



The impact of climate policy uncertainty on ESG performance, carbon emission intensity and firm performance: evidence from Fortune 1000 firms

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Abstract

ESG performance has become vital for business in recent years. Consumers, stakeholders and investors alike seek companies that can show that they are environmentally and socially responsible, especially in periods of uncertainty. Using a new measure of uncertainty, the Climate Policy Uncertainty Index developed by Gavrilidis (Measuring climate policy uncertainty, 2021), this study investigates environmental, social and governance (ESG) performance, firm performance and carbon dioxide emission performance in the context of major developments related to climate policy and events. Further, the study provides insights into how ESG performance moderates the impact of climate policy uncertainty on firm performance and carbon dioxide emission performance. Finally, this paper examines how investor sentiment influences ESG performance during periods of high uncertainty. Based on a large sample of 2640 firms (6462 firm-year observations) from the US Fortune 1000 list covering the years 2008–2018, the empirical results demonstrate that climate policy uncertainty positively affects ESG performance and negatively affects firm performance and carbon dioxide emission performance. In addition, we find that firms enhance their ESG performance when investors are pessimistic, especially during periods of high uncertainty. Finally, we show that ESG performance does not moderate the effects of climate policy uncertainty on firm performance and carbon dioxide emission performance. These findings may help managers and policymakers to boost ESG performance to reap the benefits of ESG activities during periods of uncertainty related to changes in climate policy. Further, the results identify a promising channel via investor power that the government and ESG reporting advocates can utilise to encourage firms to act responsibly during periods of uncertainty.

Keywords ESG performance · Carbon dioxide emission performance · Firm performance · Investor sentiment · Climate policy uncertainty

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1 Introduction

The most serious threats facing humanity today are deeply complex. They include economic crises, pandemics, poverty, violence, conflict and wars. Irrespective of these threats, in the past five decades, the global climate system has experienced significant changes in most parts of the world, as manifested by the increasing frequency, intensity and impact of extreme weather events (Li et al., 2021). Therefore, according to Fuss et al. (2008), Deere-Birkbeck (2009), Hambira et al. (2020) and Li et al. (2021), climate change is considered one of the major systematic risks for global society in the twenty-first century. Climate change impacts human societies and economies in an unpredictable way. Initially, its effect may well be positive (Hope, 2006; Long et al., 2006; Mendelsohn et al., 2000; Tol, 2020). However, in the long run, these benefits will be sunk (Maddison, 2003; Rehdanz & Maddison, 2005; Tol, 2008, 2020), with a negative impact on the global economy (see Nordhaus, 1991; Nordhaus & Yang, 1996; Maddison, 2003; Rehdanz & Maddison, 2005; Tol, 2020). Batten (2018) reports that climate change leads to economic shocks—defined as unpredictable events that produce significant change within an economy—and could affect either the demand or the supply side of the economy. Demand-side shocks are those that impact the components of the aggregate demand, such as private or public consumption and investment, business investment and international trade. Supply-side shocks influence the productive capacity of the economy through the components of potential supply: labour, physical capital and technology.

In light of its dangers, governments tend to treat climate change primarily as an issue of environmental policy. Fischer and Sterner (2012) and Dogru et al. (2019) identify two types of policy tools that are important in dealing with climate change. The first are policies that encourage abatement directly, such as carbon taxes or tradable emissions permits, and possibly instruments to encourage the use of non-fossil energy or energy conservation. The second are technology policies that focus on lowering the costs of reducing carbon emissions. Further, Kompas et al. (2018) indicate that the adverse effects of climate change could be diminished if carbon dioxide emissions are curbed. However, the implementation of mitigating strategies and regulations to reduce emissions is considerably complicated by uncertainties (Fischer & Sterner, 2012). Cai et al. (2020) point out that there are significant uncertainties in the climate and economic systems that have been ignored by many studies on climate change mitigation. This gap motivates the present study. Therefore, for the purpose of this research, a new climate policy uncertainty index developed by Gavrilidis (2021) is examined.

First, the vast majority of the previous literature examined the link between economic policy uncertainty and corporate environmental, social and governance (ESG) practices, which may in turn influence ESG performance, carbon dioxide emissions and firm performance (see Bendickson et al., 2018; Aprisma & Sudaryati, 2020; Adams et al., 2020; Anser et al., 2021; Vural-Yavas, 2020; Ahsan & Qureshi, 2021; Muriithi et al., 2022). For instance, Vural-Yavas (2020) shows that during periods of high uncertainty, firms are more dedicated to sustainability issues and attain higher levels of ESG performance. Further, Muriithi et al. (2022) indicate that if firms use ESG investment as a strategic option to protect themselves or signal their prospects to stakeholders during periods of uncertainty, they are more likely to increase their ESG engagement during such periods. Bendickson et al. (2018) and Aprisma and Sudaryati (2020) show that firm performance is negatively associated with environmental uncertainty. Previous evidence also reveals that higher levels of uncertainty adversely affect environmental sustainability in countries with higher

levels of risks, which contributes to carbon dioxide emissions (Adams et al., 2020; Anser et al., 2021). Therefore, in line with the existing literature, the present study goes beyond the findings of Gavrilidis (2021) to investigate how climate policy uncertainty influences ESG performance, firm performance and carbon dioxide emission performance. This study supports the view that during periods of uncertainty related to changes in climate policies, firms increase their overall ESG performance to mitigate negative outcomes. Further, we illustrate the negative effect of climate policy uncertainty on firm performance and carbon dioxide emission performance.

Second, the effects of ESG performance on firm performance and carbon dioxide emission performance can provide further insights into the impact of ESG practices. The findings of previous literature regarding these relationships are ambiguous. Shaikh (2022) and Nguyen et al. (2022) suggest that better ESG practices can enhance firms' financial performance. In contrast, Di Tommaso and Thornton (2020) and Ruan and Liu (2021) state that ESG activities have a significantly negative impact on firm performance. Further, Shakil et al. (2019) and Junius et al. (2020) find that the ESG score does not influence firm performance. In this regard, we explore the impact of ESG performance on carbon dioxide emission and firm performance, and we find that better ESG performance could enhance firm performance and lower carbon dioxide emission performance.

Third, after exploring the impact of ESG performance on carbon dioxide emission performance and firm performance, we examine the question of how they may be jointly affected by ESG activities and climate policy uncertainty. Previous papers show that ESG performance enhances firm performance (Nguyen et al., 2022). Further, according to Churchill et al. (2019) and Dicuonzo et al. (2022), ESG performance may negatively influence carbon dioxide emissions since research and development (R&D) investment boosts ESG performance and lowers carbon emissions. Based on previous evidence and in light of the potential effect of climate policy uncertainty on ESG performance, carbon emission performance and firm performance, we expect that the nexus of ESG performance and climate policy uncertainty may influence firm performance and carbon emission performance. Our empirical analysis demonstrates that there is no effect of ESG performance on the climate policy uncertainty–firm performance and climate policy uncertainty–carbon dioxide emission performance nexuses.

Fourth, previous evidence signals that investor sentiment plays a significant role in managers' actions towards enhancing ESG performance (Bofigner et al., 2022). Therefore, we expect that ESG performance is positively associated with investor sentiment. Additionally, Idnani et al. (2021) and Ugurlu-Yildirim et al. (2021) suggest that investors react more to bad news than to good news. Consequently, we explore the moderating role of investor sentiment on the relationship between ESG performance and climate policy uncertainty. Our results indicate that the positive effect of climate policy uncertainty on ESG performance is more prominent in periods of negative investor sentiment.

Our study contributes to the literature in several ways. First, it sheds light on how climate policy uncertainty influences ESG performance, firm performance and carbon dioxide emission performance. Second, it provides empirical evidence from little-explored areas regarding the effects of interactions between (a) climate policy uncertainty and ESG performance on firm performance and carbon dioxide emission performance and (b) climate policy uncertainty and investor sentiment on ESG performance. Third, it is the first paper to investigate the levels of ESG performance, firm performance and carbon dioxide emission performance at different levels of climate policy uncertainty in light of industry categorisation (i.e. high- and low-profile industries). Specifically, previous literature concentrates on high- and low-profile industries by investigating how this categorisation

influences sustainability report disclosure (Martin et al., 2018; Mirfazli, 2008; Solikhah, 2016; Suwasono & Kurniasiwi, 2021). Further, most previous studies employ small samples to illustrate this industry categorisation. For instance, Mirfazli (2008) uses 357 firms, Solikhah (2016) 117 firms, Martin et al. (2018) 21 firms and Suwasono and Kurniasiwi (2021) 32 firms. Fourth, using the Fortune 1000 company list as the research sample is noteworthy because of two unique characteristics: it comprises market best performers (firms with the highest performance) and geographically dispersed firms (30 countries). Therefore, the data is a singular combination of big players and global diversification (Malik & Makhdoom, 2016). In addition, the Fortune 1000 constitutes a good barometer of successful firms around the world because it has tracked the numerous changes that have occurred in the global landscape over the last 20 years (Sledge, 2011).

The remainder of this study is structured as follows. The next section reviews the existing literature and develops hypotheses. In the third section, the research methodology is described, including sample selection and measures of climate policy uncertainty, ESG performance, investor sentiment, firm performance and carbon dioxide emission performance. The design of the regression equations and endogeneity tests are discussed. The penultimate section presents the empirical tests and reports their results. The final section summarises and concludes the study.

2 Prior literature and hypothesis development

2.1 ESG performance and firm performance under climate policy uncertainty

ESG performance evaluates a firm's environmental, social and corporate governance practices and indicates the rights and responsibilities of the firm's management (Yoon et al., 2018). More precisely, ESG performance reflects the firm's efforts to reduce resource consumption and emissions, respect human rights and ensure the quality of employment, the responsibility of the product and community relations (Yoon et al., 2018).

Although there is a growing body of literature examining fluctuations in corporate ESG practices in times of uncertainty (e.g. Ahsan & Qureshi, 2021; Ongsakul et al., 2021; Rjiba et al., 2020; Vural-Yavas, 2020; Zhang et al., 2018), research into how ESG performance is influenced by uncertain climate conditions is limited. For example, Zhang et al. (2018) demonstrate a positive link between policy-induced uncertainty and corporate social responsibility (CSR) engagement. Their findings imply that firms send signals to stakeholders by getting involved in CSR activities during periods of high uncertainty. Meanwhile, the work of Jia and Li (2020) reveals that uncertainty due to climate change, economic policy and political instability negatively affects firms' sustainability performance. In addition, their results show that delaying sustainability investment moderates the relationship between uncertainty at the national level and firms' sustainability performance. Vural-Yavas (2020) and Ahsan and Qureshi (2021) demonstrate that during periods of high uncertainty, firms improve their overall ESG performance, corporate environmental performance and governance performance to enhance their reputation as a result of policy-induced uncertainty.

Similarly, emerging evidence focuses on the potential resilience of firms with high ESG performance in times of unexpected shocks (e.g. Albuquerque et al., 2020; Barro et al., 2020; Rameli & Wanger, 2020; Kocak et al., 2021; Broadstock et al., 2021). Hoepner et al.

(2019) and Broadstock et al. (2021) show that ESG performance mitigates financial risk during financial crises and that the role of ESG performance is attenuated in normal times, confirming its incremental importance during crises. Broadstock et al. (2021) also suggest that high ESG performance to be relatively more resilient during periods of uncertainty, with investors being more patient and not selling their shares to avoid losses during the turbulent market. Chen et al. (2022) find that a firm's stock should be more resilient during a crisis if the firm achieves greater ESG success, as investors enjoy investing in and holding such companies. In turn, these views are also coherent with Whelan et al. (2021), Gianfrate et al. (2021) and Cardillo et al. (2023), suggesting that investing to ESG activities may contribute to stock price resilience during periods of crisis upon the belief that corporate social responsibility activities help to build social capital and trust in the firm, and that will motivate the firms' stakeholders to remain loyalty, helping the firm to rise above the challenges imposed by an uncertain period.

In line with the aforementioned papers, we support the view that ESG responsibility serves as insurance during periods of high uncertainty (Ahsan & Qureshi, 2021; Hwang et al., 2021; Vural-Yavas, 2020) by lowering downside risk for the sake of the portfolio construction (Whalen et al., 2021) and by increasing the firm resilience to the shocks for the sake of costumer and investor loyalty (Albuquerque et al., 2020). Therefore, we expect that during periods of high climate policy uncertainty, firms intensify their ESG engagement to reap the benefits of ESG activities. Accordingly, we formulate the following hypothesis:

Hypothesis 1: Climate policy uncertainty is positively associated with ESG performance.

A large body of literature examines the effect of climate change on economic performance (e.g. Dell et al., 2014; Fuss, 2016; Gallup et al., 1999; Hsiang & Narita, 2012; Nordhaus, 2006). Gallup et al. (1999) and Dell et al. (2014) find a negative relationship between temperature and economic performance. Specifically, they find that countries in warmer regions are typically poorer per capita than their counterparts in cooler climates and that their economies and equity markets grow more slowly. Nordhaus (2006) shows that climate is a key variable in explaining per-capita income differences between Africa and wealthier regions of the world. Fuss (2016) presents evidence that climate change destroys financial assets and disrupts related economic activities. Hsiang and Narita (2012), for their part, note that extreme weather events and losses are associated with higher fatalities and economic losses.

In addition, Gavriilidis (2021) states that climate policy uncertainty peaks near important events related to climate policy, such as new emissions legislation, global strikes about climate change and heads of states' statements about climate policy, among other developments. This affects the accuracy and quality of the information available to decision-makers (Daft et al., 1988) and the ability to predict how changes in the environment or firm decisions will impact the firm (Dean & Sharfman, 1993). In this regard, previous evidence of how policy-induced uncertainty influences firm performance is embryonic. Chin et al. (2014) emphasise that supplier and customer integration can reduce the adverse effects of environmental uncertainties on firm performance. Cadeaux and Ng (2012), Bendickson et al. (2018) and Aprisma and Sudaryati (2020) show that environmental uncertainty has a negative effect on firm performance. Further, Phan et al. (2020) and Song and Yang (2022) find evidence of a negative effect of crude oil price uncertainty on firm performance and address the negative effect of economic policy uncertainty on firm performance. Iqbal et al. (2020), Feng et al. (2021) and Ahsan and Qureshi (2021) also observe that economic policy

uncertainty reduces firm performance but note that sustainability disclosure moderates this destructive impact of policy uncertainty on firm performance.

In sum, although the aforementioned papers present evidence that different aspects of uncertainty have an economic impact on firm performance and insights into how economic performance is influenced by climate changes, there is a lack of direct evidence of an impact of the new climate policy uncertainty index developed by Gavriilidis (2021) at the firm level. It would be very useful in understanding the impact of climate policy uncertainty on managerial decisions and firm performance. Research by Cadeaux and Ng (2012), Bendickson et al. (2018) and Aprisma and Sudaryati (2020) shows that the decrease in sales volume and the increase in firms' operating expenses when environmental uncertainty grows may hurt firm performance. Therefore, it is expected that climate policy uncertainty negatively affects firm performance. We thus present the following hypothesis:

Hypothesis 2: Climate policy uncertainty is negatively associated with firm performance.

An extensive number of studies analyse the driving factors of carbon dioxide emissions as climate change has become a serious issue around the globe over the last two decades. These factors include foreign direct investment (e.g. Nguyen et al., 2021; Peng et al., 2016; Zhang & Zhou, 2016), financial development (e.g. Abbasi & Riaz, 2016; Amin et al., 2020), trade (e.g. Farhani & Ozturk, 2015; Peng et al., 2016), natural resources (e.g. Bekun et al., 2019; Joshua & Bekun, 2020), economic policies (e.g. Ullah et al., 2020) and market expansion (e.g. Peng et al., 2016).

The findings of Jiang et al. (2019), Adedoyin and Zakari (2020) and Amin and Dogan (2021) reveal that carbon dioxide emissions are amplified by economic policy uncertainty when the rise in carbon dioxide emissions occurs in a higher or lower growth period. Along the same lines, Danish et al. (2020) state that economic policy uncertainty boosts energy consumption, which increases carbon dioxide emissions. Wang et al., (2020, 2022), Pirgaip and Dincergok (2020), Tiwari et al. (2021), Yu et al. (2021) and Khan et al. (2022) report that economic policy uncertainty has a positive and significant effect on the intensity of firms' carbon dioxide emission. Adams et al. (2020) and Anser et al. (2021) reveal that the world uncertainty index increases carbon dioxide emissions. On the contrary, Abbasi and Adedoyin (2021) argue that economic policy uncertainty has an insignificant effect on carbon dioxide emissions.

In addition, low-carbon fuel policies should explicitly acknowledge, quantify and incorporate uncertainty in life-cycle emissions to achieve emissions reductions more effectively (Kocoloski et al., 2013). Jotzo et al. (2012) point out that policy uncertainty regarding carbon prices eventually leads to cost increases in the energy sector and lowers carbon emissions. Moreover, for Koch et al. (2016), the carbon emission trading market has a high response-ability to the shocks generated by political announcements. Chan (2020) finds that greater productivity uncertainty discourages production and reduces the intensity of carbon emissions. The empirical results presented by Li et al. (2022) show that trade policy uncertainty and monetary policy uncertainty both positively affect the carbon emission trading market price, while exchange-rate policy uncertainty has a negative influence. Wan et al. (2022) report that monetary policy uncertainty weakens the technical efficiency of R&D as well as increases the costs pertaining to financial constraints, causing a decrease in environmentally friendly innovation and higher carbon emissions.

With respect to the aforementioned papers, there is controversy regarding how different types of uncertainty influence carbon emission performance (e.g. Abbasi & Adedoyin,

2021; Adams et al., 2020; Anser et al., 2021; Chan, 2020). Therefore, we examine the influence of the new climate policy uncertainty index developed by Gavrilidis (2021) on carbon dioxide emission performance. Based on the findings of Gavrilidis (2021), we expect important events related to climate policy to be associated with lower carbon emission performance. Accordingly, we propose the following hypothesis:

Hypothesis 3: Climate policy uncertainty is negatively associated with carbon emission performance.

2.2 Moderating effect of investor sentiment in the relationship between climate policy uncertainty and ESG performance

Several studies investigate the impact of investors and financial markets on ESG performance (e.g. Bofinger et al., 2022; Cheng et al., 2014; Cheong et al., 2017; Keles & Cetin, 2018; Neughton et al., 2019; Orlitzky, 2013; Song et al., 2018; Sun et al., 2018; Vuong & Suzuki, 2021). Orlitzky (2013) argues that CSR creates noise in equity markets, causing many investors to reconsider their investment decisions. Cheng et al. (2014) provide evidence that firms with better ESG performance face significantly lower capital constraints thanks to enhanced stakeholder engagement and transparency. Cheong et al. (2017) and Song et al. (2018) claim that negative sentiment in the previous year motivates firms to improve their CSR performance the next year. Further, Sun et al. (2018), Keles and Cetin (2018) and Neughton et al. (2019) find that during low-sentiment periods, managers are more likely to issue a standalone CSR report and the quality of CSR reports is higher, signalling that firms with a more substantial social and environmental commitment might be safer investment places. Vuong and Suzuki (2021) and Bofinger et al. (2022) report that negative sentiment in the previous year plays a driving role in a firm's actions related to its CSR strategy the next year, with market sentiment having a more powerful impact.

In addition, risk is reflected in investors' uncertainty about future returns, which, in turn, influences their decisions (e.g. Behloul & Gupta, 2018; Bird & Yeung, 2012; Kim et al., 2021). For example, Conrad et al. (2002), Brav and Heaton (2002) and Francis et al. (2007) show an asymmetry in the response to good and bad earnings announcements, suggesting that investors react more negatively to bad news as the strength of the market increases. Bird and Yeung (2012), Zhang et al. (2018) and Idnani et al. (2021) find evidence that investors adopt a pessimist attitude in reacting to bad news at times of high market uncertainty because they feel less confident in their trading ability. They also observe the reverse when uncertainty is low, with investors taking an optimistic stance in reacting to good news. Kim et al. (2021) state that investor sentiment explains stock market reactions to changes in analyst recommendations only under high uncertainty. For their part, Shahzad et al. (2019) and Ugurlu-Yildirim et al. (2021) demonstrate that there is a bidirectional and negative relationship between policy-induced uncertainty and investor sentiment in the short and long run.

According to the aforementioned papers, investor sentiment plays a significant role in managers' actions related to the CSR strategy and aiming to enhance ESG performance (Bofinger et al., 2022; Keles & Cetin, 2018; Vuong & Suzuki, 2021). Consequently, we expect that investor sentiment is positively associated with ESG performance. Further, previous papers have shed light on the question of how uncertainty impacts investor sentiment behaviour, suggesting that in times of high uncertainty, investors react more to

bad news than to good news (Bird & Yeung, 2012; Idnani et al., 2021; Kim et al., 2021; Shahzad et al., 2019; Ugurlu-Yildirim et al., 2021). They demonstrate that investors take a bearish attitude in periods of uncertainty because they feel less confident in their trading ability. Therefore, we expect firms to improve their ESG performance when investors are pessimistic in order to enhance their public image and make better investment decisions, especially during periods of high uncertainty. Accordingly, we put forward the following hypothesis:

Hypothesis 4: Investor sentiment positively moderates the relationship between climate policy uncertainty and ESG performance in that investor sentiment intensifies the positive effects of the climate policy uncertainty on ESG performance.

2.3 Moderating effect of ESG performance in the relationship between climate policy uncertainty and firm performance

Extensive literature explores the relationship between ESG and firm performance, drawing different conclusions. The vast majority finds that ESG performance is positively correlated with firm performance (e.g. Aboud & Diab, 2019; Al Hawaj & Buallay, 2022; Alareeni & Hamdan, 2020; Bahadori et al., 2021; Cek & Eyupoglu, 2020; Lins et al., 2019; Mohammad & Wasiuzzaman, 2021; Nguyen et al., 2022; Shaikh, 2022; Ting et al., 2020; Triyani et al., 2020; Yawika & Handayani, 2019; Yu et al., 2018). For instance, Yu et al. (2018) demonstrate that firms with greater asset sizes, better liquidity, higher R&D intensity, fewer insider holdings and good past financial performance are more transparent on ESG issues. Aboud and Diab (2019) show that firms with high ESG ratings enjoy better financial and market performance. Meanwhile, Lins et al. (2019) suggest that during crisis periods, companies with high CSR report better operating performance, higher growth, higher employee productivity and greater access to debt markets. Additionally, Shaikh (2022) and Nguyen et al. (2022) reveal that better ESG practices could enhance firms' financial performance measured by return on assets, return on equity, and Tobin Q.

In contrast, opposing evidence has been reported regarding the relationship between ESG and firm performance (e.g. Alareeni & Hamdan, 2020; Albitar et al., 2020; Barnea & Rubin, 2010; Brammer et al., 2006; Fahad & Busru, 2020; Lee et al., 2009; Ruan & Liu, 2021). For instance, Brammer et al. (2006) state that scores on a composite social performance indicator are negatively related to stock returns. Barnea and Rubin (2010) show that insiders' ownership and leverage are negatively associated with a firm's social rating, while institutional ownership is uncorrelated with it. Lee et al. (2009) and Ruan and Liu (2021) suggest that ESG activities have a significantly negative impact on firm performance.

In addition, other papers show no correlation between ESG and firm performance (e.g. Atan et al., 2018; Friede et al., 2015; Junius et al., 2020; Shakil et al., 2019). Atan et al. (2018) argue that there is no significant relationship between individual and combined factors of ESG and firm profitability as well as firm value. Shakil et al. (2019) and Junius et al. (2020) find that ESG performance does not influence financial performance and market value.

Thus, the aforementioned papers report conflicting evidence of how ESG performance influences firm performance. For the purpose of this research, we expect that better ESG performance enhances firm performance because it translates into better outcomes for investors (Aboud & Diab, 2019; Alareeni & Hamdan, 2020; Mohammad & Wasiuzzaman, 2021; Nguyen et al., 2022; Yu et al., 2018). More precisely, firms with a strong ESG profile

(a) are more competitive through the efficient use of resources, human capital development and innovation management to increase profitability and pay more dividends, (b) decrease systematic risk to lower the cost of capital and produce higher valuation and (c) strengthen risk management to lower the risk of severe incidents and tail risks. Moreover, under the theory of resilience (e.g. Ding et al., 2020; Lins et al., 2017), we expect that firms with higher ESG performance will contribute to firm performance resilience during uncertain periods premising upon the belief that CSR activities help to build social capital and trust in the firm which in turn will motivate the firm's stakeholders to remain loyal, helping the firm to rise above the challenges imposed by an uncertain event, such as climate policy uncertainty. Therefore, this paper aims to provide insights into how ESG performance influences the relationship between firm performance and the new climate policy uncertainty index developed by Gavriilidis (2021). In light of the potential effect of climate policy uncertainty on ESG performance and firm performance, it is reasonable to assume that the pursuit of higher ESG performance enhances firms' reputation and allows them to lower the negative effects of the new climate policy uncertainty index (Gavriilidis, 2021) on firm performance. This logical assumption is supported by the theory of resilience, where firm performance exhibits a more resilient recovery in uncertain periods, particularly when the firm is committed to ESG practices. Accordingly, we propose the following hypothesis:

Hypothesis 5: ESG performance positively moderates the relationship between climate policy uncertainty and firm performance in that ESG performance alleviates the negative effects of climate policy uncertainty on firm performance.

2.4 Moderating effect of ESG performance in the relationship between climate policy uncertainty and carbon dioxide emission performance

Bosetti et al. (2008) examine the role of R&D investment in addressing climate change. Specifically, previous studies have encouraged investment in technology and boosting the productivity of R&D efforts to share knowledge in order to decrease carbon dioxide emissions (e.g. Churchill et al., 2019; Fernandez et al., 2018; Garrone & Grilli, 2010; Lee & Min, 2015; Li & Wang, 2017; Shahbaz et al., 2018; Zhang et al., 2017) and improve ESG performance (e.g. Dicuonzo et al., 2022; Fernandez et al., 2021; Xu et al., 2021).

Lee and Min (2015) reveal a negative relationship between green R&D and carbon emissions and a positive association of green R&D with financial performance at the firm level. Zhang et al. (2017) indicate that most environmental innovation measures in China reduce carbon emissions effectively. Garrone and Grilli (2010) provide evidence that public energy R&D is successful in improving energy efficiency at the country level but does not have a significant impact on the carbon factor and carbon intensity. Li and Wang (2017) find that technology change reduces aggregate carbon dioxide emissions, but the scale and intensity of the effects separately express positive and negative values. For Fernandez et al. (2018), since the net effects of innovation translate into a reduction of emissions, innovation appears to be a suitable tool in the fight against climate change. Churchill et al. (2019) also find that the relationship between R&D and carbon emissions is negative.

Further, Barbieri et al. (2010) and De Santis and Presti (2018) identify innovation as a useful tool to promote sustainable business. The relationship between innovation and sustainability performance is confirmed by Carrasco and Buendia-Martinez (2016), Du and Li (2019) and Ahmad and Wu (2022). However, few empirical studies demonstrate the existence of a relationship between firms' ESG initiatives and innovative performance

(Dicuonzo et al., 2022; Do & Kim, 2020; Fernandez et al., 2021; Triguero et al., 2018; Xu et al., 2021; Zhang et al., 2020). The results reported by Do and Kim (2020) indicate that investors in the Korean stock market do not view CSR activities as a means of supporting their long-term sustainability, judging from the firm's value over a long period after their rating. Xu et al. (2021) suggest that R&D investment has a positive impact on green innovation performance and that ESG performance can increase the number of green invention patents. Additionally, Dicuonzo et al. (2022) find a positive and significant relationship between ESG practices and innovation. They also show that companies investing more in R&D and patents have better ESG performance.

The aforementioned works suggest that investment in R&D has a negative impact on carbon emissions (Churchill et al., 2019; Fernandez et al., 2018; Shahbaz et al., 2018) and a positive impact on ESG performance (Dicuonzo et al., 2022; Fernandez et al., 2021; Xu et al., 2021). Moreover, Fukushima (2013) argues that reducing carbon emissions is an integral part of firms' ESG performance and investment. In this regard and because of the lack of evidence regarding the direct relationship between ESG performance and carbon dioxide emissions, we assume that higher ESG performance decreases the intensity of carbon dioxide emissions. Therefore, we expect ESG performance to magnify the negative effects of climate policy uncertainty on carbon dioxide emission performance. Accordingly, we test the following hypothesis:

Hypothesis 6: ESG performance positively moderates the relationship between climate policy uncertainty and carbon dioxide emission performance in that ESG performance magnifies the negative effects of climate policy uncertainty on carbon dioxide emission performance.

3 Data, variables and empirical models

3.1 Sample selection

Our empirical analysis is performed on the Fortune 1000 companies from 2008 to 2018. The Fortune 1000 is a list of the largest American companies operating globally, which are often considered leaders in their field, and is used in several studies as a sample source (e.g. Amini et al., 2018; Desmukh & Haleem, 2020; Fasan et al., 2021; Huang et al., 2020). This list is a good indicator of the current state of the business sector as it ranks eligible companies by revenue generated from core operations, discounted operations and consolidated subsidiaries. The initial sample consists of 11,000 observations for 4285 firms. Excluding missing values, we obtain a sample of 3756 firms (7578 firm-year observations). In addition, firms in the financial industry are removed from the sample because accounting variables are not comparable with industrial ones. Therefore, our final sample consists of 2640 firms (6462 firm-year observations). Table 1 breaks down the sample by industry and year. The most important industries are the energy sector (approximately 15% of the observations), technology (12%) and retailing (11%). To limit the impact of anomalous values and outliers, we follow Lehn et al. (2007) and winsorise all measures: dependent and independent variables are winsorised at the 5% level, while control variables are winsorised at the 1% level.

Table 1 Sample breakdown by year and industry

Year	N	%	Industry	N	%
2008	512	7.92	Aerospace and defence	183	2.83
2009	559	8.65	Apparel	170	2.63
2010	583	9.02	Business services	238	3.68
2011	633	9.80	Chemicals	240	3.71
2012	464	7.18	Energy	955	14.78
2013	597	9.24	Engineering, construction	177	2.74
2014	646	10.00	Food and drug stores	109	1.69
2015	553	8.56	Food, beverages and tobacco	311	4.81
2016	667	10.32	Health care	558	8.64
2017	618	9.56	Hotels, restaurants and leisure	167	2.58
2018	630	9.75	Household products	162	2.51
Total	6462	100	Industrials	435	6.73
			Materials	298	4.61
			Media	108	1.67
			Motor, vehicles and parts	182	2.82
			Retailing	692	10.71
			Technology	804	12.44
			Telecommunications	127	1.97
			Transportation	241	3.73
			Wholesalers	305	4.72
			Total	6462	100

The final sample is categorised into three clusters as follows: (a) the whole sample (Cluster 1; 6462 firm-year observations), (b) high-profile industries (Cluster 2; 4061 firm-year observations) and (c) low-profile industries (Cluster 3; 2401 firm-year observations). According to Roberts (1992), high-profile industries have high consumer visibility, a high level of political risk or concentrated intense competition. The following industries are identified as high-profile: petroleum, chemical, extractive and mining, forest and paper, automobile, airline, energy and fuel, transport and tourism, agriculture liquor, tobacco, and media communications (Hackston & Milne, 1996; Roberts, 1992). Conversely, low-profile industries do not receive much public attention when a company experiences any failure in their production process or products (Hackston & Milne, 1996; Roberts, 1992). The following industries are considered low-profile: finance and banks, food, health and personal products, hotel, building, electrical, textiles and apparel, retailers, medical suppliers, property and appliances and household products (Hackston & Milne, 1996; Roberts, 1992).

3.2 Variables

3.2.1 Climate policy uncertainty

With regard to climate uncertainty, the measure used in this study is the new climate policy uncertainty index (CU_{it}) developed by Gavrilidis (2021). To construct CU_{it} , Gavrilidis (2021) follows the established methodology of Baker et al. (2016) from 2008 to 2018.

Table 2 Pillar scores of ESG.
Source: Thomson Reuters Eikon

Pillar	Major components
Environmental	Resource use, emissions, innovation
Social	Workforce, human rights, community, product responsibility
Governance	Management, shareholders, CSR strategy

Using the scaled frequency of eight leading US newspapers (*Boston Globe*, *Chicago Tribune*, *Los Angeles Times*, *Miami Herald*, *New York Times*, *Tampa Bay Times*, *USA Today*, *Wall Street Journal*), the CU_{it} index captures important events related to climate policy. A number of CU_{it} index spikes are observed over the sample period around important events related to climate policy. For instance, the CU_{it} index spikes in 2009 (Todd Stern's statement about a new climate change treaty, UN climate change conference), 2011 (Todd Stern's doubts about the Kyoto Protocol), 2014 (national climate assessment reports, US-China deal on climate change) and 2015 (Obama rejects the Keystone XL pipeline permit), 2017 (Volkswagen pleads guilty to the EPA, the US withdraws from the Paris Accord), among other events. Therefore, a high CU_{it} indicates high climate uncertainty.

3.2.2 ESG performance

There are various measures of the ESG performance of corporations, such as KLD, EIRIS, SAM, MSCI's and Asian Sustainability Reporting. Deciding which rating tool is the most accurate to use for the independent variable is difficult because the rating agencies' methodologies all differ (Guenster et al., 2011; Orlitzky, 2013). However, for the purpose of this research, the Thomson Reuters ESG rating (ESG_{it}) is chosen because it is the most comprehensive of the ESG rating databases worldwide, and it is transparent regarding its methodology. Further, Siew (2015) states that one of the main concerns with the ESG rating is the lack of disclosure of ESG-relevant factors by firms. The Thomson Reuters ESG rating takes this into account, and firms that disclose more relevant information are acknowledged for doing so (Thomson Reuters, 2019). In addition, the Thomson Reuters ESG rating is used in numerous studies (e.g. Baraibar-Diez & Odriozola, 2019; Billio et al., 2021; Birindelli et al., 2018; DasGupta, 2022; Garcia et al., 2017; Nirino et al., 2021; Velte, 2017, 2020).

Following Gallego-Alvarez and Quina-Custodio (2017), the Thomson Reuters ESG score is calculated from 178 underlying measures based on relevance, comparability and availability. These are grouped into ten categories and produce pillar scorings. Tables 2 and 3 show the ESG pillar and category scores. The overall measure is the ESG score (ESG_{it}), which comprises the social pillar score, the environmental pillar score and the governance pillar score (Thomson Reuters, 2019). The scoring relies on algorithmic data selection and human process selection from 400 different measures. The data is collected from annual reports, company websites, NGO websites, stock exchange filings, CSR reports and news sources, processed by ESG research analysts and built-in functions and then independently audited (Thomson Reuters, 2019). Each score within each category ranges from 0 to 100. The score takes into account firms in the same category, the number of companies with scores and how well they performed. Thomson Reuters's industry grouping is used to benchmark the firms for the environment, social and controversy score, which means that

Table 3 Category scores of ESG. *Source:* Thomson Reuters Eikon

Scores	Measurement
ESG resource use score	The resource use score highlights a firm's performance and capacity to reduce the use of materials, energy or water and to find eco-efficient solutions by improving supply chain management
ESG emission score	The emission reduction score reflects the firm's commitment and effectiveness in reducing environmental emission in the production and operational processes
ESG innovation score	The innovation score reflects a company's capacity to reduce the environmental costs and aims to create new market opportunities through new environmental technologies and processes or eco-designed products
ESG workforce score	The workforce score measures a company's effectiveness towards job satisfaction, healthy and safe workplaces, maintaining the diversity and equal opportunities and development opportunities for its workforce
ESG human rights score	The human rights score measures a company's effectiveness towards respecting fundamental human rights conventions
ESG community score	The community score measures a company's commitment towards being a good citizen, protecting public health and respecting business ethics
ESG product responsibility score	The product responsibility score reflects a company's capacity to produce quality goods and services integrating the customer's health and safety, integrity and data privacy
ESG management score	The management score measures a company's commitment and effectiveness towards following the best corporate governance principles
ESG shareholder score	The shareholder score measures a firm's effectiveness towards the equal treatment of shareholders and the use of anti-takeover devices
ESG CSR strategy score	The CSR strategy score reflects a company's practices to communicate, in which it integrates the economic (financial), social and environmental dimensions into its day-to-day decision-making processes

firms within one category are compared to each other. The governance score uses the country in which the headquarters is located as a benchmark.

3.2.3 Investor sentiment

Studies use a variety of sentiment indicators (e.g. Calomiris & Mamaysky, 2019; Chen et al., 2021; Chiu et al., 2018; Hsieh & Nguyen, 2020; Hu et al., 2021; Luo et al., 2021; Muhammad, 2022; Nisar & Yeung, 2018). We apply firm-level investor sentiment (IS_{it}) using overnight returns, which was developed by Aboody et al. (2018) and is widely used in the existing literature (e.g. Bogousslavsky, 2021; Guo et al., 2022; Kim & Suh, 2021; Lee et al., 2022; Seok et al., 2019; Weibofner & Wessels, 2019; Zhou et al., 2021). Berkman et al. (2012) show that high-attention stocks, classified by large squared stock returns or strong net purchases by individual investors over a trading day, attract more retail buying near the opening of the next trading day than low-attention stocks. Additionally, the retail buying of high-attention stocks concentrates during the first hour of the next trading day. Further, they suggest that overnight returns may be suitable for measuring firm-level investor sentiment. Aboody et al. (2018) confirm this suitability by showing that overnight returns possess four characteristics of a firm-level investor

sentiment measure: (a) they are persistent, (b) their persistence is stronger for harder-to-value firms, (c) their persistence is higher for firms with lower institutional ownership, and (d) stocks with high overnight returns underperform those with low overnight returns in the longer term. All these characteristics are expected from a measure of sentiment driven by the persistent share demand of sentiment-influenced investors (Aboody et al., 2018).

Following Guo et al. (2022), we use the annualised proxy of Aboody et al.'s (2018) firm-level investor sentiment (IS_{it}). Aboody et al. (2018) define the firm- i , day- d close-to-open overnight stock return, CTO_{id} , as follows:

$$CTO_{id} = \frac{(O_{id} - C_{id-1})}{C_{id-1}} \quad (1)$$

where O_{id} is firm i 's opening price on trading day d , and C_{id-1} is firm i 's closing price on trading day $d-1$. All opening and closing prices are adjusted for stock splits, stock dividends and cash dividends. If either O_{id} or C_{id-1} is missing, the overnight return is undefined. Based on Guo et al. (2022), we use annualised firm-level investor sentiment as follows:

$$CTO_{it} = 250 * \frac{\sum_{d=1}^N CTO_{id}}{N} \quad (2)$$

where 250 is the approximate number of trading days within fiscal year t , and N is the number of non-missing CTO_{id} over the year. Further, we treat CTO_{it} as missing if N is less than 100.

3.2.4 Firm performance

Several financial ratios can be used to evaluate and analyse firm performance (Zaini & Mahmuddin, 2019). However, there is no consensus in the literature regarding the best proxy for determining firm performance. Most studies employ more than two financial ratios, which is found to be sufficient to evaluate the firm performance. For instance, to detect financial patterns, Delen et al. (2013) and Yousaf and Dey ((2022) use 31 and 16 ratios, respectively. According to Manogna and Mishra (2021) and Yousaf and Dey (2022), there are seven main financial ratios to measure financial performance: profitability ratios, liquidity ratios, leverage ratios, efficiency ratios, growth ratios, solvency ratios and market value ratios.

We use the return on equity (profitability ratio) as a measure of firm performance (ROE_{it}) because it is the most employed in previous research (e.g. Atan et al., 2018; Fatemi et al., 2018; Yoon et al., 2018; Yawika and Handayam, 2019; Buallay, 2019; Iqbal et al., 2020; Aprisma & Sudaryati, 2020; Ting et al., 2020; Ahsan & Qureshi, 2021; Huang, 2021; Mohammad & Wasiuzzaman, 2021; Shaikh, 2022; Nguyen et al., 2022; Song & Yang, 2022). The return on equity reflects operating performance in terms of profitability (Kumbirai & Webb, 2010). ROE_{it} is defined as a firm's net income divided by the firm's total equity.

3.2.5 Carbon dioxide emission performance

Zhou et al. (2010) point out that various indicators have been developed and applied to evaluating carbon emission performance trends in previous studies. Busch (2010) examines carbon dioxide emission performance indicators at the firm level and believes that these indicators can provide firm-specific information for developing performance at the micro level. In addition, Busch et al. (2011) develop a generic framework for the assessment of firms' carbon emission performance, with the purpose of discussing carbon reduction strategies and policies. Reviewing previous literature, Hu et al. (2017) outline two aspects of carbon emission dioxide emission performance measures. First, many measures of carbon emission efficiency reflect the partial performance of carbon emissions (Zhou et al., 2010). Second, other studies evaluate carbon emission performance by measuring carbon emission and desirable outputs simultaneously, as is the case of a popular indicator of carbon intensity (Hu et al., 2021).

We use firm-level carbon dioxide emission intensity as a measure of carbon dioxide emission performance (CEP_{it}). Based on Qian and Schaltegger (2017), Forslid et al. (2018), Alam et al. (2019), Alsaifi (2021) and Zhu et al. (2022), CEP_{it} is measured as a firm's total carbon dioxide emissions divided by the firm's total sales.

3.3 Empirical models

3.3.1 ESG performance under climate policy uncertainty (Hypotheses 1 and 4)

To measure the relationship between climate policy uncertainty and ESG performance, we estimate linear model (3). We run regression model (3) twice. First, testing Hypothesis 1, we calculate Eq. (3) to investigate the effect of the climate policy uncertainty index (CU_{it}) on the ESG performance index (ESG_{it}). We expect ESG performance to be positively associated with climate policy uncertainty. We then run one linear model (3) to test Hypothesis 4 and explore the impact of investor sentiment as potentially offsetting the influence of climate policy uncertainty on ESG performance. Therefore, we expect firms to improve their ESG performance when investors are pessimistic in order to enhance their public image and help investors make better investment decisions, especially during periods of high uncertainty.

$$ESG_{it} = \beta_0 + \beta_1 CU_{it} + \beta_2 IS_{it} + \beta_3 CU_{it} * IS_{it} + \beta_4 FS_{it} + \beta_5 LEV_{it} + \beta_6 ROA_{it} + \beta_7 MTB_{it} + \beta_8 ECN_{it} + \beta_9 COR_{it} + \beta_{10} UR_{it} + \beta_{11} GDP_{it} + \varepsilon_{it} \quad (3)$$

where ESG_{it} , as the dependent variable, is the Thomson Reuters ESG performance index (as presented in Sect. 3.2.2), β_0 is the constant, and β_{1-11} is the slope of the control and independent variables. The independent variable is the new climate policy uncertainty index (CU_{it}) developed by Gavrilidis (2021) (as presented in Sect. 3.2.1). The moderating variable is investor sentiment measured by the firm-level investor sentiment (IS_{it}) developed by Aboody et al. (2018) (as presented in Sect. 3.2.3).

The firm control variables are as follows: FS_{it} is firm size measured as the natural logarithm of the firm's total sales; LEV_{it} is leverage measured as total liabilities divided by shareholders' equity; ROA_{it} is the return on assets measured as net profit divided by total assets; MTB_{it} is the market-to-book ratio measured as market value divided by the book value of the firm's equity; and ECN_{it} is economic

sustainability performance, which considers various inputs such as shareholder loyalty, shareholders' performance, client loyalty in generating sustainable growth and long-term shareholder value through the use of bet management practices. It ranges from 0 to 100, indicating poor to good performance (Alsayegh et al., 2020). Based on the previous literature (e.g. Abdul Rahman & Alsayegh, 2021; Hummel & Schlick, 2016; Menassa & Dagher, 2019; Sun et al., 2018; Vuong & Suzuki, 2021), we expect that larger companies have larger resources for ESG activities, higher returns on assets increase the efficiency of a company utilising its assets for its operational activities, which, in turn, boosts ESG performance, and firms with higher economic sustainability performance disclose more ESG information to remain legitimate. Further, in line with the findings of Crespi and Migliavacca (2020), we expect high-level leverage companies to be riskier than lower-level leverage companies, which may have a negative influence on ESG performance. Additionally, firms with more growth potential are likely to have less money to dedicate to ESG activities.

The country control variables are as follows¹: COR_{it} is the level of corruption extracted from the official site of the World Bank; UR_{it} is the unemployment rate provided by the official site of OECD; and GDP_{it} denotes economic development measured as the annual percentage growth rate of GDP. It is expected that in countries characterised by a high level of corruption, companies have lower levels of ESG disclosure because they are more likely to engage in unethical practices. Thus, the resulting benefits of ethical firms may be lower in more corrupt countries. Further, based on Boulouta and Pitelis (2014), Martinez-Del-Rio et al. (2015) and El Khoury et al. (2021), we expect that economic development positively affects ESG performance. Accordingly, a high unemployment rate creates competition among firms to attract a higher number of skilled employees (Vuong & Suzuki, 2021). A more skilled workforce is enticed by ESG disclosure as it is considered an indicator of higher career prospects (Freeman et al., 2007). Therefore, we predict a positive association between the unemployment rate and ESG performance. ε_{it} is the random error.

3.3.2 Firm performance under climate policy uncertainty (Hypotheses 2 and 5)

To measure the relationship between climate policy uncertainty and firm performance, we estimate linear model (4). We run regression model (4) twice. First, testing Hypothesis 2, we calculate Eq. (4) to investigate the effect of the climate policy uncertainty index (CU_{it}) on firm performance (ROE_{it}). We expect that firm performance is negatively associated with climate policy uncertainty. We then run linear model (4) one more time to test Hypothesis 5 and explore the influence of ESG performance as a factor that potentially offsets the impact of climate policy uncertainty on firm performance. We expect that higher ESG performance enhances firms' reputation and reduces the negative effects of the climate policy uncertainty index on firm performance.

¹ The corruption control reflects perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as the 'capture' of the state by elites and private interests. The estimate provides the country's score on the aggregate indicator, in units of a standard normal distribution (i.e. ranging from approximately - 2.5 to 2.5).

$$\begin{aligned}
ROE_{it} = & \beta_0 + \beta_1 CU_{it} + \beta_2 ESG_{it} + \beta_3 CU_{it} * ESG_{it} + \beta_4 FS_{it} \\
& + \beta_5 CR_{it} + \beta_6 LEV_{it} + \beta_7 FA_{it} + \beta_8 CI_{it} + \beta_9 TAN_{it} \\
& + \beta_{10} LR_{it} + \beta_{11} IR_{it} + \beta_{12} GDP_{it} + \beta_{13} INR_{it} + \beta_{14} FDI_{it} + \varepsilon_{it}
\end{aligned} \quad (4)$$

where ROE_{it} , as the dependent variable, is the return on equity as a measure of firm performance (as presented in Sect. 3.2.4), β_0 is the constant, and β_{1-14} is the slope of the control and independent variables. The independent variable is climate policy uncertainty (CU_{it} , as presented in Sect. 3.2.1). The moderating variable is ESG performance (ESG_{it}) extracted from Thomson Reuters (as presented in Sect. 3.2.2).

The firm control variables are as follows: FS_{it} is firm size as described in linear model 3; CR_{it} is the cash ratio measured as the total cash holdings divided by current liabilities; LEV_{it} is the leverage ratio as described in linear model 3; FA_{it} is firm age captured by the number of years of operation; CI_{it} is capital intensity measured as fixed assets divided by sales; TAN_{it} is tangibility measured as fixed assets divided by total assets; and LR_{it} is liquidity measured as current assets divided by current liabilities. In line with other studies (e.g. Klapper & Love, 2004; Muritala, 2012; Hatem, 2014; Vu et al., 2019), it is expected that firm performance is correlated with firms achieving higher productivity and greater output in capital-intensive industries and large firms because they may lead to significant growth opportunities. Further, we anticipate that firm age is positively associated with firm performance because firm efficiency increases with age. Accordingly, this study predicts that a high amount of cash in the hands of managers may cause a problem of over-investment, which, in turn, may negatively affect firm performance (Dursun et al., 2013; Hatem, 2014). Based on Asimakopoulos et al. (2009) it is expected that the need to continue servicing the debt reduces the ability of companies to invest in profitable projects, with negative effects on firm profitability and high liquidity as it may cause firm profitability to decline (Bari et al., 2021; Egbunike & Okerekeoti, 2018). We predict that a high ratio of fixed assets to total assets provides the creditors with a high level of security as they would be able to liquidate more assets in the event of bankruptcy and, therefore, affects firm profitability positively (Baker & Martin, 2011; Zainudin et al., 2018).

The country control variables are as follows: IR_{it} is the inflation rate measured as the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or change yearly; GDP_{it} is economic development as described in linear model 3; INR_{it} is the interest rate of government bonds maturing in ten years; and FDI_{it} is foreign direct investment measured as flows recording the value of cross-border transactions related to direct investment during a year. We expect higher inflation and interest rates, which slow down the economy, to have negative effects on firm performance (e.g. Egbunike & Okerekeoti, 2018; Mirza & Javed, 2013; Odusanya et al., 2018). Accordingly, in line with the findings of Pattitoni et al. (2014) and Pervan et al. (2019), during periods of economic growth and higher levels of foreign direct investment, demand for the firm's goods and services potentially increases; therefore, we predict a boost in sales and higher profitability. ε_{it} is the random error.

3.3.3 Carbon dioxide emission performance under climate policy uncertainty (Hypotheses 3 and 6)

To measure the relationship between climate policy uncertainty and carbon emission intensity, we estimate linear model (5). We run regression model (5) twice. First, testing

Hypothesis 3, we calculate Eq. (5) to investigate the effect of the climate policy uncertainty index (CU_{it}) on carbon emission performance (CEP_{it}). We expect that carbon dioxide emission performance is negatively associated with climate policy uncertainty. We then run linear model (5) one more time to test Hypothesis 6 and explore the impact of ESG performance as a factor that potentially offsets the impact of climate policy uncertainty on carbon dioxide emission performance. We anticipate that ESG performance magnifies the negative effects of climate policy uncertainty on carbon dioxide emission performance.

$$\begin{aligned} CEP_{it} = & \beta_0 + \beta_1 CU_{it} + \beta_2 ESG_{it} + \beta_3 CU_{it} * ESG_{it} + \beta_4 EFF_{it} + \beta_5 FS_{it} \\ & + \beta_6 EI_{it} + \beta_7 CI_{it} + \beta_8 LI_{it} + \beta_9 DY_{it} + \beta_{10} ENI_{it} + \beta_{11} FDI_{it} \\ & + \beta_{12} GDP_{it} + \beta_{13} ISG_{it} + \beta_{14} TI_{it} + \beta_{15} TP_{it} + \beta_{16} UP_{it} + \varepsilon_{it} \end{aligned} \quad (5)$$

where CEP_{it} , as the dependent variable, is the intensity of firm-level carbon dioxide emissions as a measure of carbon emission performance (as presented in Sect. 3.2.5), β_0 is the constant, and β_{1-16} is the slope of the control and independent variables. The independent variable is the new climate policy uncertainty index (CU_{it} , as presented in Sect. 3.2.1). The moderating variable is ESG performance (ESG_{it}) extracted from Thomson Reuters EIKON (as presented in Sect. 3.2.2).

The firm control variables are as follows: EFF_{it} is efficiency measured as the cost of goods sold divided by the average inventory; FS_{it} is firm size as described in linear model 3; EI_{it} is export intensity measured as the natural logarithm of total exports divided by total sales; CI_{it} is capital intensity as described in linear model 4; LI_{it} is labour intensity measured as the natural logarithm of total wages divided by total sales; and DY_{it} is dividend yield measured as annual dividends per share divided by price per share. Based on the findings of Papadogonas et al. (2007), Duran et al. (2015) and Zaekhan et al. (2021), an increase in firm size is expected to result in more efficient energy use, which may, in turn, increase carbon emission intensity. Additionally, capital intensity seems to have a positive relationship with carbon emission intensity due to the positive association between capital and energy intensity. Accordingly, we predict that higher efficiency lowers carbon emissions because of a greater ability to liquidate the inventory and better production management (Cheng et al., 2021) and that export activity is positively correlated to carbon emission intensity (Cole et al., 2013; Richter & Schiersch, 2017). Further, we expect labour intensity to have a negative relationship with carbon emission intensity, meaning that labour-intensive firms emit less pollution (Cole et al., 2005). Based on the work of Balachandran and Nguyen (2018), we anticipate a negative association between carbon emission intensity and dividend yield, indicating that firms in the highest-emitting industries pay smaller dividends.

The country control variables are as follows: ENI_{it} is energy intensity measured as energy consumption divided by gross domestic product (GDP); FDI_{it} is foreign direct investment as described in linear model 4; GDP_{it} is economic development as described in linear model 3; ISG_{it} is the industrial share of growth captured by the industrial value added to GDP per year expressed as a percentage; TI_{it} is technological innovation measured as the natural logarithm of the total end-of-year number of patents; TP_{it} is the total population measured as the natural logarithm of the total population; and UP_{it} is the urban population measured as the natural logarithm of the total population living in urban areas. In keeping with Andersson and Karpestam (2013), we expect that energy intensity, foreign direct investment, the industrial share of growth and technological innovation have a positive association with carbon emission intensity. Moreover, we anticipate that economic

development, total population and urban population have a negative impact on carbon emission intensity. ε_{it} is the random error.

A summary of all the variables and their operationalisation in this study is presented in Appendix A.

3.4 Endogeneity

Our empirical analysis may be subject to the endogeneity bias due to unobservable firm- and country-level characteristics affecting ESG performance, investor sentiment, climate policy uncertainty, firm performance and carbon dioxide emission performance. According to Monti et al. (2022), in CSR literature, a common concern is endogeneity stemming from omitted variables and/or reverse causality.

To address the endogeneity problem, in line with similar studies (e.g. Barros et al., 2020; Cahan et al., 2015; Jo et al., 2016), we incorporate several instrumental variables into each of the equations above by utilising a two-stage least-square (2SLS) regression analysis. We use the return on assets (ROA_{it}), the market-to-book ratio (MTB_{it}), leverage (LEV_{it}), labour cost (LC_{it}), export intensity (EI_{it}), capital intensity (CI_{it}), the unemployment rate (UR_{it}), economic development (GDP_{it}) and technological innovation (TI_{it}). All variables are described in Appendix A.

Following Zahid et al. (2020), to utilise instrumental variables, we must fulfil two criteria in the 2SLS regression. First, there should be a high correlation between the instrumental variable and its predicted value; second, there should be no significant correlation between the instrumental variables and the error terms in the dependent variable regression. The results in Tables 6, 7 and 8 indicate that our regression models do not suffer from endogeneity. Specifically, the instrument relevance tests (Gragg & Donald, 1993) show that the null hypotheses could be rejected—that is, the instruments of the study are not weak. This confirms the relevance of the instrumental variables used in this research. Further, the overidentification tests (Sargan, 1958) demonstrate that the instrumental variables do not violate the overidentification restriction; therefore, our instrumental variables are valid instruments. Finally, Durbin-Wu-Hausman tests confirm the presence of exogeneity in all regression equations, with p values of Hausman's tests under 5%. This refutes the null hypothesis and indicates the capacity of a fixed-effect model to best represent the relationship, confirming our assumption that the instrumental variables are exogenous.

4 Empirical results

4.1 Descriptive statistics and correlation analysis

In this section, we use descriptive statistics to present the variables. We first analyse the mean, maximum, minimum and standard deviation of the variables. We then illustrate skewness to measure the lack of asymmetry and kurtosis to evaluate whether the data is heavy-tailed or light-tailed relative to a normal distribution.

As shown in Table 4, the values for asymmetry and kurtosis are between -2 and $+2$, which is considered acceptable proof of normal univariate distribution (George & Mallery,

Table 4 Descriptive analysis

Variables	Mean	Median	Maximun	Minimun	Standard deviation	Skewness	Kurtosis
CEP _{it} (Cluster 1)	75.119	81.589	98.460	34.730	17.103	−0.669	−0.535
CEP _{it} (Cluster 2)	75.927	85.639	97.150	34.730	19.417	−1.098	−0.272
CEP _{it} (Cluster 3)	74.328	72.379	98.460	50.000	14.641	0.232	−1.351
CI _{it} (Cluster 1)	2.328	0.640	10.819	0.060	2.563	0.855	−0.437
CI _{it} (Cluster 2)	0.436	0.341	1.388	0.118	0.302	1.305	1.686
CI _{it} (Cluster 3)	3.924	4.619	10.819	0.060	2.568	−0.124	−0.514
COR _{it}	1.364	1.400	1.500	1.300	0.064	0.593	−0.293
CR _{it} (Cluster 1)	0.443	0.368	1.872	0.000	0.351	1.793	4.689
CR _{it} (Cluster 2)	0.381	0.226	1.872	0.055	0.407	2.482	6.766
CR _{it} (Cluster 3)	0.481	0.486	1.133	0.000	0.272	0.510	−0.059
CU _{it}	106.429	100.858	199.918	59.336	36.922	1.377	2.764
DY _{it} (Cluster 1)	0.026	0.026	0.204	0.001	0.025	0.215	2.258
DY _{it} (Cluster 2)	0.030	0.023	0.093	0.012	0.014	2.490	6.989
DY _{it} (Cluster 3)	0.024	0.018	0.204	0.001	0.032	0.990	2.775
ECN _{it} (Cluster 1)	45.430	43.163	79.800	30.440	10.139	1.373	1.868
ECN _{it} (Cluster 2)	45.127	43.119	77.850	31.850	9.640	1.622	3.122
ECN _{it} (Cluster 3)	46.274	43.318	79.800	30.440	11.079	1.078	0.775
EFF _{it} (Cluster 1)	15.405	13.963	29.867	3.673	6.515	0.093	−0.926
EFF _{it} (Cluster 2)	16.245	15.358	29.867	7.982	5.864	0.206	−1.005
EFF _{it} (Cluster 3)	14.518	12.653	29.867	3.673	6.979	0.210	−0.960
EI _{it} (Cluster 1)	0.556	0.548	0.838	0.337	0.129	0.118	−0.893
EI _{it} (Cluster 2)	0.588	0.581	0.752	0.410	0.099	0.016	−1.092
EI _{it} (Cluster 3)	0.531	0.526	0.838	0.341	0.146	0.481	−0.880
ENI _{it}	0.126	0.127	0.139	0.114	0.008	−0.004	−1.434
ESG _{it} (Cluster 1)	71.272	73.893	89.620	46.540	10.043	−0.666	−0.235
ESG _{it} (Cluster 2)	69.476	73.492	87.880	46.540	10.768	−0.743	−0.639
ESG _{it} (Cluster 3)	72.736	74.068	89.620	49.010	9.429	−0.337	−0.470
FA _{it} (Cluster 1)	34.300	36.600	55.000	13.000	9.597	−0.110	−0.509
FA _{it} (Cluster 2)	38.100	40.100	46.000	24.000	5.722	−0.908	0.093
FA _{it} (Cluster 3)	31.100	30.100	54.000	13.000	11.198	0.539	−0.567
FDI _{it}	11.474	11.422	11.709	11.207	0.134	0.092	0.447
FS _{it} (Cluster 1)	5.572	5.426	6.419	4.403	0.637	−0.175	−1.169
FS _{it} (Cluster 2)	5.216	5.311	5.543	4.551	0.310	−1.196	0.038
FS _{it} (Cluster 3)	5.868	6.279	6.410	4.403	0.687	−1.241	−0.054
GDP _{it}	1.655	2.200	3.100	−2.500	1.555	−1.967	4.045
INR _{it}	2.618	2.500	3.700	1.800	0.592	0.270	−0.852
IR _{it}	1.645	1.700	3.000	0.100	0.824	−0.243	−0.317
ISG _{it}	100.712	102.000	108.667	89.167	5.261	−0.859	0.710
IS _{it} (Cluster 1)	0.196	0.084	3.078	−0.421	0.540	0.645	6.644
IS _{it} (Cluster 2)	0.132	0.043	2.966	−0.416	0.541	1.090	5.654
IS _{it} (Cluster 3)	0.264	0.169	3.078	−0.421	0.533	1.523	6.011
LEV _{it} (Cluster 1)	−0.119	0.843	6.601	−161.975	16.631	−1.515	4.210
LEV _{it} (Cluster 2)	−2.896	0.349	6.601	−161.975	23.279	−0.784	4.120
LEV _{it} (Cluster 3)	2.568	2.483	4.716	0.305	1.249	−0.146	−0.801

Table 4 (continued)

Variables	Mean	Median	Maximum	Minimum	Standard deviation	Skewness	Kurtosis
LI_{it} (Cluster 1)	0.410	0.405	0.987	0.187	0.166	1.762	3.377
LI_{it} (Cluster 2)	0.450	0.396	0.987	0.243	0.204	1.508	0.968
LI_{it} (Cluster 3)	0.376	0.405	0.634	0.189	0.098	-0.205	0.515
LR_{it} (Cluster 1)	1.557	1.266	6.737	0.790	1.038	0.622	5.194
LR_{it} (Cluster 2)	1.559	1.248	6.737	0.760	1.288	0.406	1.491
LR_{it} (Cluster 3)	1.495	1.356	3.431	0.790	0.620	1.441	1.692
MTB_{it} (Cluster 1)	0.761	1.543	8.124	-99.408	10.221	-0.692	5.899
MTB_{it} (Cluster 2)	0.141	1.996	8.124	-99.408	14.470	-0.913	4.492
MTB_{it} (Cluster 3)	1.559	1.008	5.660	0.000	1.275	1.594	2.218
ROA_{it} (Cluster 1)	3.640	2.349	14.285	-6.777	3.986	0.653	-0.210
ROA_{it} (Cluster 2)	6.554	7.005	14.285	-0.768	3.625	-0.153	-0.674
ROA_{it} (Cluster 3)	1.343	0.863	8.655	-2.312	1.702	1.902	6.175
ROE_{it} (Cluster 1)	1.773	10.872	134.178	-1021.340	104.811	-0.564	4.378
ROE_{it} (Cluster 2)	-3.921	17.215	134.178	-1021.340	148.364	-0.835	4.840
ROE_{it} (Cluster 3)	8.994	8.429	46.811	-11.615	8.595	1.653	6.155
TAN_{it} (Cluster 1)	0.394	0.315	0.890	0.212	0.181	1.301	0.344
TAN_{it} (Cluster 2)	0.479	0.351	0.890	0.241	0.216	0.506	-1.302
TAN_{it} (Cluster 3)	0.326	0.301	0.746	0.212	0.107	0.471	6.447
TI_{it}	5.437	5.463	5.541	5.261	0.097	-0.760	-0.787
TP_{it}	8.500	8.500	8.515	8.482	0.010	-0.196	-1.134
UP_{it}	8.410	8.410	8.430	8.388	0.013	-0.078	-1.194
UR_{it}	6.695	6.170	9.630	3.900	1.961	0.169	-1.573

For variable definitions, see Appendix A

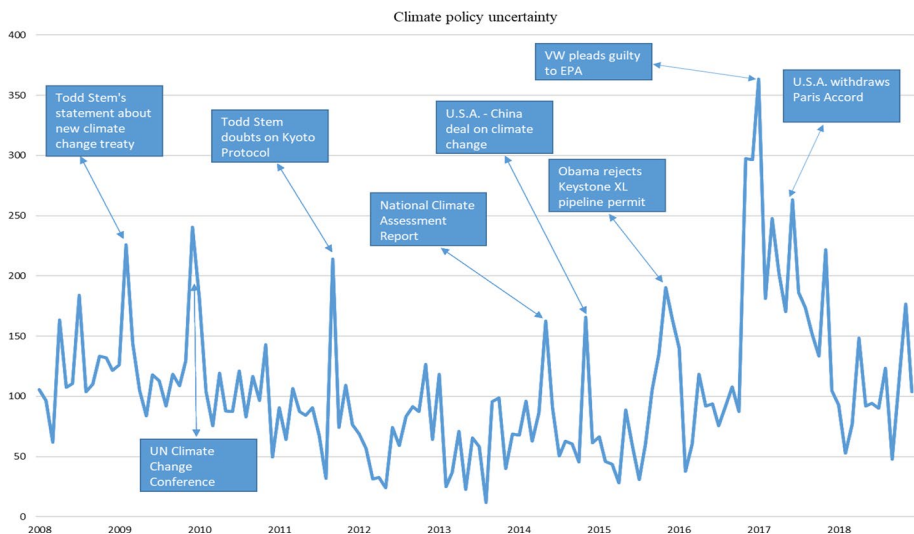


Fig. 1 Climate policy uncertainty over time. *Source:* Gavrilidis (2021)

2010). Further, Table 4 indicates that the data is considered to be normal because skewness is between -2 and $+2$ and kurtosis between -7 and $+7$ (Byrne, 2010; Hair et al., 2010).

The results of the descriptive analysis show that the mean (median) of climate policy uncertainty (CU_{it}) is 106.429 (100.858). In addition, Fig. 1 reveals that climate uncertainty spikes in periods surrounding important events related to climate policy (Gavriilidis, 2021).

Concerning ESG performance, the mean (median) of ESG_{it} differentiates high- from low-profile industries. Table 4 shows that ESG_{it} remains high in the whole sample and low-profile industries. The mean (median) of the whole sample is 71.272 (73.893), while that of low-profile industries is 72.736 (74.068). Meanwhile, high-profile industries obtain a value of 69.476 (73.492).

Investor sentiment (IS_{it}) varies non-monotonically throughout the sample period. As indicated by Lou et al. (2019) and Akbas et al. (2021), some investors prefer to trade more intensively around the market opening, while others prefer to trade intensively during the rest of the trading day. The descriptive statistics indicate that overnight returns (IS_{it}) are higher for low-profile industries, with a value of 0.264 (0.169); by contrast, overnight returns (IS_{it}) are lower for the whole sample and high-profile industries, with a value of 0.196 (0.084) and 0.132 (0.043), respectively.

Table 4 shows that the means (medians) of firm performance (ROE_{it}) reported in the whole sample and low-profile industries are significantly larger than those reported in high-profile industries. Further, high-profile industries have a negative mean of firm performance (ROE_{it}), with a value of -3.921 , compared to 1.773 and 8.994 for the whole sample and low-profile industries, respectively.

As expected, the impact of climate policy uncertainty on carbon dioxide emission performance is significant in high-profile industries. As seen in Table 4, carbon dioxide emission performance (CEP_{it}) tends to influence high-profile industries more than the whole sample and low-profile industries. The mean (median) of the whole sample is 75.119 (81.589), that of low-profile industries is 74.328 (72.379), and that of high-profile industries is 75.927 (85.639).

To measure the collinearity between the dependent, independent and control variables in all regression equations, we use the correlation matrix (see Table 5). Even though there are significant correlations among some of the variables, none of the coefficients exceeds 0.8, which is used as an indicator of serious multicollinearity (Gujarati, 1992; Rapp, 1978). Hence, we conclude that multicollinearity is not an issue.

Further, to assess the possibility of multicollinearity among the independent variables, we calculate variance inflation factors. These range from 1.188 to 9.375, substantially lower than the cutoff of 10 for multiple regression models (Gujarati, 1992; Hair et al., 1998; Studenmund, 2016). Therefore, the study models do not present collinearity problems.

Considering the tested hypotheses, the correlation matrices show the following: a) climate policy uncertainty (CU_{it}) is positively correlated with ESG performance (ESG_{it}) and negatively correlated with firm performance (FP_{it}) and carbon dioxide emission performance ($FLCE_{it}$); b) investor sentiment (IS_{it}) positively moderates the relationship between climate policy uncertainty and ESG performance (ESG_{it}); c) ESG performance (ESG_{it}) positively moderates the relationship between climate policy uncertainty (CU_{it}) and firm performance (FP_{it}); and d) ESG performance (ESG_{it}) positively moderates the relationship between climate policy uncertainty (CU_{it}) and carbon dioxide emission performance ($FLCE_{it}$) (see Table 5).

Table 5 Pearson correlation matrix for the whole sample (Cluster 1)

ESG performance under climate policy uncertainty (Linear model 3)													
	ESG _{it}	CU _{it}	IS _{it}	CU _{it} *IS _{it}	FS _{it}	LEV _{it}	ROA _{it}	MTB _{it}	ECN _{it}	COR _{it}	UR _{it}	GDP _{it}	
ESG _{it}	1												
CU _{it}	0.065**	1											
IS _{it}	-0.130*	-0.082	1										
CU _{it} *IS _{it}	-0.109**	-0.006	0.776**	1									
FS _{it}	0.554**	-0.021	0.171	0.162	1								
LEV _{it}	-0.021**	-0.004	-0.149	-0.165	0.123	1							
ROA _{it}	0.205	-0.062	-0.291**	-0.305***	-0.450**	-0.048	1						
MTB _{it}	-0.079*	0.000	-0.148	-0.160	-0.016	0.779**	0.051**	1					
ECN _{it}	0.025**	-0.002	-0.159	-0.166	-0.427**	0.038	-0.065*	0.093**	1				
COR _{it}	-0.063	0.210*	-0.000	0.016	-0.020	0.101	0.048*	0.115	-0.013**	1			
UR _{it}	0.007	-0.327**	0.046	0.029	-0.034	-0.150	-0.024**	-0.151	-0.008	-0.471**	1		
GDP _{it}	0.025*	-0.256**	-0.004	-0.047	0.013	-0.071**	-0.016***	-0.074	-0.020	-0.022	-0.390**	1	
Firm performance under climate policy uncertainty (Linear model 4)													
	ROE _{it}	CU _{it}	ESG _{it}	CU _{it} *ESG _{it}	FS _{it}	CR _{it}	LEV _{it}	FA _{it}	CI _{it}	TAN _{it}	LR _{it}	GDP _{it}	FDI _{it}
ROE _{it}	1												
CU _{it}	-0.015***	1											
ESG _{it}	0.057*	-0.015	1										
CU _{it} *ESG _{it}	0.035**	0.718**	0.360**	1									
FS _{it}	0.010**	-0.005	0.539**	0.198*	1								
CR _{it}	-0.058*	-0.027	0.354*	0.110	0.235*	1							
LEV _{it}	0.780	-0.000	-0.015	-0.006	0.118	-0.005	1						
FA _{it}	0.026	0.012	0.612**	0.241*	0.158	0.362**	-0.020	1					
CI _{it}	0.022	0.046	0.229*	0.129	0.768*	0.152	0.136	-0.193**	1				
TAN _{it}	0.060**	0.023	-0.361*	-0.119	-0.306*	-0.126	0.043	0.308**	-0.138**	1			
LR _{it}	-0.028**	0.012	0.072	0.038	-0.024	0.705**	-0.014	0.152	-0.054	-0.063	1		

Table 5 (continued)

Firm performance under climate policy uncertainty (Linear model 4)

	ROE _{it}	CU _{it}	ESG _{it}	CU _{it} *ESG _{it}	FS _{it}	CR _{it}	LEV _{it}	FA _{it}	CI _{it}	TAN _{it}	LR _{it}	IR _{it}	GDP _{it}	INR _{it}	FDI _{it}
IR _{it}	-0.011**	0.245**	0.043	0.241*	-0.009	-0.008	-0.014	0.006	0.034	0.038	-0.072	1			
GDP _{it}	0.049	-0.254**	0.003	-0.232*	0.003	-0.167	-0.065	0.043	0.009	0.006	-0.167	-0.234**	1		
INR _{it}	-0.096**	0.168	-0.003	0.135	0.003	0.151	-0.073	-0.041	-0.024	-0.024	0.157	-0.128		1	
FDI _{it}	0.050**	0.128	0.049	0.139	0.000	-0.135	0.019	0.031	0.029	0.006	-0.011	-0.394***	0.515**		1

Carbon dioxide emission performance under climate policy uncertainty (Linear model 5)

	CEP _{it}	CU _{it}	ESG _{it}	CU _{it} *ESG _{it}	EFF _{it}	FS _{it}	EI _{it}	CI _{it}	LI _{it}	DY _{it}	ENI _{it}	FDI _{it}	GDP _{it}	ISG _{it}	TI _{it}	TP _{it}	UP _{it}
CEP _{it}	1																
CU _{it}	-0.009**	1															
ESG _{it}	-0.605**	-0.065**	1														
CU _{it} *ESG _{it}	-0.233**	0.715*	0.320**	1													
EFF _{it}	-0.173*	-0.070	-0.237**	-0.153	1												
FS _{it}	0.289*	-0.020	0.554**	0.199**	0.212*	1											
EI _{it}	-0.086	-0.066	0.097	-0.023	0.545**	0.362*	1										
CI _{it}	0.002***	0.046	0.261**	0.148	0.185	0.773*	0.322**	1									
LI _{it}	-0.417*	0.049	-0.522**	-0.171	0.031	-0.356*	-0.289**	-0.163	1								
DY _{it}	-0.051**	-0.040	0.121	0.007	0.011	0.066	-0.110	-0.066	0.137	1							
ENI _{it}	0.077	0.231*	-0.009	-0.218**	0.082	-0.026	-0.067	-0.048	0.074	0.058	1						
FDI _{it}	0.012	0.130	0.031	0.134	-0.092	-0.130	0.009	0.022	-0.008	-0.043	-0.502**	1					
GDP _{it}	-0.040	-0.256**	0.025	-0.232**	-0.090	0.010	0.043	0.010	-0.036	-0.002	-0.607**	0.507*	1				
ISG _{it}	0.105**	-0.061	0.026	-0.005	-0.005	0.046	0.108	0.015	-0.121	0.043	-0.746**	0.546**	0.700**	1			
TI _{it}	0.067**	0.011	0.020	0.014	-0.067	0.021	0.056	0.038	-0.058	-0.020	-0.735**	0.478**	0.773**	0.764**	1		
TP _{it}	-0.074	0.139	0.021	0.136	-0.071	0.030	0.072	0.044	-0.079	-0.048	-0.785*	0.447**	0.681**	0.763**	0.664**	1	
UP _{it}	-0.077**	-0.183	-0.020	-0.167	0.064	-0.033	-0.078	-0.043	0.086	0.044	0.787***	-0.455**	-0.652**	-0.783*	-0.644*	-0.696*	1

This table displays correlation coefficients of the variables used in our main analysis. All variables are winsorized at the 1st and 99th percentiles. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$. For brevity, we present only the results for the whole sample (Cluster 1). For variable definitions, see Appendix A

Table 6 ESG performance under climate policy uncertainty, using IV-2SLS (instrumental variables—two stage least squares)

Dependent variable	Expected sign	Cluster 1 ESG _{it}	Cluster 2 ESG _{it}	Cluster 3 ESG _{it}
<i>Panel A: ESG performance under climate policy uncertainty</i>				
Constant		− 12.487** (26.606)	− 66.680* (39.548)	− 23.594** (34.300)
CU _{it}	+	0.001** (0.002)	0.002*** (0.003)	0.002 (0.003)
FS _{it}	+	14.166*** (1.889)	27.088*** (3.714)	11.389** (3.364)
LEV _{it}	−	− 0.537* (0.323)	− 0.157** (0.334)	− 0.682 (1.242)
ROA _{it}	+	0.354 (0.246)	0.345 (0.344)	1.218 (0.884)
MTB _{it}	−	− 0.749** (0.524)	− 0.178 (0.541)	− 0.136 (1.350)
ECN _{it}	+	0.378*** (0.092)	0.179** (0.127)	0.658** (0.121)
COR _{it}	−	− 8.259 (14.124)	− 4.459** (19.723)	− 0.924 (17.440)
UR _{it}	+	0.198 (0.586)	0.201 (0.835)	0.049 (0.663)
GDP _{it}	+	0.157** (0.642)	0.606 (0.890)	0.035* (0.730)
Year fixed effects		Yes	Yes	Yes
Industry fixed effects		Yes	Yes	Yes
Hausman test (<i>p</i> value)		0.000	0.000	0.000
Grang and Donald test (<i>F</i> -value)		10.819	10.518	10.617
Overidentifying restriction test (<i>p</i> value)		0.517	0.619	0.671
R ²		0.445	0.586	0.62
Adjusted R ²		0.39	0.493	0.534
N		6462	4061	2401
<i>Panel B: Moderating effect of investor sentiment in the climate policy uncertainty and ESG performance relationship</i>				
Constant		− 12.576** (26.809)	− 75.209* (39.902)	− 21.673* (35.622)
CU _{it}	+	0.001** (0.002)	0.001** (0.003)	0.001* (0.003)
IS _{it}	−	− 4.281** (7.253)	− 9.319** (12.167)	− 2.492** (9.147)
CU _{it} *IS _{it}	−	− 0.003** (0.006)	− 0.004* (0.010)	− 0.003 (0.008)
FS _{it}	+	13.996*** (1.912)	27.057** (3.696)	10.986** (3.676)
LEV _{it}	−	− 0.480** (0.343)	− 0.191 (0.409)	− 0.854 (1.445)

Table 6 (continued)

Dependent variable	Expected sign	Cluster 1 ESG _{it}	Cluster 2 ESG _{it}	Cluster 3 ESG _{it}
ROA _{it}	+	0.410 (0.270)	0.036 (0.410)	1.315 (0.952)
MTB _{it}	-	-0.665** (0.551)	-0.362* (0.651)	-0.207 (1.398)
ECN _{it}	+	0.388** (0.095)	0.234** (0.132)	0.639** (0.135)
COR _{it}	-	-8.526 (14.222)	-1.972** (19.700)	-1.359 (17.936)
UR _{it}	+	0.195 (0.592)	0.182 (0.848)	0.046 (0.681)
GDP _{it}	+	0.166* (0.656)	0.616 (0.895)	0.007 (0.764)
Year fixed effects		Yes	Yes	Yes
Industry fixed effects		Yes	Yes	Yes
Hausman test (<i>p</i> value)		0.000	0.000	0.000
Gragg and Donald test (F-value)		12.896	15.916	13.637
Overidentifying restriction test (<i>p</i> value)		0.719	0.637	0.371
R ²		0.45	0.61	0.621
Adjusted R ²		0.382	0.498	0.511
N		6462	4061	2401

The dependent variable across all models is ESG_{it} and represents the ESG performance extracted by Thomson Reuters EIKON. Panel A indicates the effect of climate policy uncertainty (CU_{it}) on ESG performance (ESG_{it}). Panel B presents the joint effect of climate policy uncertainty and investor sentiment (MS_{it}*CU_{it}) on ESG performance (ESG_{it}). The standard errors may be found in the parentheses. For variable definitions, see Appendix A. **p* < 0.10; ***p* < 0.05; ****p* < 0.01

4.2 ESG performance under climate policy uncertainty (Hypotheses 1 and 4)

Panel A of Table 6 presents the impact of climate policy uncertainty on ESG performance in all clusters using an IV-2SLS approach. We observe that CU_{it} has a significant positive impact on ESG_{it} in the whole sample (p value < 0.05) and high-profile industries (p value < 0.10); thus, we accept Hypothesis 1. Our results agree with those of Ongsakul et al. (2021), Hwang et al. (2021) and Broadstock et al. (2021) and indicate that during periods of high climate policy uncertainty, firms increase their ESG performance to reap the benefits of ESG activities.

We also examine the moderating role of investor sentiment in the relationship between ESG performance and climate policy uncertainty. Panel B in Table 6 shows that the coefficients of IS_{it} in all clusters are negative and statistically significant (p value < 0.05). In line with the findings of Serafeim (2020), Vuong and Suzuki (2021) and Bofinger et al. (2022), our results suggest that firms improve their ESG performance when investors are pessimistic in order to enhance their public image and help investors make better investment decisions. Further, Panel B in Table 6 indicates that the coefficients of the interaction term $CU_{it} * IS_{it}$ in the whole sample (p value < 0.05) and high-profile industries (p value < 0.10) are negative and significant, suggesting that the impact of investor sentiment on ESG performance is more prominent during periods of climate policy uncertainty. Consequently, we accept Hypothesis 4.

Regarding the control variables in Table 6, most of the coefficients have the predicted sign (e.g. Freeman et al., 2007; Boulouta & Pitelis, 2014; Crespi & Migliavacca, 2020; Menassa and Dagher, 2020; Vuong & Suzuki, 2021; El Khoury et al., 2021; Abdul Rahman & Alsayegh, 2021). FS_{it} , ROA_{it} and ECN_{it} have positive coefficients, supporting the notion that more profitable and larger companies and firms with higher economic sustainability performance disclose more ESG information to remain legitimate. Similarly, high unemployment (UR_{it}) and economic development (GDP_{it}) positively affect ESG performance. On the contrary, the negative and statistically significant coefficients of LEV_{it} , MTB_{it} and COR_{it} indicate that leverage, the market-to-book ratio and the level of corruption decrease ESG performance.

4.3 Firm performance under climate policy uncertainty (Hypotheses 2 and 5)

The results in Panel A of Table 7 provide evidence of the impact of climate policy uncertainty on firm performance. We find a significant negative association between CU_{it} and FS_{it} in all clusters (p value < 0.05). This implies that policy-induced uncertainty in the environment reduces accounting as well as firm performance. Thus, climate policy uncertainty is caused by changes in the external environment, which put great pressure on the finances of a firm by increasing the intensity of competition, which, in turn, decreases firm profitability. These results corroborate those of Dell et al. (2014) and Fuss (2016). Therefore, we accept Hypothesis 2.

Further, Panel B in Table 7 shows a highly significant positive association of ESG performance (ESG_{it}) with firm performance (ROE_{it}) in the whole sample and high-profile industries at the 5% level. Therefore, in line with Atan et al. (2018), Shakil et al. (2019) and Junius et al. (2020), we deduce that better ESG performance enhances firm performance. Panel B of Table 7 also presents the results regarding the moderating impact of ESG performance on the relationship between firm performance and climate policy uncertainty. We observe no association of the interaction term of ESG_{it} with CU_{it} on ROE_{it} in all clusters.

Table 7 Firm performance under climate policy uncertainty, using IV-2SLS (instrumental variables—two stage least squares)

Dependent variable	Expected sign	Cluster 1 ROE _{it}	Cluster 2 ROE _{it}	Cluster 3 ROE _{it}
<i>Panel A: Firm performance under climate policy uncertainty</i>				
Constant		−455.808** (239.194)	−1005.263** (371.213)	−104.598** (140.090)
CU _{it}	−	−0.006** (0.005)	−0.005** (0.007)	−0.004** (0.003)
FS _{it}	+	0.095** (8.164)	65.203* (19.282)	2.480 (7.047)
CR _{it}	−	−15.507* (11.100)	−65.747 (26.306)	−18.470* (9.163)
LEV _{it}	−	−6.279 (0.104)	−6.399 (0.114)	−0.967*** (1.658)
FA _{it}	+	0.002 (0.339)	3.111 (1.151)	0.241** (0.261)
CI _{it}	−	−4.682 (2.025)	−24.125** (17.035)	−0.842** (1.338)
TAN _{it}	+	14.464** (11.622)	14.371** (23.497)	9.320 (13.599)
LR _{it}	−	−2.494** (3.136)	−18.447* (7.387)	−1.335 (1.849)
IR _{it}	−	−4.059** (2.792)	−6.880 (4.250)	−0.325** (1.557)
GDP _{it}	+	0.949 (1.474)	0.338 (2.200)	0.054 (0.833)
INR _{it}	−	−0.074** (4.108)	−1.958 (5.933)	−0.740 (2.249)
FDI _{it}	+	41.899** (19.851)	69.536** (30.338)	12.199** (11.503)
Year fixed effects		Yes	Yes	Yes
Industry fixed effects		Yes	Yes	Yes
Hausman test (<i>p</i> value)		0.000	0.000	0.000
Gragg and Donald test (<i>F</i> -value)		15.916	12.718	11.347
Overidentifying restriction test (<i>p</i> value)		0.357	0.159	0.483
R ²		0.978	0.99	0.556
Adjusted R ²		0.975	0.987	0.412
N		6462	4061	2401
<i>Panel B: Moderating effect of ESG performance in the climate policy uncertainty and firm performance relationship</i>				
Constant		−463.136** (248.630)	−985.298** (386.213)	−151.742** (151.118)
CU _{it}	−	−0.015** (0.028)	−0.016** (0.035)	−0.001* (0.022)

Table 7 (continued)

Dependent variable	Expected sign	Cluster 1 ROE _{it}	Cluster 2 ROE _{it}	Cluster 3 ROE _{it}
ESG _{it}	+	0.336** (0.583)	0.153** (0.886)	0.194** (0.378)
ESG _{it} *CU _{it}	+	0.000 (0.000)	0.000 (0.001)	0.000 (0.000)
FS _{it}	+	1.070*** (8.712)	64.306*** (24.236)	0.966 (7.285)
CR _{it}	-	-14.934*** (11.315)	-65.729 (27.067)	-21.340* (9.640)
LEV _{it}	-	-6.278 (0.105)	-6.400 (0.117)	-0.627** (1.706)
FA _{it}	+	0.112 (0.420)	3.137 (1.191)	0.499** (0.356)
CI _{it}	-	-4.826 (2.077)	-24.272* (18.886)	-1.160* (1.388)
TAN _{it}	+	18.730* (15.679)	16.366** (37.502)	13.396 (14.351)
LR _{it}	-	-2.264** (3.220)	-18.406** (7.587)	-0.772 (1.946)
IR _{it}	-	-4.366** (2.897)	-6.836 (4.389)	-0.328 (1.686)
GDP _{it}	+	1.026 (1.501)	0.272 (2.273)	0.216 (0.855)
INR _{it}	-	-0.123** (4.166)	-1.831 (6.198)	-0.859 (2.279)
FDI _{it}	+	43.874** (20.536)	69.096* (31.180)	16.345** (12.249)
Year fixed effects		Yes	Yes	Yes
Industry fixed effects		Yes	Yes	Yes
Hausman test (<i>p</i> value)		0.000	0.000	0.000
Gragg and Donald test (F-value)		11.718	13.619	16.712
Overidentifying restriction test (<i>p</i> value)		0.348	0.288	0.462
R ²		0.978	0.99	0.57
Adjusted R ²		0.974	0.986	0.398
N		6462	4061	2401

The dependent variable across all models is ROE_{it} and represents the firm performance measured by return on equity. Panel A indicates the effect of climate policy uncertainty (CU_{it}) on firm performance (ROE_{it}). Panel B presents the joint effect of climate policy uncertainty and ESG performance (ESG_{it}*CU_{it}) on firm performance (ROE_{it}). The standard errors may be found in the parentheses. For variable definitions, see Appendix A. **p* < 0.10; ***p* < 0.05; ****p* < 0.01

Table 8 Carbon dioxide emission performance under climate policy uncertainty, using IV-2SLS (instrumental variables—two stage least squares)

Dependent variable	Expected sign	Cluster 1 CEP _{it}	Cluster 2 CEP _{it}	Cluster 3 CEP _{it}
<i>Panel A: Carbon dioxide emission performance under climate policy uncertainty</i>				
Constant		−9658.803** (71,563.668)	12,335.969** (26,277.233)	18,358.858* (60,326.282)
CU _{it}	−	−0.004** (0.266)	−0.000** (0.002)	−0.003 (0.005)
EFF _{it}	−	−0.743*** (0.266)	−0.586*** (0.135)	−1.435*** (0.240)
FS _{it}	+	33.452** (5.224)	20.572** (6.959)	16.175** (4.198)
EL _{it}	−	−13.249 (14.040)	−61.482 (6.527)	−12.723** (19.634)
CI _{it}	+	7.304** (1.220)	11.094** (2.716)	1.414 (1.440)
LI _{it}	−	−9.461** (10.115)	−39.287** (10.216)	−49.230 (16.528)
DY _{it}	−	−123.008** (60.286)	−96.186*** (43.305)	−146.737*** (43.230)
ENI _{it}	+	487.629 (1517.884)	1205.028 (572.710)	653.343 (1265.625)
FDI _{it}	+	7.314 (16.761)	12.643 (6.497)	2.926 (14.592)
GDP _{it}	−	−0.890 (2.187)	−1.598 (0.849)	−1.043** (1.867)
ISG _{it}	+	0.531** (0.851)	0.058** (0.315)	0.438** (0.720)
TI _{it}	+	50.350** (108.867)	8.170 (41.186)	115.230** (96.849)
TP _{it}	−	−232.713 (5176.467)	−1239.689** (1891.730)	−1909.102** (4356.779)
UP _{it}	−	−881.467** (3384.318)	−181.706** (1254.394)	−319.987** (2861.919)
Year fixed effects		Yes	Yes	Yes
Industry fixed effects		Yes	Yes	Yes
Hausman test (<i>p</i> value)		0.000	0.000	0.000
Gragg and Donald test (<i>F</i> -value)		10.819	10.557	10.349
Overidentifying restriction test (<i>p</i> value)		0.173	0.148	0.277
R ²		0.471	0.976	0.777
Adjusted R ²		0.384	0.966	0.687
N		6462	4061	2401
<i>Panel B: Moderating effect of ESG performance in the climate policy uncertainty and carbon dioxide emission performance relationship</i>				
Constant		−4398.720** (69,446.026)	11,536.963** (26,205.200)	33,107.316** (62,353.547)

Table 8 (continued)

Dependent variable	Expected sign	Cluster 1 CEP _{it}	Cluster 2 CEP _{it}	Cluster 3 CEP _{it}
CU _{it}	–	–0.020** (0.022)	–0.014** (0.007)	–0.020** (0.027)
ESG _{it}	–	–0.198* (0.431)	–0.190 (0.172)	–0.015 (0.466)
ESG _{it} *CU _{it}	–	–0.000 (0.000)	–0.000 (0.000)	–0.000 (0.000)
EFF _{it}	–	–0.379** (0.296)	–0.588 (0.161)	–1.256** (0.288)
FS _{it}	+	21.311** (6.933)	19.723*** (8.590)	9.460* (7.096)
EL _{it}	–	–10.118 (13.698)	–63.700 (8.777)	–1.624 (23.127)
CL _{it}	+	5.369** (1.409)	10.479** (3.701)	1.027 (1.484)
LI _{it}	–	–0.493** (10.335)	–43.913** (10.636)	–60.932 (19.677)
DY _{it}	–	–134.946** (58.540)	–86.935** (43.137)	–148.422** (43.467)
ENI _{it}	+	1191.216 (1504.591)	1133.628 (622.215)	737.151 (1275.364)
FDI _{it}	+	16.769 (16.670)	11.696 (6.872)	8.128 (15.293)
GDP _{it}	–	–0.142 (2.151)	–1.591 (0.871)	–0.701** (1.900)
ISG _{it}	+	0.676** (0.826)	0.015** (0.308)	0.413* (0.726)
TI _{it}	+	40.440** (105.485)	9.002 (40.178)	130.929** (98.793)
TP _{it}	–	–331.900 (5028.339)	–1158.625* (1899.212)	–2978.952* (4505.421)
UP _{it}	–	–859.547** (3280.229)	–170.848*** (1237.275)	–991.073** (2951.605)
Year fixed effects		Yes	Yes	Yes
Industry fixed effects		Yes	Yes	Yes
Hausman test (<i>p</i> value)		0.000	0.000	0.000
Gragg and Donald test (<i>F</i> -value)		10.552	10.819	10.349
Overidentifying restriction test (<i>p</i> value)		0.452	0.372	0.486
R ²		0.516	0.978	0.787
Adjusted R ²		0.423	0.968	0.684
N		6462	4061	2401

Table 8 (continued)

The dependent variable across all models is CEP_{it} and represents the carbon dioxide emission performance calculated as total carbon emissions divided by total sales. Panel A indicates the effect of climate policy uncertainty on carbon dioxide emission performance (CEP_{it}). Panel B presents the joint effect of climate policy uncertainty and ESG performance ($ESG_{it} * CU_{it}$) on carbon dioxide emission performance (CEP_{it}). The standard errors may be found in the parentheses. For variable definitions, see Appendix A.

* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

These results imply that higher ESG performance does not moderate the destructive impact of policy uncertainty on firm performance. Consequently, we reject Hypothesis 5.

As for the control variables, Table 7 shows that most of the coefficients have the predicted sign (e.g. Bari et al., 2021; Vu et al., 2019; Zainudin et al., 2018). Specifically, firm performance (ROE_{it}) is higher in capital-intensive industries (CI_{it}) and large firms (FS_{it}) because they have led to significant growth opportunities. Moreover, firm age (FA_{it}) is positively associated with firm performance (ROE_{it}) because firm efficiency increases with age. In contrast, a higher amount of cash in the hands of managers (CR_{it}) causes an over-investment problem, which, in turn, negatively affects firm performance. Accordingly, higher levels of leverage (LEV_{it}) and liquidity (LR_{it}) reduce the ability of companies to invest in profitable projects, with negative effects on firm performance (ROE_{it}). Higher tangibility (TAN_{it}) provides creditors with a high level of security since they are able to liquidate more assets in the event of bankruptcy; therefore, it affects firm performance (ROE_{it}) positively. In addition, during periods of economic growth (GDP_{it}) and higher levels of foreign direct investment (FDI_{it}), firms increase their sales and achieve higher firm performance. On the contrary, higher inflation (IR_{it}) and interest rates (INR_{it}), which slow down the economy, have a negative effect on firm performance (ROE_{it}).

4.4 Carbon dioxide emission performance under climate policy uncertainty (Hypotheses 3 and 6)

Panel A of Table 8 examines how climate policy uncertainty influences carbon dioxide emission performance. We report that the CU_{it} coefficients for the whole sample and high-profile industries are significant and have negative values (p value < 0.005). This means that climate policy uncertainty has a detrimental effect on the environment. In other words, uncertainty regarding climate factors causes volatility or uncertainty in carbon dioxide emission performance (CEP_{it}). These findings are possible, expected and in keeping with those of Gavrilidis (2021) because climate policy may influence carbon emissions in the government's policies, which may also impact the uncertainty of carbon dioxide emission performance. Therefore, Hypothesis 3 is accepted.

Panel B in Table 8 investigates the association between carbon dioxide emission performance and ESG performance under climate policy uncertainty. Our results reveal that CEP_{it} in the whole sample is negatively correlated with ESG_{it} performance at the 1% significance level. In accordance with the findings of previous literature (Dicuonzo et al., 2022; Fernandez et al., 2021; Xu et al., 2021), ESG performance reduces carbon dioxide emission performance. In addition, we explore whether ESG performance moderates the relationship between carbon dioxide emission performance and climate policy uncertainty. Panel B in Table 8 does not provide support for the moderating role of ESG_{it} in the relationship between CEP_{it} and CU_{it} . Hence, given that the interaction term between ESG performance and climate policy uncertainty is negatively and insignificantly associated with carbon dioxide emission performance, we cannot accept Hypothesis 6.

As for control variables, we find firm size (FS_{it}) and capital intensity (CI_{it}) to be positively and significantly related to carbon emission intensity (see Table 8). These results confirm the findings of Papadogonas et al. (2007), Duran et al. (2015) and Zaekhan et al. (2021), indicating that an increase in firm size and capital intensity seems to have a positive impact on carbon emission intensity. Contrasting results are found for efficiency (EFF_{it}), export intensity (EI_{it}), labour intensity (LI_{it}) and dividend yield (DY_{it}), which display a negative and significant relationship with carbon dioxide emission performance CEP_{it} (see

Table 8). Higher efficiency lowers carbon emissions due to a stronger ability to liquidate inventory and better production management (Cheng et al., 2021). Higher export activity also decreases carbon dioxide emission performance (CEP_{it}) (Cole et al., 2013; Richter & Schiersch, 2017). Additionally, labour intensity has a negative relationship with carbon emission intensity, meaning that labour-intensive firms emit less pollution (Cole et al., 2005). Based on the findings of Balachandran and Nguyen (2018), we observe that firms in the highest-emitting industries pay less dividends. Further, in line with Andersson and Karpestam (2013), we find that energy intensity (ENI_{it}), foreign direct investment (FDI_{it}), the industrial share of growth (ISG_{it}) and technological innovation (TI_{it}) are positively correlated with carbon dioxide emission performance (CEP_{it}). Conversely, as seen in Table 8, the coefficients of economic development (GDP_{it}), total population (TP_{it}) and urban population (UP_{it}) are significant and have negative values.

5 Discussion

Our results highlight the growing interest of scholars in ESG performance, firm performance and carbon dioxide emission performance in uncertain periods. First, our findings suggest that there is a positive association between corporate ESG practices and climate policy uncertainty, implying that during periods of high uncertainty, managers prefer to enhance their ESG engagements. These results are in accordance with those of Zhang et al., (2018, 2020) and Ahsan and Qureshi (2021), which refer to ESG practices as risk-reducing activities. In addition, Nguyen et al. (2018) show that during periods of high uncertainty, firms increase their financial derivatives to mitigate their exposure to policy-related risk. Therefore, based on our results, we support the idea that ESG practices serve an insurance function to eliminate risk in uncertain periods (Borghesi et al., 2019; Rjiba et al., 2020; Zhang et al., 2018). In turn, our results are also coherent with Boccia and Sarnacchiaro (2020) and Di Vaio et al. (2022) who outline the positive reasons for ESG reporting during specific negative events, namely increasing trust and social capital, reducing risks and avoiding negative impacts on corporate brands. Furthermore, our results support the theory of resilience of firms with high ESG performance in times of uncertain periods (e.g. Albuquerque et al., 2020; Barro et al., 2020; Rameli & Wanger, 2020; Kocak et al., 2021; Broadstock et al., 2021; Whelan et al., 2021; Gianfrate et al., 2021; Cardillo et al., 2023), suggesting that investing to ESG activities may contribute to stock price resilience during periods of crisis upon the belief that corporate social responsibility activities help to build social capital and trust in the firm, and that will motivate the firms' stakeholders to remain loyalty, helping the firm to rise above the challenges imposed by an uncertain period. Overall, we conclude that firms increase their ESG performance to benefit from the protection afforded by ESG practices during periods of high uncertainty.

Second, our results are related to the existing literature on the fluctuations of firm performance in periods of high uncertainty. Specifically, we highlight the negative influence of climate policy uncertainty on firm performance, as found by Cadeaux and Ng (2012), Bendickson et al. (2018) and Aprisma and Sudaryati (2020). Further, we enhance the findings of Aprisma and Sudaryati (2020), who report that to minimise the effects of environmental uncertainty, firms invest more in new technology to keep up with changes in the market and stabilise their performance. Therefore, we establish that increased climate policy uncertainty results in decreased returns on equity and, consequently, a reduction in firm performance.

Third, we give a clear view of how carbon dioxide emissions fluctuate during periods of uncertainty since previous conclusions are controversial (Gill et al., 2019; Shabir et al., 2021). In line with Adedoyin and Zakari (2020) and Yu et al. (2021), we demonstrate that climate policy uncertainty has adverse effects on carbon emissions. In other words, an increase in uncertainty should lead to a decrease in the consumption of energy and environmentally harmful products, which, in turn, should decrease consumption and, therefore, carbon dioxide emissions. Further, our results conflict with those of Chen et al. (2021) and Dogan and Guler (2021), who find that uncertainty has a positive role in reducing carbon emissions, whereas other researchers argue that there is no influence of uncertainty on carbon emissions (Abbasi & Adedoyin, 2021; Liu & Zhang, 2021).

Fourth, our findings also show that the empirical results highlighted the level of investor sentiment as moderator between ESG performance and climate policy uncertainty, which generates pressure on the firm and its directors, conditioning their behaviour. In fact, our results demonstrate that investors adopt a bearish attitude in periods of uncertainty because they feel less confident in their trading ability (Bird & Yeung, 2012; Idnani et al., 2021; Zhang et al., 2018). Additionally, we find that firms enhance their ESG performance when investors are pessimistic in order to maintain their stakeholders and improve their public image, especially in uncertain times. Our findings are in line with those of Sun et al. (2018), Keles and Cetin (2018) and Neughton et al. (2019), suggesting that firms take a conservative stance vis-à-vis investors who play a watchdog role, and managers are more likely to issue a standalone CSR report during low-sentiment periods. In this regard, higher ESG performance indicates that firms with a more substantial social and environmental commitment may be safer investment places.

Fifth, the previous literature (Aprisma & Sudaryati, 2020) reports that when climate policy uncertainty rises, an effective corporate governance organ is needed to raise ESG performance and mitigate the effect of uncertainty so that firm performance and carbon emission performance remain stable. Furthermore, several academic studies focusing on periods of turbulence find evidence to support the case for ESG as mitigator of risk. For instance, Lins et al. (2017) present evidence to suggest that firms that have higher CSR scores enjoy stock returns during uncertain periods than those with lower CSR scores, and that high CSR firms also experienced higher profitability, growth and sales per employee. These authors conclude that when the overall trust in firms and markets suffers a negative shock, firms build the trust between firm and its stakeholders through investments in CSR. In addition, Bouslah et al. (2018) show that CSR reduces volatility during uncertain periods, and also that risk reduction is mainly due to the strengths rather than the concerns component of CSR performance. In overall, Matos (2020) and Whelan et al. (2021) claim that high sustainability firms enjoy lower risk and are resilient during turbulent times. They suggest that CSR is particularly as a risk mitigation strategy, offering the prospect of significant downside protection in uncertain periods. Consistent with this, firms pursue to increase ESG performance in order to succeed firm performance resilience because managers have all been trumpeting the value of ESG as a firm performance “vaccine”, during uncertain periods. Therefore, based on these results, our study therefore calls into question if ESG performance is a resilience factor in times of uncertainty. Contrary to these widespread claims, however, the extensive analyses present robust evidence that ESG performance does not play a moderating role in the firm performance–climate policy uncertainty nexus or the carbon emission performance–climate policy uncertainty nexus. This means that although management seeks to take steps to minimise the impact of climate policy uncertainty on the firm’s financial position by raising ESG performance, financial performance and carbon emission performance are not influenced during periods of uncertainty.

6 Conclusions and implications

ESG has progressively become a requirement for any organisation. This study concentrates on the impact of the new climate policy uncertainty index developed by Gavriilidis (2021) on ESG performance, firm performance and carbon dioxide emission performance. In addition, we analyse the moderating effects of investor sentiment on the relationships between ESG performance and climate policy uncertainty and those of ESG performance on the link between firm performance and climate policy uncertainty and between carbon dioxide emission performance and climate policy uncertainty. The analysis comprises 6462 firm-year observations from the US Fortune 1000 list covering the years 2008–2018. By splitting our sample into high- and low-profile industries, we ensure that our results are robust across different sub-samples.

Based on the results of our study, we conclude that the new climate policy uncertainty index developed by Gavriilidis (2021) decreases firm performance and carbon dioxide emission performance. On the contrary, the impact of climate policy uncertainty on ESG performance is positive and strong because firms enhance ESG reporting as insurance during periods of high uncertainty.

Further, we find that firms with a better ESG index tend to exhibit better firm performance. Contrasting results are found for ESG performance, which has a negative and significant impact on carbon dioxide emission performance. Meanwhile, the findings show that investor sentiment negatively affects ESG performance, especially during periods of high uncertainty, suggesting that in times of bearish investor sentiment, firms boost ESG activities in response to investor sentiment regarding ESG activities. In addition, we find that ESG performance enhances firms' reputation and investor trust and allows them to lower (magnify) the negative effects of climate policy uncertainty on firm performance (carbon dioxide emission performance).

All the aforementioned results are robust across different sub-samples but more prominent in firms belonging to high-profile industries than low-profile industries.

The results of this paper contribute to the ESG and CSR literature demonstrating that climate policy uncertainty influences the ESG score. This paper enhances the findings of Gavriilidis (2021), indicating that during periods of high uncertainty, firms are more dedicated to sustainability issues and attain higher levels of ESG performance to increase firm performance and decrease carbon emission intensity. This paper also contributes to the literature by showing that firm performance and carbon dioxide emission performance do not moderate the relationship between uncertainty and ESG. Further, we add to the previous literature (e.g. Martin et al., 2018; Nainggolan & Handoyo, 2019) arguing that better ESG performance enhances firm performance and lowers carbon emissions. Finally, concerning the influence of investor sentiment on ESG performance, we add to the limited evidence (e.g. Serafeim, 2020; Vuong & Suzuki, 2021) showing that negative investor sentiment influences investors' views about the value of ESG activities.

6.1 Theoretical implications

This paper provides a comprehensive understanding of the behaviour of companies during periods of high climate policy uncertainty. Specifically, the study contributes to the literature on ESG performance, firm performance and carbon emission performance by providing empirical evidence of the negative effect of climate policy uncertainty on ESG

performance, firm performance and carbon dioxide emission performance (Abbasi & Ade-doyin, 2021; Adams et al., 2020; Anser et al., 2021; Bendickson et al., 2018; Chan, 2020; Fukushima, 2013) and by pointing out the benefits of ESG practices. In this regard, while several studies find a positive impact of ESG performance on different performance measures (Al Hawaj & Buallay, 2022; Mohammad & Wasiuzzaman, 2021; Nguyen et al., 2022; Shaikh, 2022), others report a negative or neutral relationship (Alareeni & Hamdan, 2020; Albitar et al., 2020; Junius et al., 2020; Ruan & Liu, 2021; Shakil et al., 2019). We complement these studies by proposing a positive effect of ESG performance on firm performance. Further, our research contributes to the existing literature advocating the inclusion of ESG performance as a moderating factor to studies analysing fluctuations in firm performance and carbon dioxide emission performance during periods of uncertainty.

However, our findings do not allow us to confirm the moderating effect of ESG performance on the relationships between climate policy uncertainty and firm performance and between climate policy uncertainty and carbon dioxide emission performance. Although the significance of these interaction terms is weak and lower than the direct effects on firm performance and carbon dioxide performance, these effects are negative and significant. Our research also contrasts with studies suggesting that if a firm has implemented ESG practices in the past, it can minimise the risks to its reputation during periods of uncertainty (Klein & Dawar, 2004).

6.2 Practical implications

Our findings have implications for policymakers, regulators, managers and investors. First, the practical implications derived from our analysis can help managers in their decision-making to increase ESG performance. Our results enhance ESG literature by analysing the impact of ESG performance on firm performance and carbon emission intensity and show that customers appreciate ESG disclosure, resulting in an increase in revenues that generates higher profits for the firm. Consequently, we conclude that higher levels of ESG performance are increasingly integrated into business operations and play a significant role in influencing customers' purchasing decisions. Another practical implication of our research is that it encourages managers to reconsider sustainable practices as a way to enhance their firm's reputation. Managers must focus on ESG performance by adopting responsible practices to alleviate risks in uncertain times. They should prevent rather than wait to cure. Therefore, managers should focus on substantive sustainable practices rather than symbolic ones (Kim et al., 2012).

Second, higher ESG performance should contribute to sustainability. Therefore, during periods of high uncertainty, policymakers and regulators should adopt policies aiming to foster companies' involvement in environmental innovation and protect shareholder rights.

Third, this study provides evidence that could be useful to the capital market as well as to policymakers in their efforts to promote responsible investment in listed companies with ESG policies. Therefore, firms should be compelled to engage in and report on their ESG initiatives.

Fourth, our results have implications for governments as incentive policies promoting firms' ESG engagement are becoming increasingly crucial to boost firm performance and lower carbon emission intensity.

Fifth, with regard to investors, our study demonstrates that the pessimistic outlook of shareholders and outside investors may be critical in enhancing companies' ESG activities.

In addition, our findings identify a promising channel to investor power that the government and ESG-reporting advocates can utilise to encourage firms to act responsibly during periods of uncertainty. Finally, this research suggests the need to require firms to inform and integrate ESG performance indicators as part of firm performance.

Appendix A: Variables for the study

Measure	Operationalization	Source
CEP _{it}	Carbon emission performance measured by firm-level carbon dioxide emission intensity, as presented in Sect. 3.2.5	Datastream
CI _{it}	Capital intensity measured as the fixed assets divided by sales	Datastream
COR _{it}	Level of corruption measures the annual country's level of corruption	Official site of world bank
CR _{it}	Cash ratio measured as the total cash holdings divided by current liabilities	Datastream
CU _{it}	Climate policy uncertainty developed by Gavrilidis (2021), as presented in Sect. 3.2.1	Official site of policy uncertainty
DY _{it}	Dividend yield measured by the annual dividends per share divided by price per share	Datastream
ECN _{it}	Economic sustainability performance is an index obtained from Thomson Reuters	Datastream
EFF _{it}	Efficiency measured by the cost of goods sold divided by average inventory	Datastream
EI _{it}	Export intensity measured as the natural logarithm of total export divided by total sales	Datastream
ENI _{it}	Energy intensity measured as the energy consumption divided by GDP	Official site of statista
ESG _{it}	ESG performance is the Thomson Reuters ESG performance index, as presented in Sect. 3.2.2	Datastream
FA _{it}	Firm age is the number of years that a firm has been in operation	Datastream
FDI _{it}	Foreign direct investment measures the annual country's foreign direct investment	Official site of OECD
FS _{it}	Firm size measured by natural logarithm of the firm's total assets	Datastream
GDP _{it}	Economic development measures the annual percentage growth rate of GDP	Official site of OECD
INR _{it}	Interest rate measures the annual country's interest rate	Official site of OECD
IR _{it}	Inflation rate measures the annual country's inflation rate	Official site of OECD
ISG _{it}	Industrial share of growth measures the industrial value added to GDP per year expressed as a percentage	Official site of OECD
IS _{it}	Investor sentiment developed by Aboody et al. (2018), as presented in Sect. 3.2.3	Datastream
LEV _{it}	Leverage measured by the total liabilities divided by shareholder's equity	Datastream
LI _{it}	Labor intensity measured by the natural logarithm of total wages divided by total sales	Datastream
LR _{it}	Liquidity measured by the current assets divided by current liabilities	Datastream

Measure	Operationalization	Source
MTB_{it}	Market-to-book ratio measured by the market value divided by book value of the firm's equity	Datastream
ROA_{it}	Return on assets measured by the net profit divided by total assets	Datastream
ROE_{it}	Firm performance measured by the return on equity as presented in Sect. 3.2.4	Datastream
TAN_{it}	Tangibility measured by the fixed assets divided by total assets	Datastream
TI_{it}	Technological innovation measured by the total end of the year number of patents	Official site of statista
TP_{it}	Total population measured by the natural logarithm of the total population	Official site of OECD
UP_{it}	Urban population measures the percentage of the total population lives in urban areas	Official site of world bank
UR_{it}	Unemployment rate measures the annual country's level of unemployment rate	Official site of OECD

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Declarations

Conflict of interest None, no conflict of interest.

Data availability The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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