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The Impact of Government Subsidies on Green Innovation in Family Firms - Evidence from Chinese Family Firms

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Abstract

Family firms are an important part of the world economy, but the R&D investment of Chinese family firms is generally insufficient. Research Objective: To explore the influencing factors of green innovation in family firms. Research Method: Based on the collected data related to Chinese listed family firms from 2008-2021, empirical regression was conducted to analyse the impact of government subsidies on substantive and strategic green innovation of family firms; considering economic policy uncertainty and family involvement, its moderating role in the above impacts was further analysed. Findings: Government subsidies promote both substantive and strategic green innovation in family firms, and the mediation effect test finds that government subsidies promote substantive and strategic green innovation in family firms by increasing R&D investment in family firms; further research finds that both economic policy uncertainty and family involvement negatively moderate the relationship between government subsidies and substantive and strategic green innovation in family firms. Further, it is found that both economic policy uncertainty and family involvement negatively moderate the relationship between government grants and family firms' substantive and strategic green innovation. Conclusion: The government can provide more R&D subsidies for family firms or alleviate the financing constraints of family firms, and ensure the consistency and stability of the policy to a certain extent, and the degree of family involvement in family firms needs to be reduced, and the gradual separation of the ownership and management rights should be carried out.

Keywords

Family firm, Government subsidy, Substantive green innovation, Strategic Green Innovation, EPU, Family involvement.

1. INTRODUCTION

Family enterprises, widely spread across the globe, represent the most ancient and prevalent form of economic organization. They account for up to 90% of all business entities and contribute over 70% to the world's gross domestic product[1], thereby constituting a significant component of the global economy. Family firms are usually relatively conservative, with a high level of organizational commitment to traditional products and a tendency to be risk-averse, and their familial nature makes them more concerned with non-economic goals, blessing the neighborhood and the community with a symbiotic development philosophy. However, research indicates that family corporations have historically invested less in research

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and development (R&D) compared to non-family corporations, and this gap has been gradually widening. Academics widely agree on the lower R&D investment of family corporations relative to their non-family counterparts[2]. The " Science and Technology Support for Carbon Peak Achievement and Carbon Neutrality Implementation Programme (2022-2030)" proposes to strengthen the development of fundamental, disruptive, and original green and low-carbon technologies, thereby reinforcing the support of science and technology for the "dual-carbon" goal. This plan underscores the need to strengthen the development of fundamental, disruptive, and original green and low-carbon technologies, thereby enhancing the role of science and technology in supporting the "dual-carbon" goal. As key actors in achieving this objective, corporations must rely on the leadership of green innovation[3]. Green innovation plays a crucial role in China's sustainable development strategy, particularly in the context of family corporations. It significantly contributes to their sustainable growth and has far-reaching implications for corporate performance[4].

Green innovation encompasses the introduction of a novel or enhanced technologies, techniques, or processes aimed at reducing energy consumption and pollution, thereby facilitating environmental improvement and fostering a harmonious coexistence between humans and nature[5]. Green innovations can specifically be divided into two types: green new utility innovations and green invention innovations. Specifically, green innovation is divided into green new utility innovation and green invention innovation, which, since green new utility innovation does not have a sufficient competitive advantage, it is a kind of strategic behavior and is also known as strategic green innovation, such as the manufacturing enterprise adopts environmentally friendly materials instead of traditional materials, to improve the green sustainability of the product; and green invention innovation can increase the enterprise's market value to promote the development of the enterprise Green invention innovation is a strategic behavior, which is also known as substantive green innovation, e.g. a manufacturing company develops a new solar energy collection and storage system. Existing research into the relationship between green innovation to firm performance largely supports the view that there is a positive impact of green innovation on firm performance[6]. Notably, there is a significant positive effect of green innovation on a company's customer, technological, and financial advantages [7]. Moreover, it has been established that green innovation promotes firm performance [8], and its significance has generally been acknowledged. In this context, while pursuing their development, family businesses need to consider the ways to achieve a proper equilibrium between green development, resource conservation, and preservation of the environment. This balance is critical to facilitate the green shift of family businesses, fulfill their environmental responsibilities, and complement China's low-carbon development strategy.

However, the fact that companies have to pay all the costs of green innovation but do not get all the rewards reduces their incentive to innovate green without policy support [9]. Furthermore, green innovation typically necessitates substantial and sustained capital investment[10]. External factors, such as government interventions, significantly influence firms, with subsidies being an indicator of the government's support for corporate research and development (R&D). Despite extensive research on the relationship that exists between government subsidies and business innovation, in the context of the Chinese government's industrial subsidies to emerging industries, the effect of government innovation subsidies on the output performance of individual firms has been found to be limited [11]. Additionally, government grants for research and development (R&D) tend to be temporary rather than permanent, which affects the long-term sustainability of enterprise innovation[12]. Scholars have explored the influence on corporate innovation of government subsidies from different viewpoints, including risk-taking levels, quality and quantity considerations, enterprise scale, and product market competition. It was discovered that government subsidies show a "U" type effect on enterprise innovation[13]; [14], [15]. Yet, the current literature about the relationship

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between government subsidies and green innovation is insufficient and there is no consensus among scholars. Due to the complexity of the industry, government subsidies may provide incentives for green innovation [16]. Some researchers have observed an inverted "U"-shaped relationship between government subsidies and the performance of substantial green innovation in listed companies, particularly in the case of heavily polluted companies[17].

In addition to the aforementioned connection of government grants to green innovation, economic policy uncertainty, which is also an external variable affecting family enterprises, along with government grants, plays an important role in influencing green innovation among family firms. After the three-year epidemic, China's economy has been facing challenges, leading the government to introduce policies aimed at stimulating economic growth. In theory, these government policies are expected to facilitate resource allocation in the market and promote economic development. However, in practice, the implementation of policies and the increasing uncertainty surrounding economic policies create a higher probability of non-compliance for companies[18]. This also generates policy risks as family firms struggle to accurately predict potential adjustments to current economic policies [19]. Research has demonstrated that economic policy uncertainty can have a negative impact on investment, employment, and productivity [20]. On a macro level, economic policy uncertainty reduces bank liquidity creation and increases the national savings rate[21]. This, in turn, affects bank lending and the nation's willingness to consume, which influences business growth. Existing studies about economic policy uncertainty's impact on firms have reached inconsistent conclusions. Some argue that economic policy uncertainty inhibits firms' investment behavior, taking into account factors like financing constraints and real options[22]. However, economic policy uncertainty has its specificity in influencing business decisions through the uncertainty of the external environment. Government policies themselves also have a certain guiding effect on business behavior. Higher economic policy uncertainty makes the external environment riskier for firms, leading investors to be more cautious and discouraging riskier investments[23]. Banks also become more cautious under higher economic policy uncertainty, resulting in higher costs for corporate lending[24]. Under these circumstances, firms are more likely to adopt risk-averse strategies, which inhibit investment in innovation[25]. Business innovation, like other investment activities, involves adjustment costs and requires continuous inputs[26]. Increased uncertainty can lead to higher uncertainty about future product prices, which, in turn, affects the profitability of future markets[27] [28]

In addition to the above two variables of government subsidies and economic policy uncertainty, the green innovation of family firms will also be affected by their internal factors, and at the same time, due to the characteristics of family firms in terms of asset concentration, family control, and family-centered non-economic goals, family firms should be studied in depth in comparison with the general private enterprises. The family's socio-emotional wealth, as an important feature that distinguishes family firms from non-family firms, will have a certain impact on family firms' willingness to innovate. Family involvement is a prerequisite for socio-emotional wealth, and it gives the family legitimacy to shape the firm's goals, strategies, and behaviors. The higher the degree of family involvement, the greater the influence of the family on the strategic decisions of the enterprise, the stronger the sense of identity and attachment of family members to the enterprise, and thus the stronger the ability and willingness to protect the family's socio-emotional wealth; on the contrary, with a low degree of family involvement, the family's emotional and relational aspects will be weakened in comparison with the family enterprise with a high degree of family involvement, and thus the willingness to protect the socio-emotional wealth will be reduced. As the level of family involvement increases, the more likely it is that the family will be risk-averse and thus less inclined to innovate to preserve the family's existing interests. Although some scholars have argued that family owners may carry out innovative projects with a long-term orientation for the benefit of future generations in the

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interest of family inheritance, there are factors of a long return cycle and high uncertainty in innovation, which will jeopardize the current status and interests of the family business, or even the survival of the family business in the event of a mistake. Therefore, to avoid investment losses and maintain existing interests, family business owners try to avoid the risks associated with investment in innovation, even though innovation can bring higher returns in the long run.

Based on the above literature and theories, government subsidies and economic policy uncertainty, as external variables of family firms, and family involvement, as an important characteristic of family firms and an internal influencing factor, all have an impact on the green innovation of family firms. To fill the gap in the above literature, this paper will focus on the following two questions: is there a difference in the impact of government subsidies on strategic and substantive green innovation in family firms? How do family firms' external economic policy uncertainty and internal family involvement affect the relationship between government grants and family firms' strategic and substantive green innovation? In order to solve the above problems, a specific theoretical framework is established: government subsidies as an external factor affect the R&D investment and green innovation capacity of family firms, the relationship between government subsidies and substantive and strategic green innovation of family firms is analysed through empirical regression to explore the relationship of government subsidies on green innovation of family firms, and the use of R&D investment as a mediator variable verifies that government We use R&D investment as a mediating variable to verify that government subsidies promote green innovation of family firms by increasing their R&D investment; economic policy uncertainty as an external variable affects the green innovation ability of family firms, and we analyse the moderating effect of economic policy uncertainty on the green innovation of family firms, i.e., the higher the degree of economic policy uncertainty, the more the impact of government subsidies is strengthened or weakened; considering the impact of family involvement on the business decisions of family firms, we analyse the impact of the degree of family involvement on the business decisions of family firms. The moderating effect of family involvement on the relationship between government subsidies and substantive and strategic green innovation in family firms is examined, i.e., the higher the degree of family involvement, the stronger or weaker the effect of government subsidies on green innovation capability; the relationship between green innovation and performance in family firms is added to the exploration of the relationship between green innovation and performance in family firms. enterprise performance, analyze the impact of green innovation on Tobin's q value of enterprises, and further explore the relevance of green innovation on the performance of family enterprises.

In short, the possible marginal contributions of this paper lie in the following parts: firstly, previous studies on the relationship between government subsidies and corporate green innovation have not been detailed to family firms, and by studying family firms, the relevant theories can be enriched; secondly, economic policy uncertainty, as an external environmental variable, affects aspects such as corporate decision-making, and previous studies are very enriching but there is no relevant literature on its moderating effect on the relationship between government subsidies and There is no relevant literature about its moderating effect on the relationship between government grants and green innovation in family firms, and economic policy uncertainty is mostly due to government policies. Finally, family involvement, as a sign and internal influence that distinguishes family firms from other firms, is also worth exploring further in terms of its effect on the relationship between government grants and green innovation; therefore, conducting relevant research not only enriches the theory related to economic policy uncertainty and family involvement but also provides an opportunity for government grants to be used as a tool for the development of green innovation in family firms. Therefore, conducting relevant research can not only enrich the theory of economic policy

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uncertainty and family involvement but also provide a coherent relationship between government subsidies to firms and policy considerations.

2. CONCEPTUAL FRAMEWORK AND RESEARCH HYPOTHESES

2.1. Government subsidies and green innovation in family firms

According to the motivation for green innovation in firms, green innovation in family firms is divided into two categories: substantive green innovation and strategic green innovation. Substantive green innovation refers to high-quality innovation aimed at promoting technological progress, market advantage, and corporate social responsibility for environmental protection. It often leads to transformative innovations in existing technologies, requiring significant resource investment and carrying greater risks and uncertainties. On the other hand, strategic green innovation refers to innovation that primarily caters to government policies and focuses on "speed" and "quantity" for the sake of other benefits. It typically involves advances in existing technologies and is driven by short-term benefits or policy compliance. Therefore, this paper analyzes the impact of government grants on green innovation in family firms, considering factors such as family profit maximization and socio-emotional wealth.

Government subsidies and strategic green innovation: Strategic green innovation may not provide significant technological progress, making it challenging for firms to gain a competitive advantage in the market. Consequently, firms often resort to strategic green innovation as a means to comply with government policies. Government subsidies, in this context, serve as a tool for the government to promote research and development (R&D) in firms. Family enterprises, in particular, tend to engage in green innovation activities to align with the government grants they receive. Furthermore, the information asymmetry between family firms and the government, resulting from the confidentiality of firms' R&D projects, can lead to a reverse behavior where family firms seek subsidies without actively pursuing green innovations to improve their technologies. Instead, they engage in strategic green innovations to signal their compliance with government requirements and secure present or future grants.

Based on the above, this hypothesis is proposed in this paper as follows:

H1: Government subsidies can promote strategic green innovation in family businesses.

Government subsidies and substantive green innovation: Government grants have a direct impact on firms by providing incremental cash flow. This additional cash flow compensates, to some extent, for market distortions in the allocation of innovation resources. Government subsidies are non-reciprocal transactions characterized by gratuitousness, which incentivizes enterprises to invest in R&D. Substantive green innovation can provide technological advantages to family businesses, leading to competitive advantages and increased profits. However, due to the delayed benefits, inherent risks, and uncertain investment cycles associated with substantive green innovation, significant financial investment is often required. Family firms, with their limited access to external resources and financing constraints, face challenges in obtaining the necessary funding[29]. Excessive investment in R&D can also crowd out other business activities of the company. In this context, Government grants perform a crucial job in reducing the financial burden of R&D activities. They provide external support and reflect the government's commitment to corporate R&D. Consequently, family firms are incentivized to invest in R&D for substantive green innovations.

Based on the above, this hypothesis is proposed in this paper as follows:

H2: Government grants can promote substantive green innovation in family businesses.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202501_11(1).0008

2.2. Moderating effects of economic policy uncertainty

Economic policy uncertainty means that microeconomic agents cannot accurately predict when and how the current economic policy will be changed by the government. General economic policy uncertainty is gauged by the Economic Policy Uncertainty Index constructed by Baker[30]. The process of innovation expansion by firms involves investing pre-existing tangible assets into intangible assets. While increased economic policy uncertainty can discourage firms from investing in physical capital, it may also redirect some of the planned capital for physical goods towards innovation. However, family companies differ from general private companies as their investment in green innovation also considers factors such as the family's socio-emotional wealth alongside profit maximization. Therefore, Further analysis is needed to understand how economic policy uncertainty affects how government subsidies relate to green innovation in family firms.

From the viewpoint of signaling in government grant certification, the policy conditions attached to government grants indicate that firms are eligible to apply for such grants only if they comply with the provisions of the government grants policy. Additionally, the conditions of use attached to government subsidies require enterprises to use the funds in accordance with the purposes stipulated in the relevant government documents. Through due diligence on business operations and R&D activities, the government identifies companies that meet the eligibility criteria [12]. Strategic green innovation does not entail significant technological advancements, and enterprises find it challenging to achieve substantial technological advantages from such innovation to improve market competitiveness. Based on the resource dependence theory, formulation, and investment decisions are largely constrained by resource providers. When economic policy uncertainty increases, strategic green innovations carried out by family firms may fail to meet government policy requirements as they lack substantial progressiveness. Consequently, government subsidies may be limited, and family firms, faced with increased economic policy uncertainty, have a greater likelihood of investing their limited resources in production and operations.

Based on the above, this hypothesis is proposed in this paper as follows:

H3: Economic policy uncertainty negatively moderates the relationship between government grants and strategic green innovation in family firms.

Increased economic policy uncertainty exposes family businesses to higher risks in the external environment, leading to uncertain investment returns. Analyzing from the perspective of technological innovation diffusion, the successful application of substantive green innovations by family firms in the market environment faces imitation from competitors[31]. Consequently, the profits from their own substantive green innovations, developed at a higher cost, may be shared by other firms, undermining family businesses' incentives to innovate. Family businesses tend to adopt a conservative investment approach in the face of risk. Additionally, due to the need to preserve "socio-emotional wealth" specific to family businesses, the prevailing view suggests that family firms are disinclined to invest in innovation or engage in risky innovation activities[2]. As economic policy uncertainty increases, so does product market uncertainty, making it more challenging to anticipate future developments [32]. Considering "socio-emotional wealth," family businesses may view investments in substantive green innovations, which are inherently more uncertain, as potentially affecting the family's reputation in the business when market conditions change in the future. To preserve the family legacy, family enterprises may choose to allocate more of their government subsidies to productive business operations rather than riskier substantive green innovations when economic policy uncertainty is heightened.

Based on the above, this hypothesis is proposed in this paper as follows:

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202501_11(1).0008

H4: Economic policy uncertainty negatively moderates the relationship between government grants and substantive green innovation in family firms.

2.3. Moderating effects of family involvement

Socio-emotional wealth, an important characteristic of family firms that distinguishes them from non-family firms, and family involvement, which is a prerequisite for their socio-emotional wealth, have an impact on the willingness of family firms to invest in riskier green innovations. Family involvement gives the family legitimacy to shape the firm's goals, strategies, and behaviors. As the level of family involvement increases, so does the family's influence on the decision-making aspects of the firm. Therefore, when it comes to riskier green innovations, whether for the purpose of preserving the existing or for the sake of family heritage, as family involvement increases, it will be more inclined to preserve the family's existing wealth and status, and thus make risk-avoiding decisions that are not conducive to green innovations in the family firm.

For strategic green innovation, for family firms, the higher the level of family involvement, the greater the family's control over the firm, and the concentration of power may lead to problems of opaque internal information and weak corporate governance. As the family's control over the firm increases, it means that more rights within the firm belong to family members, and the more likely it is that the family will have complete control over the firm. Due to the natural sense of kinship and attachment between family members, the higher the degree of family involvement, the more likely to lead to the family business in order to maintain control of the family only to let their relatives take important positions, and then miss the key positions needed professional and technical personnel. Based on the resource base theory, the purpose of family involvement is to strengthen the control of the family business, which will not only lead to a lack of actual capital investment but also encroach on the external resources needed by the family business green innovation, which will lead to an imbalance in resource allocation. Even if family firms take advantage of the information gap through the asymmetric relationship between the enterprise and the government to seek subsidies through strategic green innovation, the cost of "disguising" family firms through rent-seeking and "disguising" behaviors will also increase.

Based on the above, this hypothesis is proposed in this paper as follows:

H5: Family involvement negatively moderates the relationship between government subsidies and strategic green innovation in family firms.

Substantial green innovation, at the same time, the purpose of the government to give subsidies to the family business is that the government hopes that the family business on behalf of their own to achieve some long-term, can bring practical environmental protection innovation projects, while the primary purpose of the family business is to their own survival, the government and the family business is not the same goal. As the degree of family involvement increases, family enterprises will be more inclined to achieve their own survival goals rather than the goals of the government, which will also lead to the incentive for family enterprises to "divert" government subsidies. Substantial green innovation requires a large amount of capital, time, and personnel investment, and has a high risk of failure, with the increase in the degree of family involvement, the family will be more inclined to avoid the risk of substantial innovation problems, at the same time, the nepotism of the family members involved in the nepotism and narrow familyism will also hinder the development of the family business, and it is easier to link the interests of the enterprise and the family to form a synergistic effect of the interests of the family. In order to better safeguard the family's existing interests, family members are likely to be reluctant to sacrifice the immediate interests of the family business for substantial green innovation inputs, or even to misappropriate government subsidies.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202501_11(1).0008

Based on the above, this hypothesis is proposed in this paper as follows:

H6: The degree of family involvement negatively moderates the relationship between government grants and substantive green innovation in family firms.

3. DATA AND METHODOLOGY

3.1. Data sources

Due to the implementation of new accounting standards since 2007, this paper selects the panel data of A-share-listed family firms from 2008 to 2021 for the study. The number of green patent applications in the data is from CNRDS, the economic policy uncertainty indicator is from the economic policy uncertainty website, and all others are from the CSMAR database. After data integration, the sample data of ST, *ST (risky enterprises), and family enterprises not of this type (family enterprises in which at least 1 family member with relatives other than the actual controller holds shares/manages/controls the listed company or the controlling shareholder company, and when the relative only holds shares/acts as the director and supervisor in the controlling shareholder unit, the actual controller of the controlling shareholder unit needs to be the actual controller of the listed company at the same time) are excluded, and finally the sample data of the listed company is formed. person) of the sample data, resulting in 7,276 sample data.

3.2. Model setup and variable descriptions

The following model was developed to test the above hypothesis:

$$GNi,t = \partial_0\, LNSUBi,t + \partial_1 Contral + \sum DMi,t + \sum Yeari,t + \varepsilon i,t \quad (1)$$

$$GIi,t = \beta_0 LNSUBi,t + \beta_1 Contral + \sum DMi,t + \sum Yeari,t + \varepsilon i,t \quad (2)$$

$$GNi,t = \gamma_0 LNSUBi,t + \gamma_1 EPUi + \gamma_2 LNSUB * EPU + \gamma_3 Contral + \sum DMi,t + \sum Yeari,t + \varepsilon i,t \quad (3)$$

$$GIi,t = \lambda_0 LNSUBi,t + \lambda_1 EPUi + \lambda_2 LNSUB * EPU + \lambda_3 Contral + \sum DMi,t + \sum Yeari,t + \varepsilon i,t \quad (4)$$

$$GNi,t = \mu_0 LNSUBi,t + \mu_1 \mathrm{FM}i,t + \mu_2 LNSUB * FM + \mu_3 Contral + \sum DMi,t + \sum Yeari,t + \varepsilon i,t \quad (5)$$

$$GIi,t = \theta_0 LNSUBi,t + \theta_1 \mathrm{FM}i,t + \theta_2 LNSUB * FM + \theta_3 Contral + \sum DMi,t + \sum Yeari,t + \varepsilon i,t \quad (6)$$

Where model (1) (2) is to test hypotheses H1 and H2, model (3) (4) is to test hypotheses H3 and H4, and model (5) (6) is to test hypotheses H5 and H6.

In the model: "i" is the ID of the listed company, "t" is the year, DM is the industry classification, and controls are the control variables. The specific measurements of the indicators are located in Table 1. (The tables are all placed at the end of the article.)

Explained variables: GN and GI, “t” is the green innovation of family firm “i” in year “t”. Substantive green innovation and strategic green innovation. According to the definition of green patents in the United Nations Framework Convention on Climate Change, the number of green new utility patents applied by family firms is used as an indicator of strategic green innovation of family firms, and the number of green invention patents applied is used as an indicator of substantive innovation of family firms, and the number of green patents applied is processed by taking the logarithm of the number of green patents applied after adding 1 to the number of green patents.

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Table 1. Definitions of relevant variables

Typology	variable	Symbol	Definition
explanatory variable	Strategic Green Innovation	GN	Ln (1+ Number of green new type utility patent applications in the year)
	Substantive Green Innovation	GI	Ln (1+ Number of patent applications for green inventions in the year)
explanatory variable	Government Subsidies	LNSUB	Logarithm of the amount of government subsidies received during the year
moderator variable	Economic policy uncertainty	EPU	Annual arithmetic mean of economic policy uncertainty index/100
	Level of family involvement	FM	Percentage of family members among family business executives
control variable	Firm size	LNSIZE	Logarithmic total assets
	Divergence rate between two rights	TW	Proportion of ownership/control by beneficial owners
	Equity Checks and Balances	BA	The total proportion of ownership of the 2nd-5th largest shareholders /proportion of ownership of the first largest shareholder.
	Gearing ratio	Asslib	Total Assets/Total Liabilities
	Tobin's Q	TBQ	Market capitalization / total assets
	Return on Total Assets	Total	(net profit/average total assets) x 100%
	Return on invested capital	Return	(Net Income + Finance Costs) / (Total Assets - Current Liabilities + Notes Payable + Short-term Borrowings + Long-term Liabilities Due Within One Year)
	Revenue Growth Rate	Operating	(Amount of operating income current single quarter - Amount of operating income previous single quarter) / (Amount of operating income previous single quarter)
Dummy Variables	Industry	DM	Industry dummy variables
	Year	Year	Time dummy variable

Explanatory variable: LNSUB denotes government grants received by family firms during the year, which includes all government grants received during the year in the financial statements of listed family firms.

Moderator variable: EPU denotes economic policy uncertainty, which is compiled as an indicator of economic policy uncertainty based on Baker's proposal to search for the terms "economy", "policy", "uncertainty" and other related terms in mainstream media newspapers[33]. And other related terms in mainstream media newspapers were used to compile an indicator of economic policy uncertainty. In this paper, the arithmetic average method is used to transform China's monthly EPU index into annual data, which is obtained from the website of Economic Policy Uncertainty. An increase in economic policy uncertainty leads to an increase in the external risk of family firms, which affects the investment decisions of family firms, including green innovation, etc.; LNSUB*EPU is the cross term of economic policy uncertainty and government subsidy intensity, which is used as a test indicator to examine the moderating effect of economic policy uncertainty on the government subsidy and green innovation of family firms.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202501_11(1).0008

FM represents the percentage of family members' executives, which is used to reflect the degree of family involvement in family businesses, according to the database from Cathay Pacific. The higher the degree of family involvement, the stronger the familial nature of the family business, in order to maintain the existing interests of the family, which may lead to the avoidance of higher-risk green innovations; LNSUB * FM is the cross term between the degree of family executive involvement and the intensity of government subsidies, which will be used as a test indicator to examine the moderating effect of the degree of family involvement on the government subsidies and the degree of family involvement.

Control variables: the green innovation of family firms is affected by many factors, in order to explore the factors that may have an impact, the size of the enterprise, equity concentration, the rate of deviation of the two rights, the degree of equity checks and balances, the balance sheet ratio, the Tobin's Q value, the return on invested capital and the growth rate of operating income are used as control variables.

LNSIZE denotes the size of the firm, in general, large family firms are more likely to have more capital, technology, and R&D capabilities. OS denotes the concentration of shareholding, shareholding structure is an important issue in modern corporate governance, concentrated shareholding can reflect the will of the majority shareholders, which affects the willingness of family firms to innovate in a green way.TW denotes the two-way divergence ratio, a higher two-way divergence ratio means that the ownership of the family business and control gap is large, which may lead to principal-agent problems, but it is also possible that good business people can avoid the short-sightedness caused by family control.BA denotes the balance of equity, a higher degree of balance of equity allows for more democratic and transparent decision-making, which provides a better supportive environment for green innovation. “Asslib” denotes the gearing ratio, a lower gearing ratio implies that the firm has a better TBQ is Tobin's Q. Tobin's Q reflects the market's expectation of the firm's future profitability, so the higher the Tobin's Q, the more likely the family firm is to engage in green innovation. return is the return on invested capital. higher return on invested capital means that family firms are better able to obtain economic returns, which also provides family firms with more resources for green innovation. Operating is the growth rate of operating income, a higher growth rate of operating income indicates that the firm has achieved good results in the market, which also provides the family firm with more market opportunities for green innovation.

Dummy variables: ϵ DM denotes industry classification and is used for industry fixed effects. year denotes year and is used for year fixed effects.

ϵit denotes random error.

3.3. Descriptive statistics

Table 2. Descriptive statistics

Variable	Mean	p50	SD	Min	Max
GN	0.227	0	0.571	0	5.050
GI	0.104	0	0.381	0	5.412
LNSUB	15.35	15.59	1.834	5.598	21.04
EPU	3.037	2.444	2.083	0.989	7.919
OS	56.76	57.99	14.51	10.64	94.65
LNSIZE	21.68	21.55	1.026	18.19	27.01
Asslib	0.356	0.337	0.192	0.00800	1.748
Total	0.0630	0.0620	0.0730	-1.445	0.666
Return	0.0620	0.0640	0.0960	-2.538	0.662
TBQ	2.704	2.063	2.321	0.117	56.06
Operating	0.520	0.133	10.23	-11.68	865.9
BA	0.802	0.640	0.615	0.00500	4
FM	0.174	0.167	0.160	0	1

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Table 2 shows the descriptive statistics of the dependent, independent, moderating, and control variables. As can be seen from Table 2, both the strategic and substantive green innovation measures of family firms, of which the median is 0, the mean is 0.227 and 0.104, respectively, and the variance is 0.571 and 0.381, respectively, suggesting that the level of green innovation in family firms is generally low; the government subsidy measure has a mean of 15.23 and a variance of 1.926, considering that the Government grants are treated in logarithmic terms, so there is a large gap between government grants; the mean value of economic policy uncertainty is 0.946, and the variance is 2.147, indicating that there are relatively large changes in economic policy uncertainty over the years; in terms of family involvement, the mean value of the proportion of family members among executives is 0.174, the median is 0.167, and the variance is 1.6, with the minimum value being 0 and the maximum value 1, indicating that there is a large gap between the degree of family involvement in different There is a certain difference between the degree of family involvement in family firms, which is also related to the different scales of different family firms.

4. EMPIRICAL RESULTS AND EXPLANATION

In order to test the hypotheses proposed in this paper, benchmark regression analyses were carried out through the collected data related to family firms in accordance with the set model, where controls are the control variable part of the model.

4.1. The impact of government grants on green innovation in family firms

Based on model (1) and model (2), the regression results are shown in Table 3 through benchmark regression analyses for the corresponding family firms from 2008 to 2021. Specifically, (A) and (B) of Table 3, for strategic green innovation, whether or not controlling for industry and year, the coefficient of government grants is significantly positive at the level of 0.05, indicating that government grants have a positive impact on strategic green innovation of family firms, implying that government grants can improve strategic green innovation of family firms, and H1 is verified. Among them, (C) and (D) in Table 3 show the empirical results of government subsidies on substantive green innovation of family firms, regardless of controlling the year, the coefficient of government subsidies is significantly positive at the level of 0.01, indicating that government subsidies can promote substantive green innovation of family firms, and the H2 is established.

Table 3. Impact of government grants on green innovation in family firms

	(A)	(B)	(C)	(D)
Variables	GN	GN	GI	GI
LNSUB	0.00822**	0.00999**	0.01282***	0.00843***
	(0.00374)	(0.00421)	(0.00249)	(0.00285)
controls	YES	YES	YES	YES
Constant	-1.66444***	-2.02045***	-1.52751***	-1.88521***
	(0.17801)	(0.19734)	(0.11873)	(0.13379)
N	7,276	7,276	7,276	7,276
R-squared	0.030	0.087	0.037	0.064
Year-fixed	NO	YES	NO	YES
Industry-fixed	NO	YES	NO	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202501_11(1).0008

4.2. Robustness check

Substitution of explanatory variables

In order to make the results of this study more stable, this paper replaces the explanatory variable government grants (LNSUB) with the ratio of government grants to the total assets of the family firms as the subsidy strength of government grants in the current period (TBLD) and brings the replaced indicator into models (1) and (2) for the robustness test of the results of the study.

(A) and (B) in Table 4 present the results of the robustness test for the impact of government subsidies on strategic green innovation in family firms, which show that the indicator of subsidy intensity is significantly positive at the 0.05 level, regardless of the inclusion of industry and year fixed effects, which is in line with the significance of the results in the previous section (4.1), and H1 is still supported.

(C) and (D) in Table 4 present the results of the robustness test for government subsidies on substantive green innovation in family firms, and the empirical results show that the indicator of subsidy intensity is significantly positive at the 0.01 level, both with the inclusion of year and industry fixed effects, which is also consistent with the significance of the results in the previous section (4.1), and the stability of H2 is supported.

The addition of area fixed effects

In the previous benchmark regression, only year and industry fixed effects were conducted, which can eliminate the impact of environmental changes brought by different industries and different years to a certain extent, but the level of economic development, environmental protection policies, and innovation environments in different regions are not the same, and these factors will also have an impact on the green innovation of family firms, so adding regional fixed effects can eliminate the impact due to regional differences as much as possible. influence of regional differences as much as possible. According to the announcement of the National Bureau of Statistics of China on 2021.7.21, family firms in the sample are divided according to the eastern, central, western, and northeastern regions, and regression tests are conducted after adding regional dummy variables, and the test results are shown in (E) and (F) in Table 4.

The correlation coefficients of government grants on strategic and substantive green innovation in family firms are significantly positive at the 0.05 and 0.01 levels, respectively, after the inclusion of region fixed effects, and the significance of the results is consistent with the previous section, and the robustness of hypotheses H1 and H2 are supported.

The combination of region fixed effects with year and industry fixed effects shows that government subsidies have a significant positive impact on both substantive and strategic green innovation in family firms. These findings validate the hypothesis mentioned earlier, highlighting the influential role of government subsidies in promoting green innovation within family firms.

4.3. Endogenous issues

Considering that the motivation and ability to innovate that family firms have on their own is a possible factor for the government to provide them with subsidies, there may be an endogeneity problem of reverse causality between two different types of green innovations, namely, government subsidies and family firms. Further, considering the possible omission of other key variables affecting the green innovation of family firms, in order to mitigate the endogeneity problem as much as possible, this paper adopts both the instrumental variable method (IV) and the propensity score matching method (PSM) for the treatment.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202501_11(1).0008

Table 4. Robustness check

VARIABLES	(A) GN	(B) GN	(C) GI	(D) GI	(E) GN	(F) GI
BTLD	0.18617**	0.22706**	0.28233***	0.18663***		
	(0.08210)	(0.09228)	(0.05476)	(0.06257)		
LNSUB					0.01008**	0.00868***
					(0.00422)	(0.00286)
Controls	YES	YES	YES	YES	YES	YES
Constant	-	-	-	-	-	-
	1.79530***	2.17854***	1.72399***	2.01481***	1.95271***	1.85438***
	(0.19331)	(0.20944)	(0.12894)	(0.14200)	(0.19760)	(0.13388)
N	7,276	7,276	7,276	7,276	7,276	7,276
R-squared	0.030	0.087	0.037	0.064	0.087	0.065
Year-fixed	NO	YES	NO	YES	YES	YES
Industry-fixed	NO	YES	NO	YES	YES	YES
Area-fixed	NO	NO	NO	NO	YES	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Instrumental variables approach:

Since government grants in the later period do not affect green innovation in current family firms, this paper chooses government grants in the later period (ZHYQ) as an instrumental variable and employs the instrumental variable method for endogeneity testing. (A) and (B) in Table 5 show the test results of the two-stage regression method with industry and year fixed effects.

In particular, the results of the study show that when instrumental variables are used, the correlation coefficients of government grants in the latter period are significantly positive for both substantive and strategic green innovations, which is consistent with the results of the benchmark test. In addition, the statistical results of the unidentifiable test and the weak instrumental variable test show that there is no problem with unidentifiable as well as weak instrumental variables in this paper. Therefore, the regression results are still robust to the findings of this paper after controlling for endogeneity.

PSM methodology:

Considering that other relevant indicators of family firms also have an impact on their own green innovation, in order to avoid the endogeneity problem caused by omitted variables, this paper adopts the Propensity Score Matching (PSM) method to conduct the test. In this paper, according to the mean value of government subsidies, family enterprises are divided into two groups, based on which the size of the family enterprise, the deviation rate of the two rights, the degree of equity checks and balances, the balance sheet ratio, Tobin's Q value, the return on invested capital, and the growth rate of operating income are taken as the matching variables, and the samples are matched using the caliper matching method with the caliper radius of 0.05, and the final number of effective samples is obtained to be 3,695, and the matched number of samples is again regressed, and its regression results are shown in Table 5. regression, the regression results are shown in Table 5 (C), (D), (E) and (F). The results show that the correlation coefficients of government grants on substantive and strategic green innovations of family firms after propensity matching scores are significantly positive regardless of controlling the year and industry, implying that there is a significant promotion effect of government grants

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202501_11(1).0008

on both types of green innovations of family firms, which is in line with the results of the baseline regression, indicating that the study in this paper is still robust.

Table 5. Endogenous issues

VARIABLES	(A) GN	(B) GI	(C) GI	(D) GI	(E) GN	(F) GN
ZHYQ	0.00716*	0.00602**				
	(0.00378)	(0.00256)				
LNSUB			0.01632***	0.01259***	0.01835***	0.02186***
			(0.00339)	(0.00392)	(0.00513)	(0.00580)
Controls	YES	YES	YES	YES	YES	YES
Constant	-	-	-	-	-	-
	2.01948***	1.88247***	1.54379***	1.86745***	1.77234***	2.02002***
	(0.19729)	(0.13379)	(0.17211)	(0.19301)	(0.26088)	(0.28563)
N	7,275	7,275	3,695	3,695	3,695	3,695
R-squared	0.087	0.064	0.038	0.068	0.037	0.111
Year-fixed	YES	YES	NO	YES	NO	YES
Industry-fixed	YES	YES	NO	YES	NO	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.4. Moderating effects of economic policy uncertainty

After adding the economic policy uncertainty adjustment variable, based on models (3) and (4), the results of the regression are shown in Table 6 by conducting a benchmark regression analysis for the corresponding family firms from 2008-2021.

In Table 6, (A) and (B) are the moderating effects of economic policy uncertainty against government subsidies on strategic green innovation of family firms, the coefficients of the cross terms (LNSUB*EPU) of government subsidies (LNSUB) and economic policy uncertainty (EPU) are significantly negative regardless of controlling for the industry and the year, while the coefficients related to government subsidies are significantly positive, which suggests that economic policy uncertainty plays a negative moderating role in the negative moderating role in the effect of government subsidies and strategic green innovation in family firms, and hypothesis H3 is valid.

In Table 6, (C), and (D) the moderating effect of economic policy uncertainty against government subsidies on substantive green innovation in family firms, the coefficients of the cross terms of government subsidies and economic policy uncertainty are significantly negative regardless of controlling for the industry and the year, while the correlation coefficient of government subsidies is significantly positive, suggesting that economic policy uncertainty plays a negative moderating role, and hypothesis H4 is established.

4.5. Moderating effects of family involvement

After adding the family involvement level (FM) moderating variable, based on models (5) and (6), the regression results were analysed through benchmark regressions for the corresponding family firms for the years 2008-2021, as shown in Table 7.

Table 7, (A) and (B) show the moderating effect of family involvement on the strategic green innovation of family firms in response to government subsidies. Regardless of controlling for industry and year, the coefficients of the cross terms of government subsidies and family involvement (LNSUB*FM) are significantly negative, and the coefficients of the correlation coefficients of government subsidies are significantly positive, which suggests that family involvement plays a negative moderating role in the process of government subsidies to

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202501_11(1).0008

promote the strategic green innovation of family firms. degree plays a negative moderating role. Hypothesis H5 is valid.

Table 6. Moderating effects of economic policy uncertainty

VARIABLES	(A) GN	(B) GN	(C) GI	(D) GI
LNSUB	0.02969***	0.02443***	0.02582***	0.02066***
	(0.00774)	(0.00810)	(0.00517)	(0.00549)
LNSUB*EPU	-0.00449***	-0.00350**	-0.00349***	-0.00297***
	(0.00165)	(0.00168)	(0.00110)	(0.00114)
EPU	0.07546***	0.09128***	0.05031***	0.04477**
	(0.02505)	(0.03068)	(0.01671)	(0.02080)
Controls	YES	YES	YES	YES
Constant	-1.83536***	-2.24803***	-1.71431***	-2.01971***
	(0.19704)	(0.21452)	(0.13144)	(0.14542)
N	7,276	7,276	7,276	7,276
R-squared	0.032	0.088	0.039	0.065
Year-fixed	NO	YES	NO	YES
Industry-fixed	NO	YES	NO	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In Table 7, (C) and (D) are the moderating effects of family involvement against government subsidies on substantive green innovation in family firms, and the coefficients of the cross terms of government subsidies and family involvement are significantly negative regardless of whether they control for the year or not, and the correlation coefficients of government subsidies are significantly positive, which suggests that family involvement negatively moderates the facilitating effect of government subsidies on substantive green innovation in family firms. Hypothesis H6 holds.

Table 7. Moderating effects of family involvement

VARIABLES	(A) GN	(B) GN	(C) GI	(D) GI
LNSUB	0.01557***	0.01694***	0.02026***	0.01565***
	(0.00522)	(0.00553)	(0.00348)	(0.00375)
LNSBU*FM	-0.04446**	-0.04083*	-0.04504***	-0.04274***
	(0.02217)	(0.02164)	(0.01478)	(0.01467)
FM	0.64834*	0.53528	0.65253***	0.59177***
	(0.34131)	(0.33331)	(0.22755)	(0.22590)
Controls	YES	YES	YES	YES
Constant	-1.75672***	-2.08303***	-1.61963***	-1.96054***
	(0.18563)	(0.20341)	(0.12376)	(0.13786)
N	7,276	7,276	7,276	7,276
R-squared	0.031	0.088	0.039	0.065
Year-fixed	NO	YES	NO	YES
Industry-fixed	NO	YES	NO	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202501_11(1).0008

4.6. Further analysis

Tests for mediating effects:

Considering the fact that the causal relationship between government subsidies and green innovation is incomplete, there should be a process between government subsidies and green innovation of family enterprises, i.e., the government subsidies are transformed into R&D inputs within the family enterprises to promote the green innovation of the family enterprises, and the complete causal relationship should be "government subsidies - R&D inputs - green innovation". innovation". Therefore, this paper further takes R&D investment as the mediating variable R&D investment (research) and chooses the "three-step method" to test it in order to explain the completeness of the causal relationship.

Table 8 shows the mediation effect test for substantive green innovation, where (A) and (B) are the first part, i.e., the effect of government subsidies on substantive green innovation of family firms, which results in government subsidies being able to promote substantive green innovation of family firms regardless of controlling for year and industry. (C) and (D) are the second part, i.e., the effect of government subsidies on family firms' R&D investment, which can significantly increase family firms' R&D investment regardless of controlling for year and industry. (E) and (F) for the third part of the test results, the government subsidy correlation coefficient is significantly positive, R & D investment correlation coefficient is also significantly positive, indicating that there is a partial mediation effect of "government subsidies - R & D investment - substantial green innovation in family enterprises".

Table 8. Mediation effect tests for substantive green innovation

VARIABLES	(A) LNGI	(B) LNGI	(C) research	(D) research	(E) LNGI	(F) LNGI
LNSUB	0.00981***	0.01352***	0.06194***	0.01680**	0.00716**	0.01280***
	(0.00318)	(0.00275)	(0.00855)	(0.00824)	(0.00317)	(0.00273)
research					0.04280***	0.04299***
Controls	YES	YES	YES	YES	YES	YES
Constant	2.10176***	1.73592***	3.92017***	-1.19536***	1.93397***	1.68453***
	(0.15230)	(0.13366)	(0.40930)	(0.40065)	(0.15236)	(0.13265)
N	6,565	6,565	6,565	6,565	6,565	6,565
R-squared	0.068	0.046	0.455	0.306	0.081	0.062
Year-fixed	YES	NO	YES	NO	YES	NO
Industry-fixed	YES	NO	YES	NO	YES	NO

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 9 is a mediation effect test for strategic green innovation, where (A) and (B) are the first part, the effect of government subsidies on strategic green innovation in family firms, and the empirical results show that government subsidies significantly promote green innovation in family firms regardless of whether the year and industry are controlled. (C) and (D) are the second part, i.e., the study of the impact of government subsidies on family firms' R&D investment, which is the same as parts (C) and (D) of Table 8. (E) and (F) are the third part, the correlation coefficients of government subsidies are not significant, and the correlation coefficients of R&D investment are significantly positive, which indicates that there is a complete mediation effect of "government subsidies-R&D investment-strategic green innovation of family firms".

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202501_11(1).0008

Table 9. Mediation effect test for strategic green innovation

VARIABLES	(A) LNGN	(B) LNGN	(C) research	(D) research	(E) LNGN	(F) LNGN
LNSUB	0.01073**	0.00711*	0.06194***	0.01680**	0.00649	0.00602
	(0.00467)	(0.00409)	(0.00855)	(0.00824)	(0.00466)	(0.00406)
research					0.06848***	0.06459***
					(0.00671)	(0.00608)
Controls	YES	YES	YES	YES	YES	YES
Constant	-	-	-	-	-	-
	2.23493***	1.89264***	3.92017***	1.19536***	1.96648***	1.81543***
	(0.22365)	(0.19898)	(0.40930)	(0.40065)	(0.22346)	(0.19744)
N	6,565	6,565	6,565	6,565	6,565	6,565
R-squared	0.090	0.043	0.455	0.306	0.105	0.059
Year-fixed	YES	NO	YES	NO	YES	NO
Industry-fixed	YES	NO	YES	NO	YES	NO

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Relevance of the study:

In order to verify the practical significance of strategic and substantive green innovation of family firms to family firms, this paper further analyses the economic value of two kinds of green innovation to family firms chooses Tobin's Q to measure it, and constructs an economic model of the economic value of two kinds of green innovation to family firms, and the empirical results are shown in Table 10, where Tables (A) and (B) are the Tobin's Q results of strategic green innovation to family firms regression results, and (C) and (D) are the regression results of substantive green innovation on the Tobin's Q value of family firms.

Substantial and strategic green innovations shown in Table 10 have a significant contribution to Tobin's Q value of family firms, i.e., family firms that engage in green innovations can increase their economic value. Therefore, this study has some practical significance.

Table 10. Relevance of the study

VARIABLES	(A) TBQ	(B) TBQ	(C) TBQ	(D) TBQ
GN	0.07308*	0.10279***		
	(0.04228)	(0.03731)		
GI			0.19582***	0.18980***
			(0.06331)	(0.05505)
Controls	YES	YES	YES	YES
Constant	16.74477***	18.13351***	16.90646***	18.28205***
	(0.60195)	(0.59048)	(0.60480)	(0.59436)
N	7,276	7,276	7,276	7,276
R-squared	0.230	0.438	0.231	0.438
Year-fixed	NO	YES	NO	YES
Industry-fixed	NO	YES	NO	YES

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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5. CONCLUSIONS AND INSIGHTS

Based on the panel data of A-share listed family firms from 2008 to 2021, the correlations of government subsidies, economic policy uncertainty, and family involvement with strategic green innovation and substantive green innovation are explored. The results of the study show that government subsidies promote both strategic and substantive green innovation in family firms, which is realised by the mediating variable R&D investment, indicating that government subsidies can alleviate the problem of operating cost crowding out due to R&D costs for family firms that are relatively short of capital and have greater financing constraints, and allow family firms to have more funds to invest in green innovation R&D. Economic policy uncertainty will inhibit the above facilitating effect, the increase of economic policy uncertainty will lead to the increase of external uncertainty and risk of the family business, so that compared with R&D and innovation activities, the family business will use more funds to maintain the existing business activities, thus negatively regulating the facilitating effect of the government subsidy; family involvement will also negatively regulate the above facilitating effect, with the increase of the family involvement, the family business of the "family business" will be more and more difficult for the family business. As the degree of family involvement increases, the "family nature" of the family business will also increase, in order to avoid risks and maintain the survival of the family business, it will make the family business "misappropriation" of green innovation and R & D funds.

Based on the above research conclusions, the following insights are drawn: First of all, the government subsidy which there is a positive role, improves the government subsidy policy, family-owned enterprises compared to state-owned enterprises which face financing difficulties, easy because of the lack of funds in the R & D funds and working capital of the run, improve the government subsidy policy, can alleviate the problem of insufficient funds for R & D in family-owned enterprises. In addition, economic policy uncertainty will play a negative regulatory role, indicating that the increase in economic policy uncertainty amplifies the external risk of the family business problem, in order to their own stable development will choose to reduce green R & D investment, which is not conducive to the green sustainable development of the family business, the government needs to reduce the uncertainty to a certain extent, to ensure the continuity and stability of the policy. Finally, the degree of family involvement in the family business needs to be further reduced, and the separation of management and ownership is more conducive to the recruitment of talented people and the rational use of the limited resources of the family business.

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CONFLICTS OF INTEREST

We declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

AUTHOR CONTRIBUTIONS:

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by GC, XD and PY. The first draft of the manuscript was

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written by GC and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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DATA AVAILABILITY STATEMENT

Original datasets are available in a publicly accessible repository: The original contributions presented in the study are publicly available. This data can be found here: [link CSMAR , Economic Policy Uncertainty Index: China's mainland Papers (CHNMAINLANDEPU) | FRED | St. Louis Fed (stlouisfed.org), Chinese Research Data Services Platform (cnrds.com)].

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