Understanding the Impact of Mandatory CSR Disclosure on Green Innovation: Evidence from Chinese Listed Firms

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Conflict of interest: The authors declare that they have no conflict of interest.

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ABSTRACT

Drawing on the institutional view of legitimacy theory, we examine whether and under which conditions a policy tool, mandatory corporate social responsibility (CSR) reporting, enforced by constituents positively triggers firms to make substantive environmental responses. Using China's 2008 CSR reporting policy as a quasi-natural experiment and the difference-in-differences (DID) estimation approach, the results reveal that after implementation of this policy, mandatory CSR reporting firms show substantially higher green innovation performance than non-CSR reporting firms. We further find that this effect is stronger for firms located in areas with high environmental enforcement intensity, for state-owned enterprises (SOEs), and for those with higher levels of media coverage. Moreover, we make a nuanced investigation on whether the media coverage is laden with a negative or positive tone, and find that both negative and positive coverage strengthen the relationship between mandatory CSR disclosure and green innovation.

Keywords: Mandatory CSR disclosure; Green innovation; Institutional view; Difference-in-difference; China

INTRODUCTION

Concern has been growing substantially over firm behaviors that cause serious social and environmental problems (Teeter and Sandberg, 2017). Corporate social responsibility (CSR) reporting, a business and policy response to these concerns, is becoming an important business practice and gaining the attention of the regulatory authorities (Chen, Hung and Wang, 2018). For example, the European Union (EU) adopted a new Directive (2014/95/EU) that requires large European firms to disclose their social and environmental impacts, and requires all member states to transpose this Directive into their national legislation by 6 December 2016.

Mandatory CSR disclosure, one type of CSR reporting, is a policy tool/regulation which forces firms to publish transparent and non-selective CSR information including environment-related information. More and more economies, such as the EU, China, and the US, have adopted mandatory CSR disclosure regulation (KPMG, 2017) in the hope that it will improve the CSR information available to stakeholders, which in turn stakeholders may become more effective in rewarding responsible corporate activities or imposing sanctions on irresponsible activities (Jackson et al., 2020).

However, the existing empirical evidence remains inconclusive and provides contradictory findings on the effects of mandatory CSR disclosure on firm behavior and outcomes. A small strand of studies shows that mandatory CSR disclosure has an impact on firm behavior and outcomes such as financial performance, social externalities, and equity management (Chen et al., 2018; Wang, Cao and Ye, 2018b). While, another strand suggests that such disclosure has little influence on firm performance (Gong, Xu and Gong, 2018). We posit that the conflicting findings may be due to the nature that this policy compels firms to disclose CSR information but does not require any behavioral changes. This complex nature may result in symbolic practices to meet minimum requirements rather than substantive

behavioral changes to solve CSR problems fundamentally. Therefore, the impact of mandatory CSR disclosure on firm behavior, especially substantive behavior, remains unclear. We contribute to this debate by focusing on a substantive environmental practice, i.e., green innovation, because a core element in mandatory disclosure lies in environment-related information disclosure (Chen et al., 2018). Thus, our first research question is: *how does mandatory CSR disclosure influence green innovation?*

Green innovation refers to the invention of new designs and the creation of novel products and processes to reduce environmental pollution (Berrone et al., 2013). Although there is a broad consensus on the value of green innovation in terms of providing solutions to sustainable environmental problems, it is risky in terms of knowledge spillovers and financial returns. These characteristics result in firms having few or no incentives to engage in green innovation unless they are compelled or nudged to do so (Borghesi, Cainelli and Mazzanti, 2015). Drawing on the institutional view of legitimacy theory, we argue that mandatory CSR disclosure regulation is an example of recognized institutional patterns that makes the reporting firms expose to and recognize the beliefs and expectations of key external stakeholders, and in turn drive them to overcome stregical operational challenges and engage in more substantive environmental practice (i.e., green innovation) to respond to institutional pressure. We thus predict that the firms mandated to provide CSR reports (mandatory CSR reporting firms) will engage in higher levels of green innovation than those that are not under such disclosure (non-CSR reporting firms).

While institutional research emphasizes coercive isomorphism (DiMaggio and Powell, 1983), it might simply trigger apathetic and cosmetic practices, such as the adoption of environmental management systems (e.g., ISO 14001) (Delmas and Toffel, 2008). That said, coercive isomorphism could not explain the extent to which green innovation as a substantive environmental practice may be a viable option to deal with external pressure (Berrone et al.,

2013). Different from isomorphism effects, recent studies show that firms' responses to external pressure by adopting green innovation vary according to their internal characteristics and external institutional environment (Berrone et al., 2013). Therefore, we further posit that among the factors related to firm characteristics and the institutional environment, those that reinforce monitoring mechanisms will strengthen legitimacy pressure of mandatory CSR reporting firms, which drives them to engage in green innovation more due to added pressure on legitimacy. The second research question is thus *how do factors that reinforce monitoring mechanisms set the boundary conditions on the effect of mandatory CSR disclosure on green innovation?*

By leveraging the implementation of China's mandatory CSR disclosure policy in the year 2008, which mandates a subset of Chinese listed firms to publish their stand-alone CSR reports, we employ a quasi-natural experimental design to test our theoretical predictions.

Our research makes three contributions to the existing literature. Firstly, our study contributes to the CSR disclosure literature from two perspectives. One is that previous studies focus largely on voluntary CSR disclosure[1] with only a few paying attentions to mandatory disclosure (Christensen, Hail and Leuz, 2019). The other is that those studies that examine mandatory CSR disclosure shed light only on its effect on firm behavior and outcomes other than green innovation (e.g., earnings management and profitability) (e.g., Chen et al., 2018; Wang et al., 2018b). Therefore, we strengthen this stream of literature by extending mandatory CSR disclosure to the context of a substantive environmental practice (i.e., green innovation).

Secondly, we contribute to the legitimacy theory by examining how a mandatory policy tool that compels information disclosure affects a substantive environmental practice. Our

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[1] Voluntary CSR reporting is a proactive practice that firms strategically and selectively report information (Nekhili et al., 2017).

findings reveal that the policy mandating information disclosure indeed promotes green innovation. Drawing on the institutional view of legitimacy theory, we argue that although mandatory CSR disclosure does not require changes to specific environmental practices, going through the mandatory information disclosure processes alters firm beliefs and understanding of the expectation of other constituents (e.g., government, the public), in turn, adds legitimacy pressure and changes firm behavior. Therefore, we provide a new theoretical perspective to understand how mandatory CSR disclosure triggers substantive environmental responses.

Thirdly, we advance the institutional research on heterogeneity in firm responses to institutional stimuli (Berrone et al., 2013) by considering how monitoring mechanisms constitute the boundary conditions of the effect of a mandatory policy on firm behavior. Our finding supports that mandatory CSR disclosure triggers green innovations as an outcome legitimizing the CSR effort but monitoring mechanisms of high environmental enforcement intensity, state ownership, and high levels of media coverage compel more environmental innovation activity because of the added strains on legitimacy. We thus provide new insights for the debate on how internal and external factors reinforcing monitoring mechanisms set the boundary conditions on the effect of institutional change on firm behavior.

INSTITUTIONAL BACKGROUND, THEORETICAL DEVELOPMENT, AND RESEARCH HYPOTHESES

CSR disclosure, mandatory CSR disclosure and green innovation

CSR disclosure literature distinguishes between mandatory and voluntary disclosure. Mandatory disclosure refers to "the law and regulation that compel firms to inform interest groups about the social and environmental impacts of their activities by providing transparent and comprehensive information" (Delbard, 2008, p. 400). Voluntary disclosure is considered

as "any information disclosed by managers beyond mandatory reports" (Christensen et al., 2019, p. 9).

Our research focuses on mandatory CSR disclosure not only because research on mandatory CSR disclosure is scarce (Christensen et al., 2019) but also because it has distinct features from its voluntary counterpart. Given voluntary CSR disclosure depends on what managers choose to report, its content is highly diverse in terms of the amount and format due to the absence of reporting standards (Nekhili et al., 2017). Moreover, the credibility of voluntary CSR reports is a common concern because of the opportunistic incentives of managers (Dhaliwal et al., 2014). For example, managers can manipulate their voluntary CSR reports to disclose positive or "self-laudatory" information while avoiding negative or potentially harmful information (Nekhili et al., 2017).

In contrast, mandatory CSR disclosure suppresses this "self-laudatory" issue, because firms are forced to disclose specific types of information according to the "one-size-fits-all" regulation (Hung, Shi and Wang, 2015). By doing so, mandatory disclosure limits managers' attempt to offer only symbolic representations, and results in higher quality information and improved social externalities (Mobus, 2005; Neu, Warsame and Pedwell, 1998). For example, mandatory CSR disclosure is found to be correlated positively with market information asymmetry (Hung et al., 2015), financial reporting quality (Wang et al., 2018b), fair tax contribution (Lin, Cheng and Zhang, 2017), and overall CSR performance (Jackson et al., 2020). However, mandatory CSR disclosure has a negative impact on profitability (Chen et al., 2018) and shareholders' interests when coupled with reduced environmental violation (Mobus, 2005). Therefore, the outcome variables investigated by prior studies are largely focus on financial performance with the effect of mandatory CSR disclosure on inventive solutions to environmental problems mostly overlooked.

The current research extends the idea of mandatory CSR disclosure to the context of green innovation. Green innovation requires the creation of new product designs and novel processes to generate unique solutions to reduce and prevent environmental damage (Berrone et al., 2013), and thus it is generally a less symbolic and more substantive environmental practice (Bammens and Hünermund, 2020). Therefore, we build the direct link between mandatory CSR disclosure and green innovation to understand how, and under what circumstances mandatory CSR disclosure leads to a substantive environmental practice.

Institutional background on mandatory CSR disclosure in China

In December 2008, the Shanghai Stock Exchange (SSE) and Shenzhen Stock Exchange (SZSE) jointly issued *the Notice on Completing the 2008 Annual Report of Listed firms* (hereafter, the Notice), requiring a subset of firms to publish their CSR reports henceforth. Specifically, the SSE mandates firms included in its Corporate Governance Index, financial firms, and firms with overseas-listed shares to publish stand-alone CSR reports along with their annual reports, while the SZSE obligates firms included in its 100 Index to publish. The regulation requires that the CSR reports must be reviewed and approved by the firm's board of directors (Chen et al., 2018), and published on the SSE and SZSE websites.

The Notice provides the specific guidelines for the CSR reports, requiring that CSR reports should include information about corporate activities in the following aspects (Chen et al., 2018): (1) protection of the interests of shareholders and creditors; (2) protection of employees' interests; (3) protection of the interests of suppliers, customers and consumers; (4) environmental protection and sustainability; (5) promotion of public relations and social welfare. In terms of environmental protection and sustainability, firms should disclose the following details: specific environmental protection investments, technology developments, energy conservation and emissions reduction, and recycling and reuse of waste; firms should use specific numerical indicators to indicate current conditions and improvements compared

to national and industrial standards and their own previous indicators; any non-attainment(s) should be stated in the report, and if a firm had a major environmental accident, was punished by the government, or listed as a key polluting firm, the report should state the reasons for circumstances, current conditions, and their impact on firm operation and development.

Panel A of Appendix A (in the online supporting information) shows the requirements for the CSR reports from the SZSE, and those of the SSE are similar (Chen et al., 2018). Panel B shows excerpts from the CSR report of China Southern Glass (CSG) holding Co., one of our sample firms mandated to publish CSR reports.

Mandatory CSR disclosure and green innovation

To examine the effect of mandatory CSR disclosure on green innovation, we draw on the institutional view of legitimacy theory. The strategic and institutional views of legitimacy theory are regarded as two sides of the same coin (Suchman, 1995; Mobus, 2005). The strategic view refers to organizational managers looking "out" and extracting legitimacy from the external environment; the institutional view refers to society looking "in" and infiltrating external institutions into the organization (Suchman, 1995). Most prior studies on voluntary disclosure adopt the strategic view to explain the disclosure dynamic (Chelli, Durocher and Fortin, 2018). From a strategic view perspective, legitimacy is a strategic resource, and society and environmental reporting is considered as a device for managers to ensure organizational legitimacy and survival (Chelli et al., 2018). These studies emphasize that organizations can manage their legitimacy by voluntarily providing CSR disclosure, and that such disclosure is not necessarily associated with actual organizational performance (Neu et al., 1998). However, the institutional view holds that legitimacy is not an operational resource, but a set of recognized institutional patterns (Mobus, 2005). Organizations strive to conform to these patterns to acquire and maintain legitimacy for the purpose of survival (DiMaggio and Powell, 1983).

Mandatory disclosure regulations can be reasonably regarded as an example of such institutional pattern, an accurate representative of social values and beliefs, and compliance with the regulations is an important way to obtain and maintain legitimacy (Chelli, Durocher and Richard, 2014). Existing studies have shown that after the implementation of mandatory disclosure regulations, the quantity and quality of CSR disclosure have experienced significant improvements (Chelli et al., 2018), which shows a high level of conformity. We argue that mandatory disclosure regulation impacts firms from two perspectives. On one hand, going through the mandated information disclosure processes helps managers understand the beliefs and expectations of stakeholders. Although such mandatory disclosure regulations may not incur direct penalties for non-compliance, they are a binding system of rules with which managers must conform (Jackson et al., 2020). It consequently alters firms' beliefs on the expected appropriateness, to which they adhere the current behavior to stakeholders' expectations.

On the other hand, mandatory CSR disclosure increases transparency substantially, which reduces information asymmetries between firms and external stakeholders. Because environment-related information disclosure is a core element in mandatory disclosure, reducing information asymmetry increases the possibility that firms to be rewarded or punished for their environmental performance. For example, firms are more likely to suffer increased levels of government scrutiny, negative press, consumers boycotts, or criticism from non-governmental organizations (NGOs) due to their poor performance (Chen et al., 2018). Thus, reporting firms are exposed to the monitoring of stakeholders (e.g., investors, consumers, the media, the public, government, NGOs), thereby facing greater legitimacy pressure to improve their environmental performance.

Compared to other environmental practices that are off-the-shelf alternatives oriented toward meeting minimum environmental standards, green innovation is a proactive initiative

that has a greater and longer-term impact not only in reducing emissions, but also in preventing pollution (Bammens and Hünermund, 2020). In particular, since the mandatory CSR regulation is not temporary but requires firms to disclose CSR reports every year, the firms cannot hope to take cosmetic or symbolic measures to meet the expectations of external stakeholders. Although firms require relatively high investment in green innovation in the short term, 'green investments' can be justified in the long run (Berrone et al., 2013). Green innovation not only helps firms to improve their legitimacy, but also creates a cost advantage by making better use of inputs, reducing waste disposal costs, and removing unnecessary steps in the production process (Berrone and Gomez-Mejia, 2009; Ferreira et al., 2021).[2] Thus, we hypothesize that:

Hypothesis 1 (H1): Mandatory CSR reporting firms experience an increase in green innovation relative to non-CSR reporting firms.

The moderating role of environmental enforcement intensity

Confronted with the same mandatory CSR disclosure regulation, are some firms more likely than others to carry out green innovation? Early works of institutional theory increases hold that powerful institutions compel organizations to adopt specific practices, which may lead to coercive isomorphism (DiMaggio and Powell, 1983). However, recent research emphasizes that isomorphic effects may only apply to superficial and cosmetic practices, rather than substantive practices, such as green innovation (Berrone et al., 2013). The extent to which firms adopt green innovation to cope with coercive pressure may vary depending on the internal characteristics of the firm and the external institutional environment (Berrone et al., 2013). As mentioned above, we propose that the impact of mandatory CSR disclosure on green innovation depends on legitimacy pressure. Thus, we argue that among the factors

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[2] Green innovation has been found to be associated positively with production efficiency (Aldieri et al., 2021), new employment in emerging sectors (Dell'Anna, 2021), and green growth (Fernandes et al., 2021).

related to firm characteristics and institutional environment, those that reinforce monitoring mechanisms will strengthen legitimacy pressure of reporting firms, which increases their engagement in green innovation. Specifically, we focus on the contingent roles of three notable factors: environmental enforcement intensity, state ownership, and media coverage.

The government plays a monitoring role to scrutinize to what extent firms act in an environmentally responsible manner (Wang, Wijen and Heugens, 2018a). Environmental enforcement intensity is a way to realize government monitoring efforts. It is defined as the strength of the local Environmental Protection Bureau's (EPB) enforcement of environmental regulations and policies (Segerson and Tietenberg, 1992). The EPB can regulate firms through coercive measures such as warning, fines, operation suspension for rectification, and shutdown (Marquis and Bird, 2018).

We argue that the higher environmental enforcement intensity, the greater legitimacy pressure brought by mandatory CSR disclosure policy. This is because higher environmental enforcement intensity is associated with stronger power of realizing government monitoring efforts. The disclosure of poor performance is more likely to be punished by the government and results in substantial negative outcomes of obtaining social resources from other stakeholders (Luo, Wang and Zhang, 2017). Consequently, firms face higher pressure to deal with the outcomes when the required information does not meet requirements. In this case, firms are more likely to invest in green technologies and their riskiness can be justified. While when environmental enforcement intensity is low, government monitoring efforts may not be realized such that even if firms disclose unsatisfactory CSR performance, they have a lower probability of being penalized for disclosing negative CSR information. In this case, the legitimacy pressure resulting from mandatory CSR disclosure is weak, so it is difficult to justify the risky investment in green innovation; and in turn firms lack motivations to carry out green innovation. This indicates that the effect of mandatory CSR disclosure on green

innovation will be stronger when environmental enforcement intensity is higher, and weaker when environmental enforcement intensity is lower. We thus propose our second hypothesis:

Hypothesis 2 (H2): The positive effect of mandatory CSR disclosure on green innovation will be stronger for firms located in areas with high environmental enforcement intensity.

The moderating role of state ownership

State ownership is defined as the percentage of ownership shares held by the government in a firm; state-owned enterprises (SOEs) refer to firms with majority government ownership (Zhou, Gao and Zhao, 2017). We argue that mandatory CSR disclosure results in greater legitimacy pressure for SOEs, because they are subject to closer monitoring and supervision from the government (Jia, Huang and Zhang, 2019).

In China's centralized political and economic system, because the leaders of SOEs are appointed by the government and regarded as government officers, SOEs have a greater need to conform to government policies and meet government goals (Yi et al., 2017). The literature points out that, unlike non-SOEs that aim to maximize economic profits, SOEs are forced to serve government political and social goals, among which environmental protection is increasingly important (Zhang et al., 2020). For example, in the Twelfth Five-Year Comprehensive Work Plan for Energy Conservation and Emission Reduction released by the State Council in 2011, it requires authorities to strengthen the supervision and assessment of energy conservation and emission reduction of SOEs, and to take the assessment results as part of the performance management of SOE leaders. The disclosure of poor environmental performance will increase the probability that leaders of SOEs to be punished by the government, such as demotion or removal; in contrast, the disclosure of satisfactory environmental performance will increase the opportunities of their leaders for political promotion. Therefore, compared with non-SOEs, SOEs face greater legitimacy

pressure and thus are more likely to engage in green innovation, which is a particularly persuasive way to demonstrate greater commitment to improving the environment (Berrone et al., 2013).

Hypothesis 3 (H3): The positive effect of mandatory CSR disclosure on green innovation will be stronger for SOEs.

The moderating role of media coverage

Media coverage has also been identified as an important monitoring mechanism, because the media helps to keep external stakeholders informed about corporate activities and plays a role of external evaluator (Cheng et al., 2022). We propose that two dimensions – media coverage intensity and media tone – moderate the relationship between mandatory CSR disclosure and green innovation. Media coverage intensity refers to how much attention a firm receives from media coverage (Dawkins and Fraas, 2011); some studies refer to this as media visibility, media attention, or media exposure (Jia and Zhang, 2014). Media tone refers to how the media evaluate a firm (Shipilov, Greve and Rowley, 2019). On the one hand, because stakeholders have limited attention, media coverage becomes an important channel for them to obtain firm information (Kölbel, Busch and Jancso, 2017), and increased media coverage intensity results in increased concern for the firm. On the other hand, media tone can shape public perception of the firm (Brown and Deegan, 1998). We argue that both media coverage intensity and media tone have substantial impacts on the firm's legitimacy pressure. We explain the mechanisms below.

A high level of media coverage creates corporate visibility and exposes the focal firm to the expectations and requirements of multiple stakeholders (Fiss and Zajac, 2006). The firm with higher visibility is under the spotlight of the media, making it subject to stricter scrutiny and closer monitoring (Zyglidopoulos et al., 2012). The disclosure of poor environmental performance or even less satisfactory one could be highlighted by the media, thereby

increasing the probability of taking substantial negative social consequences. Previous research points out that a high level of media coverage will amplify the loss perceived by managers if they presented poor performance (Cheng et al., 2022). Specifically, when the media blames the poor performance on managers' incompetence and spreads it widely, managers may suffer from substantial loss, such as reduced salaries and future career opportunities, and dismissal in extreme cases (Bednar, Boivie and Prince, 2013). Thus, the legitimacy pressure brought by the mandatory CSR disclosure policy is greater for firms with higher levels of media coverage, which ultimately drives them to engage in proactive and substantive environmental practices – green innovation. According to the above arguments, we propose:

Hypothesis 4a (H4a): The positive effect of mandatory CSR disclosure on green innovation will be stronger for firms with high levels of media coverage.

Media tone adds a layer of monitoring by pointing out whether the media coverage is positive or negative (Deegan, Rankin and Tobin, 2002). We argue that the directional monitoring effect of media tone will exert legitimacy pressure to foster green innovation and such effect differs across positive and negative tones. Prior works suggest that when the tone of media coverage toward corporations becomes negative, corporate legitimacy will decline (Li et al., 2018; Bansal and Clelland, 2004). Negative media coverage brings a pressing reputational problem for the focal firm, which will lead to greater legitimacy pressure on the firm (Deegan et al., 2002). In other words, when a firm's media coverage is more negative, that firm has a greater incentive to provide more positive or favorable CSR information in an attempt to counteract negative impact and thus repair its legitimacy (Deegan et al., 2002). Green innovation has higher environmental benefits and signals a long-term commitment to dealing with the environment issues (Berrone et al., 2013), which provides a more substantial response to negative media coverage. Thus, negative media coverage increases legitimacy

pressure on the reporting firms, which in turn drives them to undertake more green innovation to repair legitimacy.

Conversely, positive media coverage should reduce the likelihood of improved CSR practices, as it indicates that the firm is already viewed favorably by the public and obtains a good reputation (Shipilov et al., 2019). In circumstances where firms receive positive feedback, they will be complacent about the current situation and reduce the likelihood of making organizational changes (Greve, 2003; Shipilov et al., 2019). More specifically, positive media coverage circulates the firm's positive image, which makes external stakeholders believe that the focal firm has obtained a relatively high level of legitimacy. Firms' efforts in increasing green innovation become less necessary, and therefore are no longer managerial priorities. That is, positive media coverage can alleviate legitimacy pressure on a firm, thereby reducing the firm's efforts to undertake green innovation. According to the above arguments, we propose:

Hypothesis 4b (H4b): The positive effect of mandatory CSR disclosure on green innovation will be stronger (weaker) for firms with negative (positive) media coverage.

Our hypotheses are summarized graphically in Figure 1.

[INSERT FIGURE 1 ABOUT HERE]

DATA AND METHODS

Sample and data collection

Our empirical analysis is based on a sample of Chinese industrial firms listed on the Shanghai and Shenzhen Stock Exchanges (the SSE and SZSE) over 2006-2015.[3] The

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[3] Our sample starts in 2006 because this was the first year for listed firms to disclose detailed R&D expenditure in their annual reports in accordance with new accounting standards (Li et al., 2021); R&D expenditure is an important control variable in our study. Our sample ends in 2015 because the Chinese legislative institution approved "the Environmental Protection Tax Law" in 2016, a very ambitious environmental policy, which

industrial sector includes mining, manufacturing, and electricity industries. Our sector choice is underpinned by the fact that most green patent applications are filed by industrial firms owing to their high energy consumption and high polluting production models.

Following previous studies, we screened the sample as follows: (1) we excluded financial firms and firms with overseas-listed shares (i.e., B-share firms), since these two types of firms are subject to different market trading regulations (Chen et al., 2018); (2) we eliminated observations with special treatment (ST/ *ST), since these observations are at risk of delisting due to losses in two or three consecutive fiscal years (Zhang et al., 2020); (3) we excluded observations with missing information for all variables used in the regressions; (4) we excluded voluntary CSR reporting firms (1,633 firm-year observations pertaining to 172 firms) to identify the only effect of mandatory disclosure on green innovation. This left a final sample of 5,966 firm-year observations: the treatment group consists of 1,786 observations pertaining to 183 firms mandated by the SSE and SZSE to disclose annual CSR reports (mandatory CSR reporting firms)[4]; the control group consists of 4,180 observations pertaining to 457 non-CSR reporting firms.

Our data were obtained from several sources: (1) the list of firms in the SSE Corporate Governance Index and SZSE 100 Index is collected from the SSE and SZSE websites; (2) we used patent counts to measure firm innovation, and patent information is collected from the State Intellectual Property Office (SIPO) of China database; (3) data on accounting variables are obtained from the China Stock Market and Accounting Research (CSMAR) database and the WIND database, which are widely used in research on Chinese firms (Li and Lu, 2020); (4) information on administrative punishments related to environmental violations is

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greatly increased the cost of corporate environmental violations (Wu and Tal, 2018). We are concerned that this policy could potentially affect green innovation and confound our analysis.

[4] After excluding financial firms and firms with overseas listed shares, mandatory CSR reporting firms consist only of the firms included in SSE Corporate Governance Index and those included SZSE 100 Index.

collected from the China Environmental Statistical Yearbook; (5) data on media coverage are from the financial news database of Chinese listed firms developed by the Chinese Research Data Services Platform (CNRDS), which is used in previous studies (e.g., Cheng et al., 2022).

Measurement of the variables

Dependent variable

    Green innovation (*GI*). Because standard accounting items on R&D expenditures usually do not distinguish expenditures related to green innovation activities, it is difficult to use R&D expenditures to measure green innovation (Amore and Bennedsen, 2016). Some studies have measured green innovation through questionnaire surveys, but this method may be subject to subjective bias because respondents tend to show that their firms are responsible for the environment (Berrone et al., 2013). Thus, green patents provide an important and objective measure of green innovation activities (Amore and Bennedsen, 2016).

    Following prior works (Kim, Pantzalis and Zhang, 2021; Liao, 2020), we use International Patent Classification (IPC) codes to identify green patents. All patents include one or more IPC codes which reflect their technology area. We search manually for green patents using IPC codes with reference to the IPC Green Inventory[5]. Although Chinese Patent Law categorizes patents as invention, utility model, and design patents (Tan et al., 2020), green patents based on IPC searches include only two types of patents: invention and utility model patents, which represent significant technological improvements. In line with previous works (Wang, Farag and Ahmad, 2021), we use application year instead of grant year to count the number of patents since the former better captures the actual timing of innovation. We follow prior works to use the natural logarithm of one plus green patents to

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[5] The IPC Green Inventory is developed by the World Intellectual Property Organization and involves environmental-friendly technologies. See http://www.wipo.int/classifications/ipc/en/green_inventory/ for more details.

measure green innovation (Li et al., 2018; Kim et al., 2021).

Independent variable

Mandatory CSR disclosure (MD*Post). Our variable of interest is the interaction between MD and Post, that is, *MD*Post*. *MD* is a dummy variable that equals 1 if the firm is a mandatory CSR reporting firm and 0 if it is a non-CSR reporting firm. We follow Chen et al. (2018) to define 2006-2008 as the pre-policy period and 2009-2015 as the post-policy period. The dummy variable *Post* equals 1 for the post-policy period and 0 otherwise.

Moderators

Environmental enforcement intensity (EEI). We measure *EEI* as the number of provincial-level administrative punishments related to environmental violations (Huang and Chen, 2015), scaled by provincial population.

State ownership (SO). Following prior studies (e.g., Zhou et al., 2017), *SO* is measure as a dummy variable that takes the value of 1 if the firm is an SOE and 0 otherwise.

Media coverage intensity (Media_All). Media coverage intensity is reflected by the yearly number of newspaper articles that mention the corporate name (or stock name, stock code, name abbreviation) (Zyglidopoulos et al., 2012). Following Deegan et al. (2002) and Zyglidopoulos et al. (2012), media coverage intensity is measured as the log value of the number of news articles, which we label as *Media_All*. The CNRDS covers more than 600 national and local newspapers, especially including the eight largest national financial newspapers (You, Zhang and Zhang, 2018): *China Securities Journal, Securities Daily, Securities Times, Shanghai Securities Journal, China Business Journal, First Financial Daily, The Economic Observer,* and *21st Century Business Herald*. We find 514,097 news articles related to our sample firms between January 1st, 2006 and December 31st, 2015.

Media tone (Media_Neg and *Media_Pos)*. The CNRDS also provides information on

media tone. The CNRDS uses the machine learning technique to calculate whether the tone of a news article is negative, positive, or neutral.[6] We count the number of negative, positive, and neutral articles at the firm level. Note that the variable *Media_All* is measured as the sum of negative, positive, and neutral articles. Following Deegan et al. (2002), we use the log value of the number of negative (positive) articles to measure negative (positive) tone of media coverage, indicated by *Media_Neg* (*Media_Pos*). The moderating variables are centered to make up the interaction terms.

Control variables

Following previous studies (e.g., Arena, Michelon and Trojanowski, 2018), we include firm characteristics that might matter for green innovation or innovation: Firm size (*Size*), Firm age (*Age*), Financial leverage (*Lev*), Board independence (*Board_indep*), R&D intensity (*R&D*), Environmental performance (*EP*), Institutional ownership (*IO*). We also consider intensity of industry competition using Herfindahl-Hirschman Index (*HHI*). Definitions of variables used in our study are presented in Appendix B.

Model specification

China's mandatory CSR disclosure policy provides us a good opportunity to employ a difference-in-differences (DID) approach for identification. Specifically, we adopt the following DID model as our baseline model:

$$GI_{it} = \beta_0 + \beta_1 MD_i * Post_t + \beta_j Controls_{it} + \mu_t + \gamma_i$$
$$+ \varepsilon_{it} \tag{1}$$

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[6] Specifically, CNRDS programmers have developed a tone word list in a financial context, and then randomly selected 24,000 news articles as a training sample and encoded whether the tone of each article in the training sample was negative, positive, or neutral. Afterwards, they fed this training sample to a Support Vector Machine (SVM) algorithm to calculate the tone of all the news articles.

where subscript i and t represent firm and year, respectively. β_1 gives the estimates on the effect of mandatory CSR disclosure on green innovation, and is therefore our focus. $Controls_{it}$ indicates a set of the control variables. μ_t and γ_i represent the year fixed-effects and firm fixed-effects, respectively; we include them to control for unobserved heterogeneity across different year and firms. When including year- and firm-fixed effects, the non-interacted MD and $Post$ dummy variables are absorbed. ε_{it} is the stochastic error term. We cluster the standard errors at the firm level.

In Equation (2), we add a three-way interaction term among MD, $Post$, and $Moderator$ to test the potential moderating effects.

$$
GI_{it} = \beta_0 + \beta_1 MD_i * Post_t + \beta_2 MD_i * Post_t * Moderator_{it} + \beta_3 Moderator_{it} + \beta_j Controls_{it} + \mu_t + \gamma_i + \varepsilon_{it}
$$

RESULTS

Descriptive statistics

Panel A of Table 1 reports descriptive statistics. The mean value of MD is 0.299, suggesting that about 30% of our firm-year observations are mandated to release an CSR report. The mean value of the natural logarithm of green patents are 0.232, indicating that on average, each sample firm has 1 (computed as exp (0.232)) green patent per year.

Based on the t-test approach, Panel B provides the univariate analysis of the mean difference for mandatory CSR reporting firms and non-CSR reporting firms. The univariate analysis shows that the two groups of firms are different in many characteristics, which indicates that it is necessary to employ a regression model with firms fixed-effects.

Panel C reports pairwise correlations. Because *Media_Neg and Media_Pos* are part of *Media_All*, they inevitably are both highly positively correlated to *Media_All*. Additionally,

the correlation coefficient between *Media_Neg and Media_Pos* is 0.848, similar to Shipilov et al. (2019) where the correlation coefficient is 0.84. Since we separately add different theoretical variables into our estimation models, the high correlation between these variables is less of a problem (Shipilov et al., 2019). We perform the variance inflation factor (VIF) tests to assess whether there are serious multicollinearity problems. VIFs range from 1.01 to 4.02, well below the critical value of 10, implying that that there is no serious multicollinearity problem.

[INSERT TABLE 1 ABOUT HERE]

Validating the parallel trend assumption for the DID design

The validity of a DID identification depends on the parallel trend assumption, which requires that if there is no policy shock, the outcome variables of the treatment and control groups would exhibit parallel trends (He and Shen, 2019; Shipilov et al., 2019). Figure 2 shows that during the pre-policy period, the average number of green patents between the mandatory CSR reporting firms and non-CSR reporting firms exhibit nearly parallel trends. The graphical evidence on parallel trends provides support for our use of the DID method as our identification strategy. Figure 2 also shows that during the post-policy period, especially after 2009, the growth rate of green patents of mandatory CSR reporting firms is much higher than that of non-CSR reporting firms, which provides preliminary support for the positive effect of mandatory CSR disclosure on green innovation.

[INSERT FIGURE 2 ABOUT HERE]

Hypotheses testing

Hypothesis 1 predicted that mandatory CSR reporting firms engage in more green innovation than non-CSR reporting firms. Table 2 presents that the interaction terms

MD*Post in column (1)-(9) are all positive and statistically significant. This provides strong support for H1. This result is also economically significant. Since our dependent variable (i.e., green innovation) is log-transformed, we need to exponentiate the regression coefficients to infer the magnitude of effects (Chakraborty and Chatterjee, 2017). The magnitude of the coefficient in model 1 (β_{model1}=0.233, $p<0.01$) reveals that the mandatory CSR disclosure policy resulted in an average increase of 26% in green patents for mandatory CSR reporting firms compared to non-CSR reporting firms.

H2 proposed that environmental enforcement intensity strengthens the relationship between mandatory CSR disclosure and green innovation. Model 2 tests H2 by including the three-way interaction term *MD*Post*EEI*, and shows a positively significant coefficient (β_{model2}=0.043, $p<0.05$). Hence H2 receives support.

H3 posited that state ownership strengthens the main relationship. Model 3 tests H3 by including the three-way interaction term *MD*Post*SO*, and shows that the coefficient is positive and statistically significant (β_{model3}=0.253, $p<0.01$), suggesting that H3 is supported.

H4a predicted that media coverage intensity strengthens the main relationship. Model 3 adds the three-way interaction term *MD*Post*Media_All* to test H4a, and finds that the coefficient is positively significant (β_{model4}=0.099, $p<0.01$), which provides support for H4a.

H4b concerns the moderating effect of media tone. We proposed that negative media coverage strengthens the main relationship, whereas positive media coverage weakens the relationship. Model 5 adds the three-way interaction term *MD*Post*Media_Neg* to test the moderating role of negative media coverage, and finds a positive and significant coefficient (β_{model5}=0.083, $p<0.01$). Model 6, which includes the three-way interaction term *MD*Post*Media_Pos*, also shows a positive and significant coefficient (β_{model6}=0.095, $p<0.01$). Our results imply that positive media coverage strengthens the association between mandatory CSR disclosure and green innovation, which plays the same role as negative

media coverage. H4b is thus partially supported.

Models 7-9 present the full models that include the moderating effects of environmental enforcement intensity, state ownership, and media coverage (media coverage intensity, negative coverage, and positive coverage, respectively).

[INSERT TABLE 2 ABOUT HERE]

Robustness tests

To alleviate the potential endogeneity that mandatory CSR reporting firms are not randomly selected, we adopt the propensity score matching (PSM) approach. We also conduct a series of robustness checks, including alternative subsamples, alternative measures of green innovation, and alternative regression models, and find that our main results do not change. Table 3 summarizes the process and results of the robustness tests, and Appendix C provides all relevant details.

[INSERT TABLE 3 ABOUT HERE]

Additional analysis for the comparison between mandatory disclosure and voluntary disclosure

As discussed above, mandatory disclosure has distinct features from its voluntary counterpart. We thus predict that mandatory and voluntary CSR disclosure may have differential impacts on green innovation. To verify our conjecture, we conduct a series of tests and find that mandatory CSR reporting firms indeed experience a significant increase in green innovation, while voluntary reporting firms experience no significant change. Appendix D shows all detailed procedures and results.

CONCLUSION AND DISCUSSION

Our study seeks to understand the impact of mandatory CSR disclosure on green

innovation. By employing a DID estimation approach for identification, we find strong and consistent evidence that mandatory CSR disclosure has a positive impact on green innovation. Moreover, we find that the monitoring mechanisms of high environmental enforcement intensity, state ownership, and high levels of media coverage positively moderate the main relationship. We also identify the tone of the media coverage (i.e., positive or negative) and find that both negative and positive coverage strengthen the relationship, which is partially contradictory with the theoretical expectation.

Theoretical implications

Our study makes several important contributions to the extant literature. Firstly, we add to the CSR disclosure literature by exploring the impact of mandatory CSR disclosure on green innovation. Existing studies focus largely on voluntary CSR disclosure, with relatively little attention paid to mandatory CSR disclosure (Christensen et al., 2019). Several studies explore the impact of mandatory CSR disclosure on firm behavior and outcomes, such as earnings management (Wang et al., 2018b), profitability (Chen et al., 2018), and tax contributions (Lin et al., 2017). We enrich this stream of literature by revealing that mandatory CSR disclosure has a positive impact on green innovation.

Secondly, this study provides a new theoretical perspective on and more comprehensive insights into the impact of policy tools mandating information disclosure by applying the institutional view of legitimacy theory to explain the impact of mandatory CSR disclosure on green innovation. Previous studies question whether mandatory CSR disclosure leads to a substantive behavior (Jackson et al., 2020), because such disclosure does not require any behavioral changes, which may result in reporting firms that may simply adopt symbolic practices to meet the minimum requirements for disclosure. This debate is also reflected in the fact that studies investigating the impact of mandatory CSR disclosures on corporate behavior have not reached a consistent conclusion. However, our findings reveal that

mandatory CSR disclosure can drive organizations to move beyond conformity to more proactive strategies (i.e., green innovation). Building on the institutional view of legitimacy theory, we explain that mandatory CSR disclosure plays an important role in reflecting the beliefs and expectations of key external stakeholders, and legitimacy pressure to satisfy these expectations prompts the reporting firms to adopt substantive practices. Thus, our study improves the understanding of whether and how policy tools mandating information disclosure result in a substantive behavior.

Thirdly, our study provides support for the view that institutional stimuli may engender heterogeneous rather than isomorphic organizational responses by exploring how the influence of mandatory CSR disclosure on green innovation is contingent on three primary monitoring mechanisms-environmental enforcement intensity, state ownership, and media coverage. Thus far, we know little about the contingent role of monitoring mechanism in the mandatory CSR disclosure literature. The answer to this question is of great significance, because exploring how monitoring mechanisms that may influence legitimacy pressure constitute the boundary conditions not only allows us to better understand the main link that mandatory CSR disclosure triggers firm behavior via increased legitimacy pressure, but also helps to respond to the debate on whether firms respond to institutional stimuli heterogeneously (Berrone et al., 2013). Indeed, scholars have begun to call for more investigation of boundary conditions such as law enforcement and information environment in the relationship between mandatory CSR disclosure and corporate behavior (Lin et al., 2017). Our study responds to these calls and confirms the positive moderating effects of monitoring mechanisms of environmental enforcement intensity, state ownership, and levels of media coverage. Thus, our study contributes to the literature by introducing the boundary conditions for the mandatory CSR disclosure-green innovation relationship; that is, firm responses to institutional stimuli may differ due to monitoring mechanisms.

Moreover, it is noteworthy that we find positive media coverage plays a positive moderating role, which is contrary to the theoretical expectation that positive feedback will lower legitimacy pressure. Previous studies focus on how negative media coverage triggers corporate strategic change (e.g., Bednar et al., 2013; Harrison et al., 2018) but ignore the role of positive one. These works generally hold that negative media coverage generates greater legitimacy pressure and triggers firms to adopt changes, while positive feedback could decrease the likelihood of adopting changes due to manager complacency (Shipilov et al., 2019). We argue that positive media coverage puts more pressure on firms to maintain their established good reputation, because they will suffer from more serious losses when exposed to negative media exposure. The established positive image acts as a double-edged sword making the firm more alert and sensitive to what it could lose and thus subject to higher legitimacy pressure. Therefore, this finding suggests that the tone of media is not so important as its frequency, given that the moderating roles of positive and negative media tone do not differ across each other.

Practical implications

Our research has important implications for policymakers. Firstly, mandatory CSR disclosure has been becoming an important government policy instrument, and some countries are transitioning voluntary guidelines into mandatory reporting requirements (KPMG, 2017). However, some studies question whether mandatory CSR disclosure is effective, and to what extent (Gong et al., 2018). Our findings confirm that mandatory CSR disclosure is associated with higher legitimacy pressure, which triggers firms to make substantive environmental responses (i.e., green innovation). Our study therefore lends support for the adoption of the mandatory CSR disclosure regulation. We propose that if a policy effectively mandates firms to publish environmental reports, this could lead to substantive responses on making environmental practices.

Secondly, our study reveals that the interactions of mandatory CSR disclosure and monitoring mechanisms of environmental enforcement intensity, state ownership, and levels of media coverage could produce a more pronounced impact on green innovation. Therefore, monitoring mechanisms are essential for the effectiveness of mandatory CSR disclosure. In this regard, we recommend that government environmental authorities should punish firms that violate environmental regulations more severely and require these firms to disclose their punishment records in their CSR reports. We suggest also that the media, which act as an information intermediary for firms and stakeholders, should play a greater role in monitoring corporate CSR activities and information in CSR reports.

Our research also has important implications for managers. We find that the content of the media seems to be less important than its frequency, which suggests firm managers should improve corporate capabilities in marketing and public relations. Improving these capabilities do not mean simply increasing the absolute amount of marketing expenditures, but adopting a dynamic view to manage and respond to media coverage (Rahman, Rodríguez-Serrano and Hughes, 2020). More than ever, the social media era exposes firms to social disapproval which spreads faster among more diverse groups of stakeholders (Wang, Reger and Pfarrer, 2021). Thus, when firms counter negative media coverage, they will need strong public relations capabilities to deal with the criticism to avoid substantial negative consequences such as social sanction and consumers boycotts. Moreover, if disclosure is not avoidable, then managers may find it wise to anticipate the consequences. Developing marketing capabilities is key for firms who make substantive responses and would like to highlight their contribution on environmental practices.

Limitations and directions for future research

Similar to all studies, this paper has several limitations, which suggest opportunities for future research. Firstly, while our study has examined the relationship between mandatory

CSR disclosure and green innovation, future studies could extend this research by exploring the potential impact of mandatory CSR disclosure on other corporate behavior. Considering green innovation is a substantive environmental practice, we base our theoretical arguments on the institutional view of legitimacy theory. However, in the case of superficial and cosmetic corporate behaviors, such as the adoption of ISO14001 and environmental labels, a coercive isomorphism lens might be more appropriate. Moreover, recent research suggests that coercive isomorphism has a ripple effect, i.e., isomorphism effects not only exist in organizations that directly face coercive pressure but also can spread to others through the board interlock network (Krause et al., 2019). Thus, we encourage future research to explore whether mandatory CSR disclosure could lead to isomorphic effects in firm behavior other than green innovation, and whether these effects could spread to other firms not mandated to publish CSR reports but with interlock board members of the focal firm.

Secondly, to make the causal inference on the effect of mandatory CSR disclosure on green innovation, we use a DID estimation method to compare the changes in green innovation between the treatment group (including mandatory CSR reporting firms) and the control group (including non-CSR reporting firms) before and after the implementation of the disclosure regulation. The estimation results show that mandatory CSR reporting firms have higher green innovation performance than non-CSR reporting firms after the implementation of the regulation. However, this method treats mandatory CSR disclosure firms as a group, and does not take account of differences in disclosure levels among firms. In this regard, it is valuable to focus only on mandatory CSR reporting firms, and further explore the association between disclosure levels and corporate behavior.

Thirdly, our study explores the moderating role of monitoring factors including environmental enforcement, state ownership, and media coverage. However, other factors may also have moderating effects. For example, previous research reveals that the association

between institutional stimuli and green innovation is contingent on the deficiency gaps among firms, organizational slack, and resources specificity (Berrone et al., 2013). Hence, exploring other potential moderators to further our understanding of the mandatory CSR disclosure-green innovation relationship seems to be a promising direction for future research.

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FIGURES

	Environmental enforcement intensity		State ownership

H2(+)

H3(+)

Mandatory CSR disclosure

H1(+)

Green innovation

H4a(+)

H4b(+/-)

Media coverage intensity

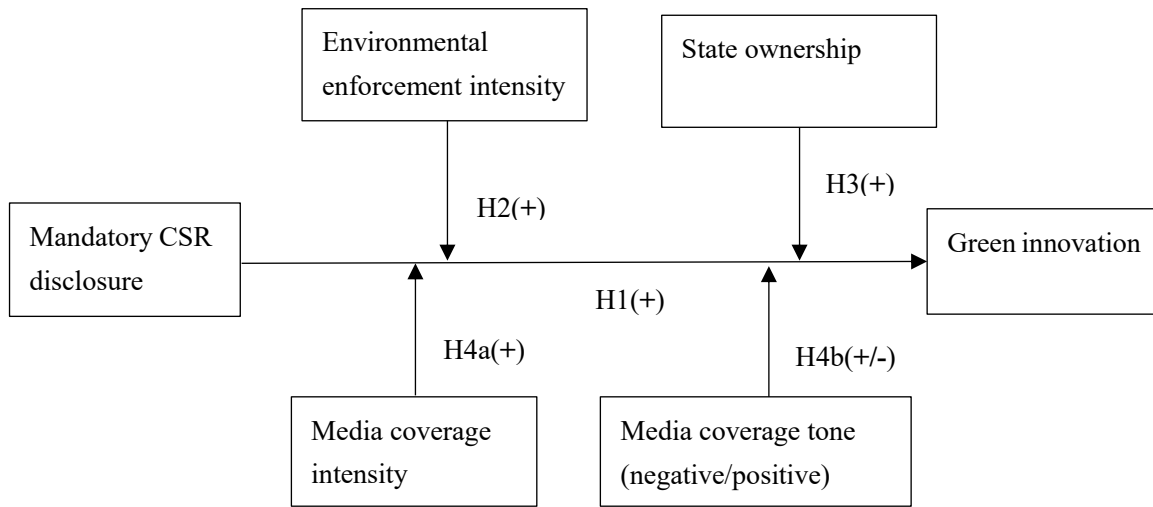Media coverage tone (negative/positive)
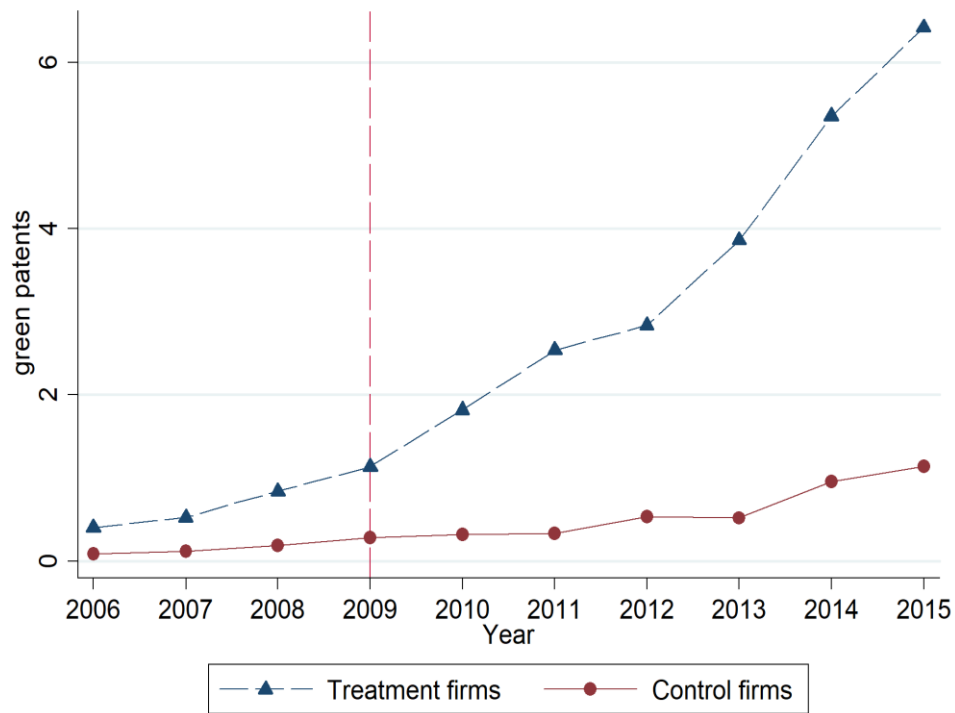
Figure 1 Conceptual model

Figure 2 Average change in green patents between treatment firms and control firms

Note: 2006-2008 is the period before implementation of the mandatory CSR disclosure policy, and 2009-2015 is the period after implementation of the policy.

Table 1 Descriptive statistics and correlations

Panel A: Descriptive statistics

Variables	N	Mean	Std. Dev.	Min	P50	Max
GI	5,966	0.232	0.641	0	0	5.553
MD	5,966	0.299	0.458	0	0	1
Post	5,966	0.711	0.454	0	1	1
EEI	5,966	0.957	1.351	0.015	0.632	11.15
Media_All	5,966	3.508	1.247	0	3.367	8.304
Media_Neg	5,966	2.226	1.210	0	2.079	7.180
Media_Pos	5,966	2.657	1.218	0	2.565	7.182
SO	5,966	0.618	0.486	0	1	1
Size	5,966	21.94	1.340	16.70	21.82	26.96
Age	5,966	2.283	0.366	1.099	2.197	3.332
Lev	5,966	0.532	0.400	0.007	0.518	13.40
Board_indep	5,966	0.358	0.063	0	0.330	1
R&D	5,966	0.009	0.014	0	0.001	0.267
EP	5,966	0.295	1.393	0	0	47.44
IO	5,966	3.634	2.337	0	3.6	16.50
HHI	5,966	0.105	0.097	0.018	0.079	0.991

Panel B: Univariate t-test between and within groups (treatment group and control group) before and after the policy

Variables	Non-CSR reporting firms (N=4,180)			Mandatory CSR reporting firms (N=1,786)			Difference	
	Pre-policy	Post-policy	Difference	Pre-policy	Post-policy	Difference	Pre-policy	Post-policy
	Mean (1)	Mean (2)	(2)-(1)	Mean (3)	Mean (4)	(4)-(3)	(3)-(1)	(4)-(2)
GI	0.062	0.168	0.106*	0.191	0.562	0.372*	0.129*	0.394*
EEI	0.827	0.926	0.099*	0.883	1.188	0.305	0.056	0.262*
Media_All	2.791	3.425	0.634*	3.660	4.325	0.665*	0.869*	0.900*
Media_Neg	1.549	2.176	0.627*	2.215	2.998	0.783*	0.666*	0.822*
Media_Pos	2.004	2.527	0.523*	2.926	3.473	0.547*	0.921*	0.946*
SO	0.566	0.558	-0.008	0.750	0.753	0.003	0.184*	0.194*
Size	21.15	21.68	0.530*	22.35	23.14	0.797*	1.199*	1.458*
Age	2.308	2.298	-0.010	2.244	2.240	-0.004	-0.064*	-0.058*
Lev	0.561	0.533	-0.028	0.489	0.521	0.032*	-0.072*	-0.012
Board_indep	0.345	0.362	0.017*	0.349	0.364	0.015*	0.004	0.001
R&D	0.001	0.011	0.010*	0.002	0.012	0.010*	0.001	0.001*
EP	0.235	0.262	0.027	0.444	0.367	-0.077	0.209*	0.104*
IO	0.157	0.393	0.236*	0.342	0.498	0.156*	0.185*	0.104*
HHI	0.118	0.104	-0.014*	0.105	0.097	-0.008*	-0.013*	-0.007*

Panel C: Correlation matrix

Variables	1	2	3	4	5	6	7	8
1 GI	1							
2 MD	0.224*	1						
3 Post	0.130*	-0.012	1					
4 EEI	0.054*	0.068*	0.053*	1				
5 Media_All	0.233*	0.324*	0.230*	-0.015	1			
6 Media_Neg	0.211*	0.291*	0.249*	-0.012	0.933*	1		
7 Media_Pos	0.245*	0.351*	0.193*	-0.015	0.957*	0.848*	1	
8 SO	0.132*	0.180*	-0.006	-0.014	0.096*	0.091*	0.109*	1

Table 1 Continued

9	Size	0.329*	0.470*	0.203*	0.055*	0.559*	0.516*	0.578*	0.245*
10	Age	-0.091*	-0.075*	-0.009	-0.049*	0.007	0.030*	-0.024	-0.040*
11	Lev	0.019	-0.033*	-0.011	-0.019	-0.001	0.022	-0.016	0.015
12	Board_indep	0.043*	0.013	0.116*	-0.014	0.043*	0.048*	0.036*	-0.037*
13	R&D	0.184*	0.029*	0.311*	0.076*	0.104*	0.080*	0.117*	-0.072*
14	EP	0.010	0.044*	-0.002	-0.011	0.021	0.020	0.027*	0.062*
15	IO	0.149*	0.246*	0.408*	0.053*	0.344*	0.321*	0.347*	0.139*
16	HHI	-0.034*	-0.041*	-0.056*	-0.018	-0.050*	-0.035*	-0.055*	-0.073*
	Variables	9	10	11	12	13	15	15	16
9	Size	1							
10	Age	-0.049*	1						
11	Lev	-0.017	0.083*	1					
12	Board_indep	0.036*	-0.022	-0.005	1				
13	R&D	0.053*	-0.138*	-0.110*	0.028*	1			
14	EP	0.066*	-0.009	0.025	-0.035*	-0.045*	1		
15	IO	0.410*	-0.121*	-0.061*	0.049*	0.199*	0.013	1	
16	HHI	-0.026*	0.029*	0.043*	-0.059*	-0.103*	-0.011	-0.056*	1

Notes: The variable definitions are provided in Appendix Table 1. Significance at the 0.05 level.

Table 2 Regression results for testing hypotheses

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
MD*Post	**0.233***	**0.225***	**0.196***	**0.155***	**0.174***	**0.158***	**0.104**	**0.123***	**0.108***
	(0.048)	**(0.047)**	**(0.045)**	**(0.042)**	**(0.043)**	**(0.042)**	**(0.041)**	**(0.042)**	**(0.041)**
MD*Post*EEI		**0.043**					**0.043**	**0.043**	**0.043**
		(0.021)					**(0.021)**	**(0.021)**	**(0.021)**
EEI		-0.010*					-0.012**	-0.012**	-0.012**
		(0.006)					(0.006)	(0.006)	(0.006)
MD*Post*SO			**0.253***				**0.186**	**0.183**	**0.187**
			(0.091)				**(0.087)**	**(0.087)**	**(0.087)**
SO			0.208				0.048	0.047	0.066
			(0.400)				(0.434)	(0.438)	(0.431)
MD*Post* Media_All				**0.099***			**0.094***		
				(0.031)			**(0.031)**		
Media_All				-0.026**			-0.023*		
				(0.013)			(0.013)		
MD*Post* Media_Neg					**0.083***			**0.077**	
					(0.029)			**(0.030)**	
Media_Neg					-0.026**			-0.023**	
					(0.010)			(0.010)	
MD*Post* Media_Pos						**0.095***			**0.089***
						(0.031)			**(0.032)**
Media_Pos						-0.023*			-0.020*
						(0.012)			(0.012)
Control variables									
Size	0.027	0.028	0.032*	0.026	0.026	0.025	0.038**	0.039**	0.038**
	(0.017)	(0.017)	(0.018)	(0.018)	(0.017)	(0.018)	(0.019)	(0.018)	(0.018)
Age	-0.277	-0.087	-0.144	-0.286	-0.282	-0.310	-0.025	-0.022	-0.048
	(0.316)	(0.343)	(0.326)	(0.311)	(0.312)	(0.307)	(0.346)	(0.348)	(0.342)
Lev	0.022*	0.022*	0.022*	0.022*	0.023*	0.021*	0.018	0.019	0.018
	(0.012)	(0.012)	(0.012)	(0.013)	(0.013)	(0.012)	(0.012)	(0.012)	(0.012)
Board_indep	-0.005	0.000	-0.019	0.003	0.001	0.006	-0.012	-0.014	-0.009
	(0.143)	(0.143)	(0.143)	(0.141)	(0.142)	(0.142)	(0.142)	(0.142)	(0.142)
R&D	2.218**	2.224**	2.435***	2.267**	2.261**	2.262**	2.479***	2.473***	2.474***
	(0.892)	(0.887)	(0.896)	(0.898)	(0.899)	(0.894)	(0.890)	(0.891)	(0.887)
EP	-0.000	-0.001	-0.000	-0.000	-0.000	-0.001	-0.001	-0.001	-0.001
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
IO	-0.080	-0.080	-0.109**	-0.061	-0.068	-0.060	-0.164***	-0.172***	-0.164***
	(0.052)	(0.051)	(0.053)	(0.052)	(0.051)	(0.052)	(0.059)	(0.058)	(0.059)
HHI	0.563*	0.558*	0.537*	0.496*	0.503*	0.500*	0.442	0.449	0.446
	(0.298)	(0.294)	(0.296)	(0.279)	(0.281)	(0.279)	(0.276)	(0.278)	(0.276)
Constant	0.184	-0.404	-0.369	0.214	0.198	0.280	-0.751	-0.769	-0.696
	(1.256)	(1.320)	(1.138)	(1.250)	(1.241)	(1.236)	(1.173)	(1.170)	(1.161)
Observations	5,966	5,966	5,966	5,966	5,966	5,966	5,966	5,966	5,966
R^2	0.657	0.658	0.658	0.660	0.659	0.659	0.664	0.663	0.664
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Standard errors clustered at the firm level are reported in parentheses. *p<0.1, **p<0.05, ***p< 0.01 (two-tailed).

Table 3 Summary of robustness tests

Robustness test	Overview of the process
The PSM-DID approach	To alleviate potential endogeneity that mandatory CSR reporting firms are not randomly selected, we adopt the propensity score matching (PSM) approach to match mandatory CSR reporting firms to non-CSR reporting firms. Then, we rerun the baseline regression with matched samples and obtain similar results.
Alternative subsamples	(1) To empirically test whether the parallel trend assumption is hold, we conduct a placebo test with the pre-policy period (2006-2008) data, and designate 2007 as the pseudo policy adoption year; (2) In order to ensure a balanced period before and after the implementation of the mandatory policy, we reduce the sample period from 2006-2015 to 2006-2011, which includes the three years before the implementation (i.e., 2006-2008) and the three years after that (i.e., 2009-2011). We rerun the baseline regression using the two alternative subsamples.
Alternative regression models	(1) Because our dependent variable (i.e., green patents) is censored/ truncated at zero, we rerun the baseline regression using a Tobit model; (2) Due to the count nature of our dependent variable, we rerun the baseline regression using a negative binomial model.
Alternative measures of green innovation	(1) In addition to identifying green patents by IPC, we collect green patents by searching whether the patent abstracts contain green-related keywords. We rerun the baseline regression by replacing the dependent variable with green patents based on keywords searches; (2) We rerun the baseline regression by replacing the dependent variable with green invention patents, which have the highest degree of novelty and technological inventiveness; (3) We use the number of granted patents as an alternative dependent variable; (4) To take account of the potential lagged effect, we measure green patent at t+1 to t+3 years and rerun our baseline regression.
Ruling out the potential confounding effect	We rule out the confounding effect that our results may capture the impact on green innovation of the environment information disclosure guidelines (draft for comments) released the Ministry of Environmental Protection in 2010.

ONLINE APPENDIX

Understanding the Impact of Mandatory CSR Disclosure on Green Innovation: Evidence from Chinese Listed Firms

Appendix A: The requirements of the CSR report and a sample CSR report

Table A1 The requirements of the CSR report and a sample CSR report

Panel A: Excerpts of the SZSE Notice regarding listed firm' preparations for 2008 annual reports

The CSR report should include but not be limited to the following aspects

1. Overview

Describe the purpose and concept of corporate social responsibility. Explain the main measures taken by the firm to ensure fulfillment of its social responsibilities. Explain important corporate activities and achievements for fulfilling its social responsibilities.

2. The fulfillment of social responsibilities should include at least the following:

(1) Protection of the interests of shareholders and creditors.

The report should focus on explaining the protection of the rights and interests of small and medium shareholders, including standardization of the procedures for holding shareholder meetings, online voting, whether there is selective information disclosure, profit distribution, and investor relationship management....

(2) Protection of employees' interests

The report should clearly state whether the firm complies with the "Labor Law" and "Labor Contract Law" .... If it fails to meet the relevant requirements and standards, it shall be truthfully stated. The report should specify specific measures to protect employee benefits, safety production, vocational training, and other aspects of employee benefits and improvement.

(3) Protection of the interests of suppliers, customers, and consumers

The report should focus on specific anti-bribery measures and methods... Specific measures in terms of product quality and safety control taken as significant product quality and safety incidents should be truthfully described.

(4) Environmental protection and sustainability

The firm should disclose the following details: specific environmental protection investments, green technology developments, energy conservation and emissions reduction, and recycling and reuse of waste; firms should use specific numerical indicators to indicate current conditions and improvements compared to national and industrial standards and their own previous indicators; any non-attainment(s) should be stated in the report, and if a firm had a major environmental accident, was punished by the government, or listed as a key polluting firm, the report should state the reasons for circumstances, current conditions, and their impact on firm operation and development.

(5) Promotion of public relations and social welfare

The firm should highlight its work in disaster relief, donation, and reconstruction....

3. Social responsibility issues and correction plans

If a firm is involved in a major environmental safety accident, is listed in the list of polluting enterprises by the environmental protection department, or is punished by the environmental and labor departments, it must explain and discuss measures to resolve the problems....

Panel B: Summary and excerpts of a sample CSR report

2010 CSR report of China Southern Glass (CSG) holding Co. Ltd. (stock code 000012)

1. Overview

2. Protection of the interests of shareholders and creditors

.... In 2010, the firm held an annual general meeting of shareholders. The firm disclosed a total of 49 reports, including 4 periodic reports including annual reports and quarterly reports, and 45 interim reports including resolutions of the board of directors, resolutions of the board of supervisors, and resolutions of the general meeting of shareholders.

2. Protection of employees' interests

.... In 2010, the firm had no major safety incidents.... More than 300 employee training courses were offered throughout the year. In this year, 17 employees were admitted by Shenzhen University for undergraduate training and 51 were accepted by Shenzhen Polytechnic....

3. Protection of the interests of suppliers, customers and consumers

.... In 2010, the firm invested 78.49 million yuan in R&D, and obtained 26 granted patents, including 3 invention patents....

4. Environmental protection and sustainability

.... In 2010, the firm successively developed the second and third generations of low-emissivity coated energy-saving glass products, and continued to expand the production capacity of existing energy-saving and environmentally-friendly products - low-emissivity insulating glass.... The Shenzhen branch implemented four energy-saving and environmental protection measures in 2010: kiln technological transformation, flue gas waste heat power generation technology, kiln flue gas desulfurization system, and kiln energy-saving insulation technology, which could save 29,268 tons of coal and reduce SO_2 and soot emissions by 1,800 tons, and reduce CO_2 emissions by 72,885 tons per year.

5. Promotion of public relations and social welfare

.... The firm invested 2.7 million yuan to set up "CSG Scholarships" in 9 colleges and universities.... The firm donated more than 2.3 million yuan for earthquake relief in Yushu, Qinghai province.

6. Conclusion

Appendix B: Variable definitions

Table B1 Variable definitions

Variables	Definition
Dependent variable	
GI	The natural logarithm of the number of green patent applications plus one.
Variables of interest	
MD	A dummy variable that equals 1 if the listed firms are mandated to publish CSR reports and equals 0 for the firms that did not publish a CSR report during the sample period (2006-2015).
Post	A dummy variable that equals 1 for years 2009-2015, and 0 for years 2006-2008.
EEI	The number of administrative punishments related to environmental violations at provincial level scaled by provincial population.
SO	A dummy variable that equals 1 if the firm is a state-owned enterprise, otherwise it is 0.
Media_All	The natural logarithm of the number of news articles plus one.
Media_Neg	The natural logarithm of the number of negative news articles plus one.
Media_Pos	The natural logarithm of the number of positive news articles plus one.
Control variables	
Size	The natural logarithm of total assets.
Age	The natural logarithm of the number of years elapsed since the firm was founded.
Lev	The ratio of total debts to total assets.
Board_indep	The proportion of independent directors on the board.
R&D	Research and development expenditure divided by total assets.
EP	Environmental protection investment divided by total assets and multiplied by 100.
IO	The total shares held by institutional investors as a percentage of the firm's total shares outstanding.
HHI	HHI is calculated by adding the squares of the sales of all firms in the same industry.
Others	
MV	The natural logarithm of market value.
Turnover	The total number of shares traded divided by the total number of shares outstanding.
Return	Annual stock return.
Analysts	The natural logarithm of the number of financial analysts plus one.
ROE	Net profit divided by net assets.
Post_2007	A dummy variable that equals 0 for year 2006 and 1 for the years 2007-2008.
VD	A dummy variable that equals 1 if the firm voluntarily publishes a CSR report during the sample period, and 0 otherwise.
Post_VD	A dummy variable that takes the value of 1 for the years after voluntary disclosure and 0 otherwise.
Year FE	Dummy variables for years.
Firm FE	Dummy variables for firms.

Appendix C: Robustness tests

The propensity score matching DID (PSM-DID) approach

To alleviate the potential endogeneity that mandatory CSR reporting firms are not randomly selected, we adopt the propensity score matching (PSM) approach to match mandatory CSR reporting firms to non-CSR reporting firms. This approach allows us to include some covariates that affect the probability of being a treated firm. Referring to (Chen et al., 2018, Wang et al., 2018), we choose the following covariates: market value (MV, measured by the log value of market value), turnover (Turnover), stock returns (Return), the number of analysts (Analysts, measured by the log value of the number of analysts plus one), return on equity (ROE), and state ownership (SO).

Referring to Chen et al. (2018), we use data for the pre-policy period (2006-2008) and adopt a logit regression to estimate the probability of being a treated firm. Next, by employing the k-nearest neighbor matching with replacement ($k=1$) and setting the caliper to 0.01*standard error of the propensity score, we match each reporting firm to the non-reporting firms. The PSM procedure is implemented in STATA as the 'psmatch2' command. Panel A of Table C1 presents that the probability of being a treatment firm is positively associated with the covariates except Return and ROE. Panel B shows that before matching, there are significant differences in the covariates between the treatment and control groups but that after matching, these differences are no longer significant. This suggests that our matching procedure is effective, that is, the matched control group is comparable to treatment group (He et al., 2018). The matching procedure results in a sample of 3,472 firm-year observations-1,765 in the treatment group and 1,707 in the control group, and we re-estimate the baseline model with this sample. Panel C shows that the interaction *MD*Post*, remains

positively significant at the 0.01 level, providing evidence for the reliability of our results.

[INSERT TABLE C1 ABOUT HERE]

Alternative subsamples

To empirically test whether the parallel trend assumption is hold, we conduct a placebo test with the pre-policy period (2006-2008) data (Chen et al., 2018). Specifically, we designate 2007 as the pseudo policy adoption year, which means that 2006 is used as the pseudo pre-policy period and 2007-2008 as the pseudo post-policy period. We create a dummy variable *Post_2007*, which equals 0 for year 2006 and 1 for the years 2007-2008. Model 1 of Table C2 presents that the interaction term *MD*Post* is insignificant, which provides empirical evidence that the parallel trend assumption is satisfied (Chen et al., 2018). This insignificant result in the placebo test also rules out the concern that our outcome may be driven by some potential confounders (Liu and Qiu, 2016).

In order to ensure a balanced period before and after the implementation of the mandatory policy, we reduce the sample period from 2006-2015 to 2006-2011, which includes the three years before the implementation (i.e., 2006-2008) and the three years after that (i.e., 2009-2011). Model 2 of Table C2 shows that this approach does not change our main results.

Alternative regression models

To investigate whether the observed effect of mandatory CSR disclosure on green innovation is independent of different estimation approaches, we perform two alternative models. First, we employ a Tobit model to test our main effect, since our dependent variable *green innovation* is censored/truncated at zero. Second, due to the count nature of our dependent variable, following Berrone et al. (2013), we use a negative binomial model to

estimate the main effect. Due to the "incidental parameter problem" (that is, there are too many parameters to be estimated), it is impossible to include firm fixed effects in Tobit model and the negative binomial model (Lancaster, 2000). We thus include industry fixed effects and city fixed effects in these models. The corresponding results are reported in model 3 and model 4 of Table C2. We find that the coefficients on *MD*Post* are both positively significant, implying that the positive effect of mandatory CSR disclosure on green innovation is not sensitive to the model choice.

Alternative measure of green innovation

To assess the sensitivity of our core results to the measure of outcome variable (i.e., green innovation), we conduct the following tests. First, referring to the approach of Li et al. (2018), all patents containing the keywords of *"low carbon"*, *"environmentally friendly"*, *"green"*, *"emission reduction"*, *"clean"*, *"recycling"*, *"economical"*, *"sustainable"*, *"ecological"*, *"energy conservation",* and *"environmental protection"* are identified as green patents. Model 5 of Table C2 reruns our baseline model by replacing the outcome variable with *GI-keyword*, measured as the log value of one plus the number of green patents based on keywords searches, and obtains similar results to the use of IPC searches to identify green patents.

Second, in the baseline regression, we use the sum of invention patents and utility model patents to construct the measure of green innovation. This might raise a potential concern that our outcome measure assesses the quantity of green innovation rather than quality. The literature on corporate innovation usually uses the number of future citations to a patent as a measure of innovation quality, and assumes that a more influential patent receives more future citations (Tan et al., 2020). One practical difficulty we faced in this study is that the State Intellectual Property Office of China (SIPO) database did not provide sufficient reliable and

available information on patent citations (Tan et al., 2020). As an alternative and in line with prior studies (e.g., Rong et al., 2017), we use invention patents with the highest degree of novelty and technological inventiveness as a measure of the quality of the innovation. We rerun our baseline model by replacing the outcome variable with *GI-invention*, measured as the log value of the number of invention patents plus one. The corresponding results are reported in model 6 of Table C2; we find that the coefficients on *MD*Post* remains positively significant, which implies that the mandatory reporting firms do not increase the quantity of green innovation by sacrificing the quality of green innovation.

Third, as a robustness test, we use grant year to calculate the number of patents. We create the variable *GI-grant* measured as the natural logarithm of 1 plus the number of granted patents and rerun our baseline regression by replacing the dependent variable with *GI-grant*. The results presented in model 7 of Table C2 show that the coefficient of *MD*Post* is positively significant, and thus our baseline results are robust to granted patents.

Fourth, to take account of the potential lagged effect, we measure green patent at t+1 to t+3 years and rerun our baseline regression. As shown in Table C2, the estimated coefficients of *MD*Post* remain positive and statistically significant across model 8 to model 10, indicating that our results are robust.

Ruling out the potential confounding effect

In September 2010, the Ministry of Environmental Protection released the *Guidelines for Environmental Information Disclosure by Listed firms (draft for comments)* (hereafter, the Guideline (draft for comments)). This raises a concern that our results may capture the impact of the Guideline on green innovation. In this regard, we make the following explanation to alleviate this concern.

First, we question whether the Guideline (draft for comments) exists on paper and has not

been implemented from two aspects. One is that only the draft for comments is available. We did not find the final version of the Guideline on the Ministry of Environmental Protection or other government websites. The other is that the Guideline (draft for comments) requires listed firms in heavily polluting industries, including 16 sectors such as coal and electricity, iron and steel, metallurgy, petrochemicals, textiles, and so on, to issue annual environmental reports. However, taking the iron and steel industry as an example, we found that no firm in that industry has issued an annual environmental report during our sample period.

Second, there may be concern also over although heavy polluting firms do not publish environmental reports, they may increase disclosure of environmental information in their CSR reports or annual financial reports. To alleviate this concern, following previous works (e.g., Kong et al., 2020, Lu et al., 2017), we augmented our baseline model by including a dummy variable, *Heavy polluting*, which equals 1 if the firm is a heavy polluting firm, and 0 otherwise. As shown in model 11 of Table C2, the coefficient of *Heavy polluting* is not significant, suggesting that there is no significant difference between heavily polluting firms and non-heavy polluting firms in terms of green innovation. We also find that the coefficient of *MD*Post* remains positive and statistically significant after controlling for the Guideline (draft for comments).

Finally, in our study, we use a DID estimation approach to compare the difference in green innovation between the treatment and control groups. Both our treatment and control groups include heavy polluting firms. Unless the Guideline (draft for comments) have differential effects on the treatment group and control group, our results are unlikely to be affected by it.

<div align="center">**[INSERT TABLE C2 ABOUT HERE]**</div>

Table C1 The propensity score matching DID approach

Panel A: Logit model used to find propensity scores

Variables	Dependent variable: MD
MV	0.586***
	(0.088)
Turnover	-0.001*
	(0.000)
Return	0.089
	(0.055)
Analysts	0.816***
	(0.076)
ROE	-0.028
	(0.073)
SO	0.639***
	(0.144)
Constant	-15.552***
	(1.879)
Observations	1,727
Year FE	YES
Firm FE	YES
Pseudo R^2	0.300

Panel B: Test of the effectiveness of the propensity score matches

Variables		Mean			% Reduction in |bias|	T-Test	
		Treated	Control	% bias		t	P
MV	Unmatched	23.055	21.794	120.9	93.6	24.66	0.000
	Matched	22.922	22.841	7.8		1.19	0.235
Turnover	Unmatched	328.16	410.97	-37.8	99.7	-6.97	0.000
	Matched	337.66	333.92	-0.1		-0.02	0.984
Return	Unmatched	0.819	0.566	18.2	62.4	3.58	0.000
	Matched	0.802	0.706	6.8		1.06	0.290
Analysts	Unmatched	2.364	0.993	134.5	97.4	25.63	0.000
	Matched	2.300	2.336	-3.5		-0.57	0.571
ROE	Unmatched	0.130	0.036	10.6	64.9	1.74	0.082
	Matched	0.129	0.162	-3.7		-0.68	0.495
SO	Unmatched	0.750	0.566	39.6	77.2	7.41	0.000
	Matched	0.738	0.780	-9.0		-1.55	0.121

Panel C: The impact of mandatory CSR disclosure on green innovation, PSM sample

Variables	Dependent variable: GI
MD*Post	0.175***
	(0.056)
Controls	YES
Constant	0.262
	(0.898)
Observations	3,472
R^2	0.682
Year FE	YES
Firm FE	YES

Notes: Controls represents a vector of the control variables. Standard errors clustered at the firm level are reported in parentheses. *p<0.1, **p<0.05, ***p< 0.01 (two-tailed).

Table C2 Robustness checks

| Variables | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 |
	Placebo Test	Reduction of time period	Tobit model	Negative Binomial model	GI-keyword	GI-invention
MD*Post_2007	0.058					
	(0.037)					
MD*Post		0.150***	0.367*	0.468**	0.268***	0.178***
		(0.041)	(0.199)	(0.233)	(0.054)	(0.040)
Controls	YES	YES	YES	YES	YES	YES
Constant	-0.069	-2.093	-15.793***	-17.964***	2.196	0.211
	(1.651)	(1.838)	(2.472)	(2.286)	(1.434)	(0.921)
Observations	1,727	2,980	5,966	5,966	5,966	5,966
R^2/Pseudo R^2	0.755	0.735	0.265	0.211	0.698	0.613
Year FE	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES			YES	YES
City FE			YES	YES		
Industry FE			YES	YES		

| Variables | Model 7 | Model 8 | Model 9 | Model 10 | Model 11 |
	GI-grant	GI_{t+1}	GI_{t+2}	GI_{t+3}	Confounding effect
MD*Post	0.187***	0.222***	0.185***	0.100**	0.233***
	(0.042)	(0.046)	(0.047)	(0.050)	(0.048)
Heavy polluting					0.386
					(0.318)
Controls	YES	YES	YES	YES	YES
Constant	1.058	0.183	0.586	1.461	-0.201
	(1.103)	(1.373)	(1.618)	(1.970)	(0.875)
Observations	5,966	5,326	4,688	4,050	5,966
R^2/Pseudo R^2	0.643	0.685	0.721	0.750	0.657
Year FE	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES

Notes: Post_2007 is a dummy variable that equals 0 for year 2006 and 1 for years 2007-2008. *GI-invention* is measured as the log value of the number of invention patents plus one. *GI-key* is measured as the log value of the number of invention patent based on keywords searches plus one. *GI-grant* is measured as the log value of the number of granted patents plus one. *Heavy polluting* is a dummy variable which equals 1 if the firm is a heavy polluting firm, and 0 otherwise. *Controls* represents a vector of the control variables. Standard errors clustered at the firm level are reported in parentheses. *p<0.1, **p<0.05, ***p< 0.01 (two-tailed).

Appendix D: Additional analysis for the comparison between mandatory disclosure and

voluntary disclosure

To verify our conjecture that mandatory and voluntary CSR disclosure may have differential impacts on green innovation, we conduct a series of tests as follows:

Firstly, we add the 172 voluntary CSR reporting firms (1,633 firm-year observations) to the control group that only includes non-CSR reporting firms, and rerun the baseline model. As reported in model 1 of Table D1, the interaction term *MD*Post* remains positively significant. Also, the magnitude of the coefficient barely changes compared to model 1 of Table 2 (0.221 in Table D1 VS 0.233 in Table 2). This suggests that the inclusion in the control group of the voluntary reporting firms does not affect the main effect, since there is no difference in green patents between voluntary CSR reporting firms and non-CSR reporting firms. In other words, the voluntary CSR reporting firms don't experience a significant change in green innovation.

Secondly, we add the interaction term *VD*Post_VD* to the baseline model to examine the impact of voluntary CSR disclosure on green innovation, and construct the estimation model as in Equation D(1) below. *VD* and *Post_VD* are both dummy variables. *VD* takes a value of 1 when the firm voluntarily publishes a CSR report and 0 otherwise. *Post_VD* equals 1 for the years after voluntary disclosure and 0 otherwise. The baseline group is non-CSR reporting firms. Model 2 of Table D1 shows that the interaction term *MD*Post* is still positively significant, whereas the interaction term *VD*Post_VD* is insignificant. Results reveal that compared to non-CSR reporting firms (i.e., the baseline group), mandatory CSR reporting firms experience a significant increase in green innovation, while voluntary reporting firms experience no significant change. This also supports our conjecture.

$$GI_{it} = \beta_0 + \beta_1 MD_i * Post_t + \beta_2 VD_i * Post_{VD_t} + \beta_j Controls_{it} + \mu_t + \gamma_i$$

$$+ \varepsilon_{it} \qquad\qquad\qquad\qquad\qquad D(1)$$

Thirdly, we exclude mandatory reporting firms and use the sample of 172 voluntary reporting firms as the treatment group and non-CSR reporting firms as the control group. We then estimate a DID model to investigate the effect of voluntary disclosure on green innovation. Our estimation model is shown in Equation D(2). Model 3 of Table D1 reports that the interaction term *VD*Post_VD* is insignificant, which again suggests that in comparison with non-CSR reporting firms, the green innovation performance of voluntary CSR reporting firms did not improve significantly after the release of their CSR reports.

$$GI_{it} = \beta_0 + \beta_1 VD_i * Post\_VD_t + \beta_j Controls_{it} + \mu_t + \gamma_i +$$

$$\varepsilon_{it} \qquad\qquad\qquad\qquad\qquad D(2)$$

[INSERT TABLE D1 ABOUT HERE]

Table D1 Mandatory CSR disclosure versus voluntary CSR disclosure

Variables	Model 1	Model 2	Model 3
MD*Post	0.221***	0.225***	
	(0.045)	(0.045)	
VD*Post_VD		0.039	0.058
		(0.037)	(0.037)
Controls	YES	YES	YES
Constant	-1.033***	-0.989***	-1.135***
	(0.360)	(0.351)	(0.352)
Observations	7,599	7,599	5,813
R^2	0.645	0.645	0.560
Year FE	YES	YES	YES
Firm FE	YES	YES	YES

Notes: Model 1 includes voluntary reporting firms; Model 2 presents the estimation results of Equation D(1). *VD* is a dummy variable that equals 1 if the firm voluntarily publishes a CSR report and 0 otherwise. *Post_VD* is also a dummy variable that takes the value of 1 for the years after voluntary disclosure and 0 otherwise. Model 3 shows the estimation results of Equation D(2). *Controls* represents a vector of the control variables. Standard errors clustered at the firm level are reported in parentheses. *p<0.1, **p<0.05, ***p< 0.01 (two-tailed).

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