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RESEARCH ARTICLE

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Do major customers encourage innovative sustainable development? Empirical evidence from corporate green innovation in China

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Abstract

This paper examines the impact of customer concentration on green innovation in Chinese listed firms between 2006 and 2018 through the dynamic panel generalized method of moments regressions. It is reported that major customers positively impact corporate green innovation, indicating that firms have more incentives to engage in innovative green practices to maintain stable relationships with major customers. In addition, the positive relationship between customer concentration and green innovation is more pronounced in state-owned enterprises, firms located in the provinces with a high level of marketization, and after China's new Environmental Protection Law implementation. Moreover, we observe that the positive impact of customer concentration on corporate green innovation is more significant among industrial firms and firms operating in heavily polluting industries. Furthermore, industrial competition is an essential channel for major customers to affect corporate green innovation.

KEYWORDS
corporate environmental responsibility, customer concentration, green innovation, patents, sustainable development

1 | INTRODUCTION

Green innovation has become an essential innovation capability of a company as the world has witnessed extreme environmental deterioration over the last decades (Chen et al., 2018). An increasing number of firms have been pressured to adopt green innovation initiatives to improve their environmental performance and achieve economic profits, environmental protection and sustainable development (Li et al., 2017). Subsequently, green innovation is often linked to the concept of corporate social and environmental responsibility and sustainable business (Chen, 2008). Green innovation bolsters positive externalities such as enhanced technological spillovers and reduced external environmental costs (Horbach, 2008). It is thus regarded as a 'superior' type of innovation and is of particular interest to businesses and governments in top polluting countries, such as China. This paper focuses on the green type of innovation and investigates major customers' roles in the firm.

While there is plenty of research on the factors that affect the companies' innovation investment (Doran & Ryan, 2016), academia has paid little attention to the impact of customer concentration on green innovation. Customer concentration indicates a company's degree of dependence upon customers; a more concentrated customer base provides stable sales channels, thus guaranteeing companies' operating efficiency. On the other hand, excessive customer

concentration will impact development decisions such as product prices and research and development (R&D) investment, thereby affecting their business strategies (Dhaliwal et al., 2016). There is an urgent need for research on the relationship between corporate customer concentration and green innovation. We are motivated to fill in the gap by advancing the role of major customers in the adoption of green innovation. Our empirical findings lend support to the promotion of green innovation to attract and retain major customers and meet new regulatory requirements.

We investigated the impact of customer concentration on green innovation in Chinese-listed firms between 2006 and 2018. Using a dynamic panel generalized method of moments (GMM) model, we examined the impact of customer concentration on green innovation. We found a positive relationship between customer concentration and green innovation, implying that firms have more incentives to engage in innovative green practices to maintain relationships with major customers. In addition, the relationship between customer concentration and green innovation was more pronounced in state-owned enterprises (SOEs) than non-SOEs. Moreover, we found that the positive impact of customer concentration on corporate green innovation was more pronounced in the provinces with a high level of marketization. Lastly, we found that such a positive relationship was more pronounced after initiating the new Environmental Protection Law.

In China, 40 years of high-speed economic growth has resulted in severe environmental pollution and ecological devastation, which has triggered genuine concern from media, customers, and other stakeholders. To address this issue, the Chinese government has recently been involved in green development and technological energy innovation as one of the fundamental principles in the 14th Five-Year Plan (2021–2025). Thus, to obtain environmental legitimacy and meet the requirements of stakeholders, green innovation is adopted by firms to mitigate the negative impact of production and operations on the environment through improved processes, technologies, systems, products and management practices (Kemp & Volpi, 2008).

The main contributions of this paper are as follows. Firstly, we fill the gap in the literature by examining green innovation instead of general innovation. Previous literature on the relationship between customer concentration and innovation focuses on general innovation and reports mixed empirical results. For instance, Krolikowski and Yuan (2017) observe that customer concentration positively impacts innovation investment in the United States, implying that suppliers with a concentrated customer base tend to hold a more bilateral relationship with their customers and pay more attention to their relationship-specific investments. On the other hand, Pan et al. (2020) find the opposite evidence that suppliers with higher customer concentrations produce fewer patents. Our research aims to alleviate this ambiguity in their relationship and further extend to green innovation. Corporate green innovation implies its capability of environmental reform and conservation. Unlike general innovation, green innovation is associated with technological improvements with environmental benefits, such as new products contributing to firm sustainable development and environmental protection (Zhang et al., 2019). Moreover, we echo Tan et al. (2019) and bridge a legitimate link between customer concentration and green innovation. In this regard, we have developed a detailed investigation of the mechanism and demonstrated that industrial competition is an essential channel that major customers can affect suppliers' green innovation.

Secondly, this study is one of the first to compare SOEs or non-SOEs to explore the potential relationship between customer concentration and green innovation in various corporate structures. China has a unique corporate ownership structure: Most listed firms have a highly concentrated ownership structure, with a single owner controlling the firms (Wang et al., 2019). The single owner often refers to the state or state agencies. In this regard, we extend previous research by showing that the positive relationship between customer concentration and green innovation is more pronounced in SOEs.

Thirdly, we advance the literature by examining the impact of customer concentration on green innovation by incorporating marketization among firms in different regions. Differences exist in social, cultural, and economic conditions among different provinces in China. Chen et al. (2017) argue that regional green innovation investment decreases gradually from developed to developing regions. Our results support this argument and show that the extent of regional development may also affect the customer concentration–green innovation relationship. This research is also the first that examines how legal factor affects the relationship between customer concentration and green innovation. In particular, China's new Environmental Protection Law was passed by the National People's Congress in 2014 and implemented the following year. This regulatory development provides legislative support for sustainable corporate development in China. Strong legislative support makes firms pay attention to the environmental welfare of the whole society, and we also find that the impact of customer concentration on green innovation is more pronounced after the implementation of the new Environmental Protection Law.

Lastly, we focus on the Chinese context, which is distinct from most of the existing studies based on developed countries (Aldieri et al., 2019); this, in turn, adds value to the literature since the concept of green innovation is relatively new in emerging economies and governments are increasingly encouraging firms to follow a sustainable growth model (Wang & Zhang, 2020). From this perspective, our findings can be generalizable to other emerging economies and encourage firms to have a more holistic orientation towards corporate sustainability.

The remainder of the paper is organized as follows. In the next section, we account for the institutional background, review the literature, and develop four hypotheses. The following section outlines the methodology and empirical results. Finally, the last section provides a conclusion.

2 | LITERATURE REVIEW

2.1 | Institutional background

2.1.1 | Major customer reporting

In the United States, according to the Statement of Financial Accounting Standards, No.14 (SFAS) promulgated by the Financial Accounting Standard Board (FASB), suppliers should disclose their external customers who contribute more than 10% of suppliers' sales. These customers are defined as 'major customers', whose names and sales need to be disclosed (Zhou et al., 2019). Similarly, listed companies in China are also required to disclose major customers. In particular, according to the Information Disclosure Standards No. 2 promulgated by the China Securities Regulatory Commission (CSRC), listed companies need to disclose relevant sales information regarding their Top 5 customers in their annual reports (Huan et al., 2017). Previous research indicates that listed firms in China have a significantly higher level of customer concentration than their US counterparts, with more than 40% of firms having customers whose sales account for more than 10% of total firm sales (Cao et al., 2021).

In firms with higher customer concentration, their customers gain greater bargaining power, which may face higher operating and financial risks (Irvine et al., 2016). For instance, relying too much on major customers would suffer a crisis when suppliers lose these customers and urgently need to seek new customers (Gulati & Sytch, 2007). In addition, higher customer concentration may lead to fewer heterogeneous resources, hindering firms' innovation activities (Irvine et al., 2016). However, if the relationship between suppliers and major customers is stable and containable, suppliers can benefit from it, thus promoting supply chain integration and increasing cooperation opportunities. Besides, companies can utilize customer contacts to gain market demand information and technical knowledge (Matsumura & Schloetzer, 2018).

2.1.2 | New Environmental Protection Law in China

The Environmental Protection Law was revised and passed by the National People's Congress of China on 24 April 2014 and implemented on 1 January 2015. The revised law emphasizes government and enterprises' responsibilities to protect the environment compared with its predecessors. Environmental protection is now included in government officials' evaluation system, and it means that environmental protection issues are linked to the performance evaluation, the record of which would be disclosed. Subsequently, local government officials have incentives to monitor firms to protect the environment and encourage corporate innovative green investments (Liu et al., 2021).

For firms, additional information related to environmental protection must be disclosed, and the frequency of reporting the disclosure also increases. For example, the new law requires key pollutant discharge companies should truthfully disclose relative information about their primary pollutants to the public, such as the names, discharge methods, discharge concentrations, total discharges and the condition of over-standard discharges, as well as the construction and operation of pollution prevention facilities.

In a similar vein, penalties for violating regulations in the New Environmental Protection Law have been increased and strengthened. The Environmental Protection Agency can seal up and detain polluting enterprises' equipment. If a company exceeds the pollution limitation, its manufacturing would be restricted to suspend production for rectification and even to shut down its operations after obtaining approval from the local government. A daily fine is imposed repeatedly on offending companies who fail to rectify the problems within a specified time (Liu et al., 2021).

The new environmental law was regarded as the strictest law regarding environmental protection in China. Strict environmental law often triggers the discovery and introduction of greener and cleaner technology improvements. In practice, driven by the firm's needs to maximize shareholder financial profits, firms tend to prioritize their interests rather than the environmental welfare of the whole society, leading to a gap between corporate and social returns to green practices, that is, green innovation (Li et al., 2018). Strict environmental law induces the certainty of environmentally innovative investments' value and creates a demand for environmental products. Subsequently, it encourages the development of green technologies. Companies are also more incentivized to improve their production and facility through green innovation because they and their customers may get more benefits and reduce the risk of punishment from the new environmental protection law. Moreover, under strict environmental law, pursuing green innovation can be regarded as an effort to implement environmental regulation to obtain regulatory legitimacy (Zhang et al., 2015).

2.2 | Theoretical framework

2.2.1 | Resource-based view

The resource-based view is concerned with how companies generate and sustain competitive advantage, given that resources are valuable, rare, imperfectly imitable, and imperfectly substitutable (Barney, 1991). Resources are '… all assets, capabilities, organizational processes, firm attributes, information, knowledge, etc., controlled by a firm' (Barney, 1991). Green innovation can be seen as an effort to increase the efficient use of resources (Chen, 2008). Companies need to acquire new resources and secure their control. Meanwhile, customers may be seen as a vital driver of corporate innovation related to products and services creation, experience and technological advancement (Christensen et al., 2005).

When companies have a solid intention to bargain and keep a relationship with alternative suppliers in resource dependence relationships, there is an imbalance among business co-operators and customers having more freedom to select the most profitable contract design (Pfeffer & Slancik, 1978). With solid bargaining power, major

customers are price setters, who usually hide demand information, thus reducing the profitability of suppliers and the allocation of resources in R&D activities (Krolikowski & Yuan, 2017).

Major customers may make special requests to demand their suppliers to prioritize their resources promote green innovation. Besides being an internal strategic asset, green innovation may be further seen as a safety net to secure a firm's major customers, the firm's critical external resources. Correspondently, from the perspective of the theory of incomplete contacts, to avoid the other party's increasing power, one party would resist engaging in ex ante investments, where the hold-up problem arises (Hart & Moore, 1990). Namely, when customers have strong bargaining power, they would expect lower accrued profits. In this situation, suppliers have less tendency to make relationship-specific investments and cut down their ex ante R&D investment (Krolikowski & Yuan, 2017). Thus, suppliers might not invest in ex ante green R&D to avoid increasing their major customers' power.

On the other hand, companies can take advantage of the strong supplier–customer relationship. In inter-organizational relations, the core factor influencing managerial decision-making is the expectation of transaction efficiency maximization and exchanging cost minimization (Williamson, 1979). Developing a strong relationship with customers allows a firm to maximize its limited resources. Also, it provides a firm with the opportunity to share resources and learn new skills to update the existing knowledge base. Further, it also allows a firm to pursue cooperation with major customers to share risks (Terziovski, 2010). However, this relationship-specific investment may lead to a high cost if suppliers lose the existing customers and cooperate with new customers (Gulati & Sytch, 2007). Thus, when managers decide on green innovation investment, they tend to invest more into it because they can gain more efficiency from the supply chain and defend the risk of paying the cost of switching customers by innovation.

2.2.2 | Legitimacy and institutional pressure view

Legitimacy refers to an organization's appropriate behaviour within social systems constructed by values, norms, beliefs and definitions (Ruef & Scott, 1998). As a branch, environmental legitimacy refers to the appropriate or desired level for a company's environmental performance (Bansal & Clelland, 2004). When a company's activities cannot be approved, the legitimacy pressure rises to that company (Li et al., 2017). Similarly, from the perspective of institutional theory, companies are motivated to gain the approval and acceptance of the institutional environment, namely, legitimacy, which inevitably and significantly imposes pressure on the operation and behaviour of firms (DiMaggio & Powell, 1983). Influential major customers may become key suppliers to promote some practices such as environmentally friendly innovation (Cheng, 2010).

The classification of legitimacy and institutional pressure is analogical. Both legitimacy pressure and institutional pressure are divided into three parts. Legitimacy pressure includes regulatory, normative and cognitive, while institutional pressure contains coercive, normative and mimetic pressure (DiMaggio & Powell, 1983). Coercive pressure is measured by the marketization index related to economic development, legal construction and public environmental protection awareness (Chen et al., 2018). Normative pressure generally stems from customers, non-governmental organizations, investors, the social public and industry associations (Berrone et al., 2013). Regulatory pressure is mainly from governmental agencies' regulations formulated and supervised (Daddi et al., 2016). Social ethics standards, such as norms and values, are included (Zhang et al., 2015). Cognitive or mimetic pressure comes from competitors who serve a similar and major customer, as the authority of the powerful major customer to impact all suppliers (the firm and its competitors) (Cheng, 2010). To cope with the volatile business environment, firms should thus learn from their competitors' behaviour and imitate it for gaining legitimacy.

Investing in green innovation might contribute to superior performance in corporate environmental responsibility disclosure, providing more opportunities to gain valuable resources, better publicity and marketing for their products and services. It also helps firms obtain popularity from socially conscious customers (Hillman & Keim, 2001). Appropriate corporate environmental responsibility disclosure can gain society's legitimacy (Liao, 2018). Hence, customer concentration-based enterprises are eager to mitigate their legitimacy and institutional pressure from customers and investors. Thus, the government might be more positive about engaging in green innovation, improve their satisfaction and win financial support from different investors and governments (Chavez et al., 2016).

Besides, in empirical studies by Chen et al. (2018) and Liao (2018), normative and coercive pressures, not cognitive pressures, have positive effects on corporate green innovation (Chen et al., 2018). Meanwhile, in recent years, sanctions on pollution and government incentive considerably increased according to various environmental regulations (Peng et al., 2021). If suppliers successfully research and develop new green production or improve the manufacturing process by adhering to environmental regulations, they will save the cost of penalties. With the achievements in green innovation, firms would be incentivized directly by governmental policy. Therefore, customer-focused suppliers may tend to invest more in green innovation.

2.3 | Hypothesis development

Traditionally, major customers tend to utilize their bargaining power to demand suppliers to give them lower selling prices, extend credit terms and deliver more frequently at a smaller quantity (Gosman et al., 2004). Major customers can thus be seen as a drive to promote innovation and quality improvement to their suppliers (Du et al., 2018). The suppliers aim to maintain satisfactory delivery to retain major customers. If the relationship between major customers and suppliers is strong, it can facilitate intra-organizational collaboration, which provides a channel to integrate diversified knowledge pools and technological information (Pan et al., 2020). Subsequently, it attracts more industrial expertise and increases the corporate

capability of research, making suppliers invest more in innovation (Pan et al., 2020).

To meet the expectations of prioritized stakeholders such as major customers, suppliers start paying attention to sustainability trends, such as green innovation. Customers' demand for sustainable suppliers is driven by a desire to protect their reputation. Adopting environmentally sustainable supply chains is related to the overarching concept of corporate environmental responsibility (Wang & Zhang, 2020). Both customers and suppliers share the same corporate environmental responsibility philosophy. Thus, implementing green innovation is one of the essential means to fulfilling this responsibility (Ramirez et al., 2014).

With a high level of customer concentration, suppliers are more likely to make more significant relationship-specific investments to maintain such valuable relationships (Zhong et al., 2020). For instance, Wu (2015) found that Chinese suppliers were more committed to environmental conduct when they received pressure from multinational consumers than local consumers. Investments in green innovations are thus seen as an essential practice to address major customers' concerns over firms' sustainable development (Krolikowski & Yuan, 2017).

Moreover, when a firm faces a product-harm related crisis, news on green innovation or environmental R&D investments can remedy its damaged reputation (Chen, 2008). In particular, major customers will blame a firm less if it invests more in green production and innovation. Indeed, maintaining a green image can increase customers' confidence and loyalty (Pan et al., 2020). Many firms nowadays specifically require suppliers to pass specific environmental-related metrics. For instance, Zhu et al. (2008) found that some automotive manufacturers needed their suppliers to pass the International Organization for Standardization environmental management system standards.

Greater investment in R&D can lead to better corporate future performance and attract more government subsidies (Wang & Zhang, 2020). Disclosure of such information can effectively reduce information asymmetry between customers and suppliers. As a result, major customers with strong bargaining power demand firms to increase environmental innovation inputs and disclosures to gain benefits from increased share price or better business prospects (Lys et al., 2015). Therefore, a concentrated customer base will likely motivate suppliers to invest more in R&D and become more environmentally innovative. These arguments lead to the first hypothesis:

> **H1.** Customer concentration has a positive impact on a firm's green innovation.

Compared to non-SOEs, the ultimate controllers of SOEs belong to central and local government or government agencies. Backed by public resources, SOEs generally have larger negotiation power when dramatic changes in regulations or policies. Moreover, due to inherent connections with the government, SOEs' operational objectives include maximizing shareholder interests and assuming policy burdens, such as maintaining social stability, improving the employment rate and protecting the environment (Wang et al., 2019). As a result, SOEs may invest in green innovations to cater to the regulators' call on sustainability, build an environmentally responsible image and act as role models for their counterparts (Wang & Zhang, 2020). In addition, as the board of SOEs is appointed by state officials, they have strong incentives to overinvest in environmentally innovative activities to serve state interests and reduce the possibility of future CEOs turnover (Wang et al., 2019). This is especially the case when the government promotes environment-related projects (Zhang et al., 2019).

Further, SOEs often better grasp the environmental regulator's intention and accurately and quickly respond to it. In some instances, the Chinese government has also established higher expectations for SOEs' environmental performance (Li et al., 2017). Unlike non-SOEs, SOEs have easier access to financial resources, for example, government-backed bank loans, state subsidies, tax deductions and other cheap factor inputs. Thus, SOEs have substantial resources to support their investment in green innovation activities (Firth et al., 2009). SOEs are more prepared to tolerate and cope with the risk of green innovation investment. Based on the above discussion, the second hypothesis is as follows:

> **H2.** Compared to non-state-owned enterprises, the relationship between customer concentration and green innovation is more pronounced in SOEs.

The degree of marketization contains the level of the legal system construction perfection, economic development and public environmental protection awareness (Xie, 2017). The marketization degree differs in diverse regions as it is expected that the development among different regions is unbalanced (Li et al., 2019). Institutional pressure positively impacts the green innovation of Chinese firms (Chen et al., 2018). Scilicet, regions with high-level marketization facilitate the government, enterprises, customers and suppliers to switch to sustainable development behaviour. Previous findings also indicate that evident regional disparities exist regarding the economic development–green innovation relationship. For instance, Chen et al. (2017) find that regional green innovation decreases gradually from developed eastern provinces to less developed western provinces in China. For those firms located in developed regions, they might be the ones that are heavily polluted. Thus, they have more incentives and financial resources to make technological improvements to address the issue of sustainable development (Zhang et al., 2019). Consequently, the impact of customer concentration on green innovation could be stronger.

Enhanced public environmental protection awareness may encourage the activities of green innovation to avoid the cost of violation of laws and regulations and gain more support from governments and environmentally conscious customers and investors. Cai and Li (2018) report that an external environment can drive a firm's green innovation and a firm may invest in green technologies to respond to regulatory pressure. Indeed, in the high-level marketization regions, a favourable market environment and increased competitiveness may encourage firms to pursue more green innovation, leading to financial benefits (Zhang et al., 2019). Thus, we state the hypothesis as follows:

H3. The impact of customer concentration on green innovation is more pronounced in high-level marketization regions.

Green innovation can be regarded as a substantial outcome of environmental regulation (Shao et al., 2020). When major customers, the firm's key stakeholders, become environmentally conscious, the firm's greener innovative activities, further enabled by the regulations, are likely to boost customer purchase decisions. China, as a resource-rich country in aggregate, is resource-poor per capita. Government engagement is key to enforcing and facilitating corporate environmental responsibility (Chang et al., 2015). The novel Environmental Protection Law was introduced to harmonize the imbalance between economic development and environmental protection, which was the most significant difference between the old and new laws. For example, 'no-ceiling' daily sanctions were introduced to penalize illegal firms, increasing the cost of violations. Similarly, officials are assessed on their environmental performance, emphasizing environmental stewardship. In most cases, it is designed to limit the environmental impact of production and is an inevitable step towards achieving sustainable development (Shao et al., 2020). In other words, it means to require regional bureaus to impose proper implementation and strict enforcement on local firms (Wong et al., 2018). Such robust legislative support may attract more corporate environmental investment and encourages companies to exploit their competitive advantages more effectively (Zhang et al., 2019).

Implementing statutory green requirements intends to protect the environment, increase resource efficiency and enhance business performance. Contrary to the reluctance to invest in green innovation as a cost centre, companies must embrace the more stringent law proactively. Environmental regulations are found to increase business performance, primarily via green process innovation (Qiu et al., 2020). Additionally, Liu et al. (2021) investigated the new law's impact on the green innovation behaviour of listed and high-polluting companies. They found an increase in green patent applications after implementing the new Environmental Protection Law.

Hence, offering environmental innovation to major customers is dual-purposed, meeting the regulatory requirements and differentiating the firm from its competitors. As an extension to H1, we hypothesize as follows:

H4. The positive relationship between customer concentration and green innovation is more pronounced after the promulgation of the new Chinese Environmental Protection Law.

3 | METHODOLOGY

3.1 | Data and variables

Our paper initially includes all firms listed in the Shanghai and Shenzhen Stock Exchanges between 2006 and 2018, with a total number of 18,876 firm-year observations. We manually collect green innovation patents from the annual report of listed firms, China's State Intellectual Property Office (SIPO) and the Baiteng patent network databases.[1] Data on corporate governance, financial performance and firm characteristics are collected from the China Stock Market and Research (CSMAR) database. In order to estimate the statistical models, our paper firstly excludes firms that issue B-shares (8014 firm-year observations) and only includes those issue tradeable A-shares to ensure that samples are comparable. We also exclude the firms listed on ChiNext board,[2] which reduces 680 firm-year observations. Moreover, we require non-missing data on control variables, further reducing 108 firm-year observations. The final sample contains 10,074 firm-year observations. In order to minimize the influence of outliers on the results of estimation, winsorization was performed on the 1% and 99% quantiles of all continuous variables.

The dependent variable is a firm's green innovation patents. Previous studies have used indicators such as green R&D expenditures and eco-labelling product certification (Lin et al., 2014) to measure green innovation. Considering data availability, a green patent indicates a firm's green innovation. The SIPO grants three types of patents: invention patents, utility model patents and design patents. In particular, for a patent to be granted as an invention patent, it needs to satisfy the requirement of novelty, inventiveness and practical applicability.

Consequently, invention patents have the highest novelty compared to utility model patents and design patents. In contrast, the others only need to satisfy the requirement that a similar application has not been granted (Zhang et al., 2019). Therefore, following Zhou et al. (2017) and Zhang et al. (2019), invention patents are used to analyse the main results. Among invention patents, only the green invention patents are used to construct the dependent variable. Our paper defines the green patents following the green inventory patent classification published by the World Intellectual Property Organization (WIPO). Specifically, the green invention patents refer to the patents in alternative energy production, transportation, energy conservation, waste management, agriculture/forestry, administrative, regulatory or design and nuclear power generation.

The independent variables include customer concentration, SOEs, marketization and law. The degree of customer concentration is measured as the percentage of sales to Top 5 customers over a firm's total sales (Dhaliwal et al., 2016). The variable SOEs is used to examine the second hypothesis. SOEs are a dummy variable, which equals 1 if the ultimate controller of a listed company is the state or state agencies and 0 otherwise.

We introduce the variable *Marketization* to examine the third hypothesis. This dummy variable equals 1 if the marketization index in a province where the firm is located is above the sample mean and 0 otherwise. The marketization index measures the degree of market development of a region. This index captures the following five aspects of a given province: first, the association between government and markets, such as the role of markets in allocating resources; second, the development of non-state business, such as the ratio of industrial output by the private sector to total industrial output; third,

the development of product markets, for example, local trade barriers; fourth, the development of factor markets, for example, foreign direct investments; and fifth, the development of market intermediaries and the legal environment, such as the protection of property rights (Firth et al., 2011). To examine H4, observations are divided into the pre-New Environmental Protection Law period (i.e. 2006–2014) and post-New Environmental Protection Law period (i.e. 2015–2018), where *Law* is a dummy variable coded as 1 for the observations in or after 2015 and 0 otherwise.

We control the following set of variables in our model: firm-specifics, financial performance, and corporate governance. First, firm size is controlled and measured as the natural logarithm of a firm's total assets. Firms with a larger size can have easier access to various resources, promoting greater investments in green innovation (Liang & Liu, 2017). Firm leverage is controlled, as firms with higher leverage tend to make efforts such as green innovation to satisfy stakeholders' expectations for sustainable corporate development (Li et al., 2018). Following Gao et al. (2020), firm listing age is controlled, as firms may lose their ability to compete and innovate over time. A firm's cash ratio is also controlled, a proxy of liquidity. Firms with greater cash holding have more resources to invest in green innovation (Tan et al., 2019). Financial performance variables such as sales growth, Tobin Q and ROA are also included. According to Du (2015), firms with worse financial performance may use green innovations as a strategy to improve their public image and increase stakeholders' confidence.

We include a firm's R&D staff ratio, which is measured as the number of staff engaging in R&D activities to the total number of staff. Firms with greater R&D staff have the capacity and incentives to participate in green innovation (Li et al., 2018). We also include institutional ownership. Institutional investors are more likely to positively influence green practices by mitigating agency problems by promoting optimal corporate resource allocation and monitoring management actions (Buchanan et al., 2018). We control managers' stock ownership in a firm as it can affect how they choose their environmental innovation strategies (Al-Shammari et al., 2019). Table 1 summarizes the definition of the variables.

TABLE 1 Variable definitions

Variable type	Variable name	Definition
Dependent variable	Green	Natural logarithm of green invention patents
Main variables	Concentration	Percentage of sales to Top 5 customers over a firms total sales
	SOEs	A dummy variable equals 1 if the ultimate controller of a listed firm is the state or state agencies and 0 otherwise
	Marketization	A dummy variable equals 1 if the marketization index is above the sample mean and 0 otherwise. The marketization index for each province was complied with by Chinas National Economics Research Institute
	Law	A dummy variable equals 1 for the observations in or after 2015 and 0 otherwise
Control variables	Size	Natural logarithm of a firm's total assets
	Leverage	Ratio of total liabilities to the company's total assets
	Age	Natural logarithm of one plus the number of years a firm has been listed on the stock exchange
	Cash	Ratio of cash, short-term investment and trading financial assets to the total assets
	Growth	Annual percentage of a firm's sales growth
	Tobin Q	Ratio of the market value of common equity divided by the book value of total assets
	ROA	Ratio of net income to total assets
	R&D staff	Ratio of R&D staff to total staff
	Institution	The proportion of shares held by institutional investors
	Managerial	The proportion of shares held by a firm's managers

3.2 | Research model

To estimate the relationship between customer concentration and firm green innovativeness capability, we model the dynamics of the green innovation patents through the dynamic panel specification:

$$Green_{i,t} = \alpha_0 + \beta_1 Green_{i,t-1} + \beta_2 Concentration_{i,t} + \beta_3 Control_{i,t} + \varepsilon_{i,t} \quad (1)$$

where i and t represent firms and years. $Green_{i,t}$ is Green patents and $Green_{i,t-1}$ is its lagged value; $Concentration_{i,t}$ is the ratio of sales to Top 5 customers over total sales; $Control_{i,t}$ is a set of control variables; ε_{it} is the error terms.

To estimate Equation 1, we use the dynamic system GMM estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998), which accommodates the possible biases of endogeneity, heteroscedasticity and serial correlation. The GMM estimator is an advanced method to solve endogeneity. A green patent may have two-way causal relationships with concentration, firm size or R&D staff. Thus, endogenous variables are instrumented with their once lagged differences in our estimations. In our estimations, the system GMM estimator uses the lagged values of the endogenous explanatory variables in the time period $t-1$ as instruments. In addition, because the GMM approach relies on moment conditions rather

than full density, it can generate heteroscedasticity-consistent estimations and asymptotically correct standard errors for statistical inferences (Roodman, 2009).

To nullify no first- or second-order serial correlation in the first-differenced residuals, we also provide the Arellano and Bond test result (Arellano & Bond, 1991). The Sargan and Hansen statistics test results are also necessary to test the homoscedasticity and validity of instruments. The test results in all the regressions significantly support the validity of instruments in our estimation and provide strong evidence of no heteroskedasticity and autocorrelation problems within panels.

4 | RESULTS

4.1 | Descriptive statistics

Panel A of Table 2 presents the overall descriptive statistics. It shows that each firm has been granted 3.72 green invention patents on average. The average sales to Top 5 customers account for 30.76% of a firm's total sales. Also, 36.8% of observations are SOEs, and 30.6% of observations are in the post-New Environmental Protection Law period. A firm's staff engaging in R&D activities account for 12.42% of the total number of staff. We also observe that the annual sales

TABLE 2 Descriptive statistics

Panel A: Summary statistics

Variables	*N*	Mean	SD	Minimum	Maximum
Green	10,074	2.711	17.590	0	138.6
Concentration (%)	10,074	30.75	22.900	0.970	99.26
SOEs	10,074	0.368	0.482	0	1
Marketization	10,074	0.478	0.500	0	1
Law	10,074	0.306	0.461	0	1
Size	10,074	9.591	0.640	8.230	11.80
Leverage	10,074	0.483	0.230	0.060	1.262
Age	10,074	1.600	1.199	0	3.235
Cash	10,074	0.159	0.131	0.005	0.655
Growth	10,074	0.207	0.539	−0.644	3.787
Tobin Q	10,074	2.218	1.661	0.931	11.570
ROA	10,074	0.036	0.068	−0.267	0.242
R&D staff (%)	10,074	12.320	11.720	0.160	62.900
Institution	10,074	0.262	0.246	0	0.885
Managerial	10,074	0.082	0.171	0	0.683

Panel B: Marketization index among different provinces in China

Province	Provincial marketization index	Province	Provincial marketization index
Jiangsu	9.58	Guangxi	6.09
Zhejiang	9.24	Hunan	6.06
Shanghai	9.09	Heilongjiang	5.86
Guangdong	8.61	Hebei	5.73
Beijing	8.50	Hainan	5.45
Tianjin	8.20	Shaanxi	5.43
Shandong	7.49	Neimenggu	5.09
Fujian	7.43	Shanxi	4.99
Chongqing	7.06	Yunnan	4.79
Anhui	6.76	Ningxia	4.58
Liaoning	6.72	Guizhou	4.37
Henan	6.63	Gansu	3.67
Hubei	6.57	Xinjiang	3.12
Sichuan	6.23	Qinghai	2.63
Jilin	6.12	Xizang	0.18
Jiangxi	6.11		

growth rate is around 25.2%, indicating that Chinese listed firms grew relatively fast during the sample period. The cash liquidity and return on asset ratios are at 16% and 5.3% on average. Moreover, the mean value of institutional ownership and managerial ownership is 26.3% and 8.3%, respectively.

Panel B presents the marketization index among different provinces in China. It is reported that there are differences in economic and market development across the various provinces of China. Jiangsu, Zhejiang, Shanghai, Guangdong, and Beijing are considered relatively well-developed provinces whose market development scores are high. Further, we also conduct a multicollinearity test using the variance inflation factor (VIF). The mean VIF value is 1.39, indicating that multicollinearity is not a concern for our study.[3]

4.2 | Regression results

We present our baseline regression results in Table 3. Model 1 shows a positive and significant association between customer concentration and green innovation. The results validate our hypothesis H1 that firms with corporate customer concentration facilitate green innovations. This is because when customer concentration is high, customers and suppliers become more interdependent, providing a channel to integrate diversified knowledge pools and technological information. Consequently, both sides are willing to maintain long-term cooperation to integrate the supply chain and collaborate to invest in green innovation (Krause et al., 2007).

Model 2 of Table 3 reports the effects of customer concentration on corporate green innovation between SOEs and private firms. Samples are divided into SOEs (4866 firm-year observations) and non-SOEs (5208 firm-year observations). The results align with H2, indicating that the positive impact of customer concentration on green innovation is more pronounced in the SOEs. However, there is no relationship between customer concentration and green innovation in private firms. This possible reason can be that SOEs can better and quickly respond to environmental regulators' policies and calls on environmental protection and fulfil their environmental duties. In addition, as indicated in Wang and Zhang (2020), SOEs have greater access to financial resources. Subsequently, they have more resources to support their engagement in sustainable, innovative activities.

Model 3 of Table 3 shows the impact of customer concentration on corporate green innovation in high and low marketization regions, respectively. Samples are divided into firms located in the high level of marketization regions (4545 firm-year observations) and those located in the low level of marketization regions (5529 firm-year observations). As expected, we see a positive impact of customer concentration on green innovation in provinces with a higher degree of market development but no significant effect in regions with a lower degree of market development. The results indicate that firms located in provinces with high legal and economic development have greater incentives to invest in green patents.

Model 4 of Table 3 presents the results for H4. Samples are divided into the pre-New Environmental Protection Law period (4793 firm-year observations) and the post-New Environmental Protection Law period (5281 firm-year observations). It is reported that customer concentration is not associated with corporate green innovation in the pre-New Environmental Protection Law subsample. In contrast, customer concentration is positively related to a firm's green innovation in the post-New Environmental Protection Law subsample. The results imply that the new Environmental Protection Law significantly motivates firms to engage in green practices. Subsequently, firms are more likely to improve their technologies and invest in green innovation to maintain a stable relationship with their major customers.

With respect to control variables, firm size is positively related to corporate green innovation. This is in line with Liang and Liu's (2017) finding that larger-sized firms can quickly access different resources, which would improve corporate environmentally innovative performance. Managerial ownership is negatively related to corporate green innovation, indicating that higher managerial shareholdings reduce managers' incentives to invest in green innovation. This suggests that managers with more significant shareholdings are more likely to focus on short-term financial interests and less concerned about green issues. Consequently, they devote less attention to supporting such environmentally innovative activities (Tang et al., 2018).

4.3 | Robustness tests

Several additional analyses are carried out to test the robustness of our empirical analyses. First, we use an alternative measure of customer concentration: percentage of sales to the first, second, third, fourth and fifth largest customer over a firm's total sales, respectively. Models 1–5 of Table 4 show that our main result still holds with the alternative customer concentration measure, which alleviates the concern that different large customer alone drives our results. Moreover, we also re-estimate H2, H3 and H4 using the proportion of sales to a firm's first, second, third, fourth and fifth largest customer as the independent variable. The results are presented in Appendix B, and they are consistent with our main findings.

Second, we examine the differences in customer concentration's impact on corporate green innovation between industrial and non-industrial firms. Industrial firms have been recognized for their significance of being low-carbon and environmentally proactive by conducting green practices and environmentally innovative activities (Zhang et al., 2015). The results are presented in Model 1 of Table 5. It is reported that the coefficient of customer concentration is significantly positive in the subsample of industrial firms, indicating that the impact of customer concentration on green innovation is more pronounced in industrial firms.

Third, we examine the impact of customer concentration on green innovation while incorporating the heavily polluted nature of an industry. Thus, we divide samples into the heavily polluted and non-heavily polluted industries. We present our results in Model 2 of Table 5. The positive association between customer concentration and green innovation is more pronounced for firms operating in heavily polluting industries. Companies in heavily polluting industries

TABLE 3 Main regression

Variables	Model 1	Model 2		Model 3		Model 4	
		SOE	Non-SOE	High Marketization	Low Marketization	After Law	Before Law
Δ*L. Green*	0.954*** (0.034)	0.908*** (0.030)	0.948*** (0.048)	0.781*** (0.044)	0.995*** (0.034)	0.986*** (25.341)	0.932*** (34.688)
Δ*Concentration*	0.025** (0.012)	0.052** (0.023)	0.023 (0.014)	0.089** (0.045)	0.004 (0.008)	0.045** (2.419)	−0.005 (−0.399)
Δ*Size*	1.843*** (0.565)	3.436** (1.366)	0.966 (0.768)	3.295** (1.435)	0.914* (0.538)	2.283** (2.284)	1.221*** (2.783)
Δ*Leverage*	−0.950 (0.848)	−9.226** (4.268)	0.451 (0.887)	0.908 (2.041)	0.377 (1.034)	−2.580 (−1.428)	0.481 (0.624)
Δ*Age*	−0.337 (0.397)	−0.165 (1.196)	−0.350 (0.527)	0.325 (1.527)	0.487 (0.392)	−0.654 (−1.229)	−0.184 (−0.516)
Δ*Cash*	−1.416 (2.115)	−0.003 (5.936)	−1.886 (2.651)	1.583 (4.661)	−0.974 (1.763)	0.669 (0.164)	2.208 (1.283)
Δ*Growth*	0.091 (0.981)	1.537* (0.785)	0.235 (0.889)	1.939** (0.982)	0.482 (1.141)	1.126 (1.225)	0.300 (0.363)
Δ*Tobin Q*	−0.104 (0.157)	−0.258 (0.430)	−0.171 (0.216)	−1.239 (0.759)	−0.073 (0.187)	−0.341 (−1.232)	0.004 (0.026)
Δ*ROA*	6.463 (5.599)	−17.746 (17.716)	12.206** (5.707)	5.488 (7.233)	5.998 (5.917)	18.455* (1.714)	−2.537 (−0.556)
Δ*R&D staff*	0.039*** (0.013)	−0.162 (0.264)	0.016 (0.015)	0.033 (0.140)	0.031** (0.014)	0.045** (2.002)	0.040*** (2.880)
Δ*Institution*	−2.895*** (0.852)	−4.044*** (1.376)	−1.311 (1.055)	−5.879** (2.316)	−2.962*** (1.032)	−6.541*** (−3.046)	−0.931 (−1.094)
Δ*Managerial*	−2.262* (1.192)	−27.627 (39.305)	−1.244 (1.251)	10.874 (11.389)	−0.259 (1.190)	−6.714** (−2.451)	−2.988* (−1.854)
Constant	−15.932*** (5.073)	−25.331** (12.417)	−8.434 (6.465)	−31.966** (13.566)	−9.477* (4.949)	−17.894** (−1.998)	−11.442*** (−2.759)
Total observations	10,074	4866	5208	4545	5529	5281	4793
Number of firms	1,872	669	1203	896	976	1837	1041
A-B AR(1) test	−8.49 [.000]	−6.51 [.000]	−6.03 [.000]	−6.03 [.000]	−6.39 [.000]	−8.47 [.000]	−8.29 [.000]
A-B AR(2) test	3.31 [.000]	2.81 [.043]	1.86 [.063]	2.27 [.023]	2.45 [.014]	3.31 [.001]	3.52 [.000]
A-B AR(3) test	0.12 [.908]	0.18 [.859]	−0.06 [.948]	−1.05 [.296]	0.25 [.232]	0.13 [.898]	0.11 [.916]
Sargan overid. test	37.78 [.388]	28.56 [.073]	64.18 [.004]	26.79 [.314]	49.06 [.072]	34.92 [.520]	115.2 [.000]
Hansen overid. test	35.32 [.501]	18.41 [.495]	36.97 [.470]	23.83 [.471]	38.81 [.344]	30.87 [.711]	55.00 [.022]
F test	159.83 [.000]	257.81 [.000]	76.39 [.000]	45.36 [.000]	157.73 [.000]	164.10 [.000]	133.00 [.000]

Notes: The dependent variable is the green invention patents. Instrumental variables in our regression specifications include the first lag of all independent variables, that is, Concentration, Size, Leverage, Age, Cash, Growth, Tobin Q, ROA, R&D staff, Institution and Managerial, and the second lag of dependent variable, that is, Green. *t*-statistics for coefficient estimates in parentheses are based on robust standard errors. *p*-values for various tests are recorded in square brackets.

*$p < .1$. **$p < .05$. ***$p < .01$.

TABLE 4 Robustness test: Different top customers

Variables	Model 1 Top1 Customer	Model 2 Top2 Customer	Model 3 Top3 Customer	Model 4 Top4 Customer	Model 5 Top5 Customer
Δ*L. Green*	0.909*** (0.045)	0.885*** (0.048)	0.910*** (0.041)	0.878*** (0.050)	0.886*** (0.053)
Δ*Concentration: Sales for different top customers*	0.110** (0.055)	0.367* (0.205)	0.567** (0.278)	0.294* (0.177)	4.197** (2.119)
Δ*Size*	0.970 (1.058)	5.432** (2.123)	1.543 (0.959)	1.470 (1.279)	1.474 (2.921)
Δ*Leverage*	−1.069 (1.459)	−4.875 (3.986)	−1.020 (1.363)	−0.292 (3.365)	−1.660 (15.449)
Δ*Age*	0.215 (0.483)	−1.190 (1.252)	0.371 (0.470)	0.881 (1.080)	0.750 (1.349)
Δ*Cash*	−6.517 (6.340)	−15.599 (10.457)	3.359 (3.271)	−6.845 (7.023)	−7.070 (11.657)
Δ*Growth*	2.541* (1.440)	10.629** (4.877)	2.711* (1.458)	0.640 (1.577)	2.083 (4.981)
Δ*Tobin Q*	−0.121 (0.283)	1.083 (0.933)	−0.112 (0.269)	−0.037 (0.336)	−0.030 (0.515)
Δ*ROA*	16.224* (9.368)	3.854 (25.353)	7.262 (8.876)	16.477 (11.717)	−10.290 (23.106)
Δ*R&D staff*	−0.082 (0.096)	−0.317 (0.316)	−0.162 (0.111)	−0.253** (0.107)	−0.139 (0.220)
Δ*Institution*	−3.055** (1.440)	−5.919*** (2.259)	−3.762*** (1.347)	−3.405* (1.785)	−6.746* (3.940)
Δ*Managerial*	0.021 (1.456)	−1.002 (2.256)	1.465 (1.465)	2.944 (2.221)	0.411 (10.443)
Constant	−8.063 (9.806)	−45.606** (23.058)	−14.988* (8.450)	−12.020 (11.721)	−20.589 (19.265)
Total observations	7788	7916	7783	6487	7908
Number of firms	1620	1628	1620	1576	1628
A-B AR(1) test	−6.73 [.000]	−6.66 [.000]	−6.84 [.000]	−6.59 [.000]	−6.42 [.000]
A-B AR(2) test	2.44 [.015]	2.39 [.017]	2.45 [.014]	2.40 [.017]	2.27 [.023]
A-B AR(3) test	−0.65 [.515]	−0.66 [.509]	−0.67 [.502]	−0.67 [.501]	−0.67 [.505]
Sargan overid. test	25.99 [.463]	10.84 [.764]	25.73 [.689]	29.66 [.196]	24.69 [.480]
Hansen overid. test	25.01 [.519]	11.35 [.727]	23.52 [.793]	27.78 [.269]	19.63 [.766]
F test	87.97 [.000]	63.26 [.000]	77.95 [.000]	67.51 [.000]	48.34 [.000]

Notes: The dependent variable is the green invention patents. Instrumental variables in our regression specifications include the first lag of all independent variables, that is, Concentration, Size, Leverage, Age, Cash, Growth, Tobin Q, ROA, R&D staff, Institution and Managerial, and the second lag of dependent variable, that is, Green. *t*-statistics for coefficient estimates in parentheses are based on robust standard errors. *p*-values for various tests are recorded in square brackets.

*$p < .1$.
**$p < .05$.
***$p < .01$.

are under the government's more stringent regulatory supervision (Boesso & Kumar, 2007). Subsequently, it motivates them to be more environmentally responsible.

Fourth, we re-estimate the main regression results by adding R&D expenditure as a control variable. R&D expenditure is one of the important inputs that can drive corporate green innovation. In addition, intense R&D investment allows firms to use knowledge created outside the firm. In this regard, firms can have easier access to new knowledge and apply it to make innovative products (Artz et al., 2010). Models 1–4 in Table 6 present the results, all in line with the main regression results.

Fifth, we consider the degree of stakeholder bargaining power. According to Dai et al. (2021), the degree of industrial competition is an essential channel for customers to affect suppliers' sustainable practices. In particular, when the degree of competition among suppliers is relatively high, the industry is less concentrated, and there are more significant threats of substitutes. Subsequently, suppliers would have less bargaining power, and customers would have the greater bargaining power to affect corporate green innovative practices. To proxy for the degree of industrial competition, we use a firm's Herfindahl–Hirschman index (HHI) and collect it from the CSMAR database. The greater the value of HHI, the less intense the industrial competition (Yan et al., 2021). The results are presented in Table 7. It is reported that there is a significantly negative relationship between the interaction variable, Concentration*HHI and green innovation. In addition, their relationship is more pronounced in SOEs, provinces with a high level of marketization and after the implementation of the new Environmental Protection Law. This is consistent with Dai et al.'s (2021) argument that when the firms (suppliers) are operating in a more intensively competitive industry, suppliers have less power and have to meet the requirements of green innovation from major customers. Therefore, major customers have the stronger bargaining power to affect suppliers to align with their green practices and push for more environmentally innovative activities. Overall, our results confirm that industrial competition is an important channel that major customers can affect suppliers' green innovation.

The operation of SOEs and the regional marketization level might be related to government policies. For instance, SOEs or

TABLE 5 Robustness test: Industrial firms and heavy-polluting firms

	Model 1		Model 2	
Variables	**Industrial firms**	**Non-industrial firms**	**Heavy polluting**	**Non-heavy polluting**
Δ*L. Green*	0.945*** (29.515)	0.638*** (8.319)	0.893*** (18.371)	0.988*** (27.172)
Δ*Concentration*	0.030* (1.847)	−0.003 (−0.148)	0.035* (1.780)	0.014 (1.045)
Δ*Size*	2.261** (2.033)	1.065 (0.970)	2.317* (1.808)	1.053 (1.500)
Δ*Leverage*	−4.301 (−1.370)	2.645 (1.060)	−2.256 (−0.661)	−1.180 (−1.248)
Δ*Age*	0.103 (0.115)	−0.421 (−0.542)	−1.177 (−1.174)	−0.107 (−0.220)
Δ*Cash*	−8.608 (−1.472)	−4.358 (−0.784)	5.931 (1.007)	−3.551 (−1.466)
Δ*Growth*	−0.249 (−0.187)	−0.168 (−0.181)	0.270 (0.165)	−0.470 (−0.438)
Δ*Tobin Q*	0.010 (0.028)	0.624* (1.670)	0.067 (0.138)	−0.099 (−0.443)
Δ*ROA*	2.044 (0.198)	9.565 (1.018)	−11.082 (−0.733)	13.908** (2.243)
Δ*R&D staff*	−0.318** (−1.991)	0.018 (0.166)	−0.012 (−0.047)	0.029** (2.059)
Δ*Institution*	−4.137** (−2.473)	−1.208 (−1.011)	−2.456 (−1.505)	−2.841*** (−2.707)
Δ*Managerial*	3.016 (0.543)	4.702 (0.570)	−5.017 (−0.728)	−2.758* (−1.877)
Constant	−14.435 (−1.403)	−11.515 (−1.109)	−18.350 (−1.421)	−8.321 (−1.293)
Total observations	8610	2525	3636	6748
Number of firms	1471	409	580	1295
A-B AR(1) test	−7.864 [.000]	−3.852 [.000]	−4.905 [.000]	−7.214 [.000]
A-B AR(2) test	2.968 [.003]	1.811 [.007]	2.036 [.042]	2.692 [.007]
A-B AR(3) test	0.159 [.874]	−0.433 [.665]	0.613 [.540]	−0.210 [.834]
Sargan overid. test	19.29 [.859]	32.57 [.212]	26.11 [.090]	54.16 [.027]
Hansen overid. test	18.51 [.887]	26.03 [.517]	33.64 [.177]	39.01 [.336]
F test	153.30 [.000]	19.52 [.000]	36.98 [.000]	136.6 [.000]

Notes: The dependent variable is the green invention patents. Industrial and heavy polluting firms are classified based on the CSRC Industrial Classification Guideline (2012). Heavy-polluting firms include firms with following industrial codes: B06-B09, C17, C19, C22, C25-C28, C30-C33 and D44. Instrumental variables in our regression specifications include the first lag of all independent variables, that is, Concentration, Size, Leverage, Age, Cash, Growth, Tobin Q, ROA, R&D staff, Institution and Managerial, and the second lag of dependent variable, that is, Green. *t*-statistics for coefficient estimates in parentheses are based on robust standard errors. *p*-values for various tests are recorded in square brackets.

* $p < .1$.

** $p < .05$.

*** $p < .01$.

firms in developed regions tend to react more actively to the implementation of laws (Li et al., 2017). Subsequently, we re-estimate the models by interacting the variable Law with SOEs and Marketization, respectively, in order to divide samples into different subgroups and examine whether the impact of customer concentration on green innovation is driven by the nature of ownership, the regional marketization level and the implementation of the law.

The results are presented in Columns (1)–(8) of Table 8. In Columns (1)–(4), we divide our samples into four subgroups, including SOEs after the implementation of the law, non-SOEs after the implementation of the law, SOEs before the implementation of the law and non-SOEs before the implementation of the law. It is observed that the positive association between customer concentration and green innovation is more pronounced for SOEs after the implementation of the New Environmental Protection Law.

Columns (5)–(8) examine the impact of customer concentration on green innovation while incorporating the factors, that is, marketization level and passage of environmental law simultaneously. Therefore, we divide our samples into four subgroups, including (a) firms located in provinces with high marketization levels after the implementation of the law; (b) firms located in provinces with low marketization levels after the implementation of the law; (c) firms located in provinces with high marketization levels before the implementation of the law; and (d) firms located in provinces with low marketization level before the implementation of the law. It is reported that the positive association between customer concentration and green innovation is more pronounced for firms in regions of China that have high-level marketization after the implementation of the New Environmental Protection Law.

Lastly, this section examines how moderating factors affect the relationship between customer concentration and green innovation by using the interaction term approach. The following regression model is applied to re-examine H2, H3 and H4.

$$Green_{i,t} = \beta_0 + \beta_1 Green_{i,t-1} + \beta_2 Concentration_{i,t} + \beta_3 \tau_{i,t} + \beta_4 (Concentration_{i,t} \times \tau_{i,t}) + \boldsymbol{X}_{i,t} + \varepsilon_i \quad (2)$$

TABLE 6 Robustness test: R&D expenditures

Variables	Model 1	Model 2		Model 3		Model 4	
		SOE	Non-SOE	High Marketization	Low Marketization	After Law	Before Law
Δ*L. Green*	1.016*** (23.790)	0.941*** (23.717)	0.887*** (14.024)	0.853*** (17.057)	0.945*** (17.667)	0.926*** (15.522)	0.887*** (22.899)
Δ*Concentration*	0.047** (2.020)	0.031** (2.039)	0.002 (0.121)	0.033* (1.723)	0.006 (0.413)	0.040* (1.730)	−0.016 (−1.173)
Δ*Size*	3.464 (1.144)	−3.103 (−1.258)	2.377* (1.733)	−0.439 (−0.202)	3.080** (2.339)	−0.614 (−0.142)	2.374** (2.026)
Δ*Leverage*	−6.080** (−2.167)	0.984 (0.576)	0.077 (0.055)	−17.965 (−1.267)	−1.365 (−0.374)	16.873 (0.754)	11.541** (2.049)
Δ*Age*	−1.069 (−1.370)	−0.153 (−0.259)	−0.600 (−1.043)	−0.871 (−0.978)	−0.570 (−0.888)	−2.044* (−1.838)	−1.050 (−1.549)
Δ*Cash*	−5.338 (−0.734)	8.775 (1.333)	−3.536 (−0.897)	0.566 (0.080)	−4.107 (−0.893)	−3.416 (−0.384)	3.624 (0.639)
Δ*Growth*	1.127 (0.480)	−7.585* (−1.729)	−1.223 (−0.393)	−7.269 (−1.486)	−2.683 (−0.636)	−2.158 (−0.375)	−2.919 (−0.701)
Δ*Tobin Q*	0.862 (1.413)	0.125 (0.155)	0.346 (0.727)	1.512** (2.491)	0.379 (0.936)	−0.510 (−0.640)	0.423 (0.944)
Δ *ROA*	−5.067 (−0.221)	−0.266 (−0.024)	2.057 (0.228)	−35.629 (−0.978)	11.737 (0.924)	71.029 (1.532)	16.022 (0.997)
Δ*R&D staff*	−0.080 (−1.291)	−0.561* (−1.898)	0.078 (0.602)	−0.870* (−1.910)	0.015 (0.088)	0.150 (0.406)	0.166 (0.549)
Δ*Institution*	−3.473 (−1.297)	0.735 (0.348)	−0.992 (−0.512)	0.713 (0.308)	−3.712** (−2.258)	−6.697* (−1.920)	0.545 (0.424)
Δ*Managerial*	−0.809 (−0.304)	12.682 (1.176)	−0.195 (−0.089)	7.808 (1.530)	−2.068 (−0.928)	−9.411 (−1.497)	−0.120 (−0.030)
Δ*R&D Exp*	2.574** (2.307)	1.719** (2.276)	0.114 (0.282)	3.666** (2.088)	−0.745 (−0.851)	0.249 (0.187)	−0.648 (−0.785)
Constant	−74.254*** (−4.185)	4.836 (0.305)	−23.678** (−1.975)	−41.346*** (−2.861)	−13.290 (−1.470)	0.069 (0.003)	−16.654* (−1.652)
Total observations	10,013	5096	5966	4918	5786	5552	5152
Number of firms	1864	667	1205	895	973	1830	1176
A-B AR(1) test	−27.08 [.000]	−6.311 [.000]	−5.618 [.000]	−5.965 [.000]	−5.986 [.000]	−7.552 [.000]	−8.135 [.000]
A-B AR(2) test	11.30 [.005]	2.739 [.006]	1.762 [.078]	2.096 [.036]	2.351 [.019]	3.111 [.002]	3.496 [.000]
A-B AR(3) test	0.846 [.398]	0.010 [.992]	−0.055 [.956]	−0.834 [.405]	1.001 [.317]	0.0114 [.991]	−0.016 [.987]
Sargan overid. test	357.6 [.000]	10.58 [.980]	45.14 [.003]	4.869 [.937]	38.51 [.022]	8.906 [.631]	18.76 [.066]
Hansen overid. test	75.46 [.000]	17.65 [.727]	31.39 [.088]	3.761 [.976]	22.49 [.491]	5.612 [.898]	17.78 [.087]
F test	219.30 [.000]	78.44 [.000]	54.69 [.000]	42.65 [.000]	71.09 [.000]	70.23 [.000]	62.68 [.000]

Notes: R&D Exp is defined as the natural logarithm of a firms R&D expenditures. Instrumental variables in our regression specifications include the first lag of all independent variables, that is, Concentration, Size, Leverage, Age, Cash, Growth, Tobin Q, ROA, R&D staff, Institution, Managerial and R&D Exp, and the second lag of dependent variable, that is, Green. *t*-statistics for coefficient estimates in parentheses are based on robust standard errors. *p*-values for various tests are recorded in square brackets.

* $p < .1$.

** $p < .05$.

*** $p < .01$.

TABLE 7 Robustness test: Considering industrial competition

		Model 2		Model 3		Model 4	
Variables	**Model 1**	**SOE**	**Non-SOE**	**High Marketization**	**Low Marketization**	**Before Law**	**After Law**
Δ*L. Green*	0.968*** (40.588)	0.973*** (51.834)	0.904*** (25.020)	0.909*** (29.390)	0.972*** (37.168)	0.992*** (49.494)	0.987*** (31.836)
Δ*Concentration*	0.894*** (2.668)	0.972** (2.441)	0.244 (0.547)	1.176** (2.457)	0.836* (1.914)	0.103 (0.442)	1.948*** (2.988)
Δ*Concentration*HHI*	−0.020** (−2.087)	−0.016* (−1.716)	−0.017 (−1.288)	−0.042*** (−2.586)	−0.006 (−0.376)	−0.004 (−0.713)	−0.051** (−2.485)
Δ*HHI*	0.398** (2.082)	0.320* (1.694)	0.344 (1.320)	0.821** (2.577)	0.100 (0.328)	0.072 (0.686)	1.029** (2.530)
Δ*Size*	1.403** (2.087)	1.487* (1.887)	1.908** (2.054)	1.548 (1.609)	2.937*** (2.712)	0.713* (1.701)	1.894* (1.690)
Δ*Leverage*	−0.559 (−1.335)	−3.968* (−1.786)	0.228 (0.863)	0.591 (1.273)	−4.406* (−1.951)	−0.150 (−0.697)	−2.690 (−1.338)
Δ*Age*	−0.629 (−1.590)	−0.402 (−0.736)	−0.658 (−1.494)	−0.252 (−0.514)	−1.132*** (−2.638)	0.106 (0.327)	−0.962 (−1.628)
Δ*Cash*	1.088 (0.418)	−1.170 (−0.393)	−0.888 (−0.312)	5.292 (1.321)	0.860 (0.188)	1.312 (0.768)	2.953 (0.554)
Δ*Growth*	0.116 (0.999)	0.349** (2.255)	0.112 (0.989)	−0.481 (−0.623)	0.389 (1.298)	−0.035 (−0.483)	−0.005 (−0.099)
Δ*Tobin Q*	0.009 (0.163)	0.018 (0.077)	−0.013 (−0.319)	−0.033 (−0.291)	0.958* (1.874)	0.011 (0.655)	−0.018 (−0.425)
Δ*ROA*	1.011 (0.217)	−0.163 (−0.024)	3.578 (1.035)	−4.043 (−1.214)	−5.530 (−0.449)	2.029 (0.594)	0.248 (0.028)
Δ*R&D staff*	−0.005 (−0.086)	−0.022 (−0.206)	0.044 (0.807)	−0.004 (−0.035)	−0.099 (−1.312)	−0.034 (−1.047)	0.120* (1.681)
Δ*Institution*	−2.567*** (−3.423)	−2.331** (−2.425)	−0.631 (−0.486)	−1.882 (−1.386)	−3.777*** (−4.397)	−0.585 (−0.795)	−5.955*** (−2.736)
Δ*Managerial*	−1.261 (−0.946)	−3.678 (−0.875)	−0.474 (−0.346)	0.220 (0.090)	−2.063* (−1.662)	−0.804 (−0.669)	−5.036* (−1.793)
Constant	−28.127*** (−4.240)	−29.411*** (−3.135)	−21.415*** (−2.992)	−36.814*** (−3.489)	−39.289*** (−3.340)	−8.410* (−1.947)	−52.770*** (−4.335)
Total observations	10,552	4902	5650	5130	6073	5026	5526
A-B AR(1) test	−8.556 [.000]	−6.151 [.000]	−6.404 [.000]	−6.379 [.000]	−6.082 [.000]	−7.903 [.000]	−8.380 [.000]
A-B AR(2) test	2.928 [.003]	0.034 [2.118]	2.175 [.030]	2.210 [.027]	2.054 [.040]	3.085 [.002]	2.925 [0.003]
A-B AR(3) test	−0.273 [.784]	−0.204 [.838]	−0.249 [.804]	−0.673 [.501]	−0.223 [.824]	−0.255 [.799]	−0.259 [.796]
Sargan overid. test	25.76 [0.977]	44.40 [0.497]	56.61 [0.115]	0.27 [38.550]	0.11 [44.130]	119.90 [0.100]	0.45 [42.400]
Hansen overid. test	40.94 [.518]	45.20 [.464]	41.59 [0.617]	41.48 [0.177]	23.34 [0.916]	53.97 [0.102]	34.48 [0.789]
F test	197.67 [.000]	282.20 [.000]	90.49 [.000]	97.18 [.000]	187.59 [.000]	272.89 [.000]	155.17 [.000]

Notes: HHI index is defined as the quadratic sum of the fraction of company sales within the CSRC industry classification. Instrumental variables in our regression specifications include the first lag of all independent variables, that is, Concentration, Size, Leverage, Age, Cash, Growth, Tobin Q, ROA, R&D staff, Institution, Managerial and HHI, and the second lag of dependent variable, that is, Green. *p*-values for various tests are recorded in square brackets.

* $p < .1$.

** $p < .05$.

*** $p < .01$.

TABLE 8 Robustness test: The interaction of SOEs, marketization level and passage of the law

	After Law& SOEs	After Law& Non-SOEs	Before Law& SOEs	Before Law& Non-SOEs	After Law& High Marketization	After Law& Low Marketization	Before Law& High Marketization	Before Law& Low Marketization
Δ*L. Green*	0.950*** (20.946)	0.982*** (19.880)	0.900*** (29.993)	0.968*** (26.374)	0.894*** (17.836)	0.840*** (14.729)	0.931*** (24.042)	0.907*** (25.816)
Δ*Concentration*	0.049** (2.057)	0.034 (0.499)	0.012 (0.328)	−0.027 (−1.351)	0.048* (1.859)	0.005 (0.279)	0.004 (0.299)	−0.002 (−0.070)
Δ*Size*	3.415** (2.546)	1.040 (0.838)	0.074 (0.081)	0.328 (0.681)	0.815 (0.449)	2.323* (1.955)	3.896*** (3.045)	0.361 (0.683)
Δ*Leverage*	−4.661	0.801	1.808	0.733	1.051	0.259	−8.366*	0.375
	(−1.507)	(0.375)	(1.339)	(1.063)	(0.130)	(0.174)	(−1.958)	(0.380)
Δ*Age*	−0.216 (−0.186)	0.200 (0.255)	0.078 (0.126)	−0.183 (−0.627)	−1.721 (−0.991)	−1.851** (−2.195)	0.253 (0.254)	0.044 (0.128)
Δ*Cash*	−4.624 (−0.691)	1.331 (0.293)	2.162 (0.867)	0.002 (0.001)	3.323 (0.101)	−2.323 (−0.488)	−2.968 (−0.808)	1.095 (0.564)
Δ*Growth*	−2.893 (−0.531)	0.690 (0.761)	−0.964 (−0.634)	−0.615 (−0.731)	−13.847 (−1.625)	−0.404 (−0.379)	0.376 (1.310)	−0.196 (−0.359)
Δ*Tobin Q*	−0.670 (−1.544)	−0.105 (−0.325)	−0.212 (−0.637)	0.218 (1.384)	1.280 (1.595)	0.214 (0.697)	0.195 (0.486)	0.113 (0.657)
Δ*ROA*	39.238 (1.419)	18.994* (1.868)	6.653 (0.568)	3.247 (0.701)	−13.329 (−0.278)	9.425 (1.213)	−18.765 (−1.148)	−1.224 (−0.241)
Δ*R&D staff*	0.099** (2.300)	0.010 (0.355)	0.002 (0.110)	0.010 (0.691)	−0.547 (−1.508)	0.004 (0.174)	0.064** (2.363)	0.003 (0.172)
Δ*Institution*	−11.363*** (−2.908)	−1.804 (−0.758)	0.459 (0.372)	−0.244 (−0.225)	−0.347 (−0.142)	−2.424 (−1.418)	−6.553*** (−3.874)	−0.607 (−0.890)
Δ*Managerial*	−8.693 (−0.875)	−1.887 (−0.675)	0.316 (0.062)	−0.131 (−0.117)	1.947 (0.098)	−0.508 (−0.276)	−25.416 (−1.366)	0.321 (0.277)
Constant	−25.943** (−2.148)	−11.491 (−0.969)	−1.480 (−0.167)	−2.726 (−0.611)	0.623 (0.034)	−17.538* (−1.729)	−31.927*** (−3.109)	−3.690 (−0.786)
Total observations	2031	3397	3068	2090	2036	2578	2907	2767
Number of firms	652	1193	564	486	276	620	393	583
A-B AR(1) test	−6.233 [.000]	−5.985 [.000]	−6.335 [.000]	−5.299 [.000]	−4.080 [.000]	−4.586 [.000]	−5.061 [.000]	−4.262 [.000]
A-B AR(2) test	2.754 [.006]	1.867 [.062]	2.784 [.005]	2.134 [.033]	1.461 [.144]	1.589 [.112]	2.282 [.023]	0.938 [.348]
A-B AR(3) test	0.208 [.835]	−0.069 [.945]	0.160 [.873]	−0.043 [.965]	−0.145 [0.885]	−1.177 [0.239]	0.530 [.596]	1.327 [.185]
Sargan overid. test	11.31 [.996]	57.15 [.010]	46.16 [.006]	37.30 [.364]	14.60 [0.554]	31.42 [0.766]	11.32 [.956]	104.6 [.000]
Hansen overid. test	21.63 [.756]	45.28 [.114]	32.88 [.134]	28.13 [.788]	9.96 [.869]	45.90 [.177]	18.69 [.605]	30.56 [.682]
F test	1452.79 [.000]	63.90 [.000]	1221.73 [.000]	93.56 [.000]	553.93 [.000]	36.74 [.000]	1772.89 [.000]	112.10 [.000]

Notes: The dependent variable is the green invention patents. Instrumental variables in our regression specifications include the first lag of all independent variables, that is, Concentration, Size, Leverage, Age, Cash, Growth, Tobin Q, ROA, R&D staff, Institution and Managerial, and the second lag of dependent variable, that is, Green. *t*-statistics for coefficient estimates in parentheses are based on robust standard errors. *p*-values for various tests are recorded in square brackets.

*$p < .1$.

**$p < .05$.

***$p < .01$.

TABLE 9 Robustness test: Interaction term approach

	Model 1	Model 2	Model 3
Δ*L. Green*	0.984*** (22.080)	0.944*** (29.567)	1.007*** (23.136)
Δ*Concentration*SOEs*	0.349** (2.241)		
Δ*Concentration*Marketization*		0.031* (1.680)	
Δ*Concentration*Law*			0.181* (1.813)
Δ*Concentration*	0.597*** (4.732)	0.003 (0.128)	0.052 (0.761)
Δ*Size*	17.275*** (7.372)	1.478 (0.729)	7.864*** (4.143)
Δ*Leverage*	−40.787*** (−5.182)	−5.937 (−1.089)	−18.717*** (−2.818)
Δ*Age*	−4.487*** (−4.199)	−1.116 (−0.487)	−5.406*** (−3.217)
Δ*Cash*	−8.370 (−0.952)	−0.448 (−0.016)	−30.867** (−2.353)
Δ*Growth*	15.220*** (4.320)	8.917* (1.813)	11.656*** (4.215)
Δ*Tobin Q*	3.513*** (4.559)	0.095 (0.155)	1.534** (2.120)
Δ*ROA*	−162.900*** (−4.599)	−49.734 (−1.286)	−69.462** (−2.182)
Δ*R&D staff*	−0.172*** (−4.232)	−0.957** (−2.308)	0.012 (0.312)
Δ*Institution*	−11.925*** (−4.469)	−4.796 (−1.171)	−15.572*** (−2.980)
Δ*Managerial*	4.965 (0.727)	3.988 (0.251)	−35.220*** (−2.805)
Constant	−157.341*** (−7.186)	4.445 (0.183)	−49.768*** (−2.788)
Total observations	10,074	10,074	10,074
Number of firms	1880	1879	1880
A-B AR(1) test	−22.79 [.000]	−23.39 [.000]	−25.44 [.000]
A-B AR(2) test	9.885 [.000]	9.621 [.000]	11.07 [.000]
A-B AR(3) test	0.052 [.959]	0.389 [.698]	0.610 [.542]
Sargan overid. test	380.70 [.000]	11.81 [.757]	391.30 [.000]
Hansen overid. test	67.37 [.000]	10.85 [.819]	71.39 [.000]
F test	95.99 [.000]	255.70 [.000]	963.62 [.000]

Notes: The dependent variable is the green invention patents. Variables 'SOEs', 'Marketization' and 'Law' are controlled in Models 1, 2 and 3, respectively. Instrumental variables in our regression specifications include the first lag of all independent variables, that is, Concentration, Size, Leverage, Age, Cash, Growth, Tobin Q, ROA, R&D staff, Institution and Managerial, and the second lag of dependent variable, that is, Green. *p*-values for various tests are recorded in square brackets.

*$p < .1$.

**$p < .05$.

***$p < .01$.

where the main independent variable, $Concentration_{i,t}$, is the percentage of sales to Top 5 customers over a firm *i*'s total sales. The dummy variable, $\tau_{i,t}$, refers to the nature of firm ownership, the level of marketization and the passage of Environmental Protection Law, depending on the analysis context. The coefficient of interest, β_4, captures the interaction effect of customer concentration and firm ownership structure, provincial marketization level and implementation of Environmental Protection Law on corporate green innovation. $\boldsymbol{X}_{i,t}$ is a vector of firm *i*'s control variables, and ε_i is the error term.

Regarding the interaction effects, our results show positive and significant coefficients (e.g. Concentration*SOEs, Concentration*Marketization and Concentration*Law) in Models 1–3 (Table 9). These findings further support H2, H3 and H4, which indicate that the positive impact of customer concentration on green donation is more pronounced if the company is state-controlled or located in the provinces with a high level of marketization or after China's new Environmental Protection Law implementation.

5 | CONCLUSIONS

This study examines the relationship between customer concentration and corporate green innovation. Using the GMM method, we find that customer concentration is positively related to firms' engagement in green innovation. These findings are consistent with the view that customers and suppliers become more interdependent when customer concentration is high. Thus, firms have more incentives to maintain a stable relationship with major customers. Subsequently, firms invest more in green innovation to promote sustainable corporate growth and maintain a firm's social legitimacy.

Our study also investigates the moderating effects of ownership type, geographical location and the New Environmental Protection Law passage. The results demonstrate that the positive relationship between customer concentration and corporate green innovation is more pronounced for SOEs. Also, we find that the positive association between customer concentration and green innovation is more pronounced for

firms located in regions with a high degree of market development. Moreover, customer concentration on green innovation is more pronounced in the post-New Environmental Protection Law period.

We have conducted several robustness tests and find that our results remain consistent with the main findings. For instance, our results are robust to alternative measures of customer concentration, that is, the sales ratios for different major customers. Besides, we observe that customer concentration positively impacts corporate green innovation among industrial firms. In addition, compared to the firms operating in non-heavy polluting industries, major customers positively influence firms' engagement in green innovation activities from heavily polluting industries. Moreover, the main findings remain unchanged after controlling 'R&D expenditures'. We also find that the positive association between customer concentration and green innovation is more pronounced for SOEs and firms located in provinces with high marketization levels after implementing the New Environmental Protection Law. Furthermore, we find that industrial competition is an important channel that major customers can affect suppliers' green innovation.

This study makes several theoretical contributions. Firstly, this study contributes to the literature debating the pros and cons of having a concentrated customer base. Specifically, previous literature argues that major customers have greater bargaining powers, which increases firm risks and relevant financing costs (Irvine et al., 2016). However, our study finds that having a concentrated customer base yields benefits of encouraging a firm's innovative sustainable development. In addition, even for previous literature that has discussed the impact of building a stable major customer–supplier relationship on innovation (Pan et al., 2020), we extend their studies by examining green innovation instead of general innovation. Moreover, we examine how the implementation of the Environmental Protection Law affects the association between customer concentration and green innovation and highlight the positive role played by environmental regulation. In this regard, we contribute to a growing number of literature by assessing the consequences of environmental regulation. It is believed that firms with major customers are more likely to take the initiative to change their strategies for production and operation of business to adapt to the high threshold of environmental regulation.

This study is also the first study examining the relationship between customer concentration and green innovation while incorporating ownership types and regional marketization levels. We find that SOEs with a major customer base may have higher incentives to invest in green innovation. In this regard, we contribute to the growing yet divided literature on debating the benefits and challenges of facing by SOEs. Although SOEs are often considered less efficient in productivity and are likely to do nothing but maintain the existing advantages (Wang et al., 2019), we find that they are more likely to fulfil their environmental responsibilities, largely due to their advantages of getting greater financial resources. Similarly, we extend previous literature by providing evidence that an effective marketization system can enhance a firm's input in sustainable innovation.

This study provides several implications for managers and regulators. Firstly, managers are expected to improve the sustainable and innovative ability of the companies by complying with the environmental rules and sticking to the environmental protection targets that were set. They should consider integrating customer resources and building more stable customer relationships to achieve more support for corporate green investment. From the view of customers, they play an important role in influencing suppliers' green innovation input. Subsequently, it is suggested that major customers consider issues relating to sustainable corporate growth. This is very important when the firms are operating in a more intensively competitive industry, as they have less power and have to meet the requirements of green innovation from major customers. Supporting suppliers' green innovation can lead to higher financial profits and a better image of fulfilling environmental duties, achieving a win-win situation for major customers.

Second, managers in SOEs are encouraged to maintain stable and sustainable relationships with major customers. Compared to non-SOEs, SOEs have greater access to financial resources, which can further support their investment in green innovation. This is especially important after implementing the revised Environmental Protection Law, as there is a greater need for green product innovation and heavier punishment for environmental misconduct. Subsequently, it is expected that managers in SOEs actively fulfil environmental responsibility and be role models for their counterparts.

Major customers play the role of fostering rather than hindering corporate green innovation investment. As the impact of customer concentration on green innovation is more pronounced in the post-New Environmental Protection Law period, central and local governments should continue to strengthen the implementation of coercive tools such as environmental protection laws and regulations to encourage more corporate engagement in green practices. In addition, regulators should encourage firms to build a more stable and stronger relationship with their suppliers, especially those with a good reputation for fulfilling environmental duties, engage more in relationship-specific investments and spend more on green R&D expenditures. To maintain and strengthen such relationships, greater investments are required in the early stage (Irvine et al., 2016). Subsequently, firms are expected to engage in more innovative product co-development and information sharing with their major customers. As the relationship matures and becomes more established, the cost will be decreased, and firms can enjoy the benefits of achieving sustainable growth.

However, we should be careful in interpreting these results. Customer concentration is a double-edged sword. On the one hand, it encourages a firm's engagement in innovative practices and focuses on its long-term sustainable growth pattern. On the other hand, high customer concentration leads to weak bargaining power. In particular, a firm tends to make a series of concessions, such as extending trade credits during business negotiations (Fabbri & Klapper, 2016). Besides, a firm with high customer concentration faces severe financial and liquidity risks of losing cash flows if the customer goes bankrupt. This is especially the case if a particular customer represents a large portion of a firm's sales (Dhaliwal et al., 2016).

Moreover, although environmental regulations can improve corporate environmental performance by encouraging green technological innovation within enterprises, it also costs firms. For instance,

Gray and Shadbegian (2003) find that environmental regulations lead to a 9.3% decline in productivity within the specific, integrated US mill industry. Therefore, regulators need to be aware of the pros and cons of such policy tools and find a more balanced approach to facilitate sustainable corporate development.

Despite this study's contributions, there are still limitations that future research can attempt to address them accordingly. For instance, Zhou et al. (2019) find that managers' expectations can moderate the impact of customer concentration on firms' innovation activities. This is because managers may have different expectations and accordingly affect the decision-making of enterprises. In particular, optimistic managers tend to make more aggressive environmental and innovative investments. However, due to the unavailability of data, our study cannot incorporate managers' expectations into our empirical model; therefore, future research is expected to collect such data through surveys or interviews and include them in the research models.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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ENDNOTES

[1] Baiteng patent network is available at the http://so.5ipatent.com/

[2] The ChiNext board mainly includes start-up firms, especially high-tech firms.

[3] We have presented a correlation matrix in Appendix A. As shown in the correlation table, the Pearson correlation coefficients among all variables are less than 0.45, indicating that the multicollinearity issue is not a concern for our paper. In this Appendix, ***, ** and * represent the 1%, 5% and 10% levels of significance, respectively.

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APPENDIX A: CORRELATION MATRIX

	Green	Concentration	Size	Leverage	Age	Cash	Growth	Tobin Q	ROA	R&D staff	Institution	Managerial	SOEs	Marketization	Law
Green	1														
Concentration	−0.031***	1													
Size	0.179***	−0.175***	1												
Leverage	0.026***	−0.036***	0.317***	1											
Age	0.061***	−0.024***	0.194***	0.282***	1										
Cash	−0.020***	−0.009	−0.156***	−0.359***	−0.256***	1									
Growth	−0.016***	0.029***	0.060***	0.030***	−0.014**	0.015**	1								
Tobin Q	−0.049***	0.138***	−0.421***	−0.127***	0.118***	0.099***	−0.015**	1							
ROA	0.013**	−0.077***	0.066***	−0.376***	−0.167***	0.270***	0.115***	0.023***	1						
R&D staff	0.065***	0.091***	−0.157***	−0.124***	−0.082***	0.154***	0.041***	0.165***	−0.004	1					
Institution	0.077***	−0.005	0.336***	0.009	0.096***	0.006	0.039***	−0.024***	0.090***	−0.034***	1				
Managerial	0.004	−0.008	−0.191***	−0.286***	−0.447***	0.146***	0.037***	−0.034***	0.135***	0.144***	−0.203***	1			
SOEs	0.046***	0.006	0.264***	0.174***	0.397***	−0.055***	−0.045***	−0.132***	−0.038***	−0.097***	0.074***	−0.409***	1		
Marketization	0.023***	−0.015**	0.045***	−0.041***	−0.070***	0.053***	−0.010	−0.006	0.037***	0.046***	0.003	0.073***	−0.063***	1	
Law	0.102***	0.008	0.209***	−0.096***	0.272***	−0.062***	0.006	0.081***	−0.022***	0.065***	0.482***	0.117***	−0.002	−0.001	1

Note: ***, **, and * represent the 1%, 5% and 10% levels of significance, respectively.

APPENDIX B: ROBUSTNESS TEST: DETAILED RESULTS FOR DIFFERENT TOP CUSTOMERS

		Model 2		Model 3		Model 4	
Variables	Model 1	SOE	Non-SOE	High Marketization	Low Marketization	After Law	Before Law
Concentration:Top 1							
Δ*L. Green*	0.909*** (0.045)	0.680*** (16.214)	0.620*** (17.696)	0.683*** (20.112)	0.639*** (14.327)	0.524*** (36.310)	0.681*** (15.922)
Δ*Concentration: Top 1*	0.110** (0.055)	0.138** (2.293)	0.004 (0.138)	0.079* (1.879)	0.057 (1.424)	0.149* (1.916)	−0.001 (−0.017)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Total observations	7788	3344	4161	3360	4145	3805	2845
Concentration:Top 2							
Δ*L. Green*	0.885*** (0.048)	0.937*** (25.571)	0.810*** (11.324)	0.816*** (12.658)	0.874*** (12.571)	0.954*** (22.663)	0.733*** (9.680)
Δ*Concentration: Top2*	0.367* (0.205)	0.159* (1.651)	0.074 (0.548)	0.433** (2.127)	0.271 (0.953)	0.121* (1.665)	0.080 (0.625)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Total observations	7916	2742	3752	3359	4144	3651	3389
Concentration:Top3							
Δ*L. Green*	0.910*** (0.041)	0.928*** (14.640)	0.930*** (18.079)	0.807*** (12.270)	0.884*** (12.273)	0.900*** (15.747)	0.851*** (19.675)
Δ*Concentration: Top 3*	0.567** (0.278)	0.244* (1.666)	0.082 (0.696)	1.111** (2.183)	0.939 (0.982)	0.274* (1.679)	0.101 (0.968)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Total observations	7783	3931	3747	3357	4142	3931	3152
Concentration:Top 4							
Δ*L. Green*	0.878*** (0.050)	0.670*** (14.478)	0.817*** (12.654)	0.751*** (13.955)	0.978*** (18.948)	0.941*** (19.320)	0.883*** (19.175)
Δ*Concentration: Top 4*	0.294* (0.177)	0.420** (2.285)	0.294 (1.136)	0.479* (1.844)	0.010 (0.062)	0.380* (1.669)	−0.045 (−0.318)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Total observations	6487	2925	4421	3562	3557	3928	2840
Concentration:Top 5							
Δ*L. Green*	0.886*** (0.053)	0.548*** (11.955)	0.912*** (18.165)	0.761*** (14.183)	0.983*** (18.958)	0.948*** (23.772)	0.868*** (20.219)
Δ*Concentration: Top 5*	4.197** (2.119)	0.898* (1.748)	0.408 (1.623)	1.298** (2.094)	0.012 (0.067)	0.543* (1.752)	0.033 (0.194)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Total observations	7908	3472	3741	3561	3555	3928	3148

Notes: The dependent variable is the green invention patents. Instrumental variables in our regression specifications include the first lag of all independent variables, that is, Concentration, Size, Leverage, Age, Cash, Growth, Tobin Q, ROA, R&D staff, Institution and Managerial, and the second lag of dependent variable, that is, Green. *t*-statistics for coefficient estimates in parentheses are based on robust standard errors. *p*-values for various tests are recorded in square brackets. ***$p < .01$, **$p < .05$, and *$p < .1$, respectively.