Mandatory Disclosure and Corporate Green Innovation

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Abstract: We examine the relation between mandatory environmental disclosure and corporate green innovation outcomes. Adopting a difference-in-differences research design, we find that greenhouse gas (GHG) emissions disclosure mandates are associated with an increase in the quantity of patents related to climate change mitigation/adaptation technologies (i.e., "green innovations"). Further tests reveal two mechanisms that moderate this association: (i) pressure from social investors and (ii) proprietary costs. We also find that mandatory environmental disclosure is associated with a reduction in the economic value of green innovation, suggesting a negative effect on shareholder welfare. Overall, this paper sheds light on the real effects of mandatory environmental disclosure and the determinants of green innovation. This study also contributes to the literature on corporate disclosure and investment decisions and offers findings that are likely informative to regulators, managers, and investors in assessing the economic consequences of mandatory environmental disclosure.

Keywords: Mandatory environmental disclosure; GHG emissions disclosure; green innovation; patents; social investors; proprietary costs; real effects.

1. Introduction

In the face of increasing climate-related risks, investors, customers, suppliers, and other stakeholders have increasingly called for firms to engage in more environmentally responsible business practices (Business Roundtable 2019; Fink 2021). One specific demand from these stakeholders is for firms to invest more in "green innovations," i.e., to increase the production and adoption of new technologies designed to reduce environmental risks (Castellacci and Lie 2017). Green innovation is often strategically important for firms' sustainable growth. Further, given the long-term nature of many environmental issues, green innovation can be crucial in solving or mitigating such issues (Popp et al. 2010). Despite the increased demand for sustainable business practices, disclosures related to firms' environmental risks and the innovations they pursue to mitigate these risks are not uniformly mandated. However, more than 25 jurisdictions have mandated or are considering mandating some form of environmental disclosure (Krueger et al. 2021), and the Securities and Exchange Commission (SEC) and the IFRS Foundation have proposed mandatory climate risk disclosures (IFRS Foundation 2022; SEC 2022). In this paper, we explore whether and how environmental disclosure mandates influence green innovation and related corporate outcomes.

To conduct our study, we exploit variation in state-level greenhouse gas (GHG) emissions disclosure mandates. Despite regulatory differences, state-level disclosure mandates generally require firms to record and file to the states their facility-level GHG emissions if the emissions level exceeds the thresholds set by the states. There were no federal disclosure requirements in place before the state-level disclosure mandates we examine in this study. Because the mandatory GHG emissions disclosure programs adopted in these states are not linked to an emissions reduction requirement (Ramseur 2007), changes in green innovation outcomes are plausibly attributable to these environmental disclosure mandates rather than other emissions reduction policies. In addition, mandatory GHG emissions disclosure is a representative type of mandatory environmental disclosure and is currently a priority of both the SEC and the IFRS Foundation (Christensen et al. 2021; IFRS Foundation 2022; SEC 2022). Therefore, our setting strikes a balance between identification and generalizability and is well suited for testing our research questions (Glaeser and Guay 2017).

We have two main tests. We first examine whether state-level disclosure mandates influence the quantity of green innovation. The quantity of green innovation reflects the firm's investment in green technologies, measured by the number of patents filed each year related to climate change mitigation/adaptation technologies. To form our prediction, we first draw on Aghamolla and An's (2021) theoretical framework that provides guidance on a potential link between mandatory environmental disclosure and the quantity of green innovation. Aghamolla and An (2021) assume managers choose to invest in: (i) green technologies of lower expected payoffs and lower social externalities or (ii) non-green technologies of higher expected payoffs and higher social externalities. Informed managers have incentives to privately deviate from the level of investment in green technologies that the market expects. Because mandatory environmental disclosure would limit managers from withholding negative signals of bad environmental performance, it is plausible that such mandates would result in more investment in green technologies. We also draw upon literature on corporate disclosure and investment decisions, which suggests that mandatory environmental disclosure could potentially increase the quantity of green innovation if peer disclosure informs managers about investment opportunities for green technologies (Christensen et al. 2021; Roychowdhury et al. 2019). Managers could also use peer disclosure for benchmarking, and benchmarking against peer firms may incentivize managers to invest in green technologies (Tomar 2021). Moreover, managers could potentially learn about investment opportunities for green technologies from the process of complying with disclosure mandates (e.g., collecting and analyzing GHG emissions data from facilities) (Chatterjee 2020; Shroff 2017). Accordingly, we expect a positive relation between mandatory environmental disclosure and the quantity of green innovation.

Second, we examine the association between state-level disclosure mandates and the economic value of green innovation. We examine this second outcome because only a small proportion of patents are commercially valuable to the patent holders (Kogan et al. 2017); thus, an increase in the number of green patents may not necessarily lead to increased economic value. The economic value of green innovation is based on the notion that changes in stock price capture changes in value from a shareholder welfare perspective (Kothari 2001) and is measured using stock price reactions to news about the patent grants (Kogan et al. 2017). Aghamolla and An (2021) suggest that mandating environmental disclosure may incentivize managers to deviate from shareholders' expectations and over-invest in green technologies, which could result in lower economic value of green innovation to the detriment of shareholder welfare. In addition, mandatory environmental disclosure may reveal proprietary information to competitors and thus impair the economic value of green innovation (Bhattacharya and Ritter 1983; Christensen et al. 2021; Zhong 2018). Conversely, environmental disclosure mandates could facilitate managerial learning from peer disclosure or the process of complying with disclosure requirements, and thus positively relate to the economic value of green innovation (Christensen et al. 2021; Roychowdhury et al. 2019; Ferracuti and Stubben 2019; Tomar 2021). Accordingly, it is unclear *ex ante* how mandatory environmental disclosure will relate to the economic value of green innovation.

To test the relation between mandatory environmental disclosure and the quantity of green innovation, we adopt a difference-in-differences (DiD) research design controlling for firm and year fixed effects that exploits GHG emissions disclosure mandates adopted by four states (Wisconsin, New Jersey, Maine, and Connecticut) over the period from 1993 to 2006 (Ramseur 2007). We find that mandatory environmental disclosure is associated with an increase in the quantity of green innovation. In economic terms, the emissions disclosure mandates are associated with an increase in the number of green patents by 0.734 per year, which corresponds to 257% of the sample mean of green patents across all firms. We perform two cross-sectional analyses to corroborate the documented relation between mandatory environmental disclosure and the quantity green innovation. First, we examine whether the relation varies based on the proportion of a firm's shares held by "social investors" (i.e., investors more likely to be concerned about the firm's social and environmental performance). Consistent with firms being more likely to increase green innovation in response to investor demand, we find that the primary relation is stronger in the presence of more social investors. Second, we consider the role of proprietary costs of increased disclosure since mandated disclosure may result in the revelation of proprietary information to competitors and thus discourage innovation. Consistent with proprietary costs moderating the relation of interest, we find that the association between mandatory environmental disclosure and the quantity of green innovation is reduced for firms with greater proprietary costs.

We next examine the effect of mandatory environmental disclosure on the economic value of green innovation. Using the same DiD research design, we document a negative association between emissions disclosure mandates and a well-established measure of the economic value of firms' green innovation. Economically, these disclosure mandates are associated with approximately a 4.09% decrease in the economic value of green patents. We also consider the effect on the scientific value of green innovation and again find a negative association between mandatory environmental disclosure and forward citations of green patents. Together, these results support the inference that environmental disclosure mandates negatively impact the value of firms' green innovation activities.

We conclude our primary empirical analyses by investigating how mandatory environmental disclosure impacts future firm performance and value. If the negative relation between these disclosure mandates and the value of green innovation does in fact impair shareholder welfare, then it is plausible that this is also manifested in reduced future firm performance/value (Acemoglu et al. 2018; Garcia-Macia et al. 2019; Kogan et al. 2017). Consistent with emissions disclosure mandates having a negative impact on future firm performance/value, we document a negative association between these disclosure mandates and both ROA and Tobin's Q in years t+2 and t+3 relative to the year of the mandate. Taken together with the economic and scientific value results, these results provide consistent evidence suggesting a negative impact of mandatory environmental disclosure on average shareholder value.

This paper makes at least three contributions. We first contribute to the literature on the real effects of environmental disclosures. In a recent review, Christensen et al. (2021) indicate that "Empirical evidence on the real effects of [sustainability] reporting is still relatively scarce." We provide evidence that mandatory environmental disclosure influences the quantity and economic value of green innovation. Our results also provide evidence of specific mechanisms through which these effects manifest. Christensen et al. (2021) stress that "It is very difficult to predict whether the described firm responses [to mandatory sustainability disclosure] are net positive or negative from the perspective of investors, other stakeholders, or society. […] We need more research to better understand these tradeoffs as well as how and why firms respond to specific reporting requirements." We respond to their call for research by showing that mandatory environmental disclosure may result in over-investment in green technologies and a reduction in the economic value of green innovation, which could negatively affect shareholder welfare.

Second, we contribute to the literature on the relation between corporate disclosure and investment decisions. Roychowdhury et al. (2019) indicate in their review of this literature that "it appears that most of the literature has concentrated on classic agency frictions arising from manager shareholder conflicts, whereas other agency conflicts have received less attention and present an opportunity for future research." Our results suggest that mandatory environmental disclosure could potentially exacerbate agency conflicts between shareholders and other stakeholders because more investment in green technologies does not necessarily lead to greater shareholder welfare.

Finally, our findings are informative to regulators and standard setters in assessing the economic consequences of mandatory environmental disclosure. Mandatory disclosure regimes can have significant costs and unintended consequences (Christensen et al. 2021; Leuz and Wysocki 2016). Therefore, mandatory environmental disclosure requires careful cost-benefit analyses (Bolton et al. 2021; Christensen et al. 2021). Our paper complements related work that uses an international setting (Mbanyele et al. 2022) by showing that mandatory environmental disclosure could promote increased green innovation in a U.S setting, where the premise of maximizing shareholder value is arguably prevalent (Friedman 1970; Lazonick and O'Sullivan 2010). Our paper also suggests that agency costs and proprietary costs arising from mandatory environmental disclosure could relate to reduced economic value of green innovation, which could be detrimental to shareholder welfare.

2. Related Literature and Hypothesis Development

2.1 Related Literature

Our paper builds on prior research on the relation between corporate disclosure and investment decisions (see Roychowdhury et al. 2019 for a review). Most studies in this literature document a positive relation between high-quality disclosure and investment efficiency. Prior research suggests that high-quality disclosure can improve investment efficiency (e.g., reducing under-investment) by reducing the adverse selection and capital rationing problem (Jensen and Meckling 1976; Verrecchia 2001; Biddle and Hilary 2006; Biddle et al. 2009). In addition, prior studies show that disclosure can influence investment decisions by mitigating or exacerbating moral hazard problems, including managers' empire-building tendency, effort aversion, and short-termism (Stein 1989, 2003; Bertrand and Mullainathan 2003; Hope and Thomas 2008; Gormley and Matsa 2016). For example, exploiting the EU Non-Financial Reporting Directive (NFRD) that increases the quality of sustainability disclosure, Allman and Won (2021) provide evidence that high-quality sustainability disclosure increases affected firms' investment efficiency. They find that the affected firms can raise additional debt capital after the NFRD. Allman and Won's (2021) findings suggest that mandatory sustainability disclosure can mitigate capital rationing problems for under-investing firms, especially in debt markets. Zhong (2018) argues that findings from the capital investment literature may not necessarily generalize to investment in innovations, primarily due to the long-term, high-risk, and proprietary nature of innovations. Zhong (2018) finds that firms' disclosure quality positively affects innovative outcomes by reducing managers' career concerns and enhancing governance. Zhong (2018) also finds that greater proprietary costs may offset the positive effect of high-quality disclosure on innovative outcomes. With the exception of Allman and Won (2021), the extant literature provides only limited evidence on whether and how sustainability disclosure could influence firms' investment in (green) innovation and innovative outcomes.

Another related stream of literature explores the real effects of mandatory environmental disclosure (see Christensen et al. 2021 for a review). Several studies find that mandatory environmental disclosure promotes environmentally friendly firm behavior, such as reducing GHG emissions (Chen et al. 2018; Downar et al. 2020; Jouvenot and Krueger 2019; Tomar 2021; Yang et al. 2021). For example, the UK has required listed firms to disclose organization-level GHG emissions in their annual reports since 2013. Downar et al. (2020) and Jouvenot and Krueger (2019) find that firms affected by the UK disclosure mandate lowered their GHG emissions. These studies argue that the GHG emissions disclosure mandate increases investor pressures for the affected firms to reduce emissions. In 2010, the US Environmental Protection Agency (EPA) introduced the Greenhouse Gas Reporting Program (GHGRP). The GHGRP requires facilities emitting more than 25,000 metric tons of CO_2 annually to report their GHG emissions to the EPA. Tomar (2021) and Yang et al. (2021) find that the affected facilities decrease their GHG emissions after the GHGRP. Tomar (2021) attributes the emission reductions to learning and benchmarking from peer disclosure as well as to stakeholder and capital market pressures. In addition, Chen et al. (2018) utilize China's 2008 sustainability disclosure mandate to examine the effect of mandatory sustainability disclosure on firm performance and social externalities. They find that cities with the most affected firms experience a decrease in industrial wastewater and SO_2 emissions. In terms of the mechanism, Chen et al. (2018) provide evidence that sustainability disclosure mandates increase political and social pressure regarding a firm's environmental impacts. However, they find that the affected firms experience a reduction in future profitability after the disclosure mandate. Overall, these studies suggest that mandatory environmental disclosure could mitigate negative externalities and promote environmentally friendly firm behavior (e.g., reducing pollutant emissions), while also potentially decreasing firms' future profitability (Christensen et al. 2021; Moser and Martin 2012). This stream of literature primarily focuses on how mandatory environmental disclosure affects firms' emissions. The existing evidence showing a reduction in emissions following disclosure mandates may not necessarily generalize to changes in green innovations, since it is likely more costly for firms to alter their innovative activities than their emissions levels in response to mandatory environmental disclosure. In the GHGRP setting, Yang et al. (2021) provide evidence that firms strategically reallocate emissions from GHGRP facilities to non-GHGRP facilities to reduce GHGRP-disclosed emissions. It is unclear whether firms could adjust their innovative activities similarly to emissions reduction after mandatory environmental disclosure, especially in the short run.

In a related study, Mbanyele et al. (2022) exploit the staggered adoption of mandatory sustainability disclosure in 28 countries to examine the effect of mandatory sustainability disclosure on green innovation. They find that mandatory sustainability disclosure increases the number and citations of green patents. Our paper complements Mbanyele et al. (2022) in a few ways. First, we focus on the relation between mandatory environmental disclosure and the quantity of patents, and we explore the mechanisms through which disclosure mandates influence firms' investment in green innovation. Second, we examine the effects of mandatory environmental disclosure on the economic value of green innovation and the associated welfare implications for shareholders. Third, we provide empirical results in a US setting. Zhong (2018) finds that institutional differences between countries, such as differences in intellectual property rights or governance regimes, moderate the effect of disclosure on innovation. In particular, the premise of shareholder supremacy is arguably more prevalent in the US than in other developed countries (Friedman 1970; Lazonick and O'Sullivan 2010). The premise of shareholder supremacy might limit the potential effect of mandatory environmental disclosure on environmentally friendly firm activities, including investment in green innovation. Given the institutional differences between the US capital market and those in other countries, we utilize GHG emissions disclosure mandates in the US to test our research questions.

2.2 Hypothesis Development

We first study the relation between mandatory environmental disclosure and the quantity of green innovation. We draw on Aghamolla and An's (2021) theory that considers the effects of mandatory versus voluntary environmental disclosure on firms' investment in green technologies. In their setting, managers privately choose between a project of non-green technologies and a project of green technologies. The non-green (green) project is more likely to generate higher (lower) future cash flows and higher (lower) negative social externalities—e.g., pollutant emissions. In a voluntary regime of environmental disclosure, the manager can decide whether to disclose or withhold the firm's environmental performance. In a mandatory disclosure regime, the manager must disclose the firm's environmental performance, but has discretion over whether to disclose the firm's future expected financial performance. Moreover, investors have heterogeneous preferences over the firm's environmental performance (Krueger et al. 2020). Aghamolla and An (2021) assume there are two types of investors: (i) traditional investors who only care about the firm's financial performance and

(ii) social investors who care about both financial and environmental performance.[1]

When the firm has a sufficiently high fraction of social investors, Aghamolla and An (2021) predict that mandatory environmental disclosure would, on average, result in more investment in green technologies. Because mandatory environmental disclosure limits managers from strategically withholding negative signals of the firms' poor environmental performance, mandatory environmental disclosure could incentivize managers to invest in green technologies in response to social investors' demand. As the quantity of green innovation likely reflects firms' investment in green technologies, Aghamolla and An's (2021) theory suggests a positive relation between mandatory environmental disclosure and the quantity of green innovation.

In addition, the literature on the relation between corporate disclosure and investment decisions finds that high-quality disclosure could reduce information asymmetry between managers and capital providers and mitigate under-investment (Biddle et al. 2009; Dou et al. 2019; Roychowdhury et al. 2019). For example, by exploiting the EU NFRD that increases the quality of sustainability disclosure, Allman and Won (2021) find that high-quality sustainability disclosure alleviates the affected firms' capital rationing problem and increases their capital investment. Moreover, prior studies provide evidence that mandatory environmental disclosure could promote environmentally friendly firm behavior (e.g., reducing pollutant emissions) (Chen et al. 2018; Tomar 2021; Yang et al. 2021). These studies attribute the effect to increased pressure and monitoring from the government, investors, and other stakeholders. Similarly, mandatory environmental disclosure may lead to more pressure from stakeholders regarding firms' environmental performance and thus increase firms' investment in green technologies. Collectively, we hypothesize a positive relation between mandatory environmental disclosure and the quantity of green innovation:

[1] Aghamolla and An (2021) argue that, relative to non-green technologies, green technologies are more costly to implement or require greater knowledge investment (e.g., R&D expenditure). Thus, while green technology projects may result in lower negative social externalities (e.g., lower pollutant emissions), they tend to have lower expected profitability.

H1: ***Mandatory environmental disclosure is positively associated with the quantity of green innovation.***

In addition to the quantity of green innovation, we study the relation between mandatory environmental disclosure and the economic value of green innovation. We examine this alternative outcome because an increase in the quantity of green innovation does not necessarily correspond to an increase in economic value. Only a small proportion of innovative outputs is commercially valuable to firms (Kogan et al. 2017). In addition, Kogan et al. (2017) argue that the economic value of innovation does not necessarily coincide with the scientific value of innovation. For example, certain innovations may represent a relatively minor scientific improvement yet be very effective in increasing the barrier of entry and restricting competition. These types of innovations thus could have a significant economic value for firms. Given the positive relation between the economic value of innovation and firm growth (Acemoglu et al. 2018; Garcia-Macia et al. 2019; Kogan et al. 2017), the economic value of firms' investment in green technologies is likely relevant for many shareholders.

Concerning the relation between mandatory environmental disclosure and the economic value of green innovation, we draw on Aghamolla and An's (2021) analysis of the effects of mandatory environmental disclosure on firm investment in green technologies and shareholder welfare. When firms have a low fraction of social investors, Aghamolla and An (2021) predict that mandatory environmental disclosure may incentivize managers to privately deviate from general shareholder expectations and over-invest in green technologies. Relative to a voluntary environmental disclosure regime, an over-investment in green technologies in the mandatory environmental disclosure regime could result in lower shareholder welfare. As the economic value of green innovation also reflects the effect of these green innovations on shareholder welfare, Aghamolla and An's (2021) theory suggests a negative relation between mandatory environmental disclosure and the economic value of green innovation. Beyond the incentive effects, mandatory environmental disclosure could be costly because required disclosures may reveal proprietary information about firms' strategy to competitors, customers, suppliers, and regulators (Breuer et al. 2020; Christensen et al. 2021; Glaeser et al. 2020; Zhong 2018). Zhong (2018) notes that disclosing proprietary information could impair the value of innovation (Bhattacharya and Ritter 1983; Jaffe 1996), further suggesting a negative association between mandatory environmental disclosure and the economic value of green innovation.

On the other hand, we may observe a positive association between disclosure mandates and the economic value of green innovation. Mandatory environmental disclosure may facilitate managerial learning from peer disclosure or the disclosure requirements, and thus encourage managers to pursue green technologies with positive economic value (Christensen et al. 2021; Roychowdhury et al. 2019). Managers may learn from peer disclosure about valuable investment opportunities for green technologies (Ferracuti and Stubben 2019; Roychowdhury et al. 2019; Tomar 2021). Managers may also learn about valuable investment opportunities for green technologies from the process of complying with the disclosure requirements (Roychowdhury et al. 2019; Shroff 2017). In summary, this potential managerial learning effect suggests that mandatory environmental disclosure could positively relate to the economic value of green innovation.

Given the competing arguments for the relation between mandatory environmental disclosure and the economic value of green innovation, we state our second hypothesis in the null form:

H2: ***Mandatory environmental disclosure is not associated with the economic value of green innovation.***

3. Research Design and Data

3.1 Mandatory GHG Emissions Disclosure

To examine the relation between mandatory environmental disclosure and the two dimensions of green innovation outcomes, we utilize GHG emissions disclosure mandates adopted by four US states during the period from 1993 to 2006: Wisconsin (WI), New Jersey (NJ), Maine (ME), and Connecticut (CT). In 1993, Wisconsin established a mandatory reporting program that includes carbon dioxide reporting for facilities generating over 100,000 tons annually; beginning in 2003, facilities in New Jersey that report air pollutant emissions must also submit emission data for carbon dioxide and methane; beginning in 2004, facilities in Maine that emit any criteria pollutant over a specific reporting threshold must also report GHG emissions; beginning in 2006, facilities in Connecticut subject to federal reporting under Title V of the Clean Air Act must annually submit greenhouse gas emissions data. Table 1 summarizes these GHG emissions disclosure mandates. These state-level environmental disclosure mandates plausibly increased GHG emissions disclosure for firms located in the four states. Exploiting the adoption of these GHG emissions disclosure mandates, we test the effect of mandatory environmental disclosure on firms' green innovation outcomes.

3.2 Green Innovation Outcomes

Following prior studies (Cohen et al. 2022; Haščič and Migotto 2015; Mbanyele et al. 2022), we measure the quantity of green innovation by the number of green patents. Given the mandatory GHG emissions disclosure setting, we define green patents as those related to climate change mitigation or adaptation technologies. Specifically, we identify patents tagged by the USPTO with the "Y02" Cooperative Patent Classification (CPC) classification (Haščič and Migotto 2015; Mbanyele et al. 2022). The CPC is a patent classification system used by the USPTO and the European Patent Office (EPO). According to the USPTO, the Y02 class covers "selected technologies, which control, reduce or prevent anthropogenic emissions of greenhouse gases [GHG], in the framework of the Kyoto Protocol and the Paris Agreement, and also technologies which allow adapting to the adverse effects of climate change."[2]

We employ Kogan et al.'s (2017) measure of the economic value of patents based on the stock price reactions to news about patent grants. Kogan et al. (2017) extract information from USPTO patent documents (e.g., assignees, citations, dates of application, and dates of issuance) and match the assignees of patents to firms in the CRSP database. Kogan et al. (2017) then estimate the economic

[2] See the USPTO's full classification scheme at: https://www.uspto.gov/web/patents/classification/cpc/html/cpc-Y.html.

value of patents by the short-window stock price reactions to the events of patent grants. They filter the component of firm return related to the patent grant from unrelated noise. Kogan et al. (2017) argue that stock prices are forward-looking and thus provide a reasonable estimate of the private, economic value of patents to the assignee firms (i.e., patent holders). As stock prices also reflect firm valuation from the shareholders' perspective (Kothari 2001), the Kogan et al. (2017) measure captures the shareholder welfare aspect of innovation.

Following prior work (He and Tian 2013; Lerner and Seru 2022), we count each firm's total number of green patents (*PATENT*) by the year of the patent application. Similarly, we summarize the total economic value of each firm's green patents (*PATENT_VAL*) by the year of the patent application. The economic value of green patents is in millions and deflated to 1982 dollars using the consumer price index (CPI). Because the Kogan et al. (2017) measure is in dollars and adjusted for inflation, it is comparable across industries and time.

3.3 Empirical Model

To test the relations between mandatory environmental disclosure and green innovation outcomes, we estimate the following generalized difference-in-differences (DiD) model using ordinary least squares (OLS) regression (Bertrand and Mullainathan 2003; deHaan 2021):[3]

$$GREEN\_INNOV_{it+1} = \beta_0 + \beta_1 GHG\_TREAT_t + \sum_{j=2}^{n} \beta_j X_{j,it} + \gamma_i FIRM + \delta_t YEAR + \varepsilon_{it} \tag{1}$$

where *i* indexes firm and *t* indexes fiscal year. $GREEN\_INNOV_{it+1}$ represents either $PATENT_{it+1}$ (the number of green patents) or $Ln(1+PATENT\_VAL_{it+1})$ (the natural logarithm of one plus the total

[3] For the dependent variable *PATENT,* we use an OLS estimator instead of nonlinear estimators (e.g., a Tobit model or Poisson regression) to accommodate a large number of firm fixed effects. Angrist and Pischke (2008) argue that the asymptotic properties and flexibility of linear models often produce more robust results than nonlinear models. In addition, Greene (2004) suggests that linear models can accommodate a large number of fixed effects with fewer estimation biases than nonlinear models. However, for robustness, we also examine the association between mandatory GHG emissions disclosure and the number of green patents using a Tobit model and Poisson regression (without controlling for firm fixed effects), respectively, and find qualitatively consistent results in each case (untabulated).

economic value of green patents) of firm *i* in year *t+1*. The main variable of interest, GHG_TREAT_{it}, is an indicator variable equal to one if the firm's headquarters is in any of the four treatment states (Wisconsin, New Jersey, Maine, or Connecticut) after these states adopted a GHG emissions disclosure mandate, and zero otherwise.

In addition to the baseline specification over the entire sample period, we employ a neighbor-state specification where the control group includes only the neighbor states of the four treatment states and the sample is restricted to observations in five-year windows before and after each state adopts the disclosure mandates. Specifically, the neighbor-state treatment group consists of firm-years in Wisconsin around 1993, New Jersey around 2003, Maine around 2004, and Connecticut around 2006, and the control group consists of firm-years in the neighbor states without a GHG emissions disclosure mandate during the same periods. For example, New Jersey, a treatment state, has a control group comprised of Pennsylvania, New York, and Delaware. Because New Jersey mandated GHG emissions disclosure in 2003, we restrict the observations in these four states to a sample period from 1998 through 2008. We also exclude observations in the treatment years in the neighbor-state specification.

$X_{j,it}$ is a set of control variables that correlate with innovation outcomes following prior studies (Chy and Hope 2021; Tian and Wang 2014). Specifically, the control variables include *R&D* (R&D expenditures scaled by the total assets), *SIZE* (the natural logarithm of total assets), *AGE* (the natural logarithm of firm age), *MTB* (market-to-book ratio), *ROA* (income before extraordinary items scaled by the beginning book value of assets), *LEVERAGE* (total liabilities scaled by total assets), *CAPEX* (capital expenditures scaled by total assets), *PPE* (net property, plant, and equipment scaled by total assets), *HHI* (Herfindahl-Hirschman index for sale revenues), *HHI_SQUARED* (*HHI* squared), and *SPREAD* (stock liquidity measured by average bid-ask spreads). All continuous variables are winsorized at the 1% and 99% levels. Appendix A provides detailed variable definitions. Eq. (1) also includes firm fixed effects (*FIRM*) to control for other time-invariant firm characteristics and year fixed effects (*YEAR*) to control for unobservable systematic differences between years.

The coefficient on *GHG_TREAT* (β_1) in Eq. (1) estimates the average treatment effect of GHG emissions disclosure mandates on the quantity or economic value of green patents. When using *PATENT* as the dependent variable, a positive and significant β_1 would support *H1*. Given competing arguments concerning the relation between mandatory environmental disclosure and the economic value of green innovation, we do not make a directional prediction of β_1 when using *Ln(1+PATENT_VAL)* as the dependent variable (*H2*).

3.4 Data, Sample Selection, and Summary Statistics

We obtain patent data from Kogan et al.'s (2017) data repository.[4] These data include the patent number, CPC codes, CRSP PERMNO of the assignee firm, issue date, application date, forward citations, and the economic value of each patent. We use the CPC codes to identify green patents of the Y02 class (Haščič and Migotto 2015; Mbanyele et al. 2022). We then map the patent data to Compustat and CRSP by the assignee firm's CRSP PERMNO and the patent application year.

We use firms' headquarters location to identify firm-years affected by the state-level GHG emissions disclosure mandates (Chy and Hope 2021; Li et al. 2018).[5] To calculate the control variables, we obtain firms' financial data from Compustat and stock data from CRSP. The sample period begins in 1988 and ends in 2010.[6] The sample for the baseline regression consists of 96,708

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[4] These data are retrieved from Kogan et al's (2017) data repository: https://github.com/KPSS2017/Technological-Innovation-Resource-Allocation-and-Growth-Extended-Data.

[5] We use firms' historical headquarters location from their 10-K filings. The 10-K header data is retrieved from Bill McDonald's website (https://sraf.nd.edu/data/augmented-10-x-header-data/). For the sample period before the SEC required firms to file 10-Ks through the EDGAR system, we backfill the headquarters location. If the historical headquarters location data is missing for a firm throughout the sample period, we use the firm's headquarters location from Compustat.

[6] The first GHG emissions disclosure mandate in the sample was adopted in Wisconsin in 1993, and the last one was adopted in Connecticut in 2006. We begin the sample in 1988 to allow for five years before the adoption of Wisconsin's mandate in 1993. We end the sample in 2010 to avoid potential issues surrounding the implementation of the Federal Greenhouse Gas Reporting Program (GHGRP) in 2011. Because we end the sample in 2010, this limits the post-mandate period in the neighbor-state specification for Connecticut's adoption to only four years instead of five (2007-2010).

firm-year observations, and the sample for the neighbor-state specification consists of 15,569 firm-year observations. Panel A of Table 2 details the sample selection process.

Panel B of Table 2 presents the summary statistics of the variables in the paper. The mean number of green patents by firm-year (*PATENT*) is 0.29. The mean economic value of green patents (*PATENT_VAL*) is $5.36 million. The mean of the treatment variable (*GHG_TREAT*) is 0.03, which suggests the GHG emissions disclosure mandates affect approximately 3% of the observations. Summary statistics of the other variables are generally consistent with those in prior studies.

4. Empirical Results

4.1 Mandatory Environmental Disclosure and Green Innovation Outcomes

To test the relation between mandatory environmental disclosure and the quantity of green patents (*H1*), we estimate Eq. (1) with $PATENT_{t+1}$ as the dependent variable. $PATENT_{t+1}$ captures the number of green patents for climate change mitigation/adaptation technologies that the firm files for in year *t+1*. The estimation results are reported in Table 3. Column (1) reports the results using the baseline sample. The coefficient on *GHG_TREAT* is positive and significant ($p < 0.01$). In economic terms, GHG emissions disclosure mandates are associated with an increase in the number of green patents by 0.734, which represents 257% of the sample mean of green patents.[7] Column (2) presents the results using the neighbor-state specification. The coefficient on *GHG_TREAT* is also positive and significant in this specification ($p < 0.05$). Together, these results are consistent with *H1*.

4.2 Cross-Sectional Analyses

In this section, we examine whether our main *H1* result varies predictably with specific cross-sectional factors that should influence the relation between mandatory emissions disclosure and the quantity of green innovation.

[7] The sample mean of the number of green patents is 0.286. The estimate of the effect magnitude is thus equivalent to a 257% (0.734/0.286) increase based on the sample mean.

4.2.1 Investor Preference

The first factor we consider is the extent of a firm's investors that are likely to be more concerned about the firm's social and environmental performance (i.e., "social investors"). Under Aghamolla and An's (2021) theoretical framework, investor preference is an important condition for the positive effect of mandatory environmental disclosure on firms' investment in green technologies. More specifically, managers are likely to face more pressure to increase investment in green innovation following emissions disclosure mandates in the presence of more social investors. Consistent with this, we expect that the positive effect on firms' investment in green technologies documented in Table 3 is more likely to manifest when firms have a sufficiently high fraction of social investors.

To empirically test this, we estimate the proportion of social investors for each firm-year following Hwang et al. (2022). Specifically, we first estimate each institutional investor's taste for social responsibility by aggregating the KLD ratings of the portfolio firms that the investor holds (which we identify using Form 13F data). KLD ratings come from the Kinder, Lyndenberg, and Domini (KLD) STATS database, which is one of the most popular CSR databases (Hwang et al. 2022). Hwang et al. (2022) state that "KLD annually reports approximately 80 indicators of corporate social responsibility that cover seven major areas that include strengths and concerns about community, corporate governance, diversity, employee relations, environment, human rights, and product issues." We use KLD scores because we are interested in how investors' revealed preference for social and environmental responsibility influences how managers respond to emissions disclosure mandates. Next, for each firm-year in the sample, we calculate a weighted average measure of investor taste for social and environmental issues that is based on each investor's aggregate KLD rating and the proportion of the firm's shares held by each investor. Finally, consistent with Hwang et al. (2022), we classify firm-years in the top tercile of this measure as the "social investor" group (where *SOC_INVESTOR* = 1).[8]

As discussed above, we expect that the positive relation between mandatory environmental disclosure and the quantity of green innovation will be more pronounced for firms with a large proportion of social investors. To test this prediction, we re-estimate Eq. (1) after including *SOC_INVESTOR* and the interactions of *SOC_INVESTOR* and all other independent variables as additional regressors. The results of these tests are reported in Panel A of Table 4. For both the baseline and neighbor-state specifications, we find a positive and significant coefficient on the interaction of *GHG_TREAT* and *SOC_INVESTOR* ($p < 0.01$). These results are consistent with our prediction and suggest that the positive relation between mandatory GHG emissions disclosure and the number of green patents is more pronounced for firms with a large proportion of social investors.

4.2.2 Proprietary Costs

Responding to the call for cost-benefit analyses on mandatory environmental disclosure policies (Bolton et al. 2021; Christensen et al. 2021), the second factor we consider is the role of the proprietary cost of disclosure in the relation between mandatory environmental disclosure and the quantity of green innovation. Prior studies suggest that mandatory disclosure may reveal proprietary information to firms' competitors and thus discourage innovation (Zhong 2018; Breuer et al. 2020; Christensen et al. 2021; Glaeser et al. 2020). Zhong (2018) and Breuer et al. (2020) argue that the proprietary cost arising from corporate disclosure may reduce the value of potential innovations, resulting in fewer innovations (Bhattacharya and Ritter 1983). Therefore, we expect the positive relation between mandatory environmental disclosure and the quantity of green innovations will be attenuated when firms face greater proprietary costs.

Following prior studies (e.g., Botosan and Stanford 2005; Ali et al. 2014), we use the level of

[8] For firm-years without KLD coverage, we code these observations as *SOC_INVESTOR* = 0. Alternatively, if we limit the sample to only observations with KLD coverage and re-estimate our tests, we find similar inferences to those reported.

industry competition to proxy for the level of proprietary costs. Specifically, we measure the level of industry competition at the two-digit SIC level by Herfindahl-Hirschman Index (HHI) for sales revenue. Lower HHI implies lower market concentration, higher industry competition, and greater proprietary costs. Using a similar partition approach to the previous cross-sectional analysis, we classify firm-years in the bottom tercile of HHI by year as the high proprietary costs group (where *HIGH_PROP* = 1).

To test our prediction that the positive relation between mandatory environmental disclosure and the quantity of green patents will be attenuated in the presence of higher proprietary costs, we re-estimate Eq. (1) after including *HIGH_PROP* and the interactions of *HIGH_PROP* and all other independent variables as additional regressors. The results of these tests are reported in Panel B of Table 4. For both specifications, we find a negative and significant coefficient on the interaction of *GHG_TREAT* and *HIGH_PROP* ($p < 0.01$). These results suggest that proprietary costs arising from mandatory environmental disclosure *ex ante* reduce firms' incentives to invest in green technologies and thereby provide further support for our interpretation of the main *H1* results.

4.3 Mandatory Environmental Disclosure and the Value of Green Innovation

To test the relation between mandatory environmental disclosure and the value of green patents (*H2*), we estimate Eq. (1) with $Ln(1+PATENT\_VAL_{t+1})$ as the dependent variable. $Ln(1+PATENT\_VAL_{t+1})$ measures the economic value of green patents for climate change mitigation/adaptation technologies that the firm files for in year *t+1*. The estimation results are reported in Panel A of Table 5. Column (1) reports the results using the baseline sample. The coefficient on the treatment variable (*GHG_TREAT*) is negative and significant ($p < 0.05$). In economic terms, mandatory GHG emissions disclosure is associated with approximately a 4.09% decrease in the economic value of green patents. Column (2) presents the results using the neighbor-state specification. The coefficient on *GHG_TREAT* is also negative and significant in this specification ($p < 0.05$). Together, these results suggest a negative relation between mandatory environmental disclosure and the economic value of green innovation. These results are also consistent with mandatory environmental disclosure incentivizing managers to deviate from shareholders' expectations and over-invest in green technologies, which could result in a negative effect on shareholder welfare (Aghamolla and An 2021; Kogan et al. 2017).

To provide further evidence on the relation between mandatory environmental disclosure and the value of green innovation, we consider the scientific value of green patents as an alternative measure of value. Even despite a negative association between emissions disclosure mandates and the economic value of green patents documented above, it is possible that the increase in green innovation following these mandates (*H1*) still corresponds to an increase in the value of this innovation to the scientific community. To test this, we follow Kogan et al. (2017) and use the number of forward citations of green patents to measure the scientific value of green innovation. Using the same generalized DiD design, we estimate a modified form of Eq. (1) with the natural logarithm of one plus the total number of citations of green patents (*PATENT_CITES*) as the dependent variable. Panel B of Table 5 reports the results of estimations of this model using both the baseline sample and the neighbor-state specification. In both cases, the coefficient on *GHG_TREAT* is negative and significant ($p < 0.01$ in Column (1); $p < 0.05$ in Column (2)). These results suggest a negative relation between mandatory environmental disclosure and the scientific value of green innovation and provide further evidence that this type of mandate reduces the value of green innovation.

4.4 Mandatory Environmental Disclosure and Firm Performance/Value

If the negative effect of mandatory environmental disclosure on the economic value of green innovation does in fact imply lower shareholder welfare, this might also result in lower future firm performance and firm value (Acemoglu et al. 2018; Garcia-Macia et al. 2019; Kogan et al. 2017). Accordingly, we next examine the association between mandatory environmental disclosure and firms' future profitability and firm value. Specifically, we estimate modified forms of Eq. (1) with ROA (*ROA*) and Tobin's Q (*TOBIN_Q*) in years *t+1*, *t+2*, and *t+3* as the dependent variables using the same DiD design. If future firm performance/value is negatively impacted by mandatory emissions disclosure, we expect a negative coefficient on the treatment variable (*GHG_TREAT*).

The results of these estimations are reported in Table 6. The results show that mandatory environmental disclosure is associated with a significant decrease in both ROA and Tobin's Q in years *t+2* and *t+3*. These results suggest that, although not immediate, firms' performance and value declines following emissions disclosure mandates. This negative association between mandatory environmental disclosure and future firm performance/value is consistent with prior studies' findings that disclosure mandates can be costly for shareholders (Chen et al. 2018; Grewal et al. 2019). When considered in conjunction, the results reported in Tables 5 and 6 suggest adverse consequences of mandatory environmental disclosure from the shareholders' perspective.

5. Additional Analyses and Robustness Tests

5.1 Parallel Trends Assumption

The key identifying assumption behind the DiD research design is that the change in green innovation outcomes for the treatment group and the control group would have been the same in the absence of the mandatory environmental disclosure treatment (i.e., the parallel trends assumption) (Glaeser and Guay 2017). While this assumption is not directly testable, we assess the validity of this assumption through a falsification analysis (Christensen et al. 2017). Specifically, we separately regress the number and economic value of green patents on *GHG_TREAT[-1]*, *GHG_TREAT[-2]*, and the same additional independent variables from Eq. (1). *GHG_TREAT[-1]* is an indicator variable equal to one in the one year before the mandatory GHG emissions disclosure treatment, and zero otherwise; *GHG_TREAT[-2]* is an indicator variable equal to one in the two years before the mandatory GHG emissions disclosure treatment, and zero otherwise. The results of these estimations are reported in Table 7. The coefficients on *GHG_TREAT[-1]* and *GHG_TREAT[-2]* are insignificant across all specifications, suggesting that the parallel trends assumption does not appear to be violated.

5.2 Stacked Regression Estimator

Following Baker et al. (2022), we adopt an alternative stacked regression estimator to address concerns over potential estimation biases using the staggered DiD design. Specifically, for each event of mandating GHG emissions disclosure, we generate event-specific firm-event identifiers ($FIRM\_EVENT_{ig}$) and year-event identifiers ($YEAR\_EVENT_{tg}$), where *g* indices the event group comprised of the treatment state and the corresponding neighbor states. We then stack these event-specific datasets together and re-estimate Eq. (1) using the neighbor-state specification. Consistent with Baker et al. (2022), we replace firm and year fixed effects in Eq. (1) with $FIRM\_EVENT_{ig}$ and $YEAR\_EVENT_{tg}$, fixed effects, respectively. Using the stacked regression estimator, we continue to find similar results for both tests of *H1* and *H2* (untabulated). These results provide comfort that our choice of research design is not unduly affecting our inference.

6. Conclusion

This paper studies the relation between mandatory environmental disclosure and corporate green innovation. Adopting a difference-in-differences research design, we find that state-level GHG emissions disclosure mandates are associated with more green patents for climate change mitigation technologies. We also provide evidence regarding the mechanism behind this association. In cross-sectional analyses, we find a larger association between disclosure mandates and the number of green patents when the firm has more social investors and a smaller association between disclosure mandates and the number of green patents when the firm faces greater proprietary costs. We conclude that disclosure mandates are likely to prompt firms to invest more in green innovation when the firm is faced with investor preferences for sustainable business practices, but mandates may discourage innovation when increased disclosure is likely to reveal proprietary information to competitors.

We also find that GHG emissions disclosure mandates are negatively associated with the value of firms' investment in green innovation, suggesting a negative effect on shareholder welfare. Specifically, we document negative associations between disclosure mandates and both the economic value of green patents and the scientific value of green patents. In supplemental tests, we also find evidence of a negative association between disclosure mandates and future firm performance/value. Together, our results suggest that environmental disclosure mandates could potentially worsen agency conflicts between shareholders and other stakeholders because increasing investment in green innovation does not appear to translate to enhanced shareholder welfare.

Our paper extends the literature on the real effects of mandatory environmental disclosure in the setting of green innovation. Our results suggest that transparency could influence companies' resource allocation and promote environmentally friendly business practices. Our paper also responds to Christensen et al.'s (2021) call for more research on how and why firms respond to specific sustainability reporting requirements. We also extend the literature on the relation between corporate disclosure more generally and firms' investment decisions. This literature has primarily focused on frictions between managers and shareholders, but our results suggest that other stakeholders (i.e., those concerned more with sustainability than with profit) could exacerbate agency conflicts.

We acknowledge some limitations of our study. First, we utilize state-level GHG emissions disclosure mandates that generally focus on Scope 1 GHG emissions directly released from facilities, while more recent GHG emissions disclosure mandates tend to require more detailed disclosures in comparison. For example, the SEC's (2022) climate disclosure proposal requires companies to disclose the levels of Scope 1 and Scope 2 GHG emissions (and Scope 3 GHG emissions, if material). More detailed disclosure requirements might strengthen the documented channels of investor pressure, peer benchmarking, and managerial learning, while the detailed disclosures might exacerbate the proprietary costs at the same time. Thus, whether and how more recent, detailed GHG emissions disclosure requirements would affect green innovation outcomes differently than what we document in our setting could warrant future research. Second, we caution that mandatory environmental disclosure can take various forms. Our results may not necessarily generalize to other forms of mandatory environmental disclosure, such as disclosure mandates requiring oil and gas companies to disclose the chemicals used in their fracking operations (Sinha 2021).

These limitations notwithstanding, we also believe that our results are relevant for regulators. GHG emissions disclosure is a representative type of environmental disclosure and is a current priority of regulators and standard setters, including the SEC (2022) and the IFRS Foundation (2022). Our results are thus informative to stakeholders interested in the implications and potential consequences of similar environmental disclosure policies. Finally, despite the negative relation between mandatory environmental disclosure and the economic value of green innovation from shareholders' perspective, it is difficult (and beyond the scope of our study) to quantify the positive externalities of green innovations to other stakeholders, such as the potential mitigation of climate change in the long run. Future research could further examine these other potential effects of mandatory environmental disclosure through firms' investment in green technologies.

Appendix A: Variable Descriptions

Variable	Description (Compustat code in parentheses if applicable)	Source
Dependent Variables		
PATENT	The number of patents for climate change mitigation/adaptation technologies according to Haščič and Migotto (2015) (i.e., patents of Cooperative Patent Classification Y02 classes) filed for in a fiscal year.	Kogan et al. (2017) data repository
PATENT_VAL	The total economic value of patents related to climate change mitigation/adaptation technologies filed for in a fiscal year.	Kogan et al. (2017) data repository
PATENT_CITES	The number of forward citations of patents related to climate change mitigation/adaptation technologies filed for in a fiscal year.	Kogan et al. (2017) data repository
ROA	Income before extraordinary items (IB) scaled by the beginning total assets (AT).	Compustat
TOBIN_Q	[Equity market value (PRCC_F x CSHO) + total liabilities (LT)]/total assets (AT).	Compustat
Test Variables		
GHG_TREAT	An indicator variable equal to one if the firm's headquarters is located in a state with a GHG emissions disclosure mandate, and zero otherwise.	Compustat, EDGAR 10-K filings
Control Variables		
AGE	The logarithm of the number of years that the firm has been listed in Compustat.	Compustat
CAPX	Capital expenditures (CAPX) scaled by total assets (AT).	Compustat
HHI	Herfindahl-Hirschman Index for sales measured at the two-digit SIC level.	Compustat
HHI_SQ	*HHI* squared.	Compustat
LEVERAGE	Total liabilities (LT) scaled by total assets (AT).	Compustat
MTB	The market value of equity and liabilities scaled by the book value of total assets.	Compustat
PPE	Net property, plant, and equipment (PPENT) scaled by total assets (AT).	Compustat
R&D	R&D expenditures (XRD) scaled by the total assets (AT), set to zero if missing.	Compustat
ROA	Income before extraordinary items (IB) scaled by the beginning total assets (AT).	Compustat
SIZE	The logarithm of total assets (AT).	Compustat
SPREAD	The annual average of monthly bid-ask spreads scaled by the lagged stock price at the fiscal-year end.	CRSP

Appendix A (continued)

Variable	Description (Compustat code in parentheses if applicable)	Source
Partitioning Variables		
SOC_INVESTOR	An indicator for firm-years in the top tercile of investor taste for socially responsible firms following Hwang et al. (2022). Institutional investors' taste for socially responsible firms is measured by the value-weighted social responsibility performance scores per KLD's ratings of their portfolio holdings which is collected from investors' 13F filings. Using the number of shares held by each institutional investor divided by the firm's total number of shares outstanding, we then calculate each firm-year observation's weighted average of its institutional investors' taste for socially responsible firms. Firm-years without KLD coverage are set equal to zero.	13F, KLD
HIGH_PROP	An indicator for firm-years in the bottom tercile of *HHI* by year.	Compustat

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Table 1: State-level GHG Emissions Disclosure Mandates

State	Year of adopting GHG emissions disclosure mandate	Description of the GHG emissions disclosure mandate	Regulation
Wisconsin	1993	In 1993, the state established a mandatory reporting program that includes carbon dioxide reporting for facilities generating over 100,000 tons annually.	Wisconsin Chapter NR 438.03
New Jersey	2003	Facilities in New Jersey that report air pollutant emissions must also submit emission data for carbon dioxide and methane. This requirement went into effect in 2003.	New Jersey Administrative Code 7:27-21.3
Maine	2004	Facilities in Maine that emit any criteria pollutant over a specific reporting threshold must also report greenhouse gas emissions. This provision went into effect in July 2004.	Maine Department of Environmental Protection Rules, Chapter 137 (per 38 MRSA, Section 575)
Connecticut	2006	Starting in 2006, facilities subject to federal reporting under Title V of the Clean Air Act must submit greenhouse gas emissions data on an annual basis.	Connecticut Public Act No. 04-252 (June 14, 2004)

This table describes state-level GHG emissions disclosure mandates (Ramseur 2007).

Table 2: Sample Selection and Summary Statistics

Panel A: Sample Selection

Sample	Observations
Non-financial firm-year obs. in Compustat Fundamentals Annual (1988-2010)	222,563
Less: Mapping with CRSP	(84,205)
Intersection between Compustat and CRSP	138,358
Less: Missing control variables	(41,650)
Sample for baseline specification	**96,708**
Less: Obs. not in the treatment or neighbor states within the five-year windows	(81,139)
Sample for neighbor-state specification	**15,569**

Panel B: Summary Statistics

Variable	N	Mean	S.D.	p25	Median	p75
PATENT	96,708	0.286	3.956	0	0	0
PATENT_VAL	96,708	5.363	101.197	0	0	0
PATENT_CITES	96,708	4.466	57.823	0	0	0
GHG_TREAT	96,708	0.030	0.172	0	0	0
R&D	96,708	0.053	0.121	0	0	0.053
SIZE	96,708	5.346	2.164	3.741	5.177	6.789
AGE	96,708	2.537	0.779	1.946	2.485	3.135
MTB	96,708	2.129	2.523	1.064	1.42	2.261
ROA	96,708	-0.069	0.502	-0.049	0.027	0.081
LEVERAGE	96,708	0.511	0.323	0.29	0.496	0.685
CAPX	96,708	0.059	0.071	0.015	0.037	0.073
PPE	96,708	0.259	0.24	0.066	0.179	0.388
HHI	96,708	0.082	0.082	0.033	0.051	0.089
HHI_SQ	96,708	0.013	0.031	0.001	0.003	0.008
SPREAD	96,708	0.034	0.042	0.006	0.02	0.045
TOBIN_Q	96,708	2.129	2.523	1.064	1.42	2.261

Panel A of this table reports the sample selection process. Panel B of this table presents summary statistics of the variables in the paper. All continuous variables are winsorized at the 1% and 99% levels. Appendix A provides the variable definitions.

Table 3: Mandatory Environmental Disclosure and the Quantity of Green Innovation

	(1)	(2)
Specification	Baseline	Neighbor-State
Dependent Variable =	$PATENT_{t+1}$	$PATENT_{t+1}$
GHG_TREAT	**0.734*** **	**0.426** **
	(0.260)	**(0.195)**
R&D	0.346***	-0.200
	(0.0719)	(0.171)
SIZE	0.166***	-0.0552*
	(0.0252)	(0.0316)
AGE	0.00664	-1.423***
	(0.0158)	(0.379)
MTB	0.00317	-9.40e-05
	(0.00540)	(0.00612)
ROA	0.00332	-0.00619
	(0.0123)	(0.0475)
LEVERAGE	-0.0865***	-0.0466**
	(0.0268)	(0.0210)
CAPX	-0.231**	-0.0919
	(0.0935)	(0.214)
PPE	-0.436***	0.204*
	(0.0742)	(0.111)
HHI	-2.905***	-2.277*
	(0.548)	(1.354)
HHI_SQ	5.154***	4.267*
	(0.978)	(2.428)
SPREAD	1.624***	1.079**
	(0.240)	(0.428)
Observations	96,708	15,569
Adjusted R-squared	0.6840	0.8317
Constant	YES	YES
Firm FE	YES	YES
Year FE	YES	YES

This table presents results testing the association between mandatory environmental disclosure and the quantity of green innovation. *GHG_TREAT* is an indicator variable equal to one if the firm is located in a state with a GHG emissions disclosure mandate, and zero otherwise. The dependent variable $PATENT_{t+1}$ is the number of green patents related to climate change mitigation/adaptation technologies filed for in fiscal year $t+1$. Column (1) presents the results using the baseline sample. Column (2) presents the results using the neighbor-state specification. Each regression includes firm fixed effects and year fixed effects. Robust standard errors in parentheses are clustered at the state-year level. ***, **, * represents significance at the 0.01, 0.05, and 0.10 levels, respectively, based on two-tailed tests. Appendix A provides the variable definitions.

Table 4: Cross-Sectional Analyses on the Relation between Mandatory Environmental Disclosure and the Quantity of Green Innovation

Panel A: Investor Preference

	(1)	(2)
Specification	Baseline	Neighbor-State
Dependent Variable =	*PATENT*$_{t+1}$	*PATENT*$_{t+1}$
GHG_TREAT	0.304**	0.104
	(0.141)	(0.0937)
SOC_INVESTOR	-5.060***	-8.747**
	(0.911)	(4.253)
GHG_TREAT x SOC_INVESTOR	**1.798*** **	**3.153*** **
	(0.631)	**(0.986)**
Observations	96,708	15,569
Adjusted R-squared	0.6899	0.8339
Constant	YES	YES
Firm FE	YES	YES
Year FE	YES	YES
Controls	YES	YES
Full Interaction	YES	YES

(Continued on the next page)

Table 4 (Continued)

Panel B: Proprietary Costs

	(1)	(2)
Specification	Baseline	Neighbor-State
Dependent Variable =	$PATENT_{t+1}$	$PATENT_{t+1}$
GHG_TREAT	1.175***	1.171***
	(0.393)	(0.385)
HIGH_PROP	-1.301***	-0.122
	(0.372)	(1.336)
GHG_TREAT x HIGH_PROP	**-1.370*** **	**-1.622*** **
	(0.370)	**(0.466)**
Observations	96,708	15,569
Adjusted R-squared	0.6873	0.8322
Constant	YES	YES
Firm FE	YES	YES
Year FE	YES	YES
Controls	YES	YES
Full Interaction	YES	YES

Panel A of this table presents the results testing the moderating effect of investor preference on the association between mandatory environmental disclosure and the quantity of green innovation. Panel B of this table presents the results testing the moderating effect of proprietary costs on the association between mandatory environmental disclosure and the quantity of green innovation. The dependent variable in each column is $PATENT_{t+1}$. Column (1) presents the results using the baseline sample. Column (2) presents the results using the neighbor-state specification. Each regression includes firm fixed effects and year fixed effects. Robust standard errors in parentheses are clustered at the state-year level. ***, **, * represents significance at the 0.01, 0.05, and 0.10 levels, respectively, based on two-tailed tests. Appendix A provides the variable definitions.

Table 5: Mandatory Environmental Disclosure and the Value of Green Innovation

Panel A: Economic Value of Green Innovation

	(1)	(2)
Specification	Baseline	Neighbor-State
Dependent Variable =	*Ln(1+PATENT_VAL$_{t+1}$)*	*Ln(1+PATENT_VAL$_{t+1}$)*
GHG_TREAT	**-0.0409****	**-0.0387****
	(0.0168)	**(0.0158)**
Observations	96,708	15,569
Adjusted R-squared	0.6672	0.773
Constant	YES	YES
Firm FE	YES	YES
Year FE	YES	YES
Controls	YES	YES

Panel B: Scientific Value of Green Innovation

	(1)	(2)
Specification	Baseline	Neighbor-State
Dependent Variable =	*Ln(1+PATENT_CITES$_{t+1}$)*	*Ln(1+PATENT_CITES$_{t+1}$)*
GHG_TREAT	**-0.101*****	**-0.0563****
	(0.0192)	**(0.0228)**
Observations	96,708	15,569
Adjusted R-squared	0.5701	0.665
Constant	YES	YES
Firm FE	YES	YES
Year FE	YES	YES
Controls	YES	YES

Panel A of this table presents the results testing the association between mandatory environmental disclosure and the economic value of green innovation. The economic value of green innovation (*PATENT_VAL*) is based on Kogan et al.'s (2017) measure of adjusted stock price reactions to news about patent grants. Panel B of this table presents the results testing the association between mandatory environmental disclosure and the scientific value of green innovation. The scientific value of green innovation is based on the number of forward citations of green patents (*PATENT_CITES*). Column (1) presents the results using the baseline sample. Column (2) presents the results using the neighbor-state specification. Each regression includes firm fixed effects and year fixed effects. Robust standard errors in parentheses are clustered at the state-year level. ***, **, * represents significance at the 0.01, 0.05, and 0.10 levels, respectively, based on two-tailed tests. Appendix A provides the variable definitions.

Table 6: Mandatory Environmental Disclosure and Firm Performance/Value

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable =	ROA_{t+1}	ROA_{t+2}	ROA_{t+3}	$TOBIN\_Q_{t+1}$	$TOBIN\_Q_{t+2}$	$TOBIN\_Q_{t+3}$
GHG_TREAT	**-0.0123**	**-0.0282*** **	**-0.0330** **	**-0.0745**	**-0.136** **	**-0.146** **
	(0.00812)	**(0.0105)**	**(0.0150)**	**(0.0491)**	**(0.0563)**	**(0.0654)**
Observations	96,619	89,639	83,124	96,455	89,177	82,589
Adjusted R-squared	0.540	0.488	0.510	0.465	0.449	0.494
Constant	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES

This table presents results examining the association between mandatory environmental disclosure and future financial performance and firm value. In Column (1), (2), and (3), the dependent variable is *ROA* in fiscal year *t+1*, *t+2*, and *t+3*, respectively. In Column (4), (5), and (6), the dependent variable is *TOBIN_Q* in fiscal year *t+1*, *t+2*, and *t+3*, respectively. Each regression includes firm fixed effects and year fixed effects. Robust standard errors in parentheses are clustered at the state-year level. ***, **, * represents significance at the 0.01, 0.05, and 0.10 levels, respectively, based on two-tailed tests. Appendix A provides the variable definitions.

Table 7: Assessment of the Parallel Trends Assumption

	(1)	(2)	(3)	(4)
Specification	Baseline	Neighbor-State	Baseline	Neighbor-State
Dependent Variable =	$PATENT_{t+1}$	$PATENT_{t+1}$	$Ln(1+PATENT\_VAL_{t+1})$	$Ln(1+PATENT\_VAL_{t+1})$
GHG_TREAT[-1]	**0.176**	**0.0740**	**-0.0200**	**0.00941**
	(0.162)	**(0.120)**	**(0.0203)**	**(0.0149)**
GHG_TREAT[-2]	**0.0293**	**-0.065**	**-0.0202**	**0.00776**
	(0.086)	**(0.170)**	**(0.0135)**	**(0.0143)**
Observations	96,708	15,569	96,708	15,569
Adjusted R-squared	0.6852	0.8315	0.6674	0.7729
Constant	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Controls	YES	YES	YES	YES

This table presents results examining the parallel trends assumption through falsification tests. We regress green innovation outcomes on *GHG_TREAT[-1]*, *GHG_TREAT[-2]*, control variables, firm fixed effects, and year fixed effects. *GHG_TREAT[-1]* is an indicator variable equal to one in the one year prior to the mandatory GHG emissions disclosure treatment, and zero otherwise; *GHG_TREAT[-2]* is an indicator variable equal to one in the two years prior to the mandatory GHG emissions disclosure treatment, and zero otherwise. Column (1) reports the results using the baseline sample and $PATENTS_{t+1}$ as the dependent variable. Column (2) reports the results using the neighbor-state specification and $PATENTS_{t+1}$ as the dependent variable. Column (3) reports the results using the baseline sample and $Ln(1+PATENT\_VAL_{t+1})$ as the dependent variable. Column (4) reports the results using the neighbor-state specification and $Ln(1+PATENT\_VAL_{t+1})$ as the dependent variable. Robust standard errors in parentheses are clustered at the state-year level. ***, **, * represents significance at the 0.01, 0.05, and 0.10 levels, respectively, based on two-tailed tests. Appendix A provides the variable definitions.