

The Green Code in Red Belts: Executives' Zodiac Beliefs and Green Investment Efficiency*

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Abstract

Executives in their Chinese zodiac year tend to shape corporate environmental practices, motivated by a desire to offset perceived misfortune. Analyzing data from Chinese listed firms (2007–2023), we find that chairpersons in their zodiac year improve corporate green investment efficiency. Mechanism analyses reveal that this effect operates through reduced greenwashing and lower default risk. Clan culture strengthens the positive effect of the zodiac year, particularly when the firm is located in the chairperson's birthplace, whereas ESG rating divergence weakens the main effect, particularly in polluting firms. Zodiac year also leads to opportunistic selling by the chairperson, partly offsetting the positive impact. Although failing to boost green innovation output, the zodiac year suppresses innovation bubbles, thereby raising green investment efficiency. Additional evidence shows that China's 2015 Environmental Protection Law raised green investment efficiency, an effect amplified when the chairperson is in their zodiac year. This study advances research on how informal institutions shape corporate sustainability.

JEL classifications: D22; M12; M14; G32

Keywords: Zodiac year, Green investment efficiency, Clan culture, ESG rating divergence, Opportunistic selling

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1. Introduction

The world is facing escalating environmental crises, including climate change and biodiversity loss, that threaten long-term sustainable development (Boakes et al., 2024; Losos et al., 2024). OECD research warns that if the global climate crisis spirals out of control, global GDP could shrink by nearly one-third by the end of the century, highlighting the urgency of effective environmental governance.¹ Against this backdrop, governments worldwide emphasize the need to improve the efficiency of green capital deployment, ensuring maximum environmental and economic returns from limited resources (Ponte, 2020).

China, as the world's largest carbon emitter, plays a pivotal role in this global effort. It has committed to peak carbon emissions by 2030 and to achieve carbon neutrality by 2060,² rolling out a range of supportive green finance policies to meet these targets. The 2012 Green Credit Guidelines, for instance, encouraged banks to redirect lending toward green industries (Zhen Huang et al., 2023), while subsequent measures (such as green finance pilot zones and official green bond catalogs) have fostered a multi-tiered green finance ecosystem (Lee et al., 2023; Zhang et al., 2023). As a result, China's green finance sector has grown rapidly: by the end of Q3 2024, the balance of green loans reached RMB 35.75 trillion (approx. US\$4.9 trillion), up 19% year-on-year and representing 13.9% of total loans, largely financing green infrastructure and clean energy projects.³

Despite the rapid growth of green finance, evidence shows that “green funds” are not always used efficiently. Studies of Chinese heavy-polluters reveal that systemic inefficiencies in green investment allocation (Dai and Zhang, 2025), while financial resource misallocation hampers green productivity growth and corporate green innovation (Che et al., 2024; Y. Li et al., 2022).

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1. Fiona Harvey, “Tackling climate crisis will increase economic growth, OECD research finds,” *The Guardian*, 26 March 2025, <https://www.theguardian.com/environment/2025/mar/26/tackling-climate-crisis-will-increase-economic-growth-oecd-research-finds>.
 2. Xinhua, “China maps path to carbon peak, neutrality under new development philosophy,” *State Council of the People's Republic of China (English)*, October 24, 2021, https://english.www.gov.cn/policies/latestreleases/202110/24/content_WS61755fe9c6d0df57f98e3bed.html.
 3. Mengdi Yue, “China Green Finance Status and Trends 2024–2025,” *Green Finance & Development Center (FISF Fudan University)*, March 7, 2025, <https://greenfdc.org/china-green-finance-status-and-trends-2024-2025/>.

Simply labeling capital as “green” does not guarantee real emissions cuts or environmental improvements. The critical challenge lies not only in the *scale* of green investment, but in its *efficiency*—the extent of actual pollution reduction and environmental improvement delivered per unit of green capital.

Yet, this outcome-oriented perspective remains underexplored. Most existing research emphasizes the scale or volume of green finance and investment, with far less attention to efficiency (e.g., Cui et al., 2024; Y. Hu et al., 2023; Tufail et al., 2024). Even more importantly, prior studies have not examined how *informal beliefs* (such as zodiac-related perceptions) may shape managers’ green investment efficiency. Focusing on efficiency through the perspective of informal beliefs is vital: it reveals whether resources are directed to projects that genuinely reduce pollution and offers managers and policymakers a more realistic basis for evaluating the effectiveness of environmental investments. Addressing this gap, our study investigates corporate green investment efficiency, providing new evidence on the role of informal beliefs in aligning capital with environmental outcomes.

Because investment choices rest with managers, informal institutions (e.g., local norms, cultural frames, and shared beliefs) shape these decisions by influencing how executives interpret and respond to environmental uncertainty. Upper-echelons theory suggests that managers’ ways of thinking directly influence company policies and performance, alongside market and regulatory pressures (Hambrick and Mason, 1984). Related behavioral work also shows that culturally conditioned heuristics and preferences can alter reporting, risk attitudes, and resource allocation (Brochet et al., 2019; Dellestrand and Kappen, 2012; Johnson and Swedlow, 2021). Taken together, these insights imply that sustainability outcomes depend not only on financial constraints and compliance incentives but also on the socio-cultural context in which managers operate. From this perspective, we examine the Chinese zodiac year, a pervasive cultural belief system, as a quasi-exogenous setting to test whether culturally ingrained beliefs influence green investment efficiency.

In examining the determinants of corporate environmental behavior, research tended to underemphasize psychological factors that are embedded within specific cultural contexts.

Chinese traditional culture is rich in symbolic concepts, and the zodiac year is an important example. The Chinese zodiac, known as “*Sheng Xiao*”, is based on an individual’s year of birth and follows a 12-year cyclical pattern. Each year within this cycle is represented by one of twelve animals;⁴ for instance, the year 2025 corresponds to the Year of the Snake. Within this zodiac framework, zodiac year (also known as “*Ben Ming Nian*”) occurs when an individual’s birth year in the 12-year Chinese zodiac cycle coincides with the current lunar year; in other words, a person’s zodiac year recurs every twelve years following their year of birth.^{5, 6}

Deeply rooted in Chinese culture, zodiac year is widely believed to bring misfortune and increased personal and professional risk (Fisman et al., 2023). Traditionally, individuals adopt symbolic practices such as wearing red clothing and carrying protective talismans to ward off misfortune.⁷ This cultural belief that the zodiac year brings misfortune exerts a significant psychological influence on corporate executives, shaping their decision-making and strategic behavior. Fisman et al. (2023) were among the first to empirically identify a negative correlation between chairpersons’ risk-taking behavior and their zodiac year. This behavioral shift is commonly attributed to heightened risk aversion and pessimism during zodiac year (Wu et al., 2023). In response to perceived misfortune, executives may also adopt precautionary or symbolic actions such as writing off impaired assets (Si et al., 2025), or making charitable donations (Cai et al., 2025). Yet how behavioral changes associated with one’s zodiac year influence firms’ green investment efficiency remains an open question.

We examine whether a chairperson’s zodiac year affects the efficiency with which green investments are translated into pollution reduction and economic gains. Following the corporate governance literature on Chinese firms (Cai et al., 2025; Fisman et al., 2023; Jiang et al., 2024;

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4. The twelve zodiac animals in order are: Rat, Ox, Tiger, Rabbit, Dragon, Snake, Horse, Goat, Monkey, Rooster, Dog, and Pig.
 5. For example, one person’s zodiac years will be in the age of 12, 24, 36, 48, 60, etc.
 6. *The Chinese zodiac* (Timothy S. Y. Lam Museum of Anthropology), 2024, <https://lammuseum.wfu.edu/education/teachers/chinese-new-year/the-chinese-zodiac/>.
 7. Therefore, the title of our paper, “The Green Code in Red Belts,” metaphorically links the traditional practice of wearing red for protection during one’s zodiac year (the “red belts”) with the strategic pursuit of green investment efficiency (the “green code”). It reflects how culturally rooted motivations of warding off misfortune and inviting blessings, symbolized by red, translates into concrete corporate environmental behavior, decoding the underlying mechanism through which superstition influences rational decision-making.

Pan et al., 2024; Si et al., 2025; Xu et al., 2024), we focus on the chairperson as the key decision-maker: in China's listed companies, the chairperson (also known as chairman, chair, or "*Dong Shi Zhang*") typically sets the board's agenda, oversees CEO appointment and evaluation, and holds ultimate authority over major strategic decisions. Our identification strategy exploits the exogenous and non-manipulable nature of the 12-year zodiac cycle, which is mechanically determined by each chair's birth year and provides a clear source of temporal variation unrelated to contemporaneous firm conditions. The empirical specification includes $Firm \times Chair$ and $Year$ fixed effects. Because year of birth is plausibly exogenous, the inclusion of these additional fixed effects further strengthens the credibility of our causal claims. The study uses a panel dataset of Chinese A-share listed companies from 2007 to 2023, comprising 10,013 firm-year observations from 2,348 unique firms.

We find that firms led by chairpersons in their zodiac year exhibit higher green investment efficiency. This finding is consistent with instrumental altruism, whereby executives engage in substantive green actions to counteract perceived misfortune during their zodiac year. Furthermore, the heightened sensitivity during this period leads to greater risk aversion (Fisman et al., 2023); chairpersons are less inclined to engage in risky symbolic or misleading green initiatives, and instead prioritize projects that tangibly reduce pollution emissions, thereby elevating green investment efficiency. Our mechanism tests confirm that the chairperson's zodiac year improves green investment efficiency by reducing greenwashing and lowering default risk. Notably, the improvement of green efficiency is unique to the chairperson's zodiac year and diminishes afterward, highlighting the temporary nature of the effect.

Additionally, we find that the positive effect of the chairperson's zodiac year on green investment efficiency is amplified in regions with strong clan culture, particularly when the firm is located in the chairperson's birthplace. Characterized by strong kinship ties and a collective identity rooted in shared ancestry, clan culture in China fosters a social environment that emphasizes and perpetuates traditional customs (Z. Chen et al., 2022; Greif and Tabellini, 2010; Peng, 2004), thereby reinforcing the behavioral influence of the zodiac year. In contrast, factors that increase uncertainty about firms' environmental performance can weaken this effect. Specifically, we find

that ESG rating divergence attenuates the positive impact of the chairperson's zodiac year on green investment efficiency, with this dampening effect being particularly strong among highly polluting firms. Because high ESG rating divergence reflects information opacity and elevated reputational risk (Berg et al., 2022), it undermines both the motivation and the effectiveness of green investment initiatives.

We further find that the zodiac year may trigger unintended consequences. Heightened risk perceptions make chairpersons more cautious, and one manifestation of this caution is defensive insider sales undertaken to shield against anticipated stock price declines (see e.g., Ali and Hirshleifer, 2017; S. Chen et al., 2023). Such behaviors suppress green investment efficiency and partially counteract the net positive effect of the zodiac year. At the same time, the risk-aversion psychology of chairpersons during their zodiac year, while not directly enhancing green innovation output, plays an important role in curbing speculative or inflated investment in green projects. By reducing the likelihood of green innovation bubbles, this cautious orientation ultimately contributes to more sustainable improvements in green investment efficiency.

Finally, we document that China's 2015 Environmental Protection Law enhances green investment efficiency among affected firms, and this effect is significantly amplified when the chairperson is in their zodiac year. This finding reveals the complementary role of culturally embedded beliefs as informal institutions in enhancing the efficacy of formal regulatory interventions.⁸

This study makes several key contributions. First, it provides the first systematic evidence that the chairperson's zodiac year, as a traditional cultural factor, exerts a causal influence on corporate green investment efficiency. Prior research has linked the zodiac year to corporate risk-taking (Fisman et al., 2023), charitable giving (Cai et al., 2025), and financial reporting conservatism (Si et al., 2025), but these studies focus largely on financial and reporting outcomes. By contrast, we examine its implications for green investment efficiency, linking traditional cultural beliefs to firms' environmental performance. To date, no research has investigated whether this seemingly irrational belief shapes the efficiency of corporate green investment. Efficiency is criti-

8. We report the research framework of this paper clearly in Figure A.1 of the Appendix.

cal because it reflects how effectively environmental spending translates into pollution reduction (Tian et al., 2024), whereas reported investment amounts, even when measured through outlays or capital expenditures, cannot capture substantive effectiveness (Pekovic et al., 2018; Yan et al., 2021). Our findings show that the chairperson's zodiac year enhances green investment efficiency, demonstrating how informal cultural factors can shape corporate resource allocation. In doing so, the study extends research on informal institutions and executive leadership, offering a new perspective on how culture-driven behavior can promote both economic and environmental outcomes.

Additionally, we strengthen the contribution of this study with a series of mechanism tests. Examining the mediating roles of reduced greenwashing and lower default risk translates the abstract “*zodiac year effect*” into observable managerial actions and financial decisions. These mechanisms reveal how traditional culture influences green resource allocation through two pathways: instrumental altruism (Andreoni, 1990) and risk aversion (Kahneman and Tversky, 1979). We also identify important boundary conditions. Clan culture (Greif and Tabellini, 2017; Peng, 2004) amplifies the effect, while ESG rating divergence (Avramov et al., 2022; Berg et al., 2022) weakens it. By delineating identifiable behavioral mechanisms and specifying contextual boundaries, our research provides a more complete account of how culturally rooted beliefs causally shape corporate environmental behavior. Finally, this study further reveals a synergistic interplay between formal regulation and informal cultural forces: the pro-environmental impact of China's 2015 Environmental Protection Law is systematically moderated by the chairperson's zodiac year. This novel insight underscores the importance of aligning policy design, functioning as a formal institution, with deeply rooted psychological and social factors that serve as complementary informal institutions.

The remainder of the paper is organized as follows. Section 2 reviews the related literature and develops hypotheses. Section 3 describes sample selection, variable construction, and empirical methodology. Section 4 presents descriptive statistics, main regression results, along with endogeneity and robustness checks. Section 5 reports a series of additional tests and analyses. Finally, Section 6 concludes the study.

2. Literature review and hypotheses development

A growing body of research emphasizes that informal institutions such as cultural values, social norms, and folk beliefs exert substantial influence on corporate decisions and performance (Bhattacharya et al., 2018; Fortin et al., 2014; Hirshleifer et al., 2018). Unlike formal institutions, these factors operate by shaping managerial cognition and risk preferences. For example, firms in regions with strong religious traditions exhibit more conservative financial reporting (Ma et al., 2020), while managers where gambling is more accepted display higher risk tolerance (Christensen et al., 2018). Thus, local cultural norms can shape corporate strategy and conduct.

Upper Echelons Theory further posits that managerial traits and cognitive frames critically influence corporate decisions (Hambrick and Mason, 1984). This perspective posits that managers are boundedly rational, and their decisions are constrained by psychological and cognitive factors. According to Hanlon et al. (2022), by incorporating cognitive, psychological, and behavioral dimensions into the analysis, we broaden our understanding of how firms function and perform. Studies have examined the enduring impact of early-life experiences (J. Hu et al., 2020; Kubick and Li, 2023; Pan et al., 2024; Xu and Ma, 2022), social relationships (Jiang et al., 2024; Xu et al., 2024), and cultural background (Yates and De Oliveira, 2016) on managerial decision styles. Yet, culturally embedded belief systems such as the Chinese zodiac remain inadequately understood in their influence on corporate behavior, particularly green conduct.

The Chinese zodiac has been linked to economic outcomes such as fertility timing (Yip et al., 2002), educational attainment (C. Huang et al., 2020), and farmers' life insurance adoption (Y. Liu et al., 2021). At the corporate level, rather than examining static zodiac attributes, we focus on its dynamic cyclical influence, particularly the behavioral effects during executives' zodiac year. Traditionally viewed as a period associated with heightened volatility in personal fortune, it prompts risk aversion and symbolic compensatory actions (Cai et al., 2025; Fisman et al., 2023), offering a unique lens to examine periodic shifts in managers' environmental decisions.

Green investment efficiency, our dependent variable, measures how well firms convert environmental spending into actual pollution reduction rather than merely tracking expenditure

levels(Dai and Zhang, 2025; Martin and Moser, 2016; Tian et al., 2024). This efficiency perspective is crucial as studies show substantial green investments often yield limited environmental returns due to resource misallocation, agency problems, or symbolic compliance(Chen and Feng, 2019; Kim and Lyon, 2015; Zhang, 2022). While existing literature predominantly focuses on investment volume(e.g., Heinkel et al., 2001; C. J. Li et al., 2023; Marshall et al., 2021), many firms worldwide engage in superficial environmental expenditures or greenwashing to enhance their ESG profiles without achieving meaningful emission reductions(Kim and Lyon, 2015; Szabo and Webster, 2021). GIE thus provides policymakers and boards with a superior metric to distinguish genuine environmental performance from mere spending. However, the micro-level drivers of effective environmental expenditure remain underexplored. We introduce a novel behavioral perspective through zodiac beliefs, where leaders' perceived misfortune during their zodiac year triggers both risk aversion and symbolic altruism. This cultural lens offers unique insights into whether non-rational factors enhance (through misfortune-offsetting motives) or distort (via risk-avoidance motives) green investment decisions, addressing an important gap in behavioral corporate finance and environmental governance beyond conventional economic explanations.

2.1. Hypotheses on the main effect and mediating mechanisms

We investigate how zodiac-year beliefs, a deeply rooted aspect of Chinese culture, shape executives' decision-making and, in turn, influence the efficiency of green investments. We argue that such beliefs, though seemingly symbolic, can alter managerial judgment in meaningful ways by amplifying perceptions of uncertainty and influencing strategic choices. In particular, we highlight two key behavioral channels through which these effects are likely to materialize: instrumental altruistic tendencies and risk aversion.⁹

First, zodiac-related beliefs shape executive instrumental altruistic tendencies. Cai et

9. The concept of *instrumental altruism*, rooted in Andreoni (1990)'s theory of impure altruism, refers to a strategic choice whereby individuals or organizations engage in altruistic behavior to advance their own interests. At its core, instrumental altruism treats other-oriented actions as a means rather than an end, with self-interest serving as the underlying motive. In this study, we argue that chairpersons exhibit instrumental altruism during their zodiac year; driven by self-interested motives to mitigate personal fate risks, they engage in socially responsible initiatives such as efficient corporate green investment, thereby indirectly promoting social welfare outcomes including pollution reduction and environmental improvement.

al. (2025) document an increase in charitable donations during the zodiac years of board chairs, suggesting that executives can seek to contribute to society to obtain auspicious blessings. Similarly, Converse et al. (2012) suggest that individuals in highly uncertain environments exhibit a stronger tendency to pursue actions that benefit others and society. Green investment efficiency, which measures pollution reduction outcomes achieved through environmental expenditures, represents a direct pathway through which firms enhance social welfare. Thus, during the psychologically salient period of their zodiac year, chairs are motivated to improve green investment efficiency as a means of contributing to societal well being and counteracting perceived misfortune.

Additionally, a higher risk aversion during zodiac years makes executives more sensitive to firm-related risks. Based on Fisman et al. (2023), who analyze the relationship between zodiac beliefs of executives and risky investment decisions in Chinese companies, we extend the discussion to perception of “green risk.” Specifically, executives may perceive environmental administrative penalties resulting from environmental accidents or pollution as significant firm risks, thereby potentially enhancing green investment efficiency, which is also crucial for reducing risks associated with environmental protection. Accordingly, we propose the following main hypothesis:

Hypothesis 1: Firms led by chairpersons in their zodiac year demonstrate higher green investment efficiency.

Building on the main hypothesis development that a chairperson’s zodiac year improves green investment efficiency through motivations of “instrumental altruism” and “risk aversion”, we propose two underlying transmission mechanisms: a reduction in greenwashing and decreased default risk.

Greenwashing is considered as a deceptive marketing strategy to appeal consumers and investors (Kim and Lyon, 2015). Specifically, when the chairperson is in their zodiac year, psychological motivations such as avoiding misfortune and seeking blessings lead them to favor genuine and sustainable environmental actions over symbolic or misleading green promotions. This self-restraint toward greenwashing stems from both an intrinsic drive for moral self-discipline

associated with the zodiac year (Cai et al., 2025; Si et al., 2025), and a proactive desire to avoid reputational and regulatory risks that could arise from false claims about green investments (Gatti et al., 2021). Reducing greenwashing allows the firm to allocate more resources to substantive projects (Szabo and Webster, 2021; Walker and Wan, 2012), such as green technology upgrades and pollution control, thereby enhancing the allocation efficiency of green investment and improving actual pollution reduction outcomes. Hence, we propose the following hypothesis:

Hypothesis 2a: *The chairperson's zodiac year reduces greenwashing, thereby improving the firm's green investment efficiency.*

Default risk provides an additional pathway through which zodiac-year beliefs may enhance green investment efficiency. During their zodiac years, executives tend to be more cautious (Zeng et al., 2022) and seek to avoid potential sources of misfortune, which include reducing the probability of financial distress for the firm. Specifically, perceived misfortune heightens managers' awareness of risk mitigation, prompting more prudent operational and financial decision-making to avoid excessive risk-taking. This leads to enhanced corporate financial robustness, increased cash holdings (J. Li et al., 2021; Si et al., 2025), and further reduces the probability of debt default. A decrease in default risk not only enhances the firm's creditworthiness and expands its access to financing sources (Subrahmanyam et al., 2014; Tang and Yan, 2010), but also provides stable resource allocation and a conducive internal governance environment for green investment projects (El Ghouli et al., 2011). These improvements, in turn, enhance the allocation efficiency of green funding and the effectiveness of pollution reduction outcomes. Thus, we propose a second transmission mechanism hypothesis:

Hypothesis 2b: *The chairperson's zodiac year reduces default risk, thereby improving the firm's green investment efficiency.*

2.2. Hypotheses on the moderating mechanisms

The influence of a chairperson's personal characteristics on corporate decision-making is shaped by the broader social and informational context in which the firm operates (Hanlon et al., 2022; Ruigrok et al., 2006). We argue that the positive effect of the chairperson's zodiac year on green

investment efficiency moderated by two key factors: clan culture as an informal institution and ESG rating divergence as a formal information factor.

Rooted in institutional theory (North, 1990), we contend that informal institutions, such as norms and values embedded in culture, significantly amplify the influence of traditional beliefs on behavioral decisions. Clan culture, a defining feature of Chinese society characterized by strong kinship ties and collective identity rooted in shared ancestry, fosters a social environment that emphasizes and perpetuates traditional customs (Greif and Tabellini, 2010; Peng, 2004). In regions with stronger clan culture, greater social legitimacy is accorded to symbolic practices such as the zodiac year (Z. Chen et al., 2022; Greif and Tabellini, 2017; Xu and Yao, 2015).¹⁰ Chairpersons operating in such contexts face heightened normative pressures to conform to culturally expected behaviors, including increasing investments in social and environmental well-being to mitigate perceived risks associated with the zodiac year. As a result, the intrinsic behavioral motivations triggered by the zodiac year are amplified by external social expectations within strong clan cultures.

Furthermore, we argue that this reinforcing effect is not uniformly distributed but contingent upon the extent of the chairperson's embeddedness in the local cultural network. Social identity theory posits that when individuals identify strongly with a particular group, their behavior tends to align with the norms of that group (Tajfel and Turner, 2004). When the firm is located in the chairperson's birthplace, the chairperson typically possesses deeper knowledge of the local clan culture, is more deeply embedded in its networks, and faces more immediate social monitoring and reputational constraints (Do et al., 2017; Tang et al., 2024). Under these conditions, the chairperson exhibits stronger motivation to align their behavior with local cultural expectations to maintain social status and clan reputation. The convergence of personal traditional beliefs and intense social scrutiny makes the zodiac year effect most pronounced. Accordingly, we hypothesize:

10. Social legitimacy refers to a generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate within a socially constructed system of norms, values, beliefs, and definitions (Suchman, 1995). It embodies a form of "social license," indicating alignment with the belief systems shared by external stakeholders (e.g., communities, cultures, industries), thereby being perceived as "right" and worthy of existence.

Hypothesis 3a: *The stronger the clan culture in a region, the stronger the enhancing effect of the chairperson's zodiac year on the firm's green investment efficiency. This positive moderating effect is more pronounced when the chairperson's birthplace aligns with the company's location.*

Based on signaling theory (Connelly et al., 2011; Spence, 1973), we argue that the positive effect of the chairperson's zodiac year on green investment efficiency is constrained by the clarity and credibility of external signals regarding the firm's environmental performance. ESG ratings serve as important informational intermediaries that help stakeholders evaluate corporate environmental behavior. However, when significant divergence exists across rating agencies, i.e., when ESG rating divergence is high, it creates information opacity and elevates reputation risk (Berg et al., 2022), thereby undermining both the motivation and effectiveness of green investment initiatives.

First, ESG rating divergence makes it difficult for stakeholders to accurately assess the firm's genuine environmental commitment (H. He et al., 2025). Even if the chairperson is motivated to enhance green investment efficiency during their zodiac year, conflicting signals from rating agencies may lead external audiences to undervalue these efforts, reducing both the financing available for green activities and the expected legitimacy benefits (Avramov et al., 2022; Berg et al., 2022). Second, rating divergence exacerbates reputation risks, particularly accusations of greenwashing (H. Chen et al., 2025). When the informational environment is contentious, firms become more cautious regarding visible green investments, as any action may invite heightened scrutiny and misinterpretation (Christensen et al., 2022), thus dampening the incentive to invest green.

Furthermore, based on risk amplification theory (Kasperson et al., 1988), we propose that this negative moderating effect is especially pronounced in heavily polluting firms. Heavy-polluting firms are already subject to intensified monitoring by regulators, investors, and the public (Zu et al., 2025). Any ambiguity concerning their environmental performance, such as that induced by rating divergence, significantly increases their operational and reputational risks. Consequently, polluting firms have stronger incentives to avoid bold green initiatives that could attract additional attention and criticism. As a result, the zodiac-year-induced motivation for

green investment is substantially weakened in such contexts. Accordingly, we hypothesize:

Hypothesis 3b: *The greater the divergence in ESG ratings, the weaker the enhancing effect of the chairperson's zodiac year on the firm's green investment efficiency. This negative moderation is more pronounced in heavily polluting firms.*

3. Research methodology

3.1. Construction of key variables

3.1.1. Chairman's zodiac year

We explore cultural beliefs as captured by zodiac-year effects among Chinese board chairs. In contrast to the collaborative norms observed in U.S. counterparts (Oliver et al., 2018), Chinese board chairs, functioning as ultimate decision-makers in Chinese firms, hold superior authority over CEOs within the corporate hierarchy. They have been shown to be more influential than CEOs in establishing strategic directions and making decisions with long-term implications for Chinese firms (Cai et al., 2025; Fisman et al., 2023; Jiang et al., 2024; Pan et al., 2024; Si et al., 2025; Xu et al., 2024). Therefore, following Fisman et al. (2023) and Cai et al. (2025), we focus on Chinese board chairs and use their zodiac cycle as a proxy for belief-driven cognitive tendencies. Drawing on the Chinese 12-year lunar cycle, where each year corresponds to a zodiac sign, we create a binary indicator, *Zodiac*, coded one when a chairman's birth year zodiac sign aligns with the current lunar year, and zero if the chairman is not in their zodiac year.

3.1.2. Green investment efficiency

Corporate green investment efficiency is measured using the Slack-Based Measure Data Envelopment Analysis (SBM-DEA) model. This approach extends the conventional DEA framework by incorporating slack variables that capture input excesses and output shortfalls, thereby allowing for a more precise assessment of inefficiencies. By benchmarking firms relative to the efficient frontier and optimizing slack adjustments, the SBM-DEA model offers a robust tool for evaluating the efficiency of green investment activities within firms.

The intuition of this model is straightforward. Industrial production inevitably generates a

large amount of pollutants, such as wastewater, exhaust gases, and solid waste. These pollutants contribute to a series of environmental issues, such as smog, the greenhouse effect, and global climate change. As a result, adopting green production methods that reduce waste has become a critical objective across all sectors of production. Traditional DEA assumes that higher outputs produced with fewer resources constitute an efficient production method. However, this assumption treats all outputs as good or desirable, which is often unrealistic in modern production contexts. From an environmental standpoint, producing undesirable outputs is not a sign of efficiency, even if resource consumption is low. Therefore, the most efficient production method in today's society must be green production, which means producing more desirable outputs with fewer inputs and generating less undesirable output.

Tone (2003) extended the SBM model developed by Tone (2001) by incorporating undesirable outputs into the SBM framework. In this approach, there are n Decision Making Units (DMUs), and each DMU consists of three elements: inputs, desirable outputs, and undesirable outputs, represented by the vectors (x, y, z) , respectively. The SBM model with undesirable outputs evaluates a DMU (x_0, y_0, z_0) as shown in the following Equation (1):¹¹

$$\rho = \min \left\{ \frac{1 - \frac{1}{m} \sum_{i=1}^m \frac{s_i^x}{x_{i0}}}{1 + \frac{1}{s_1 + s_2} \left(\sum_{k=1}^{s_1} \frac{s_k^y}{y_{k0}} + \sum_{l=1}^{s_2} \frac{s_l^z}{z_{l0}} \right)} \right\} \quad (1)$$

subject to:

$$\begin{aligned} x_{i0} &= \sum_{j=1}^n \lambda_j x_{ij} + s_i^x, \quad \forall i \\ y_{k0} &= \sum_{j=1}^n \lambda_j y_{jk} - s_k^y, \quad \forall k \\ z_{l0} &= \sum_{j=1}^n \lambda_j z_{jl} + s_l^z, \quad \forall l \end{aligned}$$

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11. The notation DMU (x_0, y_0, z_0) refers to a single decision-making unit (DMU) characterized by an input vector x_0 , a desirable output vector y_0 , and an undesirable output vector z_0 . In other words, x_0 represents the quantities of each input (i.e., total green investment) that the DMU uses, y_0 represents the amounts of each intended (desirable) output (i.e., net profit) the DMU produces, and z_0 represents the amounts of each undesirable output (i.e., pollutants) generated by that DMU. When we say “the SBM model with undesirable outputs evaluates a DMU (x_0, y_0, z_0) ,” we mean that the model is assessing the efficiency of this particular DMU given its inputs and outputs.

where: $s_i^x \geq 0$, $s_k^y \geq 0$, $s_l^z \geq 0$, $\lambda_j \geq 0$, $\forall i, j, k, l$.¹²

Let $s^x \in \mathbb{R}^m$, $s^y \in \mathbb{R}^{s_1}$, and $s^z \in \mathbb{R}^{s_2}$ denote the nonnegative slack vectors that capture inefficiencies in the production process. Specifically, s^x measures *input excess* (the degree to which inputs can be reduced), s^y measures *desirable-output shortfall* (the extent to which desirable outputs can be increased), and s^z measures *undesirable-output excess* (the extent to which pollutant emissions can be reduced). Here, $\mathbb{R}^q$ denotes a q -dimensional Euclidean space, and m , s_1 , and s_2 represent the numbers of inputs, desirable outputs, and undesirable outputs, respectively. The efficiency score $\rho \in (0, 1]$ obtained from Equation (1) reflects the relative position of the decision-making unit (DMU) with respect to the efficient frontier. When $\rho = 1$, all slack variables (s^x , s^y , and s^z) equal zero, meaning that the DMU lies on the efficiency frontier and no further improvement is possible in any input or output dimension. Conversely, when $\rho < 1$, at least one slack variable is positive, indicating that the DMU operates below the frontier and exhibits inefficiency that could be reduced by lowering inputs, increasing desirable outputs, or decreasing undesirable outputs.

Equation (1) can be estimated under different assumptions about returns to scale. Under the *constant returns to scale* (CRS) assumption, the production technology is conical, and proportional changes in inputs lead to proportional changes in outputs. Under the *variable*

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12. The subscripts i , j , k , and l denote the indices for *inputs*, *decision-making units (DMUs)*, *desirable outputs*, and *undesirable outputs*, respectively. Specifically, $i = 1, \dots, m$ corresponds to different input factors, $k = 1, \dots, s_1$ to desirable outputs, $l = 1, \dots, s_2$ to undesirable outputs, and $j = 1, \dots, n$ to all DMUs included in the analysis.

Intuitively, the three constraints describe how the evaluated unit (DMU₀) is projected onto the *efficient production frontier*, which is constructed as a *convex combination* of observed production activities in the sample. The coefficients λ_j determine the position of this reference point on the frontier, and the slack variables (s^x , s^y , s^z) capture deviations from it.

In the first constraint, $x_{i0} = \sum_{j=1}^n \lambda_j x_{ij} + s_i^x$, the input level of DMU₀ for factor i is represented as the minimum feasible input combination required to achieve the same outputs under efficient production. The non-negative slack s_i^x measures *input excess*, indicating by how much the current input could be reduced without affecting outputs.

For desirable outputs, $y_{k0} = \sum_{j=1}^n \lambda_j y_{jk} - s_k^y$, the term $\sum_j \lambda_j y_{jk}$ defines the attainable level of desirable output k on the frontier, while s_k^y captures *output shortfall*—the extent to which DMU₀'s current output falls below the efficient level.

For undesirable outputs, $z_{l0} = \sum_{j=1}^n \lambda_j z_{jl} + s_l^z$, the equation has the opposite direction because smaller values are preferable. The slack s_l^z represents *excess undesirable output*, showing how much pollutant or waste could be reduced to match the efficient frontier.

Collectively, these constraints define how each DMU's observed performance is enveloped by the production possibility set. When all slacks are zero and $\rho = 1$, the DMU lies exactly on the efficient frontier; otherwise, positive slacks indicate inefficiency and potential improvement in resource use, output generation, or emission control.

returns to scale (VRS) assumption, an additional convexity constraint $\sum_{j=1}^n \lambda_j = 1$ is imposed, allowing for increasing or decreasing returns to scale. The λ_j variables serve as *intensity* (or activity) coefficients that construct a benchmark point on the efficient frontier from a convex combination of observed DMUs.

Our study uses output-oriented SBM-DEA model with undesirable outputs under variable returns to scale (VRS) to evaluate corporate green investment efficiency; as the listed firms in our sample may differ substantially in production scale and technology, so assuming CRS would confound scale effects with pure technical inefficiency. Also, green investments often exhibit non-proportional scaling properties. Therefore, adopting the VRS framework allows us to separate pure technical inefficiency from scale inefficiency, yielding a more accurate assessment of green investment efficiency. The specifics for our case are as follows. For the *Input*, we consider the amount of green investment, which is identified from items related to environmental protection reported in the notes to the annual report under “Construction in Progress” and “Administrative Expenses,” along with all relevant investments—including those in pollutant treatment equipment, research and development activities, and fixed asset acquisitions—that align with the concept of green investment as disclosed in annual reports and corporate social responsibility reports.¹³ The *Output* is measured by net profit. The *Undesirable Outputs* include emissions of waste gas (such as sulfur dioxide and nitrogen oxides), hazardous particulate matter, wastewater, and solid waste pollutants. Data on corporate environmental pollutant emissions are obtained from the “Details of Environmental Emission of Listed Companies” table in the CSMAR database.

3.2. Baseline regression model

We employ the following model to analyze how the zodiac year influences green investment efficiency:

$$GIE_{i,t} = \alpha + \beta Zodiac_{i,t} + \gamma Control_{i,t} + Firm \times Chairman FE + Year FE + \varepsilon_{i,t} \quad (2)$$

13. Among the projects, the acquisition of relevant fixed assets serves as a critical foundation for advancing green technology development and signals an effective reallocation of resources toward sustainable objectives.

where *GIE* represents green investment efficiency of firm *i* in year *t*. The independent variable, *Zodiac*, takes the value of 1 if the chairman of firm *i* in year *t* is in their zodiac year, and 0 otherwise. *Control* includes a series of variables that account for potential determinants of corporate green investment efficiency. Specifically, from the financial perspective of firms, we control for firm size (*Size*), firm age (*Firmage*), accounting profitability (*ROA*), market valuation (*TobinQ*), cash holdings (*Cash*), income growth (*Growth*), intangible assets (*Intangible*), and financial leverage (*LEV*). In addition, we incorporate governance-related factors, including whether the firm is a state-owned enterprise (*SOE*), ownership concentration as captured by the shareholdings of the largest shareholder (*Top1*), board size (*Boardsize*), Chairman-CEO duality (*DUAL*), and characteristics of the chairman, including overseas experience (*Overseas*) and educational attainment (*Degree*). All these variables are explicitly defined in Table 1. In addition, we include the firm-chairman fixed effects to exploit within-firm, within-leader variation. The year fixed effects capture common annual socioeconomic shocks affecting the market. The model is estimated using OLS regressions with robust standard errors corrected for heteroskedasticity and firm-level clustering.

[Insert Table 1 about here]

3.3. Sample and data

We start with all public firms listed in Shanghai and Shenzhen stock exchanges over the period 2007–2023¹⁴ and source the data primarily from the CSMAR and CNRDS databases (see Table 1). We restrict our sample to firms in the secondary industry (e.g., manufacturing, chemicals, energy, and construction), as these firms exhibit relatively homogeneous production processes, typically involving substantial capital (e.g., plants, machinery), energy (e.g., electricity, coal), and raw materials, while generating significant pollutants (wastewater, exhaust gases, solid waste). These characteristics satisfy the conceptual and empirical requirements for measuring green investment efficiency. Applying the SBM-DEA model to calculate green investment efficiency

14. The starting year, 2007, is chosen because China adopted new accounting standards in accordance with the international financial reporting standards in that year.

yields a sample of 20,138 firm-year observations with valid efficiency scores. We further exclude 1,953 observations due to missing chairperson personal information. We also remove firms flagged with ST or ST* designations,¹⁵ firms with revenue growth exceeding 100% to mitigate the influence of mergers and restructuring, and observations with missing control variables in the baseline regression. This process results in the exclusion of additional 8,172 observations. Finally, we are left with a sample of 10,013 firm-year observations from 2,348 unique Chinese firms.

4. Empirical results and analysis

4.1. Descriptive statistics

Table 2 reports the descriptive statistics of the main variables used in this study. Panel A presents the statistical characteristics of the full sample. The values of green investment efficiency (*GIE*) vary from 0.001 to 1, consistent with the empirical expectations from the SBM-DEA model. *GIE* has a mean of 0.399 and a standard deviation of 0.123, indicating substantial variation in green investment efficiency across firms and suggesting room for overall improvement. Additionally, approximately 11% of the sample firms have chairpersons in their zodiac year. The statistics of *Zodiac* are close to those reported in Fisman et al. (2023). Other control variables have distributions generally consistent with the prior studies on Chinese firms, indicating that our sample is reasonably representative.

In Panel B of Table 2, we split the full sample based on whether the chairperson is in their zodiac year or not (*Zodiac* = 1 or 0), and present the mean and median of green investment efficiency (*GIE*) for each group. The *t*-test results show that firms with chairpersons in their zodiac year (*Zodiac*=1) exhibit a mean *GIE* of 0.440, significantly higher than the mean of 0.394 in firms without zodiac-year chairpersons. In addition to *GIE*, we further conduct subgroup comparisons for alternative measures *GIE_R*, *GI_a*, and *GI_b*, which are later used in the robustness tests. Here, *GIE_R* is an alternative measure of green investment efficiency, while *GI_a* and *GI_b* are

15. Firms designated with ST or ST* labels are those at risk of delisting and experiencing severe financial distress or abnormal operational conditions.

used to gauge the scale of direct green investment. All these tests suggest a preliminary positive link between zodiac year and green investment efficiency.

[Insert Table 2 about here]

Panel A of Table 3 tabulates the Pearson correlation coefficient matrix. As expected, green investment efficiency (*GIE*) is positively correlated with the chairperson's zodiac year, consistent with our hypothesis. *GIE* is also positively correlated with *ROA* and *TobinQ*, suggesting that better performing firms are more efficient in green investment. We further conduct Variance Inflation Factor (VIF) tests, with results reported in Panel B of Table 3. All VIF values are well below 5, indicating that our estimation is not subjected to severe multicollinearity. Thus, the choice of variables is suitable for subsequent regression analysis.

[Insert Table 3 about here]

4.2. Baseline regression results

Columns (1) and (2) of Table 4 report the baseline regression results examining the effect of the chairperson's zodiac year on corporate green investment efficiency, without and with control variables, respectively. The coefficient on *Zodiac* is positive and statistically significant at the 1% level in both specifications, indicating that firms whose chairpersons are in their zodiac year exhibit significantly higher green investment efficiency, in support of *Hypothesis 1*. In economic terms, the coefficient of 0.040 in column (2) can be interpreted as that the presence of the chairperson's zodiac year corresponds to an improvement in green investment efficiency (*GIE*) of approximately 10% of the sample mean ($0.040/0.399$), compared with chairpersons not in their zodiac year.

To mitigate potential biases arising from sample size imbalances or different characteristics between firms with and without chairpersons in their zodiac year, we apply three matching approaches using control variables as covariates. The first is 1:1 nearest-neighbor propensity score matching (PSM); the second is radius PSM by requiring with a caliper of 0.05; and the third is entropy balancing (introduced by Hainmueller, 2012), which reweights the control

group so that its covariate moments align with those of the treatment group. After matching, the differences in covariates are significantly reduced across all three methods, as shown in Figure A.2 of the Appendix. In the matched samples in Columns (3)-(5) of Table 4, the coefficient of *Zodiac* remains positive and statistically significant at the 1% level. The results suggest that the positive effect of the chairperson's zodiac year on green investment efficiency is unlikely to be driven by pre-existing observed differences between the two groups. Collectively, the findings are consistent with the view that zodiac years influence decision-making toward environmentally conscious investments.

Among the control variables, the coefficients of *ROA* and *Growth* are positive and significant, indicating that firms with stronger profitability and higher growth rates exhibit greater green investment efficiency, aligning with theoretical expectations. The coefficient on *SOE* is positive and significant. China has implemented many green policies, and state-owned firms, driven by their motives to implement national strategic policies and supported by stable and sufficient government funding (Genin et al., 2021), demonstrate higher green investment efficiency. Furthermore, the positive coefficient on *Top1* shows that concentrated ownership provides major shareholders greater power to monitor management, aligning managers' and shareholders' interests toward long-term value creation (Aguilera and Crespi-Cladera, 2016), thereby increasing efficiencies in green investments. Firm age (*Firmage*) is negatively associated with GIE. This aligns with the theory of organizational inertia (Hannan and Freeman, 1984), positing that established firms are often entrenched in existing routines and technologies, leading to resistance to adopting novel green practices. The effect of leverage (*Lev*) is also negative, which reveals lower green investment efficiency in firms heavily reliant on debt. Board size (*Boardsize*) is negatively associated with GIE. Larger boards are more conservative and more likely to reject projects perceived as uncertain. Green investments are often risky, capital intensive, and future-oriented. Larger boards' aversion to risk could lead to lower green investment efficiency.

[Insert Table 4 about here]

4.3. Robustness test results

4.3.1. Ruling out alternative explanations

To bolster causal inference, Table 5 presents robustness tests addressing alternative explanations. First, Chinese Communist Party (CCP) members are officially discouraged from zodiac beliefs. As a result, party members may be less influenced by such beliefs.¹⁶ To test this, we split the sample based on whether the chairperson is a CCP member. As shown in Columns (1) and (2) of Panel A in Table 5, the zodiac year effect remains positive and significant at the 1% level for both CCP (coefficient = 0.038) and non-CCP (0.041) chairs. The slightly larger point estimate among non-CCP members does not undermine the main result, indicating that CCP identity does not drive our findings.

Additionally, although China officially adopted the Gregorian calendar in 1949, zodiac signs are determined by the lunar calendar. The lunar New Year typically begins one to two months later than the Gregorian New Year.¹⁷ For chairpersons born in January or February, whether it is their zodiac year may be ambiguous.¹⁸ To eliminate this potential confounding factor, we excluded chairs born in January or February. As shown in Column (3) of Panel A in Table 5, the effect of the zodiac year on green investment efficiency remains significant at the 1% level (coefficient = 0.04); therefore, our main findings are robust.

Early-life experiences shape an individual's core psychological and behavioral traits (Black et al., 2017). We further consider a historical factor that may have shaped the chairperson's formative years: China's nationwide cultural revolution during the modern era. The "Breaking the four olds campaign (also known as *Po Si Jiu*)," launched in 1966, systematically suppressed superstitious practices for a decade, profoundly influencing social and cultural life (Y. Chen

16. Ben Blanchard, "China warns party members to stick to Marx, not 'ghosts and spirits,'" *Reuters*, February 28, 2019, <https://www.reuters.com/article/world/china-warns-party-members-to-stick-to-marx-not-ghosts-and-spirits-idUSKCN1QG1FS/>.

17. For example, the first day of the first lunar month in 2025 corresponds to January 29th in the Gregorian calendar

18. Firstly, the exact date of the lunar New Year varies relative to the Gregorian calendar, sometimes falling in January and other times in February. Additionally, in some rural regions of China with less stringent birth registration practices (Merli and Raftery, 2000), some people may still use the lunar calendar to record their birth dates in household registration.

et al., 2020; Fällman, 2010). This period was followed by the “Reform and Opening-up” policy initiated in 1978, which restored cultural and religious freedoms, including traditional folk practices. Chairpersons born before 1966, between 1966 and 1978, or after 1978 experienced markedly different cultural environments during their formative years, potentially shaping their susceptibility to zodiac beliefs. To examine this possibility, we partition the sample into three cohorts based on chairpersons’ birth years: pre-1966, 1966–1978, and post-1978. The results, reported in Columns (4)-(6) of Panel A in Table 5, show that the zodiac year consistently improves green investment efficiency across all cohorts, suggesting that early-life exposure to these cultural shifts does not significantly alter the main findings, thereby supporting its robustness.

We further control for potential confounders that may affect changes in green investment efficiency. Firstly, Xu and Ma (2022) find that CEOs’ poverty experiences enhance corporate CSR performance. Therefore, corporate green investment efficiency may also be driven by the chairperson’s early-life socioeconomic disadvantage. To rule out this alternative explanation, Column (1) of Panel B in Table 5 examines the effect of childhood poverty experience (*Poverty*) on green investment efficiency and finds no statistically significant association, providing initial evidence against this competing mechanism.¹⁹ Column (2) further controls for *Poverty* and re-examines *Zodiac*; its coefficient and significance remain virtually unchanged ($\beta = 0.04$, $p < 0.01$), confirming that early-life poverty experience does not explain the zodiac year effect.

Further, corporate anniversaries are often associated with strategic philanthropy or sustainability initiatives.²⁰ This could theoretically drive green investment efficiency, potentially confounding the zodiac year effect. We construct an *Anniversary* variable, which equals one if the firm is at its decennial anniversary (e.g., 10th, 20th), and zero otherwise. As shown in Column (3) of Panel B in Table 5, corporate anniversaries themselves exhibit no significant effect on green investment efficiency. Column (4) demonstrates that after controlling for *Anniversary*, the coefficient on *Zodiac* (0.04) and its significance level ($p < 0.01$) remain unchanged. Corporate

19. *Poverty* is constructed as reported in Table 1. Following Xu and Ma (2022), it is defined as an indicator variable that equals 1 if the chairperson’s birthplace is classified as a national-level poverty-stricken county, and 0 otherwise.

20. The underlying mechanism posits that individuals are more likely to initiate meaningful actions during salient temporal landmarks (Dai et al., 2014).

anniversaries do not explain our results. Therefore, after ruling out alternative explanations, our main findings remain robust.

Finally, we incorporate additional chairperson characteristics as controls, including gender (*Chair_Female*), financial background (*Chair_FB*), salary level (*Chair_Salary*), ownership stake (*Chair_Share*), and positional independence status (*Chair_INDEP*).²¹ Results in Column (5) of Panel B show that the coefficient on our key variable *Zodiac* remains stable and significant at the 1% level, confirming the robustness of our main finding. The lack of significance across these additional controls further suggests no systematic relationship between these chairperson attributes and green investment efficiency.²²

[Insert Table 5 about here]

4.3.2. Dynamic Analysis

To enhance causal identification and address concerns regarding omitted variable bias in the relationship between the chairperson's zodiac year and corporate green investment efficiency, we implement a dynamic changes specification drawing on approaches from J.-B. Kim et al. (2016) and Pan et al. (2024). We define two transition indicators: *Zodiac_No_To_Yes*, which equals 1 if the chairperson enters their zodiac year in the current period after not being in it the previous year, and 0 otherwise; and *Zodiac_Yes_To_No*, which takes a value of 1 upon exiting the zodiac year and 0 otherwise. The outcome variable, green investment efficiency, along with all time-varying controls are defined consistently with the baseline model but is transformed into year-over-year differences (i.e., they are computed as the difference between year t and year

21. Among these variables, *Chair_FB* (financial background) indicates whether the chairperson has work experience in financial institutions such as commercial banks, investment banks, insurance firms, securities firms, asset management firms, futures firms, trust firms, or exchanges. *Chair_INDEP* (position independence) identifies whether the chairperson holds additional roles within the firm beyond the chair position.

22. Our baseline analysis examines how a chairperson's zodiac year influences corporate green governance. In Chinese firms, the chairperson acts as the highest leader with decisive power over strategic planning and executive oversight. The corporate governance structure typically places the chairperson above the CEO, who implements strategies under the chairperson's direction (Cai et al., 2025; Fisman et al., 2023; Jiang et al., 2024; Pan et al., 2024; Si et al., 2025; Xu et al., 2024). However, given that the CEO, as part of the management team, may also influence corporate green decisions, we extend our analysis to examine the effect of the CEO's zodiac year on green investment efficiency. The results are reported in Table B.1 of the Appendix and discussed in detail therein. In short, this additional test confirm that the chairperson, rather than the CEO, plays the dominant role in shaping green investment efficiency.

$t - 1$). Time-invariant control variables are retained in levels.²³ This empirical strategy facilitates the removal of time-constant unobserved confounders and sharpens identification by exploiting within-firm variation surrounding the precise timing of zodiac year transitions.

From Columns (1) and (2) of Table 6, we observe that transitions into the zodiac year (*Zodiac_No_to_Yes*) are associated with a statistically significant increase in green investment efficiency (coefficient = 0.157, $p < 0.01$). Conversely, transitions out of the zodiac year (*Zodiac_Yes_to_No*) correspond to a pronounced decline in efficiency (coefficient = -0.095 , $p < 0.05$). These results indicate that the chairperson's zodiac year drives variation in green investment efficiency, and our main findings are robust. The results also suggest that the positive green behavior associated with the zodiac year is not persistent. The observed improvement in green investment efficiency likely reflects short-term actions aimed at offsetting perceived misfortunes, rather than sustained motivation for ecological protection.

To further examine whether the zodiac year effect on corporate green investment efficiency is transient rather than persistent, we conduct an analysis akin to a parallel trends test. This approach allows us to evaluate the persistence of any observable effects beyond the zodiac year itself. If the improvement in efficiency is short-lived, the observed effects should be concentrated exclusively in the current zodiac year, with no pre-existing trends in the preceding years or sustained impacts in the subsequent years.

As shown in Columns (3) to (6) of Table 6, we examine parallel trends for *GIE* across four event windows (from $t - 1$ to $t + 1$, $t - 2$ to $t + 2$, $t - 3$ to $t + 3$, and $t - 4$ to $t + 4$). In the years preceding the zodiac year, the coefficients on green investment efficiency are statistically insignificant across all specifications, indicating no detectable pre-trend and supporting the parallel trends assumption. During the zodiac year itself, green investment efficiency shows a significant increase in all four event windows, with *Zodiac* coefficients of 0.038, 0.037, 0.036, and 0.037, respectively, each significant at the 1% level. However, in the years following the zodiac year, the effect on *GIE* diminishes and generally becomes statistically insignificant by the second year after

23. For instance, variables such as firm ownership type (*SOE*) and the chairperson's educational attainment (*Degree*) are relatively time-invariant and do not exhibit meaningful variation over time. Thus, Conducting annual change computations between year t and $t - 1$ would be statistically uninformative.

the event ($t + 2$). These results confirm that the improvement in *GIE* during the chairperson's zodiac year reflects a psychological effect rather than a lasting shift in corporate environmental strategy.²⁴

[Insert Table 6 about here]

4.3.3. Results with alternative main variables

We further employ an alternative measure of green investment efficiency for robustness tests. While maintaining the definition of green investment efficiency as “whether corporate green investment effectively reduces pollutant emissions,” we retain corporate total green investment as the input, net profit as the desirable output, and actual pollutant emissions as the undesirable output in the computational model. Following the approach of L. Li et al. (2023), we adopt the Super-SBM model to recalculate corporate green investment efficiency (*GIE_R*) and test the effect of chairpersons' zodiac year on this reproxied outcome. The regression results are reported in column (1) of Table 7, which indicates that the chairperson's zodiac year (*Zodiac*) corresponds to a significant increase in green investment efficiency (*GIE_R*), with a coefficient of 0.049 significant at the 1% level, supporting the robustness of our main result.

We further examine the direct level of green investment as an alternative outcome variable. If improved efficiency were driven solely by reduced pollution emissions without a concomitant increase in green investment scale, it might indicate passive emission reduction rather than active green governance. However, if both green investment efficiency and direct green investment scale increase simultaneously, it would provide more intuitive evidence of a proactive expansion in corporate environmental governance. We measure green investment using two approaches (Gu et al., 2021). The first is measured as the natural logarithm of one plus the firm's green investment amount, denoted as *GI_A*. The second is measured as the ratio of green investment amount to total assets, denoted as *GI_B*.

As reported in Columns (2) and (3) of Table 7, corporate green investment increases significantly when the chairperson is in their zodiac year. Specifically, the estimated coefficient for

24. Appendix Figure A.3 presents the visual results of the parallel trends tests corresponding to the four specifications (from $t - 1$ to $t + 1$, $t - 2$ to $t + 2$, $t - 3$ to $t + 3$, and $t - 4$ to $t + 4$).

GL_a is 0.14 and that for GL_b is 0.002, both statistically significant at the 1% level. This finding complements the baseline regression results, indicating that the chairperson's zodiac year not only enhances the efficiency of green resource allocation but also stimulates an expansion in green investment scale, thereby providing more comprehensive evidence for the role of irrational beliefs in shaping corporate environmental behavior.

[Insert Table 7 about here]

5. Further tests and results

5.1. Analysis of the mediation mechanisms

We employ greenwashing (GW) and default risk (DW) as mediating variables to examine the transmission mechanism through which the chairperson's zodiac year affects corporate green investment efficiency. The mediating mechanism is tested using the three-step procedure proposed by Baron and Kenny (1986), supplemented by bootstrap testing for the significance of indirect effects. The specifications of the three-step empirical models are as follows:

$$GIE_{i,t} = \alpha_1 + \beta_1 Zodiac_{i,t} + \gamma_1 Control_{i,t} + Firm \times Chairman + Year + \varepsilon_{i,t}, \quad (3)$$

$$GW(orDR)_{i,t} = \alpha_2 + \beta_2 Zodiac_{i,t} + \gamma_2 Control_{i,t} + Firm \times Chairman + Year + \varepsilon_{i,t}, \quad (4)$$

$$GIE_{i,t} = \alpha_3 + \beta_3 Zodiac_{i,t} + \delta GW(orDR)_{i,t} + \gamma_3 Control_{i,t} + Firm \times Chairman + Year + \varepsilon_{i,t}. \quad (5)$$

In the specified models, the mediating variables GW and DR represent corporate greenwashing and default risk, respectively.²⁵ The three-step procedure is applied as follows: first, the effect of the chairperson's zodiac year on corporate green investment efficiency (GIE) is estimated (i.e., β_1 in equation (3)), which has already been reported and discussed in section 4.2.²⁶ Second, the relationship between the mediating variables (GW and DR) and the explanatory variable

25. GW and DR are constructed as reported in Table 1. Firstly, following Wang et al. (2024), greenwashing (GW) is defined as an indicator variable that equals 1 if the frequency of environment-related words in the MD&A section of the firm's annual report exceeds the industry median for the same period, yet the firm received environmental penalties in that same year. Otherwise, the variable takes the value 0. Additionally, default risk (DR) is measured by the Z-score (Altman, 1968; Favara et al., 2017; Zhou and Zhang, 2025)

26. Therefore, we skip reporting the results of the first step corresponding to equation (3) in Table 8, as they are already reported in Table 4.

(*Zodiac*) is examined (i.e., β_2 in equation (4)). Third, associations between mediators (*GW* and *DR*) and outcome variable (*GIE*) are tested (i.e., δ in equation (5)).

Table 8 reports the results of the mediation effect tests. Column (1) shows that the chairperson's zodiac year (*Zodiac*) is significantly negatively correlated with greenwashing (*GW*) at the 1% level ($\beta_2 = -0.037$), indicating that firms with chairpersons in their zodiac year are less likely to engage in greenwashing. Column (2) shows that after controlling for *GW*, *Zodiac* continues to exert a significantly positive effect on green investment efficiency (*GIE*) at the 1% level ($\beta_3 = 0.039$), while *GW* itself also has a significantly negative impact on *GIE* ($\delta = -0.007$, $p < 0.1$). This finding suggests that the zodiac year enhances green investment efficiency by curbing symbolic environmental behavior. Bootstrap tests confirm that the 95% confidence interval for the mediation effect does not include zero,²⁷ further validating the statistical significance of this mechanism, in support of *Hypothesis 2a*.

Columns (3) and (4) of Table 8 examine the mediating role of default risk (*DR*). A significant positive correlation is observed between *Zodiac* and *DR* at the 5% level ($\beta_2 = 0.216$), indicating that chairpersons in their zodiac year are associated with reduced corporate default risk.²⁸ After controlling for *DR* in Column (4), *Zodiac* remains significantly positive toward *GIE* ($\beta_3 = 0.039$), while *DR* itself also shows a significant positive association with *GIE* ($\delta = 0.002$, $p < 0.05$). These findings indicate that reduced default risk partially mediates the relationship between the zodiac year and green investment efficiency; this supports *Hypothesis 2b*. The bootstrap confidence interval excluding zero confirms the robustness of this indirect effect.

[Insert Table 8 about here]

5.2. Analysis of the moderation mechanisms

We examine how clan culture (*Clan*, an external factor of a firm) and corporate ESG rating divergence (*ESG_D*, an internal factor of a firm) moderate the effect of the chairperson's zodiac

27. In the bootstrap test, we perform 1,000 times sampling from the original data with put-back to create a number of bootstrap samples to estimate confidence intervals for the mediating effect.

28. A higher ZScore indicates lower default risk; hence, the positive coefficient reflects a risk-mitigating effect.

year on green investment efficiency, using the following empirical model.

$$GIE_{i,t} = \alpha_4 + \beta_4 Zodiac_{i,t} + \sigma Clan(or ESG_D)_{i,t} + \lambda Zodiac_{i,t} \times Clan(or ESG_D)_{i,t} + \gamma_4 Control_{i,t} + Firm \times Chairman + Year + \varepsilon_{i,t}. \quad (6)$$

Where the first moderator, *Clan*, measures the level of clan culture in a firm's region, proxied by the number of genealogies per million people (F. Liu et al., 2023). The second moderator, *ESG_D*, captures a firm ESG rating divergence, calculated as the standard deviation of the ratings from six major agencies (Avramov et al., 2022).²⁹ The sign and significance of the interaction term coefficient λ are used to evaluate moderation effects.

The moderating effect of clan culture is reported in Panel A of Table 9. In the full-sample regression (Column 1), the coefficient on *Zodiac*×*Clan* is significantly positive at the 1% level ($\lambda = 0.01$) and consistent in sign with that of *Zodiac*, indicating that clan culture significantly strengthens the positive effect of the chairperson's zodiac year on green investment efficiency. Further subgroup analyzes show that this moderating effect is driven primarily by the subsample where the chairperson's birthplace province is the same as the firm's location (Column 2, $\lambda = 0.01$, $p < 0.01$), whereas it is insignificant in the subsample with different regions (Column 3).³⁰ This suggests that clan culture, as an informal institution, exhibits strong local embeddedness. When the chairperson works in their birthplace, the cultural-psychological effect triggered by the zodiac year is more pronounced, thereby more effectively promoting corporate green investment efficiency. *Hypothesis 3a* is supported.

Panel B of Table 9 examines the moderating effect of ESG rating divergence (*ESG_D*). The

29. *Clan* and *ESG_D* are constructed as reported in Table 1.

30. Our sample split based on the chairperson's birthplace matching the firm's location shows that the interaction term *Zodiac*×*Clan* is significant in the *same_region* group but not in the *diff_region* group. However, the triple interaction term *Zodiac*×*Clan*×*Region* is not significant. This discrepancy can be explained both statistically and theoretically. First, triple interactions require large samples to detect due to high variance inflation; a threshold our sample may not reach. More importantly, we argue theoretically that *Region* operates as a binary moderator: it determines whether the clan culture mechanism is active ("1") or not ("0"), implying a qualitative rather than continuous difference. The triple interaction tests a "difference in differences of slopes," which is underpowered to detect such discrete switching. In contrast, subgroup analysis is better suited to identify this kind of structural break, as it allows full coefficient flexibility across groups. Thus, the nonsignificant triple interaction does not contradict our results. It simply suggests that the moderating effect does not vary linearly across *Region*, which is consistent with our theory of a threshold-like mechanism. The subgroup difference is further validated by a Fisher test ($p = 0.004$), confirming the robustness of our approach.

full-sample results in Column (1) show that the coefficient on the interaction term $Zodiac \times ESG_D$ is significantly negative ($\lambda = -0.106$, $p < 0.05$), indicating that ESG rating divergence significantly weakens the positive effect of the zodiac year on green investment efficiency. Subsample analyses based on whether firms are subject to key pollution monitoring by the government reveal that this negative moderating effect is concentrated in the heavily polluting subsample (Column (2), $\lambda = -0.170$, $p < 0.01$), while it is insignificant in the non-heavily polluting subsample (Column (3)). This suggests that for firms already subject to heightened environmental scrutiny, the information uncertainty and reputational risk captured by ESG rating divergence are more likely to exacerbate concerns and significantly inhibit the chairperson's ability to pursue substantive green investment during their zodiac year. *Hypothesis 3b* is supported.

[Insert Table 9 about here]

5.3. Additional analysis: suppression mechanisms

Do chairpersons invariably engage in positive behaviors during their zodiac year? Not necessarily. The zodiac year may simultaneously trigger other potentially adverse behaviors, leading to a systematic underestimation of its net effect on green investment efficiency (GIE). Specifically, traditional cultural beliefs regard the zodiac year as a period of heightened volatility and susceptibility to risk. Such perceptions may prompt individuals to adopt more cautious or self-interested actions to mitigate perceived threats. Following this logic, we posit that chairpersons may be more inclined toward opportunistic share reduction during their zodiac year as a means of managing personal financial risks. Managers' opportunistic share reduction behavior could convey negative market signals, undermine investor confidence, or directly reduce the chairperson's commitment to the firm's sustainable development strategy (Darrough and Rangan, 2005; Devos et al., 2015). Consequently, it may partially suppress the positive influence of the zodiac year on green investment efficiency. To examine this potential suppression mechanism, we employ a three-step testing procedure analogous to mediation analysis, as specified in the following models.

$$GIE_{i,t} = \alpha_5 + \beta_5 Zodiac_{i,t} + \gamma_5 Control_{i,t} + Firm \times Chairman + Year + \varepsilon_{i,t}, \quad (7)$$

$$OSR_{i,t} = \alpha_6 + \beta_6 Zodiac_{i,t} + \gamma_6 Control_{i,t} + Firm \times Chairman + Year + \varepsilon_{i,t}, \quad (8)$$

$$GIE_{i,t} = \alpha_7 + \beta_7 Zodiac_{i,t} + \omega OSR_{i,t} + \gamma_7 Control_{i,t} + Firm \times Chairman + Year + \varepsilon_{i,t}. \quad (9)$$

Where *OSR* represents the chairperson's opportunistic share reduction. Following Jiang and Yang (2025) and Huddart and Ke (2007), this variable is constructed based on the occurrence of specific events. Using the announcement date of the share reduction as the benchmark date, the estimation period consists of [-150, -31] (estimation window) trading days prior to the event. Employing the standard market model to calculate abnormal returns, we analyze the stock price movement and the excess returns following each share reduction transaction by the chairperson. A sale is classified as opportunistic if it predicts negative stock returns over the following month; otherwise, it is considered a routine reduction. We further aggregate each opportunistic share reduction transaction by listed firm chairpersons at the firm-year level. Following the approach of Huddart and Ke (2007), we measure the chairperson's opportunistic reduction behavior using both the total amount of opportunistic share reductions (*OSR_A*, Panel A of Table 10) and the frequency of such reductions (*OSR_F*, Panel B of Table 10).

In Panel A of Table 10, the amount of share reduction (*OSR_A*) is used as the suppressor variable. Column (2) shows that during their zodiac year, chairpersons significantly increase opportunistic share reductions ($\beta_6 = 0.977$, $p < 0.01$). Column (3) indicates that after controlling for *OSR_A*, the positive effect of the zodiac year (*Zodiac*) on green investment efficiency (*GIE*) increases from the baseline value of 0.040 (coefficient of *Zodiac* in Column 1) to 0.053 (coefficient of *Zodiac* in Column 3), remaining significant at $p < 0.01$, while *OSR_A* itself exhibits a significant negative effect on *GIE* ($\omega = -0.006$, $p < 0.01$). Additionally, Panel B, which uses the frequency of share reductions (*OSR_F*) as the variable, demonstrates a fully consistent pattern: the zodiac year leads to a significant increase in the frequency of the reduction ($\beta_6 = 0.091$, $p < 0.01$). After controlling for *OSR_F*, the coefficient of *Zodiac* on *GIE* increases from 0.04 to 0.051 ($p < 0.01$), and *OSR_F* has a significant negative impact on *GIE* ($\omega = -0.044$, $p < 0.01$). Bootstrap tests further confirm the statistical robustness of the suppression effect, with 95% confidence intervals excluding zero in both cases.

These findings collectively indicate that chairpersons' opportunistic share reduction behavior during their zodiac year acts as an important suppressor variable: it partially masks the positive effect of the zodiac year on green investment efficiency. After accounting for this nega-

tive mechanism, the cultural-psychological effect of the chairperson zodiac year itself becomes more clearly visible, as reflected in the larger coefficient of *Zodiac*.

[Insert Table 10 about here]

5.4. Additional analysis: chairpersons' zodiac on green innovation

Beyond its direct influence on green investment efficiency, the chairperson's zodiac year could also shape other dimensions of corporate environmental conduct, particularly green innovation. The unsustainable and resource-intensive growth model is faced with mounting physical constraints (G. He et al., 2023). Green innovation offers the potential to develop cleaner and more efficient technologies, thus fundamentally lowering the environmental costs of economic activities (Huang and Li, 2017; Kunapatarawong and Martínez-Ros, 2016; Suki et al., 2023). However, firms' incentives to pursue green innovation are not always rooted in genuine environmental concerns; they may instead be driven by the pursuit of policy subsidies or by the need to align with capital market preferences (Dimos and Pugh, 2016; Zhehao Huang et al., 2019; Xie and Wang, 2025). Such strategic motives can give rise to low-quality innovation and the emergence of a "green innovation bubble" (Geng et al., 2024). Accordingly, examining corporate green innovation (*GInnovation*) and the potential bubble (*GInnovation_bub*) effects provides a valuable extension for this study.³¹ The documented correlation between the zodiac year and green investment efficiency suggests a potential link between the chairperson's zodiac year and corporate green innovation.

The result in Column (1) of Table 11 shows that the effect of the chairperson's zodiac year (*Zodiac*) on green innovation (*GInnovation*) is not statistically significant. Green innovation activities are inherently characterized by high risk and uncertainty (Li and Vermeulen, 2021; Roper and Tapinos, 2016), which creates an inherent tension with the risk aversion and preference for stability that typify decision-making during the chairperson's zodiac year (Fisman et al., 2023).

31. *GInnovation* and *GInnovation_bub* are constructed as reported in Table 1. Firstly, following I. Kim et al. (2021) and Ren et al. (2023), *GInnovation* is calculated by the natural logarithm of the number of green patent applications by firms plus one. In addition, following Geng et al. (2024), *GInnovation_bub* is calculated by the standardized quantitative differential between applications and grants for green patents.

As a result, chairpersons exhibit a more cautious approach toward high-risk investments in green innovation during this period, leading to no significant increase in innovation.

However, results from Column (2) reveal a significantly negative effect of the chairperson's zodiac year on the green innovation bubble (*GInnovation_bub*) at the 1% level, with a coefficient of -0.055. This suggests that chairpersons in their zodiac year suppress green innovation bubbles; that is, they reduce low-quality or strategic innovation activities. Column (3) further examines the role of the green innovation bubble in the core relationship. After controlling for (*GInnovation_bub*), the positive effect of the zodiac year (*Zodiac*) on green investment efficiency (*GIE*) remains significant at the 1% level (with a coefficient of 0.039), while *GInnovation_bub* itself exhibits a significant negative impact on *GIE* (coefficient = -0.011, $p < 0.05$). These findings indicate that suppressing innovation bubbles constitutes an important channel through which the zodiac year enhances green investment efficiency. It is plausible that during their zodiac year, chairpersons motivated by pragmatic risk aversion or culturally rooted motives such as accumulating merit (Cai et al., 2025; Fisman et al., 2023), to offset misfortune place greater emphasis on substantive contributions in green behavior, thereby improving overall green investment efficiency.

[Insert Table 11 about here]

5.5. The effect of the 2015 new Environmental Protection Law

China's amended Environmental Protection Law took effect on January 1, 2015, widely regarded as the country's most stringent environmental legislation to date. The law imposes restrictions on pollutant emissions from targeted industries, enhances environmental oversight, raises penalties for violations, and mandates strict corporate disclosure of emission data. Green investment efficiency, the dependent variable in our study, is closely linked to effective corporate environmental governance. Firms subject to this regulation are motivated to increase investment in green equipment and technology to reduce harmful emissions, thereby achieving more efficient green spending. We therefore hypothesize that the implementation of the new environmental law strengthens corporate green investment efficiency. To test this hypothesis, we employ the

following difference-in-differences (DiD) model.

$$GIE_{i,t} = \alpha_8 + \beta_8 Law \times Post_{i,t} + \gamma_8 Control_{i,t} + Firm \times Chairman + Year + \varepsilon_{i,t}. \quad (10)$$

In this specification, the key explanatory variable is the interaction term *Law×Post*, a binary indicator that equals 1 for firm-year observations in industries affected by the 2015 Environmental Protection Law from the year 2015 onward (the treatment group), and 0 otherwise (the control group).³² All other variables and fixed effects follow the definitions and specifications established in our baseline regressions. As reported in column (1) of Table 12, the coefficient on *Law×Post* is 0.054, statistically significant at the 1% level, indicating that the regulatory implementation significantly improved corporate green investment efficiency.

We further introduce a triple interaction term (*Law×Post×Zodiac*) to examine whether the chairperson's zodiac year moderates the effect of the environmental law on green investment efficiency. The results, presented in column (2) of Table 12, reveal a statistically significant positive coefficient on the *Law×Post×Zodiac* (coefficient = 0.038, $p < 0.01$) and align in direction with the *Law×Post* coefficient, suggesting that the regulatory effect is strengthened when the chairperson is in their zodiac year.

To address potential estimation bias due to systematic differences between firms affected and unaffected by the law, we perform entropy balancing using control variables as covariates (Hainmueller, 2012). This approach significantly reduces post-matching covariate imbalances.³³

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32. According to the “Categorization Management Directory for Environmental Inspection of Listed Companies” issued by the former Ministry of Environmental Protection, the industries targeted by the new Environmental Protection Law have been identified as follows: B06 (Coal Mining and Washing), B07 (Oil and Natural Gas Extraction), B08 (Ferrous Metal Mining and Dressing), B09 (Non-ferrous Metal Mining and Dressing), C17 (Textile Industry), C19 (Leather, Fur, Feather, and Related Products and Footwear Manufacturing), C22 (Paper and Paper Products Manufacturing), C25 (Petroleum Refining, Coking, and Nuclear Fuel Processing), C26 (Chemical Raw Materials and Chemical Products Manufacturing), C28 (Chemical Fiber Manufacturing), C29 (Rubber and Plastic Products Manufacturing), C30 (Non-metallic Mineral Products Manufacturing), C31 (Ferrous Metal Smelting and Rolling Processing), C32 (Non-ferrous Metal Smelting and Rolling Processing), and D44 (Electric Power and Heat Production and Supply). Companies in these industries are grouped into the treatment group.
33. Unlike propensity score matching, entropy balancing method ensures exact balance on the first moments of all covariates and avoids model misspecification bias in the propensity score estimation. Additionally, entropy balancing preserves sample size by reweighting all control observations rather than discarding unmatched ones. Appendix Figure A.4 presents the covariate balance between treatment and control groups before and after entropy balancing, where groups are defined by firms' exposure to the environmental law.

Re-estimating the two legal effects (i.e., the impacts of *Law×Post* and *Law×Post×Zodiac* on *GIE*) on the matched sample yields results reported in columns (3)–(4) of Table 12. The coefficient magnitudes of key variables remain stable and statistically consistent with pre-matching estimates, confirming the robustness of the documented regulatory effects. Also, a parallel trends test conducted around the 2015 Environmental Protection Law shows insignificant pre-treatment trends in green investment efficiency, while a significant post-implementation improvement supports the validity of our findings.³⁴

The results underscore the complementary role of culturally rooted beliefs in enhancing the effectiveness of formal regulatory interventions, highlighting the importance of considering both institutional (e.g., green law) and informal psychological factors (e.g., zodiac beliefs) in shaping corporate environmental behavior.

[Insert Table 12 about here]

6. Conclusion

Our study extends the corporate finance and managerial decision-making literature beyond the rational economic agent paradigm by establishing how cultural beliefs embedded in the zodiac year systematically influence corporate green investment behavior. We show that chairpersons improve firms' green investment efficiency specifically during their zodiac year. This relationship operates through two distinct channels: a reduction in greenwashing and lower default risk. Furthermore, the positive impact is strengthened in regions with stronger clan culture, particularly when firms operate in the chairperson's birthplace, yet attenuated by ESG rating divergence, especially among heavily polluting firms. We also document that the zodiac year may induce unintended consequences; it triggers opportunistic share selling by chairpersons, which suppresses green investment efficiency and partially obscures the positive net effect of the zodiac year. While the zodiac year does not increase green innovation output, it curbs green innovation bubbles, thereby contributing to efficiency. Finally, the 2015 Environmental Protection

34. The parallel trends test for green investment efficiency around the implementation of the environmental law is presented in Appendix Figure A.5.

Law's positive impact on green investment efficiency is strengthened when the chairperson is in their zodiac year, revealing cultural cognition's nuanced yet significant role in environmental governance.

Our findings provide valuable insights for firms and their stakeholders. First, corporate boards and managers should recognize the positive driving effect of executives' cultural identity, such as the zodiac year, on environmental behaviors. Incorporating cultural identity into the company's ESG strategy and leadership incentive framework can enhance green investment efficiency, while reducing greenwashing and green innovation bubbles. In regions with strong clan culture, firms should further strengthen their commitment and sense of identity toward green investment to amplify the positive effects of cultural psychology, such as zodiac years. Also, heavily polluting firms in particular ought to pay closer attention to the evaluation criteria of different ESG rating agencies, as they face stricter external scrutiny; by engaging in substantive green actions to reduce divergence in ESG ratings, these firms can alleviate stakeholder concerns, which in turn can magnify the positive impact of executives' psychologically driven initiatives to improve green investment efficiency, creating a virtuous cycle.

Additionally, for policymakers, intervention strategies informed by cultural and behavioral science could be deployed by strategically promoting environmental subsidies or green credit policies during psychologically salient periods for corporate executives, so as to maximize firms' responsiveness. Also, environmental regulations (e.g., the 2015 Environmental Protection Law) could achieve greater traction by consciously aligning with deeply rooted cultural symbols and cyclical psychological patterns. Local governments and business associations should be encouraged to introduce region-specific green initiatives in areas with strong clan culture to amplify the positive role of traditional values in corporate environmental commitment. Furthermore, as the zodiac may trigger opportunistic reduction in shareholdings by chairpersons, regulatory authorities ought to enhance oversight of trading activities by executives during such sensitive periods; for instance, imposing temporary strengthening of disclosure requirements or cooling-off periods around specific corporate announcements would help ensure that leaders' actions remain aligned with long-term sustainability goals.

Finally, for investors, the “zodiac year” can serve as a unique cultural benchmark indicator to anticipate shifts in corporate green investment strategies, particularly when firms operate within regions characterized by strong clan culture. However, investors should recognize that the zodiac-driven improvement in green investment efficiency is transient rather than sustained; environmentally friendly behaviors spurred during this window may diminish afterward. Investors should therefore maintain ongoing scrutiny to assess whether the green behaviors of target firms are effective, thereby avoiding potential losses resulting from misjudgment. Furthermore, investors ought to be aware that executives in culturally sensitive periods may exhibit opportunistic behaviors such as shareholding reductions. It is necessary to cross-validate corporate green announcements with chairpersons’ trading activities. A simultaneous occurrence of increased green investment and chairperson share sell-offs during their zodiac year constitutes a strong warning signal, indicating potential agency problems and a misalignment between managerial actions and long-term value creation. Hence, investors should take on an active monitoring role to ensure long-term effective green governance and curb opportunistic selling by executives, thereby fostering mutually beneficial outcomes.

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Table 1: Variable definitions

Variable	Definition
<i>Dependent variables</i>	
GIE	Corporate green investment efficiency, calculated using the SBM–DEA model. Source: CSMAR (for corporate pollution emission information and basic details of green investment projects and related amounts), Juchao Information Website, and companies' websites (for further calibration of green investment information).
<i>Independent variables</i>	
Zodiac	Chairperson's zodiac year. Equals 1 if the fiscal year corresponds to the chair's zodiac year, and 0 otherwise. Source: CSMAR.
<i>Control variables</i>	
Size	Firm size, calculated as the natural logarithm of total assets. Source: CSMAR.
Firmage	Firm age, calculated as: $\ln(\text{sample year} - \text{listing year} + 1)$. Source: CSMAR.
ROA	Ratio of net profit to total assets. Source: CSMAR and CNRDS.
TobinQ	Market value to total assets at the end of the period. Source: CSMAR and CNRDS.
Cash	Ratio of cash holdings to total assets at the end of the period. Source: CSMAR.
Growth	$(\text{operating income}_t / \text{operating income}_{t-1}) - 1$. Source: CSMAR and CNRDS.
Intangible	Ratio of net intangible assets to total assets. Source: CSMAR and CNRDS.
LEV	Ratio of total liabilities to total assets. Source: CSMAR and CNRDS.
SOE	Indicator = 1 for state-owned enterprises, 0 otherwise. Source: CSMAR.
Top1	Ratio of shares held by the largest shareholder to total shares. Source: CSMAR.
Boardsize	Logarithm of number of board members. Source: CSMAR and CNRDS.
Duality	Indicator = 1 if the chairman and CEO are the same person, 0 otherwise. Source: CSMAR.
Overseas	Indicator = 1 if chairman studied or worked abroad, 0 otherwise. Source: CSMAR.
Degree	Chairman's education: 0 = below bachelor, 1 = bachelor, 2 = master, 3 = doctorate. Source: CSMAR.
<i>Mediating variables</i>	
GW	Indicator = 1 if the frequency of environment-related words in the MD&A section of the firm's annual report exceeds the industry median for the same period, yet the firm received environmental penalties in that same year. Otherwise, the variable takes the value 0. Source: CNRDS, Juchao Information Website, and company disclosures.
DR	Measured by ZScore; $\text{ZScore} = 0.012 \times \text{Working capital} / \text{Total assets} + 0.014 \times \text{Retained earnings} / \text{Total assets} + 0.033 \times \text{Earnings before interest and tax} / \text{Total assets} + 0.006 \times \text{Total market value} / \text{Book value of liabilities} + 0.999 \times \text{Sales revenue} / \text{Total assets}$. Source: CSMAR.
<i>Moderating variables</i>	
Clan	Number of genealogies per million people in a city. Source: Shanghai Library Genealogy Knowledge Service Platform.
ESG_D	Standard deviation of ESG scores across six raters (Bloomberg, Huazheng, WIND, MSCI, FTSE Russell, SynTao Green Finance). Source: Bloomberg, WIND, SynTao Green Finance ESG Ratings.
<i>Suppression variables</i>	

Continued on next page

Table 1: Variable definitions (continued)

Variable	Definition
OSR_A & OSR_F	Opportunistic share reductions: classified as opportunistic if they predict negative abnormal stock returns in the following month; otherwise routine. OSR_A is the total value of the chairperson's opportunistic reductions; OSR_F is the frequency. Source: CSMAR and companies' websites.
<i>Additional variables</i>	
Communist	Indicator = 1 if the chairperson is or has ever been a member of the Chinese Communist Party; 0 otherwise. Source: CSMAR and CNRDS.
Poverty	An indicator variable set to 1 when the chairperson's birthplace is listed among the 592 key counties under the National Poverty Alleviation and Development Program, and 0 otherwise. Source: The State Council of China's official website.
Anniversary	An indicator variable that equals 1 if the firm is celebrating its 10th anniversary or a multiple thereof (e.g., 20th, 30th, etc.), and 0 otherwise. Source: CSMAR.
Chair_Female	Additional control; it equals 1 if the chairperson is female, and 0 if male. Source: CSMAR.
Chair_FB	Additional control; it equals 1 if the chairperson has work experience in financial institutions such as commercial banks, investment banks, insurance firms, securities firms, asset management firms, futures firms, trust firms, or exchanges. Source: CSMAR and CNRDS.
Chair_Salary	Additional control, calculated as $\ln(\text{the chairperson's annual salary} + 1)$. Source: CSMAR and CNRDS.
Chair_Age	Additional control, calculated as $\ln(\text{the chairperson's age} + 1)$. Source: CSMAR.
Chair_Share	Additional control, measured as the percentage of total shares held by the chairperson. Source: CSMAR and CNRDS.
Chair_INDEP	Additional control; it equals 1 if the chairperson does not hold any other position within the firm, and 0 otherwise. Source: CSMAR and CNRDS.
GIE_R	An alternative variable for green investment efficiency, calculated based on the super-SBM model. Source: CSMAR, Juchao Information Website, and companies' websites.
GI_a & GI_b	The variables represent corporate green investment. GI_a is calculated by the natural logarithm of green investment amount plus one. GI_b is calculated by green investment amount divided by total assets. Source: CSMAR, Juchao Information Website, and companies' websites.
Region	A binary variable that equals 1 if the chairperson's birthplace is in the same province as the firm's location, and 0 otherwise. Source: CSMAR.
Pollution	A binary variable that equals 1 if the firm is a heavily polluting firm, and 0 otherwise; it is judged according to whether the firm is a key pollution source monitoring unit. Source: CSMAR.
GInnovation	Corporate green innovation capability, calculated by the natural logarithm of the number of green patent applications by firms plus one. Source: IPC Green Inventory, and China's State Intellectual Property Office (SIPO).
GInnovation_bub	Corporate green innovation bubbles, calculated by the standardized quantitative differential between applications and grants for green patents. Source: IPC Green Inventory, and China's State Intellectual Property Office (SIPO).
Law×Post	A difference-in-differences term coded as 1 for firms in industries targeted by China's 2015 New Environmental Protection Law, and 0 otherwise.

Note: This table reports the definitions and sources of variables used in this study, categorized by variable type and presented in the order of their appearance in the text.

Table 2: Summary Statistics

Panel A: Full sample						
Variables	Obs	Mean	SD	Min	Median	Max
GIE	10,013	0.399	0.123	0.001	0.432	1.000
Zodiac	10,013	0.110	0.313	0.000	0.000	1.000
Size	10,013	22.529	1.295	20.190	22.363	27.891
Firmage	10,013	2.037	1.021	0.000	2.303	3.466
ROA	10,013	0.052	0.042	0.000	0.042	0.231
TobinQ	10,013	1.796	1.008	0.843	1.468	6.578
Cash	10,013	0.628	0.455	0.004	0.538	10.524
Growth	10,013	0.220	0.407	-0.498	0.139	2.802
Intangible	10,013	0.053	0.059	0.000	0.037	0.569
LEV	10,013	0.429	0.198	0.052	0.425	0.934
SOE	10,013	0.402	0.490	0.000	0.000	1.000
Top1	10,013	0.359	0.152	0.034	0.342	0.900
Boardsize	10,013	2.107	0.199	1.334	2.145	2.890
Duality	10,013	0.254	0.435	0.000	0.000	1.000
Overseas	10,013	0.081	0.272	0.000	0.000	1.000
Degree	10,013	0.973	0.987	0.000	1.000	3.000
Poverty	10,013	0.026	0.160	0.000	0.000	1.000
Anniversary	10,013	0.101	0.301	0.000	0.000	1.000
GIE_R	9,410	0.679	0.337	0.032	0.889	1.512
GI_a	10,013	15.954	2.423	4.991	15.830	22.534
GI_b	10,013	0.008	0.015	0.000	0.002	0.084
GW	10,013	0.259	0.438	0.000	0.000	1.000
ZScore	10,013	4.215	4.178	0.445	2.911	28.407
Clan	10,013	2.754	1.921	0.000	2.780	6.575
ESG_D	8,994	0.185	0.079	0.000	0.175	0.686
OSR_A	10,013	0.708	2.881	0.000	0.000	19.537
OSR_F	10,013	0.068	0.314	0.000	0.000	2.928
GInnovation	10,013	0.412	0.805	0.000	0.000	6.599
GInnovation_bub	10,013	-0.099	0.370	-1.376	-0.123	2.391

Panel B: Subgroup sample for the dependent variable							
Variable	Zodiac = 1			Zodiac = 0			Diff (0-1)
	Obs	Mean	Median	Obs	Mean	Median	t-test
GIE	1,106	0.440	0.464	8,907	0.394	0.428	-0.046***
GIE_R	1,034	0.769	0.906	8,376	0.669	0.885	-0.100***
GI_a	1,106	15.851	15.830	8,907	15.838	15.825	-0.013**
GI_b	1,106	0.009	0.003	8,907	0.008	0.002	-0.002***

Note: Panel A reports the descriptive statistics for the full sample. Panel B reports subsample statistics for the dependent (and alternative dependent) variables stratified by Zodiac status, along with t-tests for differences in means. **, * and * indicate significance levels at the 1%, 5%, and 10%, respectively. Variable definitions and sources are in Table 1.

Table 3: Correlations and tests for multicollinearity

Panel A: Correlation matrix																
Variables	GIE	Zodiac	Size	Firmage	ROA	TobinQ	Cash	Grow	Intangible	LEV	SOE	Top1	Boardsize	Duality	Overseas	Degree
GIE	1.00															
Zodiac	0.12***	1.00														
Size	-0.37***	-0.04***	1.00													
Firmage	-0.14***	-0.05***	0.47***	1.00												
ROA	0.12***	0.02**	-0.09***	-0.18***	1.00											
TobinQ	0.20***	0.01	-0.33***	0.02**	0.33***	1.00										
Cash	0.01	0.00	0.05***	0.07***	0.11***	-0.02*	1.00									
Grow	0.04***	0.04***	-0.01	-0.06***	0.18***	0.06***	0.03***	1.00								
Intangible	-0.10***	0.00	0.06***	0.10***	-0.04***	-0.03***	-0.10***	0.01	1.00							
LEV	-0.28***	0.00	0.51***	0.40***	-0.37***	-0.25***	0.12***	0.04***	0.06***	1.00						
SOE	-0.10***	-0.05***	0.35***	0.43***	-0.17***	-0.12***	0.06***	-0.06***	0.06***	0.30***	1.00					
Top1	-0.06***	-0.03**	0.18***	-0.08***	0.07***	-0.10***	0.06***	0.00	0.03***	0.04***	0.24***	1.00				
Boardsize	-0.17***	-0.03***	0.28***	0.17***	-0.06***	-0.12***	0.02**	-0.03***	0.04***	0.20***	0.27***	0.03***	1.00			
Duality	0.04***	0.00	-0.19***	-0.27***	0.07***	0.07***	-0.03***	0.03***	-0.08***	-0.17***	-0.31***	-0.05***	-0.17***	1.00		
Overseas	0.03***	0.00	0.00	-0.04***	0.05***	0.05***	0.00	0.02*	-0.03***	-0.05***	-0.13***	-0.02	-0.02**	0.05***	1.00	
Degree	-0.03***	-0.02*	0.10***	0.04***	-0.01	0.01	-0.01	0.01	0.04***	0.02*	0.13***	0.02**	0.07***	-0.02	0.17***	1.00

Panel B: VIF test results																
Variable	Size	Firmage	LEV	SOE	ROA	TobinQ	Top1	Duality	Boardsize	Degree	Cash	Overseas	Grow	Intangible	Zodiac	
VIF	1.98	1.76	1.72	1.55	1.45	1.37	1.18	1.15	1.15	1.07	1.07	1.06	1.06	1.03	1.01	
1/VIF	0.51	0.57	0.58	0.65	0.69	0.73	0.85	0.87	0.87	0.94	0.94	0.94	0.94	0.97	0.99	

Note: This table reports the test results for the correlation and multicollinearity of the main research variables. Panel A reports the results of the Pearson correlation of main variables used in the analysis. ***, ** and * indicate significance levels at the 1%, 5%, and 10%, respectively. Panel B reports the results of variance inflation factors for the main variables to test for multicollinearity. A complete description of variables is in Table 1.

Table 4: Benchmark regression results

	Original sample		PSM (neighbor)	PSM (radius)	Entropy
	(1)	(2)	(3)	(4)	(5)
Zodiac	0.041*** (0.003)	0.040*** (0.003)	0.031*** (0.007)	0.040*** (0.003)	0.039*** (0.003)
Size		0.000 (0.006)	0.001 (0.015)	-0.001 (0.006)	0.001 (0.008)
Firmage		-0.015*** (0.005)	-0.026* (0.014)	-0.015*** (0.005)	-0.015** (0.007)
ROA		0.114** (0.049)	0.086 (0.180)	0.114** (0.050)	0.084 (0.073)
TobinQ		0.001 (0.002)	-0.002 (0.005)	0.001 (0.002)	0.002 (0.003)
Cash		0.003 (0.008)	-0.061* (0.034)	0.003 (0.008)	-0.012 (0.017)
Growth		0.008** (0.004)	0.005 (0.009)	0.008** (0.004)	0.007* (0.004)
Intangible		0.018 (0.053)	-0.221 (0.200)	0.015 (0.053)	-0.035 (0.060)
LEV		-0.084*** (0.022)	-0.095* (0.056)	-0.084*** (0.022)	-0.087*** (0.027)
SOE		0.032*** (0.011)	0.089** (0.044)	0.033*** (0.011)	0.049** (0.022)
Top1		0.085** (0.040)	-0.154 (0.097)	0.085** (0.040)	0.023 (0.049)
Boardsize		-0.139*** (0.018)	-0.239*** (0.058)	-0.138*** (0.018)	-0.157*** (0.020)
Duality		-0.008 (0.006)	-0.005 (0.018)	-0.008 (0.006)	-0.014 (0.009)
Overseas		0.010 (0.010)	0.065 (0.042)	0.010 (0.010)	0.009 (0.014)
Degree		0.001 (0.002)	-0.002 (0.008)	0.001 (0.003)	0.006 (0.004)
Constant	0.394*** (0.000)	0.707*** (0.140)	1.049*** (0.326)	0.712*** (0.140)	0.739*** (0.176)
Cluster	Firm	Firm	Firm	Firm	Firm
Year FE	Yes	Yes	Yes	Yes	Yes
Firm×Chair FE	Yes	Yes	Yes	Yes	Yes
Observations	10,013	10,013	2,099	10,006	10,013
Adj. R^2	0.621	0.636	0.702	0.636	0.711

Note: This table reports the regression results of the effect of chairmen's zodiac superstitions on their firms' green investment efficiency. **The dependent variable is green investment efficiency (GIE).** Columns (1) and (2) present the results without and with the control variables, respectively. Column (3) and Column (4) present the estimated effect of the main effect using 1:1 nearest-neighbor propensity score matching (PSM) and radius PSM, respectively. Column (5) shows the results obtained after applying entropy balancing matching. Variables are defined in Table 1. Robust standard errors, clustered at the firm level, are reported in parentheses. ***, ** and * indicate significance levels at the 1%, 5%, and 10%, respectively.

Table 5: Robustness Checks: Subsample Analysis and Confounding Controls

Panel A: Subsample-based sensitivity analysis						
	CCP	Non-CCP	Lunar	Before 1966	1966–1978	After 1978
	(1)	(2)	(3)	(4)	(5)	(6)
Zodiac	0.038*** (0.005)	0.041*** (0.004)	0.040*** (0.003)	0.041*** (0.004)	0.035*** (0.006)	0.082*** (0.018)
Constant	0.691*** (0.219)	0.657*** (0.186)	0.715*** (0.143)	0.041*** (0.004)	0.035*** (0.006)	0.082*** (0.018)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	Firm	Firm	Firm	Firm	Firm	Firm
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm × Chair FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,881	5,132	9,690	6,400	3,254	369
Adj. R^2	0.656	0.630	0.638	0.708	0.753	0.791

Panel B: Controlling for potential confounding factors					
	Childhood poverty	Corporate anniversary		Additional controls	
	(1)	(2)	(3)	(4)	(5)
Zodiac		0.040*** (0.003)		0.040*** (0.003)	0.042*** (0.003)
Poverty	0.004 (0.009)	0.005 (0.009)			
Anniversary			-0.005 (0.003)	-0.005 (0.003)	
Chair_Female					0.031 (0.020)
Chair_FB					-0.003 (0.009)
Chair_Salary					-0.000 (0.001)
Chair_Age					-0.000 (0.001)
Chair_Share					-0.014 (0.007)
Chair_INDEP					-0.030 (0.033)
Constant	0.700*** (0.142)	0.708*** (0.140)	0.699*** (0.142)	0.707*** (0.140)	-0.330 (0.528)
Controls	Yes	Yes	Yes	Yes	Yes
Cluster	Firm	Firm	Firm	Firm	Firm
Year FE	Yes	Yes	Yes	Yes	Yes
Firm × Chair FE	Yes	Yes	Yes	Yes	Yes
Observations	6,454	6,454	10,013	10,013	10,013
Adj. R^2	0.627	0.636	0.627	0.636	0.636

Note: This table presents robustness checks addressing potential confounding factors. **The dependent variable is *GIE*.** Panel A columns (1)–(2) test the main effect by splitting the sample according to the chairperson’s Communist Party membership. Column (3) presents the results after excluding chairpersons born in January or February. Columns (4)–(6) further divide the sample into the periods before, during, and after the 1966–1978 Cultural Revolution. Panel B columns (1)–(2) incorporate early-life poverty: column (1) reports its direct effect, while column (2) includes it as a control when estimating the main effect. Columns (3)–(4) examine corporate anniversaries: column (3) reports their effect, and column (4) re-estimates the zodiac effect while controlling for anniversaries. Column (5) further controls for a set of conventional chairperson characteristics. Variables are defined in Table 1. Robust standard errors clustered at the firm level are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 6: Dynamic analysis of chairperson zodiac year on green investment efficiency

<i>Dependent variable</i> →	Dynamic changes		Event analysis			
	ΔGIE (1)	ΔGIE (2)	GIE (3)	GIE (4)	GIE (5)	GIE (6)
Zodiac_No_to_Yes	0.157*** (0.024)					
Zodiac_Yes_to_No		-0.095** (0.037)				
4 years before Zodiac						0.001 (0.009)
3 years before Zodiac					-0.011 (0.007)	-0.010 (0.009)
2 years before Zodiac				-0.004 (0.006)	-0.006 (0.007)	-0.005 (0.008)
1 year before Zodiac			-0.005 (0.006)	-0.006 (0.007)	-0.008 (0.007)	-0.007 (0.008)
Zodiac			0.038*** (0.004)	0.037*** (0.005)	0.036*** (0.006)	0.037*** (0.007)
1 year after Zodiac			0.013*** (0.005)	0.013** (0.006)	0.011* (0.007)	0.013* (0.007)
2 years after Zodiac				-0.000 (0.005)	-0.001 (0.006)	0.000 (0.007)
3 years after Zodiac					0.000 (0.007)	0.002 (0.008)
4 years after Zodiac						0.006 (0.008)
Constant	0.287 (0.239)	0.369 (0.250)	0.699*** (0.141)	0.700*** (0.140)	0.702*** (0.140)	0.703*** (0.141)
Δ Controls	Yes	Yes	No	No	No	No
Controls	No	No	Yes	Yes	Yes	Yes
Cluster	Firm	Firm	Firm	Firm	Firm	Firm
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm $\times$ Chair FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,292	8,292	10,013	10,013	10,013	10,013
Adj. R^2	0.885	0.884	0.633	0.634	0.635	0.634

Note: This table presents the relationship between the main variables within a dynamic framework. Columns (1) and (2) report the impact of chairpersons' transition into her zodiac year (*Zodiac_No_to_Yes*) and out of it (*Zodiac_Yes_to_No*) on the growth of green investment efficiency ($\Delta GIE = (GIE_t - GIE_{t-1}) / GIE_{t-1}$). The control variables are defined consistently with the baseline model but are measured as year-over-year differences, except for the variables *Soe*, *Oversea*, and *Degree*, which remain in their level form as they are time-invariant. Columns (3) to (6) present the results of event analysis, examining the dynamic effects from four years prior to four years after the chairperson's zodiac year on green investment efficiency (*GIE*). Variables are defined in Table 1. Robust standard errors, clustered at the firm level, are reported in parentheses. ***, ** and * indicate significance levels at the 1%, 5%, and 10%, respectively.

Table 7: Regression results with alternative dependent variables

<i>Dependent variable →</i>	<i>GIE_R</i>	<i>GI_a</i>	<i>GI_b</i>
	(1)	(2)	(3)
Zodiac	0.049*** (0.008)	0.140*** (0.054)	0.002*** (0.000)
Size	-0.127*** (0.016)	0.331*** (0.108)	-0.004*** (0.001)
Firmage	-0.008 (0.011)	0.185** (0.092)	0.002*** (0.001)
ROA	0.381*** (0.124)	0.882 (0.844)	0.010 (0.006)
TobinQ	-0.008* (0.005)	-0.050 (0.033)	-0.000 (0.000)
Cash	-0.035* (0.018)	-0.004 (0.132)	-0.002* (0.001)
Growth	0.012 (0.008)	-0.080 (0.061)	-0.000 (0.000)
Intangible	0.028 (0.121)	-1.215 (0.993)	-0.011 (0.008)
LEV	-0.104** (0.049)	1.128*** (0.387)	0.014*** (0.003)
SOE	0.063 (0.039)	-0.329 (0.203)	-0.002 (0.001)
Top1	0.058 (0.091)	-1.736** (0.702)	-0.011** (0.005)
Boardsize	-0.280*** (0.035)	2.572*** (0.309)	0.015*** (0.002)
Duality	-0.021 (0.013)	0.085 (0.111)	0.002* (0.001)
Overseas	0.013 (0.023)	0.408** (0.191)	0.000 (0.001)
Degree	-0.007 (0.006)	0.096** (0.046)	0.000 (0.000)
Constant	4.155*** (0.359)	2.936 (2.441)	0.053*** (0.017)
Cluster	Firm	Firm	Firm
Year FE	Yes	Yes	Yes
Firm × Chair FE	Yes	Yes	Yes
Observations	9,410	10,013	10,013
Adj. R^2	0.766	0.719	0.529

Note: This table reports the regression results after replacing the core explanatory variable. Column (1) presents the results of the effect of chairpersons' zodiac year on corporate green investment efficiency, with GIE now been calculated using the super-SBM method. Columns (2) and (3) report the regression results of chairpersons' zodiac year on corporate green investment measured by two different calculation methods. Specifically, $GI_a = \ln(\text{amount of green investment} + 1)$ and $GI_b = \text{amount of green investment}/\text{total assets}$. Variables are defined in Table 1. Robust standard errors, clustered at the firm level, are reported in parentheses. ***, ** and * indicate significance levels at the 1%, 5%, and 10%, respectively.

Table 8: Mediation analysis

Panel A: Greenwashing as a mediator		
Dependent variable →	GW (1)	GIE (2)
Zodiac	-0.037*** (0.013)	0.039*** (0.003)
GW		-0.007* (0.004)
Constant	-1.406*** (0.528)	0.697*** (0.140)
Controls	Yes	Yes
Cluster	Firm	Firm
Year FE	Yes	Yes
Firm × Chair FE	Yes	Yes
Observations	10,013	10,013
Adj. R^2	0.498	0.640
Indirect effect	0.00026	
Indirect/Total	0.66%	
Bootstrap [95% conf. interval]	(0.0012, 0.0026)	
Panel B: Default risk as a mediator		
Dependent variable →	DR (3)	GIE (4)
Zodiac	0.216** (0.092)	0.039*** (0.003)
DR		0.002** (0.001)
Constant	-7.916** (3.623)	0.720*** (0.140)
Controls	Yes	Yes
Cluster	Firm	Firm
Year FE	Yes	Yes
Firm × Chair FE	Yes	Yes
Observations	10,013	10,013
Adj. R^2	0.854	0.636
Indirect effect	0.0004	
Indirect/Total	1.02%	
Bootstrap [95% conf. interval]	(0.0005, 0.0018)	

Note: This table presents regression results exploring the mediating effects of greenwashing and default risk on the main relationship. Column (1) examines the impact of chairpersons' zodiac year on greenwashing behavior. Column (2) assesses its effect on green investment efficiency, controlling for greenwashing. Column (3) evaluates the relationship between zodiac year and default risk, while Column (4) analyzes green investment efficiency after accounting for default risk. We calculate the indirect effect using the product of coefficients method. For the mediator *GW*, this is the product of the path from the independent variable to *GW* and the path from *GW* to the dependent variable: $(-0.037) \times (-0.007) = 0.00026$. The total effect is the sum of the direct effect and this indirect effect ($0.039 + 0.00026$). This same product-of-coefficients method is applied to calculate the indirect effect for the other mediator. Variables are defined in Table 1. Robust standard errors, clustered at the firm level, are reported in parentheses. ***, ** and * indicate significance levels at the 1%, 5%, and 10%, respectively.

Table 9: Cross-heterogeneity tests

Panel A: Clan culture as a moderator			
<i>Sample</i> →	Full sample (1)	Same Region (2)	Diff Region (3)
Zodiac	0.023*** (0.006)	0.031*** (0.012)	0.025*** (0.008)
Clan	-0.083*** (0.005)	-0.088*** (0.008)	-0.049*** (0.006)
Zodiac × Clan	0.010*** (0.002)	0.010*** (0.004)	0.002 (0.003)
Controls	Yes	Yes	Yes
Constant	0.931*** (0.130)	0.898*** (0.206)	0.657*** (0.210)
Cluster	Firm	Firm	Firm
Year FE	Yes	Yes	Yes
Firm × Chair FE	Yes	Yes	Yes
Observations	10,013	3,386	3,623
Adj. R^2	0.695	0.816	0.655
p-value of Fisher test		0.004	

Panel B: ESG rating divergence as a moderator			
<i>Sample</i> →	Full sample (1)	H_Pollution (2)	L_Pollution (3)
Zodiac	0.061*** (0.008)	0.065*** (0.010)	0.052** (0.022)
ESG_D	-0.010 (0.018)	0.005 (0.019)	-0.003 (0.030)
Zodiac × ESG_D	-0.106** (0.043)	-0.170*** (0.053)	-0.085 (0.115)
Constant	0.651*** (0.143)	0.353* (0.203)	0.792*** (0.210)
Controls	Yes	Yes	Yes
Cluster	Firm	Firm	Firm
Year FE	Yes	Yes	Yes
Firm × Chair FE	Yes	Yes	Yes
Observations	8,994	3,314	5,680
Adj. R^2	0.639	0.662	0.691
p-value of Fisher test		0.048	

Note: This table reports the results examining the moderating role of clan culture (**Panel A**) and ESG rating divergence (**Panel B**). **The dependent variable is *GIE*.** In Panel A, Column (1) presents the full-sample regression results including the interaction term between clan culture and chairperson zodiac year. Columns (2) and (3) report the moderating effect of clan culture on the main relationship for the sub-samples grouped by whether the chairperson's birthplace is in the same region as the firm's location. In Panel B, Column (1) shows the full-sample regression results with the interaction term between ESG rating divergence and the chairperson zodiac year. Columns (2) and (3) present the moderating effect of ESG rating divergence for the sub-samples of heavily polluting and non-heavily polluting firms. Variables are defined in Table 1. Robust standard errors, clustered at the firm level, are reported in parentheses. ***, ** and * indicate significance levels at the 1%, 5%, and 10%, respectively.

Table 10: The chairpersons' opportunistic shares reduction as a suppression mechanism

Panel A: Amount of opportunistic share sales			
Dep. variable →	GIE (1)	OSR_A (2)	GIE (3)
Zodiac	0.040*** (0.003)	0.977*** (0.103)	0.053*** (0.004)
OSR_A			-0.006*** (0.000)
Constant	0.707*** (0.140)	-7.104** (3.344)	0.786*** (0.161)
Controls	Yes	Yes	Yes
Cluster	Firm	Firm	Firm
Year FE	Yes	Yes	Yes
Firm × Chair FE	Yes	Yes	Yes
Observations	10,013	10,013	10,013
Adj. R ²	0.636	0.125	0.646
Indirect effect		-0.0059	
Indirect/Total		-12.5%	
Bootstrap [95% conf. interval]		(-0.0112, -0.0074)	

Panel B: Frequency of opportunistic share sales			
Dep. variable →	OSR_F (1)	GIE (2)	
Zodiac	0.091*** (0.013)	0.051*** (0.004)	
OSR_F		-0.044*** (0.004)	
Constant	-0.938** (0.369)	0.784*** (0.161)	
Controls	Yes	Yes	
Cluster	Firm	Firm	
Year FE	Yes	Yes	
Firm × Chair FE	Yes	Yes	
Observations	10,013	10,013	
Adj. R ²	0.101	0.643	
Indirect effect		-0.0004	
Indirect/Total		-0.85%	
Bootstrap [95% conf. interval]		(-0.0086, -0.0051)	

Note: This table reports the regression results examining the role of the chairpersons' opportunistic reduction amount (**Panel A**) and frequency (**Panel B**) as suppressor variables in the main relationship. In Panel A, Column (1) presents the result of the chairperson zodiac year on corporate green investment efficiency. Column (2) reports the effect of the chairperson zodiac year on the amount of opportunistic selling (*OSR_A*). Column (3) shows the results for the main effect after further controlling for *OSR_A*. In Panel B, Column (1) reports the effect of the chairperson zodiac year on the frequency of opportunistic selling (*OSR_F*), and Column (3) presents the results for the main effect after controlling for *OSR_F*. The indirect effect is calculated as the product of the path coefficients ($Zodiac \rightarrow OSR_A$ and $OSR_A \rightarrow GIE$), yielding $0.977 \times (-0.006) = -0.0059$. The ratio of the indirect effect to the total effect ($Zodiac \rightarrow GIE$) is then $-0.0059/[0.053 + (-0.0059)]$. The same calculation methodology is applied to derive the results for Panel B. Variables are defined in Table 1. Robust standard errors, clustered at the firm level, are reported in parentheses. ***, ** and * indicate significance levels at the 1%, 5%, and 10%, respectively.

Table 11: Impact of chairpersons' zodiac year on corporate green innovation and green bubbles

Dependent variable →	GInnovation (1)	GInnovation_bub (2)	GIE (3)
Zodiac	-0.003 (0.019)	-0.055*** (0.013)	0.039*** (0.003)
GInnovation_bub			-0.011** (0.005)
Size	0.071* (0.036)	0.025 (0.021)	-0.000 (0.006)
Firmage	-0.031 (0.028)	0.014 (0.018)	-0.015*** (0.005)
ROA	0.436* (0.254)	-0.117 (0.133)	0.113** (0.049)
TobinQ	0.018* (0.011)	0.001 (0.007)	0.001 (0.002)
Cash	0.043 (0.052)	0.063* (0.034)	0.004 (0.008)
Growth	-0.022 (0.015)	-0.018* (0.010)	0.008** (0.004)
Intangible	-0.194 (0.363)	-0.750*** (0.232)	0.010 (0.053)
LEV	0.053 (0.105)	-0.063 (0.062)	-0.085*** (0.022)
SOE	-0.172** (0.078)	0.005 (0.055)	0.033*** (0.011)
Top1	0.240 (0.193)	0.099 (0.098)	0.086** (0.040)
Boardsize	-0.066 (0.076)	0.020 (0.047)	-0.138*** (0.018)
Duality	-0.048 (0.040)	0.004 (0.020)	-0.008 (0.006)
Overseas	0.107* (0.058)	-0.170*** (0.042)	0.008 (0.010)
Degree	0.039** (0.018)	-0.047*** (0.008)	0.000 (0.002)
Constant	-1.132 (0.868)	-0.679 (0.477)	0.700*** (0.139)
Cluster	Firm	Firm	Firm
Year FE	Yes	Yes	Yes
Firm × Chair FE	Yes	Yes	Yes
Observations	10,013	10,013	10,013
Adj. R^2	0.719	0.338	0.636
Indirect effect		0.00061	
Indirect/Total		1.6%	
Bootstrap[95% conf. interval]		(0.0002, 0.0013)	

Note: This table reports the results of additional tests examining the effect of the chairperson zodiac year on corporate green innovation and its bubble. Column (1) presents the regression results of the chairperson zodiac year on corporate green innovation. Column (2) reports the estimated effect of the chairperson zodiac year on the green innovation bubble. Column (3) further presents the regression results of the chairperson zodiac year on green investment efficiency after controlling for the green innovation bubble. Variables are defined in Table 1. Robust standard errors, clustered at the firm level, are reported in parentheses. ***, ** and * indicate significance levels at the 1%, 5%, and 10%, respectively.

Table 12: The effect of China's 2015 environmental protection law

	Original sample		Entropy-DiD	
	(1)	(2)	(3)	(4)
Law×Post	0.054*** (0.006)	0.055*** (0.006)	0.064*** (0.007)	0.064*** (0.007)
Law×Post×Zodiac		0.038*** (0.006)		0.029*** (0.006)
Zodiac		0.028*** (0.004)		0.029*** (0.004)
Constant	0.593*** (0.141)	0.602*** (0.136)	0.563*** (0.147)	0.579*** (0.141)
Controls	Yes	Yes	Yes	Yes
Cluster	Firm	Firm	Firm	Firm
Firm × Chair FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	10,013	10,013	10,013	10,013
Adj. R^2	0.636	0.648	0.666	0.676

Note: This table examines the impact of China's 2015 New Environmental Protection Law. **The dependent variable is corporate green investment efficiency (GIE).** Column (1) presents the effect of the law (*Law×Post*) on GIE. Column (2) introduces the triple interaction term (*Law×Post×Zodiac*) to assess how the chairperson's zodiac year moderates the law's effect on GIE. Columns (3) and (4) report the corresponding regression results after applying entropy balancing. Variables are defined in Table 1. Robust standard errors clustered at the firm level are reported in parentheses. ***, ** and * indicate significance at the 1%, 5%, and 10% levels, respectively.

ONLINE APPENDIX

To accompany the paper:

The Green Code in Red Belts: Executives' Zodiac Beliefs and Green Investment Efficiency

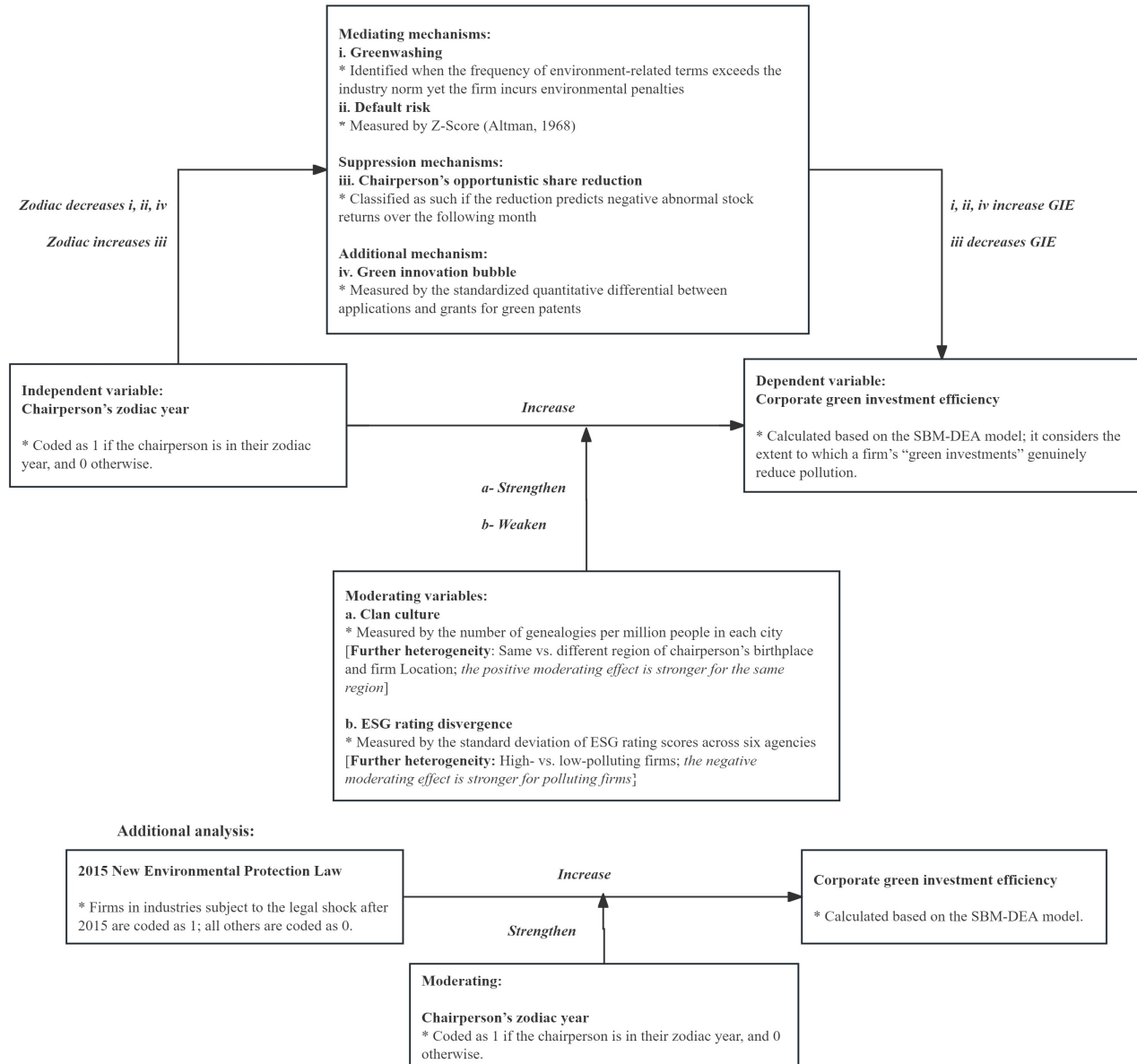
January 2026

Appendix contents

- Appendix A - This appendix contains the following figures:
 - Figure A.1 Research framework of this study;
 - Figure A.2 PSM and entropy balancing: results by chairperson's zodiac year status;
 - Figure A.3 Parallel trends in green investment efficiency around the zodiac year;
 - Figure A.4 Entropy balancing results: by exposure to the Environmental Law shock;
 - Figure A.5 Pre- and post-law parallel trends in green investment efficiency.
- Appendix B - This appendix contains the following table(s):
 - Table B.1 CEO zodiac year effects on green investment efficiency.

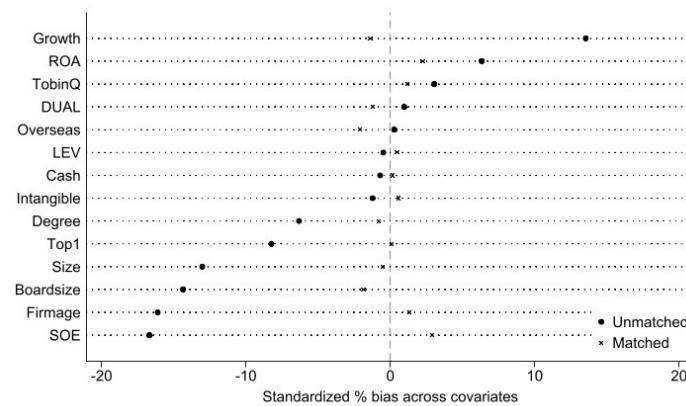
A. Figures (appendix)

Figure A.1: Research framework

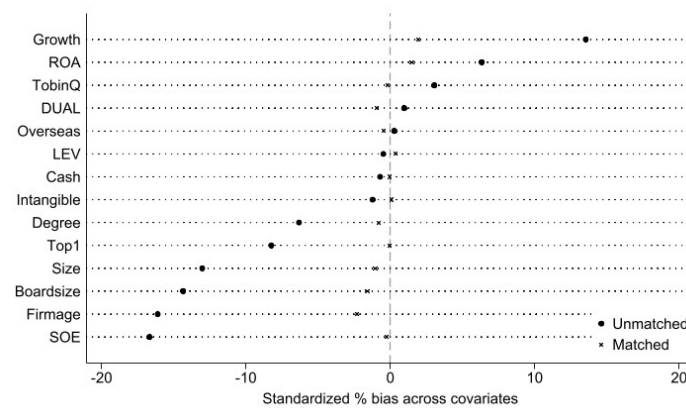


Note: The figure illustrates the conceptual relationships examined in this study.

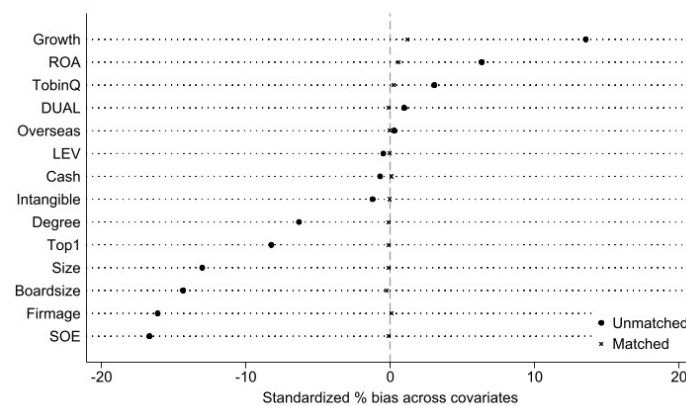
Figure A.2: PSM and entropy balancing results: by chairperson's zodiac year status



(a) 1:1 nearest-neighbor PSM



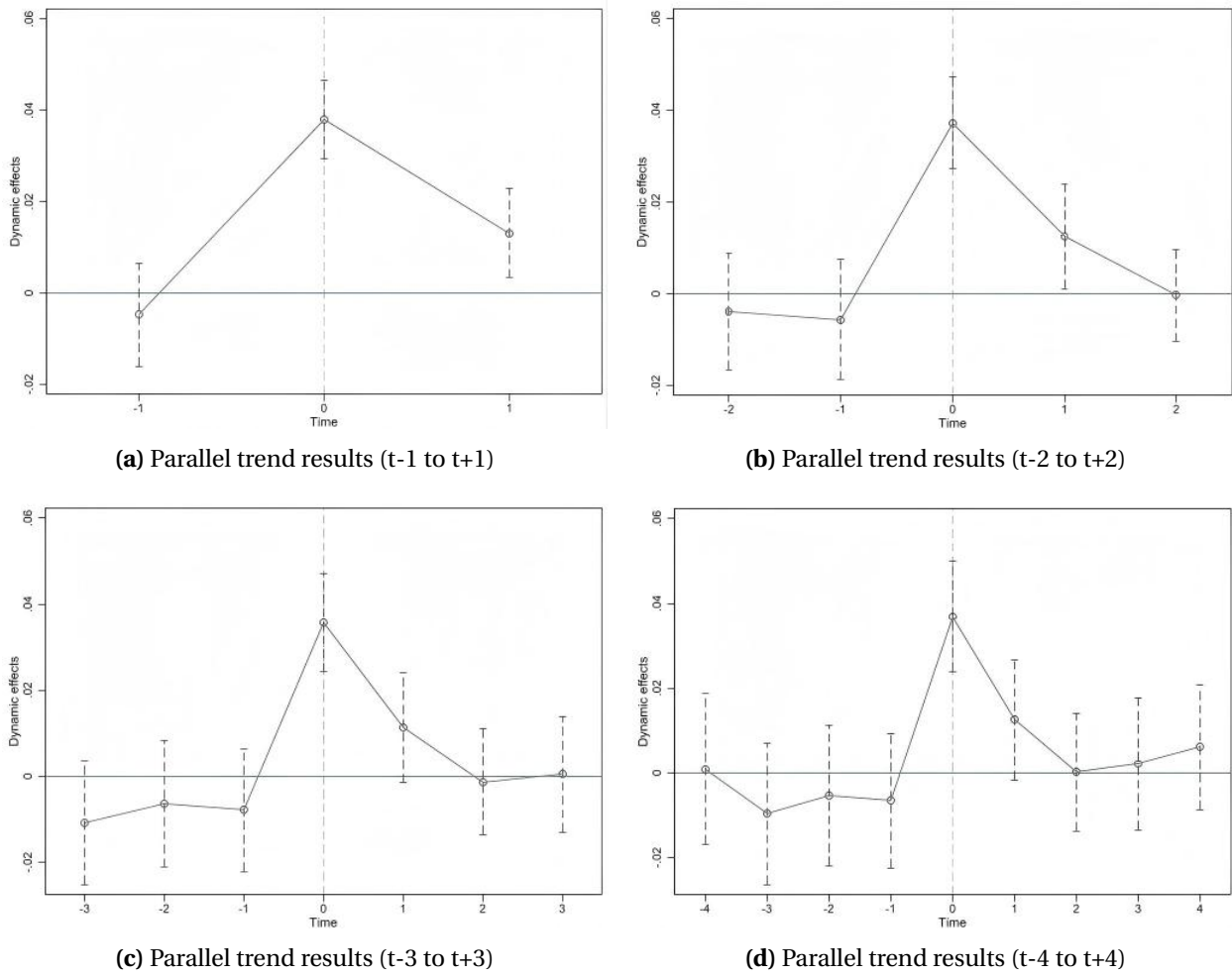
(b) Radius PSM



(c) Entropy balancing

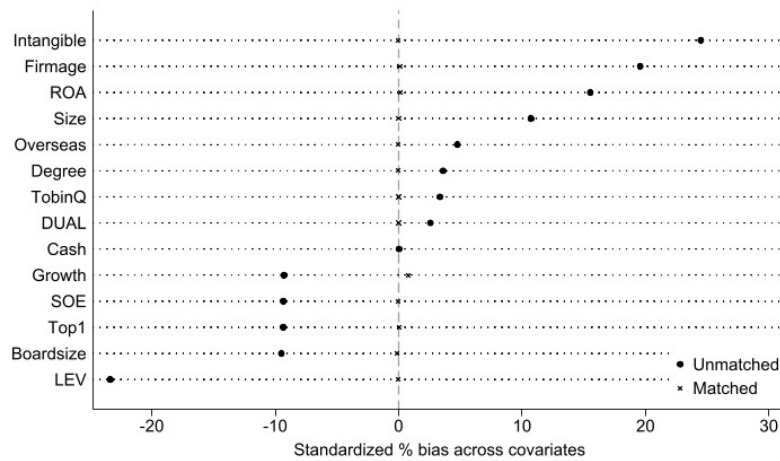
Note: The figures present a comparison of covariate balance before and after matching based on the chairperson's zodiac year status, using three distinct approaches: one-to-one nearest-neighbor propensity score matching (PSM) (subfigure a), radius PSM (subfigure b), and entropy balancing (subfigure c). The results demonstrate that all three methods substantially reduce covariate biases, with differences consistently falling below conventional thresholds after matching.

Figure A.3: Parallel trends in green investment efficiency around the zodiac year



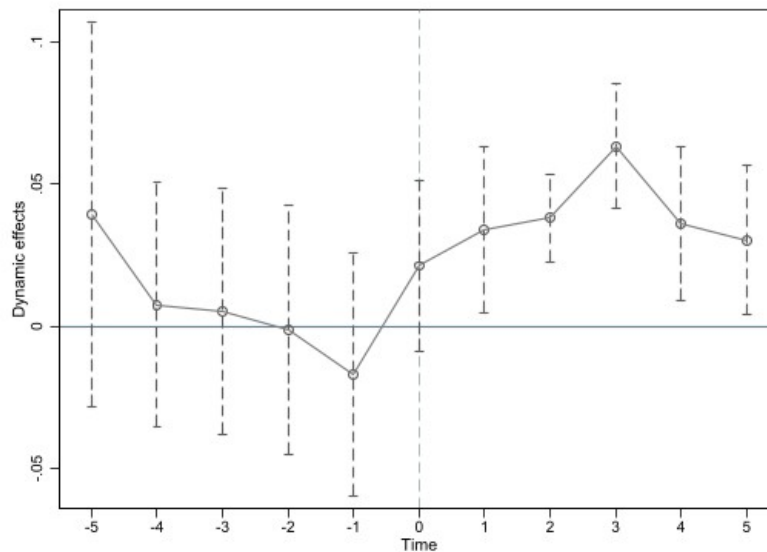
Note: Treating the chairperson's zodiac year as a shock, the figures examine the differential impact on green investment efficiency before, during, and after the chairperson's zodiac year. Subfigures (a) to (d) present parallel trends test results across four event windows ($t-1$ to $t+1$, $t-2$ to $t+2$, $t-3$ to $t+3$, $t-4$ to $t+4$). Year 0 ($t=0$) marks the zodiac year, with negative (positive) values on the horizontal axis indicating years before (after) the event. The results confirm no statistically significant pre-trends in green investment efficiency prior to the zodiac year. A significant increase occurs specifically during the zodiac year, followed by a reversion to statistically insignificant effects in subsequent years.

Figure A.4: Entropy balancing results: by exposure to the Environmental Law shock



Note: This figure displays covariate balance comparisons before and after entropy balancing, which is performed based on whether firms are affected by the 2015 New Environmental Protection Law. The results indicate that entropy balancing significantly reduced covariate imbalance, with post-matching differences consistently falling below conventional thresholds.

Figure A.5: Pre- and post-law parallel trends in green investment efficiency



Note: This figure presents the parallel trends test for corporate green investment efficiency surrounding the 2015 New Environmental Protection Law, which is treated as an exogenous shock. The base year ($t = 0$) marks the implementation of the law and the onset of the regulatory impact. Negative (positive) values on the horizontal axis indicate years before (after) the law intervention. The results confirm the absence of statistically significant pre-trends in green investment efficiency prior to the law's enactment, while showing a significant improvement following the regulatory intervention, thereby satisfying the parallel trends assumption.

B. Tables (appendix)

Table B.1: CEO zodiac year effects on green investment efficiency

	(1)	(2)	(3)	(4)
Zodiac_CEO	0.009** (0.004)	0.000 (0.003)	0.004 (0.004)	
Zodiac_chair		0.040*** (0.003)	0.036*** (0.003)	
Zodiac_both				0.046*** (0.008)
Constant	0.646*** (0.145)	0.981*** (0.111)	0.648*** (0.164)	0.641*** (0.165)
Controls	Yes	Yes	Yes	Yes
Cluster	Firm	Firm	Firm	Firm
Year FE	Yes	Yes	Yes	Yes
Firm × CEO FE	Yes	No	No	No
Firm FE	No	Yes	No	No
Firm × Chair × CEO FE	No	No	Yes	Yes
Observations	10,013	10,013	10,013	10,013
Adj. R^2	0.657	0.557	0.685	0.680

Note: This table presents supplementary analyses examining the effect of the CEO's zodiac year on corporate green investment efficiency under different specifications. **The dependent variable across all columns is *GIE*.** Robust standard errors, clustered at the firm level, are reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Column (1) reports the effect of the CEO's zodiac year (*Zodiac_CEO*) on *GIE* with *firm* × *CEO* and *year* fixed effects included. Without controlling for the chairperson's zodiac year, the CEO's zodiac year shows a positive and statistically significant effect on green investment efficiency (coefficient = 0.009, significant at the 5% level).

Columns (2) and (3) introduce the chairperson's zodiac year (*Zodiac_chair*) as a control variable while employing *firm* fixed effects and *firm* × *chairperson* × *CEO* fixed effects, respectively. After accounting for the chairperson's zodiac year, the CEO's zodiac year loses its statistical significance, whereas the chairperson's zodiac year remains highly significant. The results indicate that the zodiac year effect is primarily driven by the chairperson, not the CEO. This asymmetry underscores the chairperson's predominant role in shaping strategic environmental initiatives and highlights how corporate hierarchy filters the influence of culturally motivated behavior. The CEO's zodiac year, in contrast, exhibits no independent effect once the chairperson's influence is accounted for, reinforcing the chairperson's ultimate authority in guiding corporate green strategy.

Column (4) further reports the effect when both the chairperson and the CEO are in their zodiac years (denoted as *Zodiac_both*), controlling for *year* and *firm* × *chairperson* × *CEO* fixed effects. The coefficient of *Zodiac_both* is positively significant at the 1% level, and its magnitude (0.046) is the largest among all specifications. This suggests that when both top leaders are subject to the cultural-psychological influence of their zodiac years, it creates a mutually reinforcing decision-making environment that further amplifies corporate green investment efficiency.