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Stock market reaction to mandatory carbon disclosure announcements: The role of institutional investors

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ABSTRACT

We examine the stock market reaction to mandatory carbon disclosure (MCD) announcements in the UK, the first country to mandate the disclosure of greenhouse gas (GHG) emissions by listed firms. Our analysis reveals that, while the overall market was not greatly affected, firms with high carbon intensity and substantial institutional ownership experienced negative abnormal stock returns. This effect persists–and even becomes more pronounced–for firms owned by long-term institutional investors and those from countries with strong social norms surrounding climate and sustainability. Additionally, we find that heightened institutional investor attention on announcement days amplified price pressure, leading to more negative stock returns for these firms. Collectively, our findings underscore how mandatory carbon disclosure announcements enhanced the salience of carbon information, prompting institutional investors to incorporate carbon-related considerations into their decision-making processes.

1. Introduction

Carbon emissions are a major contributor to rising temperatures and climate change, which currently pose serious threats to human health and well-being (Intergovernmental Panel on Climate Change, 2022).[1] In light of increasing attention on carbon emissions, a firm's carbon footprint as well as its overall exposure to carbon risk have become major concerns for institutional investors who seek to decarbonize their portfolios (Krueger et al., 2020; Bolton & Kacperczyk, 2021a). Excessive greenhouse gas (GHG) emissions[2] expose firms to the risk of litigation, reputational damage and increased regulatory scrutiny (Fernando et al., 2017; Krueger et al., 2020). As a result, investors actively search for information that helps them understand and quantify firms' exposure to such risks.

Firm-level climate-related disclosures can provide useful information to investors. Institutional investors, in particular, engage in climate risk disclosure projects, seeking information on firm behavior to exert pressure and curb unethical or socially irresponsible actions when needed (Cohen et al., 2023). Accordingly, they adjust investment strategies and decarbonize portfolios to achieve

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[1] See "Climate change: a threat to human well-being and health of the planet. Taking action now can secure our future" (published on February 28, 2022).

[2] In this study, we use the terms 'GHG', 'carbon' and 'CO2′ interchangeably.

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financial and social benefits (Krueger et al., 2020; Bolton & Kacperczyk, 2021a; Bolton et al., 2022).[3] Rohleder et al. (2022) finds that selling pressure from mutual fund divestment leads to stock price declines, prompting divested firms to lower carbon emissions. However, there is no consensus on the accuracy and value of such information. While some studies demonstrate that carbon disclosure provides valuable non-financial information to investors (Matsumura et al., 2014; Griffin et al., 2017; Alsaifi et al., 2020; Choi & Luo, 2021; Aharon et al., 2024),[4] emissions are typically reported voluntarily, with varying disclosure quality (Wang & Li, 2016; Döring et al., 2023). The lack of reporting uniformity hinders investors' ability to interpret and compare information across firms (Christensen et al., 2021).

When disclosure is voluntary, managers face the dilemma of choosing between detailed and superficial reporting. The former may lead to a loss of competitive advantage and a higher litigation risk, while the latter is often associated with information asymmetry and adverse selection, increasing borrowing costs (Griffin & Sun, 2013; Leuz & Wysocki, 2016). These challenges highlight the need for mandatory carbon disclosures to enhance information dissemination to investors (Krueger, 2015; Baboukardos, 2017; Ioannou & Serafeim, 2019). However, limited research exists on how markets and investors respond to regulatory efforts mandating such disclosures.

To address this gap, we examine how stock markets and investors responded to key events and announcements regarding the decision-making process for implementing mandatory carbon disclosure (MCD) regulations in the UK. Introduced in 2013 under the Strategic Report and Directors' Report Regulations of the Companies Act 2006, these regulations required publicly listed firms to disclose their greenhouse gas emissions in their annual reports for the first time. As the first country to adopt MCD, the UK aimed to promote transparency and standardization in carbon reporting. By analyzing market and investor reactions to key events leading up to this regulatory change,[5] we provide new evidence on how investors anticipate the costs, risks, and benefits of MCD and evaluate the relevance of carbon information in investment decisions.

A priori, it is difficult to predict the effect of the new regulations on shareholder wealth. On one hand, MCD may enhance investors' monitoring effectiveness, mitigating agency problems (Christensen et al., 2021), and increase public pressure on firms to adopt environmentally sustainable practices.[6] It may also benefit investors by improving market liquidity, enabling more accurate cash flow predictions, raising awareness of risk exposure in portfolio firms, and facilitating better investment decisions (Verrecchia, 2001). Accordingly, MCD is expected to have a positive valuation effect. On the other hand, MCD may reduce shareholder wealth due to direct disclosure costs, such as expenses for information management and innovation (Elliott & Jacobson, 1994; Cappucci, 2018). Indirect costs may also arise, including agency conflicts from resource reallocation to environmental activities, loss of competitive advantage from revealing sensitive information, and political pressure to invest in environmental projects that are of no direct financial benefit (Fernando et al., 2017; Grewal et al., 2019; Kalkanci & Plambeck, 2020). These considerations suggest a potential negative valuation effect.

While the overall market impact of MCD is uncertain, we conjecture that firms with high carbon intensity and significant institutional ownership experienced the largest negative abnormal returns. Carbon intensity is a critical factor for investors when assessing the risk and environmental practices of portfolio firms. Recent evidence suggests that institutional investors increasingly pressure their portfolio firms to adhere to environmental norms and disclosure standards. Under voluntary disclosure of emission data, institutional investors face challenges in making informed divestment decisions. They can effectively relocate investments from high- to low-emission firms only when transparent and reliable data is available, as opposed to relying on third-party voluntary disclosures. This has led to increasing pressure from investors for improved carbon emissions reporting in both scope and quality (Döring et al., 2023). Following the adoption of MCD in 2013, high-carbon-intensity firms are expected to face greater regulatory and social scrutiny due to their environmentally unethical or socially irresponsible behavior, potentially threatening their legitimacy.[7] To the extent that MCD amplifies illegitimacy risk, institutional investors with substantial stakes in high carbon intensity firms are more likely to be

[3] A recent survey by BlackRock on 200 institutional investors globally reveals that 56% of respondents intend to boost their transition allocations within the next 1–3 years, while 46% identified successfully managing this transition as their top investment priority during the same time frame. See survey entitled "Global perspectives on investing in the low-carbon transition" (conducted June 2023).

[4] For instance, by utilising an international dataset containing carbon emission information voluntarily disclosed by firms, Choi & Luo (2021) demonstrate that a high level of carbon emissions has a negative impact on firm value. Importantly, they find that this effect is more pronounced for firms located in countries with a national carbon emission trading scheme and stringent environmental regulations.

[5] Our focus on the original 2013 MCD implementation is important for several reasons. First, this regulation marked a pioneering global mandate for climate-related financial disclosures, establishing a critical link between corporate transparency on carbon disclosure and investor decision-making. Examining the ex-ante market reactions to this initial mandate offers foundational insights into how investors assess the anticipated costs and benefits of new regulatory requirements during the implementation process. While revisions to the regulation occurred in 2019 and 2022, understanding the initial implementation period is essential, as it was during this time that firms and investors faced the greatest uncertainty regarding these disclosure requirements.

[6] This will positively affect financial performance through lowering the cost of finance, enhancing consumer trust, improving supply chain management, reducing staff turnover or enhancing operational efficiency *via* innovation (see Flammer & Luo, 2017; Guo et al., 2017; Breuer et al., 2020; Dai et al., 2021).

[7] For example, there are adverse economic effects associated with high carbon intensity firms such as lower credit rating, increased cost of capital, litigation costs and societal or consumer boycott (Dhaliwal et al., 2011; Griffin et al., 2017; Chabowski et al., 2019; Nguyen & Phan, 2020). More widely, it can be argued that a firm's survival depends on aligning with societal norms and values, as deviations increase legitimacy concerns (Suchman, 1995; Campbell et al., 2007; Qian & Schaltegger, 2017), often resulting in negative outcomes (see e.g., Attig et al., 2013, 2014). Liu et al. (2023b) highlight that carbon disclosure under MCD enhances legitimacy by detailing firms' carbon strategies.

impacted, influencing the stock market performance of these firms.

We therefore hypothesize that stock market reactions to key announcements leading to the implementation of MCD are negative for firms likely to be "highly impacted", particularly high-carbon-intensity firms with significant institutional ownership. Our analysis examines UK firms in the FTSE All-Share Index,[8] focusing on those that were voluntarily disclosing GHG emissions as of 2010. This approach is consistent with prior studies (e.g., Jouvenot & Krueger, 2021) and assumes that these firms were most likely to be affected by the heightened salience of carbon data during the announcement period.

To examine the market's response to the key announcements leading to the implementation of MCD, we employ an event study approach. Our analysis reveals that the aggregated effect of five major events corresponds to an average abnormal return of −0.24 %, though this result is not statistically significant. Similarly, analysis of individual events reveals no evidence of notable stock price reactions, suggesting that the market was not greatly impacted by the new regulations. However, when examining firms with both high carbon intensity and high institutional ownership, we find an average market capitalization reduction of approximately £9 million, highlighting the greater vulnerability of these "highly-impacted" firms to regulatory changes targeting carbon disclosures. The stock price reaction persists–and even becomes more pronounced–for firms with long-term institutional investors, and those from countries with strong social norms around sustainability. These investors, driven by their preference for alignment with environmental goals and long-term perspectives, responded more strongly to MCD-related announcements. To further explore the role of institutional investors in driving market reactions in carbon-intensive firms, we also show that heightened institutional investor attention on announcement days increased price pressure, resulting in more pronounced negative stock returns for highly-impacted firms. Our cross-sectional results are robust to various checks, including the use of European firms as a control group and alternative scaling measures for carbon intensity. A placebo test confirms that the observed impacts are specific to MCD implementation events.

Our study makes several contributions to the literature. First, it adds to the growing research on the value-relevance of mandatory environmental disclosures. Prior studies show that mandating financial disclosures has implications for capital market investors (e.g., Zhang, 2007; Armstrong et al., 2010; Lewis & Verwijmeren, 2014), but the value-relevance of mandating non-financial disclosures, such as those related to corporate social responsibility, remains debated due to potential benefits and costs (Grewal et al., 2019; Cousins et al., 2020). Grewal et al. (2019) find that investors respond negatively to mandatory ESG disclosures, while Cousins et al. (2020) report little market impact from mandatory supply-chain transparency disclosure in the UK. We extend this literature by examining institutional shareholders' reactions to government-mandated environmental disclosures of carbon emissions.

Second, we add to the literature on the financial market implications of regulations aimed at mitigating climate risk (Krueger, 2015; Baboukardos, 2017; Choi et al., 2020; Nguyen & Phan, 2020; Bolton & Kacperczyk, 2021b; Choi et al., 2022; Shen et al., 2023). Outside the context of the UK, several studies have examined the effect of climate regulation on stock market valuation.[9] Studies within the UK context, such as those by Krüger (2015), Baboukardos (2017), Bolton & Kacperczyk (2021a), and Jouvenot & Krueger (2021), also address the value-relevance of MCD under the UK Companies Act 2006. Krüger (2015) compares non– and quasi-compliant firms to analyze MCD's impact on firm performance, while Baboukardos (2017) examines the relationship between GHG emissions and market value after MCD's introduction. However, these studies do not explore cross-sectional differences in market value related to MCD implementation. More recently, Bolton & Kacperczyk (2021b) find that UK firms with higher emissions faced penalties from market investors after MCD was introduced.

Closest to our study is Jouvenot & Krueger (2021), which shows that following the first year of standardized GHG emission disclosures under MCD, firms with high emissions experienced negative stock returns. A key distinction is that we focus on stock price reactions during the MCD adoption period, examining key events leading up to and including its implementation, whereas Jouvenot & Krueger (2021) study post-implementation effects. Since the MCD adoption process began in 2011, it is likely the market anticipated the regulation's net effects before its enactment in 2013. Prior research indicates that stock markets recognize climate policy transition risks during regulatory adoption (Chapple et al., 2013; Pham et al., 2020; Bauer et al., 2023). Thus, examining stock price reactions during the adoption period, as we do, provides valuable additional insights.

Our study also contributes by identifying firms most affected by the implementation of MCD and emphasizing the role of institutional investors. This focus connects our research to the literature on how institutional investors price carbon risk.[10] We complement these studies by providing evidence not only on whether institutional investors respond to mandatory carbon disclosure regulations

[8] The MCD regulation applies only to firms listed on the Main Market of the London Stock Exchange and does not extend to those listed on the Alternative Investment Market (AIM). Quoted companies are defined as those whose equity share capital is included in the UKLA's Official List. As such, an AIM company is not classified as a quoted company. This distinction reflects the government's intention to reduce the regulatory burden on companies, thereby limiting the scope of the provision to quoted companies (see Attenborough, 2022; footnote 37). The FTSE All-Share Index, which covers companies listed on the Main Market and represents approximately 98% of total market capitalization, provides a strong representation of the market.

[9] For example, Shen et al. (2023) show that following announcements of legislative events related to the European Union Carbon Border Adjustment Mechanism, Chinese exporting firms with high carbon emissions destined for the EU experienced more negative market valuation. Similarly, Choi et al. (2020) find that following the implementation of the Australian Clean Energy Bill in 2011, which required carbon taxes for emissions above a certain threshold, the market penalized Australian listed firms more when they were associated with high carbon emissions. More recently, Choi et al. (2022) show that following the designation of counties into attainment or non-attainment categories induced by the Clean Air Act (CAA), investors react negatively towards firms that own a high proportion of nonattainment plants and are heavy polluters of ozone in non-attainment counties.

[10] For instance, Bolton & Kacperczyk (2021a) show that institutional shareholders screen investments based on firm-level carbon intensity, while Krueger et al. (2020) demonstrate that institutional investors incorporate climate risk into their decision-making processes.

but also on how they do so. To this end, our research addresses recent calls for more studies on factors influencing socially responsible investment strategies, the role of investor type and horizon in shaping climate-related preferences, and investor responses to firms causing negative externalities, such as high carbon emissions (Giuliani et al., 2022; Babalola et al., 2022).

2. Background and hypothesis development

2.1. The introduction of mandatory carbon Disclosure-Key events

Part 7 of the Companies Act 2006 (Strategic Report and Directors' Report) Regulations 2013 is an amendment to that Act regarding the mandatory disclosure of GHG emissions for listed companies.[11] This amendment was approved by the House of Commons on July 16, 2013.[12] However, the process had been initiated in 2011, when the Department for Environment, Food & Rural Affairs (DEFRA) formally started an impact assessment for a GHG reporting policy. Although Section 85 of the UK Climate Change Act 2008 had already required the government to make regulations mandating that the company's directors' report include information about GHG emissions, or otherwise to lay a report before Parliament explaining why no such regulations had been made, no formal steps had been taken before DEFRA started its impact assessment in 2011. This section briefly discusses the background and major events leading to the implementation of MCD.[13]

On **January 17, 2011**, DEFRA published its first impact assessment report on GHG reporting options for UK companies. Apart from mentioning policy objectives and intended effects, it also justified government intervention: "The aim of encouraging GHG reporting is to achieve behavior change by giving organizations the information and tools to reduce emissions, and, by encouraging consistency in disclosure, to provide investors and shareholders with relevant information".[14] This impact assessment model proposed four options for increasing GHG reporting: (1) enhanced voluntary reporting; (2) mandatory reporting for all UK quoted companies; (3) mandatory reporting for all large companies; (4) mandatory reporting using energy consumption criteria. This reporting would include both scope 1 (direct) and scope 2 (indirect) GHG emissions. DEFRA provided a detailed monetized cost-benefit analysis of these four options. The monetized benefits for the firms included purchasing fewer allowances under the European Union's Emissions Trading System (EU ETS) as well as reductions in electricity, energy or fuel expenditure (including gas consumption). The monetized costs included one-off expenses for the administrative expenditure on reading and understanding the guidance, the annual cost of measuring emissions and the annual cost of reporting emissions. Moreover, the impact report also highlighted the benefits relating to reduced investment risk for investors and their increased preferences for 'green' investment as well as employees' preference to work for green companies.[15]

DEFRA then started public consultation on **May 11, 2011,** to decide whether UK companies should report GHG emission on a mandatory basis or continue to report on a voluntary basis under the four options in the impact report. The consultation groups included business and voluntary sector forums, campaigning/not for profit organizations, companies, individuals, investors and investors' forums, local authorities, members of parliament, regulators, trade associations and professional bodies. The consultation explored key issues including the relative merits of voluntary versus mandatory reporting, the scope of reporting (e.g., covering all six Kyoto GHGs and Scope 1 and Scope 2 emissions), and the inclusion of GHG data in directors' reports. DEFRA also emphasized the importance of consistent methodologies and detailed emissions breakdowns.

In its consultation paper submitted to consultees, DEFRA highlighted that "The option of mandatory reporting for all UK quoted companies is proposed because the provision of information on greenhouse gas emissions by these companies is likely to be of most interest to investors and potential investors".[16] Further, it noted that "If corporate reporting of GHG emissions is made mandatory, it would be done under section 416(4) of the Companies Act 2006 ('the Act') which gives the Secretary of State power to make regulations as to other matters that must be disclosed in a directors' report. Mandatory corporate reporting of GHG emissions, therefore,

[11] On 6 April 2022, the implementation of a new regulation, commonly known as the Company Regulations, came into force. The Company Regulations amended the Companies Act 2006 to require all large UK companies with over 500 employees and £500 million in turnover (including general insurance companies), as part of their strategic reporting, to provide information in accordance with the recommendations of the Task Force on Climate-Related Financial Disclosures (TCFD). The Company Regulations serve as a complementary measure to existing obligations for publicly listed companies to disclose their energy consumption and greenhouse gas emissions. See "Mandatory climate-related financial disclosures by publicly quoted companies, large private companies and LLPs", Department for Business, Energy and Industrial Strategy, https://www.gov.uk/government/publications/climate-relatedfinancial-disclosures-for-companies-and-limited-liability-partnerships-llps.

[12] The House of Commons is the lower chamber of the UK parliament. Its main roles are examining and challenging the work of the government, debating and passing all laws and enabling the government to raise taxes.

[13] We acknowledge that the regulation introduced several changes to corporate reporting, including, but not limited to, the requirement for GHG emission disclosure. For example, Downar et al. (2021) note that "in addition to GHG emissions, the act imposes disclosure requirements pertaining to the diversity of directors, senior managers, and other employees as well as broader social and human rights issues" (p. 1143). Nevertheless, we carefully selected the key event dates to align explicitly with the regulation's emphasis on mandating GHG disclosures, as this was the primary focus of our study.

[14] See "Impact Assessment of options for company GHG reporting", Department for Environment, Food & Rural Affairs (published January 17, 2011).

[15] See Page 28 of "Impact Assessment of options for company GHG reporting", Department for Environment, Food & Rural Affairs (published January 17, 2011).

[16] See Page 10 of "Measuring and reporting of greenhouse gas emissions by UK companies: a consultation on options", DEFRA (published May 2011).

would be subject to the same regime of monitoring and offences as applies to the other contents of directors' reports; failure to comply with the directors' report requirements of the Companies Act 2006 is an offence under section 419 (3) of the Companies Act". Moreover, it also asked investors whether there are any cost savings for them from having access to better information on companies' GHG emissions.[17][18]

The first official explicit statement regarding the intention to make carbon reporting mandatory was made on **September 14, 2011**, with the publication of a report by the House of Commons Environmental Audit Committee entitled *Carbon Budgets*.[19] Section 59 of the report states: "In order to aid transparency and illustrate the contributions that businesses are making, and need to make, to help tackle climate change, we recommend that the Government should introduce mandatory reporting by businesses at the earliest opportunity" (p. 28).

The formal government response came on **June 19, 2012**, when the UK Deputy Prime Minister, Nick Clegg, wrote in The Guardian newspaper that, from 2013, all companies listed on the main London Stock Exchange would have to publish full details of the greenhouse gasses they produce.[20] The following subsequent events were more about the formal process regarding implementation of this regulatory decision. The first draft of the Companies Act 2006 (Strategic Report and Directors' Report) Regulations 2013 was published for consultation on July 25, 2012, and that consultation ended on October 17, 2012. The final draft of the regulations was finally approved by the House of Commons on **July 16, 2013**, and they were effective from October 1, 2013. This regulation mandated quoted companies to disclose annual GHG emissions related to fuel combustion, operations, and purchased energy use within their directors' report, and to state the methodologies used for calculating the disclosed information. Appendix B provides a summary of the key dates leading to the introduction of MCD.

2.2. Hypothesis development

Mandatory regulation comes with both the prospects of value-enhancement and the illegitimacy risk for firms. Thus, the stock market response to the implementation of MCD depends on the investors' perception of its net benefit and cost. Regarding the former, MCD can benefit investors in several ways. First, from a valuation perspective, such disclosures may reduce information asymmetry and adverse selection (Eleswarapu et al., 2004; Leuz & Wysocki, 2016). Second, it may help optimizing investment decisions, as firms that better manage their carbon risk usually benefit from a lower cost of capital, better access to external financing and higher credit ratings (Dhaliwal et al., 2011; Chabowski et al., 2019; Nguyen & Phan, 2020). Third, MCD may enhance the effectiveness of monitoring as it may induce firms to improve their carbon performance in order to avoid reputational damages and legal penalties (Fernando et al., 2017). Fourth, it brings more transparency because carbon reporting becomes standardized (Comyns, 2018; Christensen et al., 2021). Fifth, MCD may enhance the value of the portfolio firms by increasing their operational efficiency (Krueger, 2015; Grewal et al., 2019). Moreover, firms that better manage their environmental profile are more attractive not only to customers but also to their employees, which increases staff retention and reduces recruitment and training costs (Buysse & Verbeke, 2003).

On the other hand, shareholder value may be negatively affected by the direct and indirect costs of regulation. In its impact assessment report, DEFRA estimated that the annual cost of measuring GHG emissions for large companies would range from £5,600 to £30,000.[21] Other direct costs may include the research and development (R&D) expenditures. Although innovation can benefit the firm, managerial inefficiencies and the risk of over-investment may offset these advantages, potentially leading to increased overall costs rather than positive outcomes (Cappucci, 2018).

In addition to direct costs, firms may also face indirect costs. First, since MCD may require management effort and long-term investment, this could lead to an agency conflict between management and shareholders in terms of allocation of resources for environmental activities (Christensen et al., 2021). Second, disclosing inadequate environmental performance may result in reputational harm or even legal penalties (Fernando et al., 2017). Third, if MCD requires proprietary information to be revealed, firms may face competitive disadvantage (Kalkanci & Plambeck, 2020; Ilhan et al., 2023). Lastly, disclosure of environmental information may also raise political costs for firms (Grewal et al., 2019). Overall, these direct and indirect costs associated with MCD may adversely impact market investors' expectations regarding firms' future cash flows.

However, investors may evaluate the value relevance of carbon disclosures by considering the firm's competitive position, relative

[17] See Pages 22 and 28 of "Measuring and reporting of greenhouse gas emissions by UK companies: a consultation on options", DEFRA (published May 2011).

[18] After the consultation, DEFRA published a final revised version of the impact assessment report. See "Impact Assessment of Options for Company GHG Reporting", DEFRA (published August 31, 2011). The IA report finds that of the total of 2018 written responses, 3.96% were in favor of option 1 (voluntary reporting), 91.82% of option 3 (mandatory reporting for large companies only), and 0.69% of option 4 (mandatory reporting based on energy use criteria). Only 0.84% of respondents were in favor of mandatory reporting for all UK quoted companies, that is, option 2, with the balance expressing no view. Among the 210 responses from companies, only 3% favored option 2, and of the six investors who responded, only one voted for that option. Of the companies that responded, BP, 3M, British Airways, and EDF energy were included, among others.

[19] The report was published by the House of Commons Environmental Audit Committee on September 14, 2011, and is available at: https://publications.parliament.uk/pa/cm201012/cmselect/cmenvaud/1080/1080.pdf. The Committee is responsible for reviewing policies and programmes on environmental protection and sustainable development, auditing their performance, and reporting its findings to the House of Commons.

[20] See article entitled, "New emissions policy will force biggest UK firms to reveal CO2 figures" in *The Guardian* (published June 19, 2012).

[21] See "Impact Assessment of options for company GHG reporting", Department for Environment, Food & Rural Affairs (published January 17, 2011).

carbon efficiency, and capacity to manage carbon risks (Clarkson et al., 2015). High carbon emissions signal a firm's inability to effectively manage its environmental impact, making polluting firms less appealing to market investors (Matsumura et al., 2014; Fernando et al., 2017). This may give rise to legitimacy concerns, according to which a firm's survival depends on its ability that it complies with societal norms, values and beliefs. Thus, any shift away from these norms and values may lead to an increase in legitimacy concerns (Suchman, 1995; Campbell et al., 2007). Empirically, prior studies have shown that the market-value penalty is likely to be more pronounced for carbon-intensive firms due to their exposure to potential future regulatory and compliance costs (Konar & Cohen, 2001; Alsaifi et al., 2020). Accordingly, any news about firms' unethical environmental behavior revealed through MCD may threaten their legitimacy, which in turn could cause firms to lose their market value through under-investment and/or divestment by shareholders (Jouvenot & Krueger, 2021; Bolton & Kacperczyk, 2021b).

Further, the value-relevance of MCD is not only dependent on firms' carbon intensity, but also on investors' awareness and ability to assess the carbon risk of their portfolio firms (Benz et al., 2021). Due to their larger shareholdings, lower costs of information gathering and their formal and informal mechanisms to engage with management, institutional investors are more effective in monitoring and assessing the carbon risk of their portfolio firms as compared to other types of investors (Hartzell & Starks, 2003; Jaggi et al., 2018). A growing body of literature indicates that institutional shareholders are increasingly prioritizing environmental sustainability in their investment strategies. As a result, they are less likely to invest in carbon-intensive firms due to the heightened risks associated with the carbon transition (Benz et al., 2021; Jouvenot & Krueger, 2021). Similarly, Bolton & Kacperczyk (2021a) highlight that, although market returns show no direct association with carbon intensity levels, institutional investors appear to practice negative screening, often divesting from firms with high carbon intensity.

The preceding discussion suggests that MCD announcement returns are influenced not only by a firm's carbon intensity but also by the level of institutional ownership. While MCD regulations offer potential benefits, these may be outweighed by proprietary, political, reputational, or legal costs for carbon-intensive firms. Environmental legitimacy, defined as the perception that a firm's environmental performance is desirable, appropriate, or proper (Campbell et al., 2007; Döring et al., 2023), is often lacking in firms with high carbon intensity. Given these legitimacy concerns, the increased visibility of high carbon intensity firms following the implementation of MCD regulation is expected to draw greater attention from institutional investors, who are likely to focus more closely on carbon risk. As a result, we expect a negative stock price reaction for firms that are significantly impacted by the regulation. Formally, we state our main hypothesis as follows:

H1: Firms with high carbon intensity and high levels of institutional ownership experienced a negative stock market reaction to the implementation of MCD regulation.

3. Sample selection, methodology and univariate analysis

3.1. Sample selection and data

Table 1 describes the sample selection process. Our initial sample consists of all 628 firms in the FTSE All-Share Index, as of January 17, 2011 (the date of our first event), obtained from LSEG Eikon (formerly Refinitiv Eikon). Some of these firms were, however, exempted from MCD requirements if they met either of the following two criteria: (i) turnover lower than £6.5 million and (ii) balance sheet total lower than £3.26 million. In fact, no firms from our sample met these criteria. We exclude two firms due to lack of sufficient data to assess these criteria, and a further 92 firms because they lack complete stock price information in the study period (January 17, 2011 to July 16, 2013 – see Appendix B for details). We also exclude 12 firms that are non-UK domiciled. Our final sample therefore consists of 522 firms in total, which represents about 98 % of the total value of the UK's market capitalization (i.e., £2,159 billion). We use this sample for our event study analysis. For our baseline cross-sectional analysis, we further exclude firms with missing data on the additional variables used in the analysis. Specifically, we focus on a sample of firms that were voluntarily disclosing greenhouse gas emissions data as of 2010, prior to the implementation of MCD.[22] Therefore, our final sample for cross-sectional analysis comprises 199 firms (which had carbon emissions data), but these nevertheless represent a significant proportion (about 75 %) of the total market value of UK firms.

3.2. Event study methodology

For our benchmark analysis, similar to prior studies (e.g., Armstrong et al., 2010; Grewal et al., 2019; Cousins et al., 2020), we employ an event study methodology that aggregates market reactions across the five identified events associated with the introduction of MCD. That is, we draw our inferences from assessment of the market reaction to all events aggregated versus assessing each event individually as the implementation of MCD was a result of several events. Therefore, the stock market reactions to any event and its effect on the introduction of the regulations is dependent on the combined reactions to all previous events. In addition to that,

[22] This approach aligns with prior studies (e.g., Jouvenot & Krueger, 2021) and is based on the premise that these firms were most likely to be affected by the heightened attention to carbon data during the announcement period. Although no entirely new information about GHG emissions may have been disclosed, the regulatory discussions and approvals surrounding MCD significantly increased the relevance and visibility of this data to institutional investors. As a result, firms already disclosing GHG data—particularly those with high carbon intensity—were more likely to experience changes in investor behavior in response to these developments. This enables us to examine institutional investors' differential responses to the regulatory shock by comparing high versus low carbon-intensive firms.

Table 1
Sample Selection Process.

Steps	Number of Firms
(1) FTSE All-Share Index Constituents (Data source: LSEG Eikon)	628
(2) Less: Firms exempted from reporting criteria:	
Firms not incorporated in the UK	(12)
Turnover lower than £6.5mn, and balance sheet total lower than £3.26mn	(0)
Firms without turnover and balance sheet total information	(2)
(3) Less: Firms without complete stock price information available	(92)
(4) Baseline sample of time series data for the linear regression	522
(5) Less: Firms with missing data of variables used in baseline cross-sectional analysis	(323)
(6) Baseline sample for cross-sectional analysis	199

This table presents the sample selection process for our event study and cross-sectional analysis. The final sample in Step (4) is used for baseline event study analysis and the final sample for Step (6) is used for cross-sectional analysis.

aggregation across events reduces any noise that may result from an individual event.

To capture the market reactions across the five MCD events, we follow the event study methodology as proposed by Schipper and Thompson (1983), which has been widely utilized in recent studies (see e.g. Cousins et al., 2020). Specifically, we estimate the following regression model over the period July 1, 2010 to December 31, 2013:

$$R_{pt} = \alpha_p + \beta_p R_{mt} + \gamma_p D_t + \varepsilon_{pt} \quad (1)$$

In Eq. (1), R_{pt} is the value-weighted return on the portfolio of sample firms, with market values as of January 6, 2011 (7 trading days before the first event) as weights. Our return data is from LSEG Eikon. R_{mt} is the return on the value-weighted market index for Europe excluding the UK & Ireland. The market index is obtained from LSEG Eikon (code: TRXFLDEXPU) and we express it in sterling (£) to mitigate the impact of currency fluctuations on our results.[23] The Pearson correlation between the returns on this market index and the value-weighted return on our sample firms over the estimation period, excluding the event dates, is 0.89. This high correlation suggests that our reference market index is a good proxy to use in our event study analysis. D_t is a dummy variable that equals one for the dates of the study events and zero otherwise. ε_{pt} is an error term. The main coefficient of interest is γ_p, which captures the average abnormal stock return estimated over the five events combined.

While our primary focus is on the combined stock price effect of the five events, we also conduct an additional analysis to examine the abnormal stock returns associated with each individual event. For this purpose, we estimate the following regression model:

$$R_{pt} = \alpha_p + \beta_p R_{mt} + \sum_{k=1}^{5} \gamma_{pk} D_{kt} + \varepsilon_p \quad (2)$$

In Eq. (2), D_{kt} is a dummy variable that equals one for the announcement date of event k, and zero otherwise. The coefficient γ_{pk} captures the abnormal return associated with event k. Thus, we estimate a total of five coefficients (γ_{pk}) that represent abnormal returns for each of the five events. All other regression parameters are as defined in Eq. (1).

3.3. Univariate analysis of market reaction to MCD events

Table 2 presents the univariate results of stock price reaction to the implementation of MCD. Panel A shows the mean abnormal return as captured by γ_p for the sample firms in the portfolio due to the combined effect of the five events. Row (1), Column (2) of Panel A presents the baseline results. The estimated coefficient depicts a mean abnormal return of −0.047 %, which leads to an overall effect of −0.24 % (−0.047 % multiplied by the total number of events). However, the coefficient is not statistically significant. We next perform a sensitivity test by using an equal-weighted portfolio of the sample 522 firms (in Column 3) and Eurozone market index (in Column 4) instead of the Europe excluding the UK and Ireland market index. However, we observe no change in our main findings.

For completeness, we re-estimate our baseline Eq. (1) by extending the event window (i.e., the number of days before and after each event). We set D_t equal to 1 on these alternative event windows. The results for this extended event window are shown in Rows (2) to (4) of Column (1). However, these alternative event dummies are not statistically significant.[24] Further alternative event windows also show insignificant coefficients when we use an equal-weighted portfolio and the Eurozone market index, as reported in Columns (3) and (4), Rows (2)-(4).

Panel B of Table 2 presents the stock market reactions for each event date. The first two events exhibit positive but statistically insignificant abnormal returns. In contrast, the remaining events show negative market reactions, though the coefficients also lack statistical significance. These findings suggest that there are no abnormal stock market reactions on the event dates.

Finally, Panel C shows the baseline results for the abnormal return for an alternative sample. Financial firms are typically studied separately due to their specific regulation and unique financial structure. Row (1) shows that there is no evidence of an abnormal

[23] Currency conversion is a widely used strategy in the literature, particularly in studies with an international focus (see e.g. Aretz et al., 2018).
[24] In untabulated results, we find that the coefficient on abnormal return remains non-significant when the event window is further extended to 10 days (−5, +5).

Table 2
Market Reaction to the Key Events of MCD Introduction.

Panel A: Average abnormal return per event window, estimated over five events combined, for baseline sample ($N = 522$)			
		γ_p(%)	
Event Window	Baseline	Equal-Weighted Portfolio	Eurozone Index
(1)	**(2)**	**(3)**	**(4)**
(1) Day 0	−0.047	−0.091	0.023
	(−0.260)	(−0.360)	(0.12)
(2) Days (−1, 0)	−0.046	−0.094	−0.008
	(−0.35)	(−0.53)	(−0.06)
(3) Days (0, +1)	0.001	−0.015	0.037
	(0.01)	(−0.08)	(0.28)
(4) Days (−1, +1)	−0.014	−0.042	0.012
	(−0.13)	(−0.29)	(0.11)

Panel B: Average abnormal return per event on Day 0, for baseline sample (N=522)	
Event Date	γ_p(%)
January 17, 2011	0.091
	(0.220)
May 11, 2011	0.013
	(0.030)
September 14, 2011	−0.149
	(0.360)
June 19, 2012	−0.107
	(0.260)
July 16, 2013	−0.083
	(0.200)

Panel C: Day 0 returns for alternative samples, all events combined		
Sample	Number of Firms	γ_{pk}(%)
(1) Sample excluding financial firms	297	−0.001
		(−0.010)
(2) Carbon-sensitive firms (energy & utilities)	27	0.000
		(0.004)
(3) Sample used in baseline cross-sectional analysis	199	−0.011
		(−0.070)

This table reports the results of an event study analysis of abnormal stock price return to key events associated with the introduction of the UK mandatory carbon reporting regulation. The baseline sample consists of 522 firms (N) in the FTSE All-Share Price index. Panel A, column (2), provides baseline results for all five events combined. We estimate the following regression equation over the period July 1, 2010 to December 31, 2013: $R_{pt} = \alpha_p + \beta_p R_{mt} + \gamma_p D_t + \varepsilon_{pt}$. R_{pt} is the value-weighted return on the portfolio of sample firms, with market values as of January 6, 2011 (7 trading day before the first event) as weights. R_{mt} is the return on the value weighted market index for Europe excluding UK Ireland (Refinitiv code: TRXFLDEXPU), expressed in sterling. In Row (1), D_t is a dummy variable that equals 1 on the event date due to increasing likelihood of adoption; and 0 on all other estimation period days. In Rows (2) to (4), we also set D_t equal to 1 on alternative event windows. γ_p captures the average abnormal return estimated across the five events combined. Column (3) uses an equal-weighted portfolio of sample firms. Column (4) uses Eurozone market index (Refinitiv code: TRXFLDZEPU). Panel B presents the results for the baseline sample for individual event dates, obtained with the regression $R_{pt} = \alpha_p + \beta_p R_{mt} + \sum_{k=1}^{5} \gamma_{pk} D_{kt} + \varepsilon_p$. D_{kt} equals 1 on each five k-event date; and 0 otherwise. p_k captures the abnormal return for event k for the firms in the portfolio. All other regression components are similar to the combined events regression. Panel C uses a number of alternative samples. Row (1) is based on sample excluding financial firms. Row (2) uses a sample of carbon-sensitive firms which are under utilities and energy sector. Row (3) examines firms used in our baseline cross-sectional analysis. The t-statistics are in parentheses.

return when the 225 financial firms are excluded from our sample. Next, we estimate our baseline model using a sample firms from carbon-sensitive industries, namely energy and utilities. Row (2) reports an insignificant coefficient, though the sample size is limited to just 27 firms. Finally, Row (3) shows an insignificant abnormal return for the sample of 199 firms used in the baseline cross-sectional analysis.

There may be a concern that other events could be occurring concurrently with the regulatory events that we study, and these may also influence stock prices. To address this concern, we search the "Business" and "Economy" sections of the US and European editions of the *Wall Street Journal* to identify potential confounding news around event dates (similar to Lewis & Verwijmeren, 2014; Cousins et al., 2020). However, we find that the identified news stories are unlikely to have influenced our event study results.

4. Cross-Sectional evidence

For our cross-sectional tests, we use the following baseline regression model:

$$CAR_i = \alpha_i + \beta_1 Carbon\ Intensity_i + \beta_2 Institutional\ Ownership_i + \beta_3 Carbon\ Intensity_i \times Institutional\ Ownership_i + \beta_4 Firm\ Size_i + \beta_5 Leverage_i + \beta_6 Cash_i + \beta_7 Market - to - Book_i + \beta_8 ESG\ Disclosure_i + Industry\ FE + \varepsilon_{i,t} \quad (3)$$

In Eq. (3), the dependent variable is CAR_i, the cumulative abnormal return for firm *i* across the five events combined.[25] Our primary variable of interest, the interaction between Carbon Intensity and Institutional Ownership, identifies firms likely to be most impacted by MCD-related events due to their high carbon intensity and significant institutional ownership. *Carbon Intensity* is defined as total carbon dioxide (CO2) emissions and equivalents (i.e., Scope 1, direct, and Scope 2, indirect emissions) in tons divided by gross property, plant and equipment (PPE). PPE directly represents the physical infrastructure that drives a company's operations, which is often the primary source of emissions under Scope 1 and Scope 2.[26] *Institutional Ownership* is defined as the percentage of shares held by institutional investors at the end of fiscal year 2010 (i.e., before the first event date).

We include several firm-level characteristics in the model: *Firm Size*, defined as the natural logarithm of total assets; *Leverage*, defined as the total long-term debt divided by total assets; *Cash*, defined as cash and short-term investments divided by total assets; *Market-to-Book*, defined as the ratio of market value to book value of total assets; *ESG Disclosure Score*, which captures the firm's overall environmental, social and governance (ESG) disclosure levels based on eight indicators.[27] Detailed definitions of these variables are provided in Appendix A. Panel A of Table 3 presents summary statistics, while Panel B reports the Pearson correlations among the main variables used in the analysis.

4.1. Main results

Table 4 presents the cross-sectional results. In Column (1), we find that the coefficient of the interaction term, *Carbon Intensity x Institutional Ownership*, is negative and statistically significant, indicating that highly-impacted firms face more negative market reactions to MCD-related events. This result remains after incorporating several additional control variables, as presented in Column (2) of Table 4. Specifically, we include an environmental controversy variable, which reflects negative environment-related news stories about the firm. Prior studies show that ESG controversy may damage a firm's reputation and thus be negatively associated with stock returns (Lorraine et al., 2004; Capelle-Blancard & Petit, 2019). Next, we consider the proprietary cost of disclosure, proxied by environmental innovation score obtained from LSEG Eikon, which reflects a firm's capacity to create new market opportunities and reduce environmental costs through innovative environmental technologies, processes or eco-designed products. Prior research suggests that sustainability disclosure is influenced by the intensity of product market competition (Ryou et al., 2022). Firms with high innovation expenditures are expected to incur higher proprietary costs, as their competitiveness is positively linked to such innovation (Grewal et al., 2019). The introduction of mandatory regulation may incentivize competitors to increase their investments in innovation and enhance their environmental performance, potentially reducing the competitive advantage of high-innovation firms.

Additionally, the disclosure of nonfinancial information can increase political costs for firms, proxied by industry profitability. Government or pressure groups may compel firms to allocate resources to projects that are not financially beneficial or compel them to modify corporate actions to address social concerns, particularly in terms of improved environmental performance. Firms operating in highly profitable industries are subject to greater public scrutiny and visibility, which can amplify political costs. The introduction of mandatory carbon reporting is likely to heighten these costs due to additional disclosure requirements. Therefore, we expect stock market reactions to mandatory disclosure to exhibit a negative relationship with the political and proprietary costs associated with such disclosure (Grewal et al., 2019). Finally, we include variables for share turnover and the Herfindahl index as proxies for pre-MCD information asymmetry, following Armstrong et al. (2010) and Cousins et al. (2020). We include these controls because market liquidity (measured by turnover) and industry concentration (measured by the Herfindahl index) are typically associated with information asymmetry (see e.g. Florackis et al., 2011). Both are expected to be positively influenced by the introduction of MCD.

Overall, the results presented in Column (2) confirm our hypothesis that firms with high carbon intensity and high levels of institutional ownership experienced a negative stock market reaction to the implementation of mandatory carbon disclosure regulation.

4.2. Evidence from long-term and socially conscious institutional investors

Building on prior research, we acknowledge that institutional shareholders' monitoring capabilities and incentives are shaped by the nature and composition of their portfolio holdings (see Bushee, 2004; Ferreira & Matos, 2008; Attig et al., 2013; Dyck et al., 2019;

[25] First, we estimate CARs using the following specification for each of the 199 sample firms, over the window July 1, 2010 to December 31, 2013: $R_{it} = \alpha_i + \beta_i R_{mt} + \gamma_i D_t + \varepsilon_{it}$. R_{it} is the return on firm i's stock. R_{mt} is the return on the value weighted Refinitiv market index for Europe Ex UK & Ireland (TRXFLDEXPU), expressed in sterling. D_t is a dummy variable that equals 1 on the event date; and 0 otherwise on all other estimation period days. γ_i captures the average abnormal return for firm i. We then define the CAR for each firm as the coefficient γ_i multiplied by 5 as total number of events, which captures the impact of 5 events together (as in Lewis & Verwijmeren, 2014; Cousins et al., 2020).

[26] Carbon emission amount is significantly related with amount of fixed asset especially in the form of equipment or plant (Sullivan, 2009). The problem of other common scaler like cost of goods sold or sales revenue is that it may affect carbon risk by economic performance rather than carbon risk itself (Clarkson et al., 2011; Jung et al., 2018). Moreover, revenue-based scaling for carbon intensity measurement may represent heavier polluters as superior "carbon performers" (Haigh & Shapiro, 2012). Therefore, as a more appropriate choice, our study measures carbon emission performance relative to tangible fixed assets to ensure better cross-sectional comparability. However, our key inferences remain consistent even when carbon intensity is alternatively scaled by total assets and cost of sales (see Section 5.4).

[27] In an untabulated analysis, we also replace the ESG Disclosure score with an ESG performance score developed by LSEG (formerly Refinitiv), which shows an overall company performance score based on the self-reported information in the environmental, social, and corporate governance areas. Our result remains unchanged with this alternative specification.

Table 3
Summary Statistics.

Panel A: Summary Statistics (N = 199)

Variable	Mean	S.D.	Min	P25	Median	P75	Max
CAR	0.002	0.045	−0.180	−0.023	−0.003	0.025	0.241
Institutional Ownership	0.344	0.118	0.039	0.259	0.340	0.432	0.670
Carbon (million tons)	2.968	11.42	0.000	0.022	0.097	0.591	85.00
Carbon Intensity	0.510	0.500	0.000	0.000	1.000	1.000	1.000
Total Asset (£ billion)	9.967	27.19	0.120	0.844	1.963	5.586	180.8
Leverage	0.212	0.181	0.000	0.061	0.182	0.331	0.929
Cash	0.103	0.101	0.000	0.032	0.072	0.140	0.535
Market-to-Book	1.308	1.414	0.027	0.493	0.859	1.629	11.84
ESG Disclosure	51.40	30.60	0.000	34.24	54.57	77.10	98.16

Panel B: Pearson Correlations (N = 199)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) *CAR*	1.000	–	–	–	–	–	–	–
	–	–	–	–	–	–	–	–
(2) *Carbon Intensity*	−0.054	1.000	–	–	–	–	–	–
	(0.452)	–	–	–	–	–	–	–
(3) *Institutional Ownership*	0.095	0.026	1.000	–	–	–	–	–
	(0.181)	(0.713)	–	–	–	–	–	–
(4) *Firm Size*	0.032	−0.008	−0.094	1.000	–	–	–	–
	(0.654)	(0.909)	(0.186)	–	–	–	–	–
(5) *Leverage*	−0.031	0.110	0.051	0.151**	1.000	–	–	–
	(0.662)	(0.122)	(0.478)	(0.033)	–	–	–	–
(6) *Cash*	−0.102	−0.073	−0.013	−0.158**	−0.291***	1.000	–	–
	(0.152)	(0.306)	(0.858)	(0.026)	(0.000)	–	–	–
(7) *Market-to-Book*	−0.117*	−0.078	−0.031	−0.308***	−0.272***	0.330***	1.000	–
	(0.10)	(0.273)	(0.666)	(0.000)	(0.000)	(0.000)	–	–
(8) *ESG Disclosure*	0.101	−0.026	0.011	0.532***	0.056	0.025	−0.019	1.000
	(0.155)	(0.712)	(0.872)	(0.000)	(0.428)	(0.731)	(0.788)	–

This table presents descriptive statistics for the key variables used in our baseline cross-sectional regression analysis. The baseline sample consists of 199 firms included in the FTSE All-Share Price Index. Panel A reports summary statistics for each variable, where S.D. represents the standard deviation, and P indicates the respective percentiles (P25, Median, and P75). Panel B displays pairwise Pearson correlation coefficients, with *p*-values reported in parentheses. Appendix A provides detailed definitions of all variables. ***, **, and * denote statistical significance at the 1 %, 5 %, and 10 % levels, respectively.

Boubaker et al., 2019). Prior studies also highlight that screening processes and divestment strategies for high-carbon-intensity firms differ across institutional investor types (Bolton & Kacperczyk, 2021a; Benz et al., 2021; Rohleder et al., 2022). Motivated by these findings, we investigate whether the stock market valuation of highly-impacted firms varies across a more nuanced classification of institutional investor groups.

To do so, we split institutional investors into two broad categories, based on their ability to monitor the carbon performance of their portfolio firms. The first group comprises, long-term institutional investors (referred as, *Long-term IO*), who are considered to be active and dedicated in nature to oversee the performance of their investment and tend to be "pressure-resistant" (Ferreira & Matos, 2008; Johnson et al., 2010). Specifically, *Long-term IO* refers to the proportion of outstanding shares held by institutional investors, such as pension funds, investment advisers, and hedge funds. In the UK context, these investors are commonly classified as long-term due to their distinct characteristics and investment strategies (Faccio & Lasfer, 2002; Ferreira & Matos, 2008; Nguyen & Shiu, 2022). These investors typically hold aggregate shareholdings and are more active in trading compared to other types of institutional investors (Bushee, 2001; Ferreira & Matos, 2008). Their independence enables them to gather value-relevant information more effectively, as they maintain fewer business ties with the companies in their portfolios. Coupled with their active investment approach, this independence is expected to strengthen their oversight of the carbon performance of portfolio firms (Krueger et al., 2020).

Our second group of investors consists of those from countries with strong social norms surrounding climate and sustainability, identified using the methodologies of Dyck et al. (2019) and Ilhan et al. (2023). This metric, termed *Strong Social Norm Institutional Ownership (IO)*, represents the percentage of outstanding shares held by institutional investors based in countries characterized by strong social norms. To measure a country's stance on social norms, we utilize the Environmental Performance Index (EPI) developed by the Yale Center for Environmental Law and Policy. Institutional investors are classified as belonging to the high social norms group if their country's EPI score exceeds the sample median. Institutional investors from these countries are likely to be more concerned about high-carbon-emission portfolio firms, particularly during the adoption of mandatory carbon reporting regulations. This heightened concern stems from the stricter environmental standards and expectations prevalent in their home countries. The EPI reflects strong societal norms around sustainability and environmental responsibility, which these institutional investors are likely to incorporate into their investment practices (see Dyck et al., 2019; Ilhan et al., 2023).

Employing our refined classification of institutional ownership, we observe significant negative stock price reactions associated with both Long-term IO and Strong Social Norm IO. These effects are statistically significant, highlighting the distinct influence of these investor groups on market responses to carbon intensity (see Columns (3) to (6) of Table 4). Overall, the cross-sectional results suggest that high carbon-intensity firms with substantial institutional ownership are more negatively impacted by the MCD regulation.

Table 4
Highly-Impacted Firms and Stock Price Reaction to the Implementation of MCD.

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Carbon Intensity	4.190	4.451	2.339**	2.378*	0.496	0.483
	(1.751)	(1.720)	(2.649)	(2.252)	(1.196)	(1.094)
Institutional Ownership	0.000	0.000	–	–	–	–
	(0.480)	(0.305)	–	–	–	–
Carbon Intensity x *Institutional Ownership*	−0.110*	−0.116*	–	–	–	–
	(−1.910)	(−1.931)	–	–	–	–
Long-term IO	–	–	−0.001	−0.001	–	–
	–	–	(−0.287)	(−0.406)	–	–
Carbon Intensity x *Long-term IO*	–	–	−0.059**	−0.062**	–	–
	–	–	(−3.190)	(−2.884)	–	–
Strong Social Norm IO	–	–	–	–	−0.004	−0.006
	–	–	–	–	(−0.548)	(−0.933)
Carbon Intensity x *Strong Social Norm IO*	–	–	–	–	−1.812**	−1.879**
	–	–	–	–	(−2.954)	(−2.873)
Firm Size	−0.001	−0.002	−0.002	−0.003**	−0.002	−0.003
	(−0.971)	(−1.717)	(−1.609)	(−2.564)	(−0.806)	(−1.492)
Leverage	−0.022	−0.022*	−0.021*	−0.022*	−0.023	−0.023*
	(−1.557)	(−1.951)	(−2.027)	(−1.978)	(−1.783)	(−1.861)
Cash	−0.027	−0.030	−0.0274	−0.0316	−0.028	−0.037*
	(−1.310)	(−1.565)	(−1.381)	(−1.544)	(−1.463)	(−2.068)
Market-to-Book	−0.004**	−0.004**	−0.004***	−0.005***	−0.004**	−0.004*
	(−2.722)	(−2.340)	(−5.930)	(−6.115)	(−2.620)	(−2.236)
ESG Disclosure	0.000***	0.000**	0.000**	0.000*	0.000***	0.000**
	(3.342)	(2.413)	(2.445)	(2.039)	(3.362)	(2.708)
Environmental Controversy	–	0.000	–	0.000**	–	0.000
	–	(0.592)	–	(2.267)	–	(1.301)
Industry Profitability	–	−0.023***	–	−0.030***	–	−0.032***
	–	(−14.69)	–	(−11.51)	–	(−13.97)
Environmental Innovation	–	0.000	–	0.000	–	0.000
	–	(1.198)	–	(1.264)	–	(1.584)
Turnover	–	0.009	–	0.011	–	0.011**
	–	(1.549)	–	(1.821)	–	(2.894)
Herfindahl	–	0.086***	–	0.094***	–	0.094***
	–	(9.008)	–	(8.775)	–	(4.057)
Intercept	0.004	0.0263	–	0.060*	–	0.053
	(0.091)	(0.680)	–	(2.066)	–	(1.263)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	199	196	199	196	186	184
R^2	0.15	0.16	0.15	0.16	0.15	0.16
Max VIF	1.62	1.73	1.62	1.73	1.62	1.73

This table reports the regression results examining the stock return effect of highly-impacted firms to the MCD announcement events. The dependent variable in each regression, CAR, is the event-day abnormal return for each firm to the aggregated five events. For each firm *i*, we estimate the regression: $R_{it} = \alpha_i + \beta_i R_{mt} + \gamma_i D_t + \epsilon_{it}$. R_{it} is the return on firm *i*'s stock. R_{mt} is the return on the value weighted market index for Europe excluding UK Ireland (Refinitiv code: TRXFLDEXPU), expressed in sterling. D_t is a dummy variable that equals 1 on the event date; and 0 otherwise on all other estimation period days. γ_i captures the average abnormal return for firm *i*. We then define the CAR for each firm as the coefficient γ_i multiplied by 5 (total number of events). The main variables of interest include the interaction between carbon intensity and institutional ownership (IO) in columns (1–2), long-term IO in columns (3–4) and strong social norm IO in columns (5–6). *Carbon Intensity* is defined as total carbon dioxide (CO2) emissions and equivalents (i.e., Scope 1, direct, and Scope 2, indirect emissions) in tons divided by gross property, plant and equipment (PPE). *Institutional Ownership* is the percentage of shares held by the institutional investors at the end of the fiscal year 2010 (i.e., before the first event). *Long-term IO* is the total percentage of outstanding shares held by pension funds, investment advisors, and hedge funds. *Strong Social Norm IO* is defined as the percentage of outstanding shares held by institutional investors from strong social norms countries. The *t*-statistics in parentheses are based on robust standard errors, clustered by 2-digit TRBC industry codes. Appendix A provides detailed definitions for all variables. ***, ** and * indicate statistical significance at 1 %, 5 % and 10 % levels, respectively.

5. Additional analysis and further robustness tests

5.1. The effect of institutional investors' attention

This section extends the analysis by exploring how institutional investor attention influences stock market reactions for firms highly impacted by MCD implementation events. Previous research shows that institutional investors are more likely to focus on firms following events or news that could substantially affect their market value (see Da et al., 2011; Ben-Rephael et al., 2017). Unlike retail investor attention, which can lead to noise-driven trading due to misinterpretation or inappropriate assessment of information, institutional investors have superior capabilities in gathering and processing value-relevant information (Dong, 2020; Ballinari et al., 2022; Liu et al., 2023a). Furthermore, institutional investors tend to have large holdings, which gives them greater influence over price determination as they integrate this information into their investment decisions.[28] Accordingly, we conjecture that highly-impacted firms are more likely to attract a higher level of institutional investors' attention during the MCD period, potentially creating a price pressure mechanism and thus leading to a more negative stock return.

To test this conjecture, we examine the impact of institutional investor attention on stock price reaction for highly-impacted firms (those with high carbon intensity and institutional ownership) during the events dates. Specifically, we estimate the following equation:

$$\begin{aligned} CAR_i = {} & \alpha_i + \beta_1 Carbon\ Intensity_i + \beta_2 Institutional\ Ownership_i + \beta_3 High\ Attention_i + \beta_4 Carbon\ Intensity_i x High\ Attention_i \\ & + \beta_5 Institutional\ Ownership_i x High\ Attention_i + \beta_6 Carbon\ Intensity_i x Institutional\ Ownership_i \\ & + \beta_7 Carbon\ Intensity_i x Institutional\ Ownership_i x High\ Attention + Controls + Industry\ FE + Event\ Date\ FE + \varepsilon_{i,t} \end{aligned} \quad (4)$$

In Eq. (4), *High Attention* is a dummy variable, indicating periods of high institutional investor attention. We measure institutional investor attention using the Bloomberg's daily maximum readership (DMR) score, as suggested by Ben-Rephael et al. (2017). As institutional investors are the primary users of Bloomberg, the DMR score provides a reliable and direct proxy for capturing institutional investor attention. Bloomberg calculates the DMR score for each firm based on users' news-searching and reading activity relative to the previous month's average. The score ranges from 0 to 4, where a value of '0' indicates that the average hourly count of news reading on any given day is below 80 % of the previous 30 days' average hourly count. Values from 1 to 4 correspond to different thresholds above the 80 % level. Therefore, we define *High Attention* as a dummy variable equal to 1 if the DMR score is greater than 0, indicating that the hourly count of news searching and reading exceeds the 80 % threshold of the previous 30 days' average. We use the same control variables as in the benchmark model (1) in Table 4.

Table 5 presents the results. Our main variable of interest is the triple interaction term *Carbon Intensity* x *Institutional Ownership* x *High Attention*. We find that the interaction term is negative and significant, suggesting that high institutional investor attention leads to more pronounced negative stock price reaction for highly-impacted firms. These findings highlight the critical role of investor attention in intensifying market responses to carbon-related risks.

5.2. Carbon-Intensive and Non-Carbon-Intensive industries

In this section, we examine whether stock market reactions to the implementation of MCD regulation differ between firms in carbon-intensive and non-carbon-intensive industries. The level of carbon intensity within an industry is a key consideration for investors when assessing associated risks. Given that carbon intensity varies across industries, investors may evaluate carbon risk relative to industry peers, facilitating investment decisions that account for both industry norms and the potential financial implications of carbon-related risks.

Accordingly, we estimate our baseline cross-sectional regression on subsamples of firms in carbon-intensive and non-carbon-intensive industries. Following previous studies, we split the sample into subsamples based on industry-level carbon intensity. Industries with a median carbon intensity above the sample median are classified as carbon-intensive industries, while those with a median carbon intensity below the sample median are classified as non-carbon-intensive industries (Ott & Endrikat, 2023).

The results, as presented in Table 6, suggests that firms in carbon-intensive industries are more negatively and significantly affected by the MCD regulation compared to those in non-carbon-intensive industries. These findings demonstrate the heightened sensitivity of carbon-intensive industries to regulatory changes, emphasizing the importance of industry-level carbon performance in shaping investor responses.

[28] While we acknowledge that retail investors may also influence stock price reactions to sustainability concerns, the voluntary nature and inconsistent quality of carbon disclosures often hinder their ability to accurately evaluate carbon risk across firms. In contrast, institutional investors, with their larger shareholdings and advanced analytical capabilities, are better equipped to interpret and act on such information (Jaggi et al., 2018). Although prior research, such as Ding and Hou (2015), underscores the potential impact of retail investor attention on stock market performance, recent findings by Moss et al. (2024) indicate that ESG disclosures do not appear to inform retail investors' buy and sell decisions. This explains why our study focuses on institutional investors instead of retail investors.

Table 5
The Effect of Institutional Investor Attention.

	(1)	*(2)*
Carbon Intensity	3.594**	3.455**
	(2.738)	(2.774)
Institutional Ownership	−0.000	−0.000
	(−0.291)	(−0.314)
High Attention	−0.029***	−0.029***
	(−4.848)	(−4.728)
Carbon Intensity x *High Attention*	5.797**	6.141**
	(2.582)	(3.132)
Institutional Ownership x *High Attention*	0.001***	0.001***
	(5.124)	(4.996)
Carbon Intensity x *Institutional Ownership*	−0.097**	−0.094***
	(−3.206)	(−3.295)
Carbon Intensity x *Inst. Ownership* x *High Attention*	−0.197***	−0.206***
	(−3.286)	(−3.885)
Controls	Yes	Yes
Industry Fixed Effects	Yes	No
Event Date Fixed Effects	No	Yes
Observations	682	682
R^2	0.19	0.19

This table reports the regression results examining the effect of institutional investor attention on stock price reaction for highly-impacted firms to the MCD announcement events. The dependent variable in each regression, CAR, is the event-day abnormal return for each firm to the aggregated five events. For each firm *i*, we estimate the regression: $R_{it} = \alpha_i + \beta_i R_{mt} + \gamma_i D_t + \epsilon_{it}$. R_{it} is the return on firm *i*'s stock. R_{mt} is the return on the value weighted market index for Europe excluding UK Ireland (Refinitiv code: TRXFLDEXPU), expressed in sterling. D_t is a dummy variable that equals 1 on the event date; and 0 otherwise on all other estimation period days. γ_i captures the average abnormal return for firm *i*. We then define the CAR for each firm as the coefficient γ_i multiplied by 5 (total number of events). *Carbon Intensity* is defined as total carbon dioxide (CO2) emissions and equivalents (i.e., Scope 1, direct, and Scope 2, indirect emissions) in tons divided by gross property, plant and equipment (PPE). *Institutional Ownership* is the percentage of shares held by the institutional investors at the end of the fiscal year 2010 (i.e., before the first event). Institutional investor attention is based on Bloomberg's Daily Maximum Readership score (DMR). DMR assigns score 0 to 4 based on threshold level of average hourly count of reading and searching for a particular stock compared with the previous 30 days. *High Attention* is a dummy variable that equals 1 if the DMR score is greater than 0, indicating that the hourly count of news searching and reading exceeds the 80 % threshold of the previous 30 days' average, and 0 otherwise. The *t*-statistics in parentheses are based on robust standard errors clustered by 2-digit TRBC industry codes. Appendix A provides detailed definitions of the variables. *** and ** indicate statistical significance at 1 % and 5 % levels, respectively.

Table 6
Carbon-Intensive vs. Non-Carbon-Intensive Industries.

	Carbon Intensive Industries	*Non-Carbon-Intensive Industries*
	(1)	*(2)*
Carbon Intensity	3.566	3.781*
	(1.749)	(2.389)
Institutional Ownership	0.000	0.000
	(0.389)	(1.230)
Carbon Intensity x *Institutional Ownership*	−0.107**	−0.080
	(−2.406)	(−2.185)
Controls	Yes	Yes
Industry Fixed Effects	Yes	Yes
Observations	157	42
R^2	0.11	0.37

This table reports the regression results examining the stock price reaction to the MCD announcement events between firms under carbon-intensive and non-carbon-intensive industries. The dependent variable in each regression, CAR, is the event-day abnormal return for each firm to the aggregated five events. For each firm *i*, we estimate the regression: $R_{it} = \alpha_i + \beta_i R_{mt} + \gamma_i D_t + \epsilon_{it}$. R_{it} is the return on firm *i*'s stock. R_{mt} is the return on the value weighted market index for Europe excluding UK Ireland (Refinitiv code: TRXFLDEXPU), expressed in sterling. D_t is a dummy variable that equals 1 on the event date; and 0 otherwise on all other estimation period days. γ_i captures the average abnormal return for firm *i*. We then define the CAR for each firm as the coefficient γ_i multiplied by 5 (total number of events). We split the sample into subsamples based on industry-level carbon intensity. Industries with a median carbon intensity above the sample median are classified as carbon-intensive industries, while those with a median carbon intensity below the sample median are classified as non-carbon-intensive industries. The *t*-statistics in parentheses are based on robust standard errors clustered by 2-digit TRBC industry codes. Appendix A provides detailed definitions of the variables. ** and * indicate statistical significance at 5 % and 10 % levels, respectively.

5.3. Stock price reaction for European firms

As a robustness check, we examine whether the stock price effects observed for UK firms subject to MCD regulation are also present in firms outside the scope of the regulation. For this purpose, we use European listed firms as a control group, given that the UK was part of Europe when the regulation was enacted. This sample, sourced from LSEG Eikon (code: TRXFLDEXPU), comprises firms not subject to the UK-specific MCD regulation but broadly comparable in characteristics such as size and industry. Using this sample, we re-estimate CARs for the period from July 1, 2010, to December 31, 2013.[29] To strengthen the robustness of our findings, we adopt two approaches. First, we use the full European sample as the control group. Second, we apply a propensity score matching (PSM) approach to construct a more comparable control group. Specifically, we use nearest neighbour matching to pair UK firms with European firms from the same industry that are most similar in terms of size.

The results, presented in Table 7, demonstrate non-significant coefficients for the interaction term across both approaches. Column (1) reports the results for the full European sample, while Column (2) presents findings for the PSM-matched sample. In both cases, the lack of significant coefficients indicates that European firms were not affected by the MCD regulation. These results support the interpretation of our baseline results, showing that the MCD regulation only impacted UK-listed firms.

5.4. Further robustness checks

In this section, we perform a series of robustness tests to validate the reliability of our baseline findings and ensure that the observed effects are specific to the events related to the implementation of MCD regulation. Table 8 presents the results from these additional analyses.

In Columns (1) and (2) of Table 8, we re-estimate our baseline regression (Column (1) of Table 4) using alternative scaling measures for carbon intensity: total assets and cost of sales, respectively. The results indicate that our inferences remain consistent across these alternative scaling approaches. Next, in Column (3), we re-estimate the baseline regression with alternative CARs, estimated using a Eurozone market index instead of the Europe excluding the UK & Ireland market index. Again, the findings are robust and consistent with our baseline results.

In Column (4) of Table 8, we test the robustness of our findings by excluding financial firms from the sample. The results show no change in our inferences, confirming that our conclusions are not driven by the inclusion of financial firms.

Finally, we conduct a placebo test to verify whether the significant coefficients observed in our baseline regression (Column (1) of Table 4) are unique to event dates. To implement this test, we randomly select five non-event dates and assign a value one for each of these non-event days and zero otherwise. Then, we estimate CARs aggregated across these five non-event dates. We then estimate the baseline cross-sectional regression using our sample of 199 firms. This process is repeated 500 times to generate a distribution of regression coefficients for non-event dates. Column (5) reports that the coefficients for these non-event dates are not significant in the placebo test, in contrast to the event dates. This suggests that the observed effects in our baseline cross-sectional analyses are event specific and associated only with the implementation of MCD.

6. Conclusion

This study examines the shareholder wealth implications of the implementation of mandatory carbon disclosure regulation in the UK, the first country to introduce such regulation. We conjecture that MCD will bring both benefits and costs to firms and, thus, their equity value will depend on the market's net perceived benefit or cost. Importantly, we study whether firm-level characteristics such as institutional ownership and carbon intensity can explain cross-sectional differences in the stock market reaction.

We find that while the overall market reaction to MCD was not significant, firms with high carbon intensity and substantial institutional ownership, identified as highly-impacted firms, experienced significant negative abnormal stock returns. These effects persisted–and were even more pronounced–for firms associated with long-term institutional investors and investors from countries with strong social norms. Additionally, heightened institutional investor attention on announcement days intensified price pressure, exacerbating the negative stock price reaction for these firms. Our findings are robust across multiple tests, including alternative market indices, additional control variables, scaling measures for carbon intensity, and placebo tests. These results underscore the critical role of institutional investors and firm-specific characteristics in shaping the shareholder wealth effects of carbon disclosure regulations. Overall, our findings support the view that institutional investors factor carbon disclosure considerations into their investments, possibly in view of the future operational and reputational costs associated with excessive carbon emissions.

The results of this study could be used as guidance for corporate managers to consider environmentally sustainable business practice and potential investors' responses to these. They also have direct policy implications for the UK and other countries regarding the compliance and effects of new disclosure regulations. Starting from 2022, the UK requires listed firms to mandatorily report

[29] Specifically, we employed the following regression model: $R_{it} = \alpha_i + \beta_i R_{mt} + \gamma_i D_t + \epsilon_{it}$, where, R_{it} is the return on firm i's stock. R_{mt} is the return on the FTSE all share market index, which now serves as a proxy for the market portfolio. D_t is a dummy variable that equals 1 on the event date; and 0 otherwise on all other estimation period days. γ_i captures the average abnormal return for firm i. Similar to the UK-based analysis, we define the CAR for each firm as the coefficient γ_i multiplied by 5 (total number of events).

Table 7
Stock Price Reactions to MCD for a European Control Group.

	Full Sample	Propensity Score Matched Sample
	(1)	*(2)*
Carbon Intensity	3.743	5.660
	(0.557)	(0.870)
Institutional Ownership	0.000	0.000
	(0.142)	(1.585)
Carbon Intensity x *Institutional Ownership*	−0.280	−0.371
	(−1.516)	(−1.321)
Controls	Yes	Yes
Industry Fixed Effects	Yes	Yes
Observations	262	68
R^2	0.25	0.29

This table presents baseline cross-sectional regression results for a European sample of firms, which serves as a control group. European sample firms are listed under market index for Europe excluding the UK & Ireland, obtained from LSEG Eikon (code: TRXFLDEXPU). Column (1) reports results for the full European sample, while Column (2) presents results for the propensity-score matched sample (matched by size and industry). The dependent variable in both columns is, *CAR*, represents the cumulative abnormal return for each firm. For each firm *i*, we estimate the regression: $R_{it} = \alpha_i + \beta_i R_{mt} + \gamma_i D_t + \epsilon_{it}$. R_{it} is the return on firm *i*'s stock. R_{mt} is the return on the FTSE all share market index. D_t is a dummy variable that equals 1 on the event date; and 0 otherwise on all other estimation period days. γ_i captures the average abnormal return for firm *i*, and the CAR is defined as γ_i multiplied by 5, representing the total number of events. The *t*-statistics in parentheses are based on robust standard errors clustered by 2-digit TRBC industry codes. Appendix A provides detailed definitions of the variables.

Table 8
Additional Robustness Tests.

	Carbon Intensity by Assets	*Carbon Intensity by Cost of Sales*	*Alternative CAR*	*Excluding Financial Firms*	*Bootstrap Non-Event Day 500 reps.*
	(1)	*(2)*	*(3)*	*(4)*	*(5)*
Carbon Intensity (scaled by Assets)	14.81*	–	–	–	–
	(2.069)	–	–	–	–
Carbon Intensity (scaled by CoS)	–	5.763**	–	–	–
	–	(2.293)	–	–	–
Carbon Intensity	–	–	4.365	3.512	−1.255
	–	–	(1.787)	(1.768)	(−0.079)
Institutional Ownership	0.000	0.000	0.0003	0.000	0.000
	(0.640)	(0.711)	(0.517)	(0.412)	(0.731)
Carbon Intensity (scaled by Assets)	−0.480**	–	–	–	–
x *Inst. Ownership*	(−2.306)	–	–	–	–
Carbon Intensity (scaled by CoS)	–	−0.190**	–	–	–
x *Inst. Ownership*	–	(−2.325)	–	–	–
Carbon Intensity x *Institutional Ownership*	–	–	−0.113*	−0.106**	0.040
	–	–	(−1.930)	(−2.455)	(0.070)
Controls	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	206	187	199	172	199
R^2	0.16	0.17	0.15	0.11	0.11

This table presents additional robustness tests for the cross-sectional regression results. Columns (1) − (4) examine the stock return effect of the MCD related announcements. In Column (1), carbon intensity is scaled by total assets, while in Column (2), it is scaled by cost of sales (CoS). Column (3) uses an alternative market index return for CAR calculation, and Column (4) excludes financial firms from the sample. Column (5) reports the results of a placebo test, which is based on market reactions to five randomly selected non-event dates. The dependent variable in each regression, *CAR*, is cumulative abnormal return. For each firm *i*, we estimate the regression: $R_{it} = \alpha_i + \beta_i R_{mt} + \gamma_i D_t + \epsilon_{it}$. R_{it} is the return on firm *i*'s stock. R_{mt} is the return on the value weighted market index for Europe excluding the UK Ireland (Refinitiv code: TRXFLDEXPU), expressed in sterling, in all columns except column (3), where we use Eurozone market index (Refinitiv code: TRXFLDZEPU). D_t is a dummy variable that equals 1 on the event date for columns (1) − (4), and on the five randomly chosen non-event dates for column (5); and 0 otherwise. γ_i captures the average abnormal return for firm *i*. We then define the CAR for each firm as the coefficient γ_i multiplied by 5 (total number of events) (non-events for placebo test in column 5). The bootstrapping process of placebo test in column (5) is based on 500 iterations. The *t*-statistics in parentheses are based on robust standard errors clustered by 2-digit TRBC industry codes. Appendix A provides detailed definitions of the variables. ** and * indicate statistical significance at 5 % and 10 % levels, respectively.

climate-related financial disclosures, such as identifying, assessing, and managing climate-related risks and opportunities.[30] Future research could explore the dynamic landscape of sustainable investing, with a particular focus on emerging regulatory frameworks and evolving industry practices. One interesting topic for investigation is how various types of institutional investors adjust their shareholdings in response to the introduction of MCD and similar regulatory initiatives. Another promising direction involves examining the value relevance of environmental disclosures from a cross-country perspective. For instance, in the U.S., the recently announced Securities and Exchange Commission (SEC) climate disclosure rule and the Federal Supplier Climate Risks and Resilience Rule–requiring companies to report their greenhouse gas emissions and specific climate-related information–offers rich opportunities for comparative analysis. These inquiries could provide valuable insights into the relationship between regulatory initiatives and sustainable investment behavior.

Ethical Approval

This article does not involve any research with human participants and/or animals conducted by any of the authors.

CRediT authorship contribution statement

Chris Florackis: Writing – review & editing, Supervision, Resources, Methodology, Conceptualization. **Dewan Muktadir-Al-Mukit:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Sushil Sainani:** Writing – review & editing, Supervision, Methodology, Data curation, Conceptualization. **Ziyang John Zhang:** Writing – review & editing, Supervision, Methodology, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A

Data Definitions.
This table provides definitions of the variables used in our analysis.

Variable	Data Definition
CAR	Event-day abnormal return for each firm to the aggregated five events.
Carbon Intensity	Total emissions of carbon dioxide (CO2) and CO2 equivalents (Scope1, direct, and Scope 2, indirect, as per the regulatory requirements) in tons divided by gross property, plant, and equipment (PPE). Carbon emission data is as of year 2010, backfilled by 2011.
Cash	Cash ratio measured as cash and short-term investments divided by total assets. We measure this as of the fiscal year end before January 17, 2011 (event 1).
Environmental Controversy	Score reflecting negative environmental-related news stories (“controversies”) about the firm, through LSEG Eikon variable Environmental Controversy Score. We take the inverse of the score to reflect higher values as more controversies. We measure this as of the year 2010.
Environmental Innovation	Score reflecting company’s capacity to reduce the environmental costs and burdens for its customers, and thereby creating new market opportunities through new environmental technologies and processes or eco-designed products. Obtained through LSEG Eikon variable Environmental Innovation Score. We measure this as of the year 2010.
ESG Disclosure	Measures the firm’s overall ESG disclosure levels, through Refinitiv variable ESG Strategy Score. This variable is based on eight indicators reflecting CSR disclosure practices, such as whether the firm has an external auditor for its ESG report, whether the extra financial report takes into account the global activities of the company, and whether the ESG report is in line with Global Reporting Initiative standards. We measure this as of the year 2010.

(*continued on next page*)

[30] Under the Companies (Strategic Report) (Climate-related Financial Disclosure) Regulations 2022. See details here: https://www.gov.uk/government/publications/climate-related-financial-disclosures-for-companies-and-limited-liability-partnerships-llps.

(*continued*)

Variable	Data Definition
Firm Size	The natural logarithm of total assets. We measure this as of the fiscal year end before January 17, 2011 (event 1). In the summary statistics, we represent it in billion pounds (£).
Herfindahl Index	Industry concentration proxy variable is measured as the sum of squared sales-based market shares of sample firms in the firm's industry, where industry is determined based on 2-digit TRBC codes. Sales is measured as of the fiscal year end before January 17, 2011 (event 1).
High Institutional Investor Attention (High Attention)	We obtain attention data from the Bloomberg News Heat–User Activity variable. Bloomberg assigns a score of 0–4 to specify the level of news reading and news search activity of a particular stock on Bloomberg's terminals, called Daily maximum Bloomberg readership (DMR) score. Bloomberg creates this attention score based on threshold level of average hourly count of reading compared with the previous 30 days. A DMR value 0 indicates readership time is below 80 % threshold level. High Institutional Investor Attention is a dummy variable coded 1 if the DMR score is above 0, and zero otherwise. We measure this as of each event day.
Industry Profitability	Dummy variable coded 1 if the industry profitability of the firm is above the sample median, and 0 otherwise. Average industry profitability as earnings before interest and taxes (EBIT) divided by Sales Revenue, averaged over sample firms within the same industry, measured by 2-digit TRBC code. We measure this as of the fiscal year end before January 17, 2011 (event 1).
Institutional Ownership	The percentage of shares held by the institutional investors at the end of the fiscal year 2010 (i.e., before the first event).
Leverage	Total long-term debt divided by total assets. We measure this as of the fiscal year end before January 17, 2011 (event 1).
Long-term IO	Long institutional ownership is defined as the percentage of shares held by all long-term institutional investors (pension fund, investment advisor, and hedge fund) at the end of the fiscal year 2010 (i.e., before the first event).
Market-to-Book	Market value (measured one trading week before event 1, that is, as of January 6, 2011) divided by total assets (measured as of the fiscal year end before event 1).
Strong Social Norm IO	The percentage of outstanding shares held by institutional investors from strong social norm countries, as defined in Dyck et al. (2019). We classify an institutional investor's country as in the strong social norms group if its environmental performance index (EPI) exceeds the sample median.
Turnover	Dummy variable coded 1 if the firm's ratio of average number of daily shares traded in December 2010 to total number of common shares outstanding in 2010 is greater than the sample median, and 0 otherwise.

Appendix B

Summary of Key Events Leading up to and Including the Implementation of Mandatory Carbon Disclosure.

This table shows the dates of key events and gives a summary description and likelihood of the introduction of MCD. The dates have been identified using Lexis Library database (LexisNexis), Gale OneFile News database and other online sources.

Event Date	Relevant Events	Likelihood of Adoption
(1) January 17, 2011	Publication of first impact assessment by DEFRA on cost-benefit of government intervention in terms of change of GHG reporting policy. Five options are set out: No change, enhanced reporting, mandatory reporting for all quoted companies, mandatory reporting for large companies only and mandatory reporting for companies which meet certain energy use criteria.	Increasing
(2) May 11, 2011	Start of DEFRA's public consultation on its impact assessment regarding GHG reporting. The consultation sought views on voluntary vs. mandatory reporting, the scope of reporting (e.g., all six Kyoto GHGs, Scope 1 and 2 emissions), and the inclusion of GHG data in directors' reports. It highlighted the need for consistent methodologies, the significance of emissions breakdowns, and the potential cost implications.	Increasing
(3) September 14, 2011	Recommendation to make GHG reporting mandatory by Environmental Audit Committee (appointed by the House of Commons) in its report Carbon Budgets.	Increasing
(4) June 19, 2012	Announcement by Deputy Prime Minister that the government intended to pass legislation on mandatory GHG reporting for companies quoted on the London Stock Exchange.	Increasing
(5) July 16, 2013	Approval by Parliament of the Companies Act 2006 (Strategic Report and Directors' Report) Regulations 2013, mandating quoted companies to disclose annual GHG emissions related to fuel combustion, operations, and purchased energy use within their directors' report, and to state the methodologies used for calculating the disclosed information (PART 7: DISCLOSURES CONCERNING GREENHOUSE GAS EMISSIONS).	Increasing

Data availability

The authors do not have permission to share data.

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