Company Law* of China, the company shall convene an extraordinary shareholders' meeting within two months at the request of shareholders who individually or collectively hold more than 10% of the company's shares.

References

Abeliansky, A., & Prettner, K. (2017). Automation and demographic change. Center for European, Governance and Economic Development Research Discussion Papers.

Acemoglu, D., & Restrepo, P. (2018). The race between man and machine: Implications of technology for growth, factor shares, and employment. *American Economic Review*, *108*(6), 1488–1542. doi: 10.1257/aer.20160696.

Acemoglu, D., & Restrepo, P. (2020a). Robots and jobs: Evidence from US labour markets. *Journal of Political Economy*, *128*(6), 2188–2244. doi: 10.1086/705716.

Acemoglu, D., & Restrepo, P. (2020b). The wrong kind of AI? Artificial intelligence and the future of labour demand. *Cambridge Journal of Regions Economy and Society*, *13*(1), 25–35. doi: 10.1093/cjres/rsz022.

Ahluwalia, S., Mahto, R., & Walsh, S. (2017). Innovation in small firms: Does family vs non-family matter?. *Journal of Small Business Strategy*, *27*(3), 39–49.

Allen, F., & Gale, D. (1999). Corporate governance and competition. Center for Financial Institutions Working Paper.

Allen, F., Qian, J., & Qian, M. (2005). Law, finance, and economic growth in China. *Journal of Financial Economics*, *77*(1), 57–116. doi: 10.1016/j.jfineco.2004.06.010.

Amit, R., Ding, Y., Villalonga, B., & Zhang, H. (2015). The role of institutional development in the prevalence and performance of entrepreneur and family-controlled firms. *Journal of Corporate Finance*, *31*(1), 284–305. doi: 10.1016/j.jcorpfin.2015.01.001.

Amore, M. D., Miller, D., Le Breton-Miller, I., & Corbetta, G. (2017). For love and money: Marital leadership in family firms. *Journal of Corporate Finance*, *46*, 461–476. doi: 10.1016/j.jcorpfin.2017.09.004.

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026

Amore, M. D., Pelucco, V., & Quarato, F. (2022). Family ownership during the COVID-19 pandemic. *Journal of Banking and Finance*, *135*, 106385. doi: 10.1016/j.jbankfin.2021.106385.

Anderson, R. C., & Reeb, D. M. (2003). Founding-family ownership and firm performance: Evidence from the S&P 500. *Journal of Finance*, *58*(3), 1301–1328. doi: 10.1111/1540-6261.00567.

Anderson, R. C., & Reeb, D. M. (2004). Board composition: Balancing family influence in S&P 500 firms. *Administrative Science Quarterly*, *49*(2), 209–237. doi: 10.2307/4131472.

Aronoff, C. E., & Astrachan, J. H. (1996). How to make better decisions. *Nation's Business*, *84*(1), 39.

Arregle, J. L., Hitt, M. A., & Mari, I. (2019). A missing link in family firms' internationalisation research: Family structures. *Journal of International Business Studies*, *50*(5), 809–825. doi: 10.1057/s41267-019-00213-z.

Attig, N., & Cleary, S. (2014). Organizational capital and investment-cash flow sensitivity: The effect of management quality practices. *Financial Management*, *43*(3), 473–504. doi: 10.1111/fima.12046.

Audretsch, D. B., Hülsbeck, M., & Lehmann, E. E. (2009). Families as active monitors of firm performance. *Journal of Family Business Strategy*, *4*(2), 118–130. doi: 10.1016/j.jfbs.2013.02.002.

Bammens, Y., Voordeckers, W., & Van, A. G. (2011). Boards of directors in family businesses: A literature review and research agenda. *International Journal of Management Reviews*, *13*(2), 134–152. doi: 10.1111/j.1468-2370.2010.00289.x.

Bartholomeusz, S., & Tanewski, G. (2006). The relationship between family firms and corporate governance. *Journal of Small Business Management*, *44*(2), 245–267. doi: 10.1111/j.1540-627x.2006.00166.x.

Basco, R., Campopiano, G., Calabrò, A., & Kraus, S. (2019). They are not all the same! Investigating the effect of executive versus non-executive family board members on firm performance. *Journal of Small Business Management*, *57*(S2), 637–657. doi: 10.1111/jsbm.12535.

Bauweraerts, J., & Colot, O. (2017). Exploring non-linear effects of family involvement in the board on entrepreneurial orientation. *Journal of Business Research*, *70*, 185–192. doi: 10.1016/j.jbusres.2016.08.020.

Bertrand, M., & Schoar, A. (2003). Managing with style: The effect of managers on firm policies. *Quarterly Journal of Economics*, *118*(4), 1169–1208. doi: 10.1162/003355303322552775.

Bessen, J. (2015). Toil and technology. *Finance and Development*, *52*(1), 16–19.

Bessen, J. (2019). Automation and jobs: When technology boosts employment. *Economic Policy*, *34*(100), 589–626. doi: 10.1093/epolic/eiaa001.

Bird, M., & Zellweger, T. (2018). Relational embeddedness and firm growth: Comparing spousal and sibling entrepreneurs. *Organization Science*, *29*(2), 264–283. doi: 10.1287/orsc.2017.1174.

Brown, J. R., Fazzari, S. M., & Petersen, B. C. (2009). Financing innovation and growth: Cash flow, external equity, and the 1990s R&D boom. *Journal of Finance*, *64*(1), 151–185. doi: 10.1111/j.1540-6261.2008.01431.x.

Burkart, M., Panunzi, F., & Shleifer, A. (2003). Family firms. *Journal of Finance*, *58*(5), 2167–2201. doi: 10.1111/1540-6261.00601.

Cao, F., Li, S., Dai, M., & Li, J. (2023). Your heart is where your treasure is: Family chairman and tax avoidance in family-controlled firms. *Journal of Business Research*, *154*, 113298. doi: 10.1016/j.jbusres.2022.09.003.

Chahine, S., & Goergen, M. (2013). The effects of management-board ties on IPO performance. *Journal of Corporate Finance*, *21*(C), 153–179. doi: 10.1016/j.jcorpfin.2013.02.001.

Chen, G., Chittoor, R., & Vissa, B. (2021). Does nepotism run in the family? CEO pay and pay-performance sensitivity in Indian family firms. *Strategic Management Journal*, *42*(7), 1326–1343. doi: 10.1002/smj.3263.

Cheng, H., Jia, R., Li, D., & Li, H. (2019). The rise of robots in China. *Journal of Economic Perspectives*, *33*(2), 71–88. doi: 10.1257/jep.33.2.71.

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026

Chrisman, J. J., & Patel, P. C. (2012). Variations in R&D investments of family and non-family firms: Behavioral agency and myopic loss aversion perspectives. *Academy of Management Journal*, *55*(4), 976–997. doi: 10.5465/amj.2011.0211.

Chua, J. H., Chrisman, J. J., Steier, L. P., & Rau, S. B. (2012). Sources of heterogeneity in family firms: An introduction. *Entrepreneurship Theory and Practice*, *36*(6SI), 1103–1113. doi: 10.1111/j.1540-6520.2012.00540.x.

Combs, J. G., Jaskiewicz, P., Ravi, R., & Walls, J. L. (2023). More bang for their buck: Why (and when) family firms better leverage corporate social responsibility. *Journal of Management*, *49*(2), 575–605. doi: 10.1177/01492063211066057.

De Massis, A., Ding, S., Kotlar, J., & Wu, Z. (2018). Family involvement and R&D expenses in the context of weak property rights protection: An examination of non-state-owned listed companies in China. *European Journal of Finance*, *24*(16), 1506–1527. doi: 10.1080/1351847x.2016.1200994.

Denis, D. K., & McConnell, J. J. (2003). International corporate governance. *Journal of Financial and Quantitative Analysis*, *38*, 1–36. doi: 10.2307/4126762.

Dong, Z., Wang, C., & Xie, F. (2010). Do executive stock options induce excessive risk taking?. *Journal of Banking and Finance*, *34*(10), 2518–2529. doi: 10.1016/j.jbankfin.2010.04.010.

Du, S., Ma, L., & Li, Z. (2022). Non-family shareholder governance and corporate risk-taking: Evidence from Chinese family-controlled businesses. *Journal of Business Research*, *145*, 156–170. doi: 10.1016/j.jbusres.2022.03.003.

Du, S., Ma, L., Li, Z., & Ma, C. (2024). Non-family shareholder governance and the digital transformation of family firms: Evidence from China. *Corporate Governance: An International Review*, *32*(1), 89–115. doi: 10.1111/corg.12517.

Dyer, W. G., Jr., & Dyer, W. J. (2009). Putting the family into family business research. *Family Business Review*, *22*(3), 216–219. doi: 10.1177/0894486509333042.

Fama, E. F., & Jensen, M. C. (1983). Separation of ownership and control. *Journal of Law and Economics*, *26*(2), 301–325. doi: 10.1086/467037.

Fan, H., Hu, Y., & Tang, L. (2021). Labour costs and the adoption of robots in China. *Journal of Economic Behavior and Organization*, *186*(6), 608–631. doi: 10.1016/j.jebo.2020.11.024.

Franks, J., Maye, C., Volpin, P., & Wagner, H. F. (2012). The life cycle of family ownership: International evidence. *Review of Financial Studies*, *25*(6), 1675–1712. doi: 10.1093/rfs/hhr135.

Furman, J., & Seamans, R. (2019). AI and the economy. *Innovation Policy and the Economy*, *19*(1), 161–191. doi: 10.1086/699936.

Gan, J., Liu, L., Qiao, G., & Zhang, Q. (2023). The role of robot adoption in green innovation: Evidence from China. *Economic Modelling*, *119*, 106128. doi: 10.1016/j.econmod.2022.106128.

Gaspar, J., Massa, M., & Matos, P. (2005). Shareholder investment horizons and the market for corporate control. *Journal of Financial Economics*, *76*(1), 135–165. doi: 10.1016/j.jfineco.2004.10.002.

Gersick, K. E., Davis, J. A., Hampton, M. C., & Lansberg, I. (1997). *Generation to generation: Life cycles of the family business*. Cambridge: Harvard Business School Press.

Gómez-Mejía, L. R., Neacsu, U., & Martin, G. (2019). CEO risk-taking and socioemotional wealth: The behavioral agency model, family control, and CEO option wealth. *Journal of Management*, *45*(4), 1713–1738. doi: 10.1177/0149206317723711.

González-Cruz, T., & Cruz-Ros, S. (2016). When does family involvement produce superior performance in SME family business?. *Journal of Business Research*, *69*(4), 1452–1457. doi: 10.1016/j.jbusres.2015.10.124.

Hadlock, C., & Pierce, J. (2010). New evidence on measuring financial constraints: Moving beyond the KZ index. *Review of Financial Studies*, *23*(5), 1909–1940. doi: 10.1093/rfs/hhq009.

Hayes, A. F. (2022). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*. New York: The Guilford Press.

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026

Hearn, B., Mohr, A., Kaur, J., & Khawar, M. (2023). Non-executive director influence on informational asymmetries in Caribbean offshore financial centers. *Corporate Governance: An International Review*, *31*(2), 349–369. doi: 10.1111/corg.12453.

Ho, J. L., & Kang, F. (2013). Auditor choice and audit fees in family firms: Evidence from the S&P 1500. *Auditing A Journal of Practice and Theory*, *32*(4), 71–93. doi: 10.2308/ajpt-50533.

Ho, J., Huang, C. J., & Karuna, C. (2020). Large shareholder ownership types and board governance. *Journal of Corporate Finance*, *65*, 101715. doi: 10.1016/j.jcorpfin.2020.101715.

Hsu, D. K., Wiklund, J., Anderson, S. E., & Coffey, B. S. (2016). Entrepreneurial exit intentions and the business-family interface. *Journal of Business Venturing*, *31*(6), 613–627. doi: 10.1016/j.jbusvent.2016.08.001.

Huang, H., Lee, E., Lyu, C., & Zhao, Y. (2020). Bequest motive, information transparency, and family firm value: A natural experiment. *Journal of Corporate Finance*, *65*, 101751. doi: 10.1016/j.jcorpfin.2020.101751.

Huson, M. R., Parrino, R., & Starks, L. T. (2001). Internal monitoring mechanisms and CEO turnover: A long-term perspective. *Journal of Finance*, *56*(6), 2265–2297. doi: 10.1111/0022-1082.00405.

Jennings, J. E., Dempsey, D., & James, A. E. (2018). Bifurcated HR practices in family firms: Insights from the normative-adaptive approach to step families. *Human Resource Management Review*, *28*(1), 68–82. doi: 10.1016/j.hrmr.2017.05.007.

Jiang, F., & Kim, K. A. (2015). Corporate governance in China: A modern perspective. *Journal of Corporate Finance*, *32*, 190–216. doi: 10.1016/j.jcorpfin.2014.10.010.

Jiang, F., & Kim, K. A. (2020). Corporate governance in China: A survey. *Review of Finance*, *24*(4), 733–772. doi: 10.1093/rof/rfaa012.

Jiang, F., Shi, W., & Zheng, X. (2020). Board chairs and R&D investment: Evidence from Chinese family-controlled firms. *Journal of Business Research*, *112*(6), 109–118. doi: 10.1016/j.jbusres.2020.02.026.

John, K., Litov, L., & Yeung, B. (2008). Corporate governance and risk-taking. *Journal of Finance*, *63*(4), 1679–1728. doi: 10.1111/j.1540-6261.2008.01372.x.

Kano, L., & Verbeke, A. (2018). Family firm internationalisation: Heritage assets and the impact of bifurcation bias. *Global Strategy Journal*, *8*(1), 158–183. doi: 10.1002/gsj.1186.

Kaplan, S. N., & Zingales, L. (1997). Do investment-cash flow sensitivities provide useful measures of financing constraints?. *Quarterly Journal of Economics*, *112*(1), 169–215. doi: 10.1162/003355397555163.

Katz, L. F., & Margo, R. A. (2013). Technical change and the relative demand for skilled labour: The United States in historical perspective. NBER Working Paper No.18752.

Koerniadi, H., Krishnamurti, C., & Tourani-Rad, A. (2014). Corporate governance and risk-taking in New Zealand. *Australian Journal of Management*, *39*(2), 1–19. doi: 10.1177/0312896213478332.

Kole, S. R. (1997). The complexity of compensation contracts. *Journal of Financial Economics*, *43*(1), 79–104. doi: 10.1016/s0304-405x(96)00888-4.

La Porta, R., Lopez-de-Silanes, F., & Shleifer, A. (1999). Corporate ownership around the world. *Journal of Finance*, *54*(2), 471–517. doi: 10.1111/0022-1082.00115.

Li, S. (2018). Increased non-family ownership in family-owned firms: How does it affect CEO turnover-performance sensitivity?. *Strategic Management Journal*, *39*(13), 3434–3457. doi: 10.1002/smj.2955.

Lin, C., Ma, Y., Malatesta, P., & Xuan, Y. (2012). Corporate ownership structure and bank loan syndicate structure. *Journal of Financial Economics*, *104*(1), 1–22. doi: 10.1016/j.jfineco.2011.10.006.

Lumpkin, G. T., & Brigham, K. H. (2011). Long-term orientation and intertemporal choice in family firms. *Entrepreneurship Theory and Practice*, *35*(6), 1149–1169. doi: 10.1111/j.1540-6520.2011.00495.x.

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026

Majocchi, A., D'Angelo, A., Forlani, E., & Buck, T. (2018). Bifurcation bias and exporting: Can foreign work experience be an answer? Insight from European family SMEs. *Journal of World Business*, *53*(2), 237–247. doi: 10.1016/j.jwb.2017.11.005.

Masulis, R. W., Wang, C., & Xie, F. (2020). Employee-manager alliances and shareholder returns from acquisitions. *Journal of Financial and Quantitative Analysis*, *55*(2), 473–516. doi: 10.1017/s0022109019000036.

Miller, D., & Le Breton-Miller, I. (2014). Deconstructing socioemotional wealth. *Entrepreneurship Theory and Practice*, *38*(4), 713–720. doi: 10.1111/etap.12111.

Mira, S., Goergen, M., & O'Sullivan, N. (2019). The market for non-executive directors: Does acquisition performance influence future board seats?: The market for non-executive directors. *British Journal of Management*, *30*(2), 415–436. doi: 10.1111/1467-8551.12290.

Nordqvist, M., Sharma, P., & Chirico, F. (2014). Family firm heterogeneity and governance: A configuration approach. *Journal of Small Business Management*, *52*(2), 192–209. doi: 10.1111/jsbm.12096.

Oster, E. (2019). Unobservable selection and coefficient stability: Theory and evidence. *Journal of Business and Economic Statistics*, *37*(2), 187–204. doi: 10.1080/07350015.2016.1227711.

PricewaterhouseCoopers (2021). Global family business survey 2021: China report. Available from: https://www.pwccn.com/en/services/entrepreneurialand-private-business/private-family-business-services/global-familybusiness-survey-2021.html

Saito, T. (2008). Family firms and firm performance: Evidence from Japan. *Journal of the Japanese and International Economies*, *22*(4), 620–646. doi: 10.1016/j.jjie.2008.06.001.

Schmid, T., Achleitner, A. K., Ampenberger, M., & Kaserer, C. (2014). Family firms and R&D behaviour: Evidence from a large-scale survey. *Research Policy*, *43*(1), 233–244. doi: 10.1016/j.respol.2013.08.006.

Sharma, P., Salvato, C., & Reay, T. (2014). Temporal dimensions of family enterprise research. *Family Business Review*, *27*(1), 10–19. doi: 10.1177/0894486513516058.

Shivdasani, A., Zimmerman, J. L., Kothari, S. P., Lys, T. Z., & Watts, R. L. (1993). Board composition, ownership structure, and hostile takeovers. *Journal of Accounting and Economics*, *16*(1-3), 167–198. doi: 10.1016/0165-4101(93)90009-5.

Shleifer, A., & Vishny, R. W. (1997). A survey of corporate governance. *Journal of Finance*, *52*(2), 737–783. doi: 10.2307/2329497.

Vandebeek, A., Voordeckers, W., Lambrechts, F., & Huybrechts, J. (2016). Board role performance and faultlines in family firms: The moderating role of formal board evaluation. *Journal of Family Business Strategy*, *7*(4), 249–259. doi: 10.1016/j.jfbs.2016.10.002.

Vandemaele, S., & Vancauteren, M. (2015). Nonfinancial goals, governance, and dividend payout in private family firms. *Journal of Small Business Management*, *53*(1), 166–182. doi: 10.1111/jsbm.12063.

Verbeke, A., & Kano, L. (2012). The transaction cost economics theory of the family firm: Family-based human asset specificity and the bifurcation bias. *Entrepreneurship Theory and Practice*, *36*(6), 1183–1205. doi: 10.1111/j.1540-6520.2012.00545.x.

Villalonga, B., & Amit, R. (2009). How are U.S. family firms controlled?. *Review of Financial Studies*, *22*(8), 3047–3091. doi: 10.1093/rfs/hhn080.

Villalonga, B., & Amit, R. (2010). Family control of firms and industries. *Financial Management*, *39*(3), 863–904. doi: 10.1111/j.1755-053x.2010.01098.x.

Voordeckers, W., Van Gils, A., & Van den Heuvel, J. (2007). Board composition in small and medium-sized family firms. *Journal of Small Business Management*, *45*(1), 137–156. doi: 10.1111/j.1540-627x.2007.00204.x.

Wang, H., Liao, L., & Wu, J. (2023). Robot adoption and firm's capacity utilization: Evidence from China. *Pacific-Basin Finance Journal*, *82*, 102196. doi: 10.1016/j.pacfin.2023.102196.

Wang, L., Zhou, Y., & Chiao, B. (2023). Robots and firm innovation: Evidence from Chinese manufacturing. *Journal of Business Research*, *162*, 113878. doi: 10.1016/j.jbusres.2023.113878.

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026

Wilson, N., Wright, M., & Scholes, L. (2013). Family business survival and the role of boards. *Entrepreneurship Theory and Practice*, *37*(6), 1369–1389. doi: 10.1111/etap.12071.

Zhong, H., Zhang, X., Chan, K. C., & Yan, C. (2023), Industrial robots and firm innovation: Big data evidence from China, *Journal of Accounting Literature*, ahead-of-print (ahead-of-print). doi: 10.1108/JAL-06-2023-0098

Zhou, Z., Li, Z., Du, S., & Cao, J. (2024). Robot adoption and enterprise R&D manipulation: Evidence from China. *Technological Forecasting and Social Change*, *200*, 123134. doi: 10.1016/j.techfore.2023.123134.

Appendix

Table A1. Variable definitions

Variable	Detailed definition
Robot	The logarithm of the sum of robot penetration at the enterprise level and one
Fned	The ratio of the number of family non-executive directors to the number of the board of directors
Size	The logarithm of total assets
Lev	The ratio of debt to assets
Growth	The growth rate of sales revenue
Age	The logarithm of the firms listing years plus 1
ROA	Return on assets
Board	The logarithm of the number of directors
Indep	The proportion of independent directors
Dual	If the chairman and the CEO are the same person, the score is one, and the score is zero otherwise
Mshare	The ratio of managerial ownership
FM	The proportion of family members as directors, supervisors and executives
Child	If the descendants of the family participate in the management, the score is one, and the score is zero otherwise
HT	If the family firm belongs to the high-tech industry, the score is one, and the score is zero otherwise
Law	China marketisation index
Cashflow	The ratio of liquid assets to the book value of total assets net of liquid assets
Marriage	The natural logarithm difference between the number of registered marriages and the number of divorce cases per 10,000 people in the region
Archway	The number of archways in the Ming and Qing Dynasties in various provinces and regions of China
RiskT	The annual volatility of monthly stock returns
FO	The shareholding ratio of the controlling family
FP	the average return on total assets of enterprises in the next two years

Source(s): Table by authors

About the authors

Shanzhong Du is Assistant Professor at the International School of Business and Finance and Advanced Institute of Finance, Sun Yat-sen University. His research focuses on corporate governance and family firms. Shanzhong Du is the corresponding author and can be contacted at: dushzh@mail.sysu.edu.cn

June Cao is Assistant Professor at the School of Accounting, Economics and Finance, Curtin University. Her research focuses on corporate governance and corporate finance.

For instructions on how to order reprints of this article, please visit our website:
www.emeraldgrouppublishing.com/licensing/reprints.htm
Or contact us for further details: **permissions@emeraldinsight.com**

Downloaded from http://ftp.nowpublishers.com/cafr/article-pdf/26/4/533/9601486/cafr-08-2023-0089.pdf by guest on 27 May 2026