A fish rots from the head down: The contagion effect of upstream firms' environmental misconduct on downstream firms' green innovation continuity*

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Abstract

As economic integration advances, the interdependence between upstream and downstream firms within the supply chain intensifies. Using data from Chinese listed firms (2010–2023), we examine the impact of suppliers' environmental misconduct on downstream firms' green innovation continuity. We show that suppliers' environmental misconduct significantly undermines downstream firms' green innovation continuity. In addition, suppliers' environmental misconduct lowers downstream executives' green cognition and increases financial constraints, reducing green innovation continuity. Further, greater bargaining power in downstream firms mitigates the negative impact of suppliers' environmental misconduct, while closer geographic proximity amplifies its harm to green innovation continuity. Moreover, we find that China's 2015 environmental protection law curbed suppliers' environmental misconduct, boosting green innovation continuity in downstream firms. Finally, talent introduction policies enhance green innovation continuity, though this effect is weakened by suppliers' environmental misconduct. Our findings add to the green supply chain literature, provide a perspective of green innovation continuity for downstream firms' governance**,** and expand research on the impact of exogenous policies and environmental regulations on firms.

JEL classifications: G30, L22, Q51, Q55

Keywords: corporate green governance; supply chain information transmission; environmental misconduct; green innovation continuity; green policy; financial constraints

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1 Introduction

The environmental performance of firms has increasingly become a critical determinant of their long-term financial success and sustainability (Gillan et al., 2021; Konar & Cohen, 2001). In supply chains, the behavior of upstream firms can have significant ripple effects on downstream partners, influencing their operations, strategic decisions, and innovation capabilities (Dolgui et al., 2018; Y. Li et al., 2021). This study explores how environmental misconduct by upstream firms acts as a contagion, disrupting the green innovation continuity of downstream firms. From a corporate finance perspective, we investigate the transmission mechanisms through which supplier misconduct undermines downstream firms' efforts to maintain sustainable innovation. By analyzing these dynamics, we contribute to understanding how supply chain relationships and environmental considerations intersect, offering insights into mitigating risks and fostering sustainable development within interconnected corporate ecosystems.

Pearce et al. (1989) suggest that integrating environmental considerations into major corporate decisions can resolve the conflict between profitable growth and environmental protection. Green innovation, a distinct form of corporate social responsibility (Kraus et al., 2020), involves allocating financial and technical resources to translate environmental goals and strategies into corporate initiatives, thereby enhancing environmental performance. As such, it is the key for sustainable development and strengthening competitive advantage (Bataineh et al., 2024; Long et al., 2023; Zhang & Zhu, 2019). However, green innovation involves high costs, risks, and long payback periods (Del Río et al., 2010; Xiang et al., 2022), often discouraging firms from sustained efforts.

Firms, as major consumers of resources and contributors to environmental issues, frequently rely on traditional, unsustainable growth models that prioritize short-term gains over long-term sustainability (Soppe, 2004). This reliance not only perpetuates ecological degradation but also restricts their growth potential in the face of increasingly stringent resource and environmental regulations worldwide (Rennings & Rammer, 2011). For China, the world's largest carbon emitter, this issue is particularly critical.[1] The nation faces mounting international pressure to reduce emissions while balancing its economic development goals (Bloomberg News, 2024). As environmental regulations tighten and global expectations shift toward greener practices, Chinese firms must confront the dual challenge of transitioning to sustainable growth models and maintaining their competitiveness in the global market.

With the increasing economic integration, different enterprises have formed a new interdependence and synergistic development relationship based on a clear division of labor (Belso-Martínez et al., 2017); for example, supply chains based on the purchase and sale of products and the flow of funds are gradually being established among enterprises, which have become important stakeholders of each other (Andersson et al., 2023; Hossain et al., 2023). Therefore, in supply chain relationships, green decisions of downstream firms, i.e., customer firms, are inevitably affected by the environmental behavior of upstream firms, i.e., supplier firms, but empirical evidence is lacking; this study fills this critical gap by considering the contagion effect of environmental misconduct of upstream firms on the green investment of downstream firms.

Supplier environmental misconduct heightens downstream firms' uncertainty in green decision-making by signaling supply chain environmental risks to external stakeholders. When suppliers are exposed for environmental violations, many downstream firms adjust their decisions accordingly (Bisetti et al., 2023; Custodio et al., 2024; Dai et al., 2021). For instance, after a textile manufacturer was found discharging hazardous substances into a river, Levi's required its key suppliers to disclose pollution data and committed to achieving zero hazardous chemical discharge in its supply chain by 2020. Also, our research sample reveals that downstream firms reduce their procurement share from corresponding suppliers following the occurrence of environmental misconduct by those suppliers.[2] This highlights the strong influence of upstream firms' misconduct on downstream firms' actions. Thus, it is

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[1] For example, in 2023, green patents accounted for only 3.05% of the 27.3 million patents held by Chinese listed firms, highlighting the need for greater green innovation efforts.

[2] Appendix I illustrates this observation with parallel trends; it is not the research question or task of this paper, but an additional test to help explain our motivation.

crucial to explore how supplier environmental misconduct impacts the green innovation continuity of downstream firms.

This study uses data from Chinese listed firms spanning 2010 to 2023 to investigate how environmental misconduct by upstream suppliers influences the continuity of green innovation efforts in downstream firms. Green innovation continuity is a specialized aspect of firms' ongoing innovation efforts (Guarascio & Tamagni, 2019). Green innovation continuity, a critical aspect of sustainable corporate development, reflects a firm's ability to maintain consistent and long-term efforts in environmentally friendly innovation. Corporate green innovation continuity differs from general green innovation by emphasizing a firm's capacity to maintain ongoing green initiatives through consistent innovation and development, aiming for sustained performance over time. Transforming high-emission, high-pollution, low-output business models requires long-term green innovation investment to adapt to environmental and market changes. However, sustained green innovation demands greater resources, costs, and risks than short-term efforts, making it vital to examine external factors influencing firms' commitment. Many firms' willingness to sustain green innovation is fragile, often shaken by adverse external shocks. By focusing on the ripple effects within supply chains, this research sheds light on how suppliers' environmental failures disrupt downstream firms' innovation processes.

Figure 1 summarizes our research framework. Our empirical analysis reveals that supplier environmental misconduct weakens the green innovation continuity of downstream firms. It does so by internally diminishing executives' green cognition and externally increasing financial constraints. The spread of negative signals forces downstream firms to shoulder environmental responsibilities for their suppliers' underperformance, intensifying financing difficulties as market investors question their environmental governance. This not only erodes downstream firms' confidence in green development but also reduces executives' commitment to the sustainable advancement of green innovation projects.

[Insert Figure 1 about here]

From the perspective of supplier concentration, we find that increased bargaining power among downstream firms reduces the negative impact of supplier environmental misconduct on their green innovation continuity. Firms with higher bargaining power are less dependent on suppliers and, therefore, less affected by their environmental misconduct. Additionally, examining geographical distance reveals that closer proximity between upstream and downstream firms amplifies the negative effect of supplier environmental misconduct on downstream firms' green innovation continuity. When suppliers and downstream firms are geographically closer, the connection between them becomes more apparent to investors. As a result, supplier misconduct imposes greater financing constraints on downstream firms, further hindering the continuity of their green innovation efforts.

Recognizing that firms' environmental misconduct is influenced by a country's laws and policies, we use China's revised Environmental Protection Law of 2015—considered the strictest in the nation's history—as an exogenous policy shock to supplier firms. Our findings show that the law compelled suppliers to reduce environmental misconduct, thereby enhancing the green innovation continuity of downstream firms. Additionally, we examine the effects of high-intensity talent introduction policies implemented by various Chinese cities since 2016, recognizing that individuals with higher human capital are more inclined to adopt strategies that support green innovation. These policies are found to facilitate green innovation, but this effect is weakened by suppliers' environmental misconduct. Overall, suppliers' environmental misconduct undermines downstream firms' green innovation continuity across multiple dimensions.

This study makes three key contributions. First, by applying signaling theory to the negative spillover effects of corporate environmental misconduct, we extend its application and provide a fresh look at the study of corporate environmental underperformance. While no uniform definition of environmental misconduct exists, prior literature has not systematically explored its spillover effects on supply chain firms. We address this gap by investigating how environmental misconduct by suppliers influences the green innovation continuity of downstream firms, shifting the focus from a firm's own environmental practices to the broader supply chain context and the factors that drive corporate green development.

Second, this study contributes to the literature on corporate green innovation continuity, specifically from the perspective of supply chain ripple effects. While existing research explores factors influencing green innovation, such as leadership (Begum et al., 2022), ESG performance (Q.-J. Wang et al., 2022), and digital transformation (Gao et al., 2023; Tang et al., 2023), limited attention has been given to green innovation continuity. This concept reflects firms' long-term commitment to sustainable reforms and their positive societal and environmental impact. Our study fills this gap by analyzing how upstream firms' behavior influences downstream firms' green innovation continuity within a supply chain context.

Finally, we contribute to the literature by looking at various mechanisms underlying the negative spillover effects of corporate environmental misconduct. By using executives' green cognition—defined as their proactive willingness to allocate resources such as time and effort toward environmental protection—as a mediating variable, we examine how environmental misconduct by upstream firms affects the green investment decisions of downstream firms. In doing so, we extend the application of Upper Echelons Theory to the context of inter-firm environmental dynamics. Incorporating the physical distance between upstream and downstream firms as a moderating variable, we demonstrate that closer proximity amplifies the impact of supplier misconduct on downstream firms' green innovation continuity, expanding geoeconomics' relevance to corporate governance. We also analyze how China's new environmental protection law affects downstream firms via suppliers' environmental misconduct, enriching studies on external green policies in business development. Additionally, we investigate the effect of talent introduction policies on downstream firms' green innovation continuity and examine how this relationship is influenced by supplier misconduct.

The paper is organized as follows: Section 2 formulates our hypotheses. Section 3 outlines the methods for quantifying research variables, selecting the firm sample, and constructing the empirical research model. Section 4 presents descriptive statistics, analyzes the empirical results of the main effects, and conducts robustness tests to validate the findings. Section 5 examines the mediating and moderating effects. Finally, Section 6 concludes the study.

2 Hypotheses development

2.1 Hypothesis on the main effect

Resource dependence theory highlights that interdependence between firms influences their strategic decisions and collaboration (Hillman et al., 2009; Pugliese et al., 2014). Suppliers' environmental underperformance can disrupt downstream firms' green innovation continuity through signaling effects. Environmental violations by suppliers signal non-compliance with green standards or other environmental risks (Florackis et al., 2023), which are transmitted to downstream firms. These signals increase supply chain information asymmetries and green transaction risks, making it harder for downstream firms to accurately assess suppliers' capacity and reliability (Guo, 2020). Such uncertainties strain cooperation, as downstream firms may face disruptions, lose supply chain specificity, and incur high costs and risks when replacing suppliers (Birge et al., 2023).

Additionally, downstream firms often bear the environmental liabilities linked to their suppliers' underperformance, including product quality traceability pressures (Biswas et al., 2023). These responsibilities create financial strain, operational risks, and weakened commitment to green innovation projects. Suppliers' environmental misconduct thus leads to financing difficulties, cash flow challenges, and operational risks, ultimately discouraging downstream firms from sustaining investments in green innovation.

> ***Hypothesis 1*** *Environmental misconduct by supplier firms inhibits downstream firms from continuous green innovation.*

2.2 Hypotheses on the transmission mechanisms

Subjective risk preferences and objective resource constraints affect firms' choices of their business strategies (Dolmans et al., 2014; Opper et al., 2017), which in turn affect their willingness to continue green innovation. Drawing on signaling theory and information asymmetry theory, we propose that suppliers' environmental misconduct impacts downstream firms' green innovation continuity by internally reducing executives' environmental cognition and by externally increasing resource constraints.

We begin by examining the effect of supplier environmental misconduct on the internal cognition of downstream firms. Environmental misconduct by suppliers, as upstream firms, can increase the risk of operational disruptions and lead to reputational damage, regulatory penalties, and other losses—ultimately resulting in a contraction of the raw material supply. This can exacerbate the uncertainty and volatility of downstream firms' future operations and development, leading to a decline in downstream firms' capital turnover and an increase in their operational risk. Continuous green innovation is inherently risky and marked by uncertain returns (X. Li & Vermeulen, 2021). These challenges are further intensified when suppliers engage in environmental misconduct, making it more difficult for managers of downstream firms to assess future growth prospects. For instance, they may anticipate that the spread of negative news could limit financing opportunities or even trigger a stock price crash (Andreou et al., 2021), forcing them to adjust their innovation strategies accordingly.

Executives, as important decision makers of firms, when sensing operational risks beyond expectations, focus more on traditional profitable projects with low return uncertainty or some hot market projects that can bring relief to their current financing difficulties (Tao et al., 2022; Yu et al., 2024), leading to a short-term tendency of green innovation and R&D, which is a manifestation of reduced green awareness.[3] Thus, when suppliers' environmental misconduct occurs, it is likely to result in narrow environmental awareness of downstream firms' executives and a reluctance to continue investing funds in green innovation projects.

Hypothesis 2 *Supplier environmental misconduct reduces the green*

[3] Some believe that the punishment of an upstream firm for environmental misconduct may deter the management of downstream firms from damaging the environment or violating environmental regulations. Our proposed mechanism of "reduced green awareness among downstream firms' executives" does not contradict the notion of "enhancing environmental compliance". The "green awareness" examined in our study fundamentally refers not to passive avoidance of environmental harm but to executives' proactive willingness to allocate resources (time and effort) toward environmental protection. However, the financial constraints imposed on downstream enterprises by suppliers' environmental misconduct hinder their capacity to cultivate such proactive environmental stewardship, creating a negative contagion effect. To analogize: legal punishment of offenders may deter others from committing crimes but does not necessarily motivate them to actively engage in virtuous behaviors. Conversely, the offender's associates (e.g., family members) may face collateral consequences (such as helping to pay fines or compensating for damages) that deplete their resources, leaving them unable to allocate time or funds to philanthropic endeavors. Similarly, while administrative penalties or reputational pressures on suppliers for environmental misconduct might compel downstream enterprises to avoid environmental violations, the associated negative spillovers simultaneously deplete their resources for proactive environmental initiatives, thereby manifesting as reduced green consciousness.

cognition of executives of downstream firms, weakening their green innovation continuity.

Next, we look at how suppliers' environmental misconduct can disrupt the financial flows of downstream firms. Environmental violations harm suppliers' product sales and, combined with substantial fines for these violations (Ma et al., 2022), weaken their ability to meet accounts payable and notes payable obligations. This increases the risk of defaults and delays in commercial credits (Kouvelis & Xu, 2021; Yun & Yu, 2024), transferring liquidity risks to downstream firms (Lamieri & Sangalli, 2019).

Further, environmental misconduct by supplier firms signals to outsiders an increased likelihood of operational disruptions and a diminished environmental reputation. Investors become more cautious when they receive such signals (Darendeli et al., 2022; Gualandris et al., 2021); for example, they assess the negative impact of a supplier's environmental violation on downstream firms and thus reduce their capital investment or demand higher rates of return, exacerbating the financing constraints of downstream firms. However, continuous green investment by firms requires long-term financial support, and estimating when benefits will be generated is difficult (Farza et al., 2021). Therefore, when financing is constrained, downstream firms do not continue but tend to scale back green innovation projects with high uncertainty of returns and invest their limited funds in robust projects (Tao et al., 2022; Yu et al., 2024). Therefore, suppliers' environmental misconduct can reduce green innovation continuity by downstream firms from a financing constraints perspective.

Hypothesis 3 *Environmental misconduct by suppliers increases the financing constraints of downstream firms, thereby weakening their green innovation continuity.*

2.3 Hypotheses regarding the moderating effects

We consider how the "distance" between upstream and downstream firms affects the relationship between suppliers' environmental behavior and downstream firms. Specifically, we discuss "distance" in two dimensions, one being the bargaining power of downstream firms in relation to their suppliers, which can be interpreted as the relative distance of market power. The other dimension is the geographical distance between upstream and downstream firms. We find that these two dimensions moderate the impact of suppliers' environmental misconduct on the continuity of green innovation in downstream firms.

We begin our discussion with the moderating role of downstream firms' bargaining power. In the supply chain, a firm's bargaining power plays a crucial role in its interactions with suppliers. When a firm has high bargaining power, it is less dependent on its suppliers and less susceptible to interference and influence from major suppliers (Chang et al., 2022; Crook & Combs, 2007). Consequently, when major suppliers engage in environmental misconduct, client firms with lower bargaining power are more likely to be adversely affected by these behaviors, facing more significant transfer risks and financing constraints and thus reducing continuous investment in green innovation projects. We use supplier concentration to measure a firm's bargaining power within the supply chain (Jiang et al., 2023); the higher the supplier concentration, the more dependent the firm is on its major suppliers, and the weaker its bargaining power in the supply chain, and thus more likely to be affected by supplier misbehavior and thus reduce continued investment in green innovation projects.

> ***Hypothesis 4*** *Compared to firms with high bargaining power in the supply chain, firms with low bargaining power are more likely to be affected by suppliers' environmental misconduct, leading to lower motivation to continue green innovation.*

Then, we shift the analysis to the moderating role of geographic distance. In recent years, the application of geo-economics in corporate governance has received increasing attention. According to the theory of spatial linkage and geographic clustering, participants producing and developing in a limited range of economic activity space are vulnerable to the lock-in risk posed by their proximate stakeholders Martínez-del-Río & Céspedes-Lorente, 2014). Therefore, if suppliers are physically close to downstream firms, other external stakeholders such as investors are more aware of the linkages between the two, which can exacerbate the negative contagion effect of suppliers' environmental misconduct on the green innovation continuity of downstream firms from the perspective of financing constraints.

In addition, the closer downstream firms are to their upstream firms geographically, the easier it is for them to obtain environmental information about their suppliers through on-site visits and inspections, and the more comprehensively they can estimate the negative financial contagion impacts of their suppliers' environmental misconduct, thus reducing downstream firms' confidence in their green development and weakening their green innovation continuity.

> ***Hypothesis 5*** *The closer the spatial distance between downstream firms and their suppliers, the more the negative impact of suppliers' environmental misconduct on the green innovation continuity of downstream firms.*

3 Research methods

3.1 Variables construction

This study focuses on exploring the impact of supplier environmental misconduct on downstream firms' green innovation continuity. We use downstream firms' executives' green cognition and financing constraints as the transmission mechanisms of this relationship and supplier concentration and upstream and downstream firms' geographic distance as the moderating variables. We explain the construction of these main variables.

3.1.1 Explained variable: Downstream firms' green innovation continuity

Before measuring green innovation continuity, we need to measure green innovation. Patents are evidence of the outputs of specific innovations; therefore, they are widely used as a measure of innovation. Referring to Xu et al. (2023) and Cui et al. (2022), we use the number of green patents filed by firms to measure green innovation. Based on the "IPC Green Inventory" developed by the World Intellectual Property Organization (WIPO), we select the sample firms on the website of China's State Intellectual Property Office (SIPO). Since the SIOP of China grants two types of patents, invention patents, and utility patents, we add up the green invention patents and green utility patents applied by firms to determine their green innovation capability.

Next, by referencing Pan et al. (2024), we synthesize the current and prior inputs of firms' green innovation to measure innovation persistence; we multiply the period-on-period growth rate of firms' green patent applications with the scale of green patent applications to measure green innovation continuity. In our empirical analysis $GIC_{i,t}$ indicates the green innovation continuity of downstream firm *i* in year *t* and *Patent* indicates the number of green patents filed by a firm, accounting for the years *t*, *t-1* and *t-2*. The specific formula is as follows.

$$GIC_{i,t} = \frac{Patent_{i,t} + Patent_{i,t-1}}{Patent_{i,t-1} + Patent_{i,t-2}} \times (Patent_{i,t} + Patent_{i,t-1}).$$

3.1.2 Explanatory variable: Suppliers' environmental misconduct

This study mainly refers to the approach of Shahab et al. (2023) in designing the variable of environmental misconduct. Specifically, this study measures corporate environmental misconduct through the two dimensions of firms being subjected to environmental administrative penalties (EP) and pollutant discharges (PD). Both EP and PD are dummy variables. EP is equal to 1 if a firm suffers an administrative penalty for environmental reasons in a year and 0 otherwise, and PD is equal to 1 if a firm has pollutant discharges and 0 otherwise. Information on enterprises' environmental administrative penalties and pollutant discharge behavior is taken from firms' annual environmental reports. Specifically, we obtain data from the China Research Data Services Platform (CNRDS) database.

We then construct an indicator of firms' environmental misconduct (EM), which is scored as 1 if the firm experiences environmental penalties (EP) or/and pollutant discharges (PD) within a year and 0 if it does not have any environmental penalties or pollutant discharges (neither of them).[4]

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[4] Environmental misconduct by Chinese firms can be considered from two perspectives: receiving environmental administrative penalties (EP) and pollutant discharges (PD), a widely used measurement method, such as in the literature by Wu et al. (2021) and Shahab et al. (2023). Given the availability of data, we refer to the method of Shahab et al. (2023) to obtain data on EP and PD from the CNRDS database. The database lists EP and PD in parallel (non-intersecting) columns, indicating that the data on environmental penalties and pollutant emissions are mutually exclusive. This is also the reason why Shahab et al. (2023) directly sum the two when designing the variables. However, we consider that there are sometimes unavoidable causal links between environmental penalties and pollutant emissions. Therefore, we adopt the method of recording 1 if a firm encounters EP or PD, and 0 otherwise. This is appropriate in our structure because we consider the impact of upstream firms' environmental misconduct on downstream firms rather than the impact on the upstream firms themselves. Also, according to China's accounting disclosure standards, each downstream enterprise has five suppliers. We implement the notation of 1 or 0 for each supplier and then sum the five suppliers to construct the ordinal variable, which is more appropriate than a direct summation of EP and PD for all suppliers.

Further, to create linkages between upstream suppliers and downstream firms, we use the CSMAR database to obtain information on the top five suppliers of listed firms; this is because Chinese Accounting Standards require firms to disclose their top five suppliers. Further, using the 'enterprise search' function of the TIANYANCHA platform, we exclude the enterprises that fail to make complete disclosure among the top five suppliers. The top five suppliers are then paired to downstream companies.

To measure suppliers' environmental misconduct, we construct an ordinal variable reflecting the number of a firm's top five suppliers involved in environmental misconduct within a year. A value of 0 indicates that none of the firm's suppliers committed environmental misconduct that year, 1 indicates one supplier was involved, and so on, up to 5, which indicates all five suppliers exhibited environmental misconduct. We denote this variable *Sup_EM*.

3.1.3 Mediating variables: Executive green cognition and corporate finance constraints

We consider how suppliers' environmental misconduct may change downstream firms' executives' green cognition and financing constraints; these changes can further affect firms' green innovation continuity.

For executives' green cognition, we refer to Liu & Chen (2024)'s measurement method and improve upon it. We use textual analysis to analyze the frequency of keywords appearing in firms' annual reports; we select 19 seed words based on the three dimensions of green competitive advantage awareness, corporate social responsibility awareness, and external environmental pressures. We consider that expressors often use multiple semantically similar words to describe the same concept or thing, and, in this study, the annual report is based on the Chinese context. Therefore, to reduce the error, it is necessary to expand the seed words with similar words. We use the CBOW (continuous bag of words) method in Word2Vec to train the Management's Discussion and Analysis (MD&A) of the annual report corpus to expand the keywords for executives' green cognition; we obtain a total of 91 keywords for text analysis.[5]

Further, when analyzing texts using these keywords, it is important to exclude the

[5] We report all seed words and extended words representing the executives' green cognition in Appendix 2.

greenwashing factor and hyperbolic linguistic claims, as they do not represent executives' correct green cognition and do not contribute to actual green innovation in their firms. Therefore, we further used NLP methods to identify possible greenwashing factors. Greenwashing expressions may involve ambiguous expressions such as "chemical-free" (virtually impossible as everything is made of chemicals) and "non-toxic" (without specifying under what conditions). Or it may be exaggerated or absolute terms, such as "100% sustainable", "completely biodegradable", "zero emissions" (often ignores indirect emissions), "revolutionary", "groundbreaking", "world's first", etc.[6] When our keywords appear with these greenwashing-conscious statements, we exclude the text from the statistics. On this basis, we construct the variable of executives' green cognition by the frequency of these words appearing in company annual reports. We calculate the word frequency by assigning unequal weights of 7:3 to the MD&A section and other sections of the annual report because the MD&A is the part that best reflects the cognition of the executive level and should be given more weight.[7]

For the other mediating variable, popular measures of corporate financing constraints are the KZ index (Kaplan & Zingales, 1997), the WW index (Whited & Wu, 2006), and the SA index (Hadlock & Pierce, 2010); the SA index is the most appropriate for this study because it does not overly involve financial indicators on the companies' statements and

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[6] We report the complete term containing unrealistic elements in Appendix 3.

[7] Existing literature exhibits divergent approaches to measuring executive cognition through annual reports. Some studies directly and simplistically rely on the Management Discussion & Analysis (MD&A) section to proxy executive cognition (e.g., Cole & Jones, 2005; Lee & Park, 2019; Z. Yu et al., 2025). However, this method is limited, as executives' cognitive patterns may not be fully captured in the MD&A—particularly in cases where executives are less expressive or verbose (Demers & Vega, 2008; F. Li, 2008). Complementary sections of annual reports, such as disclosures on green initiatives and investments, may also reflect executives' strategic priorities and awareness. On the other hand, some studies (e.g., Hao et al., 2025; Liu & Chen, 2024) utilize the entire annual report (including non-MD&A sections) to assess executive cognition, though this introduces inaccuracy due to potential confounding factors in non-MD&A content (e.g., boilerplate language or regulatory-mandated disclosures). To address these limitations, we adopt a balanced 7:3 weighting approach: the MD&A section is assigned a higher weight (70%) to prioritize its concentrated reflection of executive awareness and strategic intent, while non-MD&A sections receive a lower weight (30%) to account for supplementary signals of executives' environmental awareness and decision-making patterns. This hybrid methodology preserves the MD&A's primacy in capturing executive cognition while incorporating contextual insights from other report sections, thereby mitigating biases inherent in unilateral approaches.

suffers from fewer endogeneity issues. We construct the SA index by referring to Hadlock & Pierce (2010)'s method; the formula is $SA = -0.737 \times Size + 0.043 \times Size^2 - 0.040 \times Age$. A larger SA index represents a more severe financing constraint faced by a firm.

3.1.4 Moderating variables

The concentration of suppliers can measure the strength of a downstream firm's bargaining power; if a firm has a high concentration of its suppliers, its bargaining power is fragile compared to its suppliers, and thus, it is very susceptible to the ripple effects of its suppliers' behavior. Specifically, we use the supplier concentration Herfindahl-Hirschman index (*SCHHI*) to measure the bargaining power of a downstream firm. It is calculated as the sum of the squares of the ratios of a firm's purchases from its top five suppliers to the firm's total purchases.

This study calculates the spatial distance between downstream firms and their suppliers based on the registered addresses of the firms as recorded by the Administration for Industry and Commerce, and the data are available from the CSMAR database. Referring to Kang & Kim (2008), we then measure the geographic distance between downstream firms and their suppliers using the natural logarithm of the spatial distance between listed firms and their suppliers plus one and then taking its opposite.

3.1.5 Control variables

Considering some other factors affecting the continuity of firms' green innovation, we chose control variables from enterprises' financial, governance, and ownership perspectives. The first category of control variables reflects the firm's financial characteristics, including firm size (*Size*), profitability (*ROA*), market value (*TobinQ*), intangible asset (*Intangible*), gearing ratio (*Lev*), cash holdings (*Cash*), and capital expenditure (*Capital*). The second category of control variables reflects the corporate governance structure, including firm age (*Age*), board size (*Boardsize*), equity ownership concentration (*Top1*) and number of employees (*Employee*). We also consider the nature of the firm's property rights and use whether the firm is a state-owned enterprise as a control variable. As the dependent variable represents the continuity of green innovation in downstream firms, the control variables are derived from the characteristics of these downstream enterprises.

Table 1 reports in detail the definitions, measurement methods, and sources of the main variables of this study.

[Insert Table 1 about here]

3.2 Sample selection

This study selects A-share listed companies from 2011 to 2023 as the research sample. Following prior supply chain literature, a one-year lag effect is applied in the model. Consequently, the sample period for downstream firm data is 2011–2023, while the corresponding supplier data covers 2010–2022. The data for the variables in this study are sourced as follows: Information on the top five suppliers of listed firms comes from the CSMAR database. Data on corporate environmental misconduct is obtained from the CNRDS database. Green patent information, used to construct green innovation sustainability, is sourced from the IPC Green Inventory and China's State Intellectual Property Office (SIPO). Texts of annual reports, used to measure executives' green cognition, are retrieved from the Juchao Information website and company websites. Control variable data are also collected from the CSMAR database. Additionally, we exclude companies with missing financial data, as well as banks, insurance firms, and other financial institutions. ST and ST* companies are also excluded, along with firms whose operating income growth rates exceed 100% to eliminate the influence of mergers and restructuring. Also, we use winsorization to deal with outliers. This leads to a final sample of 3,584 firm-year observations from 2011 to 2023.[8]

3.3 Econometric model

To empirically examine the impact of suppliers' environmental misconduct on downstream firms' green innovation continuity, this study sets up the following regression model:

$$GIC_{i,t} = \alpha + \beta Sup\_EM_{j,t-1} + \gamma Control_{i,t} + Year_t + Firm_i + \varepsilon_{i,t}.$$

Model I: Test for the main effect

[8] The number of observations we obtained is normal because downstream listed companies should match with their supplier listed companies.

In the above specification, $GIC_{i,t}$ is the dependent variable, measuring the green innovation continuity of downstream firm i at time t. Further, the core independent variable is $Sup\_EM_{j,t-1}$; it denotes suppliers' environmental misconduct for year *t-1*. We use a one-year lag because, in supply chains, supplier behavior takes time to have a tangible effect on downstream firms. In addition, *Control* represents the control variables included in this study for downstream firms. *Firm* and *Year* represent downstream firm- and year-fixed effects. Finally, ε indicates the error term.

If the coefficient β of the core explanatory variable *Sup_EM* is significantly negative in the empirical test, then this indicates that supplier firms' environmental misconduct reduces downstream firms' green innovation continuity, thereby supporting Hypothesis 1.

4 Empirical results and analysis

4.1 Descriptive statistics

Table 2 shows the descriptive statistics for main variables in this study. In the sample, the value of the dependent variable *GIC* ranges from 0 to 88.2, and the standard deviation is 12.5, indicating that the green innovation continuity of downstream enterprises is imbalanced. While some firms actively and consistently engage in green innovation, others exhibit low levels of continuity. Furthermore, the explanatory variable *Sup_EM*, which measures the environmental misconduct of a firm's top five suppliers, is between 0 and 5, in line with our expectations. Finally, there are no remarkable outliers in the sample, and the distributions of all variables are reasonable and similar to other studies using Chinese data.

[Insert Table 2 about here]

We also show a Pearson correlation coefficient matrix in Table 3, Panel A. As expected, suppliers' environmental misconduct is negatively correlated with downstream firms' green innovation continuity. Additionally, in general, the correlation coefficients between variables are low, except for the correlation between firm size and employment scale, which is relatively high. Therefore, to ensure the rigor of the regression results, we further perform a VIF test, the results are reported in Table 3, Panel B. The VIF values of each variable are less than 5, so there is no serious multicollinearity, and the variables can be used for subsequent regression analysis.

[Insert Table 3 about here]

4.2 Baseline results

Table 4 presents the regression results of the baseline model; columns (1) and (2) present the results without and with the control variables. The coefficient of the core explanatory variable *Sup_EM* is significantly negative at the 5% before and after the inclusion of control variables. After adding the control variables, the green innovation continuity of downstream firms decreases by about 0.702 points as the environmental misconduct of suppliers increases. In economic terms, this indicates that an increase in suppliers' environmental misconduct by one standard deviation decreases green innovation continuity (GIC) by about 1.11 percentage points, corresponding to a decrease of about 0.31 percent relative to the mean (GIC mean = 3.65). The results indicate that supplier firms' environmental misconduct leads to decreased green innovation continuity in downstream firms, supporting Hypothesis 1.

Additionally, among the control variables, the coefficients of the variables *Age, ROA, TobinQ, Intangible* and *Employee* are all significantly positive, which suggests that longer firm age, higher profitability, higher market value, more intangible assets, and having more employers can promote firms' green innovation continuity. This result is theoretically valid.

In contrast, the coefficients for the variable *Cash* and the two governance-related variables, *Board Size* and *Top 1*, are significantly negative. This suggests that a higher amount of cash held by the firm, a larger board size, and greater equity concentration may hinder the continuity of green innovation within companies. Excess cash holdings can lead to a lack of motivation to invest in challenging projects, as explained by agency theory (Chowdhury et al., 2021; H. Gao et al., 2013; Lie, 2000). Additionally, a larger board size may lead to coordination challenges (Cheng, 2008; Coles et al., 2008) and foster more conservative decision-making (Ahmed & Duellman, 2007), hindering the firm's focus on long-term innovation initiatives. Furthermore, a higher concentration of equity indicates that dominant shareholders have greater control of a company's strategic decisions (Banerjee & Homroy, 2018) and might prioritize short-term financial returns over long-term investments in green innovation (Abdelsalam et al., 2021; Fried & Wang, 2019).

[Insert Table 4 about here]

4.3 Robustness tests

4.3.1 Mitigation of endogeneity

This study may have endogeneity issues due omitted variables and reverse causality, as well as selection bias stemming from observed characteristics. To deal with the aforesaid, we utilize instrumental variables approach, as well as matching techniques.

The green innovation of downstream firms may induce upstream suppliers to improve environmental practices, thereby creating reverse causality. Additionally, unobserved industry or region-specific characteristics, such as latent technological barriers and local government rent-seeking practices, could simultaneously influence upstream environmental misconduct and downstream innovation persistence, introducing omitted variable bias. Therefore, for the instrumental variable (IV) method, we use two instruments: the mean values of supplier environmental misconduct in the (i) same industry (*Ind_Sup_EM*), and (ii) the same province (*Pro_Sup_EM*). The rationale is that industry averages capture technological linkages and regulatory commonalities, while provincial averages reflect regional differences in policy implementation. Both strongly correlate with upstream firms' environmental misconduct yet they do not directly influence downstream firms' innovation continuity.[9] By isolating exogenous variations at industry and regional levels, this design mitigates endogeneity biases. Columns (1) to (2) of Table 5 show the 2SLS estimation results. In the first stage, the regression coefficients of the two instrumental variables *Ind_Sup_EM* and *Pro_Sup_EM* are significant at the 1% level. In the second stage, the regression coefficient of supplier environmental misconduct (*Sup_EM*) is -0.881, which is significant at

[9] Downstream firms' green innovation continuity does not systematically alter the environmental behaviors of suppliers to other firms within the same industry or province, based on three reasons: (1) Corporate innovation is technology-specific and long-term in nature, making it difficult to quickly spread to other companies' supply chain management in the same industry. (2) It is difficult for downstream companies to monitor other companies' supplier behavior in the same province in real time. (3) There are sticky relationships in the supply chain, so companies cannot immediately adjust the supplier network structure of other companies at the industry/provincial level due to their own innovation needs.

the 5% level, consistent with the benchmark regression results. Considering that there were two instrumental variables, we conduct Hansen's J test to test for over-identification. We obtain a p-value of 0.47, which is much larger than 0.1, and therefore we reject the null hypothesis of over-identification. Therefore, with the instrumental variables approach, the main findings of our study still holds.

For the selection bias, we start with a Mahalanobis distance matching method. Specifically, we match based on the control variables discussed before. We take the downstream firms with one or more suppliers having environmental misconduct as the treatment group and then match them with the most similar samples of the control group, the firms without suppliers' environmental misconduct. The regression results of the main effects after Mahalanobis distance matching are reported in Column (3) of Table 5, where suppliers' environmental misconduct (*Sup_EM*) is negatively and significantly ($p<0.05$) associated with downstream firms' green innovation continuity (*GIC*).

We further use the propensity score matching (PSM) method. We use the same variables for matching as before and match firms with and without supplier environmental misconduct using 1:4 nearest-neighbor matching.[10] Figure 2 presents the difference in covariance variables between the two groups of samples before and after PSM. After matching, the differences in covariates are significantly reduced compared to before matching. The regression results of the main effects after PSM are shown in Column (4) of Table 5, where suppliers' environmental misconduct (*Sup_EM*) is negatively and significantly ($p<0.1$) associated with downstream firms' green innovation continuity (*GIC*), supporting our baseline findings once more.

[Insert Table 5 about here]

[Insert Figure 2 about here]

[10] We employ 1:4 nearest-neighbor matching instead of 1:1 to increase the precision of our estimates by retaining a larger number of control observations. Using multiple matches per treated unit enhances statistical power and reduces standard errors, as long as the additional matches are of acceptable quality (Stuart, 2010). Given the size and composition of our sample (N = 3,584), this approach allows us to utilize the available data more effectively without substantially compromising covariate balance.

4.3.2 Results from an alternative independent variable

To test the robustness of our primary findings, we adopt an alternative measure for suppliers' environmental misconduct. Specifically, we incorporate the differing purchase proportions among a firm's top five suppliers by constructing a weighted measure. This is achieved by multiplying each supplier's share of purchases by an indicator of whether that supplier engaged in environmental misconduct, and summing these products to create the new variable. For example, if two of a downstream firm's top five suppliers exhibit environmental misconduct—with one supplier representing 45% and the other 15% of the firm's total purchases—the new environmental misconduct measure for that firm would be calculated as $0.45 \times 1 + 0.15 \times 1 = 0.6$. We denote the new variable of suppliers' environmental misconduct as *Sup_EM_b* to distinguish it from the benchmark regression.

We perform the same regression method as the benchmark model (*Model I*). The results are reported in column (1) of Table 6. The coefficient of *Sup_EM_b* is significantly negative at the 5% confidence level, indicating that suppliers' environmental misconduct reduces downstream firms' green innovation continuity. Our main findings are robust to this alternative version of the main control variable.

4.3.3 Results from an alternative version of the dependent variable

We further change the measurement method of downstream firms' green innovation continuity to test the robustness of our key findings. Unlike in the previous analysis, where green innovation continuity is measured with the number of green patents, in this section, we use the number of green patents granted (*GRT*). In addition, in this section, we distinguish between the number of green invention patent applications (*GIA*) and the number of green utility patent applications (*GUA*), rather than directly summing them, to measure green innovation continuity separately. Then, we follow the method in 3.1.2 to multiply the period-on-period growth rate of *GRT*, *GIA*, and *GUA*, respectively, by the scale of each of the three to obtain three new proxy variables *GIC_GRT*, *GIC_GIA*, and *GIC_GUA* to measure downstream firms' green innovation continuity.

After replacing the dependent variable, we use the same regression method as the baseline model (Model I) for the analysis, and the results are reported in columns (2) to (4) of Table 6. The coefficients of *Sup_EM* corresponding to *GIC_GRT*, *GIC_GIA*, and *GIC_GUA* are all negative and significant at the 10%, 5%, and 1% levels, respectively, suggesting that even after replacing the three different methods to measure green innovation continuity, the effect of suppliers' environmental misconduct on downstream firms' green innovation continuity is still significant.

Finally, we measure firms' green innovation continuity by drawing on Davis and Haltiwanger (1992)'s method for measuring growth rate. Specially, we measure annual green innovation (GI) at the firm level using the natural logarithm of the number of green patent applications plus one (He et al., 2024), and then calculate green innovation continuity according to the formula: $GIC\_B_{i,t} = \frac{GI_{i,t} - GI_{i,t-1}}{0.5 \times (GI_{i,t} + GI_{i,t-1})}$.[11] The regression results of suppliers' environmental misconduct on the alternative measure are reported in column (5) of Table 6. The coefficient of *Sup_EM* is significantly negative at the 5% level, which provides further support for the finding that suppliers' environmental misconduct undermines downstream firms' green innovation continuity. This reinforces the robustness of our main findings.

4.3.4 Downstream firms' green innovation level as the explained variable

This study posits that environmental misconduct by upstream firms undermines downstream firms' capacity to sustain green innovation activities. Consequently, the underlying logic of this research inherently incorporates considerations regarding green innovation level, necessitating further exploration into the impact of suppliers' environmental misconduct on downstream firms' green innovation level. Therefore, we substitute the explained variable downstream firms' *GIC* in the baseline regression model with green innovation level (*GI*), measured as the natural logarithm of annual green patent applications (plus one to address zero values).

After replacing the dependent variable, we re-estimate the baseline regression model, with results reported in column (6) of Table 6. The coefficient estimate for the key variable

[11] We apply a modified version of the Davis and Haltiwanger (1992) growth formula, using the log-transformed values of our key variable (patents) rather than levels, due to its highly skewed distribution. This transformation shifts the interpretation from symmetric changes in levels to relative (proportional) changes in scale.

Sup_EM on *GI* is negative (−0.0424) and statistically significant at the 5% level, confirming that upstream environmental misconduct reduces downstream firms' green innovation levels. This indicates that the adverse effects of supplier misconduct extend beyond eroding green innovation momentum (i.e., persistence decline) to concurrently diminish innovation capacity and aggregate investment scale (i.e., level decline). By directly testing green innovation outputs, we obtain findings supporting the main results, alleviating concerns that the continuity metric's design drives the conclusions of this study.

4.3.5 Downstream firms' green innovation resilience as the explained variable

We further use green innovation resilience as an alternative explained variable to study the impact of suppliers' environmental misconduct on downstream firms' green innovation resilience. Based on the definition of regional economic resilience by Martin (2012), we consider corporate green innovation resilience as a firm's ability to sustain green innovation stability, recover from, and enhance shock resistance through self-learning and adaptation amid internal or external shocks. The effects of suppliers' environmental misconduct may not only manifest as a decline in downstream firms' green innovation continuity but could also undermine their dynamic adaptive capacity (i.e., resilience), thereby impeding their sustainable development trajectory.

Drawing on Martin (2012) and Wu et al. (2024), we adopt the number of green patent applications as the key variable to calculate the green innovation resilience *(GIR)* of downstream firms using the sensitivity indicator method. The higher the GIR value, the higher a firm's green innovation resilience. The specific formula is as follows:

$$GIR_{i,t} = \left(\Delta Patent_{i,t} - \Delta Patent_{c,t}\right) / \left|\Delta Patent_{c,t}\right|$$

In the above formula, $\Delta Patent_{i,t} = Patent_{i,t} - Patent_{i,t-1}$, and $\Delta Patent_{c,t} = Patent_{c,t} - Patent_{c,t-1}$. Where $GIR_{i,t}$ represents the green innovation resilience level of downstream firm *i* in year *t*. $Patent_{i,t}$ and $Patent_{i,t-1}$ respectively indicate the number of green patent applications filed by downstream firm *i* in years *t* and *t-1*, which are used to measure a firm's green innovation, while $Patent_{c,t}$ and $Patent_{c,t-1}$ respectively indicate the number of patent applications filed in the city where the downstream firm is located in years *t* and *t-1*, which are used to measure the level of green innovation in the city where the downstream firm is located. $\Delta Patent_{i,t}$ is the change in the number of green patent applications filed by firms, and $\Delta Patent_{c,t}$ is the change in the number of green patent applications filed in the city where the firm is located.

After substituting the dependent variable, we re-estimate the baseline regression model, with results presented in column (7) of Table 6. The coefficient estimate for the key variable *Sup_EM* on *GIR* is negative and statistically significant at the 1% level, confirming that suppliers' environmental misconduct reduces downstream firms' green innovation resilience. The consistent negative results derived from distinct metrics (continuity and resilience) not only corroborate the robustness of the main effect but also uncover the multidimensional suppression mechanisms through which upstream environmental misconduct inhibits downstream green innovation.

[Insert Table 6 about here]

4.3.6 Exclusion of other potential explanations

Suppliers' environmental misconduct is detrimental to downstream firms' green innovation continuity, but there may be other explanations for this finding. When downstream firms are located in the same city as their suppliers, they face the same environmental misconduct conditions as their suppliers due to local-specific emission standards and the laxity or strictness of local regulators in enforcing environmental regulations. To avoid confusion about the environmental misconduct situations faced by downstream firms and their suppliers, we re-run the regression based on *Model I* under the condition that the downstream firms and their suppliers are in different cities. The results are reported in column (1) of Table 7; the coefficient of *Sup_EM* is significantly negative at the 5% level. The results indicate that after excluding cases where the downstream firms and their suppliers are in the same city, suppliers' environmental misconduct still negatively impacts downstream firms' green innovation continuity, supporting our main findings.

In addition, obstacles to continuous green innovation may stem from firms' classification as polluting businesses, as investor and government mistrust in their environmental performance can hinder green transformation through innovation. This issue is not solely attributable to supplier environmental failures. To rule out this explanation, we categorize the full sample into two subsamples based on whether downstream firms are certified by ISO14001 or ISO9001. We then separately analyze the impact of suppliers' environmental misconduct on the green innovation continuity of downstream firms within each subsample. The group with ISO14001 or ISO9001 audits is *L_pollution*, representing firms with low pollution levels, and the group without an audit is *H_pollution*. The estimated results for *Model I* for the *H_pollution* group are listed in column (2) of Table 7, while the results for the *L_pollution* group are in column (3). Regardless of the pollution attribute level of the downstream firms themselves, the coefficient of *Sup_EM* is significantly positive at the 5% level. This suggests that even after excluding the direct effect of downstream firms' own pollution attributes on their green innovation continuity, suppliers' environmental misconduct still decreases downstream firms' green innovation continuity, indicating that Hypothesis 1 is robust.

[Insert Table 7 about here]

5 Further tests and results

5.1 Results of transmission mechanisms

We use executives' green cognition (*EGC*) and financing constraints (*SA*) of downstream firms as mediating variables to explore the transmission mechanism of suppliers' environmental misconduct impacting downstream firms' green innovation continuity. This study refers to the three-step test proposed by Baron & Kenny (1986) to test whether the two variables play a mediating role. The steps we use are the following:

$$GIC_{i,t} = \alpha_0 + \beta_0 Sup\_EM_{j,\boldsymbol{t-1}} + \gamma_0 Control_{it} + Year_t + Firm_i + \varepsilon_{i,t}, \qquad (Step\ 1)$$

$$Mediation_{i,t} = \alpha_1 + \beta_1 Sup\_EM_{j,t-1} + \gamma_1 Control_{it} + Year_t + Firm_i + \varepsilon_{i,t}, \qquad (Step\ 2)$$

$$GIC_{i,t} = \alpha_2 + \beta_2 Sup\_EM_{j,t-1} + \delta_2 Mediation_{i,t} + \gamma_2 Control_{it} + Year_t + Firm_i + \varepsilon_{i,t}. \qquad (Step\ 3)$$

Model II: Test for the mediating effects

In the above specifications, *Mediation* represents the mediating variables, including executives' green cognition and financing constraints of downstream firms. Step 1 tests the impact of suppliers' environmental misconduct on downstream firms' green innovation continuity, which has been analyzed in 4.2. Step 2 tests the relationship between the mediating variables (executives' green cognition and financing constraints of downstream firms) and the explanatory variables (suppliers' environmental misconduct). Thus, our main focus here is direction and significance of the coefficient β_1. Step 3 further tests the relationship between the mediating variables and the explained variable (downstream firms' green innovation continuity). Here we focus on the direction and significance of coefficient δ_2.

5.1.1 Executives' green cognition as a transmission mechanism

Table 8 reports the regression results for executives' green cognition of downstream firms as a transmission mechanism. Column (2) of Table 8 shows the results of suppliers' environmental misconduct on executives' green cognition of downstream firms. The coefficient of *Sup_EM* is -0.788, which is significant at 1% confidence level, indicating that suppliers' environmental misconduct can reduce downstream firms' executives' green cognition. Column (3) of Table 8 further reports the test results of the relationship between downstream firms' executives' green cognition and corporate green innovation continuity, the coefficient of *EGC* is 0.275, which is significant at 10% confidence level, indicating that executives' green cognition positively impacts corporate green innovation continuity. Further, in column (3), after including executive green cognition as a control variable, suppliers' environmental misconduct *(Sup_EM)* remains negatively and significantly associated with downstream firms' green innovation continuity ($p<0.1$). This indicates that the green cognition of downstream firms' executives partially mediates this relationship. We further perform the Sobel test and Bootstrap test.[12] The results confirm that reduced green cognition among downstream executives serves as a transition mechanism.

In summary, the results show that suppliers' environmental misconduct diminishes the

[12] In the Bootstrap test, we perform 1,000 samplings with put-back on the original data to create a large number of bootstrap samples, thereby estimating the confidence interval of the mediation effect.

green cognition of downstream firm executives, thereby reducing green innovation continuity, supporting Hypothesis 2.

[Insert Table 8 about here]

5.1.2 Financing constraints as a transmission mechanism

Table 9 reports the regression results for downstream firms' financing constraints as a transmission mechanism. Column (2) of Table 9 shows the results of suppliers' environmental misconduct on financial constraints of downstream firms. The coefficient of *Sup_EM* is significantly positive at the 1% level, indicating that suppliers' environmental misconduct increases downstream firms' financing constraints. Column (3) of Table 9 further shows the test results of the relationship between downstream firms' financing constraints and their green innovation continuity. The coefficient of *SA* is significantly negative at the 5% confidence level, indicating that firms' financial constraints negatively impact their green innovation continuity. Further, in column (3), after adding financing constraints as a control variable, the coefficient of suppliers' environmental misconduct (*Sup_EM*) loses its statistical significance, suggesting that the downstream firms' financial constraints play a full mediation effect. The Sobel and Bootstrap test results confirm that financial constraints serve as a transmission mechanism.

In summary, the results indicate that suppliers' environmental misconduct increases financing constraints for downstream firm executives, thereby reducing green innovation continuity and supporting Hypothesis 3.

[Insert Table 9 about here]

5.2 Results of the moderating effects

The strength of downstream firms' bargaining power has the potential to weaken or strengthen the negative impact of suppliers' environmental misconduct on the green innovation continuity of downstream firms. Also, the proximity of physical distance between downstream and upstream firms can moderate the effect of suppliers' influence on downstream firms. To test Hypotheses 4 and 5, we set up the following model.

$$GIC_{i,t} = \alpha_3 + \beta_3 Sup\_EM_{j,t-1} + \theta_3 SCHHI_{i,t} + \eta_3 Sup\_EM_{i,t-1} \times SCHHI_{i,t} + \gamma_3 Control_{i,t} + Year_t + Firm_i + \varepsilon_{i,t},$$

$$GIC_{i,t} = \tilde{\alpha}_3 + \tilde{\beta}_3 Sup\_EM_{j,t-1} + \tilde{\theta}_3 Distance_{i,j,t-1} + \tilde{\eta}_3 Sup\_EM_{i,t-1} \times Distance_{i,j,t-1} + \tilde{\gamma}_3 Control_{i,t} + Year_t + Firm_i + \varepsilon_{i,t},$$

Model III: Test for moderating effects

where $SCHHI_{i,t}$ is the first moderating variable and is used to measure the bargaining power of downstream firms. The larger the *SCHHI* value, the stronger the bargaining power of downstream firms, and the more it can weaken the negative impact of suppliers' environmental misconduct on the green innovation sustainability of downstream firms. $Distance_{i,j,t-1}$ is the second moderating variable that measures the geographic distance between downstream firms (subscript *i*) and their suppliers (subscript *j*), and it is kept in the same period (*t-1*) as supplier environmental misconduct in the regression analysis. The larger the *Distance* value, the closer the physical distance between downstream firms and their suppliers,[13] and the more it strengthens the negative impact of suppliers' environmental misconduct on the green innovation continuity of downstream firms. For the moderating effects, we focus on the direction and significance of the coefficients η_3 and $\tilde{\eta}_3$ of the interaction term $Sup\_EM_{i,t-1} \times SCHHI_{i,t}$(or $Distance_{i,t-1}$).

5.2.1 The moderating role of the bargaining power of downstream firms

Column (1) of Table 10 shows the regression results of downstream firms' bargaining power in moderating the relationship between suppliers' environmental misconduct and downstream firms' green innovation continuity. After including downstream firms' bargaining power as a moderating variable, the coefficient of the core explanatory variable *Sup_EM* is -1.51 and significant at 1% level, indicating the negative relationship between suppliers' environmental misconduct and downstream firms' green innovation continuity. However, the coefficient of the intersection term *Sup_EM*SCHHI* is positive and significant at the 10% confidence level, showing the opposite direction to the coefficient of the independent variable. The result suggests that stronger bargaining power of downstream firms weakens the negative impact of suppliers' environmental misconduct on the green innovation sustainability of downstream

[13] This is because, following prior literature, *Distance* is defined as the negative natural logarithm of the spatial distance between downstream firms and their suppliers, increased by one.

firms, thereby supporting Hypothesis 4. Additionally, the coefficient of *SCHHI* is significantly positive at the 5% level, indicating that the high bargaining power of downstream firms can promote their green innovation continuity.

5.2.2 The moderating role of geographic distance between upstream and downstream firms

Column (2) of Table 10 shows the regression results of geographic distance between upstream and downstream firms in moderating the impact of suppliers' environmental misconduct on downstream firms' green innovation continuity. After including the moderating variable, the coefficient of the core independent variable *Sup_EM* is -0.511 and significant at 5% level, indicating the negative relationship between suppliers' environmental misconduct and downstream firms' green innovation continuity. Further, the coefficient of the intersection term *Sup_EM*×*Distance* is negative and significant at the 5% confidence level, showing the same direction as the coefficient of the independent variable. The result suggests that the closer geographic distance of downstream firms to their suppliers exacerbates the negative impact of supplier environmental misconduct on the green innovation sustainability of downstream firms, thereby supporting Hypothesis 5.

[Insert Table 10 about here]

5.3 Does China's new environmental protection law play a role?

China's revised Environmental Protection Law came into effect on January 1, 2015, and has been called "the toughest environmental protection law in China's history." The law limits a firm's emission of pollutants, strengthens regulatory measures for environmental management, increases pollution penalties, and requires firms to make strict disclosures of pollutant emissions and other information. Therefore, we hypothesize that implementing the new environmental protection law can reduce suppliers' environmental misconduct and thus positively affect downstream firms' green innovation continuity. In this context, suppliers' environmental misconduct serves as a transmission mechanism. We set up a DID model as follows to test this mechanism.

$$GIC_{i,t+1} = \alpha_4 + \beta_4 Sup\_treat * post_{j,t} + \gamma_4 Control_{i,t+1} + Year + Firm_i + \varepsilon_{i,t,} \quad (Step\ 1)$$

$$Sup\_EM_{j,t} = \alpha_5 + \beta_5 Sup\_treat * post_{j,t} + \gamma_5 Control_{i,t+1} + Year + Firm_i + \varepsilon_{i,t}, \quad (Step\ 2)$$

$$GIC_{i,t+1} = \alpha_6 + \beta_6 Sup\_treat * post_{j,t} + \delta_6 Sup\_EM_{j,t} + \gamma_6 Control_{i,t+1} + Year + Firm_i + \varepsilon_{i,t}. \quad (Step\ 3)$$

Model IV: Transmission mechanism of the law affecting downstream firms' GIC

In the model, we first use the policy's shock effect on a firm's top five suppliers as an explanatory variable, i.e. $Sup\_treat * post_{j,t}$. In this variable, *treat* is used to measure policy shocks; firms in the industry targeted by the environmental protection law are categorized as the treatment group,[14] denoted as 1, and otherwise as the control group, denoted as 0. In addition, *post* is a time dummy variable; all firms before the enactment of the law take value 0, and firms affected after the enactment of the law take value 1.

Then, we use the green innovation continuity of downstream firms, lagged by one year after the policy shock to their suppliers, as the dependent variable. We hypothesize that the policy shock to suppliers affects the green innovation continuity of downstream firms, with this impact mediated through suppliers' environmental misconduct. As such, we include suppliers' misconduct as the mediating variable.

Columns (1) to (3) of Table 11 present the results of a three-step analysis examining how the new environmental law shock to suppliers influences the green innovation continuity of downstream firms. Column (1) reports that the shock from the new environmental protection law positively affects downstream firms' green innovation continuity, as indicated by the significantly positive coefficient of *Sup_treat*post* at the 1% confidence level. Column (2) tests the transmission mechanism, showing that the law significantly reduces suppliers' environmental misconduct, with a negative coefficient for *Sup_treat*post* at the 10%

[14] 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.

level. Column (3) confirms the relationship between suppliers' environmental misconduct and downstream firms' green innovation continuity, with the coefficient of *Sup_EM* significantly positive at the 10% level. These findings suggest that the environmental protection law's impact on suppliers promotes downstream firms' green innovation continuity by reducing suppliers' environmental misconduct. Additional Sobel and Bootstrap tests further validate suppliers' environmental misconduct as an effective transmission mechanism.

To further verify that our findings are reliable, we conduct robustness tests. Firstly, the prerequisite for using the DID model is to satisfy the parallel trend assumption. We refer to Beck et al. (2010) method to test for parallel trends in the sample; the result can be found in Figure 3. There was no significant difference in the green innovation continuity among downstream firms in each of the years before the implementation of the new environmental protection law. Starting in the second year after the law was implemented and began to intervene in the behavior of suppliers, the green innovation continuity of downstream firms increased significantly. The results show that before the law's implementation, the treatment and control groups satisfy the pre-treatment trend test, and our findings are robust.

To reduce selection bias, we apply kernel matching with PSM. We employ a logit model to estimate propensity scores and match the treatment group with the control group using a kernel matching bandwidth of 0.06 (Heckman et al., 1997). Figure 4 shows the differences in covariate variables between the two sample groups before and after PSM, showing that these differences are significantly reduced following matching. Columns (4) to (6) of Table 11 present the regression results of *Model IV* after PSM, which align closely with the results obtained before matching. These findings confirm that the new environmental protection law's impact on suppliers enhances green innovation continuity in downstream firms through the reduction of suppliers' environmental misconduct, demonstrating the robustness of our results.

[Insert Figure 3 about here]

[Insert Table 11 about here]

[Insert Figure 4 about here]

5.4 Do talent introduction policies play a role?

In 2016, the Chinese central government issued the *"Opinions on Deepening the Reform of Talent Development Systems and Mechanisms."*[15] The reform aimed to establish a more scientific and efficient talent management system across cities, along with a comprehensive framework for talent evaluation, mobility, and incentives.

These talent introduction policies guided by central government directives aim to attract top-tier talent, including highly educated and skilled individuals, through measures such as assisting with relocation, school enrollment for children, financial subsidies, performance bonuses, and medical insurance. Unlike the more superficial policies before 2015, this wave of initiatives is notable for its scale, intensity, and scope (Wang & Miao, 2019). As a result, cities have seen significant growth in net talent inflows. For instance, Hangzhou's 2016 policy led to a 10% increase in talent inflow by 2017, with a 25% rise in net inflows, demonstrating the policies' effectiveness in both attracting and retaining talent.

Building on this context, we investigate how the talent introduction policies implemented across various cities influences the green innovation continuity of downstream firms. Highly educated and well-trained employees typically exhibit greater green awareness, and the recruitment of high-quality management talent is more likely to enhance corporate green governance and innovation (Angrist et al., 2024; H. Tang et al., 2024). Moreover, firms in cities with talent introduction policies are better positioned to attract innovative talent, fostering sustained green innovation.

However, given that suppliers' environmental misconduct transmits negative signals within supply chains and investment markets (Florackis et al., 2023; Guo, 2020; Hajmohammad et al., 2021, Matinheikki et al., 2022), we hypothesize that upstream environmental misconduct weakens the positive effects of these policies on downstream firms' continuous green innovation. To explore this, we use green innovation continuity as the dependent variable, the impact of talent introduction policies as the independent variable, and upstream firms' environmental misconduct as the moderating variable. Employing a

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[15] Access to the *Opinions on Deepening the Reform of Talent Development Systems and Mechanisms*: https://www.gov.cn/zhengce/2016-03/21/content_5056113.htm

staggered difference-in-differences approach (*Models V and VI*), we test these effects, leveraging the variation in the timing of talent policy implementation across Chinese cities after 2016.

$$GIC_{i,t} = \alpha_7 + \beta_7 treat_i \times post_{i,t} + \gamma_7 Control_{i,} + Year_t + Firm_i + \varepsilon_{i,t},$$

Model V: The effect of talent introduction policies on the downstream firms' GIC

$$GIC_{i,t} = \alpha_8 + \beta_8 Treat_i \times post_{i,t} + \theta_8 Sup\_EM_{j,t-1} + \eta_8 Treat_i \times post_{i,t} \times Sup\_EM_{j,t-1} + \gamma_8 Control_{i,} + Year_t + Firm_i + \varepsilon_{i,t}.$$

Model VI: Upstream firms' environmental misconduct modulates policies' impacts on downstream firms

In the models, *Treat*post* is the core explanatory variable, which considers the impact of talent introduction policies on companies. The data on talent introduction policies in cities is collected from authoritative public websites including local government portals, local government talent websites, and the Talents Database of PKULAW.COM. The local talent introduction policies used in this study are determined by searching for specific policies in specific cities in specific years.[16]

The regression results for Model V are reported in column (1) of Table 12. The coefficient of *Treat*×*post* is significantly positive at the 1% confidence interval, indicating that the law's shock to suppliers promotes downstream firms' green innovation continuity. We further test how suppliers' environmental misconduct moderates the impact of talent introduction policies on downstream firms' green innovation continuity, and the results are reported in column (2) of Table 12. The coefficient of the intersection term *Treat*×*post*×*Sup_EM* is significantly negative at the 10% level, which is in the opposite direction of the coefficient of the core explanatory variable *Treat*×*post*, demonstrating that upstream firms' environmental misconduct weakens the promotion effect of talent introduction policies on downstream firms' green innovation continuity. Our findings are robust, as shown in Figure 5. The parallel trend test confirms that the green innovation

[16] We report the data on the implementation of talent introduction policies in various cities in 2016 and subsequent years in Appendix 4.

continuity of downstream firms showed no significant differences before the implementation of the talent introduction policies but significantly increased afterward.

As a final test, to mitigate self-selection bias, we apply the kernel matching method, as outlined in Section 5.3, to perform PSM on the sample firms based on their exposure to talent introduction policies, using control variables as coordinating factors. As shown in Figure 6, the differences in covariate variables are significantly reduced after PSM compared to before. The post-PSM results are presented in columns (3) and (4) of Table 12, showing that the regression outcomes of Models V and VI remain consistent with those obtained before PSM, confirming the robustness of our findings.

[Insert Figure 5 about here]

[Insert Table 12 about here]

[Insert Figure 6 about here]

6 Conclusions

With economic integration deepening, the interdependence between upstream and downstream supply chain firms has intensified. This study examines how upstream firms' environmental misconduct affects downstream firms' green innovation continuity, testing transmission mechanisms, moderating effects, and policy shocks. The findings show that suppliers' misconduct undermines green innovation continuity by reducing executives' green cognition and increasing financial constraints. Greater bargaining power among downstream firms mitigates this effect, while closer geographic proximity amplifies it. China's 2015 environmental protection law reduced suppliers' misconduct, boosting downstream green innovation. Similarly, talent introduction policies since 2016 have promoted green innovation continuity, though this effect is weakened by supplier misconduct. Overall, supplier environmental misbehavior negatively impacts downstream firms' green innovation continuity across multiple dimensions.

Our findings offer valuable insights for firms and policymakers. Downstream firms aiming for green transformation should thoroughly assess their suppliers' CSR performance and actively encourage them to fulfill environmental governance obligations, thereby minimizing risks from supplier environmental underperformance. Firms should also diversify supply channels, stay informed on market trends, and reduce reliance on single suppliers to strengthen bargaining power. Additionally, firms may benefit from selecting geographically distant suppliers to avoid overdependence, as our results indicate that low bargaining power and close proximity to suppliers amplify the negative effects of supplier environmental misconduct.

For the Chinese government, in addition to implementing policies that encourage continuous green innovation, refining environmental protection regulations remains essential. The 2015 Environmental Protection Law serves as an effective example, significantly reducing supplier environmental misconduct and thus enhancing downstream firms' green innovation continuity. Similarly, large-scale talent introduction policies have shown potential to promote green innovation but are hindered by the negative effects of upstream environmental misconduct. Therefore, the government should integrate these two policy types—environmental protection and talent introduction. Strengthening regulations to reduce supply chain pollution and environmental misconduct, alongside enhancing talent policies to support firms' green transformation, can drive continuous green innovation and foster sustainable regional economic development.

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FIGURES

Figure 1 Research framework

The figure shows the research framework of this study, explaining how this study constructs the relationships among suppliers' environmental misconduct, downstream firms' green innovation sustainability, and other variables.

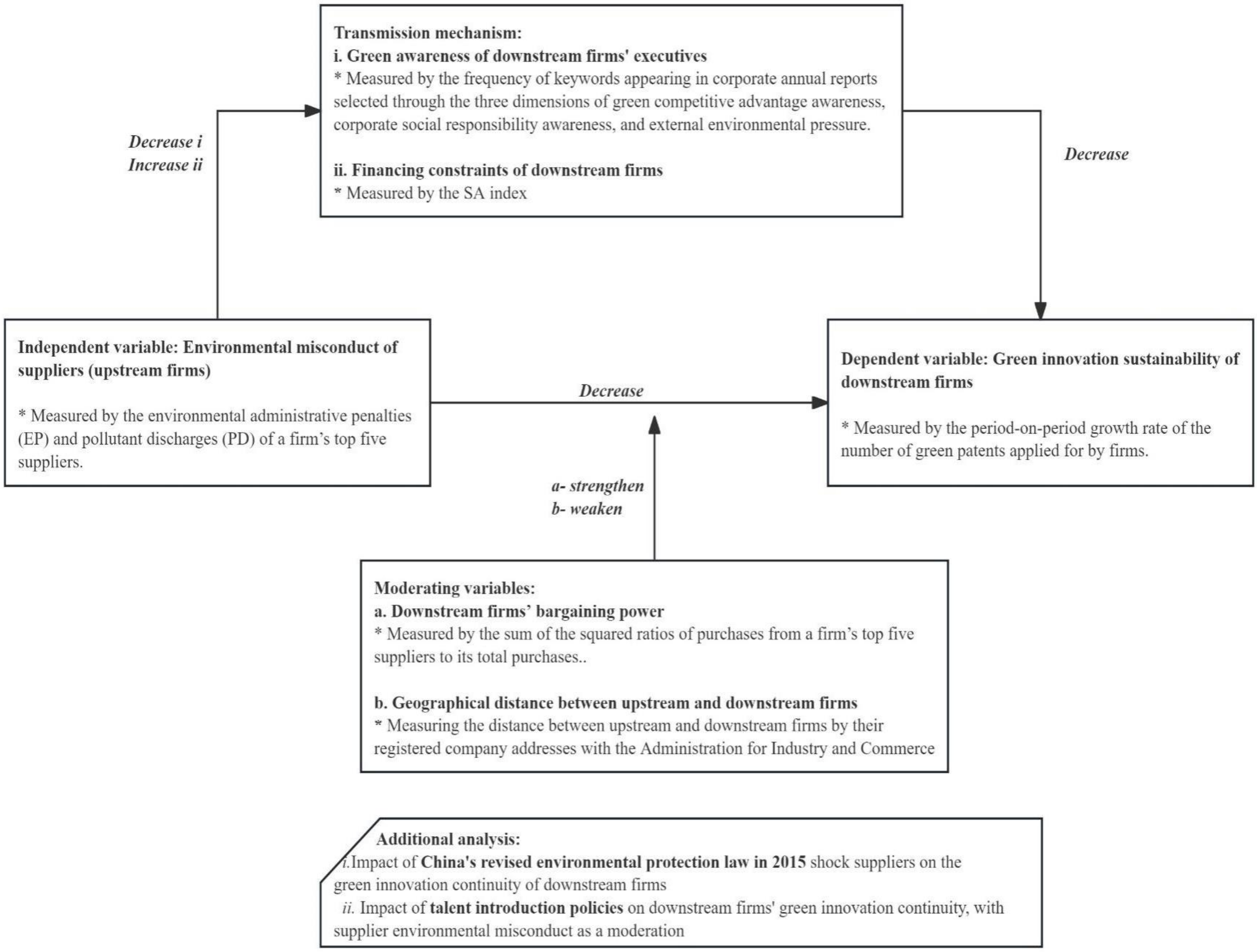


Figure 2 The result for propensity score matching (1:4 nearest neighbor matching)

The figure reports the bias across covariates of the control variables before and after propensity score matching. The definitions of the variables are given in Table 1.

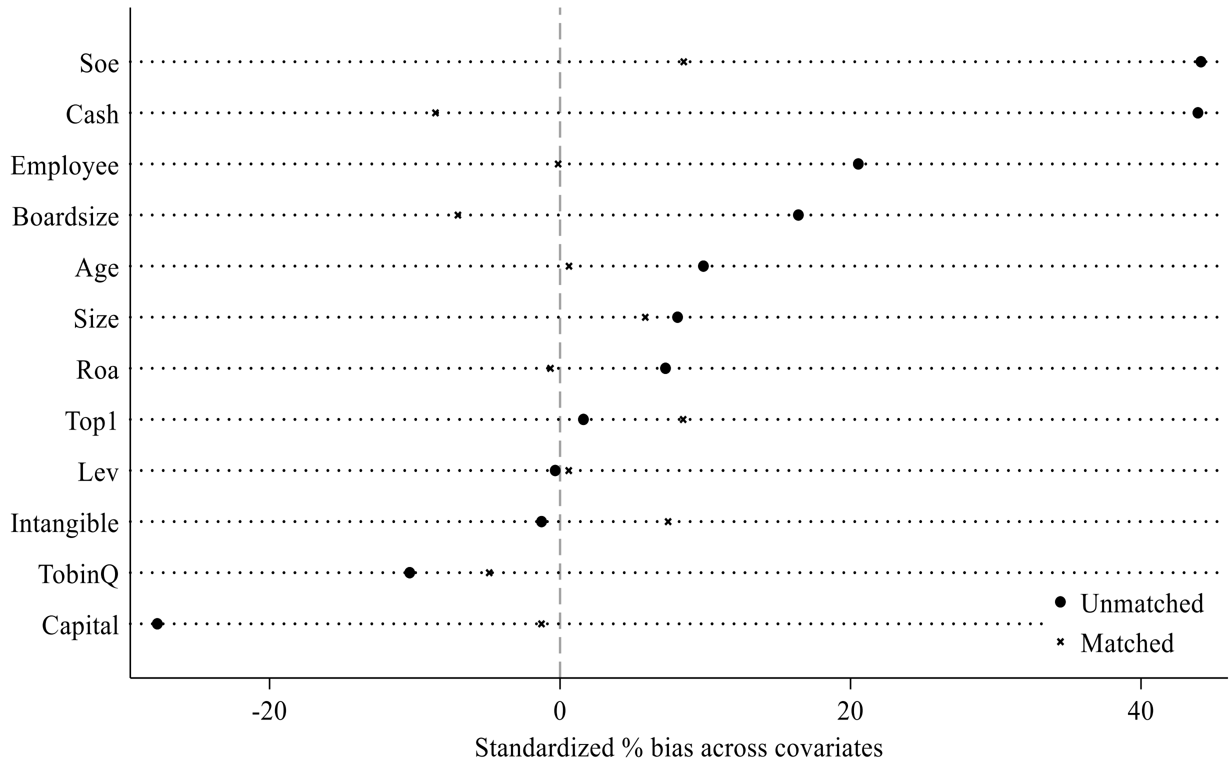


Figure 3 Parallel trends of the green law shock on suppliers affecting the green innovation continuity of downstream firms

The figure shows the results of the parallel trends test. The horizontal axis represents the number of years since the new Chinese environmental protection law intervened in suppliers' behavior, and the vertical axis represents the regression coefficient of downstream firms' green innovation continuity. The hollow circles represent the estimated coefficients of the explanatory variable *Sup_treat*post* corresponding to that period.

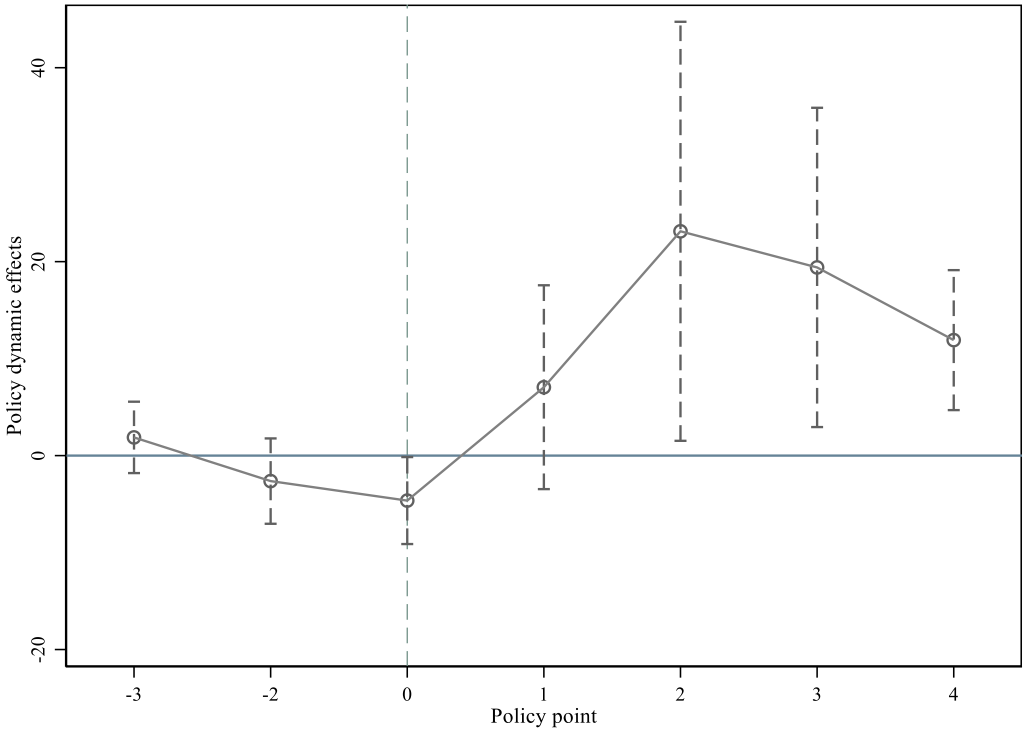


Figure 4 The result for propensity score matching - Based on China's new environmental protection law

The figure reports the bias across covariates of the control variables before and after propensity score matching. This PSM result is based on a sample with the shock effect of China's new environmental protection law. The definitions of the variables are given in Table 1.

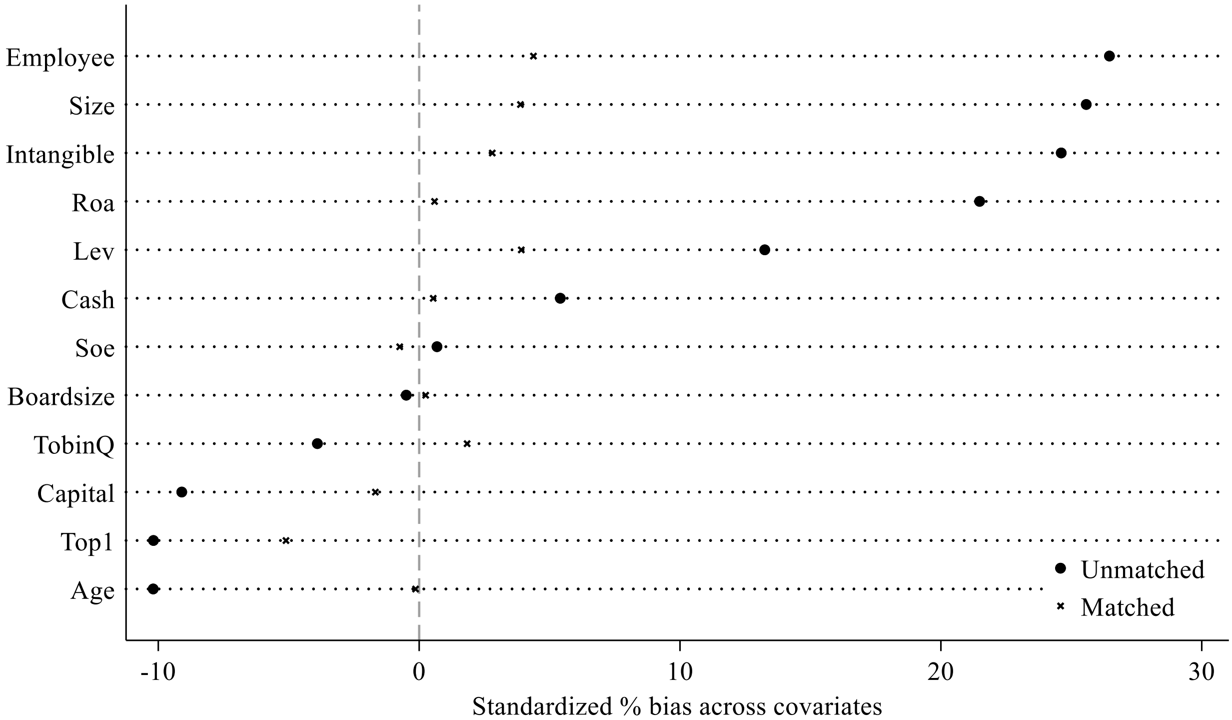


Figure 5 Parallel trends of talent introduction policies affecting downstream firms' green innovation continuity

The figure shows the results of the parallel trends test. The horizontal axis represents the point in time when downstream firms are affected by the talent introduction policies (0 represents the release of the talent introduction policies), and the vertical axis represents the regression coefficient of downstream firms' green innovation continuity. The hollow circles represent the estimated coefficients of the explanatory variable *Treat*post* corresponding to that period.

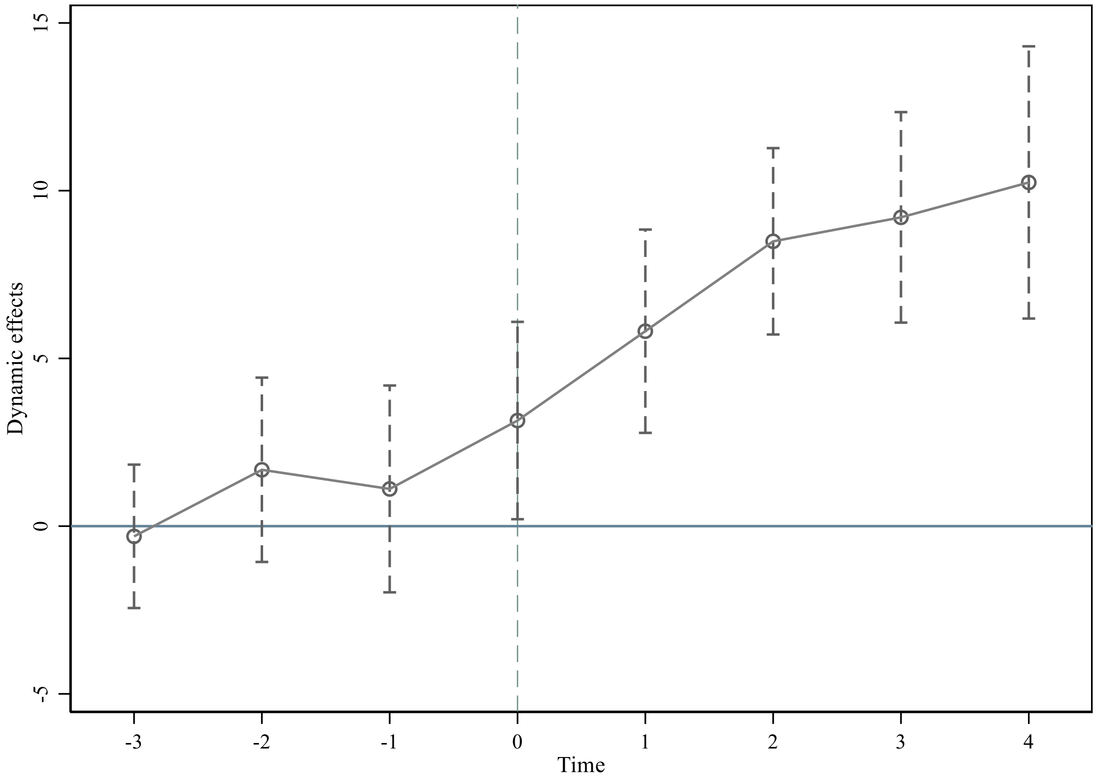
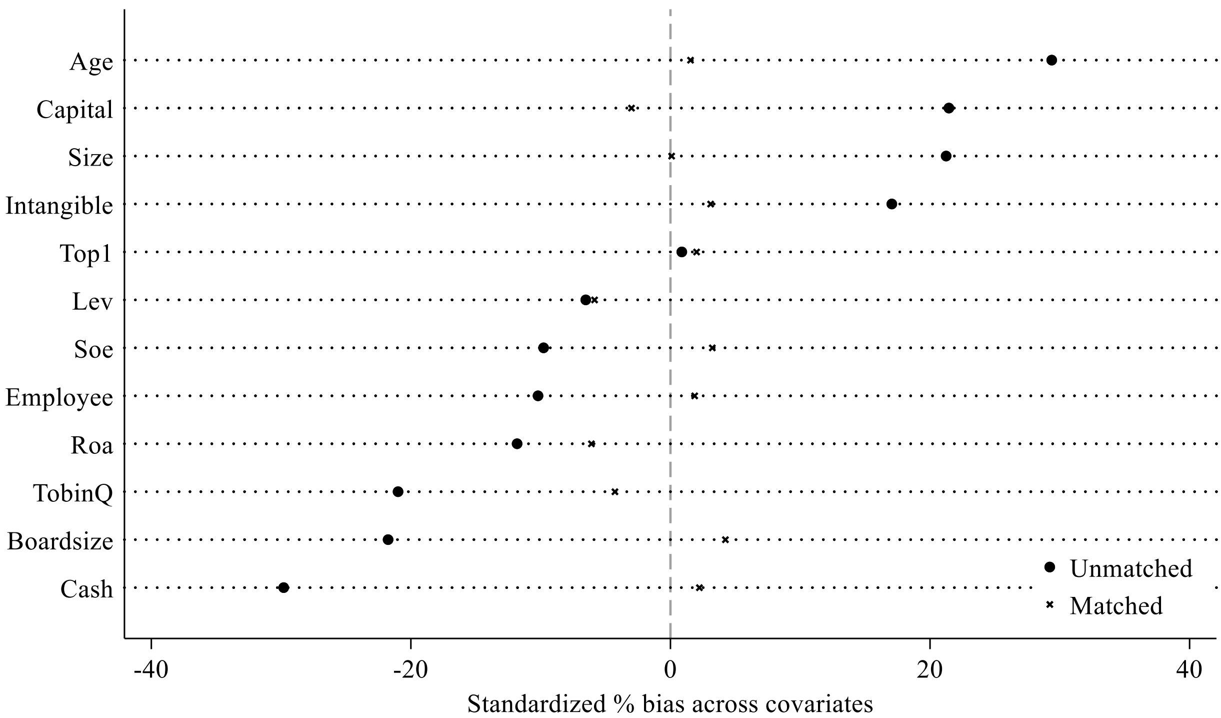


Figure 6 Result for propensity score matching based on talent introduction policies

The figure reports the bias across covariates of the control variables before and after propensity score matching. This PSM result is based on a sample with the shock being China's talent introduction policies. The definitions of the variables are given in Table 1.



TABLES

Table 1 Definition of variables

The table reports the definitions and measurements of the variables used in the analysis.

Type	Variable name	Symbol	Variable Declaration	Data base
Independent	Suppliers' environmental misconduct	*Sup_EM*	0 indicates that none of a firm's suppliers have committed environmental misconduct, 1 indicates that one supplier has committed environmental misconduct, and so on, up to 5, which indicates that all five suppliers have committed environmental misconduct.	Information on the top five suppliers for each firm - *CSMAR database*. Information on environmental penalties and pollutant discharges of supplier firms - *CNRDS database.*
Dependent	Green innovation continuity	*GIC*	The product of the period-on-period growth rate of green patent applications and the total amount of green patent applications. Specifically, $GIC_{i,t} = \frac{Patent_{i,t}+Patent_{i,t-1}}{Patent_{i,t-1}+Patent_{i,t-2}} \times (Patent_{i,t} + Patent_{i,t-1})$	*IPC Green Inventory*, China's State Intellectual Property Office (*SIPO*)
Mediating	Executive's green cognition	*EGC*	The frequency of keywords used to assess executives' green cognition in companies' annual reports.	*Juchao Information Website,* and companies' websites.
	Financing constraints	*SA*	A proxy for financial constraints.	*CSMAR database*
Moderating	Downstream firms' bargaining power	*SCHHI*	The sum of the squared ratios of purchases from a firm's top five suppliers to its total purchases.	*CSMAR database*
	Distance between upstream and downstream firms	*Distance*	- [ln (the spatial distance between downstream firms and their suppliers +1)]	
Control	Firm size	*Size*	Natural logarithm of total assets	*CSMAR database*
	Age	*Age*	log (sample year - listing year + 1)	
	Profitability	*ROA*	Ratio of net profit to total assets	
	Market value	*TobinQ*	Market value to total assets at the end of the period	
	Intangible asset	*Intangible*	Ratio of net intangible assets to total assets	
	Gearing ratio	*Lev*	Ratio of total liabilities to total assets	
	Cash holdings	*Cash*	Ratio of cash holdings to total assets at the end of the period	
	Capital expenditure	*Capital*	Ratio of capital expenditures to operating revenues	
	Board size	*Boardsize*	Logarithmic value of the number of board members	
	Equity concentration	*Top1*	Ratio of number of shares held by the largest shareholder to total number of shares	
	Number of employees	*Emplyee*	The number of employees plus one takes the natural logarithm	
	Corporate ownership	*Soe*	1 for state-owned firms, 0 otherwise	
Additional	Instrumental variable 1	*Ind_Sup_EM*	The mean values of supplier environmental misconduct in the same industry	*CSMAR database, CNRDS database*
	Instrumental variable 2	*Pro_Sup_EM*	The mean values of supplier environmental misconduct in the same province	
	Alternative variable for	*Sup_EM_b*	Supplier environmental misconduct weighted by the	Information on the top five suppliers

supplier *Sup_EM*		different procurement shares of the five top suppliers	for each firm - *CSMAR database*. Information on environmental performance of supplier firms - *CNRDS database.*
First alternative variable for GIC	*GIC_GRT*	The period-on-period growth rate of the number of green patents granted (*GRT*) by downstream firms	*IPC Green Inventory*, China's State Intellectual Property Office (*SIPO*)
Second alternative variable for GIC	*GIC_GIA*	The period-on-period growth rate of the number of green invention patent applications *(GIA)* by downstream firms	
Third alternative variable for GIC	*GIC_GUA*	The period-on-period growth rate of the number of green utility patent applications (*GUA*) by downstream firms	
Fourth alternative variable for GIC	*GIC_B*	Drawing on the growth rate measurement method proposed by Davis and Haltiwanger (1992) to assess	
Green innovation	*GI*	Natural logarithm of the number of green patent applications by downstream firms plus 1	
Green innovation resilience	*GIR*	The number of green patent applications of firms and their cities are used as key variables, and the sensitivity index method is used to calculate. Specially, $GIR_{i,t} = \left(\Delta Patent_{i,t} - \Delta Patent_{c,t}\right) / \left\|\Delta Patent_{c,t}\right\|$	
The Green law shocks suppliers	*Sup_treat *post*	Supplier firms that are impacted by the 2015 environmental law are recorded as 1, otherwise 0	*CSMAR database, Categorization Management Directory for Environmental Inspection of Listed Companies*
Talent policies shock downstream firms	*Treat*post*	Downstream firms in cities that are impacted by the policies are recorded as 1, otherwise 0	local government websites, PKULAW.COM

Table 2 Summary statistics

The table reports the summary statistics of all variables in this study. The definitions of the variables are given in Table 1.

Variables	Obs	Mean	SD	Min	Max
GIC	3584	3.6462	12.4551	0.0000	88.2000
Sup_EM	3584	0.7115	1.5861	0.0000	5.0000
Size	3584	23.2203	1.4340	20.5234	26.4263
Age	3584	2.6636	0.5985	1.0986	3.4720
Roa	3584	0.0327	0.0601	-0.2647	0.1888
TobinQ	3584	1.7011	1.0003	0.8062	6.2590
Intangible	3584	0.0567	0.0693	0.0000	0.5843
Lev	3584	0.4872	0.2034	0.0654	0.8956
Cash	3584	0.5789	0.4183	0.0621	2.3014
Capital	3584	0.1283	0.1695	0.0010	1.0355
Boardsize	3584	2.1806	0.2056	1.6094	2.8624
Top1	3584	0.3726	0.1565	0.0742	0.7382
Employee	3584	8.3876	1.3144	5.5491	11.2919
Soe	3584	0.6205	0.4853	0.0000	1.0000
EGC	3583	3.8695	4.9433	0.0000	22.0000
SA	3584	-3.8791	0.2980	-5.1907	-2.2865
SCHHI2	3274	7.8125	13.6875	0.0000	90.7677
Distance	2126	-5.0855	2.0781	-9.4257	-0.4653

Table 3 Test results for variables correlation and multicollinearity

This table presents the test results for the correlation and multicollinearity among the primary variables used in the study. Panel A reports the results of the Pearson correlation of all variables used in the analysis. Panel B reports the results of variance inflation factors (VIFs) for the main variables to test for multicollinearity; the variables are sorted from left to right by the extent of the VIF values. The definitions of the variables are given in Table 1.

A. Correlation matrix

Variables	GIC	Sup_EM	Size	Age	Roa	TobinQ	Intangible	Lev	Cash	Capital	Boardsize	Top1	Employee	Soe
GIC	1													
Sup_EM	-0.00500	1												
Size	0.118***	0.031*	1											
Age	0.0240	0.047***	0.368***	1										
Roa	0.096***	0.0180	-0.0160	-0.113***	1									
TobinQ	0.057***	-0.032*	-0.492***	-0.240***	0.210***	1								
Intangible	0.00200	-0.00300	0.038**	-0.051***	-0.042**	-0.076***	1							
Lev	0.064***	0.00700	0.575***	0.204***	-0.321***	-0.361***	0.00500	1						
Cash	0.099***	0.175***	-0.137***	-0.053***	0.222***	0.217***	-0.138***	-0.0250	1					
Capital	-0.081***	-0.084***	0.087***	-0.070***	-0.036**	-0.071***	0.224***	-0.030*	-0.396***	1				
Boardsize	0.0260	0.067***	0.261***	0.045***	0.056***	-0.205***	0.00800	0.165***	-0.0120	0.058***	1			
Top1	-0.0260	0.0210	0.271***	0.040**	0.088***	-0.186***	0.0140	0.097***	0.0210	0.060***	0.134***	1		
Employee	0.142***	0.077***	0.733***	0.233***	0.049***	-0.320***	0.061***	0.445***	0.150***	-0.078***	0.278***	0.233***	1	
Soe	0.050***	0.180***	0.314***	0.361***	-0.088***	-0.256***	0.062***	0.265***	-0.052***	0.076***	0.269***	0.291***	0.225***	1

B. VIF test results

Variable	Size	Employee	Lev	Cash	TobinQ	Soe	Age	Roa	Capital	Top1	Boardsize	Intangible	Sup_EM
VIF	2.71	2.63	1.86	1.50	1.47	1.45	1.35	1.33	1.28	1.20	1.18	1.08	1.08
1/VIF	0.3690	0.3809	0.5377	0.6675	0.6812	0.6896	0.7387	0.7502	0.7786	0.8355	0.8492	0.9217	0.9254

Table 4 Benchmark regression results

The table reports the regression results of suppliers' environmental misconduct impacting downstream firms' green innovation continuity. Columns (1) and (2) present the results without and with the control variables, respectively. The definitions of the variables are given 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.

	(1)	(2)
Variables	GIC	GIC
Sup_EM	-0.5972**	-0.7022**
	(0.2737)	(0.2880)
Size		-1.5862
		(2.2942)
Age		13.2163*
		(7.9081)
Roa		19.4788**
		(9.4300)
TobinQ		1.9425*
		(0.9928)
Intangible		25.4557**
		(12.9411)
Lev		11.6753
		(8.9401)
Cash		-9.5195**
		(4.2662)
Capital		-5.0110
		(3.4656)
Boardsize		-6.2409**
		(2.9200)
Top1		-12.8179*
		(7.2328)
Employee		2.9591**
		(1.4280)
Soe		-0.3920
		(1.8499)
Constant	4.0711***	-5.3355
	(0.1947)	(61.2233)
Cluster	Firm	Firm
Year FE	Yes	Yes
Firm FE	Yes	Yes
Observations	3,584	3,584
R-squared	0.6331	0.6577
Adj.R-squared	0.5849	0.6112

Table 5 Instrumental variables approach

The table reports the regression results of suppliers' environmental misconduct on downstream firms' green innovation continuity after accounting for endogeneity. Columns (1) and (2) show the regression results using the instrumental variables method (2SLS). Column (3) shows the regression results after Mahalanobis distance matching. Column (4) shows the regression results after PSM. The definitions of the variables are given 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.

	(1)	(2)	(3)	(4)
	2SLS		MDM	PSM
Variables	Sup_EM	GIC	GIC	GIC
Sup_EM		-0.8814**	-0.9658**	-0.8769*
		(0.3957)	(0.3879)	(0.4646)
Ind_Sup_EM	0.5886***			
	(0.0632)			
Pro_Sup_EM	0.4542***			
	(0.0638)			
Size	0.0058	-1.6093	-6.2880	-3.2850
	(0.1409)	(2.2927)	(5.8367)	(3.7612)
Age	0.0705	13.2444*	4.1829	-5.2750
	(0.3133)	(7.9088)	(7.7583)	(6.1718)
Roa	0.2296	19.7417**	34.8329	12.9208
	(0.9497)	(9.5662)	(31.9391)	(15.9330)
TobinQ	-0.0068	1.9310*	3.0443*	1.4555
	(0.0554)	(0.9915)	(1.5861)	(1.5688)
Intangible	-0.4489	25.7792**	37.1729	36.9856
	(1.3608)	(12.9986)	(36.5977)	(25.7227)
Lev	0.4917	11.8838	9.6132	28.8458*
	(0.5536)	(8.9232)	(14.0470)	(16.3841)
Cash	-0.2726	-9.5363**	-4.5024	-0.1413
	(0.1804)	(4.2672)	(4.9096)	(2.8034)
Capital	-0.2544	-5.1245	-31.5445	-35.9513
	(0.2558)	(3.4479)	(28.8758)	(22.2591)
Boardsize	-0.0019	-6.2442**	-12.2162*	-14.0648
	(0.3767)	(2.9179)	(7.1650)	(9.4756)
Top1	0.4400	-12.7839*	-37.7746	-31.4096**
	(0.6440)	(7.2335)	(24.0094)	(14.9757)
Employee	0.0380	2.9767**	8.2092*	1.5246
	(0.1429)	(1.4308)	(4.7942)	(3.3141)
Soe	-0.2552**	-0.4533	-5.8961	-6.4390
	(0.1204)	(1.8465)	(5.5422)	(10.8723)
Constant	-0.6929	-6.9508	109.3140	115.8654
	(2.7838)	(59.8512)	(106.1462)	(90.8701)
Cluster	Firm	Firm	Firm	Firm
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Observations	3,584	3,584	1,126	1,273
R-squared	0.8779	0.0703	0.7837	0.7565
Adj.R-squared	0.8613	0.0703	0.7385	0.7064
Kleibergen-Paap Wald rk F statistic		93.103		
Hansen's J (P-value)		0.4672		

Table 6 Robustness tests using alternative variables

The table presents regression results on the impact of suppliers' environmental misconduct on downstream firms' green innovation continuity after substituting the dependent or independent variables. Column (1) reports the regression results for the main effect, with an alternative proxy for supplier environmental misconduct. Columns (2) to (5) report regression results for the main effect, using three different methods to measure downstream firms' green innovation continuity. Column (6) reports the regression results of suppliers' environmental misconduct on downstream firms' green innovation. Column (7) reports the regression results of suppliers' environmental misconduct on downstream firms' green innovation resilience. The definitions of the variables are given 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.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables	GIC	GIC_GRT	GIC_GIA	GIC_GUA	GIC_B	GI	GIR
Sup_EM_b	-9.3935**						
	(4.3762)						
Sup_EM		-1.1942*	-0.4755**	-0.4610***	-0.2487**	-0.0424**	-0.0961***
		(0.6728)	(0.1886)	(0.1763)	(0.0963)	(0.0173)	(0.0282)
Size	-1.9067	1.6046	-0.0665	1.5408	-0.0657	-0.0283	0.0886
	(2.3143)	(4.1509)	(3.9293)	(1.6554)	(0.3538)	(0.1127)	(0.1039)
Age	12.5882	9.0524	1.1699	11.4766*	1.5858	0.7097*	0.3113
	(7.8609)	(9.7309)	(4.6099)	(6.3351)	(0.9715)	(0.4404)	(0.3299)
Roa	19.9680**	8.0834	26.0114**	5.4115	2.5861	0.6521	-0.1907
	(9.4736)	(13.2576)	(11.8092)	(5.1809)	(2.2431)	(0.4877)	(0.5346)
TobinQ	1.9117*	-0.3099	2.4866**	0.9343*	0.2727	0.0327	-0.0013
	(0.9997)	(1.2794)	(1.1804)	(0.5182)	(0.1968)	(0.0431)	(0.0481)
Intangible	22.8599*	8.5034	10.4870	4.6905	10.1144***	1.9122**	1.0628*
	(12.6870)	(40.7453)	(14.2167)	(7.8758)	(2.0774)	(0.8164)	(0.6123)
Lev	10.6884	-5.6682	17.3524	0.0027	1.2703	0.1828	-0.1773
	(8.8110)	(9.3162)	(11.8948)	(2.9065)	(1.1038)	(0.3892)	(0.3783)
Cash	-9.4267**	-7.9484*	-4.7838	-4.8936*	0.3646	-0.3304	0.0583
	(4.2651)	(4.2438)	(4.6552)	(2.8261)	(0.6654)	(0.2148)	(0.1854)
Capital	-4.6980	4.6417	-0.1587	-1.3016	-0.1179	-0.1861	0.3957**
	(3.4137)	(5.4745)	(2.1563)	(1.2904)	(0.7058)	(0.1710)	(0.1812)
Boardsize	-5.9981**	-15.6202**	-7.0896*	-4.8380**	-1.8582**	-0.4814***	-0.0688*
	(2.7419)	(7.5273)	(3.9562)	(2.4474)	(0.7226)	(0.1719)	(0.0268)
Top1	-13.0435*	-0.6752	-1.6325	-2.7069	0.3406	-0.3576	-0.7686*
	(7.1942)	(10.7007)	(7.5702)	(6.1125)	(1.7471)	(0.5799)	(0.4135)
Employee	2.9416**	1.2198	-0.4840	0.4775	-0.1438	0.0676	0.0309
	(1.4197)	(3.5624)	(2.9741)	(1.3210)	(0.4722)	(0.1138)	(0.0834)
Soe	-0.2674	4.6864*	-0.0072	0.1004	0.6015	0.1487	0.1445
	(1.8265)	(2.7093)	(2.4238)	(0.6603)	(1.0550)	(0.1367)	(0.2238)
Constant	3.8361	-25.8593	11.2930	-55.9730	0.2869	-0.3838	-3.0138
	(61.5512)	(75.9166)	(70.8479)	(40.5001)	(7.5435)	(3.2010)	(2.5369)
Cluster	Firm	Firm	Firm	Firm	Firm	Firm	Firm
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,584	3,584	3,584	3,584	3,584	3,584	3,584
R-squared	0.6591	0.7499	0.5097	0.4082	0.4200	0.7864	0.7267
Adj.R-squared	0.6129	0.7160	0.4432	0.3279	0.3414	0.7574	0.6896

Table 7 Accounting for other potential explanations

The table presents regression results examining the impact of suppliers' environmental misconduct on downstream firms' green innovation continuity, accounting for alternative explanations. Column (1) shows the main effect estimates for a subsample of downstream firms located outside the same city as their suppliers. Columns (2) and (3) provide the main effect estimates for subsamples of downstream firms with high pollution attributes (H-pollution) and low pollution attributes (L-pollution), respectively. The definitions of the variables are given 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.

	(1)	(2)	(3)
		H_pollution	L_pollution
Variables	GIC	GIC	GIC
Sup_EM	-0.8022**	-1.1397**	-0.9715**
	(0.3343)	(0.5200)	(0.4670)
Size	-1.4419	-10.8016*	0.4565
	(2.2511)	(5.9390)	(2.1923)
Age	13.3720*	2.7228	13.3715
	(7.3000)	(8.7799)	(9.0303)
Roa	16.5825	27.0143	25.3335*
	(10.0656)	(23.9035)	(13.5236)
TobinQ	2.3558**	-0.6975	3.4395**
	(1.1106)	(1.4532)	(1.4966)
Intangible	26.6489*	36.4588	33.3327
	(13.8316)	(22.8275)	(22.1041)
Lev	8.4238	24.2859	4.8519
	(7.1383)	(18.4058)	(5.7347)
Cash	-9.4574**	-3.2165	-10.6080*
	(4.4271)	(4.7162)	(5.6957)
Capital	-5.4925	-18.2370	-2.3941
	(3.9604)	(11.2798)	(2.7151)
Boardsize	-7.1158**	-9.6721*	-3.7447
	(3.0880)	(5.0075)	(3.2076)
Top1	-11.3279	-51.5603**	-5.1108
	(7.1127)	(20.2848)	(7.0228)
Employee	3.1957**	5.8002	3.1559*
	(1.4953)	(3.9395)	(1.6399)
Soe	0.2196	-29.4134**	-1.7654
	(2.0687)	(14.8109)	(1.6942)
Constant	-8.9125	254.4189*	-61.5458
	(55.7996)	(146.1556)	(65.1981)
Cluster	Firm	Firm	Firm
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Observations	2,109	1,244	2,340
R-squared	0.6491	0.8083	0.6880
Adj.R-squared	0.6226	0.7696	0.6375

Table 8 Executives' green cognition as a transmission mechanism

The table presents regression results examining executives' green cognition in downstream firms as a transmission mechanism for the impact of suppliers' environmental misconduct on downstream firms' green innovation continuity. The definitions of the variables are given 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. The table also reports Sobel and Bootstrap tests for downstream firms' executives' green cognition as a mediating variable.

Variables	(1) GIC	(2) EGC	(3) GIC
Sup_EM	-0.7022**	-0.7880***	-0.4857*
	(0.2880)	(0.2614)	(0.2556)
EGC			0.2747*
			(0.1626)
Size	-1.5862	-1.3399**	-1.2181
	(2.2942)	(0.5978)	(2.2762)
Age	13.2163*	0.0813	13.1940*
	(7.9081)	(1.4922)	(7.9177)
Roa	19.4788**	4.7627	18.1705*
	(9.4300)	(3.1633)	(9.3485)
TobinQ	1.9425*	0.2556	1.8723*
	(0.9928)	(0.2557)	(0.9856)
Intangible	25.4557**	-4.5078	26.6940**
	(12.9411)	(7.2364)	(13.1163)
Lev	11.6753	0.9771	11.4069
	(8.9401)	(2.0454)	(9.0178)
Cash	-9.5195**	-0.4605	-9.3930**
	(4.2662)	(0.7700)	(4.2452)
Capital	-5.0110	0.4693	-5.1399
	(3.4656)	(1.4406)	(3.4207)
Boardsize	-6.2409**	1.5524	-6.6673**
	(2.9200)	(1.9763)	(2.8194)
Top1	-12.8179*	-2.2652	-12.1956*
	(7.2328)	(2.2531)	(7.1982)
Employee	2.9591**	1.5003***	2.5469*
	(1.4280)	(0.4963)	(1.3674)
Soe	-0.3920	1.1625**	-0.7114
	(1.8499)	(0.4770)	(1.8506)
Constant	-5.3355	18.8771	-10.5189
	(61.2233)	(12.9886)	(61.2335)
Cluster	Firm	Firm	Firm
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Observations	3,584	3,583	3,583
R-squared	0.6577	0.8051	0.6600
Adj.R-squared	0.6112	0.7788	0.6138
Sobel (Z)	5.263		
Sobel (P-value)	0.000		
Bootstrap test [95% conf. interval]	(0.0648875, 0.1919392)		

Table 9 Financial constraints as a transmission mechanism

The table reports the regression results for financial constraints of downstream firms as a transmission mechanism of suppliers' environmental misconduct affecting downstream firms' green innovation continuity. The definitions of the variables are given 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. The table also reports Sobel and Bootstrap tests for downstream firms' financing constraints as a mediating variable.

	(1)	(2)	(3)
Variables	GIC	SA	GIC
Sup_EM	-0.7022**	0.0243***	0.8476
	(0.2880)	(0.0021)	(0.6090)
SA			-63.7339**
			(24.9976)
Size	-1.5862	0.0987***	4.7014
	(2.2942)	(0.0183)	(2.9558)
Age	13.2163*	-0.1084***	6.3066
	(7.9081)	(0.0355)	(6.5653)
Roa	19.4788**	-0.1092*	12.5204
	(9.4300)	(0.0570)	(8.8974)
TobinQ	1.9425*	0.0125*	2.7405**
	(0.9928)	(0.0065)	(1.1090)
Intangible	25.4557**	-0.0077	24.9663**
	(12.9411)	(0.0859)	(12.1767)
Lev	11.6753	-0.0243	10.1237
	(8.9401)	(0.0502)	(8.1819)
Cash	-9.5195**	-0.0316*	-11.5333***
	(4.2662)	(0.0177)	(4.3598)
Capital	-5.0110	-0.0121	-5.7842
	(3.4656)	(0.0180)	(3.5505)
Boardsize	-6.2409**	-0.0267	-7.9407**
	(2.9200)	(0.0209)	(3.1129)
Top1	-12.8179*	-0.1738***	-23.8928**
	(7.2328)	(0.0603)	(9.7998)
Employee	2.9591**	0.0005	2.9889*
	(1.4280)	(0.0111)	(1.5334)
Soe	-0.3920	0.0157	0.6055
	(1.8499)	(0.0202)	(1.7073)
Constant	-5.3355	-5.7748***	-373.3833**
	(61.2233)	(0.4474)	(156.3137)
Cluster	Firm	Firm	Firm
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Observations	3,584	3,584	3,584
R-squared	0.6577	0.9909	0.6586
Adj.R-squared	0.6112	0.9881	0.6387
Sobel (Z)	-2.408		
Sobel (P-value)	0.016		
Bootstrap test [95% conf. interval]	(-0.1163966, -0.0011569)		

Table 10 Moderating effects

The table reports the regression results of downstream firms' bargaining power and geographic distance between upstream and downstream firms in moderating the relationship between suppliers' environmental misconduct and downstream firms' green innovation continuity. Column (1) reports the results of downstream firms' bargaining power as a moderating variable. Column (2) reports the results for geographic distance between upstream and downstream firms as a moderating variable. The definitions of the variables are given 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.

	(1)	(2)
Variables	GIC	GIC
Sup_EM	-1.5092***	-0.5109**
	(0.3944)	(0.2519)
SCHHI	0.1832**	
	(0.0751)	
Sup_EM×SCHHI	0.0608*	
	(0.0350)	
Distance		-0.0146
		(0.0912)
Sup_EM×Distance		-0.1238**
		(0.0581)
Size	-2.1539	-0.1793
	(2.5582)	(2.0160)
Age	14.4543*	13.7707
	(8.4358)	(10.1497)
Roa	23.3663**	13.0263*
	(9.4151)	(6.9604)
TobinQ	1.5244	0.6298
	(1.0595)	(0.7014)
Intangible	29.6422**	18.8374
	(14.0889)	(12.5815)
Lev	12.1675	12.1854
	(11.2451)	(12.1149)
Cash	-9.9304**	-8.4051*
	(4.2976)	(4.3362)
Capital	-5.0887*	-4.4198
	(2.8052)	(3.1701)
Boardsize	-3.8709	-4.2531
	(2.9578)	(3.4614)
Top1	-7.5321	-11.4095
	(8.0042)	(9.0998)
Employee	3.1560**	1.5128
	(1.4562)	(1.3005)
Soe	-0.3325	-1.8606
	(2.2407)	(1.9011)
Constant	-5.3054	-31.5304
	(68.6976)	(68.3035)
Cluster	Firm	Firm
Year FE	Yes	Yes
Firm FE	Yes	Yes
Observations	3,274	2,126
R-squared	0.6855	0.6603
Adj.R-squared	0.6428	0.6003

Table 11 China's new environmental protection law and green innovation continuity

The table reports regression results of the shock effect of China's new environmental protection law on suppliers affecting downstream firms' green innovation continuity, with suppliers' environmental misconduct as the transmission mechanism. Columns (1) to (3) and columns (4) to (6) are the results of the three-step test of the mediating effect of Model IV before and after PSM, respectively. The definitions of the variables are given 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.

	(1)	(2)	(3)	(4)	(5)	(6)
		DID			PSM-DID	
Variables	GIC	Sup_EM	GIC	GIC	Sup_EM	GIC
Sup_treat×post	14.6177***	-0.2516*	14.4987***	14.6299***	-0.2555*	14.5037***
	(3.2686)	(0.1351)	(3.2784)	(3.2640)	(0.1378)	(3.2744)
Sup_EM			-0.4732*			-0.4936*
			(0.2544)			(0.2639)
Size	-1.8896	-0.1218	-1.9472	-1.9132	-0.0915	-1.9583
	(2.0207)	(0.2590)	(2.0290)	(2.0894)	(0.2568)	(2.0980)
Age	8.6484	0.2333	8.7588	8.9993	0.2762	9.1357
	(6.4749)	(0.4549)	(6.4915)	(6.5811)	(0.4632)	(6.6018)
Roa	19.5033**	1.4487	20.1888**	24.0324**	1.5188	24.7821**
	(8.7642)	(1.4709)	(8.7976)	(11.1420)	(1.6989)	(11.1753)
TobinQ	1.6619*	-0.0585	1.6342*	1.6935*	-0.0694	1.6592*
	(0.8678)	(0.1010)	(0.8673)	(0.9099)	(0.1085)	(0.9080)
Intangible	23.2737**	1.8207	24.1353**	28.7750**	2.7284	30.1218***
	(10.3392)	(2.2132)	(10.5847)	(11.1931)	(2.3322)	(11.5117)
Lev	10.8418	1.1634	11.3923	12.0643	1.1679	12.6409
	(7.4780)	(0.8448)	(7.5076)	(7.8104)	(0.8593)	(7.8320)
Cash	-8.1402**	-0.1161	-8.1951**	-8.6314**	-0.1294	-8.6952**
	(3.7062)	(0.2794)	(3.7097)	(3.8057)	(0.2803)	(3.8111)
Capital	-3.1548	-0.6576	-3.4659	-4.7336	-0.8458	-5.1511
	(2.7264)	(0.4470)	(2.7832)	(3.2150)	(0.5224)	(3.2903)
Boardsize	-2.8725	-0.0763	-2.9086	-2.7836	-0.1065	-2.8362
	(2.9596)	(0.4938)	(2.9438)	(3.0099)	(0.4870)	(2.9935)
Top1	-10.9927*	0.1558	-10.9189*	-10.9912*	0.1635	-10.9105*
	(5.9478)	(0.8063)	(5.9309)	(5.9927)	(0.8147)	(5.9702)
Employee	2.1708*	0.1106	2.2232*	2.1280	0.1091	2.1819*
	(1.2960)	(0.1844)	(1.2964)	(1.3174)	(0.1880)	(1.3184)
Soe	-1.3141	-0.3218	-1.4663	-1.4902	-0.3331	-1.6547
	(2.6326)	(0.2245)	(2.6306)	(2.6536)	(0.2269)	(2.6470)
Constant	10.9580	1.8591	11.8377	10.0905	1.1185	10.6426
	(50.9118)	(5.4750)	(51.1375)	(52.9028)	(5.4603)	(53.1482)
Cluster	Firm	Firm	Firm	Firm	Firm	Firm
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,584	3,584	3,584	3,446	3,446	3,446
R-squared	0.7076	0.7624	0.7085	0.7030	0.7608	0.7040
Adj.R-squared	0.6680	0.7302	0.6689	0.6675	0.7322	0.6684
Sobel (Z)	-1.928					
Sobel (P-value)	0.05379					
Bootstrap test [95% conf. interval]		(-0.2364142, -0.0113435)				

Table 12 Talent introduction policies on downstream firms' & green innovation continuity

The table reports the regression results of the impact of talent introduction policies on downstream firms' green innovation continuity and how suppliers' environmental misconduct moderates this relationship. The definitions of the variables are given 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.

	(1)	(2)	(3)	(4)
	DID		PSM-DID	
Variables	GIC	GIC	GIC	GIC
Treat×post	5.7505***	6.4145***	5.6929***	6.3577***
	(1.9207)	(2.3552)	(1.9171)	(2.3613)
Sup_EM		0.0337		0.0229
		(0.4002)		(0.4041)
Treat×post×Sup_EM		-1.0810*		-1.0835*
		(0.6240)		(0.6321)
Size	-2.1147	-2.3762	-2.1612	-2.4382
	(2.2809)	(2.3237)	(2.3310)	(2.3847)
Age	12.9371	12.8222	13.3472*	13.2072*
	(7.8887)	(7.8500)	(8.0105)	(7.9744)
Roa	19.2241**	21.1189**	19.3033**	21.1387**
	(9.1497)	(9.6136)	(9.2406)	(9.6777)
TobinQ	1.6402*	1.6097*	1.6578*	1.6237*
	(0.9275)	(0.9225)	(0.9329)	(0.9280)
Intangible	24.6559**	24.8014**	27.2196*	27.7859*
	(12.1601)	(12.3031)	(14.3370)	(14.6128)
Lev	11.3858	10.7824	11.2309	10.5107
	(8.8169)	(8.6975)	(8.8659)	(8.7378)
Cash	-8.4476**	-8.4558**	-8.6554**	-8.6525**
	(3.9360)	(3.9295)	(3.9701)	(3.9610)
Capital	-5.5998	-5.6899	-6.2400*	-6.2970*
	(3.4519)	(3.6548)	(3.5580)	(3.7827)
Boardsize	-5.7368**	-5.8509**	-5.7797*	-5.9268**
	(2.9040)	(2.8817)	(2.9655)	(2.9501)
Top1	-14.9083**	-14.3249**	-14.2057**	-13.6410*
	(7.0679)	(7.0986)	(7.0743)	(7.1060)
Employee	2.7215**	2.8492**	2.8964**	3.0421**
	(1.3162)	(1.3365)	(1.3249)	(1.3510)
Soe	0.0124	-0.1222	0.8604	0.7274
	(1.9623)	(2.0498)	(1.7321)	(1.8077)
Constant	5.8243	11.3929	3.8517	9.8236
	(60.8388)	(61.3884)	(62.3294)	(63.0920)
Cluster	Firm	Firm	Firm	Firm
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Observations	3,538	3,538	3,430	3,430
R-squared	0.6660	0.6680	0.6568	0.6589
Adj.R-squared	0.6213	0.6232	0.6166	0.6186

APPENDIX

To accompany the paper:

A fish rots from the head down: The contagion effect of upstream firms' environmental misconduct on downstream firms' green innovation continuity

April 2025

Appendix 1 - Figure A1: Parallel trend of the impact of suppliers' environmental misconduct on procurement share

Appendix 2 - Table A2: Key words representing the executives' green cognition

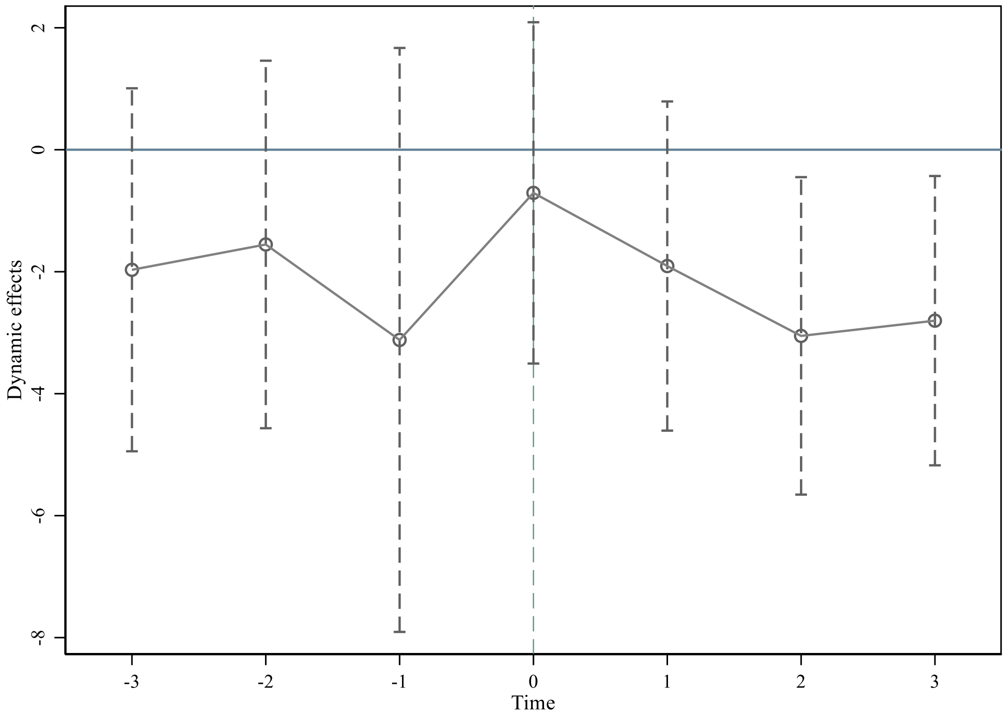
Appendix 3 - Table A3: List of terms containing unrealistic factors

Appendix 4 - Table A4: Time of implementation of talent introduction policies in various cities

Appendix 1

Figure A1: Parallel trend of the impact of suppliers' environmental misconduct on procurement share

We employ environmental misconduct by upstream firms as an exogenous shock to examine its impact on suppliers' procurement share from their clients. Specifically, we utilize this upstream environmental misconduct shock as the explanatory variable, with changes in suppliers' procurement share from distributors as the dependent variable. Controlling for year and firm fixed effects, we design a parallel trends test following a difference-in-differences (DID) framework. The results are reported in the figure below. Here, 0 denotes the reference point of a supplier's environmental misconduct occurrence. The left (-) and right (+) sides of this point represent the pre- and post-period procurement share from clients, respectively. We observe that clients began to significantly reduce their procurement share from the affected supplier in the second year following the environmental misconduct incident.



Appendix 2

Table A2 Key words representing the executives' green cognition

The table reports the word list used for text analysis to measure executives' green cognition, including seed words and extended words. We train and analyze texts related to corporate financial reports based on the Chinese context, and the Chinese keywords are reported in parentheses.

Dimensions	Seed words	Expanded words
Green competitive advantage awareness	Environmental protection strategies (环保战略), Environmental technology development (环境技术开发), Environmental protection training programs (环保培训), Environmental protection infrastructure (环保设施), Environmental education (环保教育), Environmental protection efforts (环保工作)	Green development strategy (绿色发展战略), Sustainable development strategy (可持续发展战略), Corporate green innovation (企业绿色创新), Low-carbon development (低碳发展), Environmental investment strategy (环保投资策略), Green technology (绿色技术), Clean energy technology (清洁能源技术), Eco-friendly technology (环境友好型技术), Carbon capture technology (碳捕捉技术), Energy-saving technologies (节能技术), Energy-efficient technology innovation (节能技术创新), Pollution control technology (污染控制技术), Green material development (绿色材料研发), Green management training (绿色管理培训), Environmental regulation training (环境法规培训), Enhancement of employee environmental awareness (员工环保意识提升), Ecological compensation mechanism (生态补偿机制), Pollution control equipment (污染治理设备), Low-carbon emission facilities (低碳排放设备), Wastewater treatment facilities (废水处理设施), Environmental monitoring equipment (环境监测设备), Corporate environmental culture development (企业环保文化建设), Green value education (绿色价值观教育), Low-carbon emission plan (低碳排放计划), Pollution reduction measures (污染减排措施)
Corporate social responsibility awareness	Energy conservation and emission reduction (节能减排), Low-Carbon environmental initiatives (低碳环保), Environmental philosophy (环保理念), Pollution control (环保治污), Energy conservation and environmental protection (节能环保), Environmental protection and governance (环保和环境治理), Environmental governance (环保治理)	Energy efficiency optimization (能效优化), Clean production (清洁生产), Green transformation (绿色转型), Carbon emission trading (碳排放交易), Reduction of emission intensity (排放强度降低), Carbon neutrality goals (碳中和目标), Clean energy applications (清洁能源应用), Low-carbon economic models (低碳经济模式), Carbon footprint management (碳足迹管理), Sustainability philosophy (可持续发展理念), Corporate ecological responsibility (企业生态责任), Circular economy concepts (循环经济概念), Social responsibility orientation (社会责任导向), Pollution source control (污染源控制), Pollution remediation technologies (污染修复技术), Emission compliance (排放达标), Ecological restoration measures (生态恢复措施), Air pollution prevention (大气污染防治), Water pollution treatment (水体污染治理), Efficient resource allocation (资源高效配置), Environmental risk assessment (环境风险评估), Regional ecological restoration (区域生态恢复), Soil remediation technologies (土壤修复技术), Pollution control projects (污染治理工程), Environmental governance innovation (环境治理创新), Emission rights trading (排污权交易), Ecological protection red line (生态保护红线)
External environmental pressures	Environmental management agencies (环境管理机构), Environmental audits (环境审计), Environmental laws and regulations (环保相关法律法规), Environmental policies (环保政策), Environmental supervision and inspection (环保督察), Environmental protection authorities (环保部门)	Environmental governance bodies (环境治理机构), Regional environmental bureaus (区域环保局), Sustainable operations units (可持续运营部门), Industrial environmental oversight committees (行业环保监管委员会), Environmental compliance (环保合规), Sustainability performance evaluation (可持续绩效评估), Carbon footprint verification (碳足迹核查), Environmental reporting assurance (环境报告核查), National environmental standards (国家环境标准), Environmental liability laws (环境责任法), Air and water quality standards (空气与水质量标准), Government green initiatives (政府绿色倡议), Low-carbon economy (低碳经济), Emission reduction frameworks (减排框架), Environmental compliance monitoring (环保合规监测), Environmental impact evaluations (环境影响评估), Ecological protection inspections (生态保护检查), Compliance tracking systems (合规追踪系统), Pollution control agencies (污染控制机构), Environmental regulatory bodies (环境监管机构)

Appendix 3

Table A3 List of terms containing unrealistic factors

The table lists a series of unrealistic words that appear in financial reports; these words may not represent true green awareness when they appear in the same context as words that represent executives' green cognition; this is the factor we need to exclude. These words are based on Chinese-contextualized corporate annual reports, and the Chinese words are reported in parentheses. Besides, these words appear infrequently in the annual reports of the sample companies in this study. Words that appear in the annual reports of the sample firms in this study are marked with "*" in the table.

Dimensions	Words
Vague or unverifiable claims	Chemical-free *(无化学)*, Non-toxic *(无毒)*, Green products *(绿色产品)*, Actively responding to various policies* *(积极响应各方政策)*, Harmless *(无害)*
Exaggerated or absolute term	Completely biodegradable *(完全可降解),* 100% sustainable *(100%可持续)*, Zero emissions *(零耗能)*, Zero pollution* *(零污染)*, Revolutionary *(革命性)*, Groundbreaking *(开创性)*, World's first *(世界第一)*, Epoch-making* *(划时代)*, Globally pioneering *(全球首创)*, Fully degradable *(完全降解)*, Highest standards* *(最高标准)*, Full implementation* *(全面实施)*

Appendix 4

Table A4 Time of implementation of talent introduction policies in various cities

The table reports the implementation time of talent introduction policies in various cities in China in 2016 and subsequent years.

Year	Cities implementing the policies
2016	Anqing, Baiyin, Baoji, Benxi, Chaoyang, Dehong Dai and Jingpo Autonomous Prefecture, Fuzhou, Guigang, Hangzhou, Haixi Mongol and Tibetan Autonomous Prefecture, Hezhou, Heyuan, Hotan prefecture, Huaibei, Huainan, Jiangmen, Jingmen, Linfen, Loudi, Luohe, Lu'an, Ma'anshan, Quanzhou, Sanming, Shangluo, Shangqiu, Shangrao, Shenzhen, Suining, Suizhou, Suqian, Suzhou, Tongchuan, Xiamen, Xuchang, Xuancheng, Yanbian Korean Autonomous Prefecture, Yantai, Yichang, Yulin, Yunfu, Yuxi, Zhaoqing, Zhoushan, Zhongwei
2017	Altay prefecture, Baicheng, Baishan, Bayannur, Bozhou, Cangzhou, Changchun, Changde, Changsha, Changzhi, Chengdu, Chaozhou, Chuzhou, Chongqing, Chongzuo, Datong, Fuzhou, Ganzhou, Guangyuan, Guilin, Guyuan, Harbin, Hegang, Hefei, Hohhot, Honghe hani and yi autonomous prefecture, Huzhou, Jiaxing, Jiamusi, Jiayuguan, Jinzhou, Jingdezhen, Lanzhou, Leshan, Lianyungang, Liangshan yi autonomous prefecture, Lijiang, Liaoyuan, Lüliang, Meishan, Nanping, Nanjing, Ningde, Panzhihua, Pingliang, Pingxiang, Putian, Puyang, Qinhuangdao, Qiandongnan miao and dong autonomous prefecture, Sanmenxia, Taizhou, Wuzhou, Wuhan, Xiaogan, Xinyang, Ya'an, Yangjiang, Yangzhou, Yingkou, Yingtan, Zhengzhou, Zigong, Zunyi
2018	Alxa League, Ankang, Anshan, Baise, Baoding, Beijing, Binzhou, Chenzhou, Fushun, Fuxin, Fuyang, Guang'an, Haikou, Hengshui, Hengyang, Huaihua, Huangshi, Ili Kazakh Autonomous Prefecture, Jiaozuo, Jinan, Jiujiang, Jiuquan, Jinzhong, Langfang, Lhasa, Luoyang, Maoming, Mianyang, Mudanjiang, Nanchang, Nanyang, Ningbo, Pu'er, Qingdao, Rizhao, Sanya, Sansha, Shuangyashan, Tai'an, Tacheng Prefecture, Tianjin, Tongren, Weihai, Wuhai, Wuxi, Wuzhong, Xi'an, Xiangtan, Xining, Xinxiang, Xuzhou, Yancheng, Yibin, Yichun, Yiyang, Yulin, Zhuhai, Zhoukou, Zaozhuang, Zhumadian
2019	Bengbu, Bortala Mongol Autonomous Prefecture, Chizhou, Dali Bai Autonomous Prefecture, Dalian, Danzhou, Dongying, Garze Tibetan Autonomous Prefecture, Guangzhou, Hechi, Hebi, Heze, Jixi, Karamay, Laibin, Liupanshui, Nantong, Nanning, Neijiang, Qitaihe, Qujing, Shaoguan, Shaoyang, Shanwei, Shihezi, Shiyan, Suihua, Taiyuan, Wenshan Zhuang and Miao Autonomous Prefecture, Xianning, Xiangxi Tujia and Miao Autonomous Prefecture, Yangquan, Yongzhou, Zhangjiajie, Zhangye, Zibo
2020	Anyang, Dazhou, Dezhou, Handan, Heihe, Huizhou, Jinhua, Jinchang, Jining, Ji'an, Jieyang, Kizilsu Kirghiz Autonomous Prefecture, Linyi, Lishui, Meizhou, Ngawa Tibetan and Qiang Autonomous Prefecture, Panjin, Pingdingshan, Qingyang, Qiqihar, Shanghai, Shantou, Shizuishan, Suzhou, Tonghua, Tongliao, Weifang, Wenzhou, Xianyang, Yueyang, Ürümqi
2021	Anshun, Baotou, Bazhong, Bijie, Chengde, Chifeng, Daqing, Dandong, Fangchenggang, Guiyang, Jilin, Longyan, Luzhou, Qingyuan, Shaoxing, Shuozhou, Siping, Taizhou, Tangshan, Tianshui, Tongling, Tumxuk, Weinan, Wuhu, Wuwei, Yan'an, Zhenjiang, Zhangzhou
2022	Baishan, Baoshan, Bayingolin Mongol Autonomous Prefecture, Chuxiong Yi Autonomous Prefecture, Dingxi, Dongguan, Enshi Tujia and Miao Autonomous Prefecture, Ezhou, Huludao, Hulunbuir, Huai'an, Huanggang, Huangshan, Jinan, Jincheng, Jingzhou, Jining, Kaifeng, Kashgar Prefecture, Liaocheng, Liuzhou, Longnan, Ordos, Qianjiang, Shenyang, Shijiazhuang, Tianmen, Xiangyang, Xiantao, Xining, Xinzhou, Xishuangbanna Dai Autonomous Prefecture, Yichun, Yinchuan, Zhaotong, Ziyang
2023	Beihai, Changji Hui Autonomous Prefecture, Deyang, Diqing Tibetan Autonomous Prefecture, Foshan, Hami, Kunming, Liaoyang, Quzhou, Tieling, Xingtai, Yuncheng