

# *Carbon emissions, carbon disclosure and organizational performance*

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# Carbon emissions, carbon disclosure and organizational performance

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## ABSTRACT

This study draws on the multi-perspectives of organizational legitimacy theory to investigate the simultaneous association between corporate carbon emissions, carbon disclosure and organizational performance. Based on a sample of 62 UK Financial Times Stock Exchange (FTSE) 100 firms in carbon-sensitive sectors during 2010–2017, we find that carbon emissions are negatively associated with organizational performance, but firms with higher carbon emissions tend to employ more disclosure as a communicative legitimacy process to manage the legitimacy threat in order to conform to institutional pressures and protect the firm value. Cumulatively, carbon disclosure plays a mediating role in the relationship between carbon emissions and organizational performance. Most importantly, this legitimacy effect is more pronounced following the introduction of the UK mandatory carbon reporting regulation in 2013, as a result of the increased corporate capability of carbon disclosure. This study fills the literature gap in the value-protective attribute from resource-based view of organizational legitimacy by providing important insights into corporate carbon disclosure strategy over time.

## 1. Introduction

The issue of climate change has led to increased adoption of national and international climate change mitigation policies, as well as mandatory low-carbon processes and product standards (Andreou & Kellard, 2021; Bebbington & Larrinaga-González, 2008; Chen, Hung, & Wang, 2018; Haque & Ntim, 2020; Wang, Sun, & Liu, 2019; Xu, Huang, Lucey, & An, 2023). As a result, businesses, especially those in carbon-intensive industries, face increased pressure from the public (Liesen, Hoepner, Patten, & Figge, 2015) and are giving more attention to issues related to their carbon emissions (Griffin, Lont, & Sun, 2017; Huang, Kerstein, & Wang, 2017; Matsumura, Prakash, & Vera-Muñoz, 2014).

Earlier studies on the firm performance implications of carbon emissions yield inconclusive results. For instance, with samples of Standard & Poor's (S&P) 500 companies, Matsumura et al. (2014) and Griffin et al. (2017) document an overall valuation discount for U.S. companies of \$US212 and \$79 per ton of carbon emissions respectively. Focusing on the U.S. market, Delmas, Nairn-Birch, and Lim (2015) also suggest that investors price carbon emissions as a reduction in corporate long-term financial performance while the short-term financial performance is positively associated with carbon emissions. However, when

replicating and extending Delmas et al. (2015)'s study, Busch, Bassen, Lewandowski, and Sump (2022) find higher carbon emissions are associated with not only higher short-term financial performance but also higher long-term financial performance. Due to the inconclusive results, recent research suggests that the relationship between carbon emission and firm performance requires a broader analysis of the intermediate steps and disclosure may play a mediating role (Brooks & Oikonomou, 2018).

This study responds to the aforementioned call and takes a holistic and longitudinal approach to empirically investigate how carbon disclosure influence the link between corporate carbon emissions and organizational performance in the UK context, by using a sample of 62 carbon sensitive firms from Financial Times Stock Exchange (FTSE) 100 index during the period of 2010–2017. UK carbon-sensitive companies constitute a very typical sample for carbon reporting and reporting regulation studies (Downar, Ernstberger, Reichelstein, Schwenen, & Zaklan, 2021; Jouvenot & Krueger, 2019). The firms in the sample are subject to the mandatory carbon reporting regulation and represent potential leaders in the private sector in the UK (CDP, 2012a). We constructs a comprehensive 42-item disclosure index (as shown in the Appendix Table 1) to content analyze corporate carbon-related

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disclosure (Abbott & Monsen, 1979). Our investigation focuses on the long-term financial perspective of organizational performance, measured using Tobin's Q (Tobin & Brainard, 1977), which offers a comprehensive measure of organizational performance that reflects reputational effects, investor trust, and investor risk (Busch & Hoffmann, 2011; Tobin & Brainard, 1977).

The UK has been endeavoured in reducing its carbon emissions. For instance, it is one of the countries that ratified the Kyoto Protocol in the very early stage, and it plays a key role in securing the 2015 Paris Agreement. Moreover, the UK also introduced its national legally binding carbon reduction target in the Climate Change Act 2008 and mandated carbon disclosure for listed firms in 2013. Birindelli, Miazza, Paimanova, and Palea (2023) reveal that the capital market reaction is susceptible to how authorities respond to commitments to the transition to a low-carbon economy. Therefore, we would expect that climate change issues are more salient in the UK and it is worth to investigate the financial implication of carbon emissions in the UK context and the role of carbon disclosure to explain the link between carbon emissions and organizational performance.

Studies on corporate social responsibility (CSR) disclosure have well demonstrated that firm (pro)actively disclose their CSR information to ameliorate the information asymmetry between managers and stakeholders (Al-Tuwaijri, Christensen, & Hughes, 2004; Griffin et al., 2017; Liesen, Figge, Hoepner, & Patten, 2017; Matsumura et al., 2014), benefit from lower cost of equity (Albarrak, Elnahass, & Salama, 2019; Dhaliwal, Li, Tsang, & Yang, 2011, 2014) and more accurate analyst forecast (Dhaliwal, Radhakrishnan, Tsang, & Yang, 2012). However, firms, especially those with poor environmental performance, are more likely to engage in environmental disclosure to reactively respond to social pressure (Cho & Patten, 2007; Clarke & Gibson-Sweet, 1999; Gray et al., 1995; Patten, 1992) and avoid economic penalties (Matsumura et al., 2014). Consequently, disclosure is a fundamental tool for poor environmental performers to maintain organizational legitimacy (Pfeffer & Salancik, 1978) and is recognized as one of the key value-protective CSR strategies, which is important but under-researched. Distinct from prior studies (Al-Tuwaijri et al., 2004; Griffin et al., 2017; Liesen et al., 2017; Matsumura et al., 2014) that have considered the interaction of environmental performance, environmental disclosure and organizational performance, this study offers a further step to examine the mediating role of carbon disclosure. We employ a two-level mediation model to test the direct effect of carbon emissions on organizational performance and the indirect effect of carbon emissions (as mediated by disclosure).

Majority of prior studies have investigated disclosure from the social-psychological or social-political perspectives (e.g. Cho & Patten, 2007; MacKay & Munro, 2012; Talbot & Boiral, 2018; Wang, Guo, & Tang, 2021) and revealed that firms are inclined to overemphasize the positive aspects of their environmental records to mask their actual environmental performance. Firms' disclosure is usually decoupled from their environment performance (Bowen, 2014; Cho & Patten, 2007; Kim & Lyon, 2011; Patten, 1992) and symbolically conforms to regulative institutional policy and stakeholder pressure without necessarily improving their actual environmental performance (Haque & Ntim, 2018). We argue that disclosure is not only symbolic management but also a communicative legitimacy process which has a value protection effect. Scholars have theorized that legitimacy process is an organizational resource (Suchman, 1995) or capability (Pfeffer & Salancik, 1978) and can have a positive effect on organizational performance (Czarniawska-Joerges, 1989; Dowling & Pfeffer, 1975). However, there has been very limited research addressing how legitimacy process contributes to organizational performance. Legitimacy scholars also point out that few empirical studies test the new traits or components of legitimacy (Deephouse & Suchman, 2008) and pay less attention to empirical measures of a multifaceted construct (Suddaby, Bitektine, & Haack, 2017; Tornikoski & Newbert, 2007) and investigate new or alternative views, such as communicative legitimacy (Palazzo & Scherer, 2006) or legitimacy-as-process (Berger, Hamit Fisek, Ridgeway, & Norman, 1998;

Thomas & Ritala, 2021); and, more specifically, adopt organizational capability or strategic perspective. To fill this gap, we test multi-perspectives of organizational legitimacy theory, namely, social-political, social-psychological and resource-based view. We attempt to explore how institutional and economic forces jointly shape strategic positioning and perceptions through the investigation of the interrelationship between carbon emissions, carbon disclosure and organizational performance in the same empirical context. Most importantly, our study investigates whether corporate carbon disclosure, as a communicative legitimacy process, not only conforms to regulatory pressures but also protects shareholder value.

To achieve the objectives proposed, the paper is organized as follows. First, we review the relevant literature and present the main hypotheses. Next, we discuss our research methods and then present our results. In the final section, we move on to our discussion and conclusions.

## 2. Theoretical framework and hypothesis development

### 2.1. Multi-theoretical perspectives of legitimacy theory

The notion of legitimacy theory appears to be relevant to different theoretical perspectives, not only from institutional theory and impression management (Elsbach & Sutton, 1992) but also from resource-based view (Palazzo & Scherer, 2006; Suchman, 1995). Thus, legitimacy theory encourages organizations to consider institutional pressures in addition to economic factors.

Institutional theorists assert that the external environment and the institutions function as powerful myths and strongly influence organizational structures and processes so that organizations must accept and adopt the institutionalized rules even though it might impair the economic efficiency (Bansal & Clelland, 2004; DiMaggio & Powell, 1983; Meyer & Rowan, 1977). Different from institutional theory, legitimacy theory suggests that organizations need to balance the institutional pressures and economic efficiency in order to guarantee their continued existence. Organizational legitimacy scholars point out that firms will only manage their legitimacy when institutional pressures threaten their continued existence (Cormier, Magnan, & Van Velthoven, 2005; Durand, Hawn, & Ioannou, 2019) and will merely minimize or ceremonialize the implementation to reduce the impact on organizational efficiency (Meyer & Rowan, 1977).

Impression management is a tactic largely used by organizations to bias stakeholders' perceptions, when they see their legitimacy being threatened (Elsbach & Sutton, 1992; Talbot & Boiral, 2018). Therefore, traditional legitimacy scholars believe that legitimacy theory is "a marriage of institutional and impression management theories" (Elsbach & Sutton, 1992). However, we suggest, in the modern and stakeholder-oriented society, the insulation from scrutiny is difficult to be achieved through the releasing of symbolic and manipulative information, since organizations are frequently scrutinized by stakeholders (Dhaliwal et al., 2014), and impression management may only help organizations achieve legitimacy for a short period of time. The achievement of long-term legitimacy and ultimately, the freedom to access to resources and long-term survival and efficiency, requires serious effort over a relatively longer period. Christensen, Morsing, and Thyssen (2013) point out that CSR disclosure is aspirational talk which forms the long-term strategy as constitutive of organizational life and sensemaking. Although firms' CSR communication is not always a perfect reflection of corporate CSR practices, it involves organizations in more and more processes of justification to make sense of their role in the society (Palazzo & Scherer, 2006).

Most importantly, organizational legitimacy is recognized as a particular resource or capability to ensure organizational survival by rationalizing less legitimate behaviours and sensemaking CSR activities in order to satisfy diverse groups of stakeholders (Palazzo & Scherer, 2006; Suchman, 1995; Suddaby et al., 2017). Distinguishing from the resource-based theory and other economics theories (e.g., signalling

theory), organizational legitimacy has an important value-protective attribute rather than value-adding or creation. Therefore, organizational legitimacy theory offers a comprehensive theoretical perspective to explain why carbon-sensitive firms engage in carbon disclosure and how such disclosure has an impact on organizational performance.

## 2.2. Hypotheses development

### 2.2.1. An antecedent of organizational legitimacy

From the social-political perspective of legitimacy theory, organizations need to consider the political environment in which they operate in order to gain or maintain legitimacy (DiMaggio & Powell, 1983; Wang et al., 2019). A legitimacy threat is formed as a result of changes in social awareness, pressures from regulatory or institutional sources, the media or stakeholder groups, and corporate crises (Chelli, Richard, & Durocher, 2014; O'Donovan, 2002; Vershinina, Rodgers, Tarba, Khan, & Stokes, 2020). The transition to a low-carbon economy implies movement away from traditional energies and future stringent emission control regulations (Rubio, Llopis-Albert, Valero, & Besa, 2020) and shapes the pro-environment norm across the world. More carbon emissions will therefore be seen as less legitimate behavior which is against the pro-environment norm.

Existing studies on the financial implications of carbon emissions yield mix results. Since corporate carbon emissions are increasingly scrutinized, regulated, and priced, companies must either pay the fines or buy emission allowances from the carbon trading market if they cannot fulfil their responsibilities to reduce their emissions and to meet targets under mandatory carbon management schemes, such as the Emission Trading Scheme of Europe (EU ETS). To meet these carbon reduction targets, firms have to invest heavily in carbon emission management (e.g. low-carbon technology) and 'pay for green' behavior leads to poor organizational performance (Andreou & Kellard, 2021). From the short-term financial view, prior studies find a negative implication of carbon reduction and suggest it could be costly to invest in carbon mitigation technologies (Misani & Pogutz, 2015) and the cost savings from better carbon performance largely depend on savings from liability and compliance costs, which could barely be realized in the short term (Delmas and Montiel, 2009). Focusing on the U.S. market, Busch et al. (2022) find that firms' lower carbon emissions are associated with lower Tobin's q, which is interpreted by the authors that the financial markets do not anticipate a change in external conditions that would favour firms with a proactive stance towards climate change. With an event study on the stock market reaction to COP26 (26th Conference of the Parties) as a major climate policy event, Birindelli et al. (2023) show that stock market reaction depends on how country authorities respond to the transition to the low-carbon economy and investors reward companies with the best/worst environmental performance according to the type of climate policies adopted, more or less strict. Therefore, firms, especially those operating in carbon-sensitive industries in the UK, are increasingly exposed to regulatory uncertainty and other climate change related risks (Teeter & Sandberg, 2017) and are more likely to suffer negative long-term financial implications from their carbon emissions.

In addition, from a long-term strategic resource perspective, better carbon emission performance legitimizes the continuing operation of the business within the society, which enables firms to have better access to resources that are essential to their operation and survival (Chopra & Wu, 2016; He & Baruch, 2010; Suchman, 1995). Therefore, firms with less legitimate behaviours (i.e. high carbon emissions) are likely to lose public confidence (Hillenbrand, Money, & Ghobadian, 2013; Molecke & Pinkse, 2020) and find it hard to obtain various resources (Ding, Ren, Tan, & Wu, 2023; Hartzmark & Sussman, 2019; Riedl & Smeets, 2017), customers (Horbach, Rammer, & Rennings, 2012) and a talented workforce (Greening & Turban, 2000), and this subsequently affects organizational performance. For example, a lender will incorporate carbon-related factors into their lending decisions and

charge a significant higher interest rate because lending towards carbon-intensive projects is likely to be viewed in a negative light by stakeholders and, therefore, will negatively affect a lender's reputation (Chava, 2014; Jung, Herbohn, & Clarkson, 2016). The pro-environment norms also lead investors to increase their investment in green assets (Clark & Monk, 2010). Furthermore, with an increasing awareness and concerns over climate change, customers prefer products with improved environmental performance and less energy consumption (Horbach et al., 2012).

Based on the above discussion and under the organizational legitimacy lens, we hypothesize that carbon emissions are perceived as a less legitimate behavior by the business world, which leads to a negative impact on the long-term organizational performance.

**Hypothesis 1.** There is a negative relationship between corporate carbon emissions and organizational performance.

### 2.2.2. Carbon disclosure as organizational legitimacy process

From the social-psychological perspective, legitimacy, as organizational perception management (Elsbach, 2003), has perceptual and subjective components (Habitzreuter & Koenigstorfer, 2021) and encompasses sense-making of collective actors (Bitektine & Haack, 2015). Legitimacy theory posits that organizations disclose environmental information in response to social, environmental, political and economic pressure in order to gain or maintain their licence to operate (Dowling & Pfeffer, 1975).

The climate change creates a legitimacy gap for organizations, especially those in carbon-intensive industries (O'Donovan, 2002). Organizations disclose environmental information in response to social, environmental, political and economic pressure in order to gain, maintain or repair their licence to operate (Cho & Patten, 2007; Deegan, 2002; Dowling & Pfeffer, 1975). Extant legitimacy studies in environmental disclosure suggest that firms with poor environmental performance have a greater incentive to make more extensive offsetting (Patten, 1992; Woodward, Edwards, & Birkin, 1996), or less objective disclosures (Cho, Roberts, & Patten, 2010), in an attempt to bias the perceptions of the firm's stakeholders on the environmental performance, rather than to genuinely reduce the damage to the environment and society (Aerts & Cormier, 2009; Brammer & Pavelin, 2006; Meyer & Rowan, 1977; Molecke & Pinkse, 2020). Furthermore, firms have been criticised for taking greenwashing strategy by overemphasizing the positive aspects of their environmental records to mask their decoupled performance (Bowen, 2014).

However, greenwashing studies suggest that there are significant risks to this strategy because information disclosed by firms are subject to stakeholders' monitoring (Lyon & Maxwell, 2011; Marquis & Qian, 2013). In addition, firms in more stakeholder-oriented countries, such as the UK, face more stakeholder scrutiny and therefore produce more substantive CSR disclosures (Dhaliwal et al., 2014; Palazzo & Scherer, 2006). We argue that both symbolic and substantive CSR information collectively make the disclosure more plausible and satisfy the needs of regulators, investors, employees and customers. Since the expectations of society change over time (Deegan, 2002), legitimacy is a dynamic process which forms a constraint on behaviours (Dowling & Pfeffer, 1975). de Villiers and van Staden (2006) suggest that an organization will adjust the extent (upwards or downwards) and the type (general or specific) of social and environmental disclosure to meet changing social expectations and to maintain its legitimacy. Different from one-off legitimacy repairing strategy, corporate carbon disclosure is evolving by 'recognize(ing) audience reactions and foresee(ing) emerging challenges' (Suchman, 1995, p. 595) in order to maintain organizational legitimacy. Organizations involve 'more and more processes of active justification' (Palazzo & Scherer, 2006, p. 72) and start to provide detailed information about their carbon strategies, including reduction technologies, practices and performance, to rationalize their decisions on carbon-related activities (Kolk & Pinkse, 2008). Therefore, we



propose that carbon disclosure in corporate annual reports could be a long-term corporate carbon strategy for maintaining legitimacy. We extend the knowledge of CSR disclosure as a process of legitimacy making via deliberative communication with collective actors, rather than simply strategic manipulation (pragmatic level) (Suchman, 1995) or taken-for-grantedness (cognitive level) (Meyer & Rowan, 1977).

Taken together, in response to the increased social concern over climate change and carbon emissions, we argue that carbon-sensitive firms will be expected to utilize more disclosures (as a communicative legitimacy process) to make sense of their past carbon behaviours and performance, as well as the outlook on future carbon opportunities and risks. We posit:

**Hypothesis 2.** There is a positive relationship between corporate carbon emissions and corporate carbon disclosure.

### 2.2.3. Carbon disclosure as an organizational resource

The extant organizational legitimacy studies have less investigated the impact of carbon disclosure on organizational performance. Prior studies have mainly concentrated on how firms with poor environmental performance simply use disclosure to project a more socially acceptable environmental management approach to public stakeholders (Cho & Patten, 2007; Lewis, Walls, & Dowell, 2014; Reid & Toffel, 2009), but less attention has been paid to study the effect of the environmental disclosure (i.e., how disclosure, as an operational resource, contributes to organizational performance). The organizational view of legitimacy theory suggests that 'Corporations consider these (social and environmental) rules and the expectations of powerful stakeholder groups as economic restrictions in their course towards maximizing profits. Legitimacy is thus considered as a resource to guarantee the corporation's continued existence' (Palazzo & Scherer, 2006, p. 72). When facing exposure to the social and political pressure through which legitimacy is monitored and bestowed, firms will adopt particular strategies to buffer and protect their core business functions or economic activities (Haque & Ntim, 2020; Patten, 1992; Woodward et al., 1996). Legitimacy is regarded as an organizational capability (Pfeffer & Salancik, 1978) and its outcome is linked with organizational performance (Czarniawska-Joerges, 1989; Dowling & Pfeffer, 1975). For example, investors tend to reward firms with carbon disclosure as a way of legitimization (Haque & Ntim, 2020; Kim & Lyon, 2011) and penalize non-disclosing behaviours (de Villiers & Marques, 2016; Matsumura et al., 2014). From resource-based view, once a business activity is identified as a potential resource or capability, it should have a positive effect on performance (Godfrey & Hill, 1995; Hitt, Keats, & DeMarie, 1998). Hence, we propose that superior capability of corporate carbon disclosure is an organizational resource, which will have a positive impact on performance. Based on the discussion above, the hypothesis is stated as follows:

**Hypothesis 3.** There is a positive association between corporate carbon disclosure and organizational performance.

### 2.2.4. Organizational legitimacy effect – the mediating role of corporate carbon disclosure

The direct relationship between carbon emissions and organizational performance has been examined by many extant studies (Clarkson, Li, Pinnuck, & Richardson, 2014; Griffin et al., 2017; Liesen et al., 2017; Matsumura et al., 2014), but they yield imprecise results. Recent research points out that disclosure may play a moderating or mediating role in the relationship between environmental performance and organizational performance (e.g. Brooks & Oikonomou, 2018; Sharfman & Fernando, 2008). We propose that carbon disclosure, as a communicative legitimacy process and key organizational resource, could incorporate institutional beliefs and organizational efficiency. As we discussed in the previous three hypotheses, climate change issues create legitimacy gap for organizations, and firms with poor carbon performance are under greater public pressures which threaten their survival

or growth (Chelli et al., 2014; Haque & Ntim, 2020; Molecke & Pinkse, 2020). They legitimize their carbon behaviours by increasing carbon disclosure (de Villiers & van Staden, 2006; Talbot & Boiral, 2018), indicating the fundamental resource and an organizational capability, which has a positive impact on organizational performance (Haque & Ntim, 2020). As such, we further predict that carbon disclosure is a potential mediating factor on the relationship between carbon emissions and organizational performance, which has an important value-protective attribute. Firms making more carbon disclosures are likely to offset the impact of their poor carbon performance as stakeholders penalize them less for the carbon emissions. Given the above discussion, we posit:

**Hypothesis 4a.** Carbon disclosure mediates the association between carbon emissions and organizational performance.

The UK is one of the few countries that has mandated corporate carbon disclosure. In 2013, mandatory carbon reporting was enacted by the UK government under the Companies Act 2006 (Strategic and Directors' Reports) Regulations (hereafter the 2013 Regulation). This regulation states that UK listed companies are required to report their carbon emissions in the directors' report section of their annual reports. The main purposes were to communicate publicly the information about corporate carbon emissions and encourage companies to set targets to reduce emissions in the future. The mandate is expected to increase the level of visibility of carbon sensitive firms to their stakeholders and to the public and improved reporting plays a critical role to reduce carbon emissions, as emphasized in the 2021 United Nations Climate Change Conference (also known as COP26) and in the latest UK Net Zero Strategy (HM Government, 2021). It is therefore of great significance to assess the capability of carbon disclosure in the corporate reports of the UK listed companies, pre- and post- the mandate, most especially, these companies may also change their voluntary reporting practice in response to the mandatory disclosure regulation. Government regulation can motivate firms to further adjust the extent and type of their CSR disclosures (Reid & Toffel, 2009). Unerman, Bebbington, and O'dwyer, B. (2018) suggest that the impact of such an externality (i.e., mandatory requirements) also improves the capability of disclosure. Hence, mandatory disclosure regulation enables firms to better address the needs of stakeholders and enhances their legitimacy (Hoepner, Majoch, & Zhou, 2019; Ioannou & Serafeim, 2019; Li, Huang, Ren, Chen, & Ning, 2018). More importantly, high transparency and performance comparability in the reports achieved will help improve the visibility of carbon performance (Qian & Schaltegger, 2017; Tomar, 2023) and the legitimizing effect of disclosures will become more pronounced. For example, Ioannou and Serafeim (2019) compare the CSR disclosures of firms from four countries (China, Denmark, Malaysia and South Africa) under the mandatory CSR disclosure regulations and find that the significant increases in volume and quality of CSR disclosures is value enhancing. Existing studies also observe significant carbon reduction following the mandate of carbon reporting (Downar et al., 2021; Jouvenot & Krueger, 2019; Tomar, 2023). Therefore, with the introduction of a mandatory carbon disclosure scheme, there is increased social expectation and pressure from the governments and policymakers. It can be inferred that there will be a significant increase in the capability of carbon disclosure post-2013 Regulation, which provides a more legitimizing effect. This leads to the following hypothesis:

**Hypothesis 4b.** The mediating effect of carbon disclosure is more pronounced following the introduction of the 2013 carbon reporting regulation.

## 3. Methods

### 3.1. Sample selection

We employ the annual reports and standalone CSR reports of 62

carbon-sensitive FTSE 100 firms in the UK during the period 2010–2017, which covers the four immediate years pre and 2013 Regulation.<sup>1</sup> We first define carbon-sensitive industries by identifying the industries with firms that are Carbon Trading Operator Account Holders in the European Union Emissions Trading Scheme.<sup>2</sup> An Operator Holding Account will be created for the operators of installations that hold greenhouse gas emissions permits and that are included in the list of installation allocations published in conjunction with the approved National Action Plan. The Account will be closed if the holder ceases to be the operator of an installation. The carbon emissions from those installations constitute the main sources of the UK inventory. Therefore, industries that have Account Holders operating in them are more carbon sensitive and, their carbon emissions and related activities are closely monitored by the government and the general public. Since carbon emissions disclosure may not be relevant to all industries and could lead to mixed results in terms of their influence on organizational performance (Apaydin, Jiang, Demirbag, & Jamali, 2021; Pinkse & Kolk, 2007), we consider only industries that have Account Holders operating in them as carbon-sensitive industries. The carbon-sensitive industries identified include: utilities, travel, energy, mining, manufacturing, aerospace goods and health care. We then select firms operating in carbon-sensitive industries from the FTSE 100 index as our sample. FTSE 100 companies are subject to the mandatory carbon reporting regulation and represent potential leaders for private sector adaptation in the UK (CDP, 2012a). Moreover, larger companies have more visibility and exposure to their stakeholders and the public, and more capability to disclose their carbon activities to increase the sustainability of competitive actions (Ferguson, Deephouse, & Ferguson, 2000). Therefore, they constitute an ideal sample for carbon reporting studies (Tang & Demeritt, 2018). The sample firms of the current study will therefore be more concerned with carbon emissions issues and are consequently expected to be more willing to release carbon data to the public to demonstrate the legitimacy of their operations (Dowling & Pfeffer, 1975).

### 3.2. Variable measurements

#### 3.2.1. Carbon emissions

We downloaded annual total carbon emissions from Thomson Reuters ASSET4 on DataStream for the sample period 2010–2017. The ASSET4 database provides objective, relevant and systematic corporate Environmental, Social and Governance (ESG) performance information, and it contains >750 data points, including all exclusion (ethical screening) criteria and all aspects of sustainability performance. We use the CO<sub>2</sub> Equivalent Emissions Total due to data availability (Baboukardos, 2017).

#### 3.2.2. Carbon disclosure

This paper constructs a comprehensive 42-item disclosure index to content analyze corporate carbon-related disclosure (Abbott & Monsen, 1979). Despite the existence of carbon reporting initiatives such as CDP, the Global Reporting Initiative (GRI) and the Department for Environment, Food and Rural Affairs (DEFRA), carbon emissions reporting is not standardized and is largely inconsistent across firms. Even leading firms from the most environmentally sensitive industries make vague emissions disclosure, with unexplained figures and inconsistent methodologies (Depoers, Jeanjean, & Jérôme, 2016). This is potentially troubling;

the incomparability across firms can limit the ability of stakeholders to accurately assess differences in carbon performance (Liesen et al., 2015). Employing the index as a benchmark to assess the extent of carbon reporting would eliminate the above issue and provide comparable reporting indicators among firms.

The index closely follows existing carbon accounting and reporting regulations and guidelines such as CDP (2012a, 2012b, 2020), the GRI (2011, 2013, 2016), the (World Business Council for Sustainable Development (WBCSD) and World Resource Institute (WRI, 2004), the mandatory carbon emissions reporting guidance (DEFRA, 2013) and carbon accounting and management literature (e.g. Bebbington & Larinaga-González, 2008; Burritt, Schaltegger, & Zvezdov, 2011; Cook, 2009; Haque & Deegan, 2010; Haque, Deegan, & Inglis, 2016; Haque & Ntim, 2020; Hopwood, 2009; Kolk, Levy, & Pinkse, 2008; Lohmann, 2009; Peters & Romi, 2009; Ratnatunga & Balachandran, 2009), which represents the mainstream requirements and expectations of corporate carbon information required by society and stakeholders. The index contains both general carbon reduction information and specific carbon reduction strategy and performance information, which reflects the extent of carbon information that is expected from corporate annual reports and standalone reports. Furthermore, the index considers the context of disclosure. For example, a firm will receive an additional score if it discloses its low-carbon strategy in the CEO/Chairman's reports, since the information disclosed here is highly focused on the most important agenda and performance of a firm and, therefore, more likely to impress the key stakeholders (and is also emphasized in the 2013 Regulation). In line with the requirements, the index concerns the normalizing factors in reporting. For instance, firms receive scores for disclosing their absolute emissions and additional scores if they disclose their emissions intensity ratio. This is because this information allows stakeholders to gauge the environmental impact firms have relative to a given number of indicators (such as products and/or services) and it also facilitates comparison over time and across different organizations.

We further break down the items into three themes: engagement and strategy, risk and opportunity and measurement and performance. More importantly, we categorize the items by disclosure form (quantitative and qualitative disclosure), disclosure channels (corporate annual reports and CSR reports) and disclosure requirements (mandatory and voluntary disclosure). Mandatory disclosure includes those items that mandated in the 2013 Regulation.<sup>3</sup> To quantify the extent of disclosure, a score of '1' is awarded to each item in the index when the information is disclosed; otherwise, a score of '0' is given. There are 42 items in the index and the total score ranges from 0 to 42.

Table 1 reports a summary of carbon emissions disclosure score in absolute value by legal regime, channel, format, theme and their trends during the period 2010–2017. Panel A shows the summary of carbon disclosure by category and Panel B illustrates the result of the non-parametric trend analysis (Cuzick, 1985). We first report two types of disclosure regimes: mandatory and voluntary disclosures in columns (1) and (2) respectively. The main channels of disclosure include the corporate annual report (column (3)) and the corporate social report (column (4)). We also display two formats of disclosure: quantitative disclosure (column (5)) and qualitative disclosure (column (6)). Columns (7–9) show three disclosure themes: engagement and strategy, risk and opportunity, and measurement and performance. The last two columns report the total disclosure score and the number of firm-year observations. The trend analysis results show that all categories of carbon disclosure have improved since 2013, indicating an upward trend of firm carbon emissions disclosure following the introduction of disclosure legislation. However, we note that while voluntary disclosure is on average slightly higher than mandatory disclosure, the latter is much less volatile than the former, especially after 2013.

<sup>1</sup> We lose some sample firms because they were either delisted from LSE or were being merged as a new firm between 2013 and 2017.

<sup>2</sup> Carbon Operator Holding Accounts are recorded by the European Commission in the European Union Transaction Log: <http://ec.europa.eu/environment/ets/welcome.do?languageCode=en>. The database is the most authoritative database of current carbon account holders and carbon transactions, and implements the requirements of the European Commission and the United Nations Framework Convention on Climate Change (UNFCCC).

<sup>3</sup> The mandatory disclosure before 2013 means firms voluntarily reported those type of information before they became mandate in the 2013 Regulation.

**Table 1**  
Summary statistics of the carbon disclosure index.

Year		Panel A: Summary of carbon disclosure by category									Total disclosure	Obs	
		Disclosure regime		Disclosure channel		Disclosure format		Disclosure theme					
		Mandatory	Voluntary	Annual report	Corporate social report	Quantitative disclosure	Qualitative disclosure	Engagement and strategy	Risk and opportunity	Measurement and performance			
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	
2010	Mean	4.17	5.19	11.59	8.66	3.95	12.00	3.11	5.21	7.61	15.95	61	
	St. d	2.85	2.55	6.24	11.39	3.00	5.88	1.24	3.14	5.06	8.29		
2011	Mean	4.47	5.20	12.65	9.18	4.45	12.50	3.32	5.56	8.05	16.95	62	
	St. d	2.77	2.48	6.36	11.42	2.85	5.95	1.29	2.93	5.08	8.08		
2012	Mean	4.53	5.36	13.37	9.48	4.60	13.08	3.26	5.92	8.50	17.68	62	
	St. d	2.57	2.46	6.49	11.51	2.74	5.53	1.14	2.82	4.84	7.52		
2013	Mean	6.14	13.57	16.46	8.76	5.19	14.46	3.22	4.86	11.56	19.64	59	
	St. d	2.33	5.07	6.88	10.87	2.41	4.80	1.42	2.68	4.31	6.41		
2014	Mean	7.39	14.63	18.80	10.22	6.14	15.78	3.42	4.97	13.47	21.92	59	
	St. d	1.50	4.88	5.82	11.25	1.74	4.44	1.46	2.74	2.67	5.35		
2015	Mean	7.52	15.34	19.49	11.07	6.42	16.25	3.44	5.24	14.02	22.68	59	
	St. d	1.31	4.86	6.09	11.67	1.65	4.31	1.39	2.87	2.56	5.11		
2016	Mean	7.29	15.48	19.63	11.42	6.37	16.15	3.39	5.76	13.41	22.53	59	
	St. d	2.02	5.60	7.11	12.41	2.20	5.36	1.47	2.93	3.90	6.90		
2017	Mean	7.07	15.89	19.58	11.67	6.82	16.05	3.44	5.96	13.54	22.88	57	
	St. d	2.26	6.34	8.30	12.81	2.47	6.08	1.75	3.43	4.27	8.06		
Panel B: <a href="#">Cuzick (1985)</a> trend analysis													
Trend analysis (2010–2012)		Mean	z-value	0.85	0.43	1.73	0.34	1.40	0.96	0.89	0.99	1.58	1.36
			Prob> z	0.98	0.665	0.083	0.73	0.163	0.337	0.373	0.32	0.113	0.174
Trend analysis (2013–2017)		Mean	z-value	2.44	2.41	3.23	1.35	4.10	2.16	0.85	3.12	2.18	3.12
			Prob> z	0.015	0.016	0.001	0.178	0.000	0.031	0.395	0.002	0.029	0.002
Trend analysis (2010–2017)		Mean	z-value	9.92	14.64	10.07	1.94	8.46	6.39	1.51	0.97	10.72	7.85
			Prob> z	0.000	0.000	0.000	0.052	0.000	0.000	0.131	0.330	0.000	0.000

This table reports the summary of carbon emissions disclosure by legal regime, channel, format and theme during the period 2010–2017. We first report two types of disclosure regimes: mandatory and voluntary disclosures in columns (1) and (2) respectively. The main channels of disclosure include the corporate annual report (column (3)) and the corporate social report (column (4)). We also display two formats of disclosure: quantitative disclosure (column (5)) and qualitative disclosure (column (6)). Columns (7–9) show three disclosure themes: engagement and strategy, risk and opportunity and measurement and performance. The last two columns report the total disclosure score and the number of firm-year observations. Panel A shows the summary of carbon disclosure by category and Panel B illustrates the result of the non-parametric trend analysis.

Fig. 1 reports the changes in the relative value of carbon disclosure<sup>4</sup> by category for 2010–2017. Regarding the legal regimes of disclosure, it can be seen that, on average, the percentage of voluntary disclosure increased sharply in 2013 and then continued to grow, but slowly, in the years that followed. The rate of mandatory disclosure rose slightly in 2013 and has remained steady in the following years. When we look at the channels of disclosure, it shows that firms often choose to disclose more carbon information in their annual report than the CSR report. Fig. 1 also illustrates that qualitative disclosure rate is twice as high as the quantitative disclosure rate. Turning to disclosure by theme, Fig. 1 suggests that it varies between themes. Firms tend to disclose more measurement and performance-themed information after 2013, followed by engagement and strategy-themed information. Under the measurement and performance theme, in addition to the disclosure of the amount of corporate carbon emissions, firms provide more detailed information on the methodologies and the consolidation approach they use for the measurement, and baseline year in their carbon reporting. For example, BP mentioned that ‘Our GHG KPI encompasses all BP’s consolidated entities as well as our share of equity-accounted entities other than BP’s share of TNK-BP and Rosneft for the relevant periods’ (BP, 2016, p. 19) and ‘Our approach to reporting GHG emissions broadly follows the IPIECA/API/IOGP Petroleum Industry Guidelines for Reporting GHG Emissions’ (BP, 2016, p. 43). In addition, most of the sample firms provided detailed explanations for their carbon emission

performance and disclosed that their carbon emission information has been verified by professional third parties. For instance, ‘The increase in our reported emissions is primarily due to operational variations such as returning to normal operations after planned shutdowns and start-up activities in Canada and Angola’ (BP, 2016, p. 19). Before the mandate, many firms disclosed the amount of their emissions without any explanation, while post the mandate, firms tried to sense-making of their disclosure by providing comprehensive information, such as the methodologies and benchmarks they use for their emission measurement and reporting. Looking closely, we find that this sharp increase is mainly attributed to the absolute quantitative disclosures of direct carbon emissions, growing by 50% in 2013, which indicates organizations recognize their exposure to the new reporting mandate and pursue strategies to minimize such exposure to the compliance risks. Under the risk and opportunity theme, most firms recognize and analyze the relevant risks and opportunities associated with carbon emissions and climate change on top of the generic discussion of their carbon reduction strategies. Examples include ‘Transition to a lower carbon and digitally enabled future – we are pursuing and developing new offers and products that support the transition to a lower carbon and digitally enabled future over the long term’ (BP, 2016, p. 30) and ‘To help anticipate greater regulatory requirements for GHG emissions, we factor a carbon price into our own investment decisions and engineering designs for large new projects and those for which emissions costs would be a material part of the project’ (BP, 2016, p. 43). More comprehensive disclosure could deliver information under different themes and therefore gain more scores. Overall, we find more detailed information, both qualitative and quantitative, is disclosed in firms’ annual reports.

<sup>4</sup> The relative value of carbon disclosure for each category is obtained using the score for a type of carbon disclosure divided by the total score for that type.



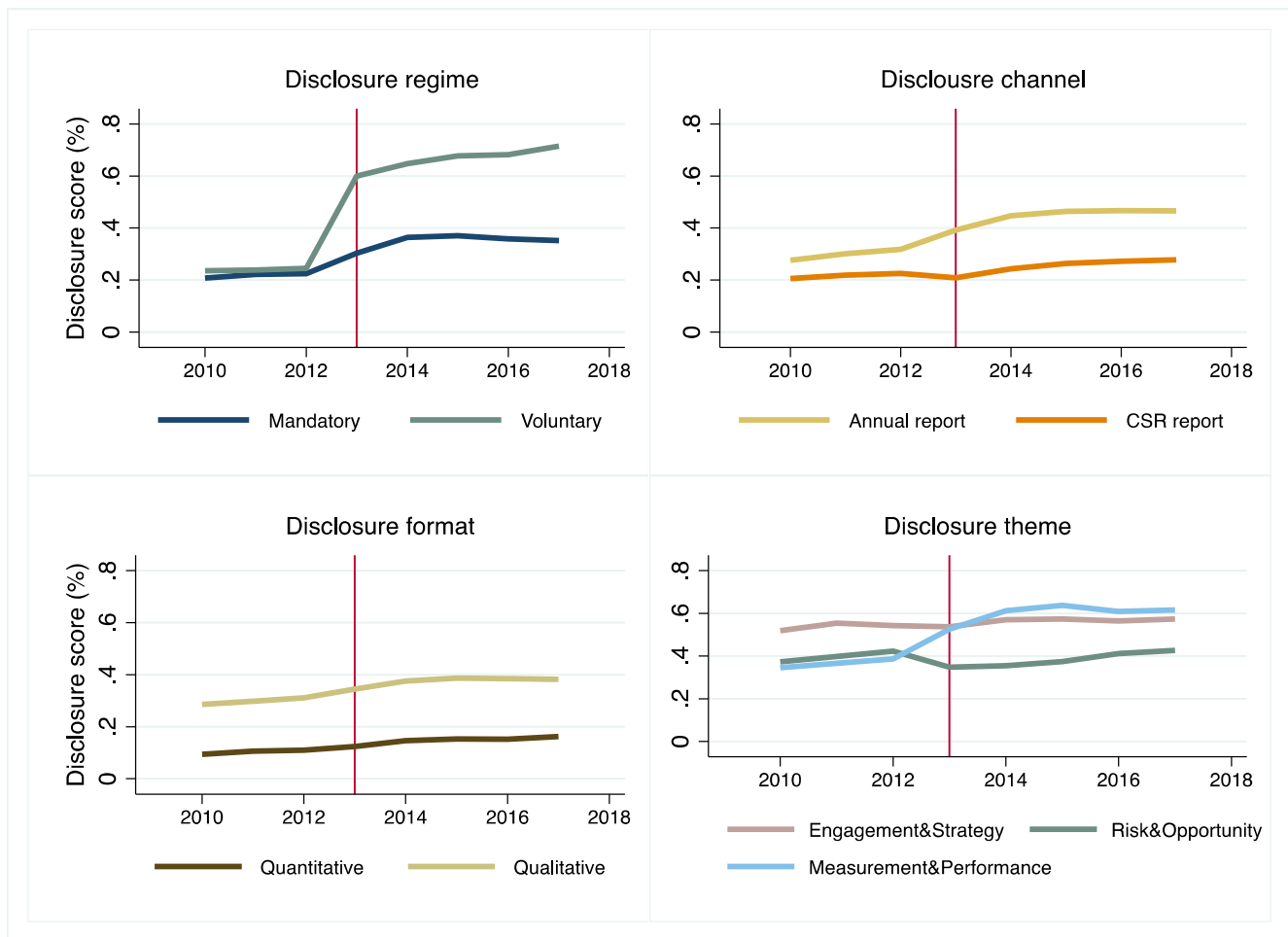


Fig. 1. Carbon emissions disclosure trend by regime, channel, format and theme.

Although firms have been criticised that their environmental disclosures are largely symbolic and do not necessarily reflect their actual environmental performance, our content analysis reveals that carbon disclosures are not only symbolic or substantive, but also strategic driven to achieve the goal of communication to their stakeholders. The disclosures reflect firms' capability and readiness to deal with climate change issues and to meet the regulatory requirements.

### 3.2.3. Organizational performance

Following previous studies on the influence of CSR on organizational performance (Busch & Hoffmann, 2011; Haque & Ntim, 2020; Nekhili, Nagati, Chtioui, & Rebolledo, 2017), we use Tobin's Q to measure the market's assessment of a firm's future cash flows based on current and future information. Tobin's Q is a mix of market-based and accounting-based measure (Lindenberg & Ross, 1981; Tobin & Brainard, 1977) and reflects reputational effects, investor trust, and investor risk (Busch & Hoffmann, 2011; Tobin & Brainard, 1977). Following Chung and Pruitt (1994) and King and Lenox (2001), Tobin's Q is calculated as:

$$\text{Tobin's } Q = \frac{MV + Debt}{TA}$$

Where MV is the market value of common equity. Debt is the book value of long-term debt and current liabilities. TA is the book value of total assets. All the mentioned variables are collected from Thomson Reuters Datastream.

### 3.3. Empirical model and tests

Two-level mediational modelling is designed to test mediating effects in clustered datasets, and it can accommodate independent and mediator variables measured in the longitudinal data. The three variables of interest – the independent variable ( $Emissions_{j,t-1}$ ), the mediator or mediation variable ( $Disclosure_{j,t-1}$ ) and the dependent variable ( $Organizational\ performance_{j,t}$ ) – are all measured at firm-year level. Carbon emissions performance in previous years relates to carbon disclosure during that same year, which in turn associates with organizational performance in the current year. It should also be noted that there is a direct relationship between  $Emissions_{j,t-1}$  and  $Organizational\ performance_{j,t}$  – that is, the direct effect of carbon emissions on organizational performance. The reason to lag the variables is to account for the potential existence of a contemporaneous, bidirectional association between carbon emissions, carbon disclosure and organizational performance. In addition, the market participants need time to process accounting disclosure and incorporate it in the analysis or investment decision-making at the next stage (Busch & Hoffmann, 2011; Clarkson, Li, Richardson, & Vasvari, 2010).

The control variables ( $Controls_{j,t-1}$ ) are firm characteristics at year  $t - 1$  that could potentially influence organizational performance at year  $t$  to avoid reverse causality (Desai, 2012). Following the previous literature (Busch & Hoffmann, 2011; Clarkson et al., 2010; Shaikat & Trojanowski, 2018), we control for size, leverage, capital intensity, intangible assets, growth, market-to-book value (MTBV), year and sector effects. We use the logarithm of market value to measure firm size. Leverage is measured as the ratio of total debt to common equity. Capital

intensity is defined as capital expenditure divided by sales. We use the ratio of intangible assets to total assets to capture the effect of firm strategy and advertising. Growth is the percentage change in sales. The MTBV is measured as the market value divided by the balance sheet value of ordinary equity in the firm.

Control variables ( $Controls_{j,t-2}$ ) are firm characteristics in year  $t - 2$  that could affect carbon disclosure in year  $t - 1$  (Clarkson et al., 2010). We follow the earlier environmental reporting literature (Cho & Patten, 2007; Clarkson et al., 2010) and control for size, sales, leverage, capital intensity, MTBV, return on assets (ROA) and intangible assets.

The two-year lagged disclosure ( $Disclosure_{j,t-2}$ ) is also included as a control variable. The symbols alongside each arrow correspond to the relationship of carbon emissions performance to carbon disclosure,  $\beta_a$ ; the relationship of carbon disclosure to organizational performance,  $\beta_b$ ; and the relationship of carbon emissions to organizational performance,  $\beta_c$ . The relationship of carbon emissions to organizational performance has a prime,  $\beta_c$ , to reflect adjustment for the mediating variable.

A two-level model is considered in which the subscript  $t$  refers to the within-firm level (level 1) and the subscript  $j$  refers to the across-firm level (level 2). The  $j$  and  $t$  subscripts show that the variables can take on a unique value for each year observation  $t$  within firm  $j$ . It is hypothesized that the previous year's ( $t - 1$ ) carbon emissions and carbon disclosure affect the current year's ( $t$ ) organizational performance. Following this hypothesis and the notation of Krull and MacKinnon (2001) and Kenny, Korchmaros, and Bolger (2003), a two-level mediation model is depicted with the following two equations. The two-level mediation estimation includes (1) a regression equation predicting organizational performance based on the previous year's carbon emissions and the carbon disclosure variable, and (2) a regression equation predicting carbon disclosure from carbon emissions performance.

$$\begin{aligned} (1) \text{ Level 1: } Tobinsq_{j,t} &= \beta_{0j} + \beta_c Emissions_{j,t-1} + \beta_b Disclosure_{j,t-1} + \beta_2 Controls_{j,t-1} + \epsilon_{j,t} \\ \text{Level 2: } \beta_{0j} &= \gamma_{00} + \mu_{0j} \\ (2) \text{ Level 1: } Disclosure_{j,t-1} &= \beta_{0j} + \beta_a Emissions_{j,t-1} + \beta_4 Disclosure_{t-2} + \beta_5 Controls_{j,t-2} + \omega_{j,t-1} \\ \text{Level 2: } \beta_{0j} &= \gamma_{00} + \mu_{0j} \end{aligned}$$

Where  $Emissions_{j,t-1}$  is the independent variable observed for firm  $j$  in year  $t - 1$ ,  $Disclosure_{j,t-1}$  indicates carbon disclosure and is the mediator observed for firm  $j$  in year  $t - 1$ , and  $Organizational\ performance_{j,t}$  is the dependent/outcome variable observed at year  $t$  for firm  $j$ .  $Controls_{j,t-2}$  is the control variable observed in year  $t - 2$  for regression equations predicting carbon disclosure and  $Controls_{j,t-1}$  is the control variable observed in year  $t - 1$  for regression equations predicting organizational performance. The two-year lagged disclosure ( $Disclosure_{j,t-2}$ ) is considered to be control variables in regressions (2). This set of equations includes a within-firm level (level 1) equation and an across-firm-level equation (level 2).

The intercept term ( $\beta_{0j}$ ) has been indexed by subscript  $j$ , which denotes that it is treated as a random intercept and varies across firm-level units. It equals the overall mean of the intercept ( $\gamma_{00}$ ) and a deviation from the mean for each across-firm-level unit ( $\mu_{0j}$ ). It is the second-level error term ( $\mu_{0j}$ ) that allows the two-level model to address the within-firm homogeneity of errors in the longitudinal data.

The slopes in level 1 of all three regressions  $\beta_c, \beta_a, \beta_b$  are path coefficients. The direct effect of carbon emissions (H1) on organizational performance controlling the mediator (carbon disclosure) is designated  $\beta_c$ , the effect of carbon disclosure on the dependent variable (H3) is designated  $\beta_b$  and the effect of carbon emissions on carbon disclosure (H2) is designated  $\beta_a$ . The product  $\hat{\beta}_a \hat{\beta}_b$  is a second point estimate of the mediated effect, which evaluates the extent to which carbon emissions affect carbon disclosure and the extent to which the carbon disclosure, in turn, affects organizational performance. The path coefficient is

measured by the standardized regression coefficient. It represents the change in the dependent variable for a one standard deviation change in the independent variable. The error term  $\epsilon_{ij,t-1}$  represents the part of the organizational performance that is not explained by its relationship with carbon emissions and carbon disclosure in regression (1). The error term  $\omega_{ij,t-1}$  indicates the part of carbon disclosure that is not explained by its relationship to carbon emissions in regression (2).

We employ the lagged structure of our research design where the outcome variables in year  $t$  are hypothesized to be affected by carbon emissions and disclosure in the previous year  $t - 1$ . Given the lagged research design and some missing values of organizational performance, we document 379 final firm-year observations for 62 firms during the period of 2010–2017 in the mediation analysis.

## 4. Empirical results

### 4.1. Descriptive statistics

The summary statistics for the variables are presented in Tables 2A and 2B. Panel A provides the observations, mean and standard deviation for the whole sample period and subsample period – pre and post the 2013 Regulation. It is worth noting that the mean of carbon disclosure increased greatly, and the disclosure variation decreased as indicated by the lower standard deviation after 2013.

Panel B breaks down the standard deviation, minimum values and maximum values across firms ('between') and over time ('within') for the independent variable (carbon emissions), mediation variable (carbon disclosure) and the outcome variable (organizational performance). The overall summary statistics of carbon disclosure suggest that the variation of distribution is moderate. The between-firm and within-firm standard deviations are very close, 5.42 and 5.34 respectively, indicating that the carbon disclosure changes across firms as much as over the sample period of 2010–2017. However, the distribution of carbon emissions shows a quite different pattern. The overall mean and standard deviation of carbon emissions (million tons) are 8.65 and 16.62 respectively, with a minimum value of 0.01 and a maximum value of 86, indicating that values of carbon emissions vary greatly. In addition, the dispersed distribution is largely caused by between-firm variation. The mean of organizational performance is 0.59, with a minimum value of 0.04 and a maximum value of 1.10. Its standard deviations across firms and within firms are 0.18 and 0.08 respectively, suggesting that organizational performance is much more dispersed between firms than over time. The control variables' descriptive statistics show that the Market to Book Value (MTBV) distribution is the most dispersed, whereas the size is the least variable.

Table 3 reports carbon disclosure (column 1), emissions (column 2), organizational performance (column 3) and market capitalizations (column 4) with industry breakdowns. Among those, the mining, energy and travel sectors, with 23 firms in total, account for 78% of all emissions, 34% of carbon disclosure and 30% of total market value. As revealed in Tables 2 and 3, carbon emissions and organizational performance vary significantly across sectors and over time and need to be treated carefully. Thus, we use sector-year adjusted carbon emissions and organizational performance in the latter analysis.

### 4.2. Analyzing the interrelationship

Fig. 2 depicts the hypotheses and the corresponding regression coefficients. The estimates are reported for the whole sample period (2010–2017) and following the introduction of the reporting regulations (2013–2017) in brackets, respectively (the detailed estimates are presented in Appendices). During the whole sample period, the direct effect of carbon emissions on firm sector-adjusted performance (hypothesis 1) is measured by  $\beta_c$  and estimated to be  $-0.1\%$  at a 10% significance level. This significance level increases to 5% after the carbon reporting

**Table 2A**  
Summary statistics of variables.

Variables	Obs			Mean			St.d		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(8)
Variables of interest	2010–2017	2010–2012	2013–2017	2010–2017	2010–2012	2013–2017	2010–2017	2010–2012	2013–2017
Carbon disclosure	478	185	293	19.96	16.86	21.92	7.96	7.69	6.51
Carbon emissions	555	244	311	8.65	8.55	8.73	16.57	16.64	16.68
Tobin's Q	580	240	340	0.59	0.57	0.61	0.19	0.19	0.19
Control variables									
Log (MV)	612	240	372	9.10	9.13	9.23	1.16	1.16	1.22
Leverage	574	244	330	0.97	0.96	1.22	1.37	1.32	1.63
Capital intensity (%)	585	245	340	0.11	0.11	0.10	0.13	0.13	0.15
Intangible assets (%)	586	246	340	0.26	0.26	0.27	0.22	0.22	0.23
MTBV	592	232	360	3.15	3.06	0.86	5.37	5.83	51.32
Growth (%)	573	233	340	0.63	0.50	0.06	4.02	3.59	0.28
ROA (%)	580	244	336	8.55	8.13	6.27	7.01	6.91	8.08
Sales (log)	586	246	340	18.60	19.13	20.31	42.11	43.65	43.12

**Table 2B**  
Within- and between-firm summary statistics for the variables of interest.

Variables	Mean	St. d	Min	Max	Observation
CO <sub>2</sub> disclosure					
Overall	19.96	7.51	0	38	N = 478
Between	5.42	11	32.13	firm = 62	
Within	5.34	−1.04	33.59		
CO <sub>2</sub> emissions					
Overall	8.65	16.62	0.01	86	N = 478
Between	15.98	0.01	82.67	firm = 62	
Within	4.09	−12.09	27.84		
Organizational performance					
Overall	0.59	0.19	0.04	1.10	N = 478
Between	0.18	0.08	0.93	firm = 62	
Within	0.08	0.16	0.94		

**Table 3**  
Summary of carbon disclosure and emissions and organizational performance by industry.

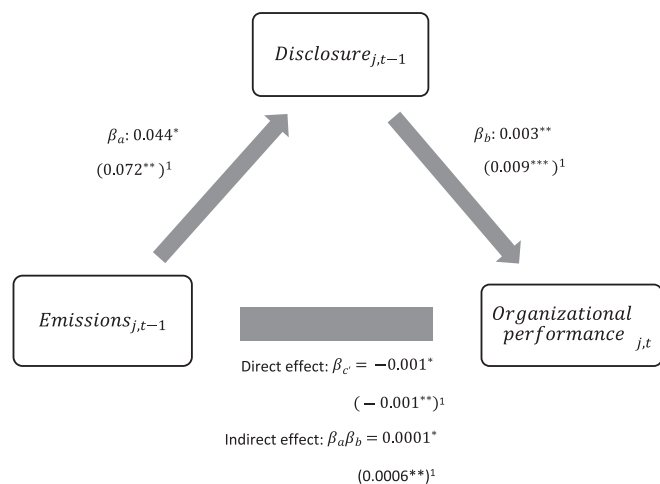
Sector	CO <sub>2</sub> disclosure	CO <sub>2</sub> emissions (million tons)	Organizational performance	Log (MV)	No. of firms
(1)	(2)	(3)	(4)	(5)	
Utilities	25.55	7.37	0.82	9.19	5
Travel	25.52	15.25	0.62	8.60	3
Energy	22.10	27.75	0.60	9.66	6
Mining	20.94	18.24	0.48	9.04	14
Manufacturing	19.20	3.29	0.59	8.51	6
Aerospace and defence	18.92	0.52	0.65	8.65	6
ICT	18.91	0.83	0.53	9.76	4
Consumer	17.38	1.49	0.59	9.99	9
Industrials	16.60	2.71	0.62	7.98	5
Health care	16.59	0.61	0.59	10.21	4
Number of firms					62

This table reports the mean of carbon disclosure and emissions, organizational performance and size by industry and it is sorted by carbon disclosure score.

legislation came into effect in 2013, indicating that carbon emissions have a negative and significant influence on sector-adjusted performance ( $\beta = -0.1\%$ ;  $p < 0.05$ ).

The path coefficient  $\beta_a$  indicates the effect of carbon emissions on carbon disclosure (hypothesis 2). The coefficient estimate is 4.4% at a marginal significance level for the whole sample period and this positive effect, and its significance, are particularly pronounced following the introduction of the firm-level carbon disclosure UK legislation ( $\beta = 7.2\%$ ;  $p < 0.05$ ). We can accept hypothesis 2.

The direct effect of carbon disclosure on the sector-adjusted perfor-



**Fig. 2.** Structural results for hypotheses testing for the whole sample period and post the introduction of reporting regulation 2013–2017.

<sup>1</sup> The results for post the introduction of reporting regulation 2013–2017.

Note: \*, \*\* and \*\*\* denote statistical significance at the 10%, 5% and 1% levels respectively.

mance is measured by  $\beta_b$  (hypothesis 3). This effect is 0.3% at a 5% significance level for the whole sample period. Once again, both effect and its significance level increase after the introduction of the 2013 Regulation. This result indicates that carbon disclosure is positively related to the sector-adjusted performance.

Hypothesis 4a proposes that carbon disclosure mediates the relationship between carbon emissions and organizational performance for the whole sample period. The results of  $\beta_a$  and  $\beta_b$  together suggest that carbon emissions affect carbon disclosure, which in turn affects organizational performance. This indirect effect of carbon emissions on organizational performance equals the effect of carbon emissions on carbon disclosure ( $\beta_a$ ) multiplied by the effect of carbon disclosure on organizational performance ( $\beta_b$ ), which is 0.01%. The total effect of carbon emissions on organizational performance equals the direct effect ( $\beta_c$ ) plus the indirect effect  $\beta_a\beta_b$ , and the result is  $-0.09\%$ .

In addition, we find that this mediating effect is most pronounced post the introduction of the mandatory reporting regulations in 2013, which supports hypothesis 4b. We notice that the indirect effect of carbon emissions on organizational performance increased to 0.06%. In turn, the total effect of carbon emissions on organizational performance is  $-0.04\%$ . Thus, carbon disclosure mediates the relationship between carbon emissions and organizational performance. Details of these estimates are reported in Table 4.

Furthermore, we investigate whether the mediation effect varies

**Table 4**

Main results of the two-level mediation model.

Panel A: CO <sub>2</sub> disclosure effect on organizational performance			
Dependent variable:	Sector-year adjusted organizational performance		
	2010–2017	2013–2017	2010–2012
	(1)	(2)	(3)
CO <sub>2</sub> disclosure ( $\beta_c$ )	0.003** (2.43)	0.009*** (4.68)	–0.002 (–0.99)
CO <sub>2</sub> emissions ( $\beta_b$ )	–0.001* (–1.66)	–0.001** (–1.96)	–0.001 (–1.49)
Log (MV)	0.016* (1.84)	–0.006 (–0.54)	0.049*** (3.59)
Leverage	0.114*** (14.79)	0.132*** (12.35)	0.101*** (9.87)
Capital intensity	–0.356*** (–5.43)	–0.323*** (–4.15)	–0.572*** (–5.38)
Growth	–0.028 (–0.94)	–0.007 (–0.18)	–0.110** (–2.33)
MTBV	0.003 (0.90)	–0.000 (–0.02)	0.003 (0.61)
Intangible assets	0.122*** (3.16)	0.119** (2.57)	0.109* (1.81)

Panel B: CO <sub>2</sub> emissions effect on CO <sub>2</sub> disclosure			
Dependent variable	CO <sub>2</sub> disclosure		
CO <sub>2</sub> emissions ( $\beta_a$ )	0.044* (1.71)	0.072** (2.80)	–0.009 (–0.19)
CO <sub>2</sub> disclosure (lagged)	0.572*** (15.81)	0.347*** (7.81)	0.805*** (15.18)
Log (MV)	1.540*** (5.39)	2.313*** (7.11)	0.805* (1.77)
Sales	–0.017* (–1.83)	–0.018* (–1.88)	–0.022 (–1.34)
Leverage	–0.126 (–0.79)	–0.128 (–0.79)	0.614* (1.84)
Capital intensity	–1.664 (–0.84)	–1.755 (–0.80)	1.174 (0.37)
MTBV	0.058 (0.63)	–0.056 (–0.55)	–0.030 (–0.19)
ROA	–0.072*** (–2.59)	–0.062* (–1.95)	–0.025 (–0.55)
Intangible assets	–0.190 (–0.16)	–0.421 (–0.33)	–2.113 (–1.04)
Year FE	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes
Obs	379	266	113

This table reports the mediating effect of carbon disclosure on the relationship between carbon emissions and firm financial performance for the whole sample period of 2010–2017, post and pre the introduction of carbon reporting legislation in 2013, in columns (1), (2) and (3) respectively. Panel A shows the direct effect of carbon emissions and total disclosure on organizational performance (sector-year adjusted); Panel B illustrates the carbon emissions (sector-adjusted) effect on carbon disclosure. In this analysis, we employ a lagged two-year structure of research design that the outcome variables-organizational performance in year  $t$  are hypothesized to be affected by carbon disclosure in year  $t - 1$ , which in turn is influenced by firm characteristics in year  $t - 2$ . \*, \*\* and \*\*\* denote statistical significance at the 10%, 5% and 1% levels respectively.

across disclosure regimes (mandatory and voluntary), carbon disclosure channels (annual reports and CSR reports), disclosure forms (quantitative and qualitative) and disclosure themes (engagement and strategy, risk and opportunity and measurement and performance). This is an important analysis; it indicates which aspects of carbon disclosures can yield the most effective results. The results are presented in Table 5. We find that while both disclosure regimes and disclosure forms are effective in influencing organizational performance following the introduction of the 2013. The size of effect is larger for mandatory and quantitative disclosures, where mandatory disclosure indicates the

conformation to the Regulation and the plausibility of the information and quantitative disclosure is to sensemaking firms' activities. Regarding the disclosure theme, the carbon disclosure mediation effect is most pronounced for the measurement and performance theme and the most effective disclosure channel is the annual report, whereas disclosure in the CSR report has no mediation effect, which indicates that the annual financial report provides the most visible channel for carbon disclosures and firms effectively take advantage of this channel to communicate to the capital market and their stakeholders and deliver the signal in their disclosures that they are ready to tackle the institutional dynamics and their capability to even go beyond the reporting requirement to differentiate themselves and turn the legitimacy threat into their competitive advantages.

To sum up, our analysis shows that organizational performance improves in the context of a mandatory carbon disclosure regime, which requires standardized information on carbon emissions to be disclosed in annual reports. We find that, to a certain extent, carbon disclosure exerts a mediation effect on the relationship between carbon emissions and organizational performance. This effect is mainly achieved by mandatory, qualitative, and measurement and performance-themed disclosure in annual reports.

#### 4.3. Endogeneity issues

We also addressed possible endogeneity biases, which can arise from unobserved heterogeneity, measurement errors and omitted variables. One approach to address unobserved heterogeneity is to include fixed effects in the model (Imbens & Wooldridge, 2009). In our regression, we control for fixed effects of year and sector to correct potential bias induced by unobserved sector year-specific effects. Additionally, we incorporate additional controls for dividend yield, profit margin, and earnings per share in the robustness test to address concerns about omitted variables. The results remain consistent and are reported in Appendix Table 2. Moreover, to deal with measurement errors, we employ industry-adjusted market return as an alternative proxy of firm performance and obtain consistent results.

To further alleviate endogeneity concerns, we also employ the GMM approach to account for possible endogeneity in the relationship between carbon emission disclosure and firm financial performance. The results of the GMM regression are reported in Table 6 and is consistent with our main regression results presented in Table 4. We also add the post hoc analyses using GEE by category, and the results (Table 7) are consistent with those reported in Table 5.

Furthermore, following (Jouvenot & Krueger, 2019), we employ the 2013 mandatory disclosure regulation in the UK as a natural experiment and utilize a difference-in-difference model to assess the impacts of carbon disclosure. We examine how UK public firms modify their policies<sup>5</sup> and financial expenditures on carbon emissions<sup>6</sup> in response to the 2013 mandatory reporting regulation in comparison to their European peers. Prior to the launch of mandatory carbon reporting in 2013, there are generally parallel trends between the two groups. This trend changed after 2013; the firms that are subject to the mandatory disclosure regulation have a higher level of environmental expenditures and emission policy than the European control firms that are not subject to the regulation. This finding supports our main result, which suggests that the effect of carbon disclosure becomes more pronounced after introducing the mandatory reporting regulations in 2013.

<sup>5</sup> It measures whether the company have a policy to improve emission reduction including processes, mechanisms, or programs in place as to what the company is doing to reduce emissions in its operations.

<sup>6</sup> It measures whether the company report on its environmental expenditures or the company report to make proactive environmental investments to reduce future risks or increase future opportunities.



**Table 5**  
Two-level mediation model results by category

Panel A: CO2 disclosure effect on organizational performance									
Dependent variable:	Sector-year adjusted organizational performance (2013–2017)								
	CO <sub>2</sub> disclosure requirement		CO <sub>2</sub> disclosure channel		CO <sub>2</sub> disclosure type		CO <sub>2</sub> disclosure theme		
	Mandatory	Voluntary	Annual report	CSR report	Quantitative	Qualitative	Engagement and strategy	Risk and opportunity	Measurement and performance
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CO <sub>2</sub> disclosure ( $\beta_c$ )	0.031*** (6.81)	0.006*** (2.59)	0.009*** (6.47)	−0.001 (−1.45)	0.022*** (4.96)	0.009*** (3.29)	0.014** (2.19)	−0.001 (−0.30)	0.016*** (5.79)
CO <sub>2</sub> emissions ( $\beta_b$ )	−0.002** (−2.55)	−0.001 (−1.52)	−0.001** (−2.17)	−0.001 (−1.32)	−0.001 (−0.84)	−0.002** (−2.13)	−0.001 (−1.51)	−0.001 (−1.43)	−0.001** (−1.97)
Panel B: CO <sub>2</sub> emissions effect on CO <sub>2</sub> disclosure									
Dependent variable	CO <sub>2</sub> disclosure requirement								
	CO <sub>2</sub> disclosure requirement		CO <sub>2</sub> disclosure channel		CO <sub>2</sub> disclosure type		CO <sub>2</sub> disclosure theme		
	Mandatory	Voluntary	Annual report	CSR report	Quantitative	Qualitative	Engagement and strategy	Risk and opportunity	Measurement and performance
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CO <sub>2</sub> emissions ( $\beta_a$ )	0.034*** (3.25)	0.036* (1.72)	0.045* (1.66)	0.051 (1.10)	0.019* (1.71)	0.056*** (2.94)	0.001 (0.16)	0.003 (0.24)	0.076*** (3.85)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	266	266	266	266	266	266	266	266	266

This table reports the mediating effect of carbon disclosure by legal regime, channel, format and theme during the period 2013–2017. We first report two types of disclosure regimes: mandatory and voluntary disclosures, in columns (1) and (2) respectively. The main channels of disclosure include the corporate annual report (column (3)) and the corporate social report (column (4)). We also display two formats of disclosure: quantitative disclosure (column (5)) and qualitative disclosure (column (6)). Columns (7–9) show three disclosure themes: engagement and strategy, risk and opportunity and measurement and performance. In this analysis, we employ a lagged two-year structure of our research design that the outcome variable—organizational performance in year  $t$  is hypothesized to be affected by carbon disclosure in year  $t-1$ , which in turn is influenced by firm characteristics in year  $t-2$ . \*, \*\* and \*\*\* denote statistical significance at the 10%, 5% and 1% levels respectively.

## 5. Discussion

This paper contributes to the literature in several ways. First, addressing the call for more management research on clarifying conceptual ambiguity of legitimacy theory (Deephouse & Suchman, 2008; Jahn and Brühl, 2019; Suddaby et al., 2017; Tornikoski & Newbert, 2007), we analyze the simultaneous association between corporate carbon emissions, the disclosure of carbon information and organizational performance through multiple perspectives of organizational legitimacy theory. Although a substantial body of legitimacy studies in environmental disclosure has examined how firms engage in using disclosure to either reduce institutional constitutive pressures (Ioannou & Serafeim, 2019; Li et al., 2018) from institutional perspective or address stakeholders' challenges (Cho et al., 2010; Patten, 1992; Woodward et al., 1996) from impression management perspective, less work has explored how organizations balance the conflicting expectations of different influential stakeholders and receive their support from resource-based view. Different from institutional theory, legitimacy theory is based on the opinion that organizations need to consider both institutional beliefs and organizational efficiency in order to guarantee their continued existence. Applying this concept allows us to explore the unique strategic phenomena from multiple perspectives, which distinguishes our study from the extant literature. Our two-level mediation analysis shows that corporate carbon emissions affect organizational performance through both direct and indirect mechanisms. For the direct impact, we find that corporate carbon emissions are negatively associated with organizational performance, indicating that stakeholders penalize less legitimate behaviours from institutional perspective. For the indirect impact, the results show that corporate carbon emissions are positively related to the carbon disclosures (i.e., firms with greater carbon emissions make more extensive disclosures) from

communicative legitimacy perspective. This, in turn, reduces the negative effect of carbon emissions on organizational performance from resource-based perspective.

Second, our study augments the debate on the financial implications of corporate carbon reduction by highlighting the mediating role of corporate carbon disclosure as a new dimension of this phenomenon. Existing studies, which focus on the corporate carbon emissions and financial performance link alone (e.g., Andreou & Kellard, 2021; Busch et al., 2022; Delmas and Montiel, 2009; Jouvenot & Krueger, 2019), find that firms have to undertake costly operational adjustments to achieve the reduction target and the cost saving from better carbon performance largely depend on savings from liability and compliance costs, which could barely be realized in the short term. Busch et al. (2022) and Delmas et al. (2015) find contradicting results with regards to the long-term financial impact of corporate carbon emissions. However, Downar et al. (2021) argue that corporate performance is not adversely affected by the carbon reduction activities, but they hardly provide an explanation on how and why firms can reduce the negative effects of carbon reduction activities. Our paper contributes to this argument and theoretically and empirically explains how UK firms employ carbon disclosure as an effective communicative legitimacy strategy to protect firm value. Although the climate change creates a legitimacy gap and carbon emissions adversely impact on corporate financial performance, firms employ comprehensive disclosure to communicate their carbon reduction strategy and sense-making their carbon activities in order to maintain the legitimacy and reduce the negative impact on the organizational performance.

Third, our paper complements existing carbon disclosure mandate studies (e.g., Downar et al., 2021; Jouvenot & Krueger, 2019). Both Downar et al. (2021) and Jouvenot and Krueger (2019) studies reveal that the 2013 Regulation had a real effect on corporate carbon emission

**Table 6**

Main results of the Generalized Estimating Equations (GEE) model.

Panel A: CO <sub>2</sub> disclosure effect on organizational performance			
Dependent variable:	Sector-year adjusted organizational performance		
	2010–2017	2013–2017	2010–2012
	(1)	(2)	(3)
CO <sub>2</sub> disclosure ( $\beta_c$ )	0.003** (2.15)	0.008*** (3.90)	−0.001 (−0.06)
CO <sub>2</sub> emissions ( $\beta_h$ )	−0.001*** (−2.67)	−0.001 (−1.54)	−0.002** (−2.05)
Log (MV)	0.021** (2.47)	−0.011 (−0.88)	0.045*** (3.60)
Leverage	0.072*** (14.02)	0.059*** (8.52)	0.087*** (9.41)
Capital intensity	−0.369*** (−5.83)	−0.293*** (−3.36)	−0.521*** (−6.12)
Growth	0.001 (0.51)	−0.025 (−0.61)	−0.000 (−0.01)
MTBV	0.002 (1.31)	0.012*** (2.95)	0.002 (1.05)
Intangible assets	0.099** (2.56)	0.159*** (3.11)	0.058 (1.05)

Panel B: CO <sub>2</sub> emissions effect on CO <sub>2</sub> disclosure			
Dependent variable	CO <sub>2</sub> disclosure		
CO <sub>2</sub> emissions ( $\beta_a$ )	0.044* (1.88)	0.073*** (3.01)	−0.009 (−0.19)
CO <sub>2</sub> disclosure (lagged)	0.602*** (16.90)	0.389*** (8.75)	0.805*** (15.18)
Log (MV)	1.362*** (4.96)	2.039*** (6.48)	0.805* (1.77)
Sales	−0.014 (−1.59)	−0.015 (−1.52)	−0.022 (−1.34)
Leverage	−0.021 (−0.14)	−0.097 (−0.65)	0.614* (1.84)
Capital intensity	−0.805 (−0.42)	−0.621 (−0.29)	1.174 (0.37)
MTBV	0.196*** (4.73)	0.138*** (3.42)	−0.030 (−0.19)
ROA	−0.080*** (−3.06)	−0.076** (−2.51)	−0.025 (−0.55)
Intangible assets	−0.386 (−0.33)	−0.674 (−0.53)	−2.113 (−1.04)
Year FE	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes
Obs	379	266	113

This table reports the mediating effect of carbon disclosure on the relationship between carbon emissions and firm financial performance using GEE approach for the whole sample period of 2010–2017, post and pre the introduction of carbon reporting legislation in 2013, in columns (1), (2) and (3) respectively. Panel A shows the effect of carbon emissions and total disclosure on organizational performance (sector-year adjusted); Panel B illustrates the carbon emissions (sector-adjusted) effect on carbon disclosure. In this analysis, we employ a lagged two-year structure of research design that the outcome variables—organizational performance in year  $t$ —are hypothesized to be affected by carbon disclosure in year  $t - 1$ , which in turn is influenced by firm characteristics in year  $t - 2$ . \*, \*\* and \*\*\* denote statistical significance at the 10%, 5% and 1% levels respectively.

reduction, but their findings of the economic effect are contradictory. Different from these two prior studies, which treat the mandate as external shock without assessing its impact on the comprehensive disclosure in corporate reports, we argue that corporate carbon disclosure plays a key mediating role in the corporate carbon management studies so it should not be ignored. Our study, thus, provides important insights into how carbon-sensitive firms engage in carbon disclosure as an organizational resource to offset the negative effect of carbon emissions on organizational performance and explains the heterogeneous

influence of carbon emissions on organizational performance evidenced in previous studies (e.g., Busch et al., 2022; Clarkson et al., 2014; Downar et al., 2021; Griffin et al., 2017; Jouvenot & Krueger, 2019; Matsumura et al., 2014).

Furthermore, our results reveal that corporate carbon disclosure for carbon-sensitive firms is not just a simple response to social forces and event, but also helps turn the legitimacy threat into an opportunity. We find that carbon-sensitive firms attempted to make more carbon-related disclosure, which is beyond the mandatory requirements and reflects an individual firm's value proposition and sensemaking processes. They employ disclosure to perceive future changes and protect their past accomplishments, such as investments in low-emission technologies or reduction plans; demonstrate the appropriateness of methods and goals, and compliance with major reporting frameworks; show they are working collaboratively with environmental practitioners and organizations in their value chain; evidence their investments in research, as well as other reputable initiatives, and so on. Although most of CSR scholars (Jahdi & Acikdilli, 2009; Kim & Lyon, 2011; Lyon & Montgomery, 2015) suggest that disclosure is mostly symbolic and simply corporate spin to gain legitimacy without providing any substantive information, Palazzo and Scherer (2006, p. 81–82) argue that ‘the challenge of communicative access to legitimacy is to engage in true dialogue, to convince others of the validity of one's arguments but not to persuade or manipulate by means of strategic instrumentalization’. Our study demonstrates that corporate carbon disclosure offers a powerful explanation of their carbon activities to the stakeholders and forms a communicative legitimacy process. Moreover, we argue that corporate carbon disclosure not only conforms to regulatory pressures but also differentiates organizational legitimacy performing to turn the legitimacy threat into competitive advantages. Since mandatory carbon disclosure becomes more congruent, firms tend to employ more voluntary disclosure to differentiate themselves. Our study provides important empirical evidence showing that carbon reporting regulation in the UK is effective at improving the capability of corporate carbon disclosure. Differing from studies of the US and China contexts, the study of the UK setting has greater implications for Commonwealth and other European countries, as well as for all countries considering the deployment of further regulations for carbon emission mitigation. Most importantly, the mandate of carbon reporting further strengthens the organizational legitimacy effect.

Last but not least, we construct a comprehensive 42-item corporate carbon disclosure index to complement previous studies (e.g., Kim & Lyon, 2011; Luo & Tang, 2016; Matsumura et al., 2014; Schiemann & Sakhel, 2018). This index takes us beyond the existing view of disclosure as either information asymmetry reduction (Al-Tuwaijri et al., 2004; Healy & Palepu, 2001) or self-interested manipulation (Cho et al., 2010; Talbot & Boiral, 2018). The comprehensive index allows us to firstly measure the capability of corporate carbon disclosure and then identify whether such capability is an organizational resource. In the prior studies, researchers face significant challenges in empirical testing of the resource-based view (Deephhouse, 2000; Hitt et al., 1998) as most valuable resources are difficult to measure Godfrey and Hill (1995). The existing corporate carbon disclosure studies (e.g. Kim & Lyon, 2011; Luo & Tang, 2016; Matsumura et al., 2014; Schiemann & Sakhel, 2018) only simplify the measure of carbon disclosure. They mainly use corporate response to a Carbon Disclosure Project (CDP) questionnaire as a proxy for disclosure – a 0 score for no response and a 1 otherwise. Following Godfrey and Hill (1995) and Hitt et al. (1998) 's suggestion, we offer a unique measure of resource by constructing a thorough 42-item corporate carbon disclosure index, identified from existing carbon accounting and reporting regulations, guidelines and important literature. Through the examination of a positive effect of disclosure on organizational performance, we provide an important empirical validation that corporate carbon disclosure can be seen as an organizational resource for communicative legitimacy.

**Table 7**  
Subsample results of Generalized Estimating Equations (GEE) model.

Panel A: CO <sub>2</sub> disclosure effect on organizational performance									
Dependent variable:	Sector-year adjusted organizational performance (2013–2017)								
	CO <sub>2</sub> disclosure requirement		CO <sub>2</sub> disclosure channel		CO <sub>2</sub> disclosure type		CO <sub>2</sub> disclosure theme		
	Mandatory	Voluntary	Annual report	CSR report	Quantitative	Qualitative	Engagement and strategy	Risk and opportunity	Measurement and performance
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CO <sub>2</sub> disclosure ( $\beta_c$ )	0.027*** (5.19)	0.006*** (2.29)	0.01*** (5.96)	−0.001 (−1.33)	0.021*** (4.37)	0.008*** (2.61)	0.017** (2.45)	−0.004 (−0.86)	0.015*** (4.92)
CO <sub>2</sub> emissions ( $\beta_b$ )	−0.001** (−2.55)	−0.001 (−1.52)	−0.001** (−2.17)	−0.001 (−1.32)	−0.001 (−0.84)	−0.001** (−2.13)	−0.001 (−1.51)	−0.001 (−1.43)	−0.001** (−1.97)
Panel B: CO <sub>2</sub> emissions effect on CO <sub>2</sub> disclosure									
Dependent variable	CO <sub>2</sub> disclosure requirement		CO <sub>2</sub> disclosure channel		CO <sub>2</sub> disclosure type		CO <sub>2</sub> disclosure theme		
	Mandatory	Voluntary	Annual report	CSR report	Quantitative	Qualitative	Engagement and strategy	Risk and opportunity	Measurement and performance
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CO <sub>2</sub> emissions ( $\beta_a$ )	0.036*** (3.49)	0.037* (1.83)	0.047* (1.75)	0.046 (1.05)	0.016 (1.42)	0.062*** (3.31)	0.001 (0.16)	0.003 (0.24)	0.079*** (4.12)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	266	266	266	266	266	266	266	266	266

This table reports the mediating effect of carbon disclosure by legal regime, channel, format and theme during the period 2013–2017. We first report two types of disclosure regimes: mandatory and voluntary disclosures, in columns (1) and (2) respectively. The main channels of disclosure include the corporate annual report (column (3)) and the corporate social report (column (4)). We also display two formats of disclosure: quantitative disclosure (column (5)) and qualitative disclosure (column (6)). Columns (7–9) show three disclosure themes: engagement and strategy, risk and opportunity and measurement and performance. In this analysis, we employ a lagged two-year structure of our research design that the outcome variable—organizational performance in year  $t$  is hypothesized to be affected by carbon disclosure in year  $t-1$ , which in turn is influenced by firm characteristics in year  $t-2$ . \*, \*\* and \*\*\* denote statistical significance at the 10%, 5% and 1% levels respectively.

## Data availability

Data will be made available on request.

## Appendix

**Table 1**  
Carbon disclosure coding variables.

Engagement and strategy
1. The CEO/chairperson articulates the organization's views on the issue of climate change in annual reports or CSR reports.
2. Quantitative carbon emission information is disclosed in executive's reports.
3. Carbon emissions issue is under the supervision of Board or executive management level.
4. Firm discloses its general knowledge of climate change and/or carbon emission abatement but without any target or result related information.
5. Firm implements or plans to implement any specific carbon management schemes.
6. Firm has a quantitative target for its future carbon emission reduction.
Measurement and performance
7. Firm discloses the methodology it employed to measure or calculate its carbon emissions.
8. Firm measures its carbon emissions in compliance with any carbon footprint measurement standard, e.g., GHG Protocol, ISO 14064-1, BS8901, UK Government's Environmental Reporting Guidance WRI/WBCSD, Climate Change Agreements, EU ETS, The Carbon Reduction Commitment Energy Efficiency Scheme (CRC Energy Efficiency), or measurement standards in other countries.
9. Firm discloses the consolidation approach for its carbon emissions measure and/or any changes during the reporting period.
10. Firm discloses its carbon operational/ inventory boundary.
11. Firm discloses its baseline year to measure and/or benchmark its carbon emissions.
12. Firm discloses the quantity of its direct carbon emissions (scope 1 emission).
13. Firm quantitatively compares its direct carbon emissions with those of either previous year (s) or baseline year.
14. Firm discloses the quantity of its indirect carbon emissions from purchasing energy (scope 2 emissions).
15. Firm quantitatively compares its indirect carbon emissions from purchasing energy with those of either previous year (s) or baseline year.

(continued on next page)

Table 1 (continued)

16. Firm discloses its scope 1 and/or 2 emission intensity.
17. Firm discloses the quantity of its other indirect carbon emissions (scope 3 emissions).
18. Firm quantitatively compares its other indirect carbon emissions from purchasing energy with those of either previous year (s) or baseline year.
19. Firm discloses its scope 3 emissions intensity.
20. Firm breaks down its carbon emissions, e.g., by business activities, by products or services.
21. Firm explains its carbon emission performance and/or any significant changes in its carbon emissions performance.
22. Firm discloses the financial implications of its carbon emissions.
23. The carbon disclosures are independently verified by a third party.
24. The third party gives unqualified opinion of the disclosed carbon information.
25. Firm discloses its carbon allowance recognition policy (e.g., net position method or donated asset method).
26. Firm discloses its carbon allowance valuation basis.
27. Firm reports its carbon information in compliance with any standards or guidance, e.g., GRI, DEFRA Guidance, Climate Change Reporting Framework.
28. Firm responses or plans to responses to CDP.

Risk and opportunity

29. Firm recognises any carbon related regulatory or compliance risks.
30. Firm recognises carbon price risks.
31. Firm discloses its strategies to manage its carbon related risks.
32. Firm discloses any other carbon-related risks.
33. Firm discloses its energy efficiency and/or renewable energy policy to reduce its carbon emissions.
34. Firm discloses the amount of investments in energy efficiency and/or renewable energy.
35. Firm discloses its lower-carbon technology policy.
36. Firm discloses the amount of investments in lower-carbon technology.
37. Firm improves in its business process to reduce carbon emissions.
38. Firm requires its employees and/or its value chain organizations to reduce carbon emissions.
39. Firm works with any other organizations towards carbon abatement.
40. Firm provides financial support to other organizations on carbon abatement activities.
41. Firm discloses the amount of financial support to other organizations on carbon abatement activities.
42. Firm discloses any other carbon related opportunities.

Table 2

Results of the two-level mediation model (with additional controls)

Panel A: Co2 disclosure effect on Tobin's Q			
Dependent variable:	Sector_Year Adjusted Tobin's Q		
	2010–2017	2013–2017	2010–2013
	(1)	(2)	(3)
Co2 disclosure	0.004** (2.23)	0.009** (2.37)	0.001 (0.45)
Co2 emission	−0.001** (−1.98)	−0.001* (−1.82)	−0.002** (−2.42)
log(MV)	0.010 (1.01)	−0.009 (−0.57)	0.032** (2.36)
Leverage	0.122*** (16.84)	0.128*** (11.86)	0.112*** (7.88)
Capital intensity	−0.166** (−2.03)	−0.158 (−1.44)	−0.312*** (−2.62)
Growth	0.120*** (3.10)	0.139*** (2.87)	0.065 (1.12)
MTBV	0.006*** (3.94)	0.003 (0.76)	0.004** (2.37)
Intangible assets	−0.015 (−0.48)	−0.006 (−0.16)	−0.068 (−1.38)
Dividend yield	0.000 (0.09)	−0.005 (−1.11)	0.021*** (2.99)
Profit margin	−0.002*** (−3.08)	−0.002** (−2.18)	−0.003** (−2.34)
Earning per share	0.000** (2.16)	0.000 (1.04)	0.000** (1.99)
Panel B: Co2 emission effect on Co2 disclosure			
Dependent variable	CO2 disclosure		
Co2 emission	0.044* (1.90)	0.072*** (2.99)	0.008 (0.18)
Co2 disclosure (lagged)	0.599*** (16.42)	0.387*** (8.45)	0.777*** (13.38)
log(MV)	1.389*** (4.90)	2.055*** (6.38)	1.049** (2.14)

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Table 2 (continued)

Panel B: Co2 emission effect on Co2 disclosure			
Dependent variable	CO2 disclosure		
Sales	−0.015 (−1.64)	−0.015 (−1.54)	−0.033* (−1.90)
Leverage	−0.015 (−0.10)	−0.091 (−0.60)	0.607* (1.83)
Capital intensity	−1.035 (−0.52)	−0.749 (−0.34)	−1.186 (−0.34)
MTBV	0.196*** (4.73)	0.138*** (3.43)	0.003 (0.02)
ROA	−0.082*** (−3.09)	−0.078** (−2.47)	−0.043 (−0.94)
Intangible assets	−0.433 (−0.37)	−0.719 (−0.56)	−2.161 (−1.06)
Year FE	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes
Obs	379	266	113

This table reports the mediating effect of carbon disclosure on the relationship between carbon emissions and firm financial performance for the whole sample period of 2010–2017, post and pre the introduction of carbon reporting legislation in 2013, in columns (1), (2), and (3) respectively. Panel A shows the direct effect of carbon emissions and total disclosure on organizational performance (sector-year adjusted); Panel B illustrates the carbon emissions (sector-adjusted) effect on carbon disclosure. In this analysis, we employ a lagged two-year structure of research design that the outcome variables-organizational performance in year  $t$  are hypothesized to be affected by carbon disclosure in year  $t - 1$ , which in turn is influenced by firm characteristics in year  $t - 2$ . \*, \*\*, and \*\*\* denote statistical significance at the 10%, 5%, and 1% levels respectively.

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