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To what extent the UK emissions disclosure mandate of 2013 impacted the subsequent emissions level and ESG ratings?

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Executive Summary

This research thesis aims at assessing the impact of the Companies Act 2006 (Strategic Report and Directors' Report) Regulations 2013 on UK-incorporated listed firms' subsequent level of emissions and ESG ratings. A difference-in-difference approach has been implemented to assess the effect of the mandate between a treatment group composed by UK-incorporated listed firms and a control group composed by other European listed peers. Data concerning Scope 1 GHG emission levels for each company have been obtained using the EUTL registry. Results show that firms subject to the mandate reduced their GHGs emissions by 15% on average, compared to the control group. Additionally, the analysis points out that treated firms experience a significant positive effect on their aggregate ESG ratings, Social ratings and Innovation scores, after the introduction of the mandate. On the other hand, no significant effect has been observed on Environmental and Governance ratings. Future researches might improve the completeness and generalizability of the analysis, including also Scope 2 emissions and repeating the analysis with ESG Ratings from different agencies.

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1. Introduction

Over the last 30 years, the attention toward environmental concerns rose exponentially, as a consequence of the substantial increase of carbon dioxide emissions (CO2) in the atmosphere. According to the IPCC (2021), in the near term, the global temperature is going to increase by 1.5°C in the best scenario, while by the end of the 21st century, the most likely scenario ranges between 2.1°C and 3.5°C, with an increase of 5.7°C that could be observed in case of a high greenhouse gases (GHG) emissions scenario. Evidence suggests that every 0.5°C rise in global warming increases the intensity and frequency of heatwaves, heavy precipitation, agricultural and ecological droughts, and tropical cyclones. From 2011-2020, the Arctic sea ice area reached its lowest level since 1850 and the global sea level increased by 3.7 mm per year, compared to the 1.9 mm per year in the period 1971-2006. Following a tremendous expansion in global population, humans have thoroughly re-engineered natural ecosystems to satisfy their needs: according to the Stockholm Resilience Centre (2015), the human effect on the environment is so extensive that the current geological age should be dubbed the 'Anthropocene.' Individuals and businesses, in particular, have historically used natural resources for free, without factoring them into their "cost structures." However, in spite of the immense technological development and progress, our economies and societies remain inextricably linked to the planet for what concerns climate, water, food and an unlimited number of other goods and services. To avoid total depletion of natural resources, it is critical to assign a value to natural capital and require firms to pay for replenishing the resources consumed in order to properly manage the value of natural settings (Polyakov, 2021). One of the key metrics to assess the impact of human activity on the environment is the Earth Overshoot Day, which marks the date when humanity has used all the biological resources that Earth regenerates during the full year (Earth Overshoot Day, 2022). When this measure was first implemented in 1971, the overshoot day was on December 25th, however this year it fell on July 28th. This indicates that we are currently utilizing the resources that 1.75 "Earths" would have produced, even though we only have one. However, there is a significant variation across countries: if the entire world population behaved like the most developed economies, the Earth Overshoot day would occur before June. In terms of Europe's most advanced economies, Luxembourg has the lowest performance, with an overshoot day on February 14th, while the UK has the highest performance (19th of May). Because of these variations between countries, as well as the reality that poor and even fast-growing economies

lack the resources and technology to pursue "green growth" in the short term, it is critical to mobilize a worldwide effort to combat climate change (Aldy et al., 2003). The first world climate conference was held in Geneva in 1979, and it was mostly attended by scientists and climate specialists. It was one of the first big meetings to explore climate change issues from a scientific standpoint. Then, in 1992, the first Earth Summit was held in Rio, where 154 nations signed the United Nations Framework Convention on Climate Change (UNFCCC) to establish a collaborative effort to decrease human interference in the climate system. The first concrete measure implemented under UNFCCC has been the Kyoto protocol (1997), in which adhering countries set ambitious goals for cutting GHG emissions for the period 2008-2012 and 2012-2020. However, among the 36 developed countries legally committed to their GHG emissions reduction targets, only half succeeded, while high-polluting developing countries like China were excluded from binding targets and the United States even decided to not ratify the treaty (Rosen, 2015). Following this partial failure, another big failure occurred at the 2009 COP-15, when small island states voted against a 2°C GHG reduction target due to the unsustainable predicted sea level rise (Dimitrov, 2010). Finally, the Paris Agreement of 2015 established the ambitious aim of limiting global temperature rise to 1.5°C above pre-industrial levels and this target has been further confirmed by the Glasgow climate Pact of 2021. However, it is important to consider that for achieving this goal a cut of almost 50% of the global emissions should occur before 2030 and complete decarbonization should have been reached by the middle of the century (Young, 2016). Since one size does not fit, the implementation phase remains almost under the responsibility of each national government, which should tailormade interventions according to the country's social and economic context (Leal-Arcas, 2018). However, given the size of the climate change threat and the ambitious GHG reduction targets, a high level of engagement across sectors and regions is required to overcome the major governance and financial implementation issues (Gomez-Echeverri, 2018). To compensate for the lack of policy efficacy and to provide the financial resources needed to invest in green innovation, the UNFCCC has also established a supervisory body to assist national governments (Bodansky, 2016).

In this perspective, regulations play a critical role in pursuing climate goals, but research shows that effects have been mixed. However, while much has been written about environmental legislation aimed at lowering emissions, little is known about the impact of disclosure mandates, which require enterprises to simply report their carbon footprint without

any duty to reduce these emissions. This thesis aims to understand the effects of the UK mandatory GHG and environmental reporting regulation of 2013 on UK-listed companies' subsequent level of emissions, compared to the rest of Europe. Furthermore, once assessed the direction and significance of this impact, the same approach is used to determine if the regulation has favourably impacted the ESG ratings of UK-listed firms as well as their innovation scores. Specifically, the research question to be answered is:

To what extent the UK emissions disclosure mandate of 2013 impacted the subsequent emissions level and ESG ratings?

Studying the impacts of such regulation is particularly interesting in light of the European Commission's recent publication of the Corporate Sustainability Reporting Directive (CSRD), which requires publicly traded companies with more than 250 employees to disclose information and risks related to CSR-related activities. This disclosure mandate builds on the previous directive and establishes common standards for sustainability reporting developed by the European Financial Reporting Advisory Group. This proposal is expected to be approved by the second half of 2022 and to be enforced starting from January 2023. As a result, examining the effects of the UK emissions disclosure obligation could provide some important insights for a successful implementation of the CSRD at the European level. Furthermore, no research has been conducted to investigate the impact of the UK disclosure mandate on ESG ratings and green innovation performance. This could be interesting in light of the relevance of ESG ratings for external stakeholders and considering that the disclosure mandate includes diversity, social and human rights issues. Finally, a potential higher innovation score for firms subject to the regulation could represent greater investments in green innovation to reduce emissions. o answer the research question, the study employs a difference-in-difference strategy centred on the implementation of the legislation. Specifically, emissions and ESG data are compared between the treatment and control groups, before and after the mandate for ten years from 2009 to 2018. Instead of relying on voluntary data, this study traces the emissions of all installations included in the EU ETS registry and matches them with the parent company owning the installation. The treatment group is composed of UK-incorporated and publicly listed companies that are subject to the regulation, while the control group consists of a set of publicly listed firms incorporated in other EU countries.

The thesis would be organized as follows: in the first section, the ESG rating composition will be presented, along with some existing literature about environmental policies, CSR disclosure and the effects of introducing a CSR reporting mandate on stakeholders and firms; in the second part, the methodology would be described, with the hypothesis to test, data collection process and tools used; in the third part the results of analyses would be extensively discussed in light of previous findings and finally, a conclusion would recap the whole paper, with limitations and suggestions for future researches.

2. Literature Review

Before delving into the literature, it is useful to clarify some terminologies and understand their importance in the first paragraph. Then, the literature around environmental policies will be reviewed briefly, with a focus on the European Emissions Trading System. Additionally, some of the main issues connected with voluntary CSR disclosure are mentioned and potential effects related to the introduction of a CSR disclosure mandate will be reviewed. Finally, empirical evidence of firm-level real effects after the introduction of CSR disclosure mandates is explored, concluding with existing research on the 2013 UK regulation and research gaps addressed by this thesis.

2.1 Definitions

While the broad concept of Corporate Sustainability encloses many different firm dimensions, the focus of this research thesis is going to be on Corporate Social Responsibility practices. Despite the large number of research papers written on sustainability concerns since the mid-twentieth century, academics have yet to agree on a definition of Corporate Social Responsibility (CSR). According to the European Commission (2001), social responsibility entails going beyond legal compliance and spending more resources on human capital, the environment, and stakeholder relations. Within the organization, this means investing in health and safety, training, coaching and other initiatives to make the workplace a better place to work in terms of socially responsible practices. At the same time, environmentally responsible activities emphasize the management of natural resources in the manufacturing process as well as the reduction of emissions. To quantify something as complex and

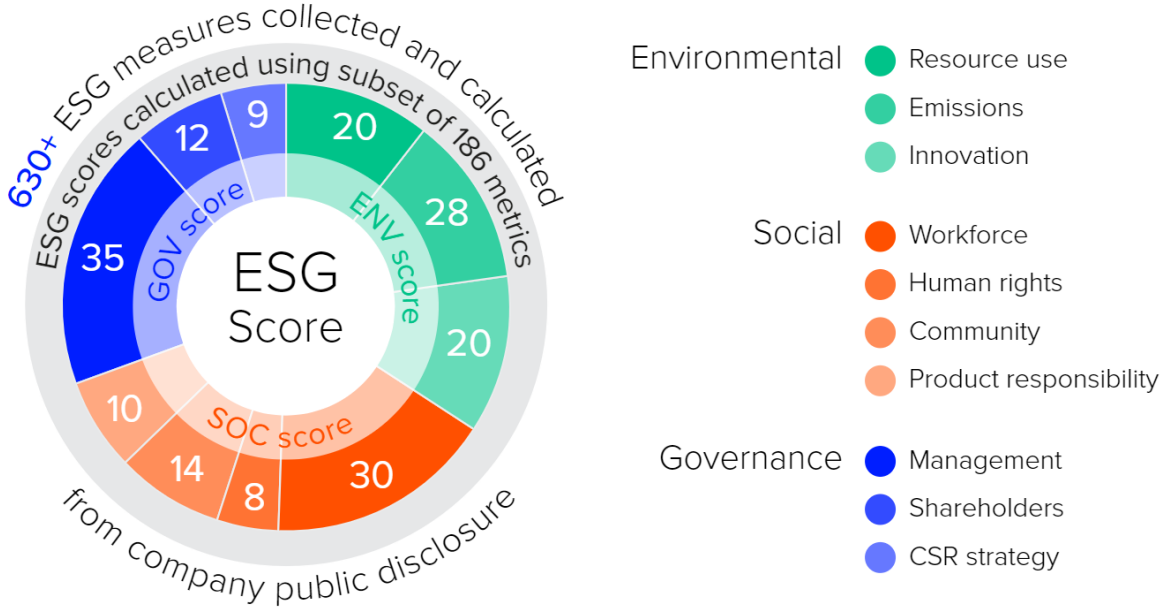
multidimensional as CSR, researchers divided it into environmental, social, and governance pillars and assigned a value to each of them, resulting in the so-called ESG ratings (Daszynska-Zygadlo et al., 2016).

Officially, the United Nations used the term ESG for the first time in 2006 in the Principles of Responsible Investing (PRI) report, which encouraged financial operators to consider environmental, social, and governance factors in their investment evaluation procedures (Atkins, 2020). Since then, there has been a steady increase in demand for sustainability reporting from investors and authorities, with 90% of companies included in the S&P 500, which published CSR-related reports in 2019 (G&A Institute, 2020). As a result, various groups have compiled this data over years and assigned ESG scores for each company, ranking them depending on their performance. This study relies on ESG scores provided by Refinitiv, but there are also other organizations providing this data, such as Sustainalytics or Bloomberg.

2.1.1 Refinitiv ESG scores

Refinitiv provides ESG scores for 12,000 companies globally, generally based on voluntary information disclosures and updated once a year (Refinitiv, 2022). Specifically, 630 company-level ESG data points are captured and aggregated in subsets of 186 comparable metrics with a weight which varies depending on their materiality. The E pillar includes resource use, emissions, and innovation; the S pillar includes workforce, human rights, community, and product responsibility; and the G pillar includes management, shareholders, and CSR strategy. Finally, the ESG score is equal to the weighted average of the three pillar scores, which vary per industry. Refinitiv's percentile rank score algorithm generates a number between 0 and 100, with a letter ranging from D- to A+ linked.

Exhibit 1 – ESG calculation methodology (Refinitiv, 2022)



The innovation score reflects a company's capacity to reduce the environmental costs and burdens for its customers, thereby creating new market opportunities through new environmental technologies and processes, or eco-designed products.

2.2 Environmental Policies

During the 1970s and 1980s, most industrialized countries implemented a slew of new legislation aimed at reducing pollution and halting environmental degradation (Lyon & Maxwell, 1999). Initially, the "command and control" was the typical approach, consisting in specifying legal standards, and often referred to the implementation of specific technologies to be implemented. However, governments have faced criticism from economists due to the inflexibility and costliness of these measures, as well as opposition from industries where they have been implemented (Stewart, 1987). By the late 1980s, emissions trading systems had grown in popularity as a means of addressing the inefficiencies of command and control practices (Lyon & Maxwell, 1999). After their introduction, several studies have analysed the impact of different environmental regulations both at the firm and industry level, trying to understand their effects on different dimensions.

For what concerns the impact of environmental policies on emissions reduction, Ellerman et al. (2000) proved that levels of SO_2 emissions dropped significantly after the introduction of a cap and trade program in the United States. Furthermore, Zhao et al. (2015) investigated the influence of a diverse set of environmental policies adopted in different regions of China in their analysis. Their research found that market incentives and government subsidies improved efficiency and reduced carbon dioxide emissions, while command and control regulations appeared to have no significant impact. On the other side, Zhang (2019) analysed the effect of environmental regulations in 30 Chinese provinces, but results show a progressive worsening in pollution.

Related to firm's productivity, an extensive study run by Greenstone et al. (2012) found a total factor productivity average decline of 4.8% for polluting instalments in strictly regulated countries, compared to less regulated ones. On top of this, Rubashkina et al. (2015) found this productivity decline to be temporary and dissipate in 2 years. Dechezleprêtre & Sato (2020) concluded that environmental regulations have both negative short-term impacts on productivity in some sectors and positive productivity impacts in others, but there are no pieces of evidence that they can boost firm competitiveness in the long run.

Certainly, environmental rules can play a strategic role in decreasing pollution; yet, despite more than 40 years of research, there is still no agreement among experts on their effectiveness. Specifically, a wide range of factors impacts regulations' effects, including policymakers' competency, execution, country culture, industries to which rules apply, and their stringency (Faure, 2012). As a matter of fact, self-regulation began to gain popularity among policymakers around the close of the twentieth century, in an attempt to cut enforcement costs and reward industry cooperation (Nash & Ehrenfeld, 1966). However, Gunningham (2011) assess that complete voluntary compliance works only for environmental leaders and it is not effective for engaging reluctant compliers. All in all, this black-and-white dichotomy appears too simplistic and a vision of regulation as something top-down, rigid and stringent and of voluntary disclosure as something bottom-up, flexible and unbinding, seems to be more than obsolete nowadays. Due to increasing internal and external pressure on executives to be "good" while doing business, which means investing in keeping GHG emissions low, workers healthy, and local communities safe, as well as the difficulty of regulations keeping up with an all-time-high complexity, "guided" voluntary disclosure

appears to be the best approach (Christensen et al., 2021). Policymakers should focus their regulatory efforts on making voluntary disclosure more efficient, easy for businesses, and transparent for stakeholders.

2.2.1 The Emission Trading System (ETS)

The European Union (EU) Emissions Trading System (ETS) is currently the world's largest cap-and-trade program and the most relevant application of market-based economic principles to face the climate problem (Ellerman et al., 2016). It covers more than 13,500 installations in major industrial sectors across all EU member states, as well as Norway, Liechtenstein and Iceland. According to Olivier et al. (2015), the program accounted for over 4% of world GHG emissions in 2014, covering approximately two billion tons of GHGs.

As established by the European Commission (2000) paper, after a trial period between 2005 and 2007, the first 5-years commitment period started officially from 2008 to 2012. In the early years of the program, each EU member had to set their cap and submit a proposal to the European Commission for approval. Once approved, a determined number of allowances were allocated for free to companies operating in sectors included in the program, which could use them to offset carbon emissions or sell to more polluting companies, as in any cap-and-trade systems (European Commission, 2000). After the first phase, the program got primarily two criticisms: free allocations prohibited the collection of some earnings, and varied member-state norms in allowance allocation generated distortions (Ellerman et al., 2016). For these reasons, in the second period from 2013 to 2017, the EU set a centralized cap for all member-states, declining at 1.74% per annum, and an auction-based allocation system for the electric utility sector, to be extended to the other industries by 2027. Following this second phase, prices observed for emitting carbon were less than 5€, raising concerns about the effectiveness of the allocation process (Ellerman et al., 2016). In response, the EU decided in 2018 to implement the invalidation rule, with the goal of reducing the number of outstanding allowances and increasing their prices to cut emissions and reach the carbon neutrality goal by 2050 (Bruninx & Ovaere, 2022). Finally, phase 4 began in 2021, tightened the emissions cap and further lowered the free allowance (Sato et al., 2022).

Evidence from literature shows that the EU ETS was able to produce positive effects in addressing the climate issue. According to Colmer et al. (2022), regulated enterprises

lowered their emissions by 8-12% on average compared to unregulated ones, there was no evidence of carbon leakage and investments targeting emissions reduction in the production process were performed. Moreover, Gillingham & Stock (2018) concluded that the emissions reductions induced by the EU ETS cost significantly less per tonne of CO_2 compared to other alternative regulatory instruments. However, since the beginning of the EU ETS program, it was clear the necessity of significant support from national regulations in order to improve the design of the EU ETS, correct for market failures, or pursue other policy objectives besides CO_2 emissions abatement (Sijm, 2005). This claim was further supported by other authors, such as Gawel et al. (2014), arguing that low allowances prices and consequently low GHGs abatement costs do not guarantee a reduction in emissions compatible with specified targets. As a result, more policies should be implemented at the national level to attain more ambitious goals and to focus on additional objectives, such as making companies more socially responsible. Currently, there are still challenges that must be taken into account for future amendments to the program. For example, the lack of evidence of carbon leakage is likely due to the generous free allocations of allowances to pollute, which are going to be gradually reduced in future years and might incentivize some outsourcing activities (Verde, 2020). Simultaneously, the EU ETS appears to have had limited effects on low-carbon innovation among regulated firms (Calel, 2020). To conclude, the fact that EU ETS challenges still exist demonstrates how national regulations could be used as a way to face these issues and testifies the relevance of this research thesis.

2.3 CSR Voluntary Disclosure

As previously stated, the emphasis on CSR has grown in recent years. In 2019, the Business Roundtable announced a new statement according to which managers and corporate leaders have the primary duty of serving customers, employees, suppliers and local communities, on top of shareholders (Business Roundtable, 2019). This is an unprecedented shift after two decades in which the main aim was to operate in the interest of shareholders, declaring the triumph of the stakeholder theory and its supporters. This trend translates also in numbers: according to Perez et al. (2022), inflows into sustainable funds passed from $5 billion in 2018 to $70 billion in 2021 and midway through 2022, global sustainable assets are worth about $2.5 trillion. Europe remains by far the most developed market for sustainable investing, accounting for 77% of net inflows in ESG-focused investment products (Marsh, 2021). This shift can be observed also on the consumer side: according to Business Wire

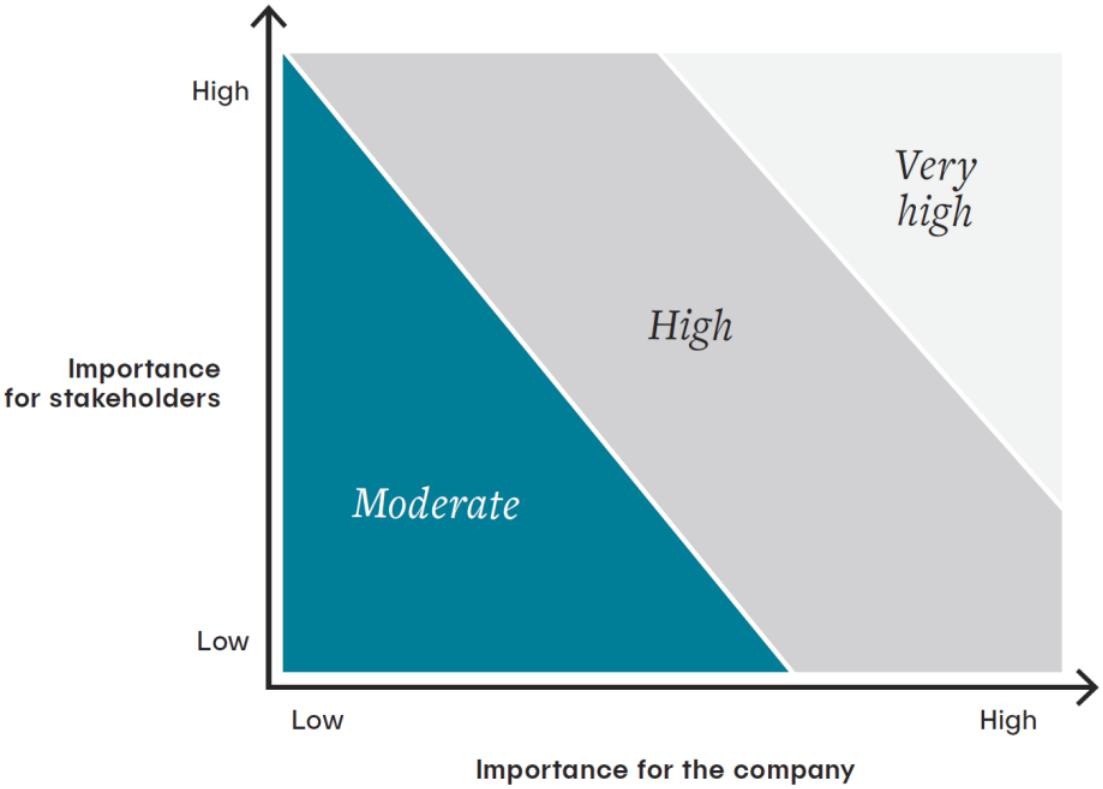
(2021), 85% of people worldwide affirm to have shifted their purchasing behaviour toward more sustainable products over the past 5 years. Although this number varies significantly across generations and countries, 60% of consumers rate sustainability as an important purchasing criterion and they declare a higher willingness to pay for these products (Business Wire, 2021). Adopting an internal perspective, organizations have also to deal with the changing behaviour of employees, especially of younger generations of talents. Indeed, 44% of millennials and 49% of Gen Zs declared to have chosen their job and employer based on personal ethics, with 60% of them complaining that most business leaders are not currently focused on protecting the environment (Deloitte, 2021).

This increasing pressure from external stakeholders has pushed corporate executives to disclose more and more CSR-related data, but still largely voluntarily (Huang & Watson, 2015). This condition leads to substantial variability in the quality and quantity of information disclosed. For example, larger firms tend to disclose more and higher quality data than smaller ones (Hahn & Kühnen, 2013), possibly due to greater public scrutiny or lower communication costs (Wickert et al., 2016). Furthermore, Höllerer (2013) found a positive relationship between dispersed ownership and CSR disclosure and according to Christensen et al (2019), also corporate governance and management characteristics impact voluntary disclosures. Similar heterogeneities can be observed when looking at CSR from the perspective of a firm's specific business: companies operating in high-polluting industries tend to have higher levels of environmental disclosure (Gamerschlag et al., 2010). At the same time, Byrd et al. (2017) discovered that firms in the tobacco, alcohol and firearm industries tend to disclose more on social and community actions to legitimize their operations in the face of potential social protests. Finally, there is evidence that exceptional negative events affect CSR reporting: Helfin and Wallace (2011) observe an increase in CSR disclosures following the BP oil spill in 2010 and the same for Fukushima nuclear disaster in 2011 (Bonetti et al., 2013).

Some organizations have created voluntary standards in an attempt to unify reporting procedures in order to compensate for this scenario of excessive generality, lack of uniformity, and comparability across enterprises and sectors. In particular, the Sustainability Accounting Standards Board (SASB) developed a guide for companies to disclose financially material sustainability information to their investors. These risk-based criteria identify a

subset of environmental, social, and governance challenges that are most important to financial success in each business (SASB, 2022). Similarly, the Global Reporting Initiative (GRI) provides a common language to help businesses and organizations to disclose their CSR performance. It is the world's most used set of standards and is more impact-centric compared to SASB (GRI, 2022). Finally, the International Financial Reporting Standards (IFRS) should be noted as one of the most prominent participants in the sustainability standards environment, providing a holistic approach to addressing the proliferation of standard-setting initiatives (IFRS, 2020). A fundamental guiding principle of sustainability reporting standards is materiality. Specifically, a material issue can be defined as one that can have a major impact on the financial, economic, reputational and legal aspects of a company, as well as on the system of internal and external stakeholders of that company' (Datamaran, 2021). A seminal research paper by Khan et al. (2016) found that companies high-performing only on material factors can experience larger stock returns compared to companies high-performing both on material and immaterial factors. This is because investors penalize business leaders who waste money to enhance performance on non-material concerns. For this reason, it became extremely important to identify material issues at stake and re-direct the effort to what is perceived as valuable by external stakeholders (Jørgensen & Pedersen, 2019). In this perspective, sustainability standards setters have developed extensive frameworks to assess the most material issues for different industries and they have also provided some useful tools, such as the materiality matrix (Exhibit 2), that companies use in their sustainability reports.

Exhibit 2 – Materiality matrix (Jørgensen & Pedersen, 2019)



However, the adoption of these reporting standards remains voluntary and companies are free to choose the most accommodating framework for them and customize the disclosing process as they want. For this reason, investors largely complain about the lack of financial materiality, consistency and reliability of info provided (Bernow et al., 2019).

2.4 CSR Reporting Mandates

The evidence of the financial materiality of ESG factors and the request for better information on firms' CSR performance has determined the rise in demand for disclosure mandates (Ho, 2022). This statement has been confirmed by the analysis of Bernow et al. (2019), conducted among both investors and executives about the introduction of a sustainability reporting regulation. Specifically, the authors discovered that 75% of investors and 58% of executives polled think that there should be only one sustainability reporting standard. Furthermore, 82% of investors and 66% of executives believe that sustainability reports should be mandated by law. A similar consensus exists on the need for various types of auditing According to a sizable proportion of respondents, these measures would be capable of addressing the top challenges associated with current sustainability reporting

practices: inconsistency, incomparability, lack of standardization, high monetary costs and time intensity for preparing these reports, and unclear benefits and added value. Moreover, the majority of investors believe that harmonization would help companies to attract more capital for long-term sustainable investments.

Due to this rising pressure, jurisdictions have made a step forward. The SEC requests that its registrants provide information on ESG issues that are material to investors in the United States (Coates, 2021), while the European Commission, as mentioned in the introduction, is currently reviewing the Non-Financial Reporting Directive of 2014, which requires large companies with more than 500 employees to provide some general "non-financial and diversity information" (European Commission, 2011). From this perspective, it is worthwhile to review prior research on the effects of CSR disclosure in general, and then CSR reporting regulations, on various groups of beneficiaries (firms, investors, consumers, etc.), even if empirical information on this issue is still sparse (Christensen et al., 2021).

2.4.1 The Impact On Stakeholders

For what concerns the impact of CSR disclosure on firm value and performance, evidence from the literature shows mixed effects. Specifically, many studies found a significant relationship between measures for CSR activities and firm value, but there is still no consensus on the direction of this correlation, which seems to largely depend on a various number of mediating factors (Christensen et al., 2021), including customer awareness of CSR (Servaes & Tamayo, 2013), or positive media coverage (Cahan et al., 2015). About the relationship between CSR and financial performance, an extensive literature review provided by Tencati et al. (2012) shows that results have been mixed and in many cases overly simple. Chen et al. (2018) investigated the implications of a CSR disclosure mandate implemented in two Chinese exchanges, requiring large companies to provide a CSR report. The study finds a reduction in future profitability for firms subject to the mandate. On the opposite side, Downar et al. (2021) evaluated the effects of the 2013 UK disclosure rule on the financial operating performance of UK-listed enterprises and discovered an increase in both production costs and revenues, with no effect on gross margins. Furthermore, capital expenditures were not significantly higher for firms subject to the mandate. These findings demonstrate that financial performance has not decreased following the mandate's implementation. More empirical data is needed to properly understand the possible implications of a CSR disclosure

obligation on financial performance, however, these two research articles imply a general uncertain and case-specific effect.

Concerning the impact of CSR disclosure on equity investors, various studies, including one by Flammer (2013), reveal that stock markets react negatively or positively, typically depending on the direction of the news. Jouvenot and Krueger (2020) analyse market returns related to the 2013 UK disclosure mandate and observed that businesses with larger emissions, providing carbon disclosures for the first time, experienced significant negative reactions in the period after the mandate. One of the few studies to analyse the announcement returns related to the introduction of a CSR reporting mandate is the one of Grewal et al. (2019), observing the market reaction to events leading up to the introduction of an EU directive mandating the disclosure of non-financial performance. The outcome reveals an average negative market reaction, but a less negative and often positive return for firms with a stronger CSR performance before the mandate. These findings are due to increased expenses associated with the requirement to disclose extra non-financial information, as well as higher political costs perceived by investors (Grewal et al., 2019). The same results are observed by Hombach and Sellhorn (2018) for what concerns an SEC mandating the rule of disclosure of payments made to governments by extractive issuers. Due to the predicted increased expenses for modifying company operations, market reactions are notably unfavourable for enterprises that are more vulnerable to public inspection. Other studies explore the effect of a CSR reporting mandate on market liquidity, such as the one of Barth et al. (2017), which considers the effects of the 2010 integrated reporting mandate for companies listed on the Johannesburg stock exchange. As expected, firms with high-quality integrated reports experience lower bid-ask spreads and higher firm value. Grewal & Serafeim (2020) confirm this result, observing a negative relation between material CSR disclosure and bid-ask spreads. Finally, Bonetti et al. (2013) investigate the influence of environmental disclosures on the cost of capital in the aftermath of exogenous shocks such as the 2011 Fukushima nuclear disaster. Specifically, they found that Japanese firms providing environmental reports before the event experienced a lower increase in the cost of capital, compared to those without such reports. However, there is no particular evidence of a drop in the cost of equity capital as a result of the implementation of a disclosure obligation.

Exploring the potential effect of CSR disclosure on lenders and debtholders, it is interesting to mention the study of Lu (2021) affirming that green bonds can be considered as an instrument to improve the commitment to CSR activities and sustainable investing. The study specifically reveals that bond markets respond positively to decrease debt costs, both for green and regular bonds issued by the same legal entity. So, even if there is little evidence from the literature on the effects of a CSR reporting mandate on the debt market, it would likely be more relevant for public debt offerings and publicly traded debt, increasing transparency, reducing information research by investors and making comparisons across firms easier (Christensen et al., 2021).

Finally, it is interesting to consider the impact of CSR disclosure on other stakeholders, such as media, society in general, consumers and employees. Media are an important channel for the spreading of CSR information. In particular, enterprises with a higher CSR reputation, generally receive more favourable coverage by media (Cahan et al., 2015), while it has been proven that media reinforce also the negative consequences of poor CSR performance, especially for firms in controverted industries (Kölbel et al. 2017). In this regard, a CSR reporting obligation might help media and journalists gather information and rank different corporations' CSR practices (Christensen et al., 2021). At this proposal, Christensen et al. (2017) highlighted how the introduction of a mandatory mine-safety information disclosure increased the use of this information both by analysts and journalists. A CSR disclosure obligation might be advantageous from a societal standpoint to give a genuine commitment to CSR-related activities, as voluntary disclosure is not always transparent and accurate (Christensen et al., 2021). As a matter of fact, Wu et al. (2020) show that greenwashing is directly related to the level of transparency and higher transparency leads to more observable CSR investments, preventing greenwashing. For customers, a disclosure mandate might increase awareness and allow peer comparisons, but such a one-size-fits-all measure is likely to result in a mismatch between what consumers feel is important and the CSR criteria the firm is requested to disclose (Bradford et al., 2016). For workers, Gao et al. (2014) discovered that high CSR performing organizations had fewer insider trading scandals, whereas Windolph et al. (2014) show that the pursuit of CSR-related goals varies greatly across organizational roles. Finally, it has been proven by Darendeli et al. (2021) that a better CSR disclosure impacts the selection of suppliers, reducing the number of contracts and

corporate customers for those experiencing low CSR performance and incentivizing the investments to improve.

Overall, the implementation of a CSR disclosure obligation might increase liquidity, market performance, and lead to a lower cost of capital. Furthermore, it would allow the standardization of reporting practices, facilitating firms' benchmarking and ranking. However, CSR reporting mandates must focus on material issues to prevent subject companies evading from reporting the appropriate information or claiming their immateriality (Christensen et al., 2021).

2.4.2 Firm-Level CSR Adjustments

After analysing the potential consequences of a CSR disclosure obligation on its recipients, it is interesting to examine how enterprises change their behaviour in order to comply with the regulation and adapt to expected investors' and other stakeholders' reactions. Even if the literature suggests that increased transparency should lead to a higher investment efficiency, it is still unclear the amount of new information produced due to the introduction of a CSR reporting mandate and the costs associated with compliance. Indeed, firms are typically expected by stakeholders to invest an increasing amount in CSR activities, subtracting financial resources from regular operating investments (Christensen et al., 2021).
First, firms adjust their CSR activities to meet debt and equity investors' expectations, since they would have more information available to integrate their investment decisions. Moreover, more transparency enforces better discipline among management (Cao et al., 2019). Second, CSR activities might be expanded if companies observe a strong link with financial performance, specifically in the form of enhanced stakeholder trust and loyalty (Cao & Rees, 2020). Third, higher transparency is inevitably followed by an increased market and societal pressure, with social activists, consumers or policymakers who can significantly damage poor-performing firms through protests, boycotts or imposing sustainability restrictions on the supply chain (Dai et al., 2018). In response, it is fundamental for these firms to adjust their CSR investments in order to meet the expectations of those considered the most critical stakeholders. Fourth, better CSR reporting increases inter-firm learning, accelerating the adoption of best practices and improving the CSR performance of the whole ecosystem (Tomar, 2022).

Literature about the real effects of CSR reporting is still relatively scarce, but it provides some valuable insights on how firms reacted to real disclosure mandates. In Chinese cities with more regulated enterprises, Chen et al. (2018) discover a considerable reduction in wastewater and SO2 emissions. Simultaneously, Tomar (2022) examines the impact of the 2010 GHGs emissions mandate introduced for manufacturing firms in the United States. Specifically, he focused the research on those manufacturing facilities for which emissions-related information was largely unavailable before the mandate. He observes an average 7.9% reduction in emissions following the disclosure and explored the mechanism for reduction, he affirmed that many facilities were able to improve their GHG performance once they could benchmark with peers. Similarly, Johnson (2020) shows that disclosing a firm's negative conduct prevents other peers from adopting the same behaviours. Fiechter et al. (2020) investigate the impact of the 2014 EU Corporate Social Responsibility Directive, which requires major corporations to report non-financial information beginning in 2017. He finds not only that firms on average comply with the mandate before this comes into force, but also suggests that those with low CSR expenditure tend to experience stronger effects due to the rising pressure from peers comparison. Finally, two other particularly interesting regulatory initiatives involve the mandatory disclosure of extraction payments for oil, gas and mining companies in the EU and Canada. This is relevant because such payments, related to what these companies give to foreign host governments for the right to extract resources, usually are not transparent and give room to corruption. Rauter (2020) investigates the impacts of this mandate and concludes that enterprises pay higher fees for extraction rights, make fewer investments, and receive fewer licenses. These results are more robust for highly controverted firms, facing a risk of public shaming. Moreover, regulated firms tend to reallocate their investments in unregulated areas, reducing productivity in host countries.

Overall, while generalizing results from this narrow set of disclosures is difficult, it is possible to conclude that disclosure mandates are concretely capable of changing firms' operations or compelling them to abandon some controversial activities as a result of stakeholder pressure and peer benchmarking (Christensen et al., 2021). Even if it is true that a disclosure mandate has generally a stronger impact on firms with poor CSR performance, CSR disclosure adds an additional layer of reputational risk and firms with the most valuable brands are those most exposed, even if well performing until that moment. This is why these

companies strive to anticipate the trend by revealing more information than is required and often comply with legislation even before they become effective (Christensen et al., 2021).

2.5 UK Disclosure Mandate

This study focuses on The Companies Act (Strategic Report and Director's Report) Regulations 2013. This regulatory measure has become effective starting from the 30th of September 2013 and mandates publicly listed UK-incorporated firms to report their GHG emissions alongside financial results in their annual reports. Before the passage of this legislation, a company was required to report installation-level GHG emissions in a publicly accessible register in accordance with the rules imposed by the EU ETS, but UK-incorporated listed firms were not required to report the aggregate of the installation-level emissions in their annual reports. In this regard, the reporting obligation does not request extra information concerning carbon footprint to be disclosed, but rather that the GHG emissions are included in yearly reports as a total. In this perspective, this reporting mandate is not requesting additional data about carbon footprint to be disclosed, but simply that the total amount of GHG emissions is provided in the annual reports as a total. This clearly increases transparency, because stakeholders interested in this information no longer need to access the EU ETS register and perform the sum of GHG emissions produced by all of the installations owned by that specific company, but can simply open annual reports and find the information about carbon footprint immediately available. On top of the total amount of emissions in tonnes of carbon dioxide equivalent from the firm's direct activities (Scope 1 emissions), the mandate also applies to the total quantity of emissions resulting from the purchase of electricity, steam, and heat for firm's own use (Scope 2 emissions) and methodologies used to calculate these data. The following gases are included in Scope 1 emissions: carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6). Companies are not required to report these various GHG emissions separately, but they must all be translated into a total CO2 equivalent using weighting criteria consistent with the IPCC guidelines and EU ETS regulation. Furthermore, the mandate does not indicate a specific methodology for calculating GHG emissions but rather calls for the use of 'robust and accepted methods, using 'relevant information from other domestic and international regulatory reporting processes' (Legislation.gov.UK, 2013), such as the info from the EU ETS ecosystem. The regulation also requires the disclosure at the end of each year of a breakdown showing the number of people by gender who are

directors, senior managers, or employees, as well as other information related to the development of employees and potential social and human rights issues (For a more comprehensive view see Appendix A) (Legislation.gov.UK, 2013). All this information enhances the transparency of a firm's CSR performance and facilitates sustainable investing processes. Finally, it is worth noting that the 2013 UK disclosure rule was implemented in the same year that the EU ETS transitioned to the second trading period and certain additional regulatory measures were implemented in Europe (see Appendix B for major regulatory changes around the introduction of the mandate). Although someone could argue that such changes are going to inevitably bias results obtained, there is no reason to expect UK-incorporated listed firms to be impacted differently compared to other non-UK counterparts. Because regulatory circumstances are assumed to be the same for all companies in the sample, the resulting impact of the disclosure mandate can be assessed without any confounding effect.

For the moment, three major research publications by Jouvenot & Krueger (2020), Downar et al. (2021) and Grewal (2021) examined the consequences of such a reporting obligation from various viewpoints. First, they all adopted a difference-in-difference methodology to assess the impact of such reporting mandate on the subsequent level of emissions. Given the different variables considered, sample sizes and data used, results show an average emissions reduction ranging from 8% to 18% for UK-incorporated listed firms. Specifically, Jouvenot and Krueger's (2020) study also the consequences of the mandate on institutional investors, media and stock prices. They highlight stakeholder pressure as a potential reason for this decrease in emissions, consistent with the findings of other researchers such as Dai et al., (2018). On the other side, Grewal (2021) finds emissions reduction more related to peer benchmarking, in accordance with Tomar (2022). These findings are highly insightful and consistent with past research on the implications of CSR reporting-related regulations. Nevertheless, one important limitation should be mentioned: the analysis of Grewal builds on self-reported emissions data both prior to and after the mandate, while Jouvenot and Krueger rely on voluntarily disclosed information in the CDP database and on emissions estimated by private organizations. To minimize any lack of objectivity, consistency and reliability related to the usage of voluntarily disclosed information, this thesis relies on the granular and verified data provided by the European Union Transaction Log (EUTL) register for each installation both prior to and after the mandate. This technique is

similar to that of Downar et al. (2021), but the sample of nations included in this research will be bigger, encompassing all EU member states and Norway rather than simply the 15 largest EU members. In particular, I believe that there are no reasons for limiting the analysis to a smaller sample of firms, excluding those incorporated in more peripheral countries. Moreover, the mapping system of installations to the ultimate parent company differs significantly. The study of Downar et al. relies on the database built by the European University Institute[1], which matched installations with their ultimate parent firm basing on the ownership information for the period 2005-2007. On the other side, this thesis relies on the up-to-date relational database provided by Abrell (2022), which includes data about emissions and ownership updated at the 26th of May 2021[2]. To conclude, no existing research has discussed the effects of the UK disclosure mandate on ESG ratings and Innovation Scores of companies subject to the mandate.

3. Hypothesis Development & Methodology

First and foremost, the founding hypotheses for this research will be presented, together with on adequate methodological framework to test them. Then, the research design of this thesis is mentioned, before explaining the regression equations and the data gathering procedure.

3.1 Hypothesis Development

As already stated by the research question, this thesis focuses on understanding the impact of the Companies Act (Strategic Report and Director's Report) Regulations 2013 on subsequent GHG emissions and ESG ratings of firms subject to the treatment. To do so, three main hypotheses will be tested:

H1: *Firms subject to the UK disclosure mandate are able to reach a larger reduction in their Scope 1 emissions, compared to firms not subject to the treatment*

[1] More detailed description of the matching process used by Downar et al. at: https://cadmus.eui.eu/handle/1814/64596

[2] More detailed information on the database used as a reference for this thesis and the matching process at: https://www.euets.info/

This first hypothesis addresses the most immediate impact of such a mandate on treated firms. As discussed previously, management might decide to reduce emissions as a consequence of peer benchmarking (Tomar, 2022), increased pressure by stakeholders due to higher transparency (Cao et al., 2019), or willingness to anticipate trends in environmental regulations and benefit from first move advantage (Fiechter et al., 2020). Regardless of the motivation, it seems reasonable to expect a larger reduction in Scope 1 emissions for firms subject to the mandate, but the outcome remains still uncertain. The same information about GHG emissions was already available before the mandate in the European Union Transaction Log register in connection with the EU ETS and in the CDP database in the form of voluntarily disclosed information. For this reason, other arguments suggest this effect of the mandate to be limited. Although Jouvenot & Krueger (2020), Downar et al. (2021) and Grewal (2021) have already verified this hypothesis, they all started from different assumptions. For this reason, it is interesting to assess if the same result is confirmed also with a different methodology.

H2: *Firms subject to the UK disclosure mandate experience a higher increase in their ESG ratings, compared to firms not subject to the treatment*

H2.1: *Firms subject to the UK disclosure mandate experience a higher increase in their E ratings, compared to firms not subject to the treatment*

H2.2: *Firms subject to the UK disclosure mandate experience a higher increase in their S ratings, compared to firms not subject to the treatment*

H2.3: *Firms subject to the UK disclosure mandate experience a higher increase in their G ratings, compared to firms not subject to the treatment*

The second hypothesis aims at assessing the impact of the disclosure mandate on ESG ratings. This is particularly relevant in my opinion because numerous research has been conducted on ESG ratings and their impact on different companies' dimensions. However, there is no existing research exploring the impact of the UK disclosure mandate on ESG scores. Given that the UK regulation covers both environmental and social topics, it seems particularly relevant to consider the aggregate ESG ratings first and then repeat the analysis for each of the three different pillars to assess the impact of the mandate on the single environmental, social or governance dimensions.

H3: *Firms subject to the UK disclosure mandate experience a better green innovation performance, compared to firms not subject to the treatment*

Another interesting aspect to explore is the one related to green innovation. Since it is not an easy dimension to measure, I decided to take as a reference for this analysis the Innovation Score provided by Refinitiv. This indicator includes about 36 data points on the company's product, process, and business model innovations (Kyaw, 2022). For what concerns product innovation, the score considers the impact of the product or service on the environment, in terms of energy usage, recyclability or reusability. At the same time, process innovation concerns the average amount of GHGs emitted on production sites and the inclusion of environmental and biodiversity risks in decision-making criteria. Finally, business model innovation is more related to the expenditures for environmental protection and the redesignation of the existing business model in order to transform climate change issues into a business opportunity (Jørgensen & Pedersen, 2019). The study of the effects of environmental regulation on firm's innovation has always produced mixed results in literature and considering the specific impact of the UK disclosure mandate might be valuable to provide a potential virtuous example, in case the hypothesis will be verified. Furthermore, Downar et al. (2021) found that emissions reduction is not a mere consequence of reductions in capacity utilization. In this perspective, in case the H1 will be verified, this third hypothesis can potentially complement the findings of Downar et al. (2021) and explain a cause for such emissions reduction.

3.2 Research Design

From a philosophical standpoint, this research is driven by a positivist approach toward reality, with the goal of adopting as independent and objective a perspective as possible. A quantitative study is conducted, where the data collection is based on a clear and objective methodological process from independent resources such as Refinitiv, Eurostat and the EUTL registry. At the same time, the data analysis process relies on the objectivity of statistical methods. The research approach adopted is a clear deductive approach, in which empirical observations are collected and analysed using quantitative methodologies to accept or reject the hypothesis proposed. Moreover, the difference-in-difference approach is related to an experimental design, developed over a longitudinal time frame. Indeed, the thesis relies

on secondary data collected for the period 2009-2018 and clustered in an experimental and control group. Since data analysis will be run considering different firms at different points in time, a simple cohort analysis is insufficient and a panel data analysis is necessary. Finally, the ethical issues to take into account for this thesis are limited, since not rely on primary sources for data collection. However, it is important to provide accurate information and not falsify evidence, findings or conclusions. In this perspective, ethical considerations have been taken into account to ensure transparency in data collection and objectivity in conducting appropriate statistical tests and analysing results.

3.3 Regressions

A fundamental step in methodology is to set the appropriate equations in order to test hypothesis. The aim of this section is to explain variables included in regressions (see Table 1 for an overview).

$$\textbf{H1: } Emissions = \beta_0 + \beta_1 \text{ x } Post + \beta_2 \text{ x } Post \text{ x } Treat + \sum Control\ Variables + Firms\ Fixed\ effect + Years\ fixed\ effect + \varepsilon$$

The dependent variable ***Emissions*** represent the natural logarithm of the total amount of Scope 1 GHGs emissions at the firm level for each year. This figure is obtained by adding GHG emissions at the installation level for each installation owned by a single firm from 2009 to 2018. The next section explains more in detail the process of calculation of CO_2-eq. emissions at the firm level. Although the UK reporting mandate explicitly refers both to Scope 1 and 2 emissions, this analysis will focus only on Scope 1 emissions disclosed in the EUTL registry, since Scope 2 ones are not available. Nevertheless, Scope 1 are the largest portion of total emissions and those on which firms‘ decisions can impact the most. Moreover, Scope 2 emissions are extremely difficult to quantify with reliable methods.

The independent variable ***Post*** is a dummy variable representing the introduction of the UK disclosure mandate, starting from the 30th of September 2013. In particular, it assumes a value of 0 for years preceding the introduction of the regulation and 1 for years after the treatment. For what concerns the year 2013, companies ending their financial year after the 30th of September assume a value of 1 since are required to disclose CSR-related info in their 2013 financial reports. On the contrary, companies ending their financial year

before are considered pre-treatment, since they are subject to the mandate starting from 2014. The other independent variable ***Treat*** considers firms subject to the mandate, as opposed to those not affected by the treatment. The variable assumes a value of 1 for listed UK-incorporated firms included in the treatment group and 0 for other listed non-UK-incorporated firms belonging to the control group. Finally, the most important independent variable for the purpose of this thesis is the interaction term ***Post x Treat*** and its coefficient β2, which measures the magnitude of the impact of regulation on treated firms. Specifically, a significant and negative term would confirm the hypothesis that treated firms experience a decrease in their CO2-eq. emissions compared to those not subject to the treatment.

In addition, a set of *Control Variables* must be included in order to account for some of the most relevant firm's differences which might affect their ability and incentive to abate GHGs emissions. First, ***Size*** is a relevant aspect to include, calculated as the natural logarithm of companies' revenues. Relatedly, higher revenues usually mean additional resources for a company to be used for reducing its carbon footprint. At the same time, a larger size is likely to increase external visibility and expose the company to higher pressures from external stakeholders to strengthen CSR-related activities. Second, ***ROA*** is another relevant metric, calculated as net income on total assets. A higher return on company's assets means that a larger portion of capital can be invested in reducing GHG emissions and improving CSR performance. Third, a lower ***Leverage***, calculated as debt on total assets, might decrease the pressure from creditors and allow companies to access additional capital for sustainable investments. Fourth, a higher ***Asset Intensity***, calculated as % property, plant and equipment on total assets, might pose a threat to the reduction of emissions in the short term, due to large investments in technology required. On the other side, firms with a lower asset intensity would likely be able to better reduce their emissions in the short term by simply making operations more efficient from an environmental perspective. Fifth, a high ***Price-to-Book value*** might provide firms with additional resources from equity investors for fighting climate change. At the same time, a large capitalization might also increase pressure from institutional investors and other players in the capital markets. Sixth, the variable ***Industry x Years*** captures the impact of industry-specific developments over time which might have had an impact on the level of emissions. This is particularly important since firms from different industries are naturally exposed to different dynamics over time (input prices increase, more competition, change in customer buying criteria…) and the inclusion of this variable aims at

controlling for these potential heterogeneous effects on emissions. Industries are assigned following the Global Industry Classification Standards (GICS) provided by S&P Global and MSCI (GICS, 2018). Seventh, the natural logarithm of ***GDP*** for each firm's country is considered. In this perspective, firms incorporated and operating in more advanced economies would likely experience a larger reduction in CO2-eq. emissions and better CSR-related scores. Countries with a higher GDP have the resources to invest in infrastructure to promote green growth and incentives for companies to strengthen their CSR activities. To conclude, both firm and country-specific independent variables expressed in national currencies have been converted into euros using the exchange rates provided by Refinitiv (see Appendix C).

Finally, to control for time-specific and firm-specific unobserved heterogeneity, a ***Firm fixed effect*** and a ***Year fixed effect*** are included. The latter in particular would control for exogenous shocks that impacted all firms in the period considered.

$$\textbf{H2: } ESG\ score = \beta_0 + \beta_1 \text{ x } Post + \beta_2 \text{ x } Post \text{ x } Treat + \sum Control\ Variables + Firms\ Fixed\ effect + Years\ fixed\ effect + \varepsilon$$

$$\textbf{H2.1: } Environmental\ score = \beta_0 + \beta_1 \text{ x } Post + \beta_2 \text{ x } Post \text{ x } Treat + \sum Control\ Variables + Firms\ Fixed\ effect + Years\ fixed\ effect + \varepsilon$$

$$\textbf{H2.2: } Social\ score = \beta_0 + \beta_1 \text{ x } Post + \beta_2 \text{ x } Post \text{ x } Treat + \sum Control\ Variables + Firms\ Fixed\ effect + Years\ fixed\ effect + \varepsilon$$

$$\textbf{H2.3: } Governance\ score = \beta_0 + \beta_1 \text{ x } Post + \beta_2 \text{ x } Post \text{ x } Treat + \sum Control\ Variables + Firms\ Fixed\ effect + Years\ fixed\ effect + \varepsilon$$

To test the second hypothesis and the three related sub-hypotheses, the dependent variable was adjusted to include the aggregate ESG score first, followed by the Environmental, Social, and Governance pillars individually. In order to address potential problems of non-linearity and improve the models, the dependent variables are transformed using the natural logarithm. Furthermore, the independent variables remain the same used for testing H1, since the final aim is to assess if companies in the treatment group had a larger

increase in their ESG ratings compared to firms in the control group, as a consequence of the introduction of the mandate. Finally, control variables are not changing.

$$\textbf{H3: } \textit{Innovation score} = \beta_0 + \beta_1 \text{ x } \textit{Post} + \beta_2 \text{ x } \textit{Post} \text{ x } \textit{Treat} + \sum \textit{Control Variables} + \textit{Firms Fixed effect} + \textit{Years fixed effect} + \varepsilon$$

The natural logarithm of the innovation score is used to evaluate the third hypothesis, assuming the same difference-in-difference approach structure and control variables as the other hypothesis.

The statistical software used for this study is R Studio. Since it is open-source software, no licenses are needed for access. On the other hand, Refinitiv has been accessed using a student licence provided by Bocconi University, while both Eurostat and the EUTL database are accessible without permissions needed.

Table 1: Definition of Variables

Variables	Description	Source
Dependent Variables		
ln(Emissions)	Natural logarithm of yearly emissions in metric tons. of CO2-eq.	EUTL Registry
ln(ESG Ratings)	Natural logarithm of yearly ESG score	Refinitiv
ln(Environmental Rating)	Natural logarithm of yearly Environmental score	Refinitiv
ln(Social Rating)	Natural logarithm of yearly Social score	Refinitiv
ln(Governance Rating)	Natural logarithm of yearly Governance score	Refinitiv
ln(Innovation Score)	Natural logarithm of yearly Innovation score	Refinitiv
Independent Variables		
Post	Dummy variable assuming a value of 1 for fiscal years ending after the 30th of September 2013	Refinitiv
Treat	Dummy variable assuming a value of 1 for UK-incorporated companies listed on the London Stock Exchange or other foreign stock exchanges	Refinitiv
Control Variables		
ln(Size)	Natural logarithm of yearly revenues in million of Euros	Refinitiv
ROA	Yearly net income divided by total assets	Refinitiv
Leverage	Yearly total debt divided by total assets	Refinitiv
Asset Intensity	Yearly property, plant and equipment divided by total assets	Refinitiv
Price-to-Book	Market capitalization to book value of equity	Refinitiv
Industry	Categorical variable for industries	S&P Global, MSCI
ln(GDP)	Natural logarithm of yearly GDP of countries considered	Eurostat

3.4 Sample Selection

Before proceeding to the analysis phase, it is important to clarify the process through which the treatment and control group have been composed. A summary of the sample selection process is defined in Table 2.

Table 2: Sample selection process

	Unique Installations	Unique Firms
Total installations in the EUTL registry as of May 2021	17,645	
Total installations operating in the period 2009-2018	10,612	
Total installations without missing data points in the period 2009-2018, matched with a listed and EEA-incorporated parent company	840	172
Removal of electricity prodicing installations, classified as Rev.2 sector code 35 in EUTL	648	159
Removal of installations belonging to firms operating in the financial sector	642	155
Total firms disclosing ESG ratings for the period 2009-2018		85

According to the EUTL registry, there are 17,645 unique installations under the EU ETS program in 2021. This amount includes both installations that ceased to exist, those newly opened and those with missing emissions data.

The first step consists in removing installations closed before 2009, opened after 2018, or with missing information. The total amount decreases to 10,612 unique installations operating in the period 2009-2018. Of these, there are installations which closed their activities after 2009, but before 2018 and for this reason, they have to be removed.

Additionally, each remaining installation must be matched with the corresponding owner firm, but this process has been harder than expected since there is no explicit information about the owner of the installation in the EUTL registry. For this reason, I used Refinitiv, Dun & Bradstreet and the database provided by Abrell (2022) in combination to match as many installations as possible with the owner firm, but a large portion of data points could not be used due to a lack of information. Furthermore, if the company that owns the installation is part of a group, it must be linked to the ultimate parent company. I decided to match the

privately-owned company with its parent only if the latter owns more than 50% of the firm's outstanding shares. Finally, for the sake of this analysis only listed companies incorporated in the 31 countries of the European Economic Area[3] can be considered. Thus, I excluded installations owned by privately-owned firms and listed companies not incorporated in countries belonging to the EEA. The resulting number of installations after all these removals is 840, with 172 unique firms identified.

In addition, this study excludes facilities subject to additional regulations which may have an impact on final results. In particular, if it is true that the EU ETS and other related regulations impact all countries simultaneously, there are some country-specific measures which apply solely to certain sectors that have to be considered. Specifically, the "Carbon Price Floor" (CPF) is an additional policy established by the UK government in 2013 to increase allowance prices for electricity producers. This additional emissions charge beyond the EU ETS on plants producing electricity might have incentivized to reduce emissions further. To avoid overstating the mandate's impact, I opted to exclude all installations in the energy supply sector based on NACE Rev.2 sector code 35. In the EUTL database, such a particular sequence identifies electricity-producing plants. This constraint reduced installations further to 648 and unique firms to 159.

Finally, I decided also to remove installations of firms in the financial sector, since emissions from offices and data centres are largely irrelevant compared to other industries and may distort final results. The final sample is composed of 642 unique installations and 155 unique firms, about 4.1 installations per firm on average.

Since not all firms disclose homogeneously their ESG scores on Refinitiv, the sampling process proceeds at the firm level, removing those not disclosing ESG scores at all and firms for which there are some missing data points in the period 2009-2018. The dimension of the final sample is 85 firms.

[3] The European Economic Area includes 30 countries: Austria, Belgium, Bulgaria, Croatia, Republic of Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain and Sweden. The UK is no more a member starting from 2020, but of course, is included in this analysis since the period is 2009-2018.

Table 3: Geographic and industry distribution of sample firms

	Communication Services	Consumer Discretionary	Consumer Staples	Energy	Healthcare	Industrial	Materials	Utilities	**Total**
Austria	-	-	-	1	-	1	2	-	4
Belgium	-	-	1	-	-	-	2	-	3
Denmark	-	-	1	-	-	-	-	-	1
Finland	-	-	-	-	-	-	4	-	4
France	-	2	1	1	-	5	4	3	16
Germany	-	4	2	-	1	2	3	-	12
Hungary	-	-	-	1	-	-	-	-	1
Ireland	-	-	-	-	-	-	1	-	1
Italy	-	1	-	3	-	3	1	-	8
Luxembourg	-	-	-	1	-	-	1	-	2
Netherlands	-	1	2	-	-	1	-	-	4
Norway	-	-	-	-	-	-	2	-	2
Poland	-	-	-	1	-	-	-	-	1
Spain	-	-	1	-	-	1	1	-	3
Sweden	-	1	-	-	-	-	3	-	4
UK	1	-	3	3	1	3	5	3	19
Total	1	9	11	11	2	16	29	6	85

Table 3 shows a simple breakdown of the final sample both at the country and industry levels. The final treatment group is highlighted in yellow, while the remaining companies compose the control group. The geography of firms shows a high concentration in the UK, France and Germany, representing 22.4%, 18.8% and 14.1% respectively of the entire sample. On the other side, for what concerns industries it is possible to observe that more than a third of companies belong to the Materials industry, with Industrial accounting for 18.8% of the final sample. These results are not surprising since chemicals and construction companies for example are among the most polluting in Europe (Fuller et al., 2022). Finally, Utilities represented a significant portion of the final sample, but due to the removal of electricity producers' installations, the industry accounts only for 7% of the total.

4. Empirical Results And Discussion

This section starts with a presentation of descriptive statistics, correlations among variables and diagnostics of models used. Then a panel analysis is performed using R Studio to test hypothesis, with a discussion about the results obtained.

4.1 Descriptive Statistics

Table 4 shows an overview of the summary statistics for the entire sample. Dummy variables and categorical variables have been excluded and only discrete variables have been included in the summary.

Table 4: Summary statistics for the entire sample

	Observations	Mean	Min	Max	St.Dev	Coef.Var
Emissions (t CO2-Eq.)	850	6,556,236	1,156	158,065,325	17,974,950	2.74
ESG Rating	850	68.09	13.92	94.51	14.77	0.22
Environmental Rating	850	71.91	10.40	98.74	17.46	0.24
Social Rating	850	69.03	14.82	97.99	18.33	0.27
Governance Rating	850	61.33	7.73	98.27	20.87	0.34
Innovation Score	850	58.67	2.34	99.68	26.04	0.44
Size (in M)	850	30,579	447	363,502	50,061	1.64
ROA (%)	850	4.99	-19.98	24.76	5.27	1.06
Leverage (%)	850	26.56	0.76	60.25	11.93	0.45
Asset Intensity	850	0.35	0.006	0.95	0.17	0.48
Price-to-Book	850	0.92	0.05	4.83	0.66	0.71
GDP (in M)	850	1,612,829	39,051	3,367,860	952,336	0.59

First, the dependent variable ***Emissions*** present a mean of 6,556,236 across the period 2009-2018, with a minimum of 1,156 and a maximum of 158,065,325. This substantial gap between the lowest and maximum may indicate a high level of volatility in the sample, which is supported by a ratio of 2.74 between the standard deviation and the mean (Coef. Var). Specifically, this means that the standard deviation is more than 2.5 times the mean and that values are highly dispersed. This is a normal consequence of including companies from industries with different emissions intensities. To reduce the dispersion, it is important to normalize the sample and for this reason, I applied the natural logarithm to the *Emissions* variable. For what concerns ***ESG rating***, ***Environmental Rating***, ***Social Rating*** and ***Governance Rating***, they all show a similar evolution. The E-Rating variable shows the highest mean (69.63), while the S-Rating has the lowest value (14.82) and the G-Rating the maximum value (97.64) of the sample. The standard deviation is not exceeding the mean and thus volatility is limited. Relatedly, although the ***Innovation Score*** shows a higher standard deviation compared to the other ratings, the coefficient of variation remains lower than 1. The mean is 58.67 and lower compared to the other ratings.

For the control variables, ***Size*** is the one presenting the highest volatility due to the simultaneous presence of large multinational firms with hundreds of billions in revenues and

medium-sized businesses with revenues lower than a billion. In this perspective, I decided to apply a natural logarithm also in this case in order to normalize the distribution of data points. Also, the ***ROA*** shows a coefficient of variation slightly higher than 1, but in this case, the presence of a few outliers is dramatically affecting the variance and skewing the distribution. From this standpoint, I decided to remove those outliers and reduce dispersion. Furthermore, other control variables are ***Leverage*** with a mean debt to asset ratio of 26.56%, a minimum of 0.76% and a maximum of 60.25%; ***Asset Intensity*** with fixed assets representing on average 35% of total assets for the entire sample, peaking at 95% for scale intensive businesses and touching the lowest point at 0.6% for more service-oriented ones. Finally, the ***Price-to-Book*** value presents a mean of 0.92, meaning that companies in the sample have on average a lower market capitalization compared to the book value of equity and ***GDP*** of countries included ranges from a minimum of 39,051 for Luxembourg in 2009 to a maximum of 3,367,860 for Germany in 2018.

To conclude this section, Table 5 and 6 show a summary statistics for the treatment and control group.

Table 6: Summary statistics for the control group

	Observations	Mean	Min	Max	St.Dev	Coef.Var
Emissions (t CO2-Eq.)	660	6,397,938	3,700	108,054,979	15,964,460	2.50
ESG Rating	660	68.10	13.92	94.51	14.79	0.22
Environmental Rating	660	72.57	10.40	98.74	17.59	0.24
Social Rating	660	69.52	15.90	97.99	18.21	0.26
Governance Rating	660	59.77	7.73	98.27	21.02	0.35
Innovation Score	660	58.50	2.34	99.68	26.71	0.46
Size (in M)	660	27,588	732	235,849	37,556	1.36
ROA (%)	660	4.43	-16.04	18.92	4.65	1.05
Leverage (%)	660	26.44	0.76	59.43	12.10	0.46
Asset Intensity	660	0.34	0.006	0.95	0.17	0.49
Price-to-Book	660	0.80	0.05	3.26	0.49	0.61
GDP (in M)	660	1,446,642	39,051	3,367,860	1,011,321	0.70

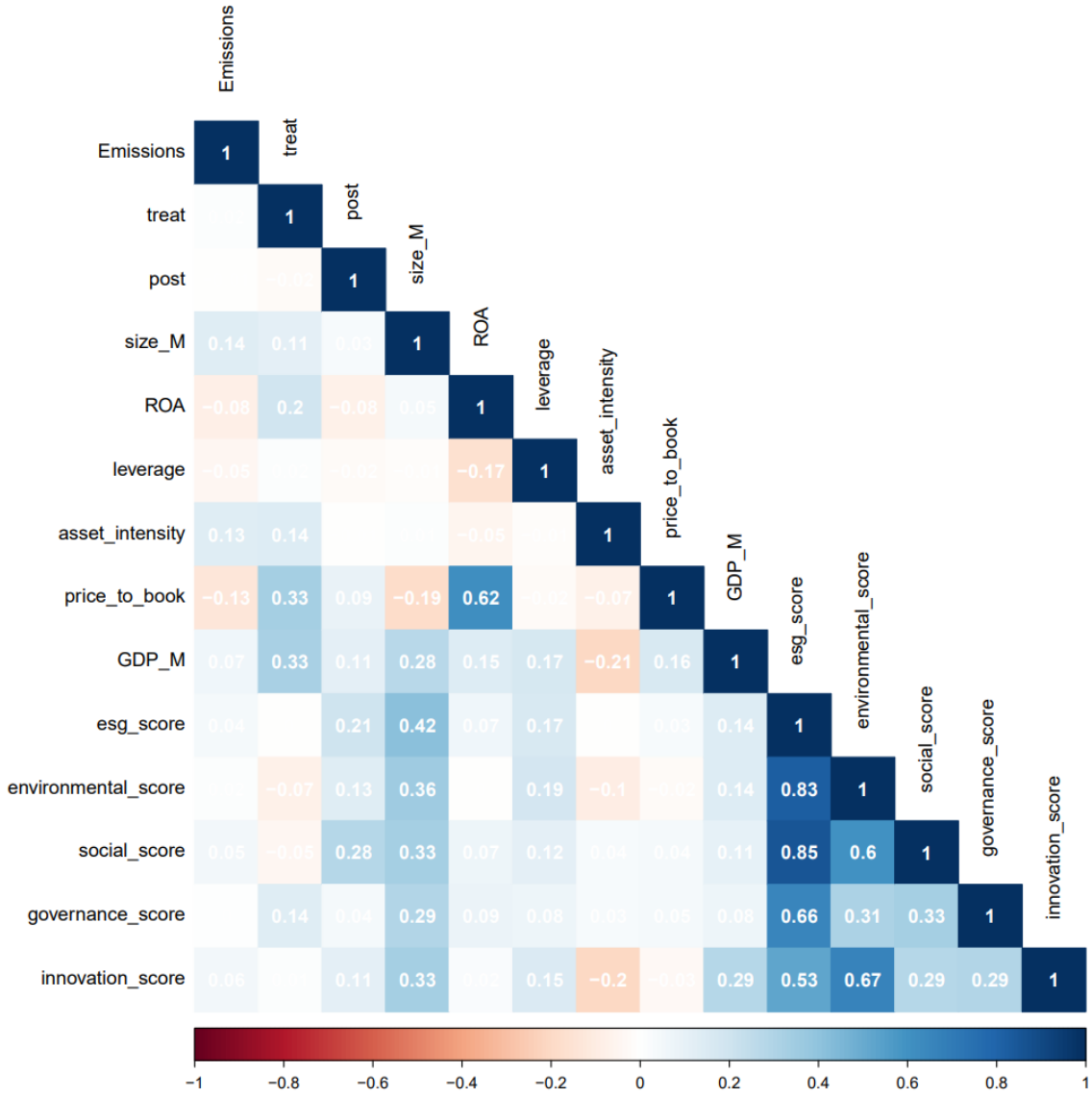
Overall, it is possible to affirm that the treatment group presents a higher mean and standard deviation for ***Emissions*** compared to the control group. Although this might be the result of a selection effect bias, the fact that the emissions mean for the treatment group is 11% higher than the control group, suggests a concrete need for pollution control measures.

Additionally, the higher standard deviation might be the consequence of a higher industry heterogeneity in the treatment group compared to the control one. For what concerns ***ESG Rating***, ***Environmental Rating*** and ***Social Rating***, the control group presents a higher mean and maximum values compared to the treatment group which on the other hand shows a greater mean for ***Governance Rating*** and ***Innovation Score***. Specifically, a higher average Innovation Score for UK-listed companies can be explained by the Global Innovation Index provided by the World Intellectual Property Organization (WIPO), which generates an annual ranking of world economies for their innovation capabilities and results obtained. Since 2012, the United Kingdom has consistently ranked among the top 5 world's most innovative economies, achieving a 2nd placement both in 2014 and 2015. These large investments in innovation at the national level, combined with adequate incentives, might have fuelled higher investments in green technologies compared to the control group. For control variables, it is possible to notice a higher mean for ***Size***, ***ROA*** and ***Price-to-Book*** value in the treatment group, associated with a larger standard deviation.

4.2 Correlation

Exhibit 3 provides an overview of the correlation between variables. This correlation matrix has been generated using built-in packages in R Studio, to measure the strength and the direction of a linear relationship between two quantitative variables with values ranging from -1 to 1.

Exhibit 3 – Correlation matrix



The variable **Emissions** show a slightly positive correlation with Size and Asset Intensity. This largely makes sense considering the composition of the sample. In particular, firms from capital-intensive industries tend to generate higher revenues by increasing their production volumes and consequently worsening their carbon footprint. The positive correlation with Asset Intensity is largely expected since companies with a higher percentage of properties, plants and equipment on total assets are likely to pollute more than those with a smaller asset base. Emissions are also slightly negatively correlated with Price-to-Book value and ROA. This is also reasonable, because firms that can receive better returns on their assets, or a market premium on the price of their existing shares, are more likely to have more

resources to invest in reducing their emissions and improving their carbon footprint (Lewandowski, 2017). The other variables are not discussed since the correlation shown is very small and thus not relevant to be considered.

The dummy variable ***Treat***, identifying companies incorporated in the UK, is positively correlated with *the Price-to-Book* value. Since most of the UK-incorporated companies included in the treatment group are listed on the London Stock Exchange, this outcome can be explained by a potential higher attractiveness for UK-listed stocks by equity investors compared to other European-listed firms. Moreover, ***the Price-to-Book*** value shows a significant positive correlation of 0.62 with *ROA* and also the variable *Treat* is positively correlated with return on assets. This means that UK-incorporated companies experience an average higher *ROA* compared to other firms in the control group, which contributes to increasing the *Price-to-Book* value as a consequence of the better returns generated. The dummy variable ***Post***, assuming a value of 1 for all annual financial reports disclosed after the 30th of September 2013, shows a positive correlation with *ESG Rating*, *Environmental Rating* and *Social Rating*. This result can be potentially explained by the introduction of Directive 2013/34 in Europe related to the disclosure of non-financial information for large entities with more than 500 employees.

For what concerns control variables, ***Size*** is negatively correlated with Price-to-Book value, while shows a positive correlation with *GDP, ESG Rating, Environmental, Social* and *Governance Rating* and *Innovation Score*. The same positive correlations apply for ***Leverage***, but with reduced strength. On the other hand, ***Asset Intensity*** shows a negative correlation both with *Environmental Rating* and *Innovation Score*. This appears to be logical since companies with a higher asset base would likely produce higher GHGs emissions. Moreover, replacing existing machinery with more innovative and less polluting ones, or restructuring processes to reduce energy usage and enhance recyclability might be extremely costly and difficult to implement for such scale-intensive firms. Finally, ***GDP*** shows a positive correlation with *ESG, Environmental, Social and Governance Ratings* and a stronger positive correlation with the *Innovation Score*. This is because most advanced economies are most likely to invest their resources to fight climate change and promote green innovation (Stellner et al., 2015).

To conclude, expectedly the ***ESG Rating*** shows a very high positive correlation with the *Environmental* and *Social Rating* since the ones weighing the most to the final ESG Rating. The ***Environmental Rating*** and the ***Social Rating*** show a significant positive correlation and also the ***Innovation Score*** is highly positively correlated with the ***Environmental Score*** since the former is one of the most relevant components for the generation of the latter.

In Exhibit 4,5,6,7,8 the evolution of the average ESG, Environmental, Social, Governance Ratings and of the Innovation Score is presented for the ten years considered across the treatment and control groups. The variable treat_cat located on the right of the exhibits represents the introduction of the mandate. Looking at Exhibit 4, it is possible to affirm that the average ESG Rating increased sharply, following a similar trendline for both UK and non-UK firms across the period 2009-2018. On the other hand, for the average Environmental Rating in Exhibit 5, some differences can be observed, since it increased every year for the control group, while it shows a more fragmented path for the treatment group. Specifically, the trendline shows almost a net zero growth between 2009 and 2012, it increases dramatically until 2016, before dropping in 2017 and recovering something with a rebounce in 2018. Nevertheless, the absolute value of the average Environmental Rating for the treatment group remained significantly below the control group for the entire period considered, foreshadowing a large room for improvements on this dimension to catch up with other European peers in the years after 2018. For what concerns Social Rating in Exhibit 6, the trend is again mirrored for both the treatment and control group, with the former average absolute value remaining slightly lower than the latter for the entire period 2009-2018. On the other hand, significant differences can be observed for the Governance Rating in Exhibit 7, with the trendline for the treatment group remaining largely above the control group one for the entire period considered. In particular, for the former, the net growth is negative until 2014, before increasing exponentially until a value slightly above 72, while for the latter the net growth has stagnated until 2017, with a spike in 2018 reaching a value slightly above 66. This might be the consequence of a stronger UK regulation concerning governance issues, or of higher materiality perceived for governance-related topics by UK-listed firms. Finally, while the average Innovation score in Exhibit 8 increases smoothly for the entire period considered for the control group, it presents a more mixed evolution for the treatment one. Specifically, it shows a net zero growth between 2009 and 2012, before rising exponentially

until the end of the period considered and outpacing the Non-UK trendline between 2012 and 2013. As stated previously, this could be the consequence of an increased focus on innovation by the UK government which is also confirmed by the annual rankings of WIPO.

Exhibit 4 – ESG Rating

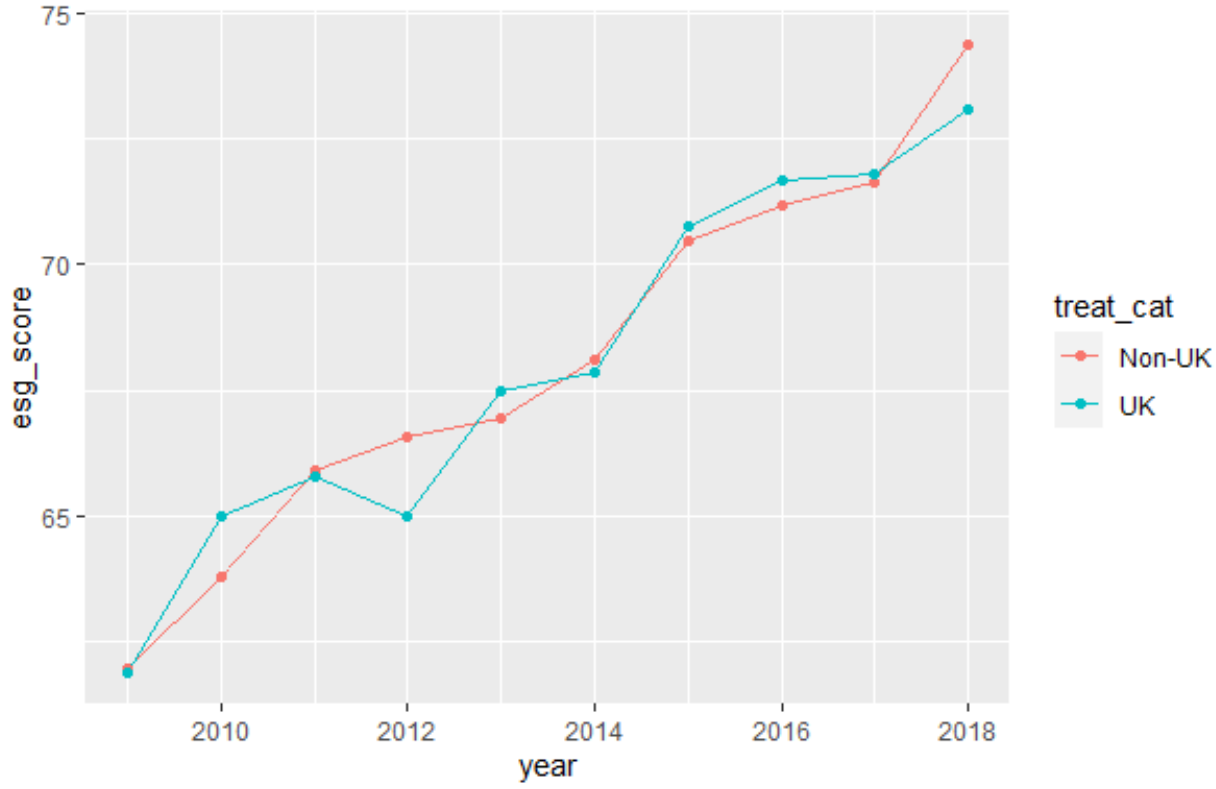


Exhibit 5 – Environmental Rating

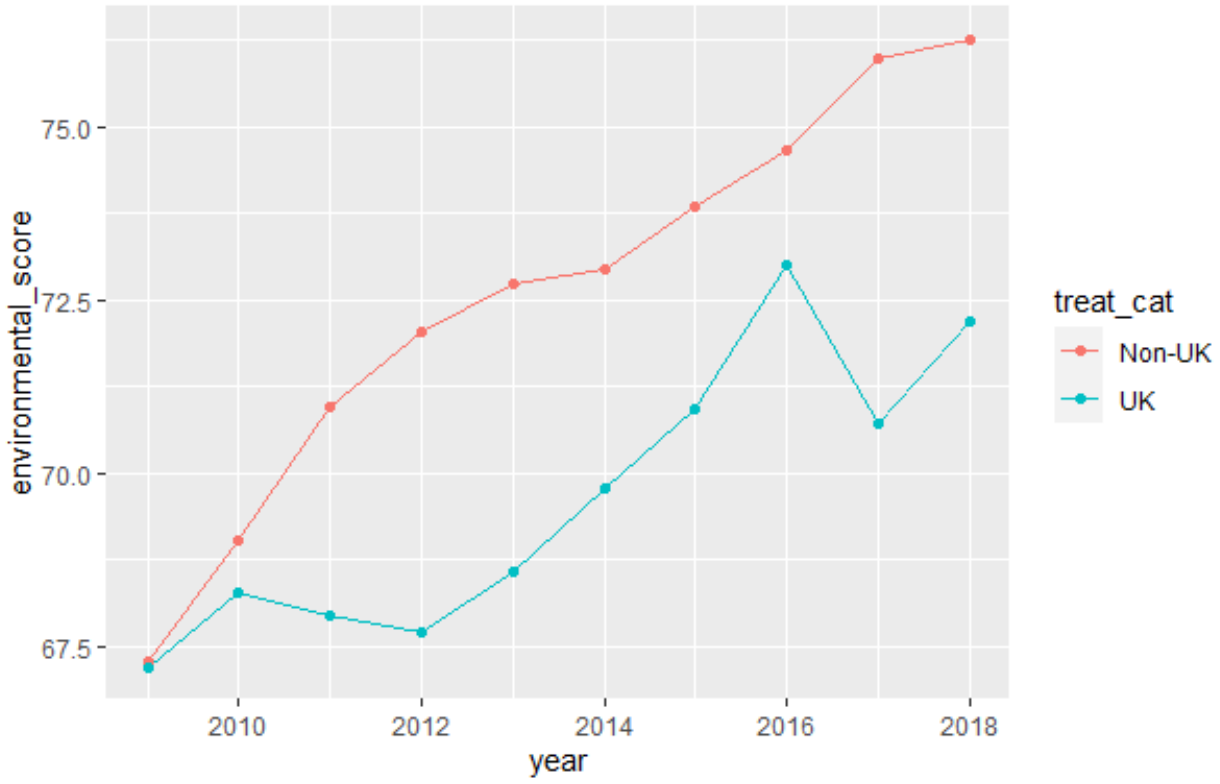


Exhibit 6 – Social Rating

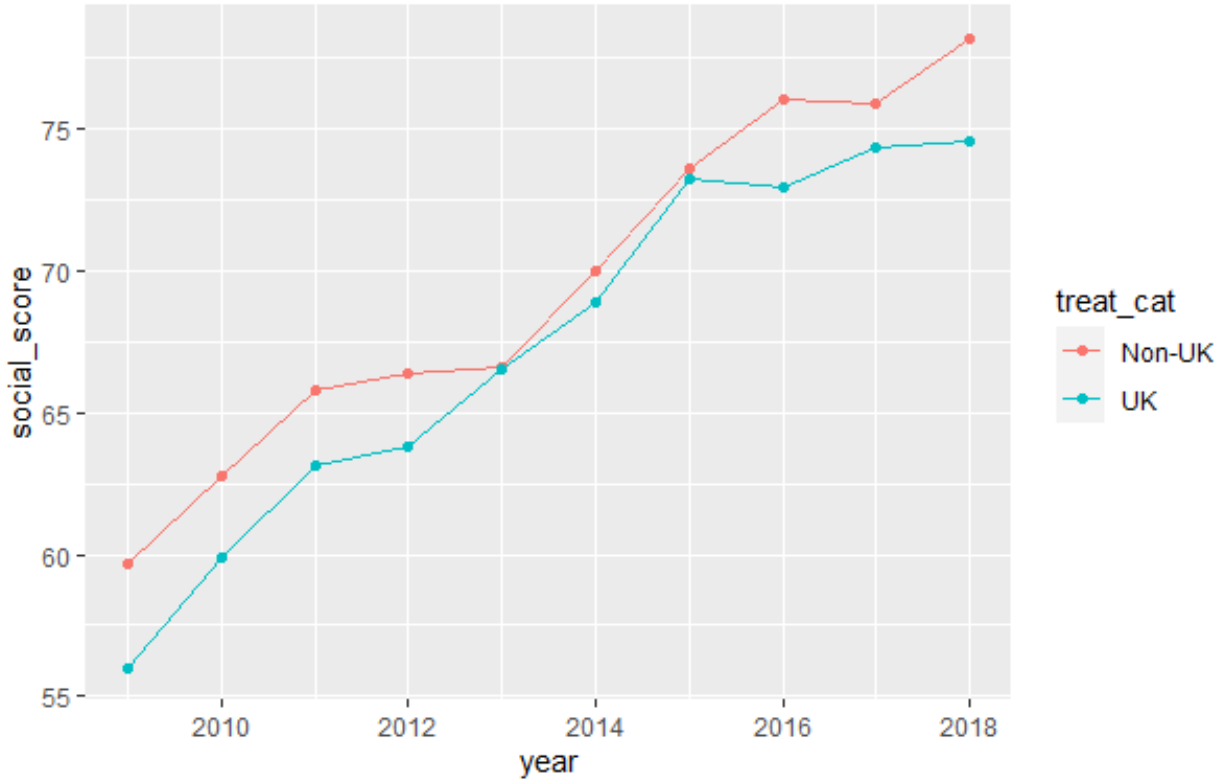


Exhibit 7 – Governance Rating

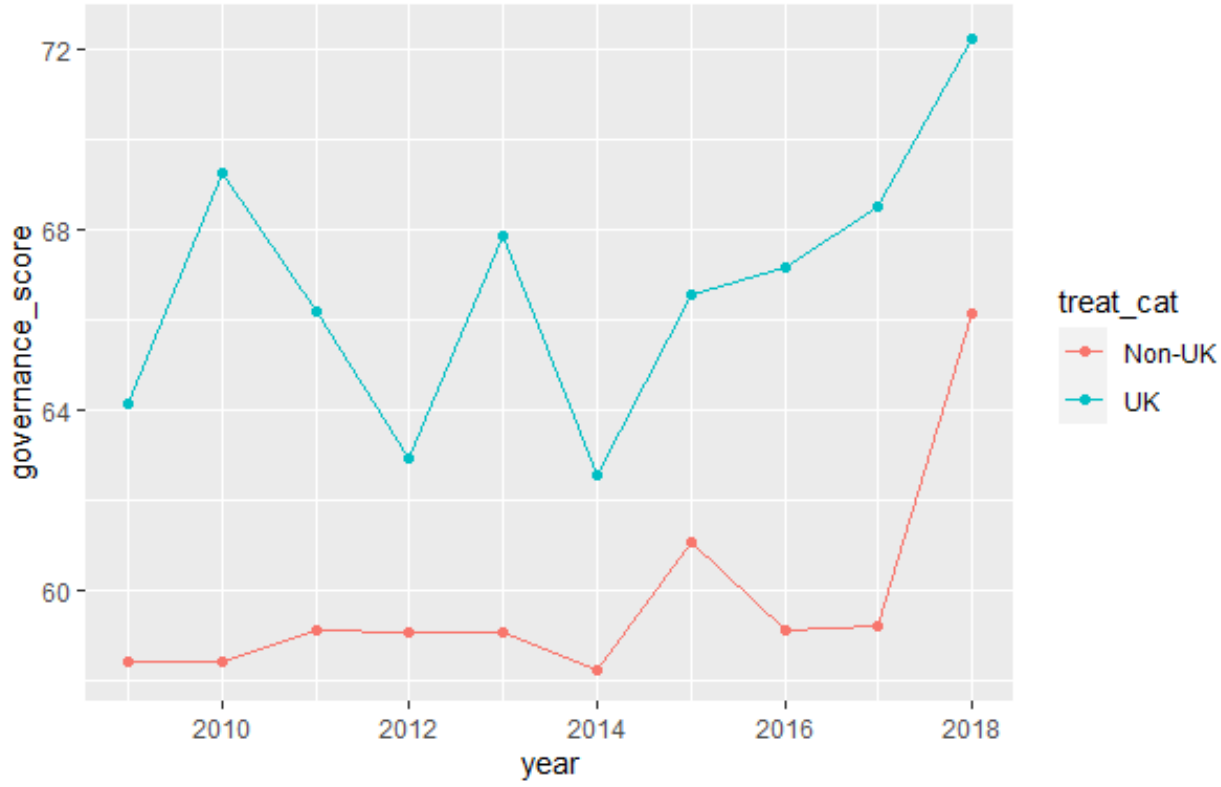
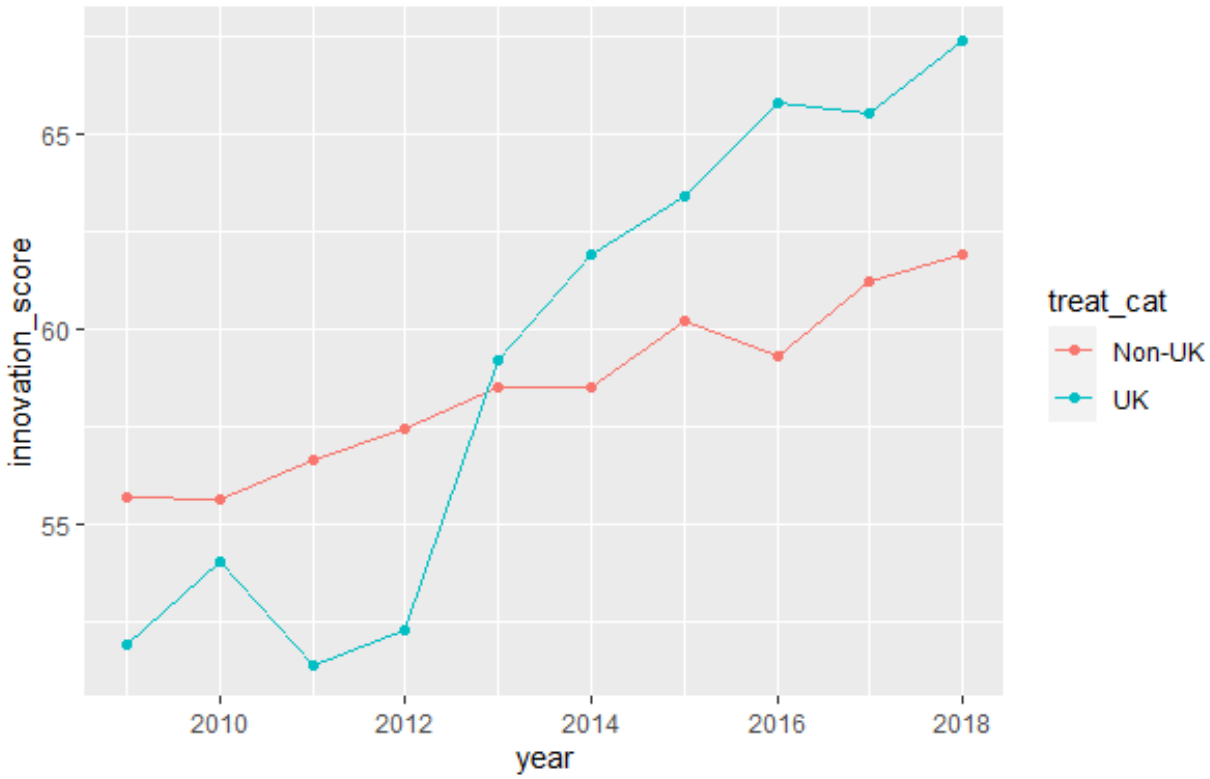


Exhibit 8 – Innovation Score



4.3 Model Diagnostic

Before proceeding with performing panel regressions, it is important to run appropriate tests to assess if heteroskedasticity and multicollinearity are present.

4.3.1 Heteroskedasticity

One of the assumptions which must hold in regression analyses is that data are homoscedastic. Specifically, homoskedasticity is present when there is a "homogeneity of variance" and residuals are equal for all values of the independent variables. Heteroskedasticity occurs when this assumption does not hold, with the variance of residuals which is unequal for different values (Goldberger, 1964). The problem of heteroskedasticity is not related to resulting estimators, but to biased standard errors. Due to the centrality of standard errors in assessing the significance of estimators, the presence of heteroskedasticity might lead to incorrect conclusions on the significance of regression coefficients. In order to test the presence of heteroskedasticity in the different models, I adopted one of the most widely used methodologies in research, which is the Breusch-Pagan test. Specifically, if the p-value resulting from this test is lower than 0.05 and thus significant, heteroskedasticity is present. After conducting the B-P test for all the models considered, I found the presence of heteroskedasticity for all of them. Since I already applied a logarithmic transformation to variables with the highest standard deviation, to deal with this issue I decided to follow a common strategy for research involving panel data analysis, which is the adoption of cluster-robust standard errors, using the built-in package for R Studio called "clubSandwich". In particular, I used the unweighted "within" estimation approach to absorb both the firm and year-fixed effect. The robust standard errors are consistent regardless if the error term is heteroskedastic (Wooldridge, 2010).

4.3.2 Multicollinearity

Another important issue that must be detected is the potential presence of multicollinearity among independent variables. Specifically, this is a situation in which independent variables show a high correlation among each other, undermining their statistical significance due to inflated standard errors (Allen, 1997). There are two main ways for testing for multicollinearity. First, looking at the correlation matrix and assessing if high correlations among variables are present (conventionally higher than 0.8). For this specific case, the

correlation matrix does not show any sign of high correlations, except for ESG, Environmental and Social Ratings. However, these three are never used as independent variables and thus there is no need to address for multicollinearity problems. Second, it is possible to use the Variance Inflation Factor (VIF) test, a widely used method in research to assess for the presence of multicollinearity. Specifically, if the VIF shows a value higher than 5, there are some multicollinearity issues to solve for that specific independent variable. For this thesis, I ran a VIF test using a built-in package for R Studio called "car". As expected, the test shows no value higher than 5 for the independent variables. To conclude, it is possible to affirm that models are not affected by multicollinearity issues.

4.4 Results

In the following section, the final results of regression models are presented and discussed to assess if in line with the hypothesis stated. Moreover, the outcome is analysed in light of previous literature.

4.4.1 Hypothesis 1

The purpose of the first hypothesis is to test the impact of the UK disclosure mandate on total CO2-equivalent emissions, expressed as a logarithmic transformation of the original dependent variable. On top of improving the models statistically, the logarithmic transformation has the advantage of simplifying results interpretation, since the regression coefficients will represent the additive percentage changes on the dependent variable.
To test the hypothesis, I built three different models, whose final output is shown in Table 7. Specifically, Model 1 includes the variable *Post*, the interaction term *Post x Treat* and both year and firm fixed effects. Results show that total emissions are on average 32% lower for firms included in the treatment group compared to the control one, after the introduction of the mandate. Although the regression coefficient for the interaction term is significant on a 1% level, the adjusted-R2 is negative at -7.6%. This means that the explanatory power of this model is extremely poor and thus it is not possible to extract reliable insights. This is not surprising since it is likely that the inclusion of control variables would improve the goodness of the model.

At this proposal, Model 2 was built including firm-specific control variables, such as *Size, Leverage, ROA, Asset Intensity* and *Price-to-Book* value. The regression coefficient

estimated this time for *Post x Treat* is -27%, on a 5% level of significance. Not surprisingly, this output is in line with the one of Model 1, indicating a statistically significant reduction in GHG emissions for treated firms. Moreover, a negative and statistically significant ($p < 0.01$) coefficient for Price-to-Book value, suggests that firms experiencing a market premium on their equity value can further reduce their emissions. However, the other control variables appear to be statistically insignificant and for this reason, the goodness of the model expressed in the adjusted-R2 is not increased significantly compared to Model 1. Specifically, the value remains slightly negative, suggesting that the model should be improved again to produce reliable insights.

Finally, Model 3 was built introducing a country-specific control variable (*GDP*) and industry trends, to account for the impact that operating in a specific industry might have on the total GHGs emissions. This time, the interaction term coefficient indicates that on average firms in the treatment group experience an emissions reduction effect of about 15%, compared to firms in the control group. The significance is again on a 5% level. The other firm-specific control variables remain statistically insignificant, while the Price-to-Book value coefficient improves its significance at the 0.1% level. Furthermore, a negative and statistically significant estimator for GDP, suggests that firms incorporated in countries with higher GDPs, experience a larger reduction in their GHGs emissions. This is probably due to higher incentives provided by more advanced economies to fight climate change. Additionally, different industry trends appear to positively and significantly impact the total GHGs emissions. Specifically, firms operating in the Consumer Discretionary and Materials industries experienced an average increase of 19% in their Scope 1 emissions over the period considered. This can be explained by the fact that these industries are among the most polluting ones. However, evidence suggests that Industrial is surprisingly the least positively impacting on emissions among industries considered, even if it is considered among the most polluting ones. The statistical significance is on at least a 1% level, with Healthcare which is the only one not significant. This was again expected since the sample of companies from this sector is probably too small to make some statistically significant inferences. Finally, the resulting adjusted-R2 is 49%, showing this time a significant amount of variability explained by this model. Since independent variables are able to explain almost 50% of the variability, it is possible to affirm that reliable insights can be extracted from Model 3 to fulfil hypothesis 1.

Table 7: The impact of the UK disclosure mandate on GHGs emissions

Variables	Model 1	Model 2	Model 3
Experimental Variables			
Post x Treat	**-0.325055****	**-0.266190***	**-0.15041***
	(0.2464)	(0.0939)	(0.0819)
Post	0.216344	0.223269	-0.99062***
	(0.0686)	(0.2209)	(0.1492)
Control Variables			
ln(Size)		0.447661	0.06619
		(0.1994)	(0.0738)
Leverage		0.000348	0.00229
		(0.0028)	(0.0026)
ROA		0.017887	-0.00141
		(0.0083)	(0.0037)
Asset Intensity		0.023742	-0.05201
		(0.2729)	(0.1346)
Price-to-Book		-0.433412**	-0.24270***
		(0.1308)	(0.0672)
ln(GDP)			-0.5418*
			(0.2256)
Consumer Discretionary x Year			0.19404***
			(0.0215)
Consumer Staples x Year			0.13666**
			(0.0149)
Energy x Year			0.13815**
			(0.0126)
Healthcare x Year			0.08740
			(0.0133)
Industrials x Year			0.11777**
			(0.0122)
Materials x Year			0.18998***
			(0.0186)
Utilities x Year			0.13943**
			(0.0108)
Firm fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
Observations	850	850	850
Adjusted-R2	-0.075763	-0.003340	0.48902

Specifically, evidence shows that firms in the treatment group experience an average 15% emissions reduction compared to the control group. As stated in the literature review, this reduction effect has been investigated by Jouvenot & Krueger (2020), Downar et al. (2021) and Grewal (2021) and they all identified an emissions reduction range from 8% to 18%. In this perspective, even if this thesis starts from different assumptions, results obtained for this first hypothesis appear to be perfectly in line with previous research. This was largely desirable, considering that a different approach should not have produced a final output completely misaligned with other authors' results. This 15% emissions reduction effect for UK-incorporated firms may be perceived as surprising since the disclosure mandate simply requires listed firms to disclose the "annual quantity of emissions in tonnes of carbon dioxide equivalent from activities for which the company is responsible" (Legislation.gov.UK, 2013) and this information was already publicly available. In particular, listed UK-incorporated firms are also part of the ETS and information about their Scope 1 CO2 equivalent emissions are available in the EUTL registry at the installation level. This registry is available online and easy to access for everyone who wants to gather information on emissions or allowances allocation for a specific installation. However, there is one major issue related to the EUTL registry, which is the lack of transparency. Although it is true that the total amount of emissions in tons is clearly displayed for each installation, it is difficult to match it with the corresponding owner firm and final parent company. Specifically, each installation is associated with a code identifying the owner firm, but there are no open-access official databases providing a matching between the code and the name of the owner firm. One potential way to do so could be to access the land registry for the specific country in which the installation is built to gather the name of the owner. However, this method would not be consistently reliable since many firms pay a rent or lease fee for their installations. Moreover, if the installation is connected successfully with the owner firm, that specific firm should be matched with its parent company. This process can be accomplished by using tools such as Refinitiv or Bloomberg. Finally, the emissions at the installation level should be summed up to obtain the aggregate amount of CO2 equivalent emissions at the parent level, paying attention to not including those installations which ceased to produce. As a matter of fact, it is possible to conclude that this process is complex and highly time-consuming for all the stakeholders that are interested in accessing emissions information. Except for qualified investors, other major stakeholders such as consumers, employees or retail investors might not have the competencies to pursue this process and thus have to rely on voluntarily

disclosed information. In this perspective, the mandate to disclose the aggregate amount of GHGs emissions for listed companies in their annual financial reports makes this information extremely accessible for all the stakeholders and this might explain the magnitude of emissions reduction. Indeed, listed companies would face considerably higher pressure from most critical stakeholders as a consequence of increased transparency on their GHGs emissions. Additional confirmation of this comes from a supplementary analysis, which shows that companies operating in highly polluting industries experience an average larger decrease in their annual emissions. This finding is consistent with the article of Grewal (2021), who stated that firms perceive the reporting mandate as a "pillory" on their carbon footprint. This "pillory effect" is highly plausible, since listed companies operating in high-polluting industries are always under pressure from media and governments to reduce their emissions and this mandate of course increases transparency and accessibility. To conclude, it is important to mention that information on the aggregate level of CO2 equivalent was also available in a voluntary form in the Carbon Disclosure Project (CDP), in which almost every firm considered in this sample yearly disclose emissions information. However, the fact that such significant emissions reduction has been observed after the mandate shows how voluntariness, combined with the lack of binding reporting standards, significantly harms the credibility and comprehensiveness of voluntary disclosures. To support this reflection, Broadstock et al. (2018) demonstrate that empirical research relying on voluntary disclosure of company emissions is heavily influenced by endogeneity issues.

4.4.2 Hypothesis 2

The purpose of this second hypothesis is to test the impact of the UK disclosure mandate on treated firms for what concerns ESG Ratings. The approach is similar to the one used to test hypothesis 1, with three models that will be estimated and the same variables taken into consideration. A logarithmic transformation is again applied to the dependent variable. The final results are provided below in Table 8.

Model 4 includes only the treatment effect without considering any control variable. While the variable Post is significant, suggesting an average 10% increase in ESG ratings after 2013 for both the treatment and control groups, the interaction term Post x Treat appears to be far from significance. Specifically, the sign of the correlation appears to be positive, but it is not possible to make any inference due to a p-value significantly higher than 5%. Furthermore, the adjusted-R2 at 9% suggests that the model has room for improvement.

At this proposal, I decided to introduce firm-specific control variables in Model 5. While the direction of the interaction term remains positive and the regression coefficient slightly increases, the p-value stands largely above the significance level. Among control variables introduced, only Size appears to be significant on a 1% level. This outcome suggests that companies with higher revenues experience better ESG ratings. However, since the other control variables are not significant, the adjusted-R2 does not increase significantly from Model 4, and thus the country and industry-specific variables should be added to explain additional variability.

Finally, Model 6 has been built including GDP and Industry trends. Surprisingly enough, the estimated coefficient for the interaction term remains positive and increases in magnitude compared to the previous model, but this time is also significant at a 5% level. This indicates that treated firms experience an average 2.5% increase in their ESG ratings after the introduction of the mandate, compared to other non-UK firms. The other firm-specific control variables remain largely not significant, except for Size, which is again positively correlated with ESG ratings on a 1% level of significance. Unexpectedly, the variable GDP appears to be not statistically significant in contradiction with the idea that firms operating in more advanced economies should experience higher ESG ratings. However, if this statement might be true at the global level, it hardly applies in Europe, where

lower-GDP countries like Luxembourg, Finland or Denmark highly perform in terms of ESG. In this perspective, a sort of country ESG rating should have been included in the model to account for ESG variability at the country level. Unfortunately, a similar indicator is not available in Refinitiv and adopting a similar indicator from other databases would not be consistent with the criteria used by Refinitiv for ESG rating calculation. Interestingly enough, some industry trends appear to be statistically significant, showing that firms operating in certain industries obtain an increase in their ESG performance. Finally, the adjusted-R2 increases to 21%, which is an acceptable level to allow for the extraction of some insights from the model to test hypothesis 2.

Table 8: The impact of the UK disclosure mandate on ESG Rating

Variables	Model 4	Model 5	Model 6
Experimental Variables			
Post x Treat	**0.00943**	**0.01093**	**0.02525***
	(0.0117)	(0.0101)	(0.0106)
Post	0.10420**	0.09427***	-0.00694
	(0.0239)	(0.0195)	(0.0062)
Control Variables			
ln(Size)		0.09257**	0.05504**
		(0.0194)	(0.0129)
Leverage		0.00005	-0.00045
		(0.0008)	(0.0009)
ROA		0.00162	-0.00012
		(0.0017)	(0.0012)
Asset Intensity		0.07711	0.05293
		(0.0446)	(0.0428)
Price-to-Book		-0.00090	-0.00544
		(0.0165)	(0.0129)
ln(GDP)			0.03165
			(0.0671)
Consumer Discretionary x Year			0.01132*
			(0.0045)
Consumer Staples x Year			0.02204*
			(0.0080)
Energy x Year			0.01001
			(0.0050)
Healthcare x Year			0.01260
			(0.0072)
Industrials x Year			0.02937*
			(0.0100)
Materials x Year			0.02540**
			(0.0068)
Utilities x Year			0.00036
			(0.0081)
Firm fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
Observations	850	850	850
Adjusted-R2	0.090239	0.11404	0.21427

The discovered 2.5% average rise in ESG ratings for treated firms is an extremely valuable insight. According to Kotsantonis & Serafeim (2019), the demand for information on how a company use the different forms of capital, including natural, social, human and intellectual on top of financial, has increased dramatically over the past years. In finance, the number of institutional investors including ESG data in their investment decisions continues to grow exponentially. According to the research of Caldeira dos Santos & Pereira (2022), about half of the assets in Europe are allocated including an analysis of ESG parameters. In recent years, the literature has mostly attempted to explain the link between ESG ratings and different firm dimensions, such as financial performance, employee satisfaction, diversity in the board of directors and so on. However, few researchers have examined the relationship between variables composing ESG ratings, such as GHG emissions, and ESG ratings themselves. The result is that there is no clear evidence on the impact of a certain element variation on ESG ratings, both in terms of magnitude and direction For example, while lowering GHG emissions should theoretically lead to higher ESG ratings, research supports the contrary. Specifically, Elmalt et al. (2021) consider the relationship between ESG metrics and emission growth across 20 countries and find that the two variables appear largely unrelated. Thus, their conclusion recommends not limiting sustainable investment strategies to ESG indicators solely, due to their multidimensional nature. Additionally, Grundström & Miedel (2021) analysed the relationship between CO2 emissions and ESG ratings for a set of companies listed in Nordic countries (Norway, Sweden, Finland, Denmark and Iceland) and they found very weak signs of positive correlation, implying that investors should be cautious when relying on ESG ratings as an indicator of low emissions. In this perspective, results from this second hypothesis could appear to be in contrast with existing literature, but it is important to remind that the UK disclosure mandate is very comprehensive from an ESG perspective, not limiting to reducing emissions, but including the mandatory disclosure of other information which might have impacted also the social dimension of ESG ratings. Simultaneously, a disclosure mandate contributes to solving one of the most relevant limitations around ESG ratings: data inconsistency. Kotsantonis & Serafeim (2019) selected a random sample of 50 Fortune 500 listed firms from different sectors and analysed how they reported employees' health and safety information. They discovered over 20 alternative reporting methods, with different terminology used and, most importantly, even different units of measure. Moreover, the information disclosed is fully voluntary. This inevitably leads to difficulties in comparing ESG ratings for companies across industries, but also within the

same industry. Indeed, the same ESG metric used to describe the same CSR-related issue might be identified by different statistical distributions, with different standard deviations and associated mean values. In this perspective, a disclosure mandate creates a common disclosing framework for all listed companies in UK and ESG rating agencies might have rewarded the improved reliability and transparency of data for these specific firms, increasing their ESG scores. The variable *Size* deserves to be mentioned since it shows to be significant both for Models 5 and 6. The most direct explanation is that firms with higher revenues experience a positive effect on their ESG ratings due to additional resources available to be invested in CSR-related activities. However, the same effect was expected for ROA, but the estimated coefficient is negative, suggesting that companies with stronger financial performance experience a decrease in ESG rating performance. Even if the coefficient is not statistically significant, this finding is a bit counterintuitive and in contrast with the vast majority of existing literature on the relationship between financial and ESG performance.

After discussing the ESG rating as a whole, it is interesting to apply the same methodology to separately analyse the impact of the disclosure mandate on the Environmental, Social and Governance pillars. This will allow us to assess the degree of connection between the ESG rating and its components, and explore which pillar has been mostly affected by the regulation.

4.4.3 Hypothesis 2.1

The first one to be considered is the impact of the UK disclosure mandate on the Environmental rating. Considering that a significant reduction in GHG emissions has been observed for treated firms, the expected result for this hypothesis is to find a significant impact of the regulation also on the E-score. To assess that, I developed three models with the same variables used for testing hypotheses 1 and 2. The dependent variable will be again logarithmically transformed. Results are shown below in Table 9.

For what concerns Model 7, I included the variable *Post*, the interaction term *Post x Treat* and the two fixed effects. Unexpectedly, the estimated coefficient for the interaction term shows a negative sign, suggesting an average 2.1% decrease in E-Rating for treated firms. However, the p-value is larger than 5% and thus it is not statistically significant. On the other side, the variable *Post* shows a positive correlation with the E-Rating and a statistical

significance on a 1% level. A potential explanation for this is related to the tightening of the ETS, entering the third trading period starting from January 2013. Likely, firms reacted positively to this tightening, improving their environmental performance. This impacted all firms, contributing to reducing their emissions and might have led to an improvement in their E-Ratings. To conclude, the adjusted-R2 appears to be negative, suggesting that as of now it is not possible to extract any reliable insight.

Thus, Model 8 has been built including firm-specific control variables in an attempt to raise the adjusted-R2 and improve the previous model. The interaction term remained almost the same both in terms of magnitude and direction, with the *Post* variable still significant on a 1% level. Among the control variables introduced, *Size*, *Leverage* and *ROA* emerge to impact positively the E-Rating, but only Size shows a statistical significance on a 1% level. On the other side, both Asset Intensity and Price-to-Book value show a negative correlation with the dependent variable. For the former, this largely makes sense due to the presence of a larger fixed assets base which tends to be more difficult to manage from an environmental perspective. However, both variables are not statistically significant. To conclude, the adjusted-R2 increases slightly, but remains negative, suggesting that other variables should be added.

For Model 9, I introduced both country and industry-specific control variables. Surprisingly enough, the regression coefficient for the interaction term remains negatively correlated with the E-Rating, suggesting that treated companies experience an average 2.5% decrease in their Environmental ratings compared to firms in the control group. However, both the interaction term and the variable *Post* are not statistically significant. The other firm-specific control variables maintain the same direction, but again only *Size* is statistically significant. The GDP variable introduced appears to be positively correlated with the E-Rating, but again not statistically significant. For what concerns Industry trends, results suggest that the industry effect is generally negative on E-ratings, except for companies operating in the Consumer Staples industry. However, none of them appears to be statistically significant. Finally, the adjusted-R2 increases until becoming positive, but remains low at 2.3%, suggesting that the explanatory power of the model is still very limited. Considering the relevance of this relationship, future research might focus on improving this model and extracting more reliable insights.

Table 9: The impact of the UK disclosure mandate on Environmental Rating

Variables	Model 7	Model 8	Model 9
Experimental Variables			
Post x Treat	**-0.02145**	**-0.02162**	**-0.02538**
	(0.0214)	(0.0196)	(0.0182)
Post	0.08344**	0.07647**	0.01889
	(0.0211)	(0.0166)	(0.0155)
Control Variables			
ln(Size)		0.08502**	0.06198**
		(0.0188)	(0.0175)
Leverage		0.00075	0.00082
		(0.0007)	(0.0008)
ROA		0.00149	0.00061
		(0.0012)	(0.0010)
Asset Intensity		-0.00226	-0.00176
		(0.0540)	(0.0647)
Price-to-Book		-0.01289	-0.02013
		(0.0124)	(0.0103)
ln(GDP)			0.04487
			(0.0796)
Consumer Discretionary x Year			-0.01266
			(0.0157)
Consumer Staples x Year			0.00200
			(0.0144)
Energy x Year			-0.01511
			(0.0124)
Healthcare x Year			-0.01331
			(0.0134)
Industrials x Year			-0.00212
			(0.0147)
Materials x Year			-0.00362
			(0.0139)
Utilities x Year			-0.01130
			(0.0139)
Firm fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
Observations	850	850	850
Adjusted-R2	-0.01607	-0.00095	0.02318

Despite the poor adjusted-R2, results obtained for hypothesis 2.1 appears to be largely unexpected. Given the observed emissions reduction effect and the fact that emissions are the primary component of the Environmental Score (see Exhibit 1), we could have expected a positive and highly statistically significant impact. Moreover, considering the findings related to ESG ratings, a dominant role played by the E-rating in driving the increase in ESG scores was largely foreseeable. In this perspective, the fact that not just the estimated coefficient is not statistically significant, but also its direction points toward a negative correlation, appears to be largely counterintuitive. For this reason, even if scarce, it is important to benchmark these findings with existing literature on the topic. First, results are in line with the research of Grundström & Miedel (2021), who discovered that higher environmental ratings tend to be related to higher CO2-equivalents company emissions. This implies that from an investor perspective, it is not sufficient to consider a firm's environmental rating alone to make sustainable investment decisions. Moreover, the E-rating is neither a reliable score to look at in case the goal is to reduce carbon footprint. Additionally, it is important to consider the findings of Boffo et al. (2020) in research by the OECD. Specifically, they focused their effort on analysing the Environmental pillar of ESG ratings to assess to what extent the E-rating is able to capture the negative effects of business activities on the environment. A positive outcome would further legitimize investors to incorporate ESG investing criteria in their decision-making process to produce more resilient portfolios to climate transition risks. To test their hypothesis, they considered E-pillar results from a global set of companies rated by different ESG rating agencies. Although the report demonstrates that E-ratings provide valuable information on firm results regarding resource usage, waste management, climate change scenarios, and strategies for transitioning to renewable energy sources, there is a general lack of alignment between emissions and E-ratings. In particular, the analysis demonstrates that for some providers a higher E-rating corresponds to a higher level of GHGs emissions. This again proves that the Environmental rating might not be a good fit for investors who are seeking for an indicator that allows them to reduce the carbon footprint of their portfolios. Additionally, Boffo et al. (2020) investigated the relationship between Environmental ratings and the overall ESG score. Interestingly enough, they found a lack of alignment for some providers between E and ESG ratings, indicating that high ESG portfolios are not necessarily aligned with a strong environmental performance. This research is critical in challenging the widely held perception among institutional and individual investors that high-ESG portfolios are automatically seen as a vehicle for addressing climate change-related

concerns. The truth is that more due diligence is needed to understand which metrics and sub-metrics a specific rating provider used, with the corresponding weights on the aggregate E and ESG ratings. The main conclusion from Boffo et al. (2020) is that methodologies for assessing the E rating are largely inconsistent, owing to the attempt to fulfil several stakeholders' interests at the same time without drawing the necessary distinctions. Indeed, including in the E pillar different indicators which are material for different groups of stakeholders at the same time, undermines the value of the composite score. The metrics used are absolutely relevant, but the fact of serving disparate investors' needs at the same time without clear distinctions, creates a confounding mix of information which impacts the reliability of the aggregate Environmental rating. Another pain point identified by Boffo et al. (2020) is related to the type and weight of metrics used by different rating providers. Specifically, evidence shows that the Environmental rating is the one with the highest variability and the impact of direct and indirect emissions for example may differ substantially according to different ESG rating providers. However, information on metrics, sub-metrics, and their weighting, as well as the criteria used to produce a specific Environmental grade, is not always generally available to investors. If the current state of the art about E scores does not evolve and issues are not solved, this situation might leave room for subjective interpretations and impact negatively investors' trust. Furthermore, Senadheera et al. (2021) take a similar stance, claiming that varied techniques utilized by rating providers, as well as the use of biased scoring measures, hampered the comparability of Environmental ratings and limited their usefulness as a tool for greening the financial sector. To conclude, Gibson Brandon et al. (2021) prove that firms observing a higher ESG rating disagreement among rating providers experience an increased risk premium on their cost of equity. This positive relationship between disagreement on ESG ratings and risk premium is mostly driven by a disagreement on the Environmental dimension.

4.4.4 Hypothesis 2.2

After discussing the E dimension, it is also interesting to analyse the impact of the UK disclosure mandate on the Social Rating. In particular, it is important to remind that the regulation involves the disclosure of a breakdown of directors, senior managers and other employees depending on sex and professional development over the correspondent fiscal year. In this perspective, a positive impact of the mandate on the S dimension of listed UK-

incorporated companies can be expected. To test this hypothesis I adopted the same approach used for E and ESG Ratings. Results are shown in Table 10.

For Model 10, I included the variable *Post*, the interaction term *Post x Treat* and the year and firm fixed effects. Surprisingly enough, the interaction term shows a positive relationship with the dependent variable on a 0.1% significance level. Specifically, firms included in the treatment group experience an average 6.4% increase in their Social ratings compared to firms in the control group, as an effect of the mandate. The strong statistical significance further legitimizes this statement. Additionally, the Post variable is also positive and statistically significant, suggesting an average increase in Social ratings for all companies included in the sample after 2013. To conclude, considering that the adjusted-R2 is at 13.7%, it is interesting to test results by adding some control variables and improving the model.

For Model 11, I added firm-specific control variables, with the adjusted-R slightly improving to 16.8%. The direction of the relationship and the statistical significance do not change for the interaction term, remaining positively correlated with the dependent variable and significant on a 0.1% level. For what concerns the control variables introduced, *Size* appears to impact positively on Social ratings. This result is logical since it is likely that firms with higher revenues would be more willing to invest in employee development programs, promoting training, incentivizing mentorship and team-building activities. Moreover, there is a high possibility that large companies would experience higher pressures from stakeholders to invest in equality, diversity and inclusion and solve potential human rights issues. On the other side, the statistical significance of the variable *Asset Intensity* was less expected and this relationship should be further investigated in the following model.

Finally, for what concerns Model 12 I decided to include a control for countries and industries in which firms compete. The interaction term Post x Treat further confirms its statistical significance and positive relationship with the dependent variable. Specifically, firms subject to the treatment experience an average 8.8% increase in their social ratings compared to firms included in the control group. Furthermore, the variable *Size* confirms its positive correlation with the dependent variable and its statistical significance on a 1% level, while other firm-specific control variables reveal to be statistically not significant. The control

variable *GDP* appears positively correlated with social ratings, but it shows no statistical significance. Finally, industry trends show a positive sign and a strong statistical significance. This means that there is a general industry effect on the social ratings and that the magnitude of the impact depends on the sensitivity of the specific industry toward social issues and their materiality for key stakeholders. The Utilities and Healthcare industries are probably not statistically significant due to the lack of a sufficient number of data points. The resulting adjusted- R2 is around 30%, showing a good fit and allowing us to extract reliable insights from the model.

Table 10: The impact of the UK disclosure mandate on Social Rating

Variables	Model 10	Model 11	Model 12
Experimental Variables			
Post x Treat	**0.06385*** **	**0.06415*** **	**0.08756*** **
	(0.0115)	(0.0123)	(0.0173)
Post	0.17524**	0.15421***	-0.01688
	(0.0391)	(0.0318)	(0.0172)
Control Variables			
ln(Size)		0.15068**	0.08356**
		(0.0343)	(0.0242)
Leverage		-0.00075	-0.00197
		(0.0009)	(0.0011)
ROA		0.00268	-0.00066
		(0.0024)	(0.0017)
Asset Intensity		0.15412*	0.08059
		(0.0661)	(0.0600)
Price-to-Book		0.03645	0.02637
		(0.0270)	(0.0214)
ln(GDP)			0.13616
			(0.0894)
Consumer Discretionary x Year			0.02002**
			(0.0044)
Consumer Staples x Year			0.02958***
			(0.0031)
Energy x Year			0.01527***
			(0.0031)
Healthcare x Year			0.00874
			(0.0051)
Industrials x Year			0.05477***
			(0.0043)
Materials x Year			0.04975***
			(0.0027)
Utilities x Year			0.00324
			(0.0041)
Firm fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
Observations	850	850	850
Adjusted-R2	0.13707	0.16818	0.29935

The outcome for hypothesis 2.2 revealed to be extremely interesting. Considering the average 2.5% increase in ESG Ratings for treated firms identified in hypothesis 2, a significant contribution from the Environmental and Social pillars could be expected, since those weighing the most on the final aggregate score. While the E-pillar appears to follow an independent path, results for the Social rating outperformed expectations, both in terms of statistical significance and magnitude. Potential explanations for this average 8.8% increase in Social ratings for treated firms might be multiple. First, it is possible to ascertain that the UK regulation includes the disclosure of social topics related to the workforce and more generically to community development and human rights issues. According to Exhibit 1, these three categories are those mostly contributing to the generation of the final S-score. Moreover, while for community and human rights-related metrics the disclosure mandate is less specific, for workforce-related data the regulation fragments more information to disclose. Specifically, on top of general policies related to employees' welfare and development, the mandate focuses on disclosing sex for directors, senior managers and all other positions, to understand the gender balance at the different levels of the corporate hierarchy. Indicators about gender balance and workforce quality in general, are those mostly impacting the final Social rating (see Exhibit 1). The requirement to disclose such statistics may have raised the pressure on publicly traded companies to enhance their social performance. Another reason which could partially explain such an impact could be related to the increased level of transparency. While social information was previously disclosed without clear guidelines and voluntarily, the disclosure mandate has improved the reliability and accessibility of such data. This is extremely important for social information which is more qualitative in nature and thus more exposed to subjectivity, compared to the level of emissions or resource usage. ESG rating agencies might likely have rewarded treated companies for their higher quality information compared to the rest of Europe. The importance of these findings related to Social rating has been further confirmed by a recent piece of literature from Serafeim & Yoon (2022) of the Harvard Business School. The article analyses 3,109 companies to assess market reactions to different ESG-related news. They started classifying firm-level news as positive or negative and expected or unexpected to assess stock prices reaction. Final results evidence that market players react only to issues identified as financially material for a given industry by sustainability accounting standards. The positive and surprising news that receives greater media coverage and is tied to social capital concerns, elicits a stronger reaction. Specifically, human rights and community

relations positive news have been observed to produce a +3.9% stock price reaction. This highlights the importance of social topics for firms' stakeholders, in particular when these issues are perceived as material. For what concerns the potential impact of a disclosure mandate on the Social dimension, it is interesting to consider the article by Karpoff et al. (2022). Since the U.S. SEC is considering introducing an ESG disclosure mandate, the Financial Economist's Roundtable stepped in recommending not to mandate disclosure of the firm's impact on environmental and social outcomes. Specifically, the claim is that measuring something qualitative in nature such as Social aspects is complex and poorly defined terms might exacerbate the measurement problem. Since treated firms have experienced a positive reaction in their ESG and Social ratings after the introduction of the UK disclosure mandate, this could serve as a reference for the U.S. SEC to develop its own ESG disclosure mandate. Having said that, it is important to consider that a causal relationship between the introduction of the UK disclosure mandate and an increase in Social ratings has not been proved yet and that each regulation must be tailormade to the social and economic landscape in which applies. In this perspective, even if the UK disclosure mandate would not probably produce the same effects in the US, it could be still interesting for the U.S. SEC to examine the regulation to extract some useful insights. To conclude, according to an article by Hunt et al. (2022), the attention toward the S pillar increased after the pandemic. Over the previous decade, the focus was on working on improving the E rating, not considering that many companies were not meeting their employees' expectations. It is now time to reallocate resources to invest in systemic elements that can significantly enhance working conditions and provide a competitive advantage in recruiting talent.

4.4.5 Hypothesis 2.3

In the end, it is interesting to explore the impact of the UK disclosure mandate on the Governance Rating. Although the regulation does not provide any specific mandate concerning governance topics, some indirect effects could be observed and for this reason, it seems appropriate to examine this relationship. The approach is the same used for the analysis of the other pillars and results are shown in Table 11.

Model 13 has been built including the variable *Post*, the interaction term *Post x Treat* and the firm and year fixed effects. Although the interaction term points toward a positive correlation with the dependent variable, the magnitude of the impact is low and the

coefficient appears to be statistically not significant. Furthermore, the largely negative adjusted-R2 suggests that the explanatory power of the model is extremely poor.

For Model 14, I added firm-specific control variables to improve the model. The direction of the interaction term remains positive and the value of the estimated coefficient increases, but it is still not statistically significant. Among control variables introduced, *Size* appears to be statistically significant on a 5% level and positively correlated with Governance ratings. This could be explained by the fact that external stakeholders exert a high amount of pressure on corporate executives of large companies to keep governance issues under control. However, it is not possible to extract any valuable insights since the adjusted- R2 of the model remains negative.

Finally, Model 15 includes country and industry-specific control variables. The variable Post x Treat maintains its positive correlation with the dependent variable, but the estimated coefficient remains not statistically significant. While the p-value for the variable Size increases above the significance level of 5%, the newly introduced control variables appear to be largely not significant, except for some industry trends such as Energy and Healthcare which probably experienced some developments from a governance perspective. Moreover, *GDP* shows a counterintuitive negative correlation with the dependent variable. However, the adjusted- R2 remains negative also for this model.

Table 11: The impact of the UK disclosure mandate on Governance Rating

Variables	Model 13	Model 14	Model 15
Experimental Variables			
Post x Treat	**0.00461**	**0.01171**	**0.04821**
	(0.0339)	(0.0332)	(0.0399)
Post	0.02077	0.01546	-0.06486
	(0.0243)	(0.0256)	(0.0415)
Control Variables			
ln(Size)		0.07451*	0.05029
		(0.0307)	(0.0412)
Leverage		0.00020	-0.00058
		(0.0015)	(0.0018)
ROA		0.00059	-0.00078
		(0.0028)	(0.0023)
Asset Intensity		0.20418*	0.17322*
		(0.0872)	(0.0725)
Price-to-Book		-0.03346	-0.02638
		(0.0395)	(0.0381)
ln(GDP)			-0.12684
			(0.1061)
Consumer Discretionary x Year			0.04310
			(0.0198)
Consumer Staples x Year			0.04716
			(0.0230)
Energy x Year			0.04777*
			(0.0173)
Healthcare x Year			0.06506*
			(0.0211)
Industrials x Year			0.05175
			(0.0246)
Materials x Year			0.05150
			(0.0238)
Utilities x Year			0.01833
			(0.0229)
Firm fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
Observations	850	850	850
Adjusted-R2	-0.11002	-0.10775	-0.09042

Unfortunately, due to a negative adjusted- R2 for all three models considered, it is not possible to extract any valuable insight into the impact of the UK disclosure mandate on the Governance Rating. As stated previously, even if any direct impact was expected since the regulation does not explicitly provide any measure related to governance issues, it could be plausible to expect some side effects from the impact on other ESG pillars. However, although governance issues are an integral part of CSR activities and governance ratings contribute to generating aggregate ESG scores, they appear to follow different trends and rationales than Social and Environmental pillars (Crespi & Migliavacca, 2020). Specifically, according to Christensen et al. (2021), governance mechanisms are complex and firms are usually subject to rigorous disclosure mandates on governance issues. Regulations tend to be industry and country-specific, depending also on the historical damages that governance issues caused in a certain economic landscape. For this reason, it is unlikely that a single disclosure mandate not even focused on governance topics would be able to affect Governance ratings. Moreover, treatment and control groups appear to be biased in this case, since large differences in terms of regulations and corporate governance practices appear to exist across European economies. For example, it is enough to consider that UK is a common law country, while in Europe civil law systems dominate. An article by Zalata & Roberts (2015) demonstrates the strength of UK corporate governance mechanisms. Specifically, they adopted a sample of 713 UK firm-year observations and found high-quality internal governance, both in terms of general quality of the board and committees. Specifically, strong internal governance and independence of directors appear to mitigate governance issues, such as classification shifting. This could potentially explain the average high Governance ratings assigned to companies belonging to the treatment group, as shown in Exhibit 7. At the same time, the significant differences identified with the rest of the European listed firms could be explained by the fact that in the control group are included also countries with poor corporate governance mechanisms. Even if the Governance rating cannot be reduced entirely to the notion of corporate governance, the latter plays a major role in the generation of the G score (Monteiro et al., 2021). In this perspective, the existence of some forms of biases on the corporate governance dimension would inevitably affect inferences on the Governance Rating.

4.4.6 Hypothesis 3

To conclude the hypothesis testing phase, the impact of the UK disclosure mandate on the Innovation Score will be assessed to determine the impact of the regulation on green innovation. This score is a significant component contributing to the generation of the aggregate Environmental Rating and that could have been impacted by the regulation. Indeed, companies might have decided to invest in new technologies, processes or product innovations to cut emissions. For this reason, a positive and statistically significant relationship is expected in this case. Results are shown in Table 12.

For building Model 16, I included the independent variable *Post*, the interaction term *Post x Treat* to represent the effect of the regulation and the firm and year fixed effect. Interestingly enough, the interaction term appears to be positively correlated with the Innovation Score and with a strong statistical significance on a 0.1% level. However, the adjusted- R2 is negative, suggesting some room for improvement in the model, by adding some control variables.

In Model 17, I included firm-specific control variables. The interaction term remains positively correlated with the dependent variable and is highly statistically significant. For what concerns the control variables introduced, *ROA* shows a positive and significant correlation with the Innovation Score, even if the size of the coefficient is fairly low. This could be expected in light of the fact that firms experiencing a higher return on their assets would be more likely to invest in innovation. Surprisingly enough, even if positively correlated, the variable *Size* is not statistically significant. To conclude, also in this case the explanatory power of this model appears to be poor, since the adjusted- R2 remains negative.

In Model 18, I included also country and industry-specific control variables. Most importantly, the interaction term Post x Treat remains positively correlated with the Innovation Score and statistically significant on a 5% level. Specifically, firms in the treatment group experience an average 12.8% increase in their innovation scores compared to listed firms incorporated in other European economies. For what concerns firm-specific control variables, the ROA remains significant and positively impacts the dependent variable, while the independent variable Size appears to be significant this time on a 5% level. Moreover, while it seems that any statistically significant industry effect is present, the GDP

shows a positive correlation, combined with a p-value lower than 5%. This was expected, considering that the Innovation score should follow the level of innovativeness of specific countries and high-GDP economies are likely to provide large incentives to boost green innovation. As stated previously, the UK can be considered one of the world's most innovative countries in this perspective. To conclude, although the adjusted-R2 rose above zero, it remains very low, suggesting that all the information extracted from this model should be considered carefully and further tested to assess their reliability and validity.

Table 12: The impact of the UK disclosure mandate on Innovation Score

Variables	Model 16	Model 17	Model 18
Experimental Variables			
Post x Treat	**0.19712*** **	**0.20204*** **	**0.12786***
	(0.0216)	(0.0275)	(0.0405)
Post	0.09837**	0.09137***	0.01960
	(0.0209)	(0.0177)	(0.0200)
Control Variables			
ln(Size)		0.09052	0.08646*
		(0.0405)	(0.0352)
Leverage		0.00079	0.00221
		(0.0012)	(0.0011)
ROA		0.00400*	0.00436**
		(0.0013)	(0.0013)
Asset Intensity		0.07202	0.11301
		(0.1135)	(0.0890)
Price-to-Book		-0.01084	-0.00418
		(0.0331)	(0.0280)
ln(GDP)			0.24227*
			(0.1027)
Consumer Discretionary x Year			-0.02378
			(0.0443)
Consumer Staples x Year			0.04419
			(0.0494)
Energy x Year			0.00701
			(0.0419)
Healthcare x Year			0.01246
			(0.0428)
Industrials x Year			-0.01744
			(0.0410)
Materials x Year			-0.00749
			(0.0454)
Utilities x Year			0.02669
			(0.0375)
Firm fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
Observations	850	850	850
Adjusted-R2	-0.02740	-0.02652	0.01876

Apart from the low adjusted- R2, results obtained are extremely interesting and could answer some of the existing questions raised from previous research. For example, in an attempt to identify the cause of GHG emissions reduction, Downar et al. (2021) found that it cannot be attributed to a mere reduction in production volume. Thus, starting from these findings, it is possible to conclude that something else must have caused this GHGs emissions reduction and a potential answer might be related to environmental innovation. Indeed, it is likely that treated firms have directed resources to improve their environmental innovation performance in order to cut emissions. Someone could argue that since the regulation has been introduced on the 30th of September 2013, it is unlikely that treated firms have had enough time to improve their Innovation score by the end of the year, considering that environmental innovation usually involves investment plans that last years. However, two main aspects should be pointed out. First, firms were well aware of the introduction of the disclosure mandate months before the 30th of September 2013, that is the date on which the regulation become enforceable. Second, it is important to remind that environmental innovation is not limited to large infrastructural investment plans which could take years and millions to be completed. These of course play a major role in the long term to achieve carbon neutrality at the installation level. However, in the short term even small changes in processes, such as reducing resource usage, or in products, such as removing plastic packages, could produce a dramatic increase in emissions and increase the Innovation Score. This is particularly true for highly polluting firms investing a small portion of their budget in environmental innovation, for which the marginal benefit of small actions can be extremely high. The relationship between business environmental innovation and GHGs emissions reduction has been tested multiple times in literature. Konadu et al. (2022) analysed the relationship between board diversity and firms' carbon emissions reduction for a set of S&P 500 listed companies from 2002 and 2018, with environmental innovation introduced as a moderating variable. Results indicate that board diversity contributes to lower carbon emissions and that environmental innovation amplifies this effect. The magnitude of such moderating effect is expectedly more pronounced for carbon-intensive firms. At the same time, Zhang et al. (2017) examine the relationship between environmental innovation and carbon emissions reduction for Chinese firms across 30 provinces from the period 2000-2013. They identify that most of the environmental innovations introduced in China are able to effectively curb emissions. Finally, Albitar et al. (2022) investigate the impact of environmental innovation on CO2 emissions for a group of London Stock Exchange-listed

firms from 2016 to 2020. Findings suggest that a higher Innovation Score contributes to reducing both Scope 1 and Scope 2 emissions. For what concerns the impact of environmental regulations on innovation, there is a large amount of literature on this topic, starting from the seminal article of Porter & Van der Linde (1995). In particular, It implies that if conceived and executed appropriately, environmental rules can foster innovation, which can outweigh the cost of compliance in the medium to long run. Limiting the scope of the analysis to mandatory CSR disclosure laws, Hong et al. (2020) examines the implementation of a CSR disclosure requirement in China, discovering an average rise in green innovation following the mandate's implementation. On top of this, Mbanyele et al. (2022) find the same results by exploring the impact of different CSR-related regulations on green innovation around the world. However, it is important to remind that effects are extremely peculiar to the specific context in which the regulation applies and the clauses included. For example, results about the impact of the ETS on firms' innovation have been mixed, with someone arguing that a limited effect is in place, while others comply that the very low price of certificates does not incentivize treated firms to invest in innovation (Joltreau & Sommerfeld, 2018).

To sum up, according to my analyses, the UK disclosure mandate produces an evident and statistically significant impact on Emissions, ESG and Social ratings, while any significant insight could be extracted about the relationship with Environmental and Governance ratings. Finally, interesting results have been obtained also concerning the Innovation Score, but the low adjusted-R^2 prevents me to state any definitive conclusion.

5. Limitations

This thesis is of course not free of limitations, which can potentially serve as a starting point for future research.

First, although changes in the EU ETS and other major regulatory measures surrounding the UK disclosure mandate have been taken into account and considered not impacting the analysis, there might be some minor regulations developed at the national level which could interfere with results. A lot of due diligence has been performed on this topic, but of course,

something could be missing. Furthermore, it is not possible to rule out unspecified events happening in 2013 and impacting UK-listed firms differently.

Second, I adopted the ESG, Environmental, Social, and Governance ratings and the Innovation Score from Refinitiv, since the most reliable and accessible. However, scoring systems can differ dramatically among rating providers. The same firm may have different scores with a significant fluctuation band. In this perspective, results might change if another rating provider is taken as a reference.

Finally, the thesis takes into account only Scope 1 emission, since those reported in the EUTL database. However, I believe that adding Scope 2 emissions to the analysis would not have affected results decisively.

6. Conclusions And Future Research

This thesis contributes to enriching literature about the effect of mandatory disclosure regulations on treated firms in the ESG domain.

Findings related to hypothesis 1, suggest that treated firms achieve an average 15% reduction in their CO2-equivalents emissions compared to other non-UK incorporated listed peers included in the control group. Furthermore, this result is statistically significant on a 5% level. Thus, it is possible to reject the null hypothesis in favour of the alternative one, confirming that UK-incorporated listed firms are able to achieve a decrease in their emissions after the introduction of the mandate. At the same time, for hypothesis 2 treated firms show an average increase of 2.5% in their ESG ratings compared to firms included in the control group, with a statistical significance on a 5% level. Also in this case it is possible to reject the null and accept the alternative hypothesis. On the other hand, a negative and not statistically significant treatment effect has been observed for hypothesis 2.1. It is thus not possible to reject the null hypothesis and affirm that Environmental ratings have been impacted positively by the regulation. Considering the relevance of the topic and the limited literature available, it could be interesting for future researchers to explore more this relationship. For what concerns hypothesis 2.2, evidence shows that treated firms experience an average 8.8%

increase in their social ratings compared to other European listed peers. This result shows also a strong statistical significance on a 0.1% level, allowing us to reject the null hypothesis in favour of the alternative one. On the other side, even though the treatment effect appears to be positive on governance ratings, the coefficient for the interaction terms shows no signs of statistical significance, not allowing for rejecting the null hypothesis. Overall, the reasons for such differences across ESG pillars can be explained by their multidimensional nature. Each component has its own definition, and measurement criteria and responds to different stakeholder interests. In this perspective, considering only the ESG Rating in the analysis would have been limiting, also because each pillar contributes differently to the aggregate score. Finally, for what concerns hypothesis 3 it is possible to affirm that treated firms experience an average 12.8% increase in their innovation scores, with a statistical significance on a 5% level. This result suggests a positive impact of the UK disclosure mandate on innovation, supporting the theory of Porter & Van der Linde (1995). However, the limited adjusted-R2 poses a serious threat to the validity of such results.

At this point, someone could ask what differentiates the UK regulation from other disclosure mandates. The answer is that it does not simply indicate what to disclose, but also how to disclose data, providing companies with clear guidelines and forcing them to explain frameworks used when they do not comply with existing robust standards. This is in line with the article of Bernow et al. (2019) discussed previously, according to which corporate executives are requesting more legal interventions to regulate the disclosure of ESG information and to provide some forms of guidance for reporting. Results clearly show that firms and ESG rating agencies reacted positively to the introduction of such regulation. However, it is important to remind that any causal relationship has not been identified yet. The difference-in-difference design is extremely helpful to make a step ahead toward causation, but it does not automatically imply that a causal effect is in place. To do so, more randomization should be applied to the firm sample. Moreover, results are hardly generalizable due to the fact that each social, economic and cultural landscape is extremely peculiar and the effects of such regulation might not be in place if applied to other countries and periods. However, I believe that this thesis can fulfil some existing doubts raised from previous research on the topic and contributes to enriching the existing literature, which is very limited in this specific segment, but particularly actual. Finally, it is possible to affirm

that the UK disclosure mandate of 2013 could serve as a model for countries or European institutions interested in launching their own CSR reporting mandate in the future.

To conclude, I believe that this paper could provide various avenues for future research. In particular, additional studies could further explore the impact of the disclosure mandate on the Innovation Score and extract more in-depth results by improving the adjusted-R^2. This would be valuable to explain the observed emissions reduction. Furthermore, future research might repeat the analysis with different ratings such as the ones of Bloomberg or Sustainalytics, to assess the level of generalizability of results. Since ESG-related scores differ can differ significantly among the main rating providers, a similar outcome with different ratings would further strengthen this thesis' results. Finally, the analysis should be repeated taking into account also Scope 2 emissions, if a reliable method for collecting data is found. As already stated, I do not expect results to change dramatically, but it would be interesting to extend findings to Scope 2 emissions, considering that are included in the UK disclosure mandate.

APPENDIX A – REPORTING ITEMS FOR THE COMPANIES ACT 2006 (STRATEGIC REPORT AND DIRECTORS' REPORT) REGULATIONS 2013

Disclosure requirement	Section of the Act
Annual quantity of emissions in tonnes of carbon dioxide equivalent from activities for which that company is responsible including the combustion of fuel; and the operation of any facility (listed firms)	P. 7, 15. (2)
Annual quantity of emissions in tonnes of carbon dioxide equivalent resulting from the purchase of electricity, heat, steam or cooling by the company for its own use (listed firms)	P. 7, 15. (3)
Methodologies used to calculate the information on carbon dioxide equivalents (listed firms)	P. 7, 16.
At least one ratio which expresses the quoted company's annual emissions in relation to a quantifiable factor associated with the company's activities (listed firms)	P. 17, 17.
Not only the information required by paragraphs 15(2) and (3) and 17, but also that information as disclosed in the report for the preceding financial year.	P. 17, 18.
Description of the company's strategy (listed firms)	Ch. 4A, 414C (8) (a)
Description of the company's business model (listed firms)	Ch. 4A, 414C (8) (b)
A breakdown showing at the end of the financial year the number of persons of each sex who were directors of the company (listed firms)	Ch. 4A, 414C (8) (c) (i)
A breakdown showing at the end of the financial year the number of persons of each sex who were senior managers of the company (listed firms)	Ch. 4A, 414C (8) (c) (ii)
A breakdown showing at the end of the financial year the number of persons of each sex who were employees of the company (listed firms)	Ch. 4A, 414C (8) (c) (iii)
Fair review of the company's business	Ch. 4A, 414C (2) (a)
Description of the principal risks and uncertainties facing the company	Ch. 4A, 414C (2) (b)
Balanced and comprehensive analysis of the development and performance of the business	Ch 4A, 414C (3) (a)
Balanced and comprehensive analysis of the position of the company's business at the end of the year	Ch. 4A, 414C (3) (b)
Analysis using financial key performance indicators	Ch. 4A, 414C (4) (a)
Where appropriate: analysis using other key performance indicators, including information relating to environmental matters and employee matters	Ch. 4A, 414C (4) (b)
To the extent necessary for an understanding of the development, performance or position of the company's business: main trends and factors likely to affect the future development, performance and position (listed firms)	Ch. 4A, 414C (7) (a)
To the extent necessary for an understanding of the development, performance or position of the company's business: information about environmental matters (including the impact of the company's business on the environment) including information about any policies of the company in relation to those matters and the effectiveness of those policies (listed firms)	Ch. 4A, 414C (7) (b) (i)
To the extent necessary for an understanding of the development, performance or position of the company's business: information about the company's employees including information about any policies of the company in relation to those matters and the effectiveness of those policies (listed firms)	Ch. 4A, 414C (7) (b) (ii)
To the extent necessary for an understanding of the development, performance or position of the company's business: information about social, community and human rights issues including information about any policies of the company in relation to those matters and the effectiveness of those policies (listed firms)	Ch. 4A, 414C (7) (b) (iii)

The list above provides an overview of all the main reporting items included in the UK regulation. The first column includes a specification of all the information to disclose for listed companies, while the second column specifies the section of the act in which these mandatory clauses are included.

APPENDIX B – MAJOR EU ETS REGULATORY CHANGES SURROUNDING THE INTRODUCTION OF THE MANDATE

In 2013, the EU ETS entered its third trading period. Major changes in the design of the EU ETS concern the setting of an EU-wide cap and the decrease in allowances allocated free of charge, with a greater share being auctioned. As stated previously, these simultaneous regulatory changes surrounding the introduction of the UK disclosure mandate, might impact differently firms in the treatment and control group, and significantly affect final results.

First, concerning the setting of an EU-wide cap on emissions, this was introduced to decrease the political cost of a decentralized emissions cap for European governments and to further centralize it the European Commission-level climate objectives (Ellerman et al., 2016). However, considering that the EU ETS always allows the trading of allowances without any restrictions among participants, it is very unlikely that UK firms have experienced significant advantages or disadvantages concerning the introduction of this cap.

Second, the increase in auctioned allowances primarily affected the electricity sector, with power generators operating in European most advanced economies, which lost the majority of free allocated allowances. This, combined with the introduction of the UK Carbon Price Floor in 2013, persuaded me to exclude electricity sector installations from the analysis. Considering that the sample for this thesis contains mostly firms operating in industrial sectors and that for such industries emissions continued to be covered by free allowances, it is possible to affirm that there are no reasons to believe that UK firms experienced any advantage or disadvantage compared to other EU peers.

APPENDIX C – EXCHANGE RATES

	Avg. FX GBP/EUR	Avg. FX USD/EUR	Avg. FX SEK/EUR	Avg. FX DKK/EUR	Avg. FX PLN/EUR	Avg. FX HUF/EUR	Avg. FX NOK/EUR
2009	1.123392891	0.719052247	0.09436205	0.134348084	0.232045005	0.003583515	0.719052247
2010	1.165933543	0.755123562	0.104960333	0.134334151	0.250898735	0.003640798	0.755123562
2011	1.15271844	0.719024411	0.110842282	0.1342674	0.243690174	0.003595271	0.719024411
2012	1.233160229	0.778121995	0.115026843	0.134383702	0.239546757	0.003465071	0.778121995
2013	1.177791563	0.753130877	0.115663299	0.134127639	0.238636907	0.003373236	0.753130877
2014	1.240972867	0.754079205	0.109953411	0.134173422	0.239090788	0.003245257	0.754079205
2015	1.377313376	0.901417808	0.106895679	0.134091361	0.23926517	0.003231792	0.901417808
2016	1.224237738	0.904109781	0.105690026	0.134341228	0.229372667	0.003215734	0.904109781
2017	1.141468383	0.886745123	0.103822458	0.134463454	0.235090641	0.003236828	0.886745123
2018	1.130397687	0.847839562	0.097532628	0.1341946	0.234798058	0.003140748	0.847839562

In the table above it is possible to observe all the exchange rates for different years which have been used to convert other currencies in euros before performing the analyses.

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